REPORT

Dam Safety Assessment of CCW Impoundments

NRG CHESWICK POWER STATION

United States Environmental Protection Agency
Washington, DC

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REPORT

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Dam Safety Assessment of CCW **Impoundments**

NRG Cheswick Power Station

Prepared for:
US Environmental Protection Agency
Washington, DC

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1. INTRODUCTION

1.1. GENERAL

In response to the coal combustion waste (CCW) impoundment failure at the TVA/Kingston coal-fired electric generating station in December of 2008, the U. S. Environmental Protection Agency (USEPA) has initiated a nationwide program of structural integrity and safety assessments of coal combustion residuals impoundments or "management units". A CCW management unit is defined as a surface impoundment or similar diked or bermed management unit or management units designated as landfills that receive liquid-borne material and are used for the storage or disposal of residuals or by-products from the combustion of coal, including, but not limited to, fly ash, bottom ash, boiler slag, or flue gas emission control residuals. Management units also include inactive impoundments that have not been formally closed in compliance with applicable federal or state closure/reclamation regulations.

The U.S. EPA has authorized O'Brien & Gere to provide site specific impoundment assessments at selected facilities. This project is being conducted in accordance with the terms of BPA# EP10W000673, Order EP-B12S-00065, dated July 18, 2012.

1.2. PROJECT PURPOSE AND SCOPE

The purpose of this work is to provide Dam Safety Assessment of CCW management units, including the following:

- Identify conditions that may adversely affect the structural stability and functionality of a management unit and its appurtenant structures
- Note the extent of deterioration, status of maintenance, and/or need for immediate repair
- Evaluate conformity with current design and construction practices
- Determine the hazard potential classification for units not currently classified by the management unit owner or by state or federal agencies

O'Brien & Gere's scope of services for this project includes performing a site specific dam safety assessment of all CCW management units at the subject facility. Specifically, the scope includes the following tasks:

- Perform a review of pertinent records (prior inspections, engineering reports, drawings, etc.) made available at the time of the site visit (or shortly thereafter) to review previously documented conditions and safety issues and gain an understanding of the original design and modifications of the facility.
- Perform a site visit and visual assessment of each CCW management unit and complete the visual assessment checklist to document conditions observed.
- Perform an evaluation of the adequacy of the outlet works, structural stability, quality and adequacy of the management unit's inspection, maintenance, and operations procedures.
- Identify critical infrastructure within 5 miles down gradient of management units.
- Evaluate the risks and effects of potential overtopping and evaluate effects of flood loading on the management units.
- Immediate notification of conditions requiring emergency or urgent corrective action.
- Identify all environmental permits issued for the management units
- Identify all leaks, spills, or releases of any kind from the management units within the last 5 years.

- Prepare a report summarizing the findings of the assessment, conclusions regarding the safety and structural integrity, recommendations for maintenance and corrective action, and other action items as appropriate.

This report addresses the above issues for Bottom Ash Recycle Pond and Emergency Ash Pond at the Cheswick Power Station in Springdale Borough, Allegheny County, Pennsylvania. Effective December 14, 2012, NRG Energy, Inc. and GenOn Energy, Inc. combined and retained the name NRG Energy, Inc. As a result of the merger, GenOn Power Midwest LP became NRG Power Midwest LP (NRG), a subsidiary of NRG Energy, Inc. Cheswick Power Station is owned and operated by NRG Power Midwest.

In the course of this assessment, we obtained information from representatives of NRG and the Pennsylvania Department of Environmental Protection (PADEP).

2. PROJECT/FACILITY DESCRIPTION

The Cheswick Power Station is located along the north side of the Allegheny River along Pittsburgh Street in Springdale Borough, Pennsylvania. The center of the Cheswick plant is situated at approximate latitude 40.5397 degrees, and longitude -79.7919 degrees. A Site Location Map is included as Figure 1. The coal-fired power plant began commercial operation in 1970 and produces about 640 megawatts of electricity. The plant has open storage capacity for approximately 322,000 tons of coal. Coal combustion residual waste that is produced during power generation consists of fly ash, bottom ash, and flue-gas scrubber sludge. Fly ash and flue-gas scrubber sludge is dry handled and trucked to a privately-owned offsite landfill. Bottom ash is wet-sluiced to two hydrobins located across Pittsburg Street from the main plant area. The bottom ash collected in the hydrobins is trucked to the offsite landfill. Discharge water from the hydrobins contains suspended particles of bottom ash that is managed with one active and one emergency CCW impoundment, as follows:

- Bottom Ash Recycle Pond—A bottom ash impoundment composed of one cell.
- Emergency Ash Pond—A bottom ash impoundment composed of one cell.

This dam safety assessment report summarizes the September 27, 2012 assessment of the above management units at the Cheswick Power Station.

2.1. MANAGEMENT UNIT IDENTIFICATION

The location of the CCW impoundments inspected during this structural stability assessment is identified on Figure 2 – Facility Layout Plan. Bottom ash is handled in two hydrobins and two adjoining ponds— Bottom Ash Recycle Pond and Emergency Ash Pond—separated by a divider dike. Both impoundments were assessed. Bottom ash is sluiced from the ash hopper under the boiler to the hydrobins. Heavy ash particles settle in the hydrobins. The water with suspended ash particles overflows from the hydrobins to the bottom ash ponds for additional settling. A polymer is added to the hydrobin overflow water to facilitate settling in the ponds. The water is drained (decanted) from the hydrobins a few days per week to dewater the ash in the hydrobins prior to shipment to the landfill or distribution for beneficial reuse. Decanting produces more inflow to the ponds.

2.1.1. Bottom Ash Recycle Pond

The Bottom Ash Recycle Pond is located within the northwest corner of the Cheswick facility, as shown on Figure 2. The Bottom Ash Recycle Pond commenced operations in 1970. It consists of an approximately 0.6 acre impoundment that is incised on the west and north sides with earth dikes forming the eastern and southern perimeter. Tawney Run borders the access road along the eastern dike. A concrete stilling basin is located on the south end of the impoundment. Both the main pond and the stilling basin were assessed. The primary features of the Bottom Ash Recycle Pond are shown on Figure 3A.

The Bottom Ash Recycle Pond receives the ash transport water overflow from the hydrobins after settling of the heavy ash particles. Inflow enters the pond along the north side of the impoundment. Decant water flows through a long rectangular weir into the stilling basin. From the stilling basin, decant water is pumped to the Allegheny River to the south of the impoundment via a pipe along Tawney Run and over Pittsburgh Street. The discharge is authorized by Pennsylvania National Pollutant Discharge Elimination System (PA NPDES) Permit No. PA0001627 at Internal Monitoring Point (IMP) 303 via Outfall No. 003. The Bottom Ash Recycle Pond previously discharged to Tawney Run.

2.1.2. Emergency Ash Pond

Emergency Ash Pond is located adjacent to the south side of the Bottom Ash Recycle Pond, as shown on Figure 2. It consists of an approximately 0.4 acre impoundment that is incised on the west side with earth dikes forming the eastern and southern perimeter. The north side is adjacent to the Bottom Ash Recycle Pond's stilling basin. Tawney Run borders the access road along the eastern dike. The primary features of Emergency Ash Recycle Pond are shown on Figure 3B.

Emergency Ash Pond is used for about one month in the summer when the Bottom Ash Recycle Pond is drained for ash removal and inspection. Emergency Ash Pond receives flow from the hydrobins that that enter the pond through an influent trough along the north side of the impoundment. Decant water flows through an effluent trough along the south side of the impoundment. From there, it enters a 24-inch Corrugated Metal Pipe (CMP) and flows along the west side of the Emergency Ash Pond into the Stilling Basin. From the Stilling Basin, water is discharged to the Allegheny River to the south of the impoundment along Tawney Run and over Pittsburgh Street. The discharge is authorized by Pennsylvania National Pollutant Discharge Elimination System (PA NPDES) Permit No. PA0001627 at IMP 203 via Outfall No. 003.

2.2. HAZARD POTENTIAL CLASSIFICATION

The Commonwealth of Pennsylvania classifies dams or embankments in accordance with the Pennsylvania Dam Safety and Encroachments Act and Title 25 of the Pennsylvania Code, Chapter 105. The regulations are administrated by the Pennsylvania Department for Environmental Protection (PADEP), Bureau of Waterways Engineering, Division of Dam Safety. Structures and activities regulated by the PADEP are as follows (25 PA Code § 105.3.a):

- Dams on a natural or artificial watercourse, other than those licensed under the Federal Power Act (16 U.S.C.A. § § 791a—825s), where one or more of the following occur:
- The contributory drainage area exceeds 100 acres.
- The greatest depth of water measured by upstream toe of the dam at maximum storage elevation exceeds 15 feet.
- The impounding capacity at maximum storage elevation exceeds 50 acre-feet.
- Dams used for the storage of water not located on a watercourse and which have no contributory drainage where the greatest depth of water measured at upstream toe of the dam at maximum storage elevation exceeds 15 feet and the impounding capacity at maximum storage elevation exceeds 50 acre-feet.
- Dams used for the storage of fluids or semifluids other than water, the escape of which may result in air, water or land pollution or in danger to persons or property.
- Water obstructions and encroachments other than dams located in, along or across, or projecting into a watercourse, floodway or body of water, whether temporary or permanent.
- Flood control projects constructed, owned or maintained by a governmental unit.

Dam and embankment hazard classifications are established by Title 25 PA Code Chapter 105.91 and provide standards regarding impoundment facility structure classification. A dam or reservoir shall be classified in accordance with Size Category and the Hazard Potential Category which might occur in the event of an operational or structural failure. In approving a classification, the Department will consider, without limitation:

- The height of the dam and storage capacity of the reservoir.
- The physical characteristics and extent of actual and projected development of the dam site and downstream areas.
- The relationship of the site to existing or projected industrial, commercial and residential areas and other land uses downstream which may be affected by a dam failure.

The PADEP Division of Dam Safety currently does not regulate the Bottom Ash Recycle Pond or Emergency Ash Pond; therefore, no PADEP hazard classification has been assigned. In the absence of a State Hazard Potential Classification, the FEMA guidelines, *Hazard Potential Classification System for Dams* (2004) have been applied in this assessment to recommend a hazard potential classification for each of the following impoundments.

2.2.1. Bottom Ash Recycle Pond and Emergency Ash Pond

The definitions for the four hazard potentials (Less than Low, Low, Significant and High) to be used in this assessment are included in the EPA CCW checklist found in Appendix A. Based on the checklist definitions and as a result of this assessment, the hazard potential rating recommended for the Bottom Ash Recycle Pond is **SIGNIFICANT**. Likewise, the hazard potential rating recommended for Emergency Ash Pond is **SIGNIFICANT**. A failure of the embankments impounding the Bottom Ash Recycle Pond or Emergency Ash Pond would result in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns.

The **SIGNIFICANT** hazard potential is recommended primarily due to the potential for release of CCW into Tawney Run and the environmental impacts associated with such a potential release. Tawney Run flows between Duquesne and Washington Streets before crossing Pittsburgh Street and re-entering Cheswick Power Station property, then flowing into the Allegheny River. Duquesne and Washington Streets contain several twin and single residential homes. There are a few nearby homes on Pittsburgh Street. Nonetheless, loss of human life and/or damage to critical infrastructure or lifeline facilities in the event of a dike breach is unlikely. The impoundments are relatively small and the closest downstream home is over 500 feet from Emergency Ash Pond and 800 feet from the Bottom Ash Recycle Pond. Environmental impacts to waters of the U.S. are likely, due to the proximity of the impoundments to the Allegheny River and its tributaries.

2.3. IMPOUNDING STRUCTURE DETAILS

The following sections summarize the structural components and basic operations of the two subject impoundments. The location of the impoundments on the plant grounds is shown on Figure 2. Typical pond cross-sections are shown in Figure 4.

2.3.1. Embankment Configuration

Bottom Ash Recycle Pond

The Bottom Ash Recycle Pond is a combined incised/diked earthen embankment structure that impounds an area of approximately 0.6 acre. The features of The Bottom Ash Recycle Pond are shown in Figure 3A. It is a side-hill impoundment that ties into high ground on the west side, roughly level ground on the north side, and is formed by an earth dike along the east side. The south end of the impoundment is formed by a concrete stilling basin and earthen dividing dike between The Bottom Ash Recycle Pond and Emergency Ash Pond.

The crest is at approximately elevation (EL) 779 feet above mean sea level. The pond bottom (as indicated by plant record drawings) is at approximately EL 769.6. The inboard embankment slopes have an inclination of approximately 2H:1V. Diked embankments on the west and north sides vary in height from 1 to 2 feet to provide vehicle access drives. The typical water surface elevation maintained in the Bottom Ash Recycle Pond is approximately EL 777 which is within the incised portion on the west and north sides. The east embankment is 11.7 feet at its maximum height with an outboard slope of approximately 1.5H:1V. The outlet works for the Bottom Ash Recycle Pond is integrated into the south embankment as discussed below.

Emergency Ash Pond

Emergency Ash Pond is a combined incised/diked earthen embankment structure that impounds an area of approximately 0.4 acre. The features of Emergency Ash Pond are shown in Figure 3B. It is a side-hill impoundment that ties into high ground on the west side and is formed by earth dikes along the east and south sides. The north end of the impoundment is formed by an earthen dividing dike between the Emergency Ash Pond and Bottom Ash Recycle Pond's concrete stilling basin.

The crest is at approximately elevation (EL) 779 feet above mean sea level. The pond bottom (as indicated by plant record drawings) varies from EL 763.5 to EL 763.8. The inboard embankment slopes have an inclination of approximately 2H:1V. Diked embankments on the west and north sides vary in height from 1 to 2 feet to provide vehicle access drives. The typical operational water surface elevation maintained in Emergency Ash Pond is approximately EL 775.5 which is within the incised portion on the west side. The east embankment is 14 feet at its maximum height with an outboard slope of approximately 1.5H:1V. The south embankment is 10 feet at its maximum height with an outboard slope of approximately 2H:1V.

2.3.2. Type of Materials Impounded

Bottom Ash Recycle Pond

Bottom ash is wet sluiced to the hydrobins across Tawney Run from the ash ponds. Water and suspended bottom ash flow into the Bottom Ash Recycle Pond via metal pipes that run mainly above ground over Tawney run and the pond access road, along the eastern embankment outboard slope near the crest, and under the eastern embankment access road. Hydrobins store the majority of bottom ash which is trucked to dry landfills or distributed for beneficial use. Approximately 1,500 tons of bottom ash are transferred to the hydrobins daily. Approximately 48.3 tons per day flow into the Bottom Ash Recycle Pond.

Emergency Ash Pond

The Emergency Ash Pond is used approximately one month per year in the summer when the Bottom Ash Recycle Pond is drained for bottom ash removal and liner thickness testing and supplementation. While in operation, the Emergency Ash Pond receives the same materials and quantities that the Bottom Ash Recycle Pond would receive.

2.3.3. Outlet Works

Bottom Ash Recycle Pond

The Bottom Ash Recycle Pond decants water through a 40-ft long weir that discharges into a 40-ft long by 18-ft wide rectangular concrete stilling basin with an open top. A floating boom and steel slide gate serve as baffles to exclude floating debris from the discharge. The pump house directs decant water for discharge at Outfall 003. Effluent originally discharged through an 18-inch diameter pipe to nearby Tawney run. NPDES requirements led to the re-routing of pond outflow directly to the Allegheny River in the late 1970s / early 1980s based on discussions with plant personnel. The discharge is authorized by Pennsylvania National Pollutant Discharge Elimination System (PA NPDES) Permit No. PA0001627 at IMP 303 via Outfall No. 003.

An emergency overflow riser is located in the Bottom Ash Recycle Pond at the downstream end next to the pump house. The top of the 24-inch corrugated steel emergency overflow outlet pipe is at EL 778.25. The vertical riser transitions into 24-inch horizontal outlet pipes that discharge into nearby Tawney Run about 150 feet east of the riser.

Emergency Ash Pond

The outlet works for the Emergency Ash Pond consist of an 80-foot long metal effluent trough with top plates forming a triangle in cross-section. The effluent trough is underlain with a 3-foot wide sand base. Effluent originally discharged through a 24-inch corrugated metal pipe to nearby Tawney run. In the late 1970s / early 1980s, NPDES requirements led to the re-routing of pond outflow into the 40-ft long by 18-ft wide rectangular concrete stilling basin with an open top. A floating boom and steel slide gate serve as baffles to exclude floating debris from the discharge. The pump house directs decant water for reuse in the plant discharge to Outfall 003. The discharge is authorized by Pennsylvania National Pollutant Discharge Elimination System (PA NPDES) Permit No. PA0001627 at IMP 203 via Outfall No. 003.

3. RECORDS REVIEW

A review of the available records related to design, construction, operation and inspection of the Ash Ponds was performed as part of this assessment. The documents provided by NRG are listed below:

Table 3.1 Summary of Documents Reviewed

Document	Dates	By	Description
Assessment Report—Cheswick Power Station Bottom Ash Ponds	2/7/2013	GeoSyntec, Inc.	Letter report of geotechnical investigation and slope stability analysis of embankments
Bottom Ash Pond Maintenance Log Plan and Excerpt	1/8/2012 – 7/9/2012	NRG	Quarterly schedule for bottom ash pond maintenance inspections, one inspection log
Steam Electric Questionnaire Parts A, C, and D	5/20/2010	NRG	US EPA Questionnaire Part A – Steam Electric Power Plant Operations Part C – Ash Handling Part D – Pond/Impoundment Systems and Other Wastewater Treatment Operations
Cheswick Power Station Bottom Ash Recycle System Construction Drawings	1971-1973	NRG	Sheet B1: Settling Basin Location Plan B9-13: Settling Basin Cross Sections & Drainage Structures (B12) B15: Temporary Settling Pond Plan B16: Temp. Pond Long. Section & Drainage Structures B17-19: Temp. Pond Effluent through Steel Details B21: Temp. Pond Troughs & Pipe Supports B22: Temp. Pond Gate Valve Access Timber Platform B23: Temp. Pond Access Road & 24" CMP B41: Settling Basin New Bent Foundations & Drainage Structures B42: Ash Lines A&B Alterations B43: Settling Basin Plan, Sec., Prof., Det. B44: Pump House for Settling Tanks B45: Settling Basin Sludge Pump Shelter B47: Cross Sections at Ponds

3.1. ENGINEERING DOCUMENTS

Review of the above documents revealed information on the design details and construction of the Cheswick CCW impoundments, which are summarized below.

Bottom Ash Recycle Pond

- The Bottom Ash Recycle Pond was constructed and put into operation in 1970.
- No releases or significant failures have occurred at this unit.

- The existing eastern, northern, and southern dikes were constructed above natural ground and constructed generally of excavated material from the western hillside.
- The pond is lined with a layer of compacted clay.
- Geotechnical evaluations for liner thickness are completed annually when the Bottom Ash Recycle Pond is taken out of operation.
- A geotechnical investigation and slope stability analysis of the Bottom Ash Recycle Pond was completed in February of 2013, which indicated the embankment slopes to be stable with factors of safety exceeding required minimums.

<u>Emergency Ash Pond</u>

- The Emergency Ash Pond was constructed and put into operation in 1970.
- No releases or significant failures have occurred at this unit.
- The existing eastern, northern, and southern dikes were constructed above natural ground and constructed generally of excavated material from the western hillside.
- NRG completed removal of trees and woody vegetation from the western outboard slope in 2012.
- A geotechnical investigation and slope stability analysis of the Emergency Ash Pond was completed in February of 2013, which indicated the embankment height, geometry, phreatic surface, and soil shear strength to be less critical as compared to the Bottom Ash Recycle Pond, thus stability analysis of the Emergency Ash Pond embankments was not necessary as described in Section 3.1.2 below.

3.1.1. Stormwater Inflows

No hydrologic & hydraulic analyses were provided evaluating stormwater inflow into the Bottom Ash Recycle Pond and Emergency Ash Pond or the capability of the unit's storage and discharge capacity to manage design flood events. The impounding structures are surrounded by diked embankments to the eastern and southern sides. The western side is a relatively steep, roughly 2.5:1 to 3:1 H/V vegetated hillside. At the top of the steep section, where the slope becomes more gradual, are residential streets and homes in Cheswick. The northern side slopes gently up then back down to an upstream segment of Tawney Run to the north. The west and north sides of the ponds are surrounded by a low berm that probably directs the majority of runoff from the north or western hillside around the ash ponds and down the eastern or southern embankments toward Tawney Run.

Assuming stormwater inflows to the ponds are limited to direct precipitation and a freeboard of 2 feet is available in each pond, available storage volume is sufficient to contain a 24-hour 100-year storm, but not sufficient to contain a PMP (Probable Maximum Precipitation) event without overtopping the crest of the ponds. If pond discharge through the normal outlet and 24-inch emergency riser pipe is considered in combination with the freeboard storage, the ponds are likely capable of storing/passing the PMP event. Other than the 24-inch emergency riser pipe, neither the Bottom Ash Recycle Pond nor the Emergency Ash Pond has emergency spillways for management of possible pond overflow. However, both ponds are interconnected with two 14-inch diameter steel pipes ensuring all extra pond capacity is utilized during a PMP event prior to overflow via to the 24-inch corrugated metal emergency riser pipe in the Recycle Pond to Tawney Run. Under normal operating conditions, the majority of the Emergency Pond volume would be available to provide storage of overflow water from the Bottom Ash Recycle Pond, thereby containing a PMP event without overtoping. This rationale is predicated on no appreciable volume of stormwater runoff entering either of the ponds and having storage available in the Emergency Pond.

3.1.2. Stability Analyses

As mentioned above, NRG retained GeoSyntec Consultants to perform a geotechnical investigation of the Bottom Ash Recycle Pond and the Emergency Ash Pond, included as Appendix C. This assessment was completed in February of 2013 and was provided to O'Brien & Gere via email. Stability analysis of the critical embankment slopes of the Bottom Ash Recycle Pond was performed. The findings of GeoSyntec's assessment indicated the embankment slopes of the Bottom Ash Recycle Pond meet the minimum required factors of safety under static and seismic loading in accordance with US Army Corps of Engineers criteria for earth dams.

The following table provides the results of the stability analysis of the Bottom Ash Recycle Pond, completed by GeoSyntec.

Embankment Slopes	Loading Conditions	Failure Mode	Calculated F.S.	Target F.S.
Design (1.5H:1V)	Static	Circular	3.30	1.5
		Block	3.37	1.5
	Seismic	Circular	2.98	1.2
		Block	2.98	1.2
Conservative Assumption (1H:1V)	Static	Circular	2.97	1.5
		Block	2.98	1.5
	Seismic	Circular	2.78	1.2
		Block	2.73	1.2

GeoSyntec concluded that the critical slope section was the eastern outboard slope of the Bottom Ash Recycle Pond, and it was not necessary to perform slope stability analysis of the Emergency Ash Pond embankments. This judgment was based on the findings of the GeoSyntec geotechnical investigation that the slope height, geometry (inclination), phreatic surface, and soil shear strengths were most critical in terms of slope stability at the Bottom Ash Recycle Pond. Given this finding, GeoSyntec concluded that stability analysis of the Emergency Ash Pond embankments would not yield a lower factor of safety as compared to that of the Bottom Ash Pond, thus rendering the need for actual stability analysis of the Emergency Ash Pond embankments unnecessary.

Based on our review of the GeoSyntec report, O'Brien & Gere concurs with the assumptions and conclusions provided in the report.

3.1.3. Modifications from Original Construction

Based on records review and discussions with plant personnel, the original design drawings called for rubber liners which were quickly replaced with clay because of tearing when the ponds were cleaned. Original outflow from the Bottom Ash Recycle Pond was directed to Tawney Run. NPDES requirements led to the re-routing of pond outflow directly to IMP 203/303 and the Allegheny River via Outfall 003 in the late 1970s / early 1980s based on discussions with plant personnel.

3.1.4. Instrumentation

No geotechnical instrumentation has been installed. Two groundwater monitoring wells are located between the ponds and Tawney Run.

3.2. PREVIOUS INSPECTIONS

As mentioned above, a geotechnical investigation for liner thickness is performed annually. Quarterly inspections are performed to check for seepage, cracks, holes, and freeboard. Informal inspections are performed more frequently.

Based on our discussions with representatives of NRG and our observations during the visual assessment, NRG removed trees and woody vegetation from the western outboard slope in 2012.

