FINAL REPORT

Dam Safety Assessment of CCW Impoundments

NRG REMA LLC – Shawville Generating Station
Shawville, Clearfield County, Pennsylvania

United States Environmental Protection Agency
Washington, DC

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Dam Safety Assessment of CCW Impoundments

NRG REMA LLC – Shawville Generating 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 has initiated a nationwide program of structural integrity and safety assessments of coal combustion waste 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 USEPA 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 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 Ash Ponds A and B at the Shawville Generating Station in Shawville, Pennsylvania. Effective December 14, 2012, NRG Energy, Inc. (NRG) and GenOn Energy, Inc. have 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. As such, the owner and operator of the above impoundments is NRG REMA, LLC (NRG). 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 Shawville Generating Station is located at 250 Power Plant Drive in Shawville, Pennsylvania. A Site Location Map is included as Figure 1. The coal-fired power station includes four generating units with a combined generation capacity of approximately 626 MW. Operation is intermittent on an as-needed basis to meet demand. Coal combustion waste that is produced during power generation is managed on-site with one CCW impoundment and a “dry” landfill.

The facility utilizes one impoundment separated into two cells known as Ash Pond A and Ash Pond B for bottom ash management. Fly ash is dry-handled and disposed of in the on-site plant landfill. This safety assessment report summarizes the September 2012 assessment of Ash Ponds A and B at the Shawville Generating Station.

2.1. MANAGEMENT UNIT IDENTIFICATION

The locations of the CCW impoundment and its two component cells inspected during this safety assessment are identified on Figure 2 – Site Aerial Photograph and Photograph Location Map.

2.1.1. Ash Ponds A and B

Ash Ponds A and B are located to the southwest of the power plant on the southern bank of the West Branch of the Susquehanna River.

Ash Ponds A and B were constructed and brought online in 1989. Prior to 1989, bottom ash and fly ash were sluiced to two impoundments known as Pond 1 and 2. Pond 1 was decommissioned and remains in place as a stormwater management area. Pond 2 was decommissioned and converted into the new impoundment consisting of Ash Ponds A and B. The new impoundment was constructed with a continuous impermeable liner beneath the full area of the impoundment. The impoundment was then divided into two cells of approximately equal volume known as Ash Ponds A and B by means of a compacted earth embankment running through the center of the impoundment. Although the decant system for the individual Ash Ponds is interconnected, isolation valves allow the two ponds to be maintained at separate operating water levels. This presents the possibility of developing a phreatic surface through the center dividing dike. A failure of this central dividing dike would result in material from one pond entering the other pond without release to the surrounding environment. Due to the presence of a single continuous liner system and an interconnected system of decant devices, Ash Ponds A and B have been considered as a single impoundment for the purposes of assigning hazard potential.

The maximum height of the impoundment is approximately 20 feet from the crest of the northwestern embankment to the normal water surface in the West Branch of the Susquehanna River. The maximum depth of the impoundment is approximately 15 feet from the crest of the embankment to the lowest point in the bottom of each pond. Typical operating water depth is approximately 11 feet. The impoundment volumes are approximately 20,400 cubic yards (CY) in Ash Pond A and 19,700 CY in Ash Pond B.

The coal combustion waste stored in Ash Ponds A and B consists of bottom ash. Company records indicate that approximately 11,000 dry tons of bottom ash is impounded annually. Fly ash is managed dry, collected and placed in the on-site landfill. Bottom ash is sluiced to the pond using water from the West Branch of the Susquehanna River. Water that is routed through the impoundment is discharged into an outlet structure and returned to the plant for reuse. When completely dewatered for maintenance operations, water collected by the impoundment underdrain system is conveyed to the facility wastewater treatment plant. There is no direct discharge from the Ash Ponds to the West Branch of the Susquehanna River.

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):

1) *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:*
   (i) *The contributory drainage area exceeds 100 acres.*
   (ii) *The greatest depth of water measured by upstream toe of the dam at maximum storage elevation exceeds 15 feet.*
   (iii) *The impounding capacity at maximum storage elevation exceeds 50 acre-feet.*
2) *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.*
3) *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.*
4) *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.*
5) *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:

(1) *The height of the dam and storage capacity of the reservoir.*
(2) *The physical characteristics and extent of actual and projected development of the dam site and downstream areas.*
(3) *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.*

2.2.1. Ash Ponds A and B

The PADEP Division of Dam Safety currently does not regulate the impoundment containing Ash Ponds A and B, therefore no hazard classification has been assigned. Based on the results of this assessment and review comments provided by the PADEP, it is anticipated that this impoundment will be regulated by the PADEP in the future.

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 impoundment containing Ash Ponds A and B is **LOW**. A failure of the embankments impounding Ash Ponds A and B would result in no probable loss of life and only minimal economic and environmental impact. The power station is located in a predominantly rural area and the size of the impoundment is extremely small; therefore, damage to critical infrastructure or lifeline facilities in the event of a dam failure would likely be limited to the power plant facilities only. The risk of environmental impact to the adjacent West Branch of the Susquehanna River is considered minimal due to the configuration of the impoundment, the presence of an engineered liner system, and the redundant decant methods. These make the probability of a release of impounded material to the West Branch of the Susquehanna River extremely low since the most likely failure mode appears to be an overtopping failure into adjacent impoundments for a wastewater treatment tank and a stormwater basin. This would limit environmental impacts primarily to the power plant property. Further, the West Branch of the Susquehanna River at this location is classified as impaired due to abandoned mine drainage according to Category 4 of the Pennsylvania Integrated Water Quality Monitoring and Assessment Report.

2.3. IMPOUNDING STRUCTURE DETAILS

The following sections summarize the structural components and basic operations of Ash Ponds A and B. The location of these ponds on the plant grounds and their relevant features are provided on Figure 2. Typical cross-sections of the ponds are provided as Figure 3. It should be noted that the site plans shown in Figure 2 and the topographic detail shown in Figure 3 are adapted from publicly available data, plant records, and original design drawings and may not depict all current features. Additionally, photos taken during the visual assessment are incorporated in a Photographic Log provided as Appendix B.

2.3.1. Embankment Configuration

Ash Pond A

Ash Pond A is a combined incised/diked earthen embankment structure that impounds an area of approximately 2 acres. Ash Pond A is primarily incised with portions of the perimeter embankments having been diked above the former crest elevation of the previous impoundment. The northwestern embankment slopes to the West Branch of the Susquehanna River and consists primarily of the natural bank of the river. This embankment is approximately 20 feet in height from the river to the crest and includes a diked portion of approximately 2 feet which was built on top of the former impoundment embankment crest to provide additional freeboard and to create a vehicle access drive. The outboard slope of this embankment is typically wooded along the lower portion of the slope, consisting of medium to large trees and moderate underbrush. The upper 3 to 4 feet of the slope are covered by shrubs and grasses, but few or no trees. There are no engineered erosion control measures (i.e. riprap) on the outboard slope of this embankment, but no indications of erosion or slope instability were observed during this assessment. The presence of trees and woody vegetation on the lower, natural portion of the slope tends to serve as a slope stabilization measure rather than an increased hazard in this case. The northeastern outer embankment crest is approximately 3 feet above the area surrounding the facility wastewater treatment plant clarifier tank. The top 2 – 3 feet of this embankment were diked to provide additional freeboard and to create a raised vehicle access drive between the impoundment and the clarifier tank. The southwestern embankment consists of an earthen dike constructed to separate the two component cells of the overall impoundment. The southeastern embankment is completely incised into the natural slope, with a compacted gravel access drive along the crest.

The typical water surface is maintained at approximately elevation (EL) 1063 feet above mean sea level, which is within the incised portion of the impoundment. The pond bottom (as indicated by the design drawings) slopes towards the southeast (center) embankment to approximately EL 1051.8, for a maximum typical water depth of 11.2 feet. The crest of all embankments is at approximately EL 1067, providing a maximum depth of 15.2 feet. The inboard embankment slopes have an inclination of approximately 3H:1V. The outboard embankment slopes vary from 2H:1V to 3H:1V.

Ash Pond A includes a synthetic liner system comprised of a geotextile underlayment, a PVC liner, and a geotextile overlayment covered with approximately 1 to 2 feet of compacted bottom ash. This liner is continuous through Ponds A and B and extends up all side slopes to approximate EL 1065.5 according to the supplied design drawings. The exact bottom elevation of the former Pond 1 is not indicated on the design drawings provided, but is estimated to be at least 2 to 3 feet below the current bottom elevation of Pond A.

Ash Pond B

Ash Pond B is also a combined incised/diked earthen embankment structure that impounds an area of approximately 1.8 acres. Ash Pond B is primarily incised with portions of the perimeter embankments having been diked above the former crest elevation of the previous impoundment. The northwestern embankment slopes to the West Branch of the Susquehanna River and consists primarily of the natural bank of the river. This embankment is approximately 20 feet in height from the river to the crest and includes a diked portion of approximately 2 feet which was built on top of the former impoundment embankment crest to provide additional freeboard and to create a vehicle access drive. The outboard slope of this embankment is typically wooded along the lower portion of the slope, consisting of medium to large trees and moderate underbrush. The upper 3 to 4 feet of the slope are covered by shrubs and grasses, but few or no trees. There are no engineered erosion control measures (i.e. riprap) on the outboard slope of this embankment, but no indications of erosion or slope instability were observed during this assessment. The presence of trees and woody vegetation on the lower portion of the slope tends to serve as a slope stabilization measure rather than an increased hazard in this case. The southwestern outer embankment crest is approximately 6 - 7 feet above a stormwater management area which was previously part of the former ash impoundment at this location. The top 6 feet of this embankment were diked above the former impoundment bottom to separate the new Ash Pond B from the stormwater management area and to create a new raised gravel access drive. The northeastern embankment consists of an earthen dike constructed to separate the two component cells of the overall impoundment. The southeastern embankment is completely incised into the natural slope, with a compacted gravel access drive along the crest.

The typical water surface is maintained at approximately elevation (EL) 1063 feet above mean sea level, which is primarily within the incised portion of the impoundment except in the case of the southwestern embankment. Based on available design drawings, the normal operating water level is approximately 2 – 3 feet above the adjacent stormwater management area. The pond bottom (as indicated by the design drawings) slopes towards the southeast (center) embankment to approximately EL 1051.8, for a maximum typical water depth of 11.2 feet. The crest of all embankments is at approximately EL 1067, providing a maximum depth of 15.2 feet. There is an emergency overflow section constructed within the southwest embankment consisting of a 50 ft. triangular spillway with a depth of approximately 9 inches. The inboard embankment slopes have an inclination of approximately 3H:1V.

Ash Pond B includes a synthetic liner system comprised of a geotextile underlayment, a PVC liner, and a geotextile overlayment covered with approximately 1 to 2 feet of compacted bottom ash. This liner is continuous through Ponds A and B and extends up all side slopes to approximate EL 1065.5 according to the supplied design drawings. The exact bottom elevation of the former Pond 1 is not indicated on the design drawings provided, but is estimated to be at least 2 to 3 feet below the current bottom elevation of Pond B.

2.3.2. Type of Materials Impounded

Ash Pond A

Ash Pond A currently serves as the primary bottom ash management impoundment for the facility. Influent into

Ash Pond A includes water with solids consisting of bottom ash and lesser quantities of clarifier sludge and miscellaneous fines composed of coal fines and surface runoff silt. No FGD (Gypsum) or boiler slag is impounded in Ash Pond A.

Ash Pond B

Ash Pond B currently serves as a backup bottom ash management impoundment, and is typically only used during maintenance operations on Ash Pond A. Influent into Ash Pond B includes water with solids consisting of bottom ash and lesser quantities of clarifier sludge and miscellaneous fines composed of coal fines and surface runoff silt. No FGD (Gypsum) or boiler slag is impounded in Ash Pond B.