3.3. OPERATOR INTERVIEWS

Numerous plant and state regulatory authority personnel took part in the assessment proceedings along with representatives of Pennsylvania Department of Environmental Protection-Division of Water. The following is a list of participants for the September 2012 assessment of the Bottom Ash Recycle Pond and Emergency Ash Pond:

Name	Affiliation	Title
Stephen Frank, PE	NRG Cannonsburg	Senior Environmental Specialist
Jill Buckley, PE	NRG Cheswick	Environmental Engineer - Cheswick
Sara Marie Baldi	NRG Cannonsburg	Senior Environmental Specialist Environmental Operations & Compliance
Keith Schmidt	NRG Cannonsburg	Director, Environmental Policy
Ryan Knarr	PADEP Harrisburg	Dam Safety Engineer
Michael Celaschi	PADEP Pittsburgh	Waste Management Specialist
Dreher Whetstone, PE	O’Brien & Gere	Technical Associate - Geotechnical Engineer
Carrie Lohrmann, PE	O’Brien & Gere	Design Engineer

Facility personnel provided a good working knowledge of the CCW impoundments, provided general plant operation background and provided requested historical documentation. These personnel also accompanied O’Brien & Gere and the PADEP representatives throughout the visual assessments to answer questions and to provide additional information as needed in the field.

4. VISUAL ASSESSMENT

The following sections summarize the visual assessment of the Bottom Ash Recycle Pond and Emergency Ash Pond which occurred on September 27, 2012. At the time of the assessment, O'Brien & Gere completed an EPA assessment checklist for each of the above facilities, which was submitted electronically to EPA on October 17, 2012. Copies of the completed assessment checklists are included as Appendix A.

4.1. GENERAL

The weather on the date of the assessment was cloudy and approximately 60 degrees. The visual assessment consisted of a thorough site walk along the perimeter of the impoundment dikes and other portions of the impoundments to observe outlet structures and general facility operations. O'Brien & Gere team members made observations along the toe, outboard slope, and crest of the dikes, and along exposed portions of the inboard slopes. We also observed the inlet/outlet structures and current operation.

Photos of relevant features and conditions observed during the assessment were taken by O'Brien & Gere and are provided in Appendix B. Aerial photographs depicting the layout and locations and orientation of the photographs are included as Figures 3A and 3B.

4.2. SUMMARY OF FINDINGS

<u>Bottom Ash Recycle Pond</u>

The following observations were made during the assessment:

- The pond was operating at the time of assessment.
- Sluiced bottom ash enters the northeast corner of the pond through a main inflow pipe. Additional inflow pipes and outlets handle greater flows during hydrobin bottom ash decants.
- Rainwater from rainfall the previous day was ponded in areas along the crest.
- Crest roadway surfaces were mainly dirt with some grass and slag in places. They were maintained adequately for vehicular traffic.
- The majority of the inboard slope was grass covered with no unwanted vegetation, but some areas lacked adequate vegetation and showed minor erosion.
- The eastern embankment outboard slope appeared in good condition with adequate vegetation and no undesirable vegetation.
- No seepage was evident.
- The boom, slide gate, and outflow weir appeared to be in good condition and functioning normally.
- The visible portion of the concrete stilling basin was in good condition with no cracking or spalling of concrete.
- A pump house, which is used to transfer water for discharge, is positioned next to the concrete stilling basin at the pond's south end.
- Inflow and outflow pipes were operational and appeared in good condition.

<u>Emergency Ash Pond</u>

- The pond was not operating at the time of assessment. Ponded rainwater covered the pond bottom.
- Sluiced bottom ash would enter through the metal inflow pipe.
- Rainwater from rainfall the previous day was ponded in areas along the crest.

- Outer crest roadway surfaces were mainly dirt with some grass and slag in places. They were maintained adequately for vehicular traffic.
- A divider dike separates the Bottom Ash Recycle Pond from the Emergency Ash Pond. The crest of the dike serves as a road and appeared well maintained.
- Inboard slopes were adequately vegetated at the top, but lacking vegetation below the effluent trough elevation.
- Concrete jersey barriers line the west side of the pond.
- The southern embankment outboard slope appeared in fair condition with some inadequate vegetation and no undesirable vegetation.
- The eastern embankment outboard slope had been cleared of shrubs and trees earlier in the year based on discussions with plant personnel. It was lacking vegetation in several areas likely cleared earlier in the year, showed some erosion and at least one animal burrow. There was some rip rap near the toe.
- No seepage was evident.

5. CONCLUSIONS

Bottom Ash Recycle Pond

Based on the ratings defined in the USEPA Task Order Performance Work Statement (Satisfactory, Fair, Poor and Unsatisfactory), the information reviewed and the visual assessment, the overall condition of the Bottom Ash Recycle Pond is considered to be **FAIR**. Acceptable performance is expected under all loading conditions conditions, but some minor deficiencies were identified that require repair/maintenance.

Minor deficiencies include the following:

- There is poor vegetation cover over the inboard slopes which are experiencing some minor rill erosion.
- Ponding along the crest is undesirable.
- Stormwater runoff entering the pond is undesirable given that no analysis has been performed to demonstrate containment of the appropriate design storm if runoff is allowed to enter the pond.
- Areas of poor vegetation cover on the outboard slopes of both ponds, which have resulted in some erosion.
- Presence of some animal burrows.

Emergency Ash Pond

Based on the ratings defined in the USEPA Task Order Performance Work Statement (Satisfactory, Fair, Poor and Unsatisfactory), the information reviewed and the visual assessment, the overall condition of the Emergency Ash Pond is considered to be **FAIR**. Acceptable performance is expected; however, some deficiencies exist that require repair/maintenance.

Minor deficiencies include the following:

- There is poor vegetation cover on the eastern and southern embankments and erosion on the eastern embankment.
- There is poor vegetation cover over the inboard slopes which are experiencing some minor rill erosion.
- The use of concrete jersey barriers as vehicle barriers along the west access drive may contribute to erosion along the west inboard slope. Stormwater runoff from the adjacent hillside collected behind the barriers flows through gaps between the concrete units to the inboard slope below as concentrated flow.
- Stormwater runoff entering the pond is undesirable given that no analysis has been performed to demonstrate containment of the appropriate design storm if runoff is allowed to enter the pond.
- Ponding along the crest is undesirable.

Maintenance and improvement measures that should be addressed in the near future include the following:

- Supplementing vegetation cover on the outboard and inboard slopes to reduce erosion.
- Filling low areas in the crest to reduce stormwater ponding.
- Moving or replacing Jersey barriers along the Emergency Ash Pond's western inboard slope to prevent possible erosion from concentrated flow.
- Construction or maintenance of perimeter berms to prevent stormwater runoff from upgradient areas entering the ponds.

NRG has implemented remedial measures in the past year to address embankment vegetation deficiencies and performs routine maintenance which appears to be sufficient to keep the impoundments in good working order.

Additionally, NRG has implemented regular visual inspections for perimeter embankment seeps, cracks, holes, and freeboard. NRG's inspections and regular monitoring are performed with the goal of identifying, documenting, and repairing any new deficiencies early so that they do not develop into more serious problems. The Cheswick plant's staff maintains design and construction documents and inspection reports in a well organized manner for future reference. Based on these findings, O'Brien & Gere is of the opinion that the operations and maintenance procedures being practiced at the subject impoundments are satisfactory.

6. RECOMMENDATIONS

Based on the findings of our visual assessment and review of the available records for the Bottom Ash Recycle Pond and Emergency Ash Pond, O'Brien & Gere recommends that additional maintenance of the embankments be performed to correct the erosion, drainage, and other miscellaneous deficiencies cited above. In addition, it is recommended that the facility establish new or augment existing perimeter ponds to divert stormwater runoff, as no analysis was available to demonstrate that stormwater runoff does not enter the pond or can be contained by the pond during an appropriate design storm. Storage capacity is available to prevent overtopping assuming that the water level in the Emergency Pond is maintained at a low level per normal operations and appreciable runoff is diverted away from the ponds.

6.1. URGENT ACTION ITEMS

None of the recommendations are considered to be urgent, since the issues noted above do not appear to threaten the structural integrity of the dikes in the near term.

6.2. LONG TERM IMPROVEMENT

The deficient conditions observed during the assessment do not require immediate attention, but should be implemented in the near future as part of a regular maintenance plan. The recommended maintenance/improvement actions are provided below:

Bottom Ash Recycle Pond

- Enhance vegetation cover on outboard and inboard slopes where required to reduce erosion.
- Fill low areas on crest to reduce stormwater ponding and direct runoff away from the pond.
- Establish new or augment existing perimeter berms around the ponds to divert runoff away from the pond.

Emergency Ash Pond

- Enhance vegetation cover on outboard and inboard slopes where required to reduce erosion.
- Fill low areas on crest to reduce stormwater ponding and direct runoff away from the pond.
- Relocate concrete Jersey barriers to prevent concentrated flow onto west inboard slope.
- Establish new or augment perimeter berms around the ponds to divert runoff away from the pond.

6.3. MONITORING AND FUTURE INSPECTION

O'Brien & Gere recommends continued internal inspections by personnel trained in dam safety and periodic inspections by independent licensed dam safety engineers on at least a biennial basis until the ponds are formally closed.

6.4. TIME FRAME FOR COMPLETION OF REPAIRS/IMPROVEMENTS

Based on the findings of this assessment, O'Brien & Gere believes that NRG is addressing maintenance and deficiency repairs in a proactive manner and within a reasonable time frame. We recommend that the owner continue this good practice going forward.

6.5. CERTIFICATION STATEMENT

I acknowledge that the Bottom Ash Recycle Pond and Emergency Ash Pond, CCW management units, referenced herein were personally inspected by me on September 27, 2012 and were found to be in the following condition:

SATISFACTORY

FAIR

POOR

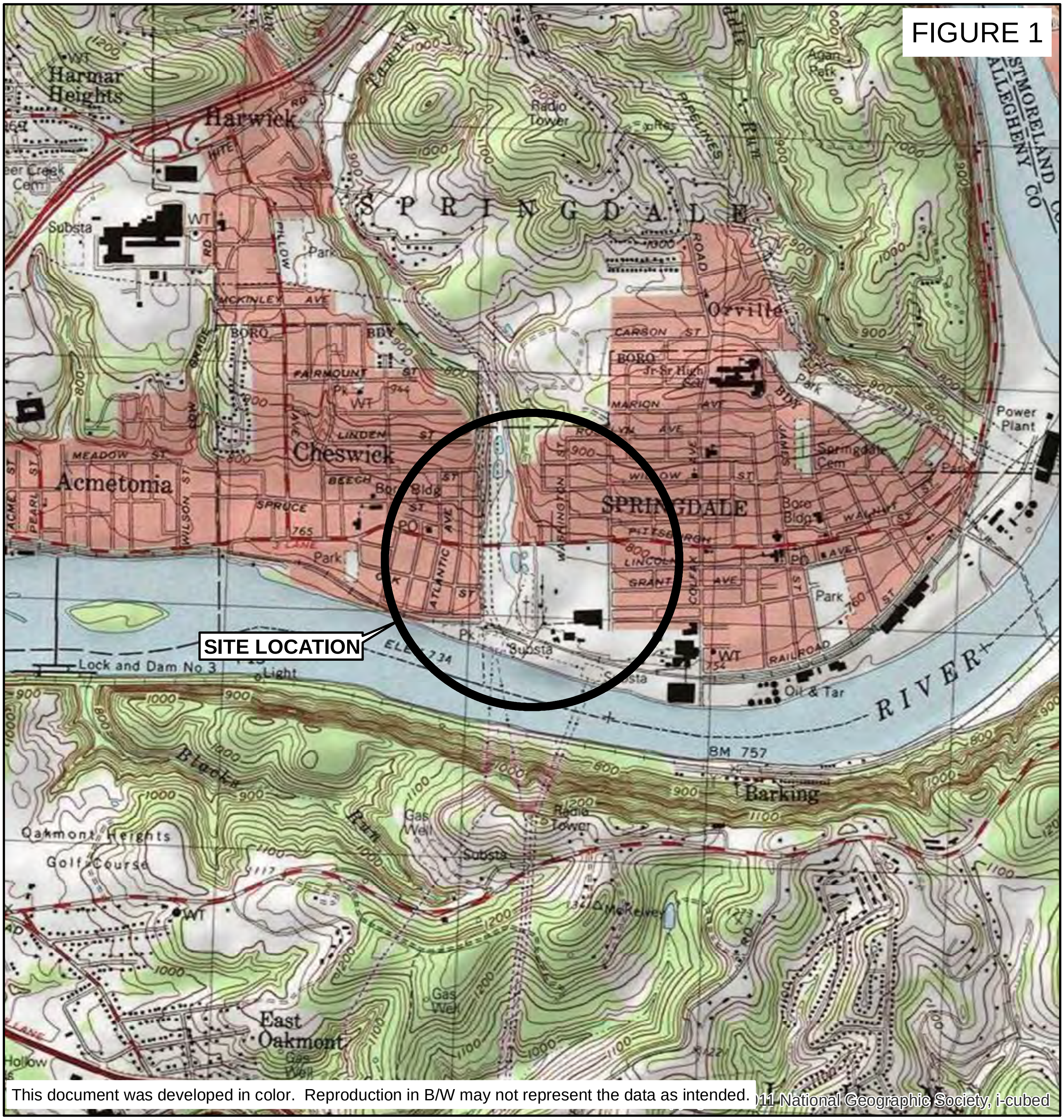
UNSATISFACTORY

Signature: ______________________ Date: January 24, 2014

D. Dreher Whetstone, PE
PA PE License # PE060840

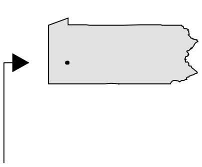
I:\US-EPA.13498\STDS\GIS\Coal_Impoundments\Figures\Cheswick\Cheswick_Figure1_SiteLocation.mxd

PLOTDATE: 1/24/2014 DRK



ADAPTED FROM: NEW KENSINGTON WEST, PENNSYLVANIA USGS QUADRANGLE

US EPA - DAM SAFETY ASSESSMENT OF CCW IMPOUNDMENTS CHESWICK POWER STATION SPRINGDALE, PENNSYLVANIA



MAP LOCATION

SITE LOCATION

N

0 1,000 2,000 4,000 6,000 8,000

Feet

O'BRIEN & GERE

JANUARY 2014
13498/46122

1:24,000

I:\US-EPA.13498\STDS\GIS\Coal_Impoundments\Figures\Cheswick\Cheswick_Figure2_FacilityLayoutPlan.mxd

FIGURE 2

DAM SAFETY ASSESSMENT OF CCW IMPOUNDMENTS
CHESWICK POWER STATION
SPRINGDALE, PENNSYLVANIA

FACILITY LAYOUT PLAN

JANUARY 2014
13498/46122

O'BRIEN & GERE

This document was developed in color. Reproduction in B/W may not represent the data as intended.

PLOTDATE: 1/24/2014 DRK

I:\US-EPA.13498\STDS\GIS\Coal_Impoundments\Figures\Cheswick\Cheswick_Figure3A_RecyclePond.mxd

FIGURE 3A

N

LEGEND

- PIPE
- ASH POND/IMPOUNDMENT
- OTHER POND/IMPOUNDMENT
- TAWNEY RUN
- 1 PHOTO LOCATION/DIRECTION

This document was developed in color. Reproduction in B/W may not represent the data as intended.

DAM SAFETY ASSESSMENT OF CCW IMPOUNDMENTS
CHESWICK POWER STATION
SPRINGDALE, PENNSYLVANIA

BOTTOM ASH RECYCLE POND PHOTO LOCATION MAP

0 20 40 80
Feet

JANUARY 2014
13498/46122

O'BRIEN & GERE

PLOTDATE: 1/24/2014 DRK

FIGURE 3B

This document was developed in color. Reproduction in B/W may not represent the data as intended.

N

LEGEND

- PIPE
- ASH POND/IMPOUNDMENT
- OTHER POND/IMPOUNDMENT
- TAWNEY RUN
- 1 PHOTO LOCATION/DIRECTION

DAM SAFETY ASSESSMENT OF CCW IMPOUNDMENTS
CHESWICK POWER STATION
SPRINGDALE, PENNSYLVANIA

EMERGENCY ASH POND PHOTO LOCATION MAP

0 20 40 80
Feet

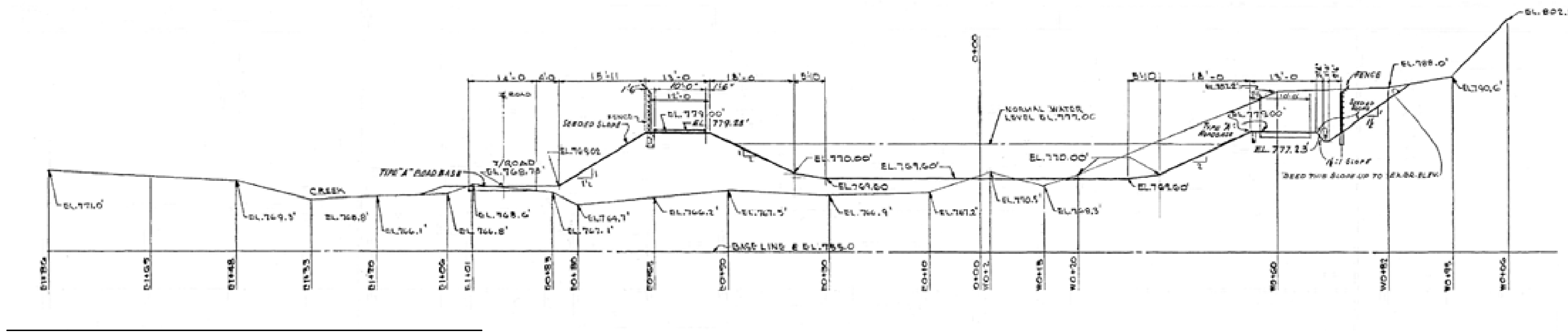
JANUARY 2014
13498/46122

O'BRIEN & GERE

I:\US-EPA.13498\STDS\GIS\Coal_Impoundments\Figures\Cheswick\Cheswick_Figure3B_EmergencyPond.mxd

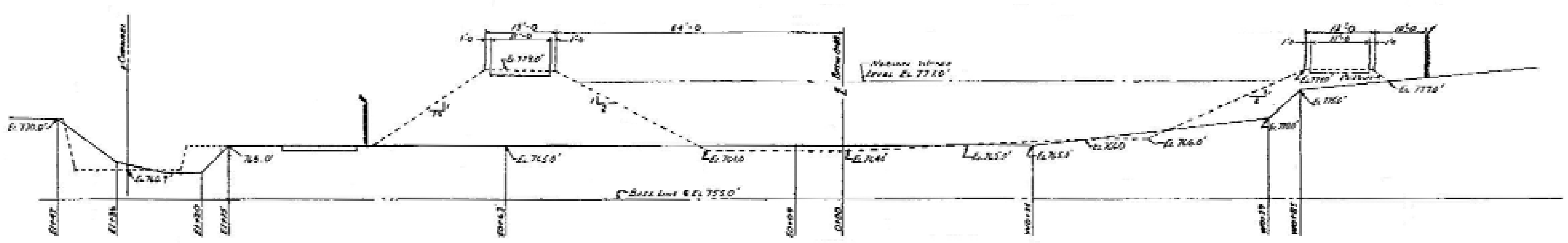
PLOTDATE: 1/24/2014 DRK

FIGURE 4



BOTTOM ASH RECYCLE POND

SECTION @ STA. 1+50 NORTH
SCALE: 1" = 30'-0"



EMERGENCY ASH POND

SECTION @ STA. 2+25 SOUTH
SCALE: 1" = 30'-0"

REFERENCE:
TAKEN FROM DRAWING NO. 9853-B10, TITLED "SETTLING BASIN CROSS SECTIONS", DATED 6/30/71; AND DRAWING NO. 9853-B47, TITLED "CROSS SECTIONS AT PONDS", DATED 3/13/73, BY DUQUESNE LIGHT COMPANY, PITTSBURGH, PA

US EPA
DAM SAFETY ASSESSMENT
OF CCW IMPOUNDMENTS

NRG ENERGY, INC.
CHESWICK POWER STATION
CHESWICK, PENNSYLVANIA

BOTTOM ASH RECYCLE POND & EMERGENCY ASH POND

1"=30' 30 0 30

46122-CHESWICK-F04
JANUARY 2014

O'BRIEN & GERE

APPENDIX A

Visual Inspection Checklists

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Cheswick Power Station	Date:	September 27, 2012
Unit Name:	Bottom Ash Recycle Pond	Operator's Name:	NRG Energy, Inc. (formerly GenOn)
Unit I.D.:	SPD-5	Hazard Potential Classification:	High (Significant — circled) Low
Inspector's Name:	D. Whetstone, PE & C. Lohrmann, PE		

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No
1. Frequency of Company's Dam Inspections?	quarterly	
2. Pool elevation (operator records)?	777.0	
3. Decant inlet elevation (operator records)?	778.3	
4. Open channel spillway elevation (operator records)?	777.0	
5. Lowest dam crest elevation (operator records)?	779.3	
6. If instrumentation is present, are readings recorded (operator records)?	N/A	
7. Is the embankment currently under construction?		✓
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?		
9. Trees growing on embankment? (If so, indicate largest diameter below)		✓
10. Cracks or scarps on crest?		✓
11. Is there significant settlement along the crest?		✓
12. Are decant trashracks clear and in place?	✓	
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓
14. Clogged spillways, groin or diversion ditches?		✓
15. Are spillway or ditch linings deteriorated?		✓
16. Are outlets of decant or underdrains blocked?		✓
17. Cracks or scarps on slopes?		✓

	Yes	No
18. Sloughing or bulging on slopes?	✓	
19. Major erosion or slope deterioration?		✓
20. Decant Pipes:		
Is water entering inlet, but not exiting outlet?		✓
Is water exiting outlet, but not entering inlet?		✓
Is water exiting outlet flowing clear?	✓	
21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
From underdrain?		✓
At isolated points on embankment slopes?		✓
At natural hillside in the embankment area?		✓
Over widespread areas?		✓
From downstream foundation area?		✓
"Boils" beneath stream or ponded water?		✓
Around the outside of the decant pipe?		✓
22. Surface movements in valley bottom or on hillside?		✓
23. Water against downstream toe?		✓
24. Were Photos taken during the dam inspection?	✓	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue #	Comments
3.	Top elevation of emergency overflow outlet pipe.
6.	No instrumentation present.
8.	Unknown.
9.	Brush and small trees removed from embankments summer 2012.
18.	Undulations on eastern embankment, some left after summer clearing.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # PA 0001627 INSPECTOR D. Whetstone/C. Lohrmann

Date: September 27, 2012
Impoundment Name: SPD-5: Bottom Ash Recycle Pond
Impoundment Company: NRG Energy, Inc. (formerly GenOn)
EPA Region: 3
State Agency (Field Office) Address: PA Dept. of Environmental Protection
Pittsburgh, PA

Name of Impoundment: SPD-5: Bottom Ash Recycle Pond

(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New X Update ____

	Yes	No
Is impoundment currently under construction		X
Is water or ccw currently being pumped into the impoundment?	X	

IMPOUNDMENT FUNCTION: **Settling suspended bottom ash solids not removed in hydrobins.**

Nearest Downstream Town Name: Springdale Borough, PA
Distance from the impoundment: 500 feet

Impoundment Location:

Latitude	40	Degrees	32	Minutes	41	Seconds	North
Longitude	79	Degrees	47	Minutes	39	Seconds	West

State PA County Allegheny

Does a state agency regulate this impoundment? YES ____ NO X

If So Which State Agency? PA Department of Environmental Protection
For effluent water quality only.

HAZARD POTENTIAL (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

__X__ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

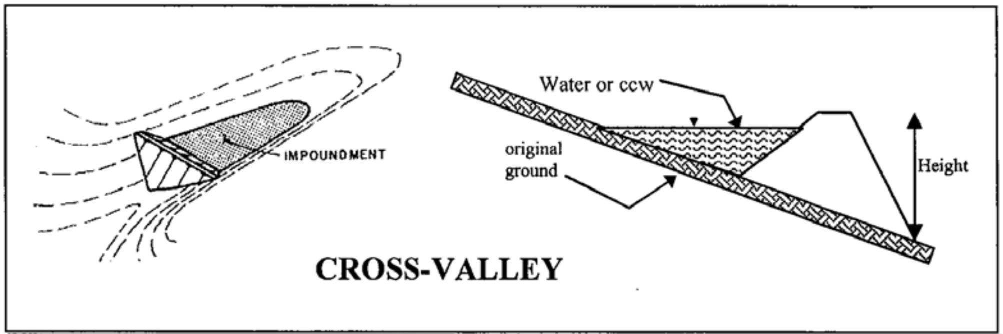
______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

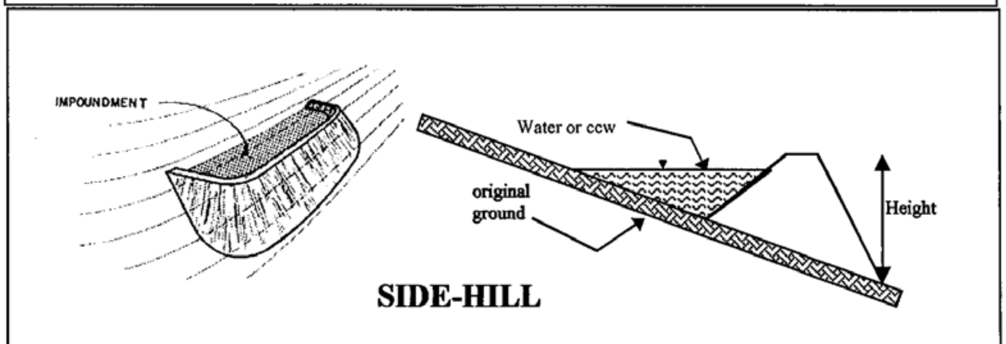
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

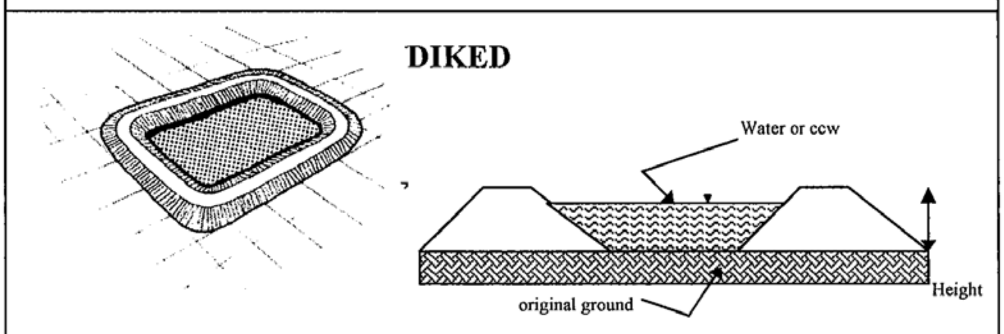
Pittsburgh Street is in direct path of downstream flow path. Several homes in likely inundation area near Pittsburgh Street.

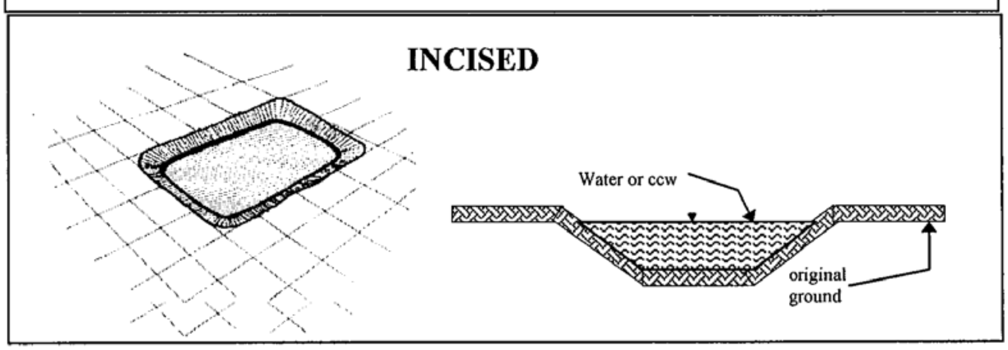
Potential for release of CCW into waters of the U.S.

CONFIGURATION:









_____ Cross-Valley _____ Side-Hill _____ Diked

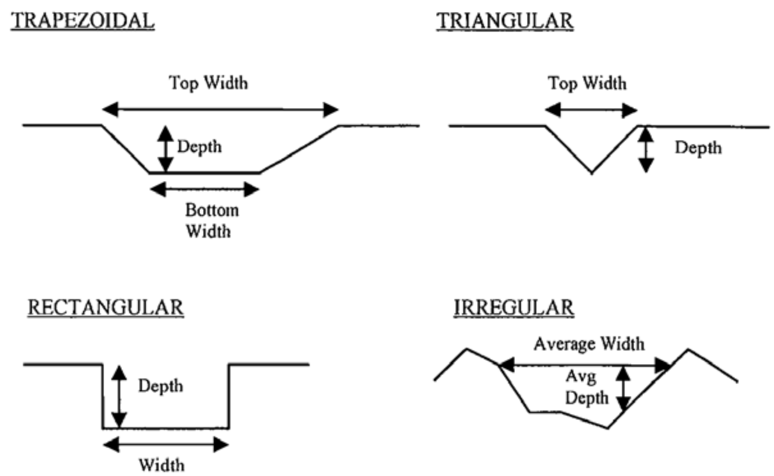
_____ Incised (form completion optional) __X__ Combination Incised/Diked

Embankment Height	11.7 (max)	Feet	Embankment Material	Earth – grass covered
Pool Area	0.6	Acres	Liner	Clay
Current Freeboard	2	Feet	Linear Permeability	Thickness tested annually

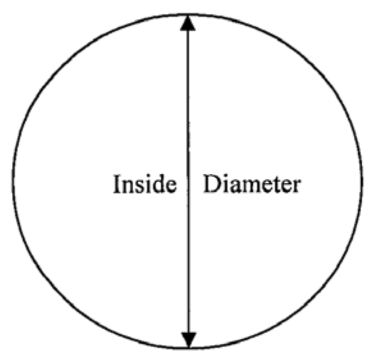
TYPE OF OUTLET (Mark all that apply)

__X__ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
__X__ Rectangular
_____ Irregular

__2__ depth (ft)
__42__ bottom (or average) width (ft)
__42__ top width (ft)



_____ **Outlet**
_____ Inside diameter



Material
_____ corrugated metal
_____ welded steel
_____ concrete
_____ plastic (hdpe, pvc, etc.)
__X__ other (specify):
Concrete weir to pump building to outlet pipe to river

Is water flowing through the outlet? YES ___X___ NO ________

_____ **No Outlet**

_____ **Other Type of Outlet** (specify) ______________________________

The Impoundment was Designed By Duquesne Light Company Engineering & Construction Division – Robert J. McAllister, Registered P.E. 5109-E in Commonwealth of PA

Has there ever been a failure at this site? YES ___________ NO ___X_______

If So When? ______________________________

If So Please Describe: ____

Have there ever been significant seepages at this site? YES _______ NO___X__________

If So When? ___________________________

IF So Please Describe: ____

Have there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ________NO___X______

If so, which method (e.g., piezometers, gw pumping,...)? ________________________

If so Please Describe: ____

Additional Inspection Questions

Concerning the embankment foundation, was the embankment construction built over wet ash, slag, or other unsuitable materials? If there is no information just note that.

No information.

Did the dam assessor meet with, or have documentation from, the design Engineer-of-Record concerning the foundation preparation?

No.

From the site visit or from photographic documentation, was there evidence of prior releases, failure, or patchwork on the dikes?

No.

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Cheswick Power Station	Date:	September 27, 2012
Unit Name:	Emergency Ash Recycle Pond	Operator's Name:	NRG Energy, Inc. (formerly GenOn)
Unit I.D.:	SPD-4	Hazard Potential Classification:	High (Significant, circled) Low
Inspector's Name:	D. Whetstone, PE & C. Lohrmann, PE		

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

Item	Yes	No	Item	Yes	No
1. Frequency of Company's Dam Inspections?	quarterly		18. Sloughing or bulging on slopes?	✓	
2. Pool elevation (operator records)?	775.5		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?			20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	775.5		Is water entering inlet, but not exiting outlet?		✓
5. Lowest dam crest elevation (operator records)?	779.0		Is water exiting outlet, but not entering inlet?		✓
6. If instrumentation is present, are readings recorded (operator records)?	N/A		Is water exiting outlet flowing clear?	✓	
7. Is the embankment currently under construction?		✓	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?			From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)		✓	At isolated points on embankment slopes?		✓
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place?	✓		From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches?		✓	Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?		✓	22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?		✓
17. Cracks or scarps on slopes?		✓	24. Were Photos taken during the dam inspection?	✓	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue #	Comments
6.	No instrumentation present.
8.	Unknown.
9.	Brush and small trees removed from embankments summer 2012.
18.	Undulations on eastern embankment, some left after summer clearing.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # PA 0001627 INSPECTOR D. Whetstone/C. Lohrmann

Date September 27, 2012
Impoundment Name SPD-4: Emergency Ash Pond
Impoundment Company NRG Energy, Inc. (formerly GenOn)
EPA Region 3
State Agency (Field Office) Address PA Dept. of Environmental Protection
Pittsburgh, PA

Name of Impoundment SPD-4: Emergency Ash Pond

(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New X Update ____

	Yes	No
Is impoundment currently under construction		X
Is water or ccw currently being pumped into the impoundment?	X	

IMPOUNDMENT FUNCTION: **Settling suspended bottom ash solids not removed in hydrobins approximately one month per year (in summer/ July) while SPD-5 is drained for cleaning and liner thickness testing.**

Nearest Downstream Town Name: Springdale Borough, PA
Distance from the impoundment: 500 feet

Impoundment Location:

Latitude	40	Degrees	32	Minutes	38	Seconds	North
Longitude	79	Degrees	47	Minutes	39	Seconds	West

State PA County Allegheny

Does a state agency regulate this impoundment? YES ____ NO X

If So Which State Agency? PA Department of Environmental Protection
For effluent water quality only.

HAZARD POTENTIAL (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

__X__ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

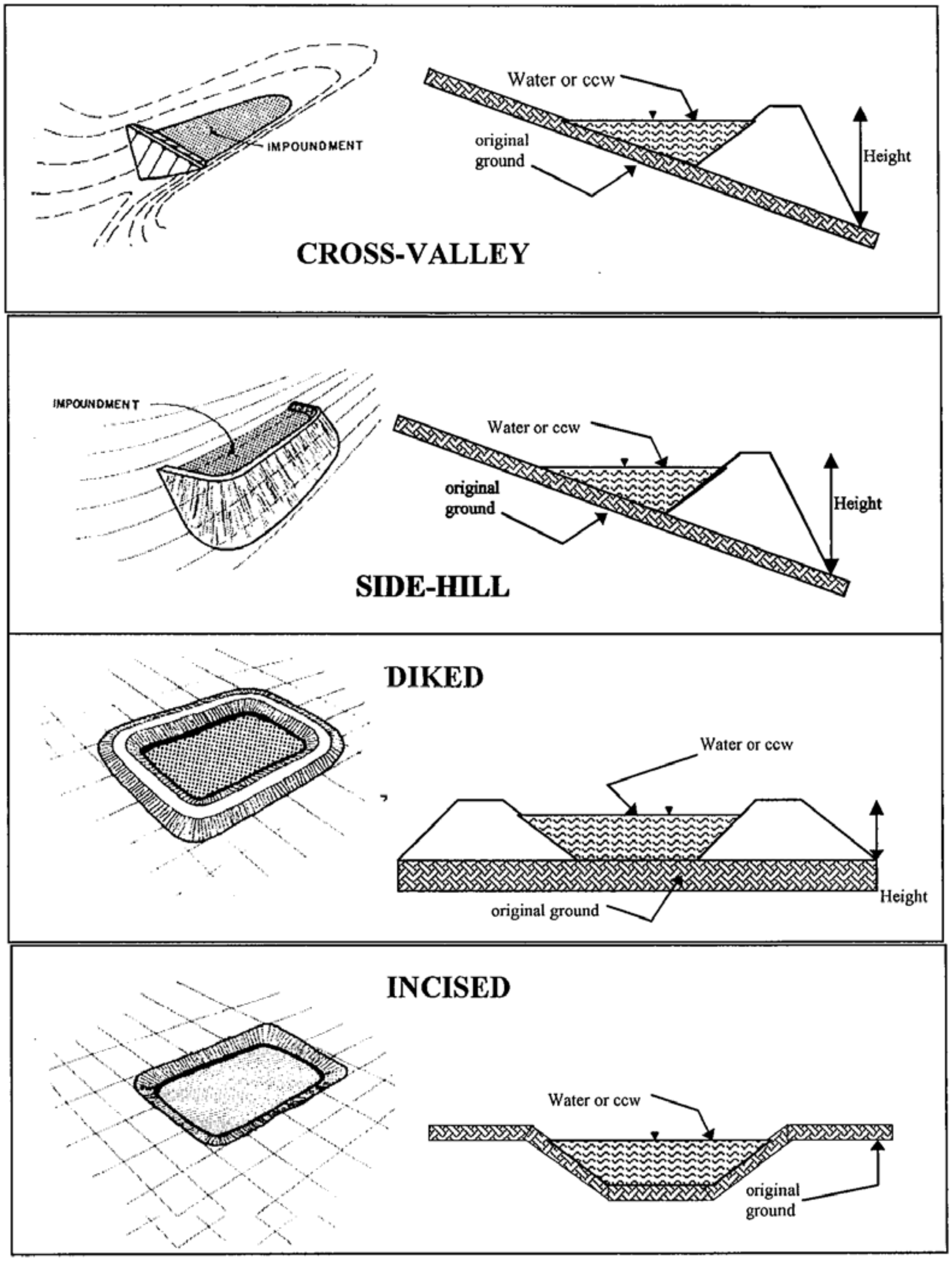
______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

Pittsburgh Street is in direct path of downstream flow path. Several homes in likely inundation area near Pittsburgh Street.

Potential for release of CCW into waters of the U.S.

CONFIGURATION:



_____ Cross-Valley   _____ Side-Hill   _____ Diked

_____ Incised (form completion optional)   __X__ Combination Incised/Diked

Embankment Height	14	Feet	Embankment Material	Earth – grass covered
Pool Area	0.4	Acres	Liner	Clay
Current Freeboard	10	Feet	Linear Permeability	Thickness tested annually

(Designed for 2 ft freeboard)

TYPE OF OUTLET (Mark all that apply)

______ **Open Channel Spillway**

______ Trapezoidal

______ Triangular

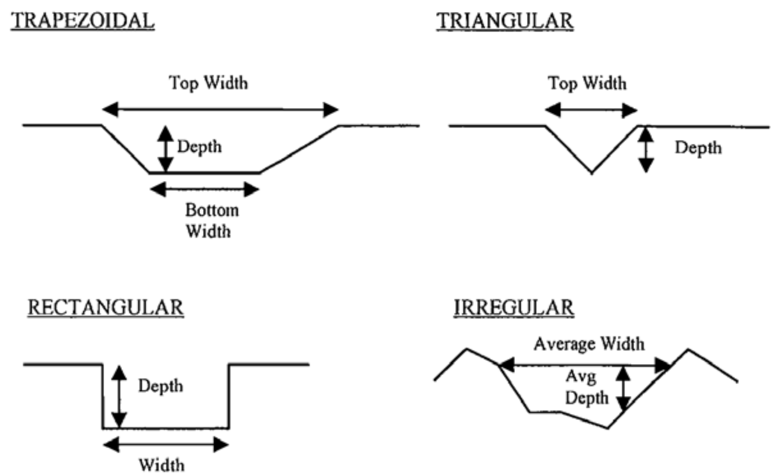
__X__ Rectangular

______ Irregular

__0.5__ depth (ft)

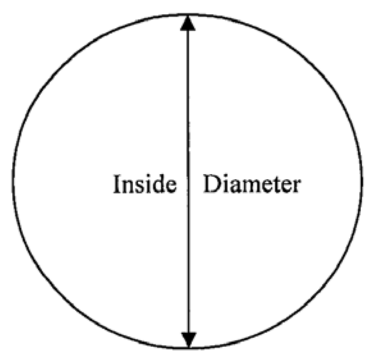
__80__ bottom (or average) width (ft)

__80__ top width (ft)



______ **Outlet**

__24”__ Inside diameter



Material

__X__ corrugated metal

______ welded steel

______ concrete

______ plastic (hdpe, pvc, etc.)

__X__ other (specify):

Effluent trough with top plates forming a triangle in cross-section to 24” CMP to river

Is water flowing through the outlet? YES _________ NO___X___

_____ **No Outlet**

_____ **Other Type of Outlet** (specify) ______________________________

The Impoundment was Designed By Duquesne Light Company Engineering & Construction Division – Robert J. McAllister, Registered P.E. 5109-E in Commonwealth of PA

Has there ever been a failure at this site? YES ___________ NO ___X_______

If So When? ______________________________

If So Please Describe: ____

Have there ever been significant seepages at this site? YES _______ NO___X__________

If So When? ___________________________

IF So Please Describe: ____

Have there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ________NO___X______

If so, which method (e.g., piezometers, gw pumping,...)? ________________________

If so Please Describe: ____

Additional Inspection Questions

Concerning the embankment foundation, was the embankment construction built over wet ash, slag, or other unsuitable materials? If there is no information just note that.

No information.

Did the dam assessor meet with, or have documentation from, the design Engineer-of-Record concerning the foundation preparation?

No.

From the site visit or from photographic documentation, was there evidence of prior releases, failure, or patchwork on the dikes?

No.

APPENDIX B

Photographs

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.240.100
Site Name: NRG – Cheswick Plant	Location: Springdale Borough, PA

Orientation: South Description: Bottom Ash Recycle Pond, bottom ash solids in foreground. Date: 9/27/12 Photo Number: 1 Photographer: DDW	
Orientation: Southeast Description: Emergency Ash Pond, not in operation, inlet in foreground, outflow weir in background. Date: 9/27/12 Photo Number: 2 Photographer: DDW	

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.240.100
Site Name: NRG – Cheswick Plant	Location: Springdale Borough, PA

Orientation: Southeast Description: Tawney Run in foreground, hydrobins in background, elevated pipes leading to and from ash ponds. Date: 9/27/12 Photo Number: 3 Photographer: DDW	
Orientation: Northeast Description: Hydrobins. Date: 9/27/12 Photo Number: 4 Photographer: DDW	

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.240.100
Site Name: NRG – Cheswick Plant	Location: Springdale Borough, PA

Orientation: Southeast

Description: Bottom Ash Recycle Pond inflow area and pipes.

Date: 9/27/12

Photo Number: 5

Photographer: DDW

Orientation: West

Description: Bottom Ash Recycle Pond north embankment. Lack of vegetation on west inboard slope visible in background. Natural hill on west side of ash ponds in background.

Date: 9/27/12

Photo Number: 6

Photographer: DDW

PHOTOGRAPHIC LOG

Client:	US EPA	Project Number:	46122.240.100
Site Name:	NRG – Cheswick Plant	Location:	Springdale Borough, PA

Orientation: Southwest

Description: Bottom Ash Recycle Pond outflow weir and pump house.

Date: 9/27/12

Photo Number: 7

Photographer: DDW

Orientation: South

Description: Bottom Ash Recycle Pond eastern embankment, intake pipes, access road, and security fence.

Date: 9/27/12

Photo Number: 8

Photographer: DDW

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.240.100
Site Name: NRG – Cheswick Plant	Location: Springdale Borough, PA

Orientation: South Description: Bottom Ash Recycle Pond western embankment and access road. Note some ponding on access road and natural hillside west of ash ponds. Date: 9/27/12 Photo Number: 9 Photographer: DDW	
Orientation: East Description: Bottom Ash Recycle Pond outflow weir and stilling basin, pump house in background. Date: 9/27/12 Photo Number: 10 Photographer: DDW	

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.240.100
Site Name: NRG – Cheswick Plant	Location: Springdale Borough, PA

Orientation: South Description: Emergency Ash Pond western and southern inboard slopes, western access road with ponding, and natural hillside on west side of ash ponds. Date: 9/27/12 Photo Number: 11 Photographer: DDW	
Orientation: East Description: Emergency Ash Pond outflow structure, southwest corner inboard slope, and south crest/access road. Hydrobins in background. Date: 9/27/12 Photo Number: 12 Photographer: DDW	

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.240.100
Site Name: NRG – Cheswick Plant	Location: Springdale Borough, PA

Orientation: South	
Description: Emergency Ash Pond eastern embankment/ outboard slope.	
Date: 9/27/12	
Photo Number: 13	
Photographer: DDW	
Orientation: West	
Description: Emergency Ash Pond eastern embankment/ outboard slope erosion and animal burrow.	
Date: 9/27/12	
Photo Number: 14	
Photographer: DDW	

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.240.100
Site Name: NRG – Cheswick Plant	Location: Springdale Borough, PA

Orientation: West

Description: Emergency Ash Pond southern embankment.

Date: 9/27/12

Photo Number: 15

Photographer: DDW

Orientation: Northwest

Description: Emergency Ash Pond southern embankment behind fence in foreground. Natural hillside west of ash ponds in background.

Date: 9/27/12

Photo Number: 16

Photographer: DDW

APPENDIX C

Geotechnical/Slope Stability Analysis

Geosyntec consultants

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7 February 2013

NRG Energy Inc.
121 Champion Way
Suite 300
Canonsburg, PA 15317

Attention: Mr. Stephen B. Dixon
Director, Coal Ash Management
Environmental Operations and Compliance

Subject: Assessment Report
Cheswick Power Station - Bottom Ash Ponds
Springdale, Pennsylvania

Dear Mr. Dixon:

Geosyntec is pleased to submit this letter report presenting the findings of an assessment of the bottom ash water recycle system pond embankments at the Cheswick Power Station (Site). These ponds are part of the bottom ash water recycle system and were recently evaluated by the United States Environmental Protection Agency (EPA) as part of its ongoing national effort to assess the management of coal combustion waste (CCW). This letter report was prepared by Geosyntec Consultants (Geosyntec) for GenOn Energy, Inc. (GenOn), in accordance with Geosyntec's proposal dated 8 November 2012. After the approval of our proposal and prior to the conclusion of this report, NRG Energy, Inc. (NRG) and GenOn combined and will retain the name NRG Energy, Inc. As a result of the merger, all GenOn entities are now wholly owned subsidiaries of NRG.

This report presents the results of the following activities: (i) field investigation of soil properties; (ii) general assessment of the stability of pond embankments; and (iii) hazard potential and condition assessment of the embankments. This letter report was prepared by Mr. Wade Tyner, P.E. and Dr. Lucas de Melo, P.E., and it was reviewed by Mr. Michael Houlihan, P.E., in accordance with Geosyntec's peer review policy.

BACKGROUND

EPA conducted inspections of the bottom ash ponds (BAPs) at the Cheswick Power Station on 27 September 2012. To date, the report of EPA's inspection has not been issued. Based on discussions with EPA at the time of the inspection and based on EPA's typical practice, it is expected that EPA will provide both a Condition Assessment and a Hazard Potential classification for each impoundment structure. During this study, Geosyntec collected data that can be used to supplement the EPA's embankment assessment results.

According to EPA's guidelines, the Condition Assessment result can be "Satisfactory", "Fair", "Poor", or "Unsatisfactory" based on potential management unit safety deficiencies, expected performance under applicable loading conditions (i.e., static, hydrologic, seismic), the need for remedial action, and the need for additional critical studies or investigations to identify any potential dam safety deficiencies. The Hazard Potential classification can be "less than low", "low", "significant", or "high" for an impoundment. By the EPA's definition, these ratings are not related to the likelihood of impoundment failure but, rather, are related to the potential for harm if the impoundment should fail.

VISUAL INSPECTION

On 28 November 2012, Mr. Tyner performed a site walkthrough and visual assessment of the BAP embankments following the general instructions presented in the EPA's Coal Combustion Dam Inspection Checklist Form (checklist). Jill Buckley and Stephen Dixon from NRG were present at the site during the walkthrough. Two BAPs (i.e., the main BAP and the Emergency BAP) were assessed. These ponds are part of the site's bottom ash water recycle system. The location of the ponds is presented in Figure 1. Pictures taken during the visual inspection of the ponds' embankments are included in Appendix A. Geosyntec used EPA's checklist as a guide to field assessment in an attempt to anticipate potential comments from EPA. A copy of this checklist form is included in Appendix B.

Mr. Tyner's observations and Geosyntec's comments regarding the overall performance of the ponds' embankments are presented in the Table 1. The items in the table are correlated to the numbering presented in the EPA's checklist form.