2.3.3. Outlet Works

Ash Pond A

The outlet works for Ash Pond A consist of three separate systems capable of controlling the water level in the pond to different ranges. The primary outlet for Ash Pond A consists of a submerged 36" diameter perforated steel pipe running parallel to the northeastern embankment. This pipe is connected to the Ash Sluice Recycle Collection Structure at the eastern corner of Ash Pond A which includes a slide gate for normal operating water level control. Water collected by this system is conveyed from the Ash Sluice Recycle Collection Structure to the plant for recycling and reuse in the sluicing of bottom ash. The secondary outlet for Ash Pond A is the decant structure which consists of a concrete box with a rectangular orifice/weir with a slide gate. The decant structure is connected to a manhole located in the central dividing dike and ultimately to the Underdrain Pump Station located in the eastern corner of Ash Pond B by a solid 12" PVC pipe. From here, the decant water is conveyed back to the plant for treatment in the wastewater treatment plant. This secondary system is typically used to lower the pond water level for maintenance operations. The third outlet system consists of 12" diameter perforated PVC underdrains in an envelope of coarse aggregate running above the pond liner system but below the bottom of the pond. The underdrains connect to the Underdrain Pump Station and the water is conveyed to the plant for treatment. These underdrains are only used when complete dewatering of the pond is required.

Ash Pond B

The outlet works for Ash Pond B are similar to those of Ash Pond A and consist of three separate systems capable of controlling the water level in the pond to different ranges. The primary outlet for Ash Pond B consists of a submerged 36" diameter perforated steel pipe running parallel to the southwestern embankment. This pipe is connected to the Ash Sluice Recycle Blowdown Structure at the southern corner of Ash Pond B which includes a slide gate for normal operating water level control. Water collected by this system is conveyed to the Ash Sluice Recycle Collection Structure in Ash Pond A and from there back to the plant for recycling and reuse in the sluicing of bottom ash. Isolation valves within the Ash Sluice Recycle Collection Structures allow for the independent control of the water levels in each cell of the impoundment. The secondary outlet for Ash Pond B is the decant structure which consists of a concrete box with a rectangular orifice/weir with a slide gate. The decant structure is connected to a manhole located in the central dividing dike and ultimately to the Underdrain Pump Station located in the eastern corner of Ash Pond B by a solid 12" PVC pipe. From here, the decant water is conveyed back to the plant for treatment in the wastewater treatment plant. This secondary system is typically used to lower the pond water level for maintenance operations. The third outlet system consists of 12" diameter perforated PVC underdrains in an envelope of coarse aggregate running above the pond liner system but below the bottom of the pond. The underdrains connect to the Underdrain Pump Station and the water is conveyed to the plant for treatment. These underdrains are only used when complete dewatering of the pond is required.

3. RECORDS REVIEW

A review of the available records related to design, construction, operation and inspection of Ash Pond A and Ash Pond B 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
Response to RFI from the USEPA Office of Water	2010	RRI Energy	Utility's response to EPA questionnaire regarding CCW impoundments
NPDES Permit PA0010031 - Amendment No. 2	2006	GenOn REMA, LLC	Authorization for Discharge of Industrial Wastewater
Partial Plan Set – Bottom Ash Handling System and Final Wastewater Treatment System	1990	Gilbert/ Commonwealth, Inc.	Portion of the original design drawings with as-built notations for the construction of Ash Pond A and B
Locations and Recorded Water Levels in Monitoring Wells MW-7R, MW-8R, MW-9 & MW-10	2012	GenOn REMA, LLC	Sketch indicating the locations of groundwater monitoring wells installed during the closure of the prior impoundment (Pond 2) and the recorded maximum water elevations in the wells for the last 4 quarters
Bottom Ash Pond Assessment Report; Shawville Power Station; Shawville, Pennsylvania	2013	GeoSyntec Consultants	Summary of subsurface geotechnical assessment and slope stability analysis performed after the September 2012 visual assessment.

3.1. ENGINEERING DOCUMENTS

As indicated above, design drawings for the impoundment were provided by NRG. Information on the original design, construction and subsequent modifications provided by NRG personnel are summarized below.

Ash Pond A

- The impoundment was originally constructed and brought online in 1989.
- Although Ash Pond A was constructed on top of a prior CCW impoundment (Pond 2), the design drawings reviewed indicate that the majority of CCW within prior Pond 2 was removed and landfilled before the construction of Ash Ponds A and B. Ash Ponds A and B were constructed within a smaller footprint than the original Pond 2.
- Ash Pond A is the primary bottom ash impoundment for the generating station.
- Ash Pond A includes an engineered liner system consisting of a PVC liner with geotextile cushion fabric. The liner was originally covered with approximately 2 feet of bottom ash or earth cover and extends to approximate EL 1065.5.
- A subdrain system was installed below the constructed liner to collect groundwater from below the liner

above the former bottom elevation of the previous impoundment at this location. This system discharges to a manhole along the northwest side of the impoundment and drains to the plant wastewater treatment plant.
- No hydrologic or hydraulic analyses were provided in the records reviewed.
- A summary of a geotechnical investigation and slope stability analysis performed after the September 2012 assessment was provided on December 2, 2013. No design geotechnical information was provided in the records reviewed.
- Ash Pond A and its embankments are located within the FEMA 100-year Floodplain for the West Branch of the Susquehanna River (Map #42033C0340D). The Flood Insurance Study does not include a detailed study to determine the 100-year flood elevation at this location.
- No indication or mention of ash, coal slimes, or other CCW by-products within the dike foundations was noted in our review of the engineering records listed above.
- No indication of former spills or releases of impounded materials from Ash Pond A was noted in the records reviewed.
- Ash Pond A has a total storage volume of approximately 20,400 cubic yards or 12.6 acre-ft.
- Ash Pond A is dredged on an annual basis to restore its impoundment capacity. The bottom ash removed from the impoundment is disposed of in the on-site landfill. NRG records indicate that approximately 11,000 dry tons of bottom ash is removed during each maintenance cycle.

<u>Ash Pond B</u>

- Ash Pond B was constructed at the same time as Ash Pond A and brought online in 1989.
- Although Ash Pond B was constructed on top of a prior CCW impoundment (Pond 2), the design drawings reviewed indicate that the majority of CCW within prior Pond 2 was removed and landfilled before the construction of Ash Ponds A and B. Ash Ponds A and B were constructed within a smaller footprint than the original Pond 2.
- Ash Pond B currently serves as a back-up bottom ash impoundment and is typically used only when Ash Pond A is under maintenance.
- Ash Pond B includes an engineered liner system consisting of a PVC liner with geotextile cushion fabric. The liner was originally covered with approximately 2 feet of bottom ash or earth cover and extends to approximate EL 1065.5.
- A sub-drain system was installed below the constructed liner to collect groundwater from below the liner above the former bottom elevation of the previous impoundment at this location. This system discharges to a manhole along the northwest side of the impoundment and drains to the plant wastewater treatment plant.
- No hydrologic or hydraulic analyses were provided in the records reviewed.
- A summary of a geotechnical investigation and slope stability analysis performed after the September 2012 assessment was provided on December 2, 2013. No design geotechnical information was provided in the records reviewed.
- Ash Pond B and its embankments are located within the FEMA 100-year Floodplain for the West Branch of the Susquehanna River (Map #42033C0340D). The Flood Insurance Study does not include a detailed study to determine the 100-year flood elevation at this location.
- No indication or mention of ash, coal slimes, or other CCW by-products within the dike foundations was noted in our review of the engineering records listed above.
- No indication of former spills or releases of impounded materials from Ash Pond B was noted in the records reviewed.
- Ash Pond B has a total storage volume of approximately 19,700 cubic yards or 12.2 acre-ft.
- Ash Pond B is dredged once every three years to restore its impoundment capacity. The bottom ash removed from the impoundment is disposed of in the on-site landfill.

Plant personnel indicated that NRG Energy has publicly announced that operations at the Shawville Generating Station will be deactivated in April 2015.

3.1.1. Stormwater Inflows

Stormwater inflows to both Ash Pond A and B are minimal. The impounding structures are surrounded by diked embankments forming vehicle access drives on all sides and a drainage swale along the southeastern side which directs storm water away from the impoundment and limits runoff to that from precipitation which falls directly on the water surface and crest of the dikes. Sufficient freeboard appears to be available for the precipitation inflows during normal operating conditions.

3.1.2. Stability Analyses

As mentioned above, no geotechnical reports or records of design were provided in the records made available by NRG. Based on our discussion with plant personnel, geotechnical/slope stability records are either non-existent or could not be located in preparation for our visit. We did not observe any indications of slope distress during our visual assessment of both ponds.

Our initial recommendation was that a slope stability analysis was not required for this site based on the documents provided and our visual assessment. USEPA concurred with this recommendation, and copies of this correspondence are included in this report as Appendix C. NRG Energy voluntarily performed a geotechnical investigation and slope stability analysis for the impoundment in December 2012, subsequent to the site assessment documented in this report. This report was provided to O'Brien & Gere on December 2, 2013 and is included in this report as Appendix D.

The geotechnical investigation performed by GeoSyntec Consultants (GeoSyntec) consisted of four test borings along the inboard crest of the northwestern embankment of Ash Ponds A and B. Three borings were advanced to a depth of approximately 25 feet below ground surface (bgs) with the fourth advanced to 30 feet bgs. Standard Penetration Tests (SPT) were performed at regular depth intervals in each boring to assess relative density or general consistency of the embankment and foundation soils. Samples were taken for laboratory analysis of particle size and Atterberg limits. The borings were backfilled with the cuttings and coated bentonite pellets.

Based on GeoSyntec's observations of the samples collected from the borings, the embankment consists of fine-grained soils with occasional layers of gravelly soils, which were visually classified under the Unified Soils Classification System as MH (high plasticity silt), ML (sandy silt), SC (clayey sand), and GP (poorly graded gravel). SPT N-values varied between 6 and 36 blows/ft, with an average value of 16 blows/ft. Sandstone bedrock was encountered at approximately 30 feet and 26 ft-bgs in the Pond B embankment.

GeoSyntec performed a slope stability evaluation of one representative cross-section of the impoundment embankment where the weakest soil layer was encountered in the test borings. This cross-section was judged by GeoSyntec as the most critical in terms of yielding the lowest factor of safety of any other cross-section. The geometry of the embankment was obtained from the design plans provided by NRG. For the purposes of slope stability analysis, GeoSyntec assumed that the prior embankments for Pond 1 consisted of either CL or ML soil and performed an analysis for each soil type. Load cases for the stability analysis included:

- Static loading case (including traffic loading) with water level in the impoundment at normal operating elevation
- Seismic loading case with water level in the impoundment at normal operating elevation. A lateral seismic load due to a peak ground acceleration of 0.146g was assumed.

The findings of GeoSyntec's assessment indicated the embankment slopes of the Ash 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 results of the stability analysis are summarized below:

Embankment Slopes	Loading Conditions	Failure Mode	Calculated F.S.	Target F.S.
Case 1 (Silt (ML) soil material in pre-existing berm)	Static	Circular	1.51	1.5
		Block	1.59	1.5
	Seismic	Circular	1.27	1.2
		Block	1.33	1.2
Case 2 (Clay (CL) soil material in pre-existing berm)	Static	Circular	1.53	1.5
		Block	1.60	1.5
	Seismic	Circular	1.28	1.2
		Block	1.34	1.2

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

The center embankment separating Ash Ponds A and B has been enlarged by using compacted bottom ash in order to provide a larger work platform for maintenance and dredging equipment. Other minor modifications include adjustments to the basin bottom elevations and side slopes created as a result of leaving some excess bottom ash in place during maintenance dredging in order to protect the liner.

3.1.4. Instrumentation

Pond water level monitors are present in the decant structures for Ponds A and B for the purposes of plant operations but detailed records of water levels are not available.

Two monitoring wells (MW-9 and MW-10) were installed within the northwestern embankment of the impoundment for the purposes of monitoring groundwater levels in the closed former impoundment below. Two additional monitoring wells (MW-7R and MW-8R) are within fairly close proximity of the impoundment. Recorded water levels for the past 4 quarters were provided by NRG for these monitoring wells.

3.2. PREVIOUS INSPECTIONS

No formal inspections are performed on the impoundment, and no records of inspection are available.

3.3. OPERATOR INTERVIEWS

Numerous plant and corporate personnel took part in the assessment proceedings. The following is a list of participants for the assessment of the Ash Ponds A and B:

Table 4 *List of Participants*

Name	Affiliation	Title
Stephen Dixon	NRG Energy	Director, Coal Ash Management
Stephen Frank	NRG Energy	Senior Environmental Specialist
Murray Kohan	NRG Energy	General Manager, Shawville Station
Karen McClelland	NRG Energy	Senior Environmental Specialist
Scott Palian	NRG Energy	Environmental/Chemical Engineer, Shawville Station
Lawrence Rapski	NRG Energy	Technical Manager, Shawville Station
Heath Maines	Pennsylvania DEP	Engineer, Division of Dam Safety
Gary Emmanuel	O'Brien & Gere	Senior Managing Engineer
Stephen Szewczak	O'Brien & Gere	Project Engineer

Facility personnel provided a good working knowledge of both Ash Pond A and Ash Pond B, provided general plant operation background and provided requested historical documentation as available. These personnel also accompanied O'Brien & Gere and the PADEP Representative 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 assessment of Ash Pond A and Ash Pond B, which occurred on September 6, 2012. At the time of the assessment, O'Brien & Gere completed an EPA assessment checklist for the overall impoundment, which was submitted electronically to EPA on September 11, 2012. A copy of the completed assessment checklist is included as Appendix A.