GEOTECHNICAL FIELD INVESTIGATION

On 29 November 2012, Geosyntec conducted a geotechnical field investigation to collect data needed to assess the BAP embankments. The geotechnical field investigation consisted of drilling four test borings, identified as HSA-1 through HSA-4, at the locations shown in Figure 1. Four borings were advanced along the centerline of the main and emergency BAPs' east embankments, which are the locations where the BAP's embankment is the highest (i.e., approximately 10 feet high). Drilling was limited to the eastern embankment by the presence of high-voltage overhead power lines on the west portion of the ponds. Borings were drilled to an approximate depth of 20 feet below the existing ground surface (ft-bgs).

TABLE 1
VISUAL INSPECTION

BAP – Cheswick Power Station
Springdale, Pennsylvania

EPA's Coal Combustion Dam Inspection Checklist Form		Comments
Item Number	**Item Description**	
1	Frequency of Company's Dam Inspections	Maintenance and inspection records were not available, but based on the conditions of the embankments' outer slopes, it appears that some maintenance is needed in some areas to repair minor erosion and stressed vegetation. The erosion in these areas is not interpreted to be a current threat to overall stability of the slopes. Neither as-built records for the ponds' embankments nor recent topographic survey are available. Therefore, it is not possible to evaluate the steepness of the embankment slope. Nonetheless, based on visual inspection, it is possible that slopes are steeper than called for in the design (i.e., 1.5 Horizontal to 1 Vertical). Pictures of steep slopes are included in Appendix A (see Photographs 1 and 2).
18	Sloughing or bulging on slopes?	Soil accumulation was encountered against the perimeter fence along the eastern slope of the main BAP – see Photograph 4 in Appendix A. Established vegetation over the displaced soils suggests that displaced soils have been there for some time although it was not possible to establish if soil accumulation happened over a gradual process due to erosion or in a single event. Because the slope has remained stable over its operational life, it is Geosyntec's opinion that this is not an indication of instability.
19	Major erosion or slope deterioration?	Signs of erosion are present through the outer slopes, notably in the eastern slopes, where lack of permanent vegetation, presence of erosion gullies, and animal burrows was evident.

TABLE 1
(continued)
VISUAL INSPECTION

BAP – Cheswick Power Station
Springdale, Pennsylvania

EPA's Coal Combustion Dam Inspection Checklist Form		Comments
Item Number	**Item Description**	
21	Seepage	Wet soils were observed along the eastern slope of the main BAP. Location of wet soils is shown in Figure 1. Weather records, available from local weather stations, indicate that very little precipitation was recorded (<0.05 inches) in the preceding three days before the site visit. Two possible causes of the presence of wet soils are: (i) the location may be a low point between the road and the berm that presents poor drainage. Ponded water was observed in the roadway north of the primary recycle pond at a location far enough away from the pond to eliminate the likelihood of seepage; the presence of this shallow standing water indicates that the water at the toe of the eastern slope could have originated from an earlier precipitation event. (ii) seepage is coming from the berm, along a path that was not identified in the nearby geotechnical boring (i.e., HAS-4). It is recommended that NRG continue to observe this location and note its condition after several days without precipitation.

A track-mounted hollow-stem auger was used to advance the test borings. The drill bit has an internal diameter of 3.25 inches and outside diameter of 6 inches. Soil samples were obtained using a split-spoon sampler in accordance with ASTM D 1586 [ASTM, 2009]. At each boring location, soil samples were obtained every 2 ft. Sampling was conducted continuously in three of the four borings; sampling in HSA-4 was conducted every five feet due to time constraints. The soil penetration resistance was measured at all sample locations using the Standard Penetration Test (SPT) and recording blow counts (i.e., N-values). The N-value is the number of blows required for a 140-pound (lb) hammer dropping 30 inches (in.) to drive the sampler through a 12-in. interval. Boring logs are included in Appendix C of this report. No Shelby-tube samples were collected during the investigation because the subsurface soils at the site were not cohesive. The geotechnical boreholes were backfilled to ground surface using a cement grout.

Based on the boring logs, the ponds' embankments were constructed using silty soils, which were visually classified under the Unified Soils Classifications system as MH (i.e., high-plasticity silt) and ML (i.e., sandy silt). The SPT N-values varied between 8 and 27 blows/ft, with an average value of 16 blows/ft. The soils below the original ground surface prior to pond construction have similar appearance and SPT-N value; thus, they are considered to have similar physical properties as the fill material used for embankment construction. Indication of rock formation was encountered at approximately 20 ft-bgs at two of the four boring locations (i.e., HSA-1 and HSA-2), but no rock coring was performed.

Shear strength properties for the embankment and foundations soils were derived from data collected during the field investigation and results are presented in Appendix D (i.e., Stability Analysis).

The groundwater table was not encountered during drilling or after completion of the borings except at Boring HSA-4, where groundwater was encountered at a depth of approximately 17 ft-bgs.

STABILITY EVALUATION

Geosyntec performed a stability analysis of the ponds' embankments. One representative cross section was selected for the analysis based on review of subsurface conditions, visual inspection, and pond geometry. The location of the selected cross section is at the main BAP, as shown in Figure 1. This section was selected because the embankment height at this location is the highest and the foundation soil had the lowest blow counts (SPT-N) obtained during the field investigation. In addition, the Emergency BAP is shallower than the main BAP (i.e., shorter embankment height), the emergency pond is operated during limited time (i.e., approximately one month a year), and the embankment material shows higher SPT-N value than the embankment material encountered at the main BAP; thus, the selected location at the main BAP represents the critical cross section and analysis results will likely represent the lowest expected factor of safety against failure of the BAPs' embankments.

The geometry of the embankment was obtained from the design plans prepared by Duquesne Light Company dated July, 1971 (Figure 1). Because during visual inspection the existing slopes appeared to be steeper than the design slopes (i.e., the design slopes are approximately 1.5 Horizontal to 1 Vertical), Geosyntec also performed an additional analysis to evaluate the stability of the embankment assuming that it is steeper than designed. For purposes of performing a conservative analysis, existing outer slopes were modeled assuming a slope of 1 Horizontal to 1 Vertical.

Stability was analyzed under static and seismic loading conditions. The pond was considered to be full because this is the critical failure scenario. No rapid drawdown analysis was found to be necessary because, under this loading condition, the inner slope of the empty pond would represent the critical failure condition, which would not cause ash release or result in a hazard of the type that is contemplated in the EPA assessment. The major static load applied to the foundation soils is the gravity load exerted by the weight of the berm. A surcharge load of 250 psf was applied to the top of the embankment to model traffic loading on top of the embankment. This is a conservative assumption, because traffic loads are not permanent loads. Seismic loading was modeled considering the maximum horizontal acceleration in bedrock for the Cheswick facility site of 0.083g (g is the gravitational acceleration) and seismic coefficient of 0.042. Details on the derivation of these parameters are included in Appendix D (i.e., Stability Analysis).

The groundwater table used in the analysis was derived from a groundwater flow analysis performed by Geosyntec that computed a phreatic line assuming the water in the pond infiltrates through the embankment towards the creek to the east of the pond. This is a conservative assumption because the groundwater table was encountered during drilling only at one boring location (i.e., HSA-4) at approximately 17 feet below the top of the embankment. Furthermore, the presence of a clay liner within the main BAP likely accounts for the dry soil conditions in the berm that were observed during the investigation.

A summary of stability analyses results are presented in Table 2. Complete analyses are included in Appendix D (i.e., Stability Analysis).

TABLE 2
RESULTING FACTOR OF SAFETY – SLOPE STABILITY ANALYSIS

BAP – Cheswick Power Station
Springdale, Pennsylvania

Embankment Slopes	Loading Conditions	Failure Mode	Calculated F.S.	Target F.S
Design (1.5H:1V)	Static	Circular	3.30	1.5
		Block	3.37	1.5
	Seismic	Circular	2.98	1.2
		Block	2.98	1.2
Conservative Assumption (1H:1V)	Static	Circular	2.97	1.5
		Block	2.98	1.5
	Seismic	Circular	2.78	1.2
		Block	2.73	1.2

HAZARD POTENTIAL EVALUATION AND CONDITION ASSESSMENT

As presented in the Background section of this letter, it is expected that EPA will provide both a Hazard Potential classification and a Condition Assessment for each BAP present at the site. Therefore, Geosyntec's efforts in this work included data collection, visual inspection, and review of existing documents to support our opinion regarding the appropriate outcome of these two assessments.

Hazard Potential: During the site walkthrough, Geosyntec personnel conducted a visual, qualitative assessment of the potential consequences of failure in terms of the likely area of impact and potential for significant losses, in accordance with the hazard potential definitions presented in EPA's CCW Impoundment Inspection Form (i.e., "less than low", "low", "significant", or "high" hazard potential). Based on our evaluation, it appears that failure or misoperation of the BAP at the site would result in no probable loss of human life and low economic and/or environmental losses and that losses, if they were to occur, would be principally limited to NRG's property. Considering the criteria set forth by EPA and the currently available information, it is Geosyntec's opinion that these ponds have a low hazard potential. The reason for this evaluation is that, in the event of failure, the structure and population at risk would be located at the a road adjacent to the east-side berms. However, this road serves as an easement access road that can only be accessed through a locked gate. Therefore, there is a very low probability for someone to be on the access road during a catastrophic failure. The potential environmental impact following a failure of the embankment structure is expected to be low because the volume supported by the BAP is small and the nearest water body is a creek located approximately 50 feet away from the east-side embankment slope.

Condition Assessment: Condition Assessment definitions, as accepted by EPA, are as follows:

- *Satisfactory:* *No existing or potential management unit safety deficiencies are recognized. Acceptable performance is expected under all applicable loading conditions (static, hydrologic, seismic) in accordance with the applicable criteria. Minor maintenance items may be required.*

- *Fair:* *Acceptable performance is expected under all required loading conditions (static, hydrologic, seismic) in accordance with the applicable safety regulatory criteria. Minor deficiencies may exist that require remedial action and/or secondary studies or investigations.*

- *Poor:* *A management unit safety deficiency is recognized for a required loading condition (static, hydrologic, seismic) in accordance with the applicable dam safety regulatory criteria. Remedial action is necessary. "Poor" also applies when further critical studies or investigations are needed to identify any potential dam safety deficiencies.*

- *Unsatisfactory:* *Considered unsafe. A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution. Reservoir restrictions may be necessary."*

During the 28 November 2012 site visit, Geosyntec personnel met with the site manager to identify and review available BAP design, construction, as-built, and maintenance data, and previous geotechnical records and analysis. Monitoring well logs and design drawings for the BAPs were made available for review and Geosyntec used this information in the preparation of this letter report. It is our opinion that the Condition Assessment result of "Fair" is applicable to the BAP ponds at Cheswick and that a result of "Poor" or "Unsatisfactory" is not applicable. This opinion is supported by the availability of design documents, and the results of the field investigation and stability analysis conducted as part of this work. Based on Geosyntec's in-situ soil tests and stability analyses, the slopes would perform with an appropriate factor of safety under the expected loading conditions. The minor deficiencies that exist, which are summarized in the Visual Inspection section of this report, can be remedied by routine maintenance or minor repair efforts.

CONCLUSIONS

Based on the assessment described in this letter, Geosyntec concludes that the appropriate Hazard Potential classification for the BAP is "Low" and the appropriate Condition Assessment result is "Fair". Other than routine maintenance to address the wet toe of slope at the east slope of the BAP and regrading and revegetation of the eroded slope, no other action is recommended at this time.

We would appreciate the opportunity to discuss the results of EPA's pond assessment after the results are transmitted to you. We would be happy to review the results of that assessment and evaluate the need for further actions to address EPA's findings.

Geosyntec appreciates the opportunity to be of assistance to NRG on this project. Please call any of the undersigned if you have any questions.

Sincerely,

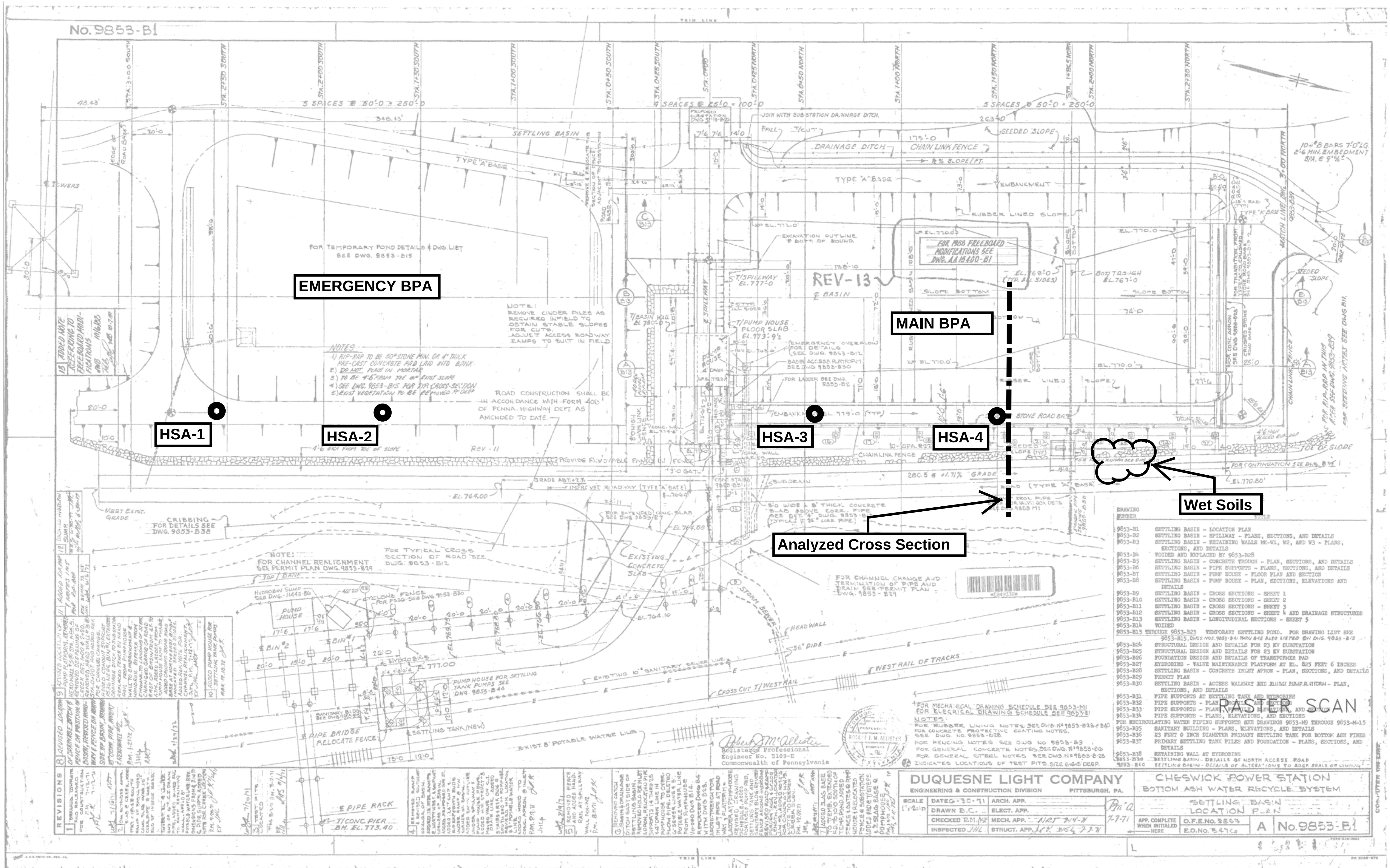
Wade Tyner, P.E.
Professional

Lucas de Melo, Ph.D., P.E.
Senior Engineer

Attachments: Appendix A – Photographic Record
Appendix B – EPA'S Combustion Dam Inspection Checklist Form
Appendix C – Boring Logs
Appendix D – Stability Analysis

Copies to: Michael Houlihan, P.E. (Geosyntec)

FIGURE



Key:

HSA-1 Approximate Boring Location

FIGURE 1 - BAP Design Drawing

Cheswick Power Station - Bottom Ash Ponds

Springdale, Pennsylvania

ME0896

APPENDIX A

PHOTOGRAPHIC RECORD

GEOSYNTEC CONSULTANTS
Photographic Record

Client: GenOn	Project Number: ME0896
Site Name: Cheswick Power Station	Site Location: Springdale, Pennsylvania

Photograph 1 Date: 11/28/2012 Location: East Embankment View of the Bottom Ash Pond (BAP) looking south depicting slopes which appears to be steeper than 1.5 Horizontal to 1 Vertical. .	
Photograph 2 Date: 11/28/2012 Location: East Embankment View of the Emergency (BAP) looking south depicting slopes which appears to be steeper than 1.5 Horizontal to 1 Vertical design slopes.	

GEOSYNTEC CONSULTANTS Photographic Record			
Client:	GenOn	Project Number:	ME0896
Site Name:	Cheswick Power Station	Site Location:	Springdale, Pennsylvania

Photograph 3 Date: 11/28/2012 Location: East Embankment Picture of wet area along the east embankment of the BAP. Location of wet area is shown in Figure 1.	
Photograph 4 Date: 11/28/2012 Location: East Embankment Signs of soil accumulation along the BAP's east embankment perimeter fence.	

GEOSYNTEC CONSULTANTS Photographic Record			
Client:	GenOn	Project Number:	ME0896
Site Name:	Cheswick Power Station	Site Location:	Springdale, Pennsylvania

Photograph 5 Date: 11/28/2012 Location: South Embankment View of Emergency BAP's east slope, looking northwest. Note sparse vegetation.	
Photograph 6 Date: 11/28/2012 Location: South Slope View of the Emergency BAP south slope. Picture show what appears to be an animal burrow.	

APPENDIX B

EPA'S COMBUSTION DAM INSPECTION CHECKLIST FORM

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Date:
Unit Name:	Operator's Name:
Unit I.D.:	Hazard Potential Classification: High Significant Low
Inspector's Name:	

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?			18. Sloughing or bulging on slopes?		
2. Pool elevation (operator records)?			19. Major erosion or slope deterioration?		
3. Decant inlet elevation (operator records)?			20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?			Is water entering inlet, but not exiting outlet?		
5. Lowest dam crest elevation (operator records)?			Is water exiting outlet, but not entering inlet?		
6. If instrumentation is present, are readings recorded (operator records)?			Is water exiting outlet flowing clear?		
7. Is the embankment currently under construction?			21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?			From underdrain?		
9. Trees growing on embankment? (If so, indicate largest diameter below)			At isolated points on embankment slopes?		
10. Cracks or scarps on crest?			At natural hillside in the embankment area?		
11. Is there significant settlement along the crest?			Over widespread areas?		
12. Are decant trashracks clear and in place?			From downstream foundation area?		
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?			"Boils" beneath stream or ponded water?		
14. Clogged spillways, groin or diversion ditches?			Around the outside of the decant pipe?		
15. Are spillway or ditch linings deteriorated?			22. Surface movements in valley bottom or on hillside?		
16. Are outlets of decant or underdrains blocked?			23. Water against downstream toe?		
17. Cracks or scarps on slopes?			24. Were Photos taken during the dam inspection?		

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue # Comments

APPENDIX C

BORING LOGS

BORING LOG

Geosyntec consultants
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Boring ID	HSA-1		
Logged By	W. Tyner	Elevation	N/A
Date	11/29/2012	Northing	N/A
Project No.	ME0896	Easting	N/A
Project Name	GenOn Coal Ash Ponds		
		Drilling Method	HSA
Drilling Co.	Eichelbergers, Inc.	Bore Hole Diameter	6 INCHES
Driller(s)	Tom Growden	Cave Depth	N/A
Rig Type	Track Mounted HSA	Depth to Water	Not Encountered

Elevation	Depth (ft)	Blow Counts				N- Value	Material Description	USCS	Sample No.	Recovery
	0-2	-	-	-	-		Poorly-graded gravel with silt (possibly some fly ash). Gravel has large pieces over 1-inch in diameter.	GM	1	N/A
	2-4	-	-	-	-		Gravelly sand with silt (possibly fly ash.	GM	2	N/A
	4-6	16	10	6	6	16	Gravel with silt	GM	3	50%
	6-8	10	17	17	15	34	Low-plasticity silt from 6 to 8 feet BGS, with a 2-inch thick layer of clean gravel (GP) (rock broken by drill?) at about 7 feet BGS	ML	4	80%
	8-10	3	7	10	27	17	No recovers/No sample	---	5	0%
	11-13	14	39	52	41	91	Low-plasticity silt with brown and black inclusions; rock (limerock) at top of split-spoon (~11 feet BGS)	ML	6	50%
	13-15	17	15	11	17	26	Clean gravel and rock that appears to have been broken by split-spoon; appreciable amount of fines present	GM	7	30%
	15-17	6	5	9	12	14	Transition from gravel to dark gray weathered shale at approximately 16 feet BGS	Shale	8	50%
	17-19	13	24	22	15	46	Combination of limerock and sandstone BORING COMPLETE AT 19 FEET BGS - BACKFILLED WITH CEMENT GROUT	GP	9	40%

BORING LOG

Geosyntec consultants
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Boring ID	HSA-2		
Logged By	W. Tyner	Elevation	N/A
Date	11/29/2012	Northing	N/A
Project No.	ME0896	Easting	N/A
Project Name	GenOn Coal Ash Ponds		
		Drilling Method	HSA
Drilling Co.	Eichelbergers, Inc.	Bore Hole Diameter	6 INCHES
Driller(s)	Tom Growden	Cave Depth	N/A
Rig Type	Track Mounted HSA	Depth to Water	Not Encountered

Elevation	Depth (ft)	Blow Counts				N- Value	Material Description	USCS	Sample No.	Recovery
	0-2	-	-	-	-		Brown silt with 5% gravel	ML	1	n/a
	2-4	-	-	-	-			ML	2	n/a
	4-6	6	13	16	15	29	Brown dense silt, possible weathered shale	ML	3	60%
	6-8	8	10	16	21	26	Low-plasticity silt from 6 to 8 feet BGS, with a 2-inch thick layer of clean gravel (GP) (rock broken by drill?) at about 7 feet BGS		4	75%
	8-10	6	8	9	12	17	Brown Mottled (w/Black) silt with 15% Gravel	ML	5	75%
	10-12	5	7	16	12	23	Gray silt transitioning to weathered rock - possibly sandstone or shale		6	55%
	12-14	14	13	15	15	28	Gray gravel and yellowish orange weathered sandstone with silt	GM	7	50%
	14-16	6	9	10	6	19	Gray to brown low-plasticity silt with some weathered shale	ML	8	50%
	16-18	9	10	13	10	23	Plastic silt, with 25% gravel. Moist, but not likely in the groundwater table.	MH	9	50%
	18-19.3	6	5	50/3"		55+	Rock (sandstone)		10	65%
							BORING COMPLETED AT ~19.3 FEET BGS - BACKFILLED WITH CEMENT GROUT			

BORING LOG

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Boring ID	HSA-3		
Logged By	W. Tyner	Elevation	N/A
Date	11/29/2012	Northing	N/A
Project No.	ME0896	Easting	N/A
Project Name	GenOn Coal Ash Ponds		
		Drilling Method	HSA
Drilling Co.	Eichelbergers, Inc.	Bore Hole Diameter	6 INCHES
Driller(s)	Tom Growden	Cave Depth	N/A
Rig Type	Track Mounted HSA	Depth to Water	*Possible GW at 17 feet BGS*

Elevation	Depth (ft)	Blow Counts				N- Value	Material Description	USCS	Sample No.	Recovery
	0-2	-	-	-	-		Brown sandy silt	ML	1	
	2-4	-	-	-	-			ML	2	
	4-6	5	8	11	11	19	Mottled brown/gray plastic silt with 15% gravel	MH	3	55%
	6-8	10	13	12	16	25	Low-plasticity silt from 6 to 8 feet BGS, with a 2-inch thick layer of clean gravel (GP) (rock broken by drill?) at about 7 feet BGS	MH	4	45%
	8-10	5	6	7	7	13	Brown and Gray mottled plastic silt; 15% gravel	MH	5	100%
	10-12	5	7	10	14	17		MH	6	70%
	12-14	10	15	12	13	27	Chalky weathered limestone	Stone	7	30%
	14-16	3	4	4	5	8	Plastic-silt with a small 1-inch thick layer of weathered shale at approximatley 15.5 feet BGS	MH	8	50%
	16-18	3	4	5	6	9	Tightly packed sandy silt (moist but no groundwater) transitioning to wet loamy soil - possible groundwater table at 17 feet BGS	MH to Loam	9	85%
	18-20	6	8	10	10	18	Wet loamy soil transitions back to relativley dry plastic silt	Loam to MH	10	100%
							BORING TERMINATED AT 20 FEET BGS - BACKFILLED WITH CEMENT GROUT			

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engineers | scientists | innovators

BORING LOG

Boring ID	HSA-4		
Logged By	W. Tyner	Elevation	N/A
Date	11/29/2012	Northing	N/A
Project No.	ME0896	Easting	N/A
Project Name	GenOn Coal Ash Ponds		
		Drilling Method	HSA
Drilling Co.	Eichelbergers, Inc.	Bore Hole Diameter	6 INCHES
Driller(s)	Tom Growden	Cave Depth	N/A
Rig Type	Track Mounted HSA	Depth to Water	*Between 17 and 20 feet BGS*

Elevation	Depth (ft)	Blow Counts				N- Value	Material Description	USCS	Sample No.	Recovery
	0-2	-	-	-	-		Brown sandy silt	ML		
	2-4	-	-	-	-			ML		
	4-6	3	6	5	7	11	Dense mottled brown/gray plastic to non-plastic silt Low-plasticity silt from 6 to 8 feet BGS, with a 2-inch thick layer of clean gravel (GP) (rock broken by drill?) at about 7 feet BGS	ML-MH	1	50%
	9-11	4	8	10	10	18	Mottled low-plasticity silt with 25% gravel (typically < 1/16%) and small layer of weathered shale around 10 feet BGS	ML	2	50%
	15-17	3	4	4	4	8	Mottled gray to brown low-plasticity silt with 5% gravel	ML	3	40%
	18-20	5	7	7	8	14	Wet silty sand with gravel with 25-40% gravel	MH	4	20%
							BORING TERMINATED AT 20 FEET BGS - BACKFILLED WITH CEMENT GROUT			

APPENDIX D

STABILITY ANALYSIS

Geosyntec consultants

COMPUTATION COVER SHEET

Client: NRG **Project:** Cheswick BAP Stability **Project/Proposal #:** ME0896 **Task #:** 02

TITLE OF COMPUTATIONS Stability Analysis for BAPs at Cheswick Power Station

COMPUTATIONS BY:
Signature [signature] 1/15/2013
DATE
Printed Name Chunling Li
and Title Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY:
(Peer Reviewer)
Signature [signature] 1/15/2013
DATE
Printed Name Lucas de Melo
and Title Senior Engineer

COMPUTATIONS CHECKED BY:
Signature [signature] 1/15/2013
DATE
Printed Name Lucas de Melo
and Title Senior Engineer

COMPUTATIONS BACKCHECKED BY:
(Originator)
Signature [signature] 1/15/2013
DATE
Printed Name Chunling Li
and Title Engineer

APPROVED BY:
(PM or Designate)
Signature [signature] 1/15/2013
DATE
Printed Name Michael Houlihan
and Title Principal

APPROVAL NOTES:

REVISIONS (Number and initial all revisions)

NO.	SHEET	DATE	BY	CHECKED BY	APPROVAL

STABILITY ANALYSIS FOR CCW POND AT CHESWICK POWER STATION

1. PURPOSE

As an ongoing national effort by the United States Environmental Protection Agency (USEPA) to assess the management of coal combustion waste (CCW), the stability of CCW ponds nationwide are target of a review. Geosyntec was engaged by NRG Energy, Inc. (NRG) to review the stability condition of two bottom ash ponds (BAPs) at the Cheswick Power Station. A slope stability analysis is conducted as a part of the review. The details of this analysis are presented in this analysis.

2. BACKGROUND

Currently, there are two BAPs at the Cheswick facility, including the main and Emergency BAPs. Geosyntec drilled four borings at the site, including two borings at each of the ponds to study the subsurface conditions. The borings were advanced from the center of the ponds' embankments to a depth of approximately 20 feet at selected critical cross sections. The pond geometry was obtained from drawings by Duquesne Light Company dated July, 1971. Because the embankment slopes appeared to be steeper than the design slopes (i.e., approximately 1.5 Horizontal to 1 Vertical), Geosyntec also performed additional analysis to evaluate the stability of the embankments under steeper outer slopes. For purposes of performing a conservative analysis, existing outer slopes were considered to be 1 Horizontal to 1 Vertical.

3. CROSS SECTIONS ANALYSED

One critical cross section was selected for the analysis based on review of subsurface condition and pond geometry. The location of the selected cross section is at the main BAP, as shown in Figure 1. This section was selected because the embankment height at this location is the highest and the foundation soil was found to be the weakest based on blow counts (SPT-N) obtained during the field investigation (i.e., undrained shear strength of 2,000 psf). In addition, the Emergency BAP is shallower than the main BAP (i.e., shorter embankment height) and the embankment material shows higher SPT-N value than the embankment material encountered at the main BAP; thus, the selected analysis location at the main BAP represents the critical cross section and analysis results will represent the lowest expected factor of safety against failure.

4. STABILITY CRITERIA

According to the US Corps of Engineers [2003], the minimum recommended factor of safety (FS) against global slope stability failure for permanent conditions under static loading is 1.5 (EM 110-2-1902). For seismic condition, the minimum acceptable FS is selected to be 1.2, based on recommendation of presented by the Mine Safety and Health Administration document entitled Engineering and Design Manual: Coal Refuse Disposal Facilities [2009].

5. LOADING CONDITIONS

5.1 Static Loads

The major static load applied to the foundation soils is the gravity load exerted by the weight of the berm. A surcharge load of 250 pound per square feet (psf) is applied to the top of the embankment to represent traffic loading on top of the embankment.

5.2 Seismic Loads

The maximum horizontal acceleration in bedrock for the Cheswick facility site is estimated to be 0.0516g (g is the gravitational acceleration), based on a seismic hazard map with contours of peak acceleration with 2% probability of exceedance in 50 years as indicated in Figure 2 [USGS, 2008]. This represents the peak ground acceleration in bedrock.

The peak ground acceleration at a soil site should be adjusted by the site classification. Using the International Building Code (IBC) 2006 soil classification table, the Cheswick lithology classifies as a site classification D, which is described as a stiff soil profile. This classification is determined from the average standard penetration resistance (N-value) within a 100 foot deep soil profile. An IBC 2006 site classification of D pertains to a soil profile with an average N-value between 15 and 50. This site classification table is attached as Figure 3. Using the site coefficient chart for site Class D the value of 1.6 is obtained as shown in Figure 4. Using the site coefficient and the PGA in rock, the PGA in soil site is estimated to be 0.083g.

In slope stability analysis, the horizontal seismic loading is typically considered as the weight of the soil mass multiplied by seismic coefficient, *k*. Because the peak ground acceleration will only occur for a short duration, the seismic coefficient *k* used in the design analysis will be smaller than the PGA. A seismic design guidance provided by USEPA [Richardson et. al.,1995] recommends to use approximately half of PGA as seismic coefficient. For a design PGA of 0.083g, a seismic coefficient of 0.042 was used in this analysis.

6. STRATIGRAPHY AND MATERIAL PARAMETERS

Based on the boring logs, the embankment is constructed using silt that classify as MH (high-plasticity silt) or ML (sandy silt). The SPT-N ranges from 8 to 27 blows/ft, with an average of 16 blows/ft. The soils below the then-existing ground surface prior to the pond construction has similar appearance and SPT-N value; thus, they are considered to have the similar physical properties as the fill material used for embankment construction. The bedrock is found at approximately 20 feet below ground surface at two of the four boring locations.

The material properties for the silt are selected based on typical material properties for compacted soil provided by NAVFAC (See Figure 5). Additionally, the typical undrained shear strength provided is verified using the empirical correlations with SPT-N value [Kulhawy and Wayne, 1990]:

$$S_u/P_a = 0.06\ N$$

Where: S_u = undrained shear strength;
P_a = atmospheric pressure (= 2,116 psf)
N = SPT-N value (blows/ft)

Using the average SPT-N value of 16 blows/ft, the undrained shear strength is estimated to be 2,000 psf, which is comparable with the typical value provided by NAVFAC.

The bedrock present at the site was found to be sandstone or limestone, which typically has very high shear strength. For this analysis, the bedrock is conservatively assumed to have a cohesion of 5,000 psf and a friction angle of 20 degrees. Table 1 summaries the material properties used in the slope stability analysis.

Table 1.Material Properties Used in Slope Stability Analyses

Material	Moist Unit Weight (lb/ft^3)	Drained Shear Strength		Undrained Shear Strength (psf)
		Cohesion (psf)	Friction Angle (deg)	
Silt (fill)	120	420	25	2,000
Silt (then-existing)	130	420	25	2,000
Bedrock	140	5,000	20	

7. GROUNDWATER CONDITION

The groundwater table was estimated to be approximately 17 ft below the top of the embankment (approximately at elevation 760 ft-msl), based on the observation during boring investigation (HAS-4). However, the groundwater table used in the analysis was derived from the groundwater flow analysis using the groundwater finite element analysis module of the SLIDE software. In this analysis, a phreatic line was calculated assuming the water in the pond infiltrates through the embankment towards the creek to the east of the pond. The total head in the pond is assumed to be at 777 ft-msl. The groundwater table is assumed to be at ground surface at the creek. The details of the finite element groundwater analysis are presented in Attachment 1.

8. METHOD OF SLOPE STABILITY ANALYSIS

The stability of the selected cross section was evaluated using the limit equilibrium method. The analyses were conducted using SLIDE [Rocscience, 2002], a two-dimensional (2D) slope stability computer program. The factors of safety for both circular and non-circular potential slip surface were evaluated. The Spencer's Method [Spencer, 1967], and the Janbu's Simplified Method [Janbu, 1954a, 1954b, 1973] were used in the analysis. The interslice force assumption made in the Spencer's Method satisfies force equilibrium in horizontal and vertical directions as well as moment equilibrium. Therefore, Spencer's method is considered as a rigorous methods, which generally provide more precise results for factor of safety than non-rigorous method. The factors of safety reported herein are from Spencer's method, and are verified using Janbu's simplified method.

Thousands of potential failure surfaces were analyzed to find the critical failure surface resulting in the minimum factor of safety for the slope. For the circular slip surface search, a search grid with 25 horizontal increments and 25 vertical increments was used. For the block failure analysis, two search windows were used for searching the most critical failure surface.

SLIDE provides results graphically and as output text files. SLIDE graphical provides both the minimum factor of safety and contours of the calculated factors of safety. For each case analyzed, a figure and text are generated and presented in Attachment 2 of this calculation package.

8. RESULTS OF SLOPE STABILITY

The results of the SLIDE analyses using the material properties listed in Table 1 are summarized in Table 2.

Table 2. Summary of Slope Stability Results

Embankment Slopes	Loading Conditions	Failure Mode	Calculated F.S.	Target F.S
Design (1.5H:1V)	Static	Circular	3.30	1.5
		Block	3.37	1.5
	Seismic	Circular	2.98	1.2
		Block	2.98	1.2
Conservative Assumption (1H:1V)	Static	Circular	2.97	1.5
		Block	2.98	1.5
	Seismic	Circular	2.78	1.2
		Block	2.73	1.2

10. SUMMARY

The stability of the BAPs at the Cheswick facility was evaluated for several scenarios. Using typically assumed material properties, the results of these analyses show factors of safety significantly above the minimum recommended factor of safety.

Based on the results of these analyses, it is considered that the BAPs at the Cheswick facility are stable.

11. REFERENCES

Bishop, A.W. (1955), "The use of the slip circle in the stability analysis of slopes", Géotechnique, Volume 5, Issue 1, pages 7 –17.

Janbu, N. (1954) "Application of composite slip surface for slope stability analysis". Proceedings of European conference on stability of earth slopes, Stockholm 3, 43-49.

Rocscience. (2002). "Slide (Version 5.0): A 2D Slope Stability Analysis for Soil and Rock Slopes", Toronto, Canada.

Spencer (1967). "A Method of Analysis of the Stability of Embankments Assuming Parallel Interslice Forces," Geotechnique, London, England, 17(1), pp. 11-26.

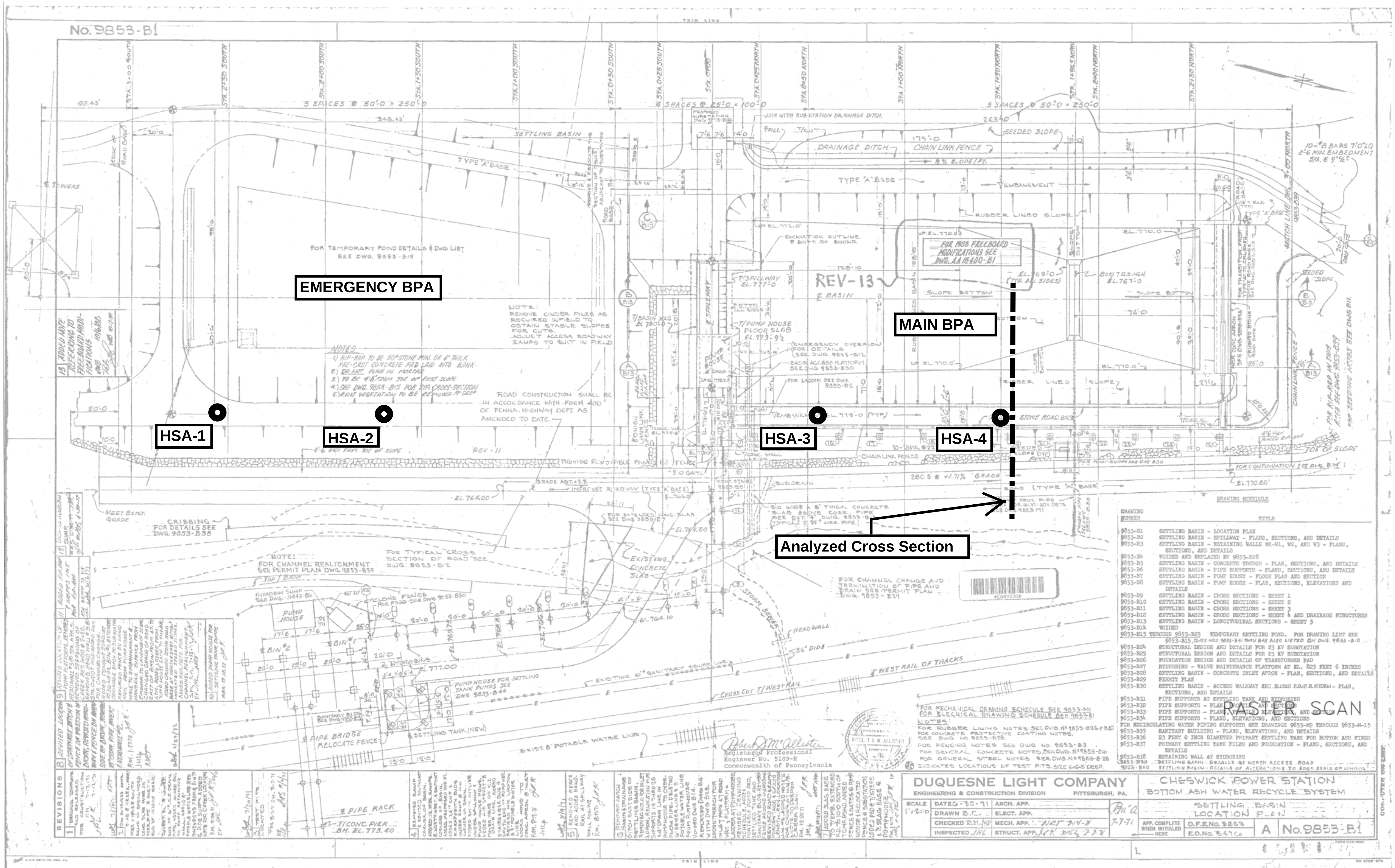
U.S. Department of Labor Mine Safety and Health Administration - MSHA (2009) "Engineering And Design Manual Coal Refuse Disposal Facilities". Second Edition.

US Army Corps of Engineers (2003) "Engineer Manual EM 1110-2-1902 Slope Stability"

U.S. Navy, (1971). "Soil Mechanics, Foundations, and Earth Structures," NAVFAC Design Manual DM-7, Washington, D.C.

USGS (2008). "2008 United States National Seismic Hazard Maps", United States Geological Survey, http://earthquake.usgs.gov/research/hazmaps/products_data/2008/

FIGURES



Key:

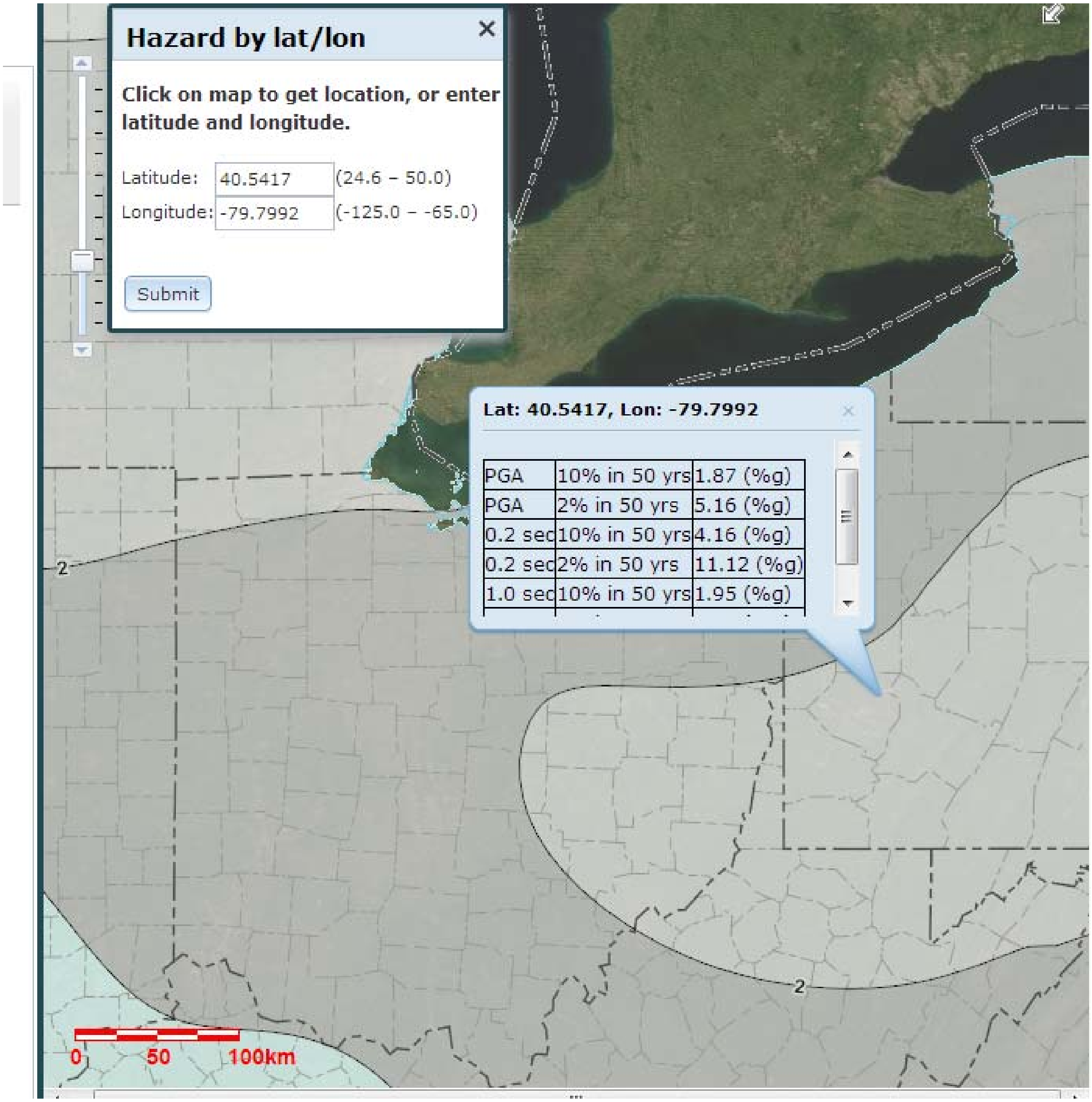
HSA-1 Approximate Boring Location

FIGURE 1 - BAP Design Drawing

Cheswick Power Station - Bottom Ash Ponds

Springdale, Pennsylvania

ME0896



Source: USGS [2008]

Figure 2. USGS Seismic Hazard Map

TABLE 1613.5.2
SITE CLASS DEFINITIONS

SITE CLASS	SOIL PROFILE NAME	AVERAGE PROPERTIES IN TOP 100 feet, SEE SECTION 1613.5.5		
		Soil shear wave velocity, $\bar{v}_s$, (ft/s)	Standard penetration resistance, $\bar{N}$	Soil undrained shear strength, $\bar{s}_u$, (psf)
A	Hard rock	$\bar{v}_s > 5{,}000$	N/A	N/A
B	Rock	$2{,}500 < \bar{v}_s \leq 5{,}000$	N/A	N/A
C	Very dense soil and soft rock	$1{,}200 < \bar{v}_s \leq 2{,}500$	$\bar{N} > 50$	$\bar{s}_u \geq 2{,}000$
D	Stiff soil profile	$600 \leq \bar{v}_s \leq 1{,}200$	$15 \leq \bar{N} \leq 50$	$1{,}000 \leq \bar{s}_u \leq 2{,}000$
E	Soft soil profile	$\bar{v}_s < 600$	$\bar{N} < 15$	$\bar{s}_u < 1{,}000$
E	—	Any profile with more than 10 feet of soil having the following characteristics: 1. Plasticity index $PI > 20$, 2. Moisture content $w \geq 40\%$, and 3. Undrained shear strength $\bar{s}_u < 500$ psf		
F	—	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays ($H > 10$ feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays ($H > 25$ feet with plasticity index $PI > 75$) 4. Very thick soft/medium stiff clays ($H > 120$ feet)		

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2, 1 pound per square foot = 0.0479 kPa. N/A = Not applicable

Source: International Building Code 2006

Figure 3. Site Classification

TABLE 1613.5.3(1)
VALUES OF SITE COEFFICIENT F_a [a]

SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIOD				
	$S_s \leq 0.25$	$S_s = 0.50$	$S_s = 0.75$	$S_s = 1.00$	$S_s \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	Note b	Note b	Note b	Note b	Note b

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at short period, S_s.
b. Values shall be determined in accordance with Section 11.4.7 of ASCE 7.