4.1. GENERAL

The weather on the dates of the assessment was sunny and approximately 78 degrees. The visual assessment consisted of a thorough site walk along the perimeter of both ash ponds. O'Brien & Gere team members made observations along the toe, outboard slope, and crest of the embankments, 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. Site Plans of the ponds are presented as Figure 2, which also provides photograph locations and directions.

4.2. SUMMARY OF FINDINGS

<u>Ash Pond A</u>

The following observations were made during the assessment:

- The annual maintenance cycle for Ash Pond A had just been completed at the time of the assessment. The water level was drawn down for this maintenance, so visual assessment of the interior side slopes and outlet structures was possible.
- Sluiced bottom ash discharge enters the pond near the southwest corner and discharges into a small settling forebay constructed of compacted bottom ash. The settling forebay is connected to the main pond by two 24" HDPE pipes.
- The southeast (center) embankment separating Ash Ponds A and B has been enlarged with compacted bottom ash to provide additional area for maintenance equipment.
- The inboard slopes are protected by a combination of rock rip rap and fair vegetative cover above the typical water surface elevation. The rip rap within approximately 150 feet of the southeast (center) embankment is grouted to prevent dislocation during maintenance dredging operations.
- Plant personnel indicated that the annual maintenance and removal of accumulated ash has left approximately 2 feet of material along the side slopes and bottom. Plant personnel report that this is material is intentionally left in place in order to prevent possible damage to the impoundment liner system during dredging. This material was visible on the side slopes beneath the normal operating water level due to the lowered water level at the time of assessment.
- The decant structure appears to be in good condition and functioning normally. The water level was low enough for observation of the main 36" diameter steel perforated pipe which appears in good condition.
- The crest is covered by compacted gravel vehicle access drives around the entire perimeter.
- The drainage diversion swale along the southeastern side of the impoundment is clear of debris and appears to be functioning adequately with no signs of erosion.
- The outboard slope along the northwestern side of the impoundment, above the West Branch of the Susquehanna River, is heavily vegetated with woody shrubs and trees. This vegetation appears limited to the natural embankment section of the river and not within the more recently constructed diked portion at the top of the embankment. The vegetation does not appear to be impacting the stability of the

embankment.

- The outboard slope along the northeastern side of the impoundment above the facility wastewater treatment plant clarifier tank is well vegetated with maintained turf grass. It appears that the typical water surface level within the impoundment is maintained at or below the outer toe of embankment elevation. The slope appears stable with no evidence of seeping, sliding, erosion, or animal burrows.

Ash Pond B

The following observations were made during the assessment:

- Ash Pond B was in use for the impoundment of bottom ash at the time of assessment due to the annual maintenance on Ash Pond A.
- Sluiced bottom ash discharge enters the pond near the southeast corner and discharges into a small settling forebay constructed of compacted bottom ash. The settling forebay is connected to the main pond by two 24” HDPE pipes.
- The northeast (center) embankment separating Ash Ponds A and B has been enlarged with compacted bottom ash to provide additional area for maintenance equipment.
- The inboard slopes are protected by a combination of rock rip rap and fair vegetative cover above the typical water surface elevation. The rip rap within approximately 150 feet of the northeast (center) embankment is grouted to prevent dislocation during maintenance dredging operations.
- Plant personnel indicated that the regular maintenance and removal of accumulated ash has left approximately 2 feet of material along the side slopes and bottom. Plant personnel report that this is material is intentionally left in place in order to prevent possible damage to the impoundment liner system during dredging. This material was not visible above the normal operating water level in Pond B at the time of the assessment.
- The decant structure appears to be in good condition and functioning normally.
- The crest is covered by compacted gravel vehicle access drives around the entire perimeter.
- The drainage diversion swale along the southeastern side of the impoundment is clear of debris and appears to be functioning adequately with no signs of erosion.
- The outboard slope along the northwestern side of the impoundment, above the West Branch of the Susquehanna River, is heavily vegetated with woody shrubs and trees. This vegetation appears limited to the natural embankment section of the river and not within the more recently constructed diked portion at the top of the embankment. The vegetation does not appear to be impacting the stability of the embankment.
- The outboard slope along the southeastern side of the impoundment, above the stormwater management area, is heavily vegetated with shrubs and tall grasses which limits visual inspection of the slope. It appears that the typical water surface level within the impoundment is maintained approximately 2 to 3 feet above the outer toe of embankment elevation. Stormwater runoff from the upstream diversion channel was present in the bottom of the stormwater management area at the time of assessment. The slope appears stable with no evidence of seeping, sliding, or erosion.

5. CONCLUSIONS

Based on the fact that the impoundment was constructed with a single liner system and an interconnected decant system, Ash Ponds A and B have been rated as a single impoundment. 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 Ash Ponds A and B is considered to be **SATISFACTORY**. Acceptable performance is expected under all loading conditions; however, some minor deficiencies exist that require repair and/or additional studies or investigations. The deficiencies include the following:

- Heavy vegetation along the outer slope of the southwestern embankment of Ash Pond B limits visual inspection and may encourage animal burrowing.
- Heavy vegetation, including large trees, exists along outer slope of the northwestern embankment of Ash Ponds A and B. This limits visual inspection and may encourage animal burrowing.

Other than the conditions cited above, the owner has implemented regular visual inspections and performs routine maintenance which appears to be sufficient to keep the impoundment in good working order.

The Flood Insurance Study for Clearfield County, Pennsylvania shows that Ash Ponds A and B are located within the 100-year floodplain of the West Branch of the Susquehanna River. The Flood Insurance Study did not include a detailed study to predict the 100-year flood elevation of the West Branch of the Susquehanna River at this location. The limits of the floodplain indicated on Map Panel 42033C0340D are based on approximate methods and are interpreted from topographic mapping. Based on this mapping, it appears that the interpreted 100-year flood elevation is relatively close to the crest elevation and normal operating water elevation in Ash Ponds A and B. It appears that floodwaters in the West Branch of the Susquehanna River do not pose a significant risk of scour or erosion to the outer slope of the northwestern embankment of the impoundment and are unlikely to interact with water impounded within the ash ponds.

No hydrologic or hydraulic analyses are on record for the impoundment to determine the likelihood of overtopping due to precipitation during various design storm events. The operating pond water level, however, provides approximately 3 to 4 feet of freeboard that would accommodate the direct runoff from a significant precipitation event including the Probable Maximum Flood.

6. RECOMMENDATIONS

Based on the findings of our visual assessment and review of the available records for Ash Ponds A and B, O'Brien & Gere recommends that additional maintenance of the embankments be performed to correct the deficiencies cited above.

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 dam 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:

<u>Ash Pond A</u>

- Inboard slopes:
    - Continue to monitor all inboard slopes for signs of erosion. Repair in accordance with an engineered design.
- Outboard slopes:
    - Continue to monitor the outboard slopes of the embankments, primarily the northwestern and northeastern sides, for signs of seepage, sliding, erosion, and animal burrowing.
    - Increase maintenance activities to control the heavy vegetation along the outer slope of the northwestern embankment adjacent to the gravel access drive for improved visual inspection of the diked portion of this embankment.
    - Evaluate the condition of the large trees along the outboard slope of the northwestern embankment, primarily those above the impoundment bottom elevation. Diseased or dead trees should be removed.
- Additional studies:
    - Perform a hydrologic and hydraulic analysis of the impoundment for the 1-year through 100-year, 24-hour duration design storm events to determine the adequacy of the provided freeboard, the gravity emergency overflow between Pond A and Pond B and the upslope diversion swales.
    - Perform a hydrologic and hydraulic analysis of the West Branch of the Susquehanna River at this location in order to determine the 100-year flood elevation and anticipated flow velocities.

<u>Ash Pond B</u>

- Inboard slopes:
    - Continue to monitor all inboard slopes for signs of erosion. Repair in accordance with an engineered design.
- Outboard slopes:
    - Continue to monitor the outboard slopes of the embankments, primarily the northwestern and southwestern sides, for signs of seepage, sliding, erosion, and animal burrowing.
    - Increase maintenance activities to control the heavy vegetation along the outer slope of the northwestern embankment adjacent to the gravel access drive for improved visual inspection of

the diked portion of this embankment.
    - Evaluate the condition of the large trees along the outboard slope of the northwestern embankment, primarily those above the impoundment bottom elevation. Diseased or dead trees should be removed.
    - Increase maintenance activities to control the heavy vegetation on the outboard slope of the southwestern embankment above the stormwater management area to facilitate visual inspection of the slope for signs of erosion, movement, seepage or animal burrows.
    - Continue to monitor the stormwater management area for signs of erosion due to stormwater runoff from upstream areas. Repair in accordance with an engineered design as needed.
- Additional studies:
    - Perform a hydrologic and hydraulic analysis of the impoundment for the 1-year through 100-year, 24-hour duration design storm events to determine the adequacy of the provided freeboard, the gravity emergency overflow between Pond A and Pond B and the upslope diversion swales.
    - Perform a hydrologic and hydraulic analysis of the West Branch of the Susquehanna River at this location in order to determine the 100-year flood elevation and anticipated flow velocities.
    - Perform ground run survey at the cross-section modeled in GeoSyntec's slope stability analysis to confirm the assumption that the existing embankment geometry is the same as the design geometry.

6.3. MONITORING AND FUTURE INSPECTION

O'Brien & Gere recommends consideration of independent inspections by licensed dam safety engineers on at least a biennial basis until the plant is decommissioned and a closure plan is implemented. Future inspections may be required by the Pennsylvania Department of Environmental Protection should they determine that these impoundments will be regulated in the future.

6.4. TIME FRAME FOR COMPLETION OF REPAIRS/IMPROVEMENTS

The improvements, surveys, engineering and repairs recommended in this report may be required or may be rendered moot by an overall closure plan for the impoundments if the anticipated plant decommissioning occurs as scheduled in 2015. Completion of these items may be deferred until that time, unless long-term continued operation of the plant is anticipated.

6.5. CERTIFICATION STATEMENT

I acknowledge that the Ash Pond A and Ash Pond B CCW management units referenced herein were personally inspected by me on September 6, 2012 and were found to be in the following condition:

SATISFACTORY
~~FAIR~~
~~POOR~~
~~UNSATISFACTORY~~

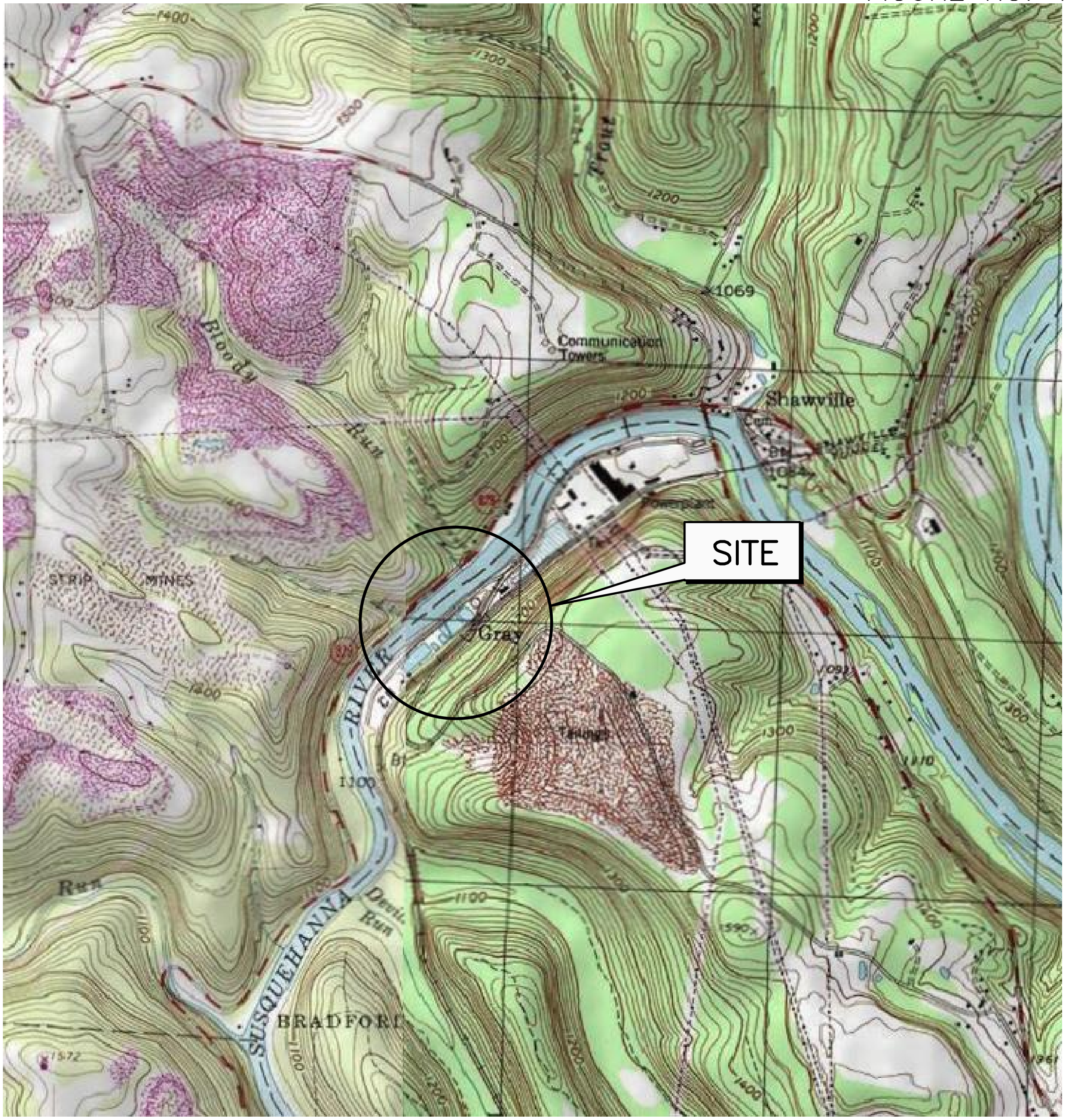
Signature: Gary B. Emmanuel   Date: 12/16/13

Gary B. Emmanuel, PE
PA PE-030497-E

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
GARY B. EMMANUEL
ENGINEER
PE-030497-E

Figures

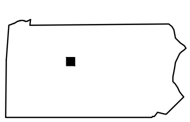
FIGURE NO. 1



ADAPTED FROM: CLEARFIELD, PA & LECONTES MILLS, PA U.S.G.S. 7.5 MIN. QUADS

US EPA – DAM SAFETY ASSESSMENT OF
CCW IMPOUNDMENTS
SHAWVILLE GENERATING STATION

SITE LOCATION MAP



QUADRANGLE LOCATION

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

SCALE: 1:24000

FILE NO. 13498.46122–220
DECEMBER 2013

O'BRIEN & GERE

NOTES:

1. SITE AERIAL PHOTOGRAPH TAKEN FROM THE 'PAMAP PROGRAM 2006 COLOR ORTHOPHOTOS OF PENNSYLVANIA' FUNDED BY THE PENNSYLVANIA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES (PA DCNR) AND AVAILABLE THROUGH PENNSYLVANIA SPATIAL DATA ACCESS (PASDA) ONLINE SERVICE

FIGURE 2

PHOTOGRAPH NUMBER AND ORIENTATION

US EPA
DAM SAFETY ASSESSMENT
OF CCW IMPOUNDMENTS

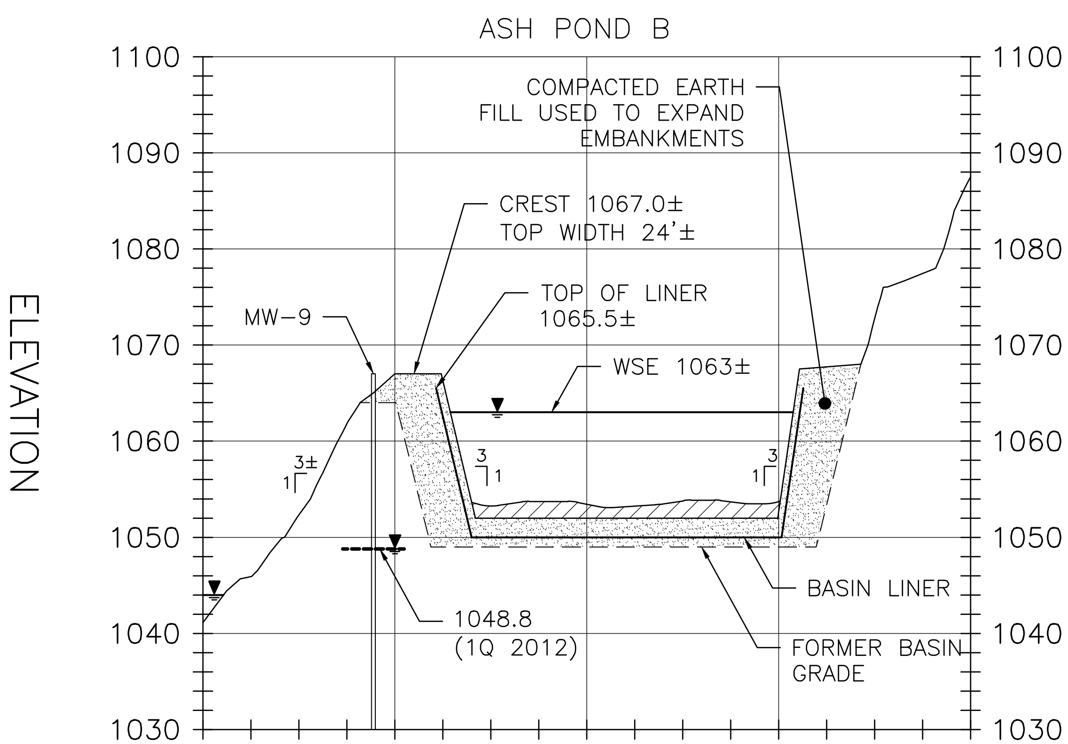
NRG REMA LLC
SHAWVILLE GENERATING STATION

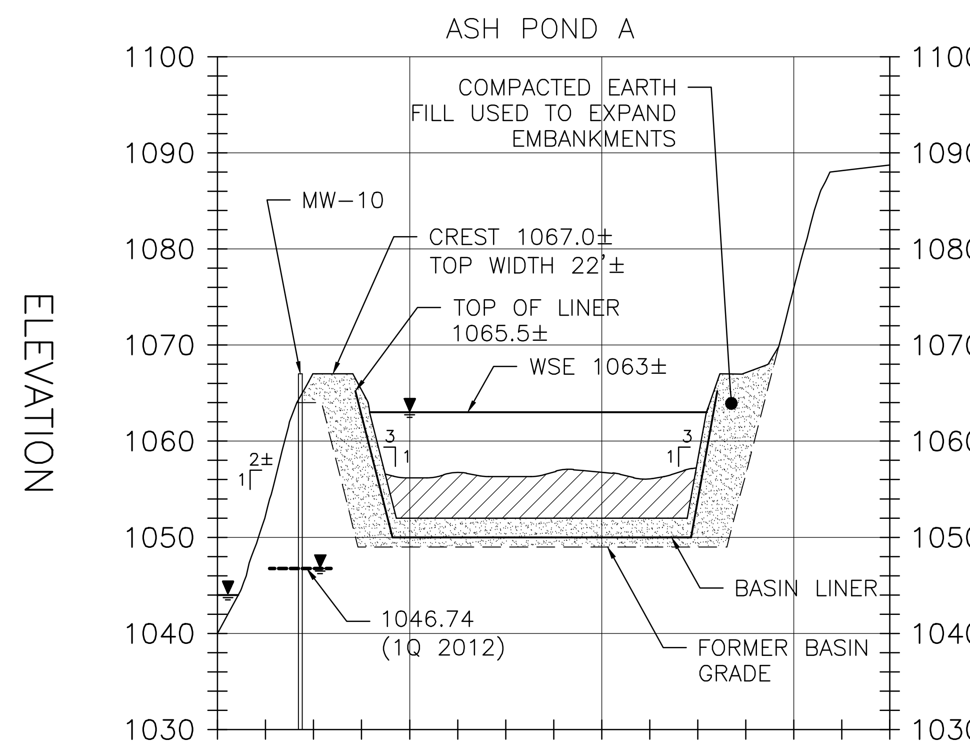
SITE AERIAL PHOTOGRAPH AND PHOTOGRAPH LOCATION MAP

FILE NO. 13498.46122.220
DECEMBER 2013

O'BRIEN & GERE

FIGURE 3





HORIZONTAL SCALE: 1"=100' (100 0 100)

VERTICAL SCALE: 1"=20' (20 0 20)

US EPA
DAM SAFETY ASSESSMENT
OF CCW IMPOUNDMENTS

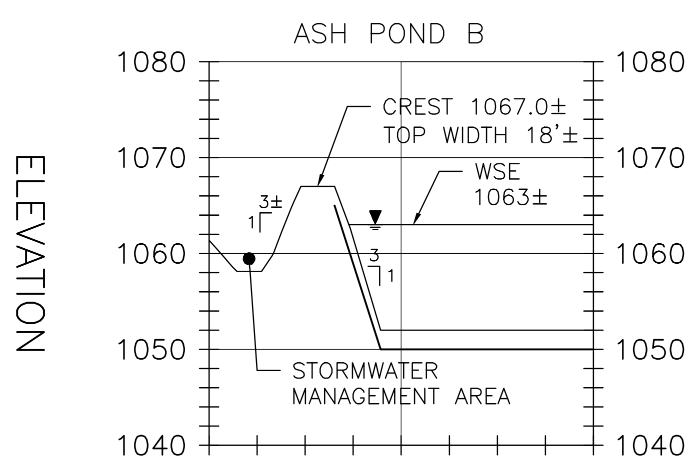
NRG REMA LLC
SHAWVILLE GENERATING STATION

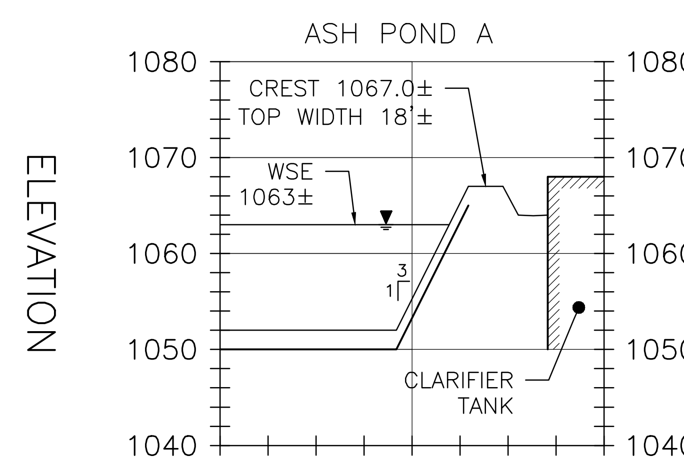
TYPICAL CROSS–SECTIONS

FILE NO. 13498.46122.220
DECEMBER 2013

O'BRIEN & GERE

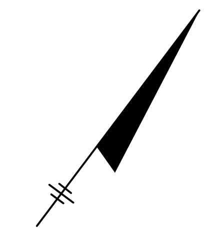
FIGURE 4





HORIZONTAL SCALE: 1"=100' (100 0 100)

VERTICAL SCALE: 1"=20' (20 0 20)