Source: International Building Code 2006

Figure 4. Site Coefficient

TYPICAL PROPERTIES OF COMPACTED SOILS (NAVFAC DM 7.2, Table 1, p7.2-39)

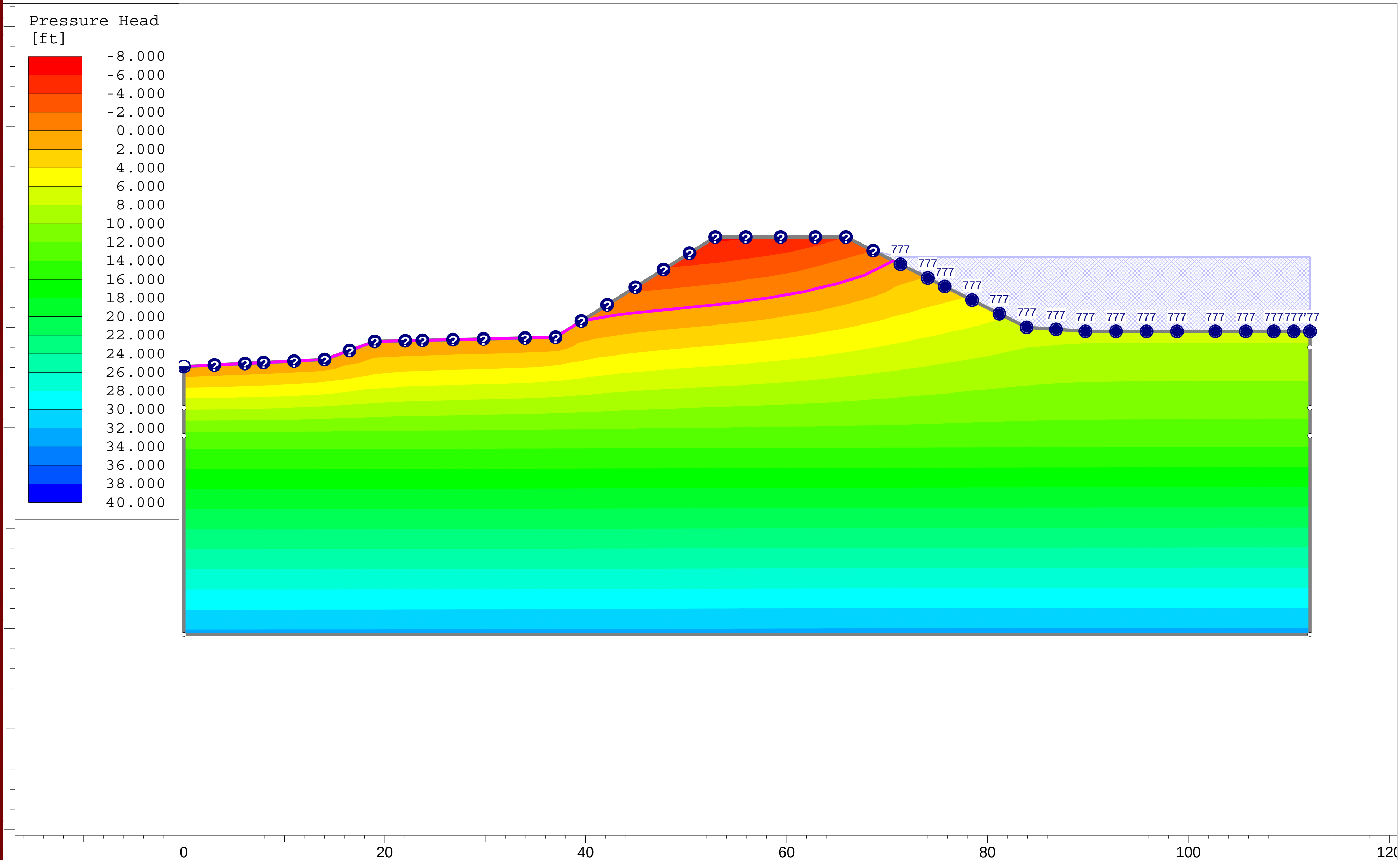
Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression (Percent of Original Height)		Typical Strength Characteristics				Typical Coefficient of Permeability ft/miin.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in
				At 1.4 tsf (20 psi)	At 3.6 tsf (50 psi)	Cohesion (as compacted) psf	Cohesion (saturated) psf	PHI (Effective Stress Friction Angle Degrees)	Tan PHI			
GW	Well-graded clean gravels, gravel-sand mixture	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt	120 - 135	12 - 8	0.5	1.1	--	--	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay	115 - 130	14 - 9	0.7	1.6	--	--	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	5×10^{-5}	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	2×10^{-6}	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	5×10^{-7}	5 - 20	100 - 300
ML	Inorganic silts and clayey silts	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	5×10^{-7}	--	--
CL	Inorganic clays of low to medium plasticity	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity	80 - 100	33 - 21	--	--	--	--	--	--	--	5 or less	50 - 100
MH	Inorganic clayey silts, plastic silts	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	5×10^{-7}	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	--	--	--	--	--	--	--	5 or less	25 - 100

Notes: All properties are for Conditions of Standard Proctor maximum density, except values of k and CBR, which are for Modified Proctor maximum density. Typical strength values are effective strengths from USBR data. Compression values are for vertical loading with complete lateral confinement.

Figure 5. Typical Shear Strength of Compacted Soils

Attachment 1

Groundwater Flow Finite Element Analysis



Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		*Scale* 1:160	*Company*
Date 12/6/2012, 1:02:59 PM		*File Name* Cross section A_groundwater.sli	

IDEINTERPRET 6.019

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: Cross section A_groundwater.sli
Slide Modeler Version: 6.019
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 12/6/2012, 1:02:59 PM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/day
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Steady State FEA
Pore Fluid Unit Weight: 62.4 lbs/ft3
Tolerance: 1e-006
Maximum number of iterations: 500
Advanced Groundwater Method: None
Mesh Element Type: 3 noded triangles
Number of Elements: 949
Number of Nodes: 525

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius Increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Silt (fill)	silt (in-place soil)	Bedrock
Color			
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	120	120	140
Cohesion [psf]	0	0.02	0.02
Friction Angle [deg]	35	35	35
Unsaturated Shear Strength Angle [deg]	0	0	0
Air Entry Value [psf]	0	0	0
Ks [feet/day]	0.00072	0.00072	0.283
K2/K1	1	1	1
K Angle [deg]	0	0	0
Groundwater Model	Simple	Simple	Simple
GW Model Properties	Soil Type: General	Soil Type: General	Soil Type: General

List Of Coordinates

External Boundary

X	Y
0	739.401
112.096	739.401
112.096	759.219
112.096	762
112.096	767.998
112.096	769.6
89.75	769.6
83.9	770

65.9	779
52.9	779
37	769.02
26.7891	768.782
19	768.6
14	766.8
0	766.1
0	762
0	759.219

Material Boundary

X	Y
35	767.1
40	764.7
55	766.2
70	767.5
90	766.9
110	767.2
112.096	767.998

Material Boundary

X	Y
26.7891	768.782
35	767.1

Material Boundary

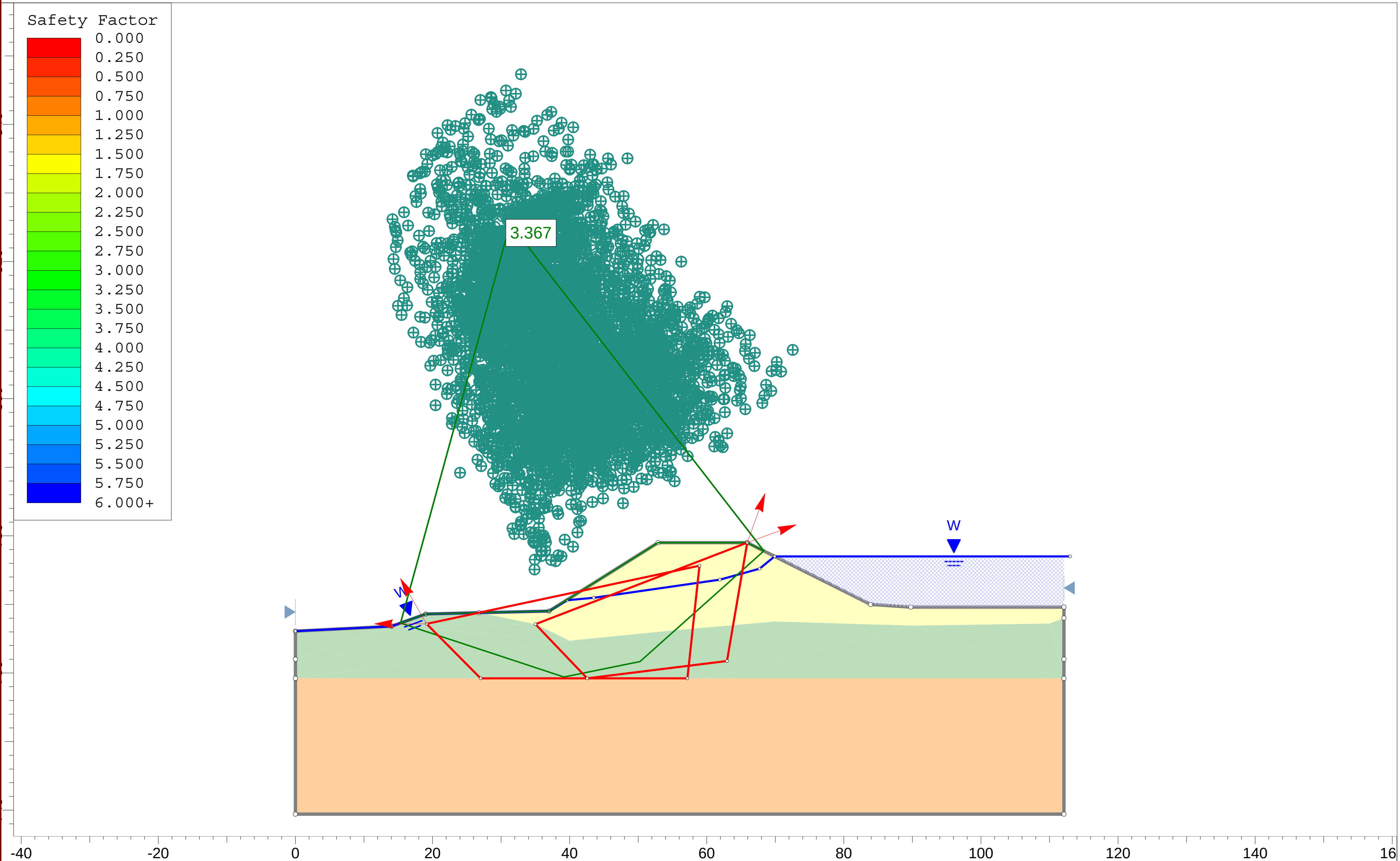
X	Y
60.342	759.219
112.096	759.219

Material Boundary

X	Y
0	759.219
60.342	759.219

Attachment 2

Slope Stability Analysis Output



rocscience

SLIDEINTERPRET 6.019

Project: SLIDE - An Interactive Slope Stability Program

Analysis Description

Drawn By

Scale: 1:235

Company

Date: 12/6/2012, 1:02:59 PM

File Name: Cross section A_Pond Full _Static_Block.slim

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: Cross section A_Pond Full _Static_Block.slim
Slide Modeler Version: 6.019
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 12/6/2012, 1:02:59 PM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/day
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Non-Circular Block Search
Number of Surfaces: 5000
Pseudo-Random Surfaces: Enabled
Convex Surfaces Only: Disabled
Left Projection Angle (Start Angle): 120
Left Projection Angle (End Angle): 180
Right Projection Angle (Start Angle): 20
Right Projection Angle (End Angle): 70
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Silt (fill)	silt (in-place soil)	Bedrock
Color			
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	120	120	140
Cohesion [psf]	420	420	5000
Friction Angle [deg]	25	25	20
Water Surface	Water Table	Water Table	Water Table
Hu Value	1	1	1

Global Minimums

Method: bishop simplified

FS: 3.002030
Axis Location: 40.720, 807.728
Left Slip Surface Endpoint: 33.103, 768.929
Right Slip Surface Endpoint: 67.189, 778.355
Resisting Moment=1.15558e+006 lb-ft
Driving Moment=384932 lb-ft
Total Slice Area=268.057 ft2

Method: janbu simplified

FS: 2.886890
Axis Location: 40.720, 807.728
Left Slip Surface Endpoint: 33.103, 768.929
Right Slip Surface Endpoint: 67.189, 778.355
Resisting Horizontal Force=23732.4 lb
Driving Horizontal Force=8220.73 lb
Total Slice Area=268.057 ft2

Method: spencer

FS: 3.367170
Axis Location: 31.313, 825.534
Left Slip Surface Endpoint: 15.323, 767.276
Right Slip Surface Endpoint: 68.326, 777.787
Resisting Moment=2.5754e+006 lb-ft
Driving Moment=764857 lb-ft
Resisting Horizontal Force=36550.1 lb
Driving Horizontal Force=10854.9 lb
Total Slice Area=440.739 ft2

Global Minimum Coordinates

Method: bishop simplified

X	Y
33.103	768.929
40.9289	762.285
50.0059	763.717
67.1892	778.355

Method: janbu simplified

X	Y
33.103	768.929
40.9289	762.285
50.0059	763.717
67.1892	778.355

Method: spencer

X	Y
15.3228	767.276
39.172	759.409
50.2515	761.661
68.3256	777.787

Valid / Invalid Surfaces

Method: bishop simplified

Number of Valid Surfaces: 4430
Number of Invalid Surfaces: 570

Error Codes:

Error Code -105 reported for 63 surfaces
Error Code -107 reported for 81 surfaces
Error Code -108 reported for 331 surfaces

Error Code -112 reported for 95 surfaces

Method: janbu simplified

Number of Valid Surfaces: 3986
Number of Invalid Surfaces: 1014

Error Codes:

Error Code -105 reported for 63 surfaces
Error Code -107 reported for 81 surfaces
Error Code -108 reported for 804 surfaces
Error Code -112 reported for 66 surfaces

Method: spencer

Number of Valid Surfaces: 3612
Number of Invalid Surfaces: 1388

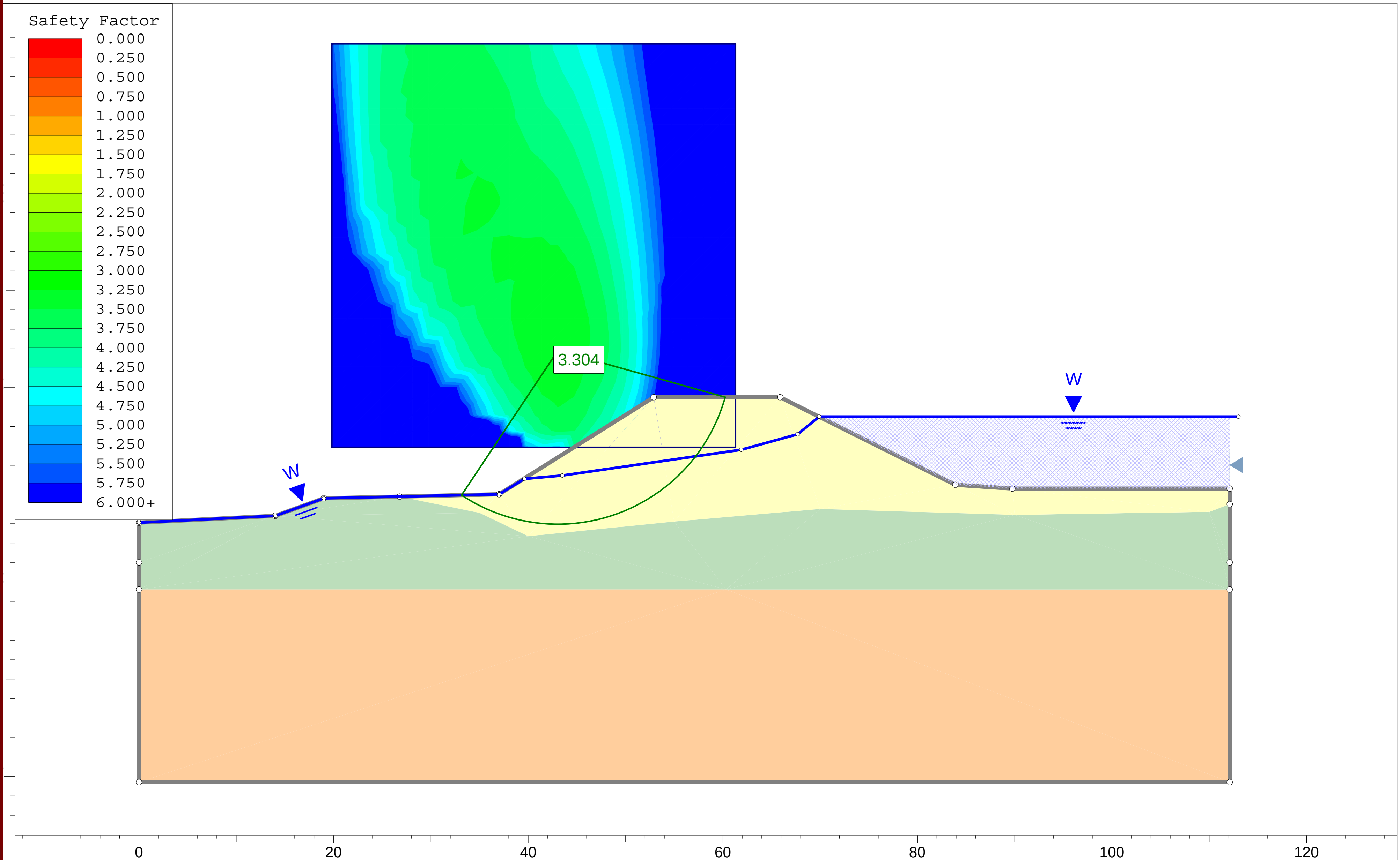
Error Codes:

Error Code -105 reported for 63 surfaces
Error Code -107 reported for 81 surfaces
Error Code -108 reported for 956 surfaces
Error Code -111 reported for 191 surfaces
Error Code -112 reported for 97 surfaces

Error Codes

The following errors were encountered during the computation:

-105 = More than two surface / slope intersections with no valid slip surface.
-107 = Total driving moment or total driving force is negative. This will occur if the wrong failure direction is specified, or if high external or anchor loads are applied against the failure direction.
-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).
-111 = safety factor equation did not converge
-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.



SLIDEINTERPRET 6.019	Project: SLIDE - An Interactive Slope Stability Program		
	Analysis Description		
	Drawn By	Scale: 1:165	Company
	Date: 12/6/2012, 1:02:59 PM		File Name: Cross section A_Pond Full _Static_Circular.slim

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: Cross section A_Pond Full _Static_Circular.slim
Slide Modeler Version: 6.019
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 12/6/2012, 1:02:59 PM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/day
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius Increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Silt (fill)	silt (in-place soil)	Bedrock
Color			
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	120	120	140
Cohesion [psf]	420	420	5000
Friction Angle [deg]	25	25	20
Water Surface	Water Table	Water Table	Water Table
Hu Value	1	1	1

Global Minimums

Method: bishop simplified

FS: 3.304470
Center: 43.051, 783.807
Radius: 17.873
Left Slip Surface Endpoint: 33.145, 768.930
Right Slip Surface Endpoint: 60.266, 779.000
Resisting Moment=375883 lb-ft
Driving Moment=113750 lb-ft
Total Slice Area=167.532 ft2

Method: janbu simplified

FS: 3.078800
Center: 41.391, 785.467
Radius: 22.509
Left Slip Surface Endpoint: 26.296, 768.770
Right Slip Surface Endpoint: 62.951, 779.000
Resisting Horizontal Force=24748.4 lb
Driving Horizontal Force=8038.3 lb
Total Slice Area=280.723 ft2

Method: spencer

FS: 3.304000

Center: 43.051, 783.807
Radius: 17.873
Left Slip Surface Endpoint: 33.145, 768.930
Right Slip Surface Endpoint: 60.266, 779.000
Resisting Moment=375830 lb-ft
Driving Moment=113750 lb-ft
Resisting Horizontal Force=17453 lb
Driving Horizontal Force=5282.39 lb
Total Slice Area=167.532 ft2

Valid / Invalid Surfaces

Method: bishop simplified

Number of Valid Surfaces: 6803
Number of Invalid Surfaces: 633

Error Codes:

Error Code -103 reported for 348 surfaces
Error Code -106 reported for 1 surface
Error Code -107 reported for 103 surfaces
Error Code -108 reported for 22 surfaces
Error Code -109 reported for 1 surface
Error Code -112 reported for 158 surfaces

Method: janbu simplified

Number of Valid Surfaces: 6741
Number of Invalid Surfaces: 695

Error Codes:

Error Code -103 reported for 348 surfaces
Error Code -106 reported for 1 surface
Error Code -107 reported for 103 surfaces
Error Code -108 reported for 116 surfaces
Error Code -109 reported for 1 surface
Error Code -112 reported for 126 surfaces

Method: spencer

Number of Valid Surfaces: 6558
Number of Invalid Surfaces: 878

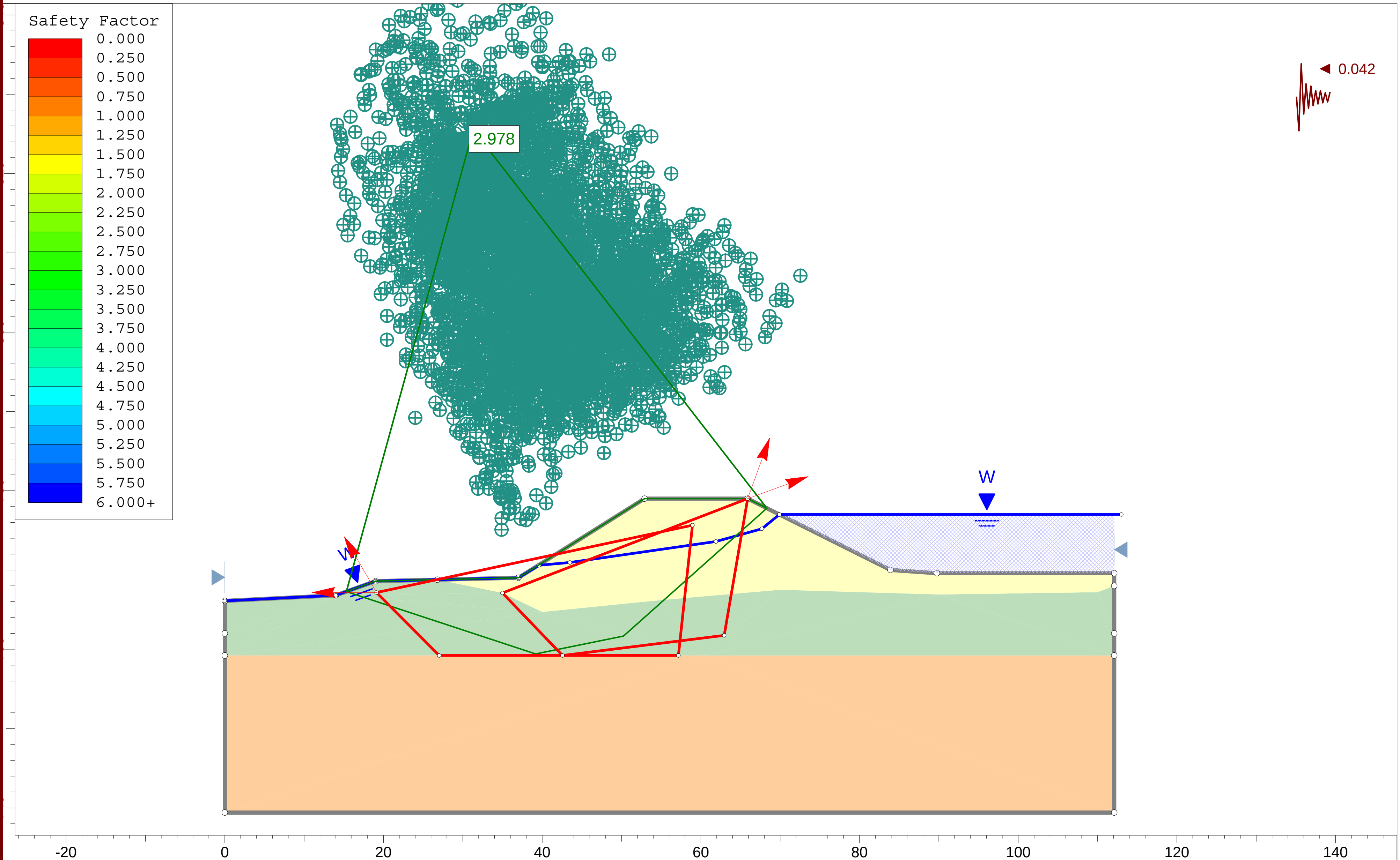
Error Codes:

Error Code -103 reported for 348 surfaces
Error Code -106 reported for 1 surface
Error Code -107 reported for 103 surfaces
Error Code -108 reported for 160 surfaces
Error Code -109 reported for 1 surface
Error Code -111 reported for 105 surfaces
Error Code -112 reported for 160 surfaces

Error Codes

The following errors were encountered during the computation:

-103 = Two surface / slope intersections, but one or more surface / nonslope external polygon intersections lie between them. This usually occurs when the slip surface extends past the bottom of the soil region, but may also occur on a benched slope model with two sets of Slope Limits.
-106 = Average slice width is less than 0.0001 * (maximum horizontal extent of soil region). This limitation is imposed to avoid numerical errors which may result from too many slices, or too small a slip region.
-107 = Total driving moment or total driving force is negative. This will occur if the wrong failure direction is specified, or if high external or anchor loads are applied against the failure direction.
-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).
-109 = Soiltype for slice base not located. This error should occur very rarely, if at all. It may occur if a very low number of slices is combined with certain soil geometries, such that the midpoint of a slice base is actually outside the soil region,even though the slip surface is wholly within the soil region.
-111 = safety factor equation did not converge
-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.



Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		Scale 1:203	Company
Date 12/6/2012, 1:02:59 PM		File Name Cross section A_Pond Full _Seismic_Block.slim	

IDEINTERPRET 6.019

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: Cross section A_Pond Full _Seismic_Block.slim
Slide Modeler Version: 6.019
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 12/6/2012, 1:02:59 PM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/day
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Surface Options

Surface Type: Non-Circular Block Search
Number of Surfaces: 5000

Pseudo-Random Surfaces: Enabled
Convex Surfaces Only: Disabled
Left Projection Angle (Start Angle): 120
Left Projection Angle (End Angle): 180
Right Projection Angle (Start Angle): 20
Right Projection Angle (End Angle): 70
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

Seismic Load Coefficient (Horizontal): 0.042

Material Properties

Property	Silt (fill)	silt (in-place soil)	Bedrock
Color			
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	120	120	140
Cohesion [psf]	420	420	5000
Friction Angle [deg]	25	25	20
Water Surface	Water Table	Water Table	Water Table
Hu Value	1	1	1

Global Minimums

Method: bishop simplified

FS: 2.712820
Axis Location: 40.720, 807.728
Left Slip Surface Endpoint: 33.103, 768.929
Right Slip Surface Endpoint: 67.189, 778.355
Resisting Moment=1.1508e+006 lb-ft
Driving Moment=424209 lb-ft
Total Slice Area=268.057 ft2

Method: janbu simplified

FS: 2.594430
Axis Location: 40.720, 807.728
Left Slip Surface Endpoint: 33.103, 768.929
Right Slip Surface Endpoint: 67.189, 778.355
Resisting Horizontal Force=23641.3 lb
Driving Horizontal Force=9112.34 lb
Total Slice Area=268.057 ft2

Method: spencer

FS: 2.978050
Axis Location: 31.313, 825.534
Left Slip Surface Endpoint: 15.323, 767.276
Right Slip Surface Endpoint: 68.326, 777.787
Resisting Moment=2.56676e+006 lb-ft
Driving Moment=861895 lb-ft
Resisting Horizontal Force=36462.5 lb
Driving Horizontal Force=12243.7 lb
Total Slice Area=440.739 ft2

Global Minimum Coordinates

Method: bishop simplified

X	Y
33.103	768.929
40.9289	762.285
50.0059	763.717
67.1892	778.355

Method: janbu simplified

X	Y
33.103	768.929
40.9289	762.285
50.0059	763.717
67.1892	778.355

Method: spencer

X	Y
15.3228	767.276
39.172	759.409
50.2515	761.661
68.3256	777.787

Valid / Invalid Surfaces

Method: bishop simplified

Number of Valid Surfaces: 4464
Number of Invalid Surfaces: 536

Error Codes:

Error Code -105 reported for 63 surfaces
Error Code -107 reported for 47 surfaces
Error Code -108 reported for 331 surfaces

Error Code -112 reported for 95 surfaces

Method: janbu simplified

Number of Valid Surfaces: 4017
Number of Invalid Surfaces: 983

Error Codes:

Error Code -105 reported for 63 surfaces
Error Code -107 reported for 47 surfaces
Error Code -108 reported for 802 surfaces
Error Code -112 reported for 71 surfaces

Method: spencer

Number of Valid Surfaces: 3590
Number of Invalid Surfaces: 1410

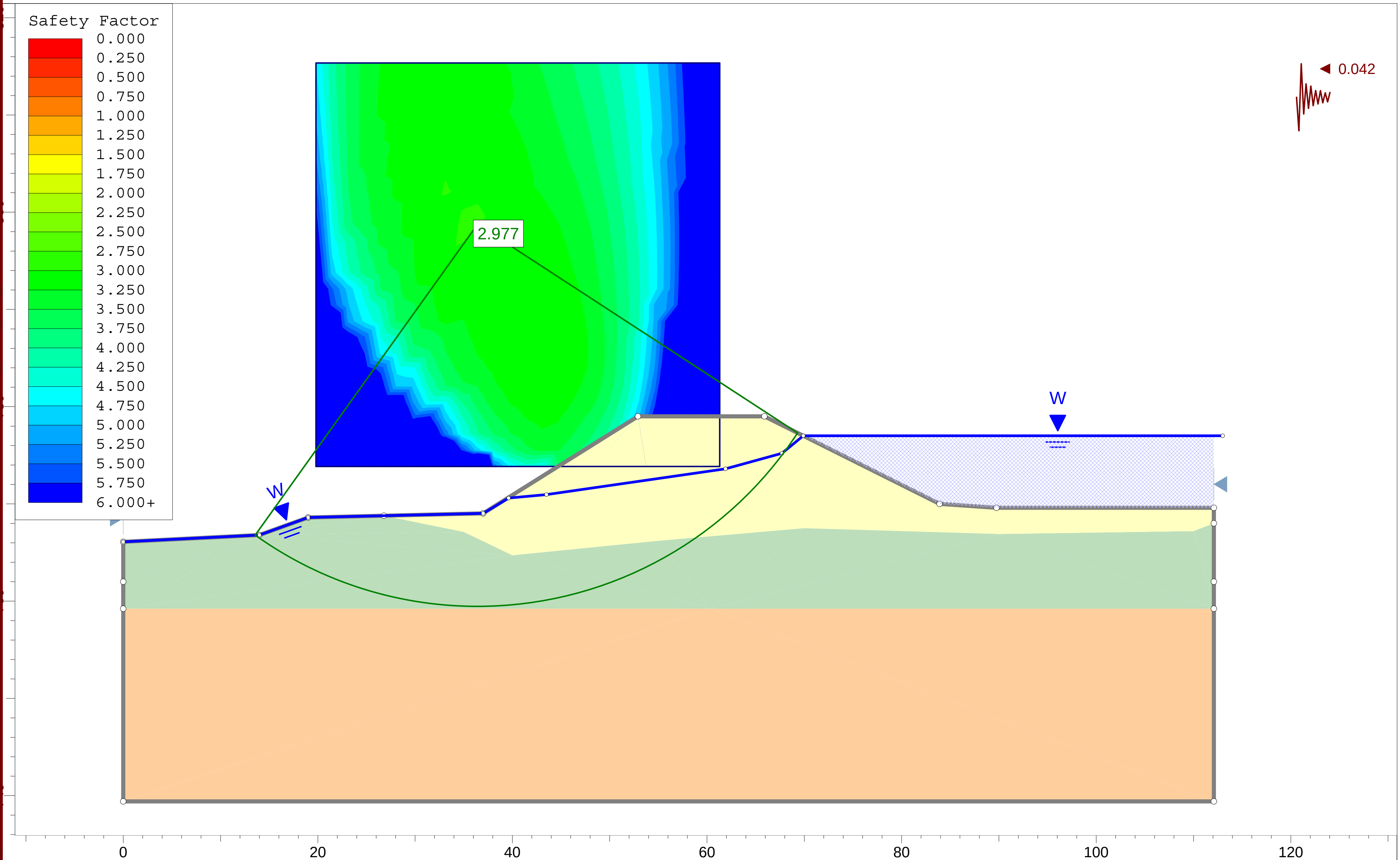
Error Codes:

Error Code -105 reported for 63 surfaces
Error Code -107 reported for 47 surfaces
Error Code -108 reported for 950 surfaces
Error Code -111 reported for 249 surfaces
Error Code -112 reported for 101 surfaces

Error Codes

The following errors were encountered during the computation:

-105 = More than two surface / slope intersections with no valid slip surface.
-107 = Total driving moment or total driving force is negative. This will occur if the wrong failure direction is specified, or if high external or anchor loads are applied against the failure direction.
-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).
-111 = safety factor equation did not converge
-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.



Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		Scale 1:165	Company
Date 12/6/2012, 1:02:59 PM		File Name Cross section A_Pond Full _Seismic_Circular.slim	

SLIDEINTERPRET 6.019

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: Cross section A_Pond Full _Seismic_Circular.slim
Slide Modeler Version: 6.019
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 12/6/2012, 1:02:59 PM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/day
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius Increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

Seismic Load Coefficient (Horizontal): 0.042

Material Properties

Property	Silt (fill)	silt (in-place soil)	Bedrock
Color			
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	120	120	140
Cohesion [psf]	420	420	5000
Friction Angle [deg]	25	25	20
Water Surface	Water Table	Water Table	Water Table
Hu Value	1	1	1

Global Minimums

Method: bishop simplified

FS: 2.976890
Center: 36.411, 798.747
Radius: 39.305
Left Slip Surface Endpoint: 13.546, 766.777
Right Slip Surface Endpoint: 69.337, 777.282
Resisting Moment=1.77611e+006 lb-ft
Driving Moment=596634 lb-ft
Total Slice Area=535.163 ft2

Method: janbu simplified

FS: 2.697920
Center: 34.751, 797.087
Radius: 37.707
Left Slip Surface Endpoint: 12.398, 766.720
Right Slip Surface Endpoint: 67.413, 778.244
Resisting Horizontal Force=38744.6 lb

Driving Horizontal Force=14360.9 lb
Total Slice Area=507.456 ft2

Method: spencer

FS: 2.976750
Center: 36.411, 798.747
Radius: 39.305
Left Slip Surface Endpoint: 13.546, 766.777
Right Slip Surface Endpoint: 69.337, 777.282
Resisting Moment=1.77603e+006 lb-ft
Driving Moment=596634 lb-ft
Resisting Horizontal Force=40323.5 lb
Driving Horizontal Force=13546.1 lb
Total Slice Area=535.163 ft2

Valid / Invalid Surfaces

Method: bishop simplified

Number of Valid Surfaces: 6908
Number of Invalid Surfaces: 528

Error Codes:

Error Code -103 reported for 348 surfaces
Error Code -106 reported for 1 surface
Error Code -107 reported for 15 surfaces
Error Code -108 reported for 3 surfaces
Error Code -109 reported for 1 surface
Error Code -112 reported for 160 surfaces

Method: janbu simplified

Number of Valid Surfaces: 6845
Number of Invalid Surfaces: 591

Error Codes:

Error Code -103 reported for 348 surfaces
Error Code -106 reported for 1 surface
Error Code -107 reported for 15 surfaces
Error Code -108 reported for 102 surfaces
Error Code -109 reported for 1 surface
Error Code -112 reported for 124 surfaces

Method: spencer

Number of Valid Surfaces: 6597
Number of Invalid Surfaces: 839

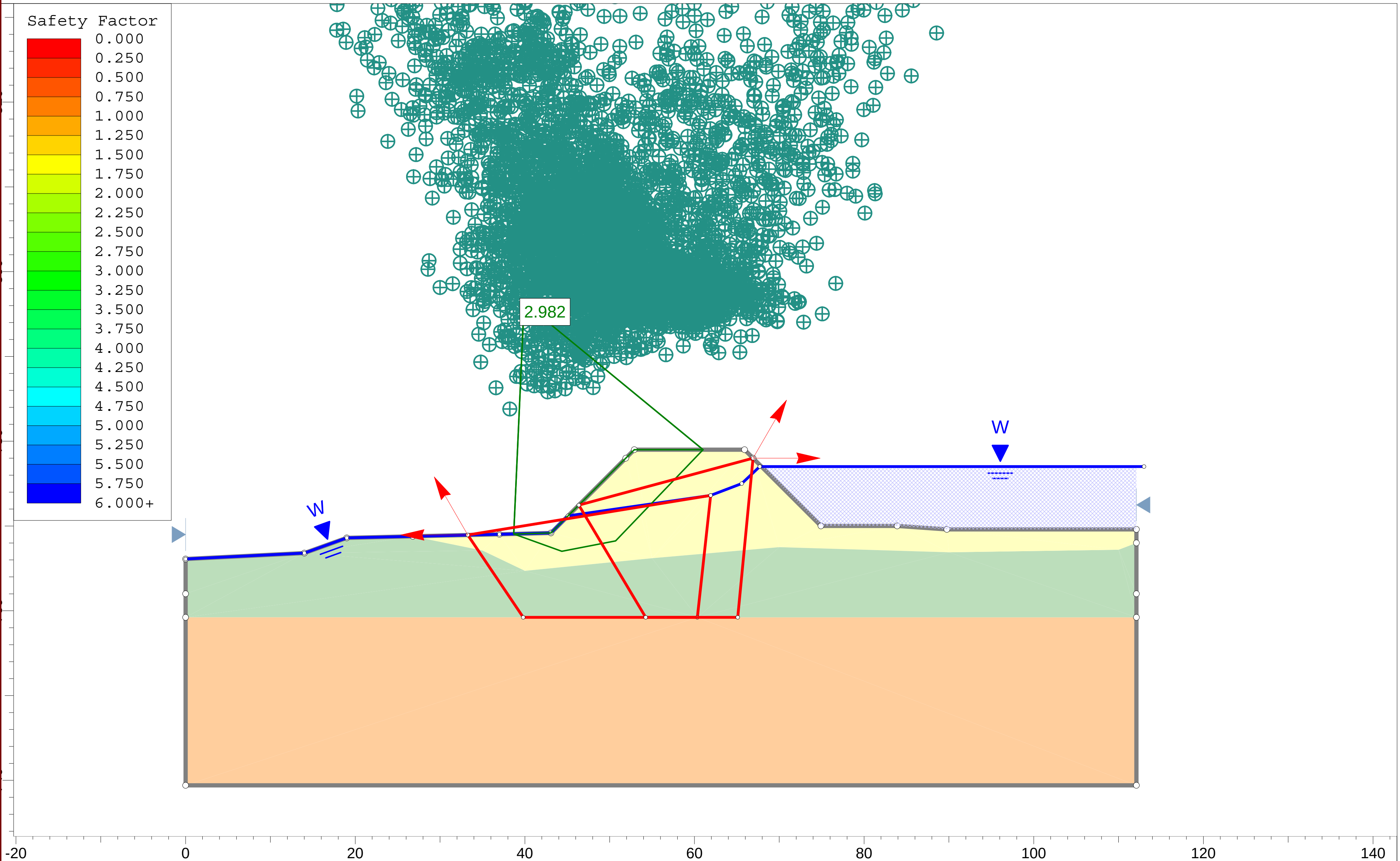
Error Codes:

Error Code -103 reported for 348 surfaces
Error Code -106 reported for 1 surface
Error Code -107 reported for 15 surfaces
Error Code -108 reported for 138 surfaces
Error Code -109 reported for 1 surface
Error Code -111 reported for 174 surfaces
Error Code -112 reported for 162 surfaces

Error Codes

The following errors were encountered during the computation:

-103 = Two surface / slope intersections, but one or more surface / nonslope external polygon intersections lie between them. This usually occurs when the slip surface extends past the bottom of the soil region, but may also occur on a benched slope model with two sets of Slope Limits.
-106 = Average slice width is less than 0.0001 * (maximum horizontal extent of soil region). This limitation is imposed to avoid numerical errors which may result from too many slices, or too small a slip region.
-107 = Total driving moment or total driving force is negative. This will occur if the wrong failure direction is specified, or if high external or anchor loads are applied against the failure direction.
-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).
-109 = Soiltype for slice base not located. This error should occur very rarely, if at all. It may occur if a very low number of slices is combined with certain soil geometries, such that the midpoint of a slice base is actually outside the soil region,even though the slip surface is wholly within the soil region.
-111 = safety factor equation did not converge
-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.



Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		*Scale* 1:190	*Company*
Date 12/6/2012, 1:02:59 PM		*File Name* Cross section A_Pond Full _Static_block_1to1.slim	

IDEINTERPRET 6.019

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: Cross section A_Pond Full _Static_block_1to1.slim
Slide Modeler Version: 6.019
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 12/6/2012, 1:02:59 PM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/day
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Non-Circular Block Search
Number of Surfaces: 5000
Pseudo-Random Surfaces: Enabled
Convex Surfaces Only: Disabled
Left Projection Angle (Start Angle): 120
Left Projection Angle (End Angle): 180
Right Projection Angle (Start Angle): 0
Right Projection Angle (End Angle): 60
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Silt (fill)	silt (in-place soil)	Bedrock
Color			
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	120	120	140
Cohesion [psf]	420	420	5000
Friction Angle [deg]	25	25	20
Water Surface	Water Table	Water Table	Water Table
Hu Value	1	1	1

Global Minimums

Method: bishop simplified

FS: 2.726420
Axis Location: 43.876, 806.083
Left Slip Surface Endpoint: 34.961, 768.972
Right Slip Surface Endpoint: 68.215, 776.685
Left Slope Intercept: 34.961 768.972
Right Slope Intercept: 68.215 777.000
Resisting Moment=1.09196e+006 lb-ft
Driving Moment=400513 lb-ft
Total Slice Area=272.297 ft2

Method: janbu simplified

FS: 2.623990
Axis Location: 43.876, 806.083
Left Slip Surface Endpoint: 34.961, 768.972
Right Slip Surface Endpoint: 68.215, 776.685
Left Slope Intercept: 34.961 768.972
Right Slope Intercept: 68.215 777.000
Resisting Horizontal Force=23139.7 lb
Driving Horizontal Force=8818.55 lb

Total Slice Area=272.297 ft2

Method: spencer

FS: 2.982330
Axis Location: 39.914, 796.353
Left Slip Surface Endpoint: 38.691, 769.063
Right Slip Surface Endpoint: 61.012, 779.000
Resisting Moment=433100 lb-ft
Driving Moment=145222 lb-ft
Resisting Horizontal Force=12799.9 lb
Driving Horizontal Force=4291.9 lb
Total Slice Area=98.0783 ft2

Global Minimum Coordinates

Method: bishop simplified

X	Y
34.9612	768.972
47.1534	761.159
52.5212	763.065
68.215	776.685
68.216	777

Method: janbu simplified

X	Y
34.9612	768.972
47.1534	761.159
52.5212	763.065
68.215	776.685
68.216	777

Method: spencer

X	Y
38.6907	769.063
44.3559	767.012
50.6938	768.244
61.012	779

Valid / Invalid Surfaces

Method: bishop simplified

Number of Valid Surfaces: 3830
Number of Invalid Surfaces: 1170

Error Codes:

Error Code -105 reported for 52 surfaces
Error Code -107 reported for 693 surfaces
Error Code -108 reported for 333 surfaces
Error Code -112 reported for 92 surfaces

Method: janbu simplified

Number of Valid Surfaces: 3617
Number of Invalid Surfaces: 1383

Error Codes:

Error Code -105 reported for 52 surfaces
Error Code -107 reported for 693 surfaces
Error Code -108 reported for 565 surfaces
Error Code -112 reported for 73 surfaces

Method: spencer

Number of Valid Surfaces: 3086
Number of Invalid Surfaces: 1914

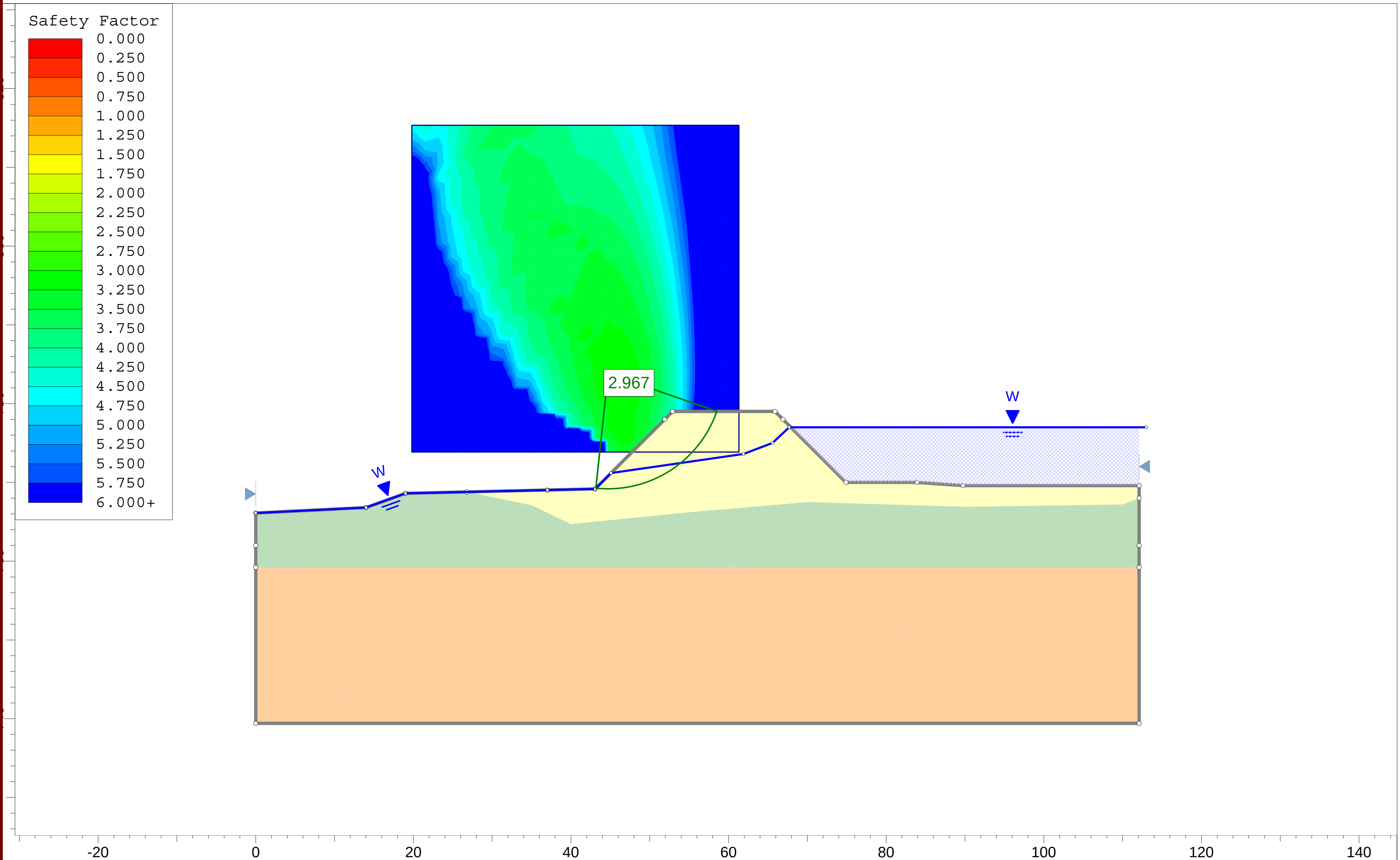
Error Codes:

Error Code -105 reported for 52 surfaces
Error Code -107 reported for 693 surfaces
Error Code -108 reported for 893 surfaces
Error Code -111 reported for 182 surfaces
Error Code -112 reported for 94 surfaces

Error Codes

The following errors were encountered during the computation:

-105 = More than two surface / slope intersections with no valid slip surface.
-107 = Total driving moment or total driving force is negative. This will occur if the wrong failure direction is specified, or if high external or anchor loads are applied against the failure direction.
-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).
-111 = safety factor equation did not converge
-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.



Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		Scale 1:204	Company
Date 12/6/2012, 1:02:59 PM		File Name Cross section A_Pond Full _Static_Circular_1to1.slim	

rocscience

SLIDEINTERPRET 6.019

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: Cross section A_Pond Full _Static_Circular_1to1.slim
Slide Modeler Version: 6.019
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 12/6/2012, 1:02:59 PM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/day
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius Increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Silt (fill)	silt (in-place soil)	Bedrock
Color			
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	120	120	140
Cohesion [psf]	420	420	5000
Friction Angle [deg]	25	25	20
Water Surface	Water Table	Water Table	Water Table
Hu Value	1	1	1

Global Minimums

Method: bishop simplified

FS: 2.960840
Center: 46.371, 780.487
Radius: 11.672
Left Slip Surface Endpoint: 43.164, 769.264
Right Slip Surface Endpoint: 57.948, 779.000
Resisting Moment=132989 lb-ft
Driving Moment=44916 lb-ft
Total Slice Area=74.2738 ft2

Method: janbu simplified

FS: 2.847960
Center: 46.371, 775.508
Radius: 8.471
Left Slip Surface Endpoint: 40.812, 769.116
Right Slip Surface Endpoint: 54.842, 775.508
Left Slope Intercept: 40.812 769.116
Right Slope Intercept: 54.842 779.000
Resisting Horizontal Force=8473.9 lb
Driving Horizontal Force=2975.43 lb
Total Slice Area=77.8514 ft2

Method: spencer

FS: 2.967260
Center: 44.711, 783.807
Radius: 14.636
Left Slip Surface Endpoint: 43.154, 769.254
Right Slip Surface Endpoint: 58.535, 779.000
Resisting Moment=162200 lb-ft
Driving Moment=54663.2 lb-ft
Resisting Horizontal Force=8895.26 lb
Driving Horizontal Force=2997.81 lb
Total Slice Area=66.8389 ft2

Valid / Invalid Surfaces

Method: bishop simplified

Number of Valid Surfaces: 6834
Number of Invalid Surfaces: 602

Error Codes:

Error Code -103 reported for 349 surfaces
Error Code -107 reported for 104 surfaces
Error Code -108 reported for 18 surfaces
Error Code -112 reported for 131 surfaces

Method: janbu simplified

Number of Valid Surfaces: 6758
Number of Invalid Surfaces: 678

Error Codes:

Error Code -103 reported for 349 surfaces
Error Code -107 reported for 104 surfaces
Error Code -108 reported for 125 surfaces
Error Code -112 reported for 100 surfaces

Method: spencer

Number of Valid Surfaces: 6521
Number of Invalid Surfaces: 915

Error Codes:

Error Code -103 reported for 349 surfaces
Error Code -107 reported for 104 surfaces
Error Code -108 reported for 179 surfaces
Error Code -111 reported for 149 surfaces
Error Code -112 reported for 134 surfaces

Error Codes

The following errors were encountered during the computation:

-103 = Two surface / slope intersections, but one or more surface / nonslope external polygon intersections lie between them. This usually occurs when the slip surface extends past the bottom of the soil region, but may also occur on a benched slope model with two sets of Slope Limits.
-107 = Total driving moment or total driving force is negative. This will occur if the wrong failure direction is specified, or if high external or anchor loads are applied against the failure direction.
-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).
-111 = safety factor equation did not converge
-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.