US EPA
DAM SAFETY ASSESSMENT
OF CCW IMPOUNDMENTS

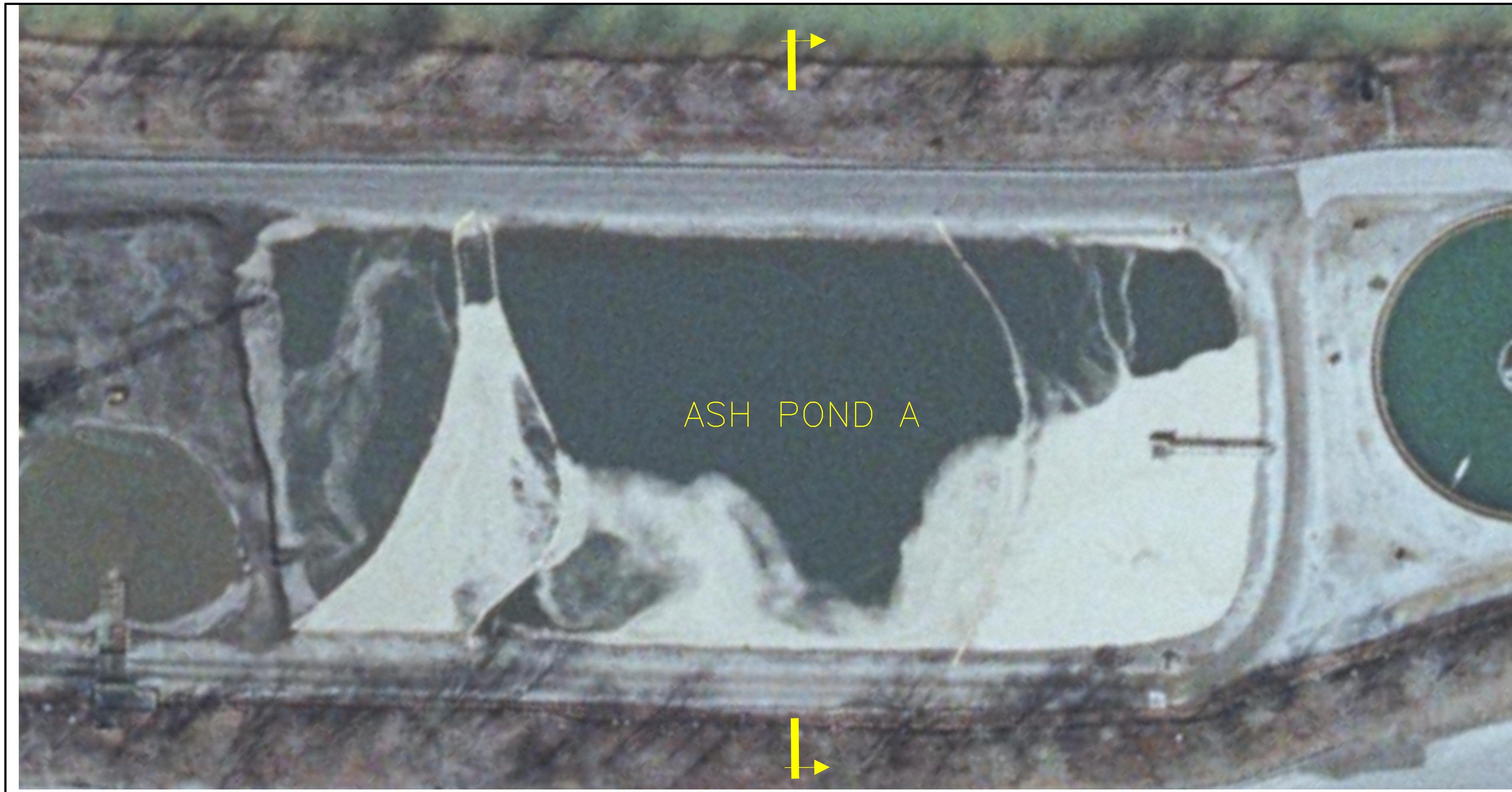
NRG REMA LLC
SHAWVILLE GENERATING STATION

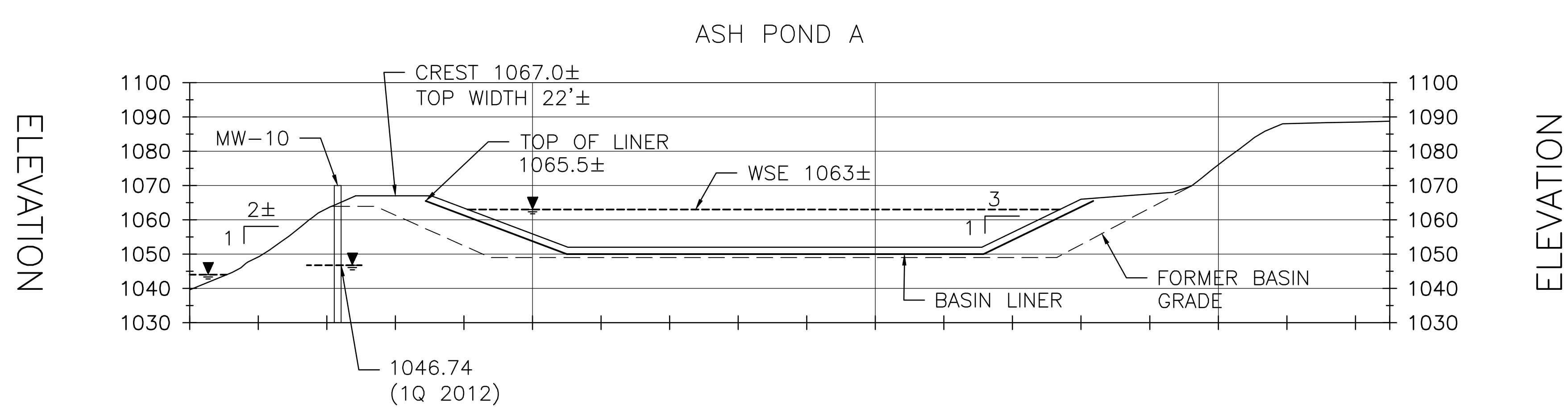
TYPICAL CROSS-SECTIONS

FILE NO. 13498.46122.220
DECEMBER 2013

O'BRIEN & GERE

FIGURE 5





SCALE: 1"=50' 50 0 50

US EPA
DAM SAFETY ASSESSMENT
OF CCW IMPOUNDMENTS

NRG REMA LLC
SHAWVILLE GENERATING STATION

TYPICAL CROSS-SECTION
ASH POND A
NO EXAGGERATED SCALE

FILE NO. 13498.46122.220
DECEMBER 2013

O'BRIEN & GERE

Appendix A

Visual Inspection Checklists

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	GenOn Shawville Generating Station	Date:	09/06/12
Unit Name:	Ash Ponds A and B	Operator's Name:	GenOn REMA LLC
Unit I.D.:		Hazard Potential Classification:	High Significant Low ✓
Inspector's Name:	Gary B. Emmanuel / Stephen M. Szewczak		

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?	Daily		18. Sloughing or bulging on slopes?		✓
2. Pool elevation (operator records)?	1,063.0		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	N/A		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	1,066.3		Is water entering inlet, but not exiting outlet?	Unknown	
5. Lowest dam crest elevation (operator records)?	1,067.0		Is water exiting outlet, but not entering inlet?	Unknown	
6. If instrumentation is present, are readings recorded (operator records)?		✓	Is water exiting outlet flowing clear? Unknown - closed system		
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? N/A			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

See attached for Comments

Site Name: **GenOn Energy – Shawville Generating Station**

Date: **September 6, 2012**

Unit Name: **Ash Ponds A & B**

Unit I.D.:

Inspection Issue #	Comments
GENERAL	Ash Ponds A & B were constructed as one large impoundment with a continuous synthetic liner system divided into two (2) cells by a compacted earth berm in the approximate center which has since been enlarged by the addition of compacted bottom ash.
GENERAL	The current impoundment was constructed in 1989. Copies of original design drawings are available. The impoundment was constructed over the location of former Ash Pond #2 which was closed. There is a sub-drain system beneath the current impoundment liner.
GENERAL	Ash Pond A is the primary settlement and storage impoundment for the facility. Ash Pond B is typically only used for storage of bottom ash during periods of maintenance on Ash Pond A.
GENERAL	At the time of inspection, the regularly scheduled annual maintenance and ash removal had just been completed on Ash Pond A. Ash Pond A was therefore at a drained down water level and Ash Pond B was in service for settlement and storage of bottom ash material.
1	Company personnel perform visual inspection of the impoundment on a daily basis; there is no formal dam inspection program.
3	The invert elevation of the primary 16" decant conveyance line is not indicated on the available design plans. The invert elevation of the primary submerged 36" diameter perforated steel pipes at each Ash Sluice Recycle Collection structure is approximately 1057.5.
9	Trees and heavy brush present on the outer embankment of the original Ash Pond #2 along the West Branch of the Susquehanna River. Trees and brush typically growing below the elevation of the built up embankment section constructed in 1989.
14	Ash Pond B includes a triangular emergency overflow spillway graded into the crest roadway approximately 9" deep. Overflow would enter a small stormwater detention area and outlet structure which drains to the plant wastewater treatment facility.
20	The primary decant system consists of two (2) perforated 36" steel pipes, one within each cell of the impoundment (A and B). The top of pipe elevation is 1060.5. Each of these perforated steel pipes discharges to an Ash Sluice Recycle Collection Structure containing a weir gate for pond level control and valves for independently regulating the water levels in the two cells during maintenance operations. The two Ash Sluice Recycle Collection Structures are connected by a 16" PVC pipe which drains back to the main plant where the decant water is recycled. A 12" underdrain system is connected to the two (2) decant structures located at either end of the impoundment, one in each cell. The decant structures are then connected to a central underdrain pumping station. During maintenance operations, the remaining water below the primary decant system is pumped to the plant wastewater treatment plant for treatment prior to discharge.

21	Impoundment constructed with an impermeable liner with a sub-drain system making seepage unlikely to be observed.
23	West Branch of the Susquehanna River runs along the toe of the outer embankment for the original Ash Pond #2.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW) Impoundment Inspection

Impoundment NPDES Permit # PA0010031 INSPECTOR G. Emmanuel / S. Szewczak
Date September 6, 2012

Impoundment Name GenOn Energy Shawville Generating Station - Ash Ponds A and B
Impoundment Company GenOn REMA LLC
EPA Region 3
State Agency (Field Office) Addresss PA DEP Northcentral Regional Office
208 W. 3rd Street, Suite 101, Williamsport, PA 17701
Name of Impoundment Ash Ponds A and B
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number) (Impoundment built with one exterior embankment and liner system, separated into 2 cells by a compacted earth berm supplemented with compacted coal bottom ash material)

New ______ Update X

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

IMPOUNDMENT FUNCTION: Settlement and storage of coal bottom ash

Nearest Downstream Town : Name Shawville, PA
Distance from the impoundment 0.9 miles
Impoundment
Location: Longitude -78 Degrees 22 Minutes 26.84 Seconds
Latitude 41 Degrees 3 Minutes 39.75 Seconds
State PA County Clearfield

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

If So Which State Agency? PA DEP - Division of Waste Management

<u>HAZARD POTENTIAL</u> (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.

__x___ **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.

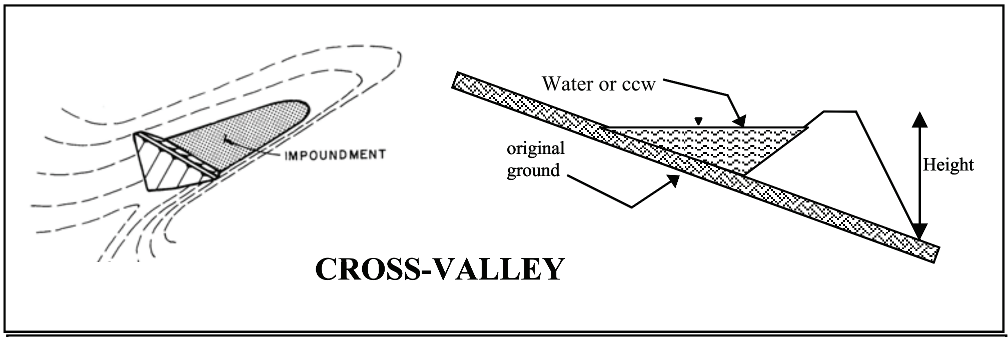
______ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. 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.