Slice Data

Global Minimum Query (bishop simplified) - Safety Factor: 2.96084

Slice Number	Width [ft]	Weight [lbs]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	0.591342	26.3862	Silt (fill)	420	25	151.366	448.171	83.6154	23.2029	60.4125
2	0.591342	78.0094	Silt (fill)	420	25	156.834	464.361	163.731	68.598	95.1333
3	0.591342	127.37	Silt (fill)	420	25	161.954	479.52	239.646	112.003	127.643
4	0.591342	174.528	Silt (fill)	420	25	167.992	497.399	311.585	145.603	165.982
5	0.591342	219.526	Silt (fill)	420	25	177.44	525.372	379.539	153.569	225.97
6	0.591342	262.388	Silt (fill)	420	25	186.473	552.118	442.984	159.656	283.328
7	0.591342	303.121	Silt (fill)	420	25	195.093	577.639	501.929	163.871	338.058
8	0.591342	341.714	Silt (fill)	420	25	203.294	601.922	556.339	166.205	390.134
9	0.591342	378.142	Silt (fill)	420	25	211.069	624.943	606.137	166.635	439.502
10	0.591342	412.36	Silt (fill)	420	25	218.405	646.663	651.202	165.121	486.081
11	0.591342	444.304	Silt (fill)	420	25	225.283	667.026	691.357	161.608	529.749
12	0.591342	473.886	Silt (fill)	420	25	231.677	685.959	726.369	156.018	570.351
13	0.591342	500.993	Silt (fill)	420	25	237.556	703.365	755.931	148.251	607.68
14	0.591342	525.479	Silt (fill)	420	25	242.877	719.119	779.642	138.179	641.463
15	0.591342	547.155	Silt (fill)	420	25	247.583	733.055	796.987	125.636	671.351
16	0.591342	565.78	Silt (fill)	420	25	251.604	744.96	807.291	110.411	696.88
17	0.591342	575.006	Silt (fill)	420	25	253.39	750.247	800.444	92.2271	708.217
18	0.591342	549.037	Silt (fill)	420	25	246.84	730.855	737.349	70.7201	666.629
19	0.591342	514.216	Silt (fill)	420	25	238.407	705.886	658.481	45.3957	613.085
20	0.591342	474.262	Silt (fill)	420	25	228.972	677.948	568.729	15.5586	553.171
21	0.591342	428.006	Silt (fill)	420	25	215.582	638.304	468.153	0	468.153
22	0.591342	373.584	Silt (fill)	420	25	197.542	584.889	353.606	0	353.606
23	0.591342	307.654	Silt (fill)	420	25	175.778	520.45	215.415	0	215.415
24	0.591342	222.793	Silt (fill)	420	25	147.514	436.765	35.9534	0	35.9534
25	0.591342	87.1597	Silt (fill)	420	25	99.7825	295.44	-267.12	0	-267.12

Global Minimum Query (janbu simplified) - Safety Factor: 2.84796

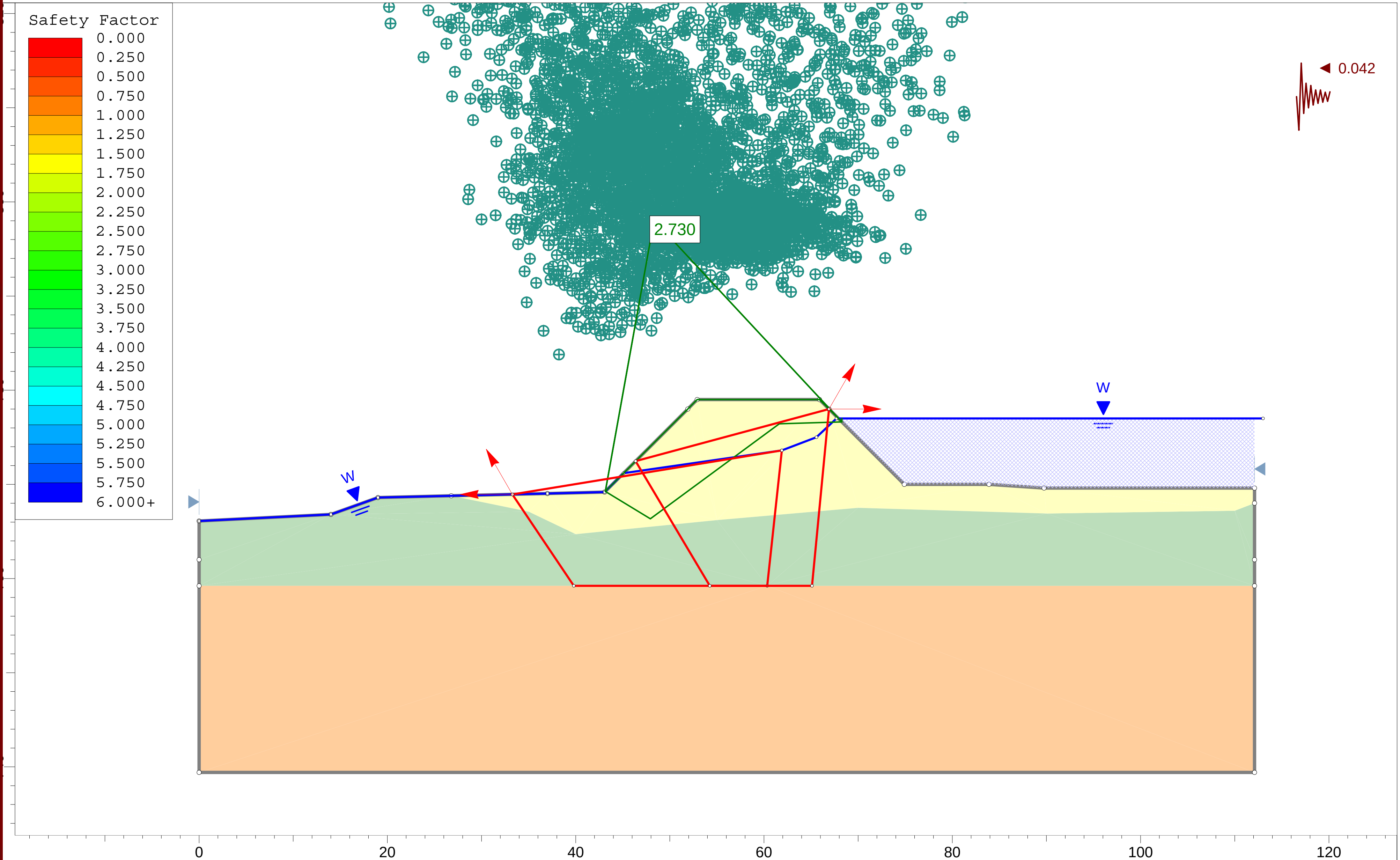
Slice	Width	Weight	Base	Base Cohesion	Base Friction Angle	Shear Stress	Shear Strength	Base Normal Stress	Pore Pressure	Effective Normal Stress

				[psf]	[degrees]	[psf]	[psf]	[psf]	[psf]	[psf]
1	0.5612	15.555	Silt (fill)	420	25	172.098	490.127	164.801	14.413	150.388
2	0.5612	44.2713	Silt (fill)	420	25	172.613	491.594	194.556	41.0212	153.535
3	0.5612	68.5599	Silt (fill)	420	25	173.014	492.737	219.511	63.5266	155.985
4	0.5612	89.0278	Silt (fill)	420	25	173.223	493.332	239.753	82.492	157.261
5	0.5612	123.44	Silt (fill)	420	25	175.793	500.652	287.322	114.363	172.959
6	0.5612	174.242	Silt (fill)	420	25	180.905	515.211	365.631	161.45	204.181
7	0.5612	222.186	Silt (fill)	420	25	185.621	528.641	438.857	205.874	232.983
8	0.5612	267.411	Silt (fill)	420	25	189.938	540.937	507.13	247.78	259.35
9	0.5612	310.026	Silt (fill)	420	25	198.257	564.628	570.96	260.804	310.156
10	0.5612	350.097	Silt (fill)	420	25	206.655	588.546	629.389	267.941	361.448
11	0.5612	387.654	Silt (fill)	420	25	214.535	610.986	682.32	272.748	409.572
12	0.5612	422.695	Silt (fill)	420	25	221.881	631.908	729.661	275.224	454.437
13	0.5612	455.182	Silt (fill)	420	25	228.671	651.245	771.239	275.333	495.906
14	0.5612	485.041	Silt (fill)	420	25	234.87	668.9	806.776	273.008	533.768
15	0.5612	512.156	Silt (fill)	420	25	240.43	684.736	835.869	268.14	567.729
16	0.5612	536.362	Silt (fill)	420	25	245.286	698.566	857.962	260.576	597.386
17	0.5612	557.424	Silt (fill)	420	25	249.347	710.129	872.283	250.1	622.183
18	0.5612	575.021	Silt (fill)	420	25	252.483	719.061	877.751	236.412	641.339
19	0.5612	588.699	Silt (fill)	420	25	254.512	724.839	872.822	219.093	653.729
20	0.5612	597.806	Silt (fill)	420	25	255.154	726.668	855.191	197.54	657.651
21	0.5612	601.357	Silt (fill)	420	25	253.962	723.275	821.213	170.837	650.376
22	0.5612	593.751	Silt (fill)	420	25	249.173	709.636	758.625	137.5	621.125
23	0.5612	547.742	Silt (fill)	420	25	233.612	665.317	620.872	94.7875	526.085
24	0.5612	479.172	Silt (fill)	420	25	209.297	596.069	413.859	36.2773	377.582
25	0.5612	337.287	Silt (fill)	420	25	130.575	371.872	-103.211	0	-103.211

Global Minimum Query (spencer) - Safety Factor: 2.96726

Slice Number	Width [ft]	Weight [lbs]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	0.615208	24.6541	Silt (fill)	420	25	149.599	443.899	72.0898	20.8387	51.2511
2	0.615208	73.0013	Silt (fill)	420	25	154.668	458.94	145.21	61.7039	83.5059
3	0.615208	119.432	Silt (fill)	420	25	159.313	472.722	214.012	100.949	113.063
4	0.615208	163.951	Silt (fill)	420	25	165.428	490.867	278.745	126.77	151.975
5	0.615208	206.555	Silt (fill)	420	25	174.45	517.64	339.291	129.902	209.389
6	0.615208	247.227	Silt (fill)	420	25	183.012	543.045	395.271	131.401	263.87
7	0.615208	285.942	Silt (fill)	420	25	191.117	567.095	446.693	131.246	315.447
8	0.615208	322.663	Silt (fill)	420	25	198.768	589.795	493.532	129.405	364.127
9	0.615208	357.34	Silt (fill)	420	25	205.96	611.136	535.729	125.836	409.893
10	0.615208	389.908	Silt (fill)	420	25	212.687	631.097	573.184	120.485	452.699
11	0.615208	420.289	Silt (fill)	420	25	218.938	649.646	605.763	113.285	492.478
12	0.615208	448.382	Silt (fill)	420	25	224.697	666.735	633.277	104.152	529.125
13	0.615208	474.067	Silt (fill)	420	25	229.943	682.301	655.489	92.9833	562.506
14	0.615208	497.194	Silt (fill)	420	25	234.647	696.26	672.093	79.6524	592.44
15	0.615208	517.58	Silt (fill)	420	25	238.773	708.503	682.702	64.0043	618.698
16	0.615208	534.422	Silt (fill)	420	25	242.148	718.517	686.019	45.8458	640.173

17	0.615208	519.225	Silt (fill)	420	25	238.633	708.085	642.736	24.9348	617.801
18	0.615208	484.344	Silt (fill)	420	25	231.201	686.034	571.473	0.962115	570.511
19	0.615208	445.365	Silt (fill)	420	25	219.58	651.551	496.563	0	496.563
20	0.615208	401.647	Silt (fill)	420	25	206.845	613.762	415.524	0	415.524
21	0.615208	352.305	Silt (fill)	420	25	192.974	572.605	327.262	0	327.262
22	0.615208	296.04	Silt (fill)	420	25	177.745	527.417	230.357	0	230.357
23	0.615208	230.817	Silt (fill)	420	25	160.824	477.207	122.681	0	122.681
24	0.615208	153.074	Silt (fill)	420	25	141.663	420.351	0.753658	0	0.753658
25	0.615208	55.248	Silt (fill)	420	25	119.216	353.746	-142.082	0	-142.082



Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		*Scale* 1:171	*Company*
Date 12/6/2012, 1:02:59 PM		*File Name* Cross section A_Pond Full _Seismic_block_1to1.slim	

rocscience

SLIDEINTERPRET 6.019

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: Cross section A_Pond Full _Seismic_block_1to1.slim
Slide Modeler Version: 6.019
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 12/6/2012, 1:02:59 PM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/day
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

- Bishop simplified
- Janbu simplified
- Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Non-Circular Block Search
Number of Surfaces: 5000
Pseudo-Random Surfaces: Enabled
Convex Surfaces Only: Disabled
Left Projection Angle (Start Angle): 120
Left Projection Angle (End Angle): 180
Right Projection Angle (Start Angle): 0
Right Projection Angle (End Angle): 60
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

Seismic Load Coefficient (Horizontal): 0.042

Material Properties

Property	Silt (fill)	silt (in-place soil)	Bedrock
Color			
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	120	120	140
Cohesion [psf]	420	420	5000
Friction Angle [deg]	25	25	20
Water Surface	Water Table	Water Table	Water Table
Hu Value	1	1	1

Global Minimums

Method: bishop simplified

FS: 2.479990
Axis Location: 43.876, 806.083
Left Slip Surface Endpoint: 34.961, 768.972
Right Slip Surface Endpoint: 68.215, 776.685
Left Slope Intercept: 34.961 768.972
Right Slope Intercept: 68.215 777.000
Resisting Moment=1.08779e+006 lb-ft
Driving Moment=438629 lb-ft
Total Slice Area=272.297 ft2

Method: janbu simplified

FS: 2.369920
Axis Location: 43.876, 806.083

Left Slip Surface Endpoint: 34.961, 768.972
Right Slip Surface Endpoint: 68.215, 776.685
Left Slope Intercept: 34.961 768.972
Right Slope Intercept: 68.215 777.000
Resisting Horizontal Force=23061 lb
Driving Horizontal Force=9730.68 lb
Total Slice Area=272.297 ft2

Method: spencer

FS: 2.730060
Axis Location: 48.325, 798.062
Left Slip Surface Endpoint: 43.146, 769.246
Right Slip Surface Endpoint: 68.270, 776.630
Left Slope Intercept: 43.146 769.246
Right Slope Intercept: 68.270 777.000
Resisting Moment=454873 lb-ft
Driving Moment=166616 lb-ft
Resisting Horizontal Force=15475.9 lb
Driving Horizontal Force=5668.7 lb
Total Slice Area=123.968 ft2

Global Minimum Coordinates

Method: bishop simplified

X	Y
34.9612	768.972
47.1534	761.159
52.5212	763.065
68.215	776.685
68.216	777

Method: janbu simplified

X	Y
34.9612	768.972
47.1534	761.159
52.5212	763.065
68.215	776.685
68.216	777

Method: spencer

X	Y
43.1465	769.246
47.9265	766.342
61.6266	776.431
68.2702	776.63

68.2712	777

Valid / Invalid Surfaces

Method: bishop simplified

Number of Valid Surfaces: 4044
Number of Invalid Surfaces: 956

Error Codes:

Error Code -105 reported for 52 surfaces
Error Code -107 reported for 469 surfaces
Error Code -108 reported for 328 surfaces
Error Code -112 reported for 107 surfaces

Method: janbu simplified

Number of Valid Surfaces: 3818
Number of Invalid Surfaces: 1182

Error Codes:

Error Code -105 reported for 52 surfaces
Error Code -107 reported for 469 surfaces
Error Code -108 reported for 574 surfaces
Error Code -112 reported for 87 surfaces

Method: spencer

Number of Valid Surfaces: 3138
Number of Invalid Surfaces: 1862

Error Codes:

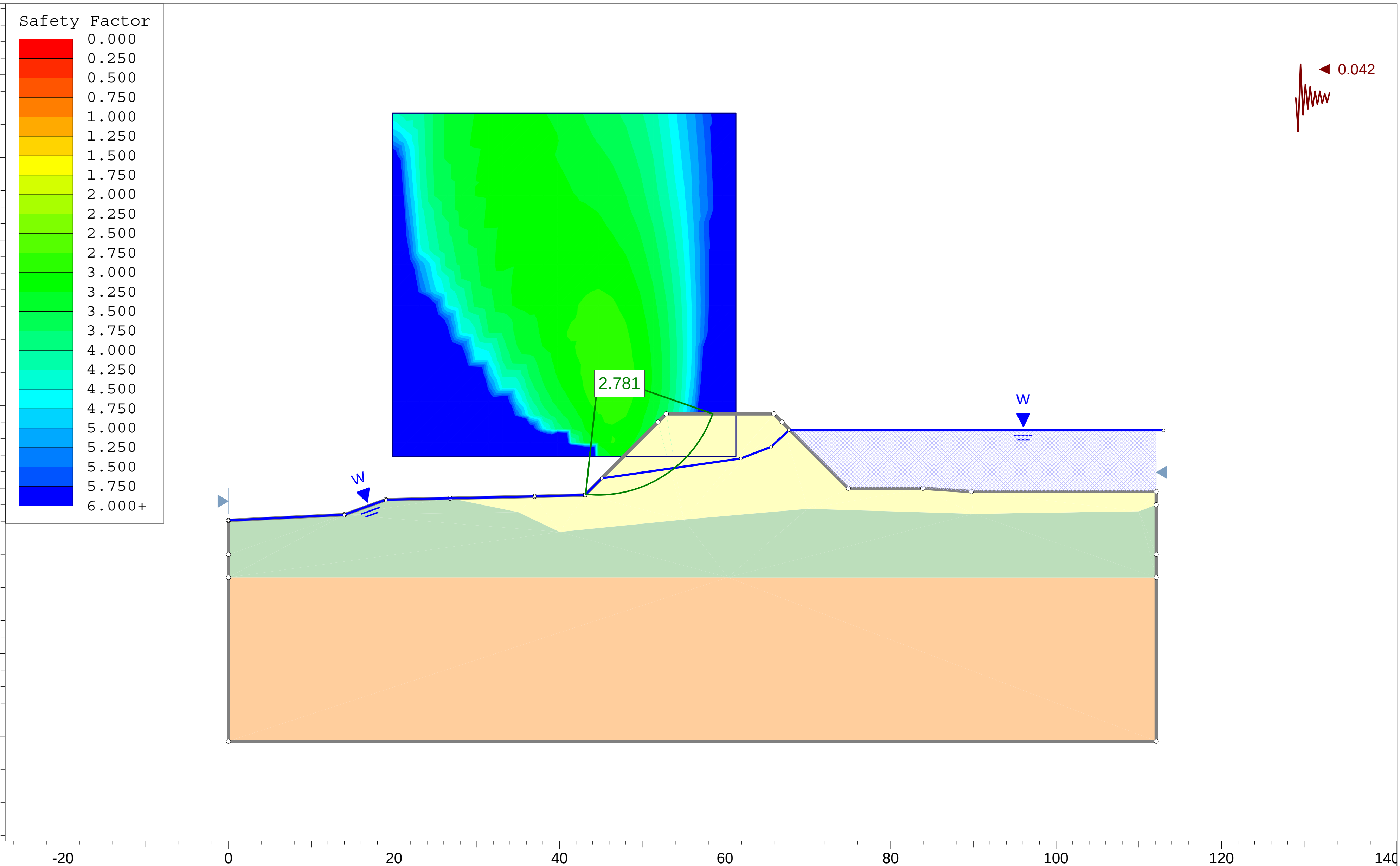
Error Code -105 reported for 52 surfaces
Error Code -107 reported for 469 surfaces
Error Code -108 reported for 945 surfaces
Error Code -111 reported for 280 surfaces
Error Code -112 reported for 116 surfaces

Error Codes

The following errors were encountered during the computation:

-105 = More than two surface / slope intersections with no valid slip surface.
-107 = Total driving moment or total driving force is negative. This will occur if the wrong failure direction is specified, or if high external or anchor loads are applied against the failure direction.
-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).
-111 = safety factor equation did not converge
-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep

seated slip surfaces with many high negative base angle slices in the passive zone.



Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		*Scale* 1:196	*Company*
Date 12/6/2012, 1:02:59 PM		*File Name* Cross section A_Pond Full _Seismic_circular_1to1.slim	

IDEINTERPRET 6.019

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: Cross section A_Pond Full _Seismic_circular_1to1.slim
Slide Modeler Version: 6.019
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 12/6/2012, 1:02:59 PM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/day
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius Increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

Seismic Load Coefficient (Horizontal): 0.042

Material Properties

Property	Silt (fill)	silt (in-place soil)	Bedrock
Color			
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	120	120	140
Cohesion [psf]	420	420	5000
Friction Angle [deg]	25	25	20
Water Surface	Water Table	Water Table	Water Table
Hu Value	1	1	1

Global Minimums

Method: bishop simplified

FS: 2.776750
Center: 44.711, 783.807
Radius: 14.636
Left Slip Surface Endpoint: 43.154, 769.254
Right Slip Surface Endpoint: 58.535, 779.000
Resisting Moment=160816 lb-ft
Driving Moment=57915.1 lb-ft
Total Slice Area=66.8389 ft2

Method: janbu simplified

FS: 2.601920
Center: 46.371, 785.467
Radius: 22.330
Left Slip Surface Endpoint: 31.411, 768.890
Right Slip Surface Endpoint: 67.278, 777.622
Resisting Horizontal Force=24766.9 lb

Driving Horizontal Force=9518.71 lb
Total Slice Area=293.035 ft2

Method: spencer

FS: 2.780810
Center: 44.711, 783.807
Radius: 14.636
Left Slip Surface Endpoint: 43.154, 769.254
Right Slip Surface Endpoint: 58.535, 779.000
Resisting Moment=161051 lb-ft
Driving Moment=57915.1 lb-ft
Resisting Horizontal Force=8848.94 lb
Driving Horizontal Force=3182.14 lb
Total Slice Area=66.8389 ft2

Valid / Invalid Surfaces

Method: bishop simplified

Number of Valid Surfaces: 6927
Number of Invalid Surfaces: 509

Error Codes:

Error Code -103 reported for 349 surfaces
Error Code -107 reported for 23 surfaces
Error Code -108 reported for 8 surfaces
Error Code -112 reported for 129 surfaces

Method: janbu simplified

Number of Valid Surfaces: 6862
Number of Invalid Surfaces: 574

Error Codes:

Error Code -103 reported for 349 surfaces
Error Code -107 reported for 23 surfaces
Error Code -108 reported for 107 surfaces
Error Code -112 reported for 95 surfaces

Method: spencer

Number of Valid Surfaces: 6570
Number of Invalid Surfaces: 866

Error Codes:

Error Code -103 reported for 349 surfaces
Error Code -107 reported for 23 surfaces
Error Code -108 reported for 143 surfaces
Error Code -111 reported for 215 surfaces

Error Code -112 reported for 136 surfaces

Error Codes

The following errors were encountered during the computation:

-103 = Two surface / slope intersections, but one or more surface / nonslope external polygon intersections lie between them. This usually occurs when the slip surface extends past the bottom of the soil region, but may also occur on a benched slope model with two sets of Slope Limits.
-107 = Total driving moment or total driving force is negative. This will occur if the wrong failure direction is specified, or if high external or anchor loads are applied against the failure direction.
-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).
-111 = safety factor equation did not converge
-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.