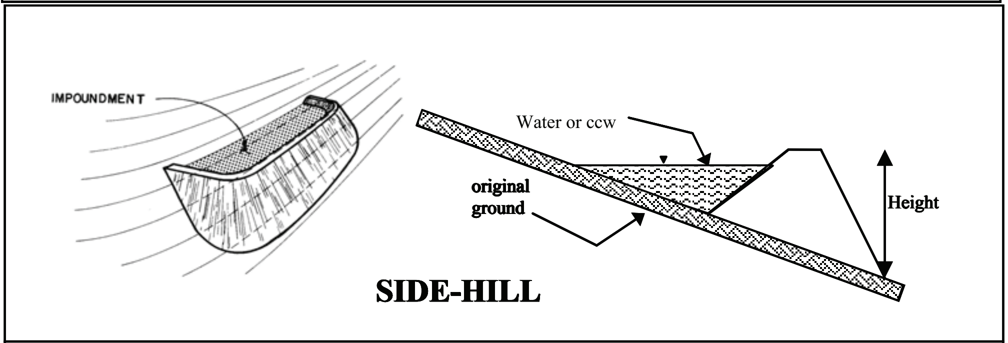
______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

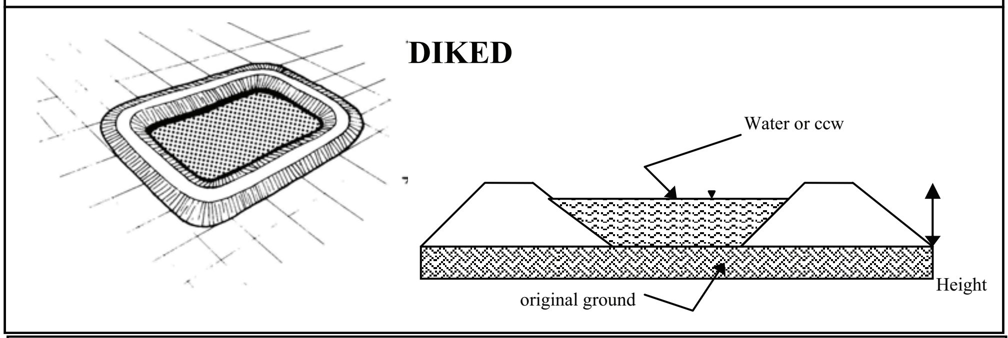
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

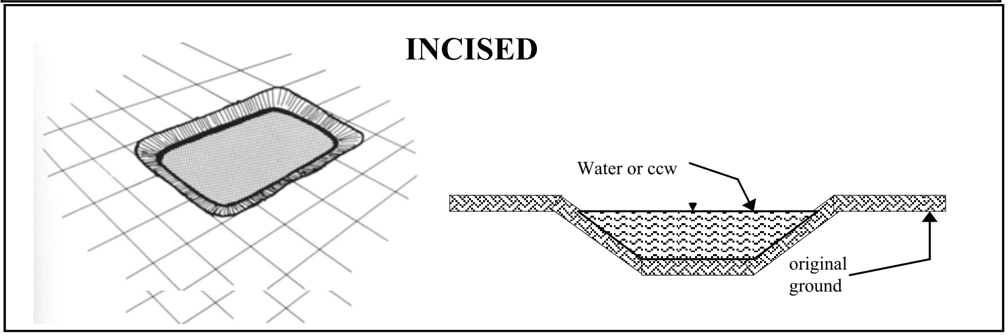
Potential failure of the impoundment would likely result in no loss of life and minimal economic losses. Failure would result in minor environmental impacts to the West Branch of the Susquehanna River.

CONFIGURATION:









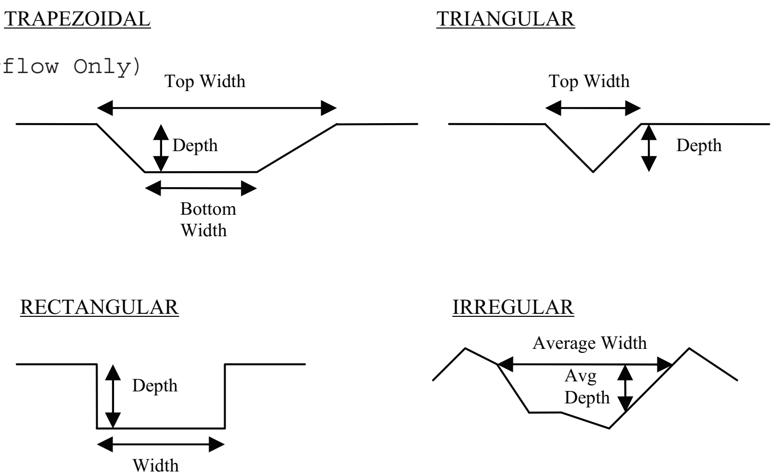
_____ Cross-Valley
_____ Side-Hill
_____ Diked
_____ Incised (form completion optional)
__x__ Combination Incised/Diked

Embankment Height 7 feet   Embankment Material Compacted Earth
Pool Area 3.3 acres   Liner Yes - Synthetic Liner System
Current Freeboard 4 feet   Liner Permeability Unknown (<< 10^-7 cm/sec)

TYPE OF OUTLET (Mark all that apply)

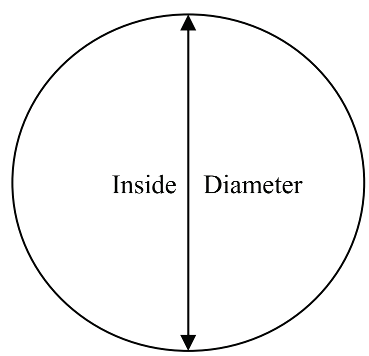
__X__ **Open Channel Spillway** (Emergency Overflow Only)
______ Trapezoidal
__X__ Triangular
______ Rectangular
______ Irregular

__9"__ depth
______ bottom (or average) width
__50'__ top width



__X__ **Outlet**

__16"__ inside diameter



Material
______ corrugated metal
______ welded steel
______ concrete
__X__ plastic (hdpe, pvc, etc.)
______ other (specify) ________________________

Is water flowing through the outlet? YES ________ NO ________ Unknown, closed system

__N/A__ **No Outlet**

__X__ **Other Type of Outlet** (specify) 12" PVC Underdrain system connected to decant structures. Decant structures drain via 12" PVC pipe to central underdrain pump station which conveys water to plant wastewater treatment plant. System used only during maintenance.

The Impoundment was Designed By Gilbert / Commonwealth W.O.

Has there ever been a failure at this site? YES __________ NO ___x_______

If So When? ___________________________

If So Please Describe : ____

Has there ever been significant seepages at this site? YES _______ NO __x______

If So When? ___________________________

IF So Please Describe: ____

Has 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 : ____________________

Groundwater elevations are monitored at four (4) monitoring wells as part of continued monitoring of the closure of the former Ash Pond #2 at this location. Two (2) wells are located within the embankment of the current impoundment (MW-9 and MW-10)

Appendix B

Photographic Log

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: NE

Description: Ash Pond B; Overall view. Ash Pond B currently active during maintenance on primary Ash Pond A.

Date: 9/6/12

Photo Number: 1

Photographer: S. Szewczak

Orientation: SE

Description: Ash Pond B; View of decant structure.

Date: 9/6/12

Photo Number: 2

Photographer: S. Szewczak

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: SE	
Description: Ash Pond B; Inboard slope and crest of southwestern embankment. Note triangular emergency overflow section located just past walkway. Building on right is the leachate pump station from facility landfill.	
Date: 9/6/12	
Photo Number: 3	
Photographer: S. Szewczak	
Orientation: NE	
Description: Ash Pond B; Inboard slope and crest of northwestern embankment.	
Date: 9/6/12	
Photo Number: 4	
Photographer: S. Szewczak	

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: E Description: Stormwater management area along outer toe of Ash Pond B southwestern embankment. Structure in foreground is the former outlet structure for prior Pond 2 now converted to a stormwater inlet structure. Date: 9/6/12 Photo Number: 5 Photographer: S. Szewczak	
Orientation: NW Description: Former outlet structure for the prior Pond 2, now converted to a stormwater inlet structure. Date: 9/6/12 Photo Number: 6 Photographer: S. Szewczak	

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: NE	
Description: Ash Pond B; Outer slope of southwestern embankment. Water along toe is stormwater runoff from upstream diversion ditches. No evidence of seepage through the embankment.	
Date: 9/6/12	
Photo Number: 7	
Photographer: S. Szewczak	
Orientation: NE	
Description: Typical view of toe of slope of Ash Pond B southwestern embankment.	
Date: 9/6/12	
Photo Number: 8	
Photographer: S. Szewczak	

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: SE	
Description: Ash Pond B; Ash Sluice Recycle Structure. Receives flow from the decant structure & perforated steel pipe; drains to the plant for recycling of sluiced water. Pipe in foreground is a discharge for blowdown of the leachate pump station.	
Date: 9/6/12	
Photo Number: 9	
Photographer: S. Szewczak	
Orientation: NE	
Description: Ash Pond B; inboard slope of southeastern embankment.	
Date: 9/6/12	
Photo Number: 10	
Photographer: S. Szewczak	

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: NE Description: Ash Pond B; Crest of southeastern embankment. Note diversion swale above (right) of the crest to collect runoff from the roadway above. Date: 9/6/12 Photo Number: 11 Photographer: S. Szewczak	
Orientation: NW Description: Ash Pond B; view of interior side slope of northwestern embankment. Note grouted rock section for maintenance dredging. Date: 9/6/12 Photo Number: 12 Photographer: S. Szewczak	

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client:	US EPA	Project Number:	46122.220
Site Name:	GenOn Energy – Shawville Generating Station	Location:	Shawville, PA

Orientation: N

Description: Ash Pond B; Constructed forebay and ash sluice piping at the southeast corner. Forebay berm constructed of compacted ash.

Date: 9/6/12

Photo Number: 13

Photographer: S. Szewczak

Orientation: W

Description: Ash Pond B; (2) 24" HDPE pipes connecting the forebay to the main portion of Pond B through the compacted ash berm.

Date: 9/6/12

Photo Number: 14

Photographer: S. Szewczak

PHOTOGRAPHIC LOG

Client:	US EPA	Project Number:	46122.220
Site Name:	GenOn Energy – Shawville Generating Station	Location:	Shawville, PA

Orientation: N

Description: Underdrain pump station. Collects water from both Pond A and B underdrains to dewater the ponds during maintenance. Water pumped to the plant wastewater treatment facility.

Date: 9/6/12

Photo Number: 15

Photographer: S. Szewczak

Orientation: NW

Description: Center Dividing Embankment separating the impoundment into the two (2) cells: Ash Pond A (right) and Ash Pond B left. Berm primarily compacted earth topped with a compacted ash roadway surface.

Date: 9/6/12

Photo Number: 16

Photographer: S. Szewczak

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: N

Description: Ash Pond A; View of constructed forebay and ash sluice discharge piping at the southwest corner. Pond A has just completed annual maintenance cycle so the forebay is dry.

Date: 9/6/12

Photo Number: 17

Photographer: S. Szewczak

Orientation: Down

Description: Close up view of grouted rock armor section, typical of both Pond A and B.

Date: 9/6/12

Photo Number: 18

Photographer: S. Szewczak

PHOTOGRAPHIC LOG

O'BRIEN & GERE

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: NW Description: Ash Pond A, interior side slope of constructed forebay berm. Date: 9/6/12 Photo Number: 19 Photographer: S. Szewczak	
Orientation: NE Description: Ash Pond A; Overall view looking towards the generating station. Note that water level has been lowered for maintenance by approximately 6 feet. Date: 9/6/12 Photo Number: 20 Photographer: S. Szewczak	

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: NE	
Description: Ash Pond A; decant structure and 36" diameter perforated steel decant pipe.	
Date: 9/6/12	
Photo Number: 21	
Photographer: S. Szewczak	
Orientation: NW	
Description: Ash Pond A; decant structure and 36" diameter perforated steel decant pipe.	
Date: 9/6/12	
Photo Number: 22	
Photographer: S. Szewczak	

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: NW

Description: Ash Pond A; close up view of decant structure.

Date: 9/6/12

Photo Number: 23

Photographer: S. Szewczak

Orientation: NW

Description: Ash Pond A; inboard side slope of northeastern embankment.

Date: 9/6/12

Photo Number: 24

Photographer: S. Szewczak

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: SW	
Description: Ash Pond A; Ash Sluice Recycle Collection Structure. Receives flow from the perforated steel pipe and drains to the plant for recycling of sluiced water. Controls are for pond level control and isolation of Ash Ponds A and B.	
Date: 9/6/12	
Photo Number: 25	
Photographer: S. Szewczak	
Orientation: NW	
Description: Ash Pond A; crest of northeastern embankment. Wastewater treatment plant clarifier tank visible to the right.	
Date: 9/6/12	
Photo Number: 26	
Photographer: S. Szewczak	

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: SW Description: Ash Pond A; crest and outboard slope of northwestern embankment looking towards Ash Pond B. Note heavy vegetation on outboard slope. Date: 9/6/12 Photo Number: 27 Photographer: S. Szewczak	
Orientation: SW Description: Ash Pond A; inboard side slope of northwestern embankment. Structure in foreground is Clarifier Bypass Structure (used for overflow only) Date: 9/6/12 Photo Number: 28 Photographer: S.Szewczak	

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: W	
Description: Monitoring Well MW-10 located in the northwestern embankment of Ash Pond A.	
Date: 9/6/12	
Photo Number: 29	
Photographer: S. Szewczak	
Orientation: NE	
Description: Ash Pond A; inboard side slope and crest of northwestern embankment looking towards the generating station.	
Date: 9/6/12	
Photo Number: 30	
Photographer: S. Szewczak	

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: W Description: Ash Pond A; Outer side slope of northwestern embankment looking down at the West Branch of the Susquehanna River. Date: 9/6/12 Photo Number: 31 Photographer: S. Szewczak	
Orientation: NE Description: Ash Pond A; Outer side slope of northwestern embankment heavily vegetated. Date: 9/6/12 Photo Number: 32 Photographer: G. Emmanuel	

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: SW

Description: Crest of the northwestern embankment at the central dividing dike. Dredged ash from Pond A temporarily stockpiled prior to landfilling.

Date: 9/6/12

Photo Number: 33

Photographer: S. Szewczak

Orientation: NW

Description: Subdrain pumping station. Collects leachate from beneath pond liners only, not used for decant.

Date: 9/6/12

Photo Number: 34

Photographer: S. Szewczak

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: SW	
Description: Ash Pond B; Outboard slope of northwestern embankment.	
Date: 9/6/12	
Photo Number: 35	
Photographer: S. Szewczak	
Orientation: SW	
Description: Ash Pond B; Overall view. Note floating turbidity curtains.	
Date: 9/6/12	
Photo Number: 36	
Photographer: S. Szewczak	

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: SW Description: Ash Pond B; Crest and outboard slope of northwestern embankment Date: 9/6/12 Photo Number: 37 Photographer: S. Szewczak	
Orientation: W Description: Monitoring Well MW-9 located in the northwestern embankment of Ash Pond B. Date: 9/6/12 Photo Number: 38 Photographer: S. Szewczak	

O'BRIEN & GERE

PHOTOGRAPHIC LOG

Client: US EPA	Project Number: 46122.220
Site Name: GenOn Energy – Shawville Generating Station	Location: Shawville, PA

Orientation: NE Description: Typical condition of outboard slope of northwestern embankment looking down at the West Branch of the Susquehanna River. Date: 9/6/12 Photo Number: 39 Photographer: G. Emmanuel	
Orientation: W Description: Typical condition of outboard slope of northwestern embankment looking down at the West Branch of the Susquehanna River. Date: 9/6/12 Photo Number: 40 Photographer: G. Emmanuel	

Appendix C

Email Correspondence Concerning Initial Comments/Inquiries on Draft Assessment Report

From: Kelly, PatrickM
Sent: Wednesday, September 11, 2013 9:40 AM
To: 'Gary Emmanuel'
Cc: 'Robert Bowers'; Hoffman, Stephen
Subject: EPA CCR Dam Assessments - GenOn/NRG Shawville

Good morning Gary,

I just needed some clarification on an issue I have regarding the configuration of the impoundments at the GenOn/NRG Shawville Generating Station, specifically the northwest embankment of Ash Pond A and Ash Pond B. The issue relates to the need for performance of structural stability analyses on the unit and therefore has some bearing on the report.

In the report, it is apparent that the existing units, Ash Pond A and Ash Pond B, are built on top of the decommissioned Pond 2. The report goes on to state that the northwest embankment of the ponds is primarily composed of the natural slope of the river bank with an additional approx. 2' diked portion overlaying the natural slope to provide drive access on the crest. It does not appear from the report that the natural slope is armored in any way by rip-rap or other material protection.

Does the configuration of the embankment, specifically as seen in elevation views from Figure 3 in the attachements of the report, present a concern in a flood condition in the West Branch of the Susquehanna River, i.e., elevated phreatic surface and potential subsequent downstream rapid drawdown condition in the downstream(outboard) slope? Additionally, would it be overly-conservative to analyze the downstream embankment based on its configuration and subsequent lack of lateral soil pressure buffering the embankment?

Typically, with incised units, we have encountered some setback or buttressing from a river, stream, or lake, and more frequently units that are a negligible proximity to water body. Because the embankment of the unit is composed of the natural slope of the river which falls to the water itself, I wanted to ensure there wouldn't be any previously unforeseen consequences.

Thanks a bunch.

-PK

Patrick M. Kelly, P.E.
Environmental Engineer
U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Phone: (703)308-7271
Kelly.PatrickM@epa.gov

From: Gary Emmanuel [mailto:Gary.Emmanuel@obg.com]
Sent: Tuesday, September 17, 2013 5:24 PM
To: Kelly, PatrickM
Cc: Robert Bowers; Hoffman, Stephen; Englander, Jana; Stephen Szewczak; Dreher Whetstone
Subject: RE: EPA CCR Dam Assessments - GenOn/NRG Shawville

Patrick-

We have evaluated your questions regarding the lack of stability analysis of the northwestern slopes and offer the following clarifications/discussions:

Given the close proximity to the West Branch of the Susquehanna River and the lack of any setbacks, benches, etc. on the slope, a recommendation to perform geotechnical slope stability analyses of these slopes would not be perceived as overly conservative in our opinion; however, we considered the following during preparation of our report recommendations:

1. The current impoundments or prior impoundment have been in operation at this site for over 60 years with no history of slope distress, failure, or other related incident.

2. The groundwater level in the embankment between the impoundment and the embankment is basically at river level. The West Br. Susquehanna River is not likely to remain at flood stage long enough to saturate the embankment to the point of elevating the phreatic surface substantially, especially considering that the soils between the river and the impoundment are not currently saturated due to the geomembrane liner on the floor and slopes of the impoundment.

3. Even if the slope did become partially saturated during flood stage, it is unlikely that the river level would recede more quickly than the soils forming the slope could drain, which is the condition that would be necessary to create the rapid drawdown instability you mentioned.

4. If the slope was prone to instability due to post-flood river recession, it is our opinion that there would be some history of slope sloughing, or other outward signs of slope distress. No signs of such distress or of past repairs or stabilization efforts was observed in the site visit.

5. The impoundment is planned for closure in about 2 years .

If this impoundment were to remain in operation for an extended period of time, we would likely recommend a geotechnical study and slope stability evaluation. However, given it's long history with no incident and upcoming closure in the near future, we believe a regular visual monitoring plan looking for signs of slope distress is the most practical recommendation for Ponds A and B.

Please contact me with any more questions.

Regards,

Gary

Gary B. Emmanuel, P.E.
Sr. Managing Engineer

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From: Kelly, PatrickM [mailto:Kelly.PatrickM@epa.gov]
Sent: Wednesday, September 18, 2013 9:17 AM
To: Gary Emmanuel
Cc: Robert Bowers; Hoffman, Stephen; Englander, Jana; Stephen Szewczak; Dreher Whetstone
Subject: RE: EPA CCR Dam Assessments - GenOn/NRG Shawville

Gary,

We concur with O'Brien and Gere's rationale for not requiring stability analysis of the embankments at the GenOn/NRG Shawille Plant based on the reasons enumerated in your email.

Please include these reasons in a signed memo on O'Brien and Gere letterhead as an attachment in the final draft of the Dam Assessment report, and include a reference in the body of the report to the attachment. Jana Englander will follow up with you regarding miscellaneous comments to the draft report to be incorporated in the final report in addition to the signed memo.

Again, thanks for your clarification on this issue.

Patrick M. Kelly, P.E.
Environmental Engineer
U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Phone: (703)308-7271
Kelly.PatrickM@epa.gov

From:	Maines, Heath
To:	Hoffman, Stephen; Englander, Jana
Subject:	GenOn Shawville Power Plant Comments
Date:	Tuesday, October 29, 2013 1:51:18 PM

All,

Pennsylvania DEP Dam Safety has reviewed the draft assessment report for GenOn's Shawville Power Plant. The Department concurs with the findings of the O'Brien & Gere report and offers the following additional comment:

Section 2.2.1 of the report states that "PADEP Division of Dam Safety currently does not regulate the impoundment containing Ash Ponds A and B." Upon review of the information presented in the report, the Department has determined that the dams are jurisdictional under 25 PA Code §105.3(a)(3) - *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.* The Department will regulate the ring dam that contains Ash Pond A and B and the appurtenant structures of the dam. The Department has preliminarily assigned the structure as class "C-4" dam based on the size and hazard potential and will regulate the dam until it is no longer used for ash disposal. The dam is now identified by the Department as D17-126 – Shawville Power Plant A and B. The dam will be periodically inspected by the Department and any deficiencies will be reported to the owner.

Thanks,

Heath

Heath A. Maines | Civil Engineer Hydraulic
Eastern Section
Division of Dam Safety
Department of Environmental Protection
Rachel Carson State Office Building
400 Market Street | Harrisburg, PA 17101
Phone: 717.772.5960 | Fax: 717.772.0409
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Appendix D

Geotechnical Assessment and Slope Stability Analysis

Geosyntec consultants

10220 Old Columbia Road, Suite A
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PH 410.381.4333
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www.geosyntec.com

22 November 2013

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

Attention: Mr. Stephen Frank, P.E.
Senior Environmental Specialist

Subject: Bottom Ash Pond Assessment Report
Shawville Power Station
Shawville, Pennsylvania

Dear Mr. Frank:

Geosyntec is pleased to submit this letter report presenting the findings of an assessment of the bottom ash pond (BAP) embankments at the NRG REMA, LLC Shawville Power Station (site). The bottom ash water recycle system at the Shawville site consists of two ponds, denoted as Ponds A and B, which 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). The results of this evaluation by EPA are presented in the preliminary report (referred to as draft EPA report hereafter), prepared by O'Brien & Gere Engineers, Inc. and dated 17 December 2012.

This letter report was prepared by Geosyntec Consultants (Geosyntec) for NRG Energy, Inc. (NRG), in accordance with Geosyntec's proposal to GenOn dated 30 November 2012. After the approval of our proposal and prior to the conclusion of this report, NRG and GenOn combined and will retain the name NRG Energy, Inc. As a result of the merger and name change, GenOn REMA, LLC is now NRG REMA, LLC, a wholly owned subsidiary of NRG.

The main purpose of this report is to document the subsurface geotechnical condition and evaluate the embankment stability for both ponds. One of the review comments in EPA's draft report is the lack of stability analyses and as-built geotechnical information. Thus, the stability analysis and geotechnical information presented in this report supplement the EPA report. This report also provides additional information to address the comments and recommendations in EPA's draft report. This report complements Geosyntec's previous report dated 21 February 2013.

This report presents the results of the following activities: (i) field investigation of site conditions and soil properties; (ii) general assessment of the stability of the embankments; and (iii) hazard potential and condition assessment of the embankments. This letter report was prepared by Dr.

Chunling Li, 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

The Shawville Power Station has two bottom ash ponds (BAPs) (i.e., Ash Pond A and Ash Pond B) that are part of the site's bottom ash water recycle system. Both ponds have an engineered liner system consisting of a PVC liner with geotextile cushion fabric. The ponds were constructed using a combination of diked and incised construction methods, with the embankments for the diked portion of the ponds running parallel to the west branch Susquehanna River (river). The current configuration of Ash Ponds A and B has been in service since 1989. The locations of the BAPs are shown in Figure 1, which also illustrates the orientation of the ponds in relation to the river. A typical cross section of the northwest embankment, depicting the spatial relationship of the pre-1989 embankment to the 1989 vertical expansion of the embankment, is provided in Figure 2.

EVALUATION BY EPA

EPA conducted inspections of the BAPs on 6 September 2012. The draft EPA report, prepared by O'Brien & Gere Engineers, Inc. on 17 December 2012, provided a Condition Assessment of "Fair" and a Hazard Assessment of "Low" to the BAPs. 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. Because the BAPs at the Shawville site have received a "low" hazardous rating in the draft EPA report, Geosyntec will not provide a hazard potential classification in this letter report.

EPA's draft report also provided recommendations on long-term improvement, maintenance and further study of both ponds. None of these recommended items are deemed as urgent by EPA. Therefore, NRG will continue to monitor and maintain the impoundments following industry standards and these long-term recommendations will be addressed at a later date. However, NRG would like to address in this present report a recommendation provided by EPA regarding the outlet of Pond A:

> "*consider installation of overflow section on the center dividing dike to control overtopping during large storm events.*"

Currently, the ash sluice discharge channel, which houses the ash discharging piping into Pond A and Pond B, also serves as an emergency discharge pathway. Pond A will drain into the Pond B through the ash sluice channel once the water level in Pond A reaches the level where the ash sluice discharging piping enter the pond at the southwest corner. This feature is shown on the Aerial Map (Figure 2) and Photo 15 of the draft EPA report. Therefore, it is our understanding that this recommendation is already implemented.

VISUAL INSPECTION

On 18 December 2012, Mr. Wade Tyner of Geosyntec performed a site walkthrough and visual assessment of the BAP embankments following the general guidance provided in the EPA's Coal Combustion Dam Inspection Checklist Form (checklist). Lawrence J. Rapski and Stephen Dixon, both from NRG, were present at the site during the walkthrough. 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 focus field observations on areas and issues that might receive 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 Table 1. The items in the table are correlated to the numbering presented in the EPA's checklist form.

GEOTECHNICAL FIELD INVESTIGATION

On 18 December 2012, Geosyntec conducted a geotechnical field investigation to collect data for assessing the stability of 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. Two borings were advanced along the inside crest of the northwest embankment for each BAP, which are the highest portions of the BAP embankments (i.e., approximately 24 feet high). Three borings were drilled to an approximate depth of 25 feet below the existing ground surface (ft-bgs); one boring (HSA-4) was drilled to a depth of approximately 30 ft-bgs.

A track-mounted drill rig with a hollow-stem auger was used to advance the test borings. The auger 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]. Sampling was conducted continuously (i.e. every 2 feet of depth) in three of the four borings; sampling in HSA-4 was conducted once for every five feet of depth. 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 and reports of laboratory test results are included in Appendix C of this report. Laboratory tests, including particle size analysis (ASTM D422, without hydrometer analysis) and Atterberg limits (ASTM D4318) were performed on select samples. The boreholes were backfilled to the ground surface using cuttings and coated bentonite pellets.

Based on Geosyntec's observations of the samples collected from the borings, the ponds' embankments were constructed using fine-grained soils with occasional layers of gravelly soils, which were visually classified under the Unified Soils Classification System as MH (high-plasticity silt), ML (sandy silt), SC (clayey sand), and GP (poorly graded gravel). SPT N-values varied between 6 and 36 blows/ft, with an average value of 16 blows/ft (excluding the soft layer between 20 to 26 ft-bgs in HSA-2, and gravel lenses where N-values were greater than 50). Sandstone bedrock was encountered at approximately 30 feet and 26 ft-bgs in the Pond B embankment, in HSA-3 and HSA-4, respectively. No rock coring was performed.

Due to the location of underground utilities, borings were progressed along the inside crest of the berms. In borings HSA-1 and HSA-2, which were drilled into the embankment of Ash Pond A, it is likely that the soil samples were collected from the portion of the embankment that was built over the pre-existing embankment (i.e. pre-1989 embankment) and from the native material that formed the bottom of the unlined ash pond that later became Ash Pond A. The cross section provided in Figure 2 depicts the approximate locations of borings HSA-1 and HSA-2 in relation to the pre-existing embankment. Because the pond was constructed using a combination of diked/incised construction methods, it is assumed that the pre-existing embankment was constructed using the material removed from the excavation of the pond. Based on the boring logs for HSA-1 and HSA-2, the native material is likely to be either a sandy clay (CL) or low-plasticity silt (ML). Therefore, it is assumed that the pre-existing berms are constructed from either CL or ML soil. Hence, two stability analyses were conducted: one assuming that the pre-existing berm was constructed using CL soils and another assuming that the pre-existing berm was constructed using ML soils. The shear strength parameters for these soils were conservatively selected based on the lower SPT N-values encountered for each material.

Shear-strength properties for the embankment, the pre-existing embankment, and the foundation soils were selected based on well-established correlations with soil type, N-value, and or plasticity of the soil (i.e. Atterberg Limits). References for these correlations and the selected shear-strength properties for each soil are presented in Appendix D (i.e., Stability Analysis).

Groundwater was encountered in the Pond A embankment at 25 feet and 22 ft-bgs in HSA-1 and HSA-2, respectively. In the Pond B embankment, groundwater was encountered at approximately 29 and 25 ft-bgs, in HSA-3 and HSA-4, respectively.

TABLE 1
VISUAL INSPECTION

BAP – Shawville Power Station
Shawville, 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 at the time of the walkthrough but, based on the conditions of the embankments' outer slopes at the time of the site walkthrough, it appears that vegetation is well established (see Photographs 5, 7, and 8 in Appendix A). No signs of significant erosion were observed (i.e., rills, gullies, or frost wedging). Design drawings that were prepared for the previous raising of the ash pond embankments were provided to Geosyntec for review by NRG for the purpose of estimating the steepness of the existing slope for use in the stability analysis. Neither as-built records for the ponds' embankments nor recent topographic surveys were available. Therefore, it was not possible to confirm that the design slopes accurately represent the dimensions of the existing embankments.

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 the approximate center of the northwest embankment of Ash Pond A, as shown in Figure 1. This section was selected because of its proximity to HSA-2, where the weakest soil layer was encountered. In addition, Ash Pond A is the primary pond, meaning that water levels in Ash Pond A are typically higher than in Ash Pond B at any given time. Thus, the selected cross section at Ash Pond A 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 Gilbert/Commonwealth, Inc., dated August 1987. Post-construction survey was not available to Geosyntec at the time of this evaluation. As a result, the actual steepness of the existing slopes could not be confirmed.

Stability was analyzed under static and seismic loading conditions. In the analysis, 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 pounds per square foot (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 Shawville facility site of 0.146g (g is the gravitational acceleration) and seismic coefficient of 0.073. Details on the derivation of these parameters are included in Appendix D (i.e., Stability Analysis).

The groundwater table in the area is connected to the water level of the Susquehanna River located to the north of the ponds, which is estimated to be at elevation 1,044 ft-msl. In the analysis, a groundwater table at elevation 1044 ft-msl was assigned to the foundation soils.

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 – Shawville Power Station
Shawville, Pennsylvania

Embankment Slopes	Loading Conditions	Failure Mode	Calculated F.S.	Target F.S
Case 1 (assume silt, i.e., ML, in pre-existing soil berm)	Static	Circular	1.51	1.5
		Block	1.59	1.5
	Seismic	Circular	1.27	1.2
		Block	1.33	1.2
Case 2 (assume clay, i.e. CL, in pre-existing soil berm)	Static	Circular	1.53	1.5
		Block	1.60	1.5
	Seismic	Circular	1.28	1.2
		Block	1.34	1.2

CONDITION ASSESSMENT

As presented in the Background section of this letter, the preliminary EPA report provided a Hazard Potential classification of "Low" to the BAPs. Thus, Geosyntec's evaluation focuses on the conditional assessment. A summary of EPA's definitions for each ratings is provided below, followed by a summary of Geosyntec's own data collection, visual inspection, and review of existing documents to support our opinion regarding the appropriate classification.

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.*

- *<u>Fair:</u> 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.*

- *<u>Poor:</u> 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.*

- *<u>Unsatisfactory:</u> 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 18 December 2012 site visit, Geosyntec personnel met with the representatives of NRG to identify and review available BAP design data and historical geotechnical records. Monitoring well logs and design drawings for the BAPs were made available to Geosyntec for review, and this information was used in the preparation of this letter report.

The Condition Assessment results provided in the draft EPA report are "Fair" for both ponds. Based on Geosyntec's past experience, the "Fair" rating is generally due to the lack of stability analysis and documentation of geotechnical information. Now that such information has been provided in this report and the embankments of the ponds showed satisfactory factors of safety in the slope stability evaluation (see Table 2), it is our opinion that that the Condition Assessment result of the BAP ponds at Shawville can be improved from "Fair" to "Satisfactory" .

CONCLUSIONS

Based on the assessment described in this letter, Geosyntec recommends that the Condition Assessment result is "Satisfactory". Other than a ground-run survey to verify the dimensions (i.e., slope) of the embankments, no other action is recommended at this time.

We would be happy to discuss with you if EPA has additional comments or requires any immediate actions.

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,

Chunling Li, Ph. D, P.E.
Project 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 and Laboratory Data
Appendix D – Stability Analysis

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

FIGURES

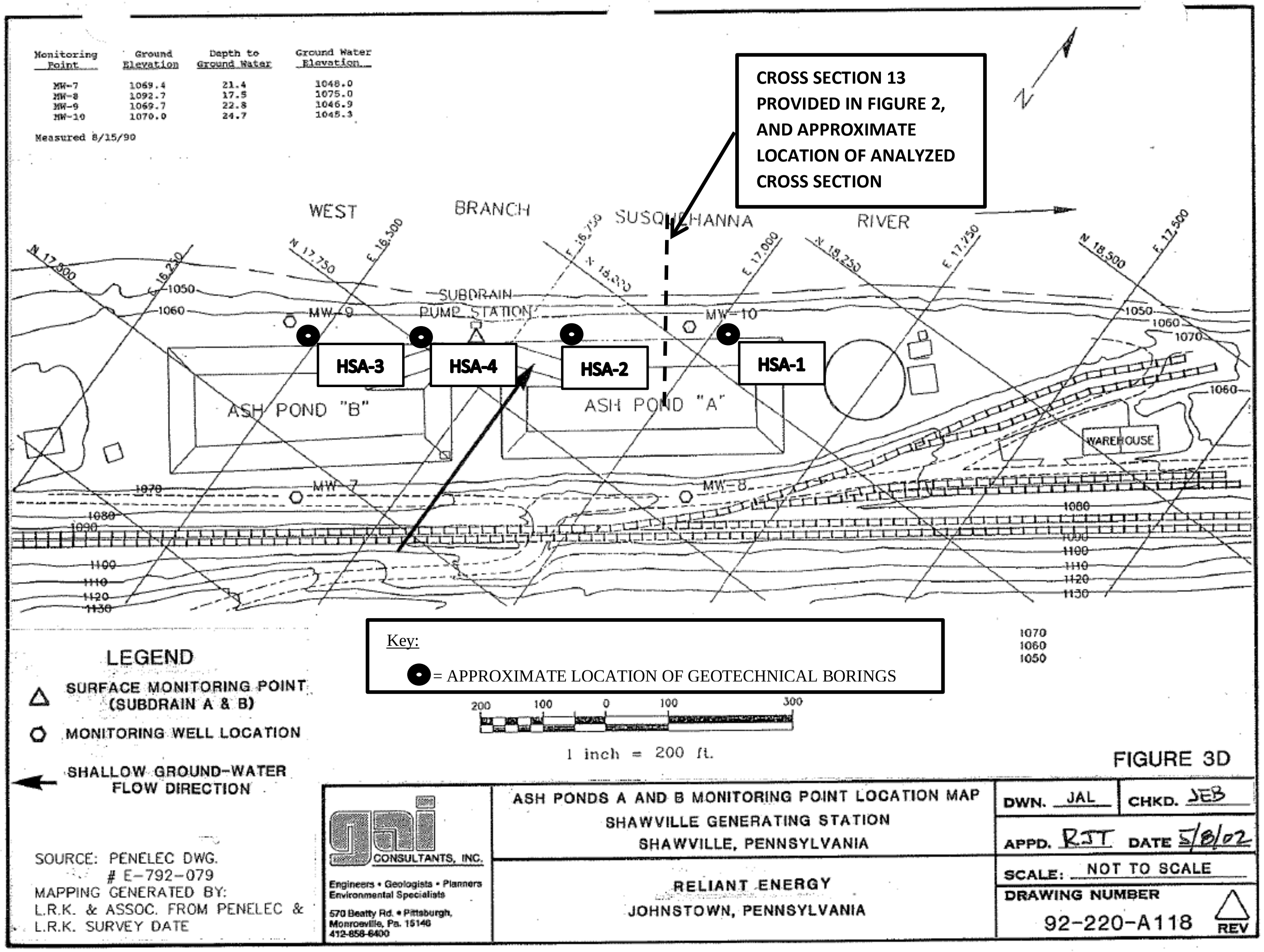

Figure 1 – Geotechnical Boring Locations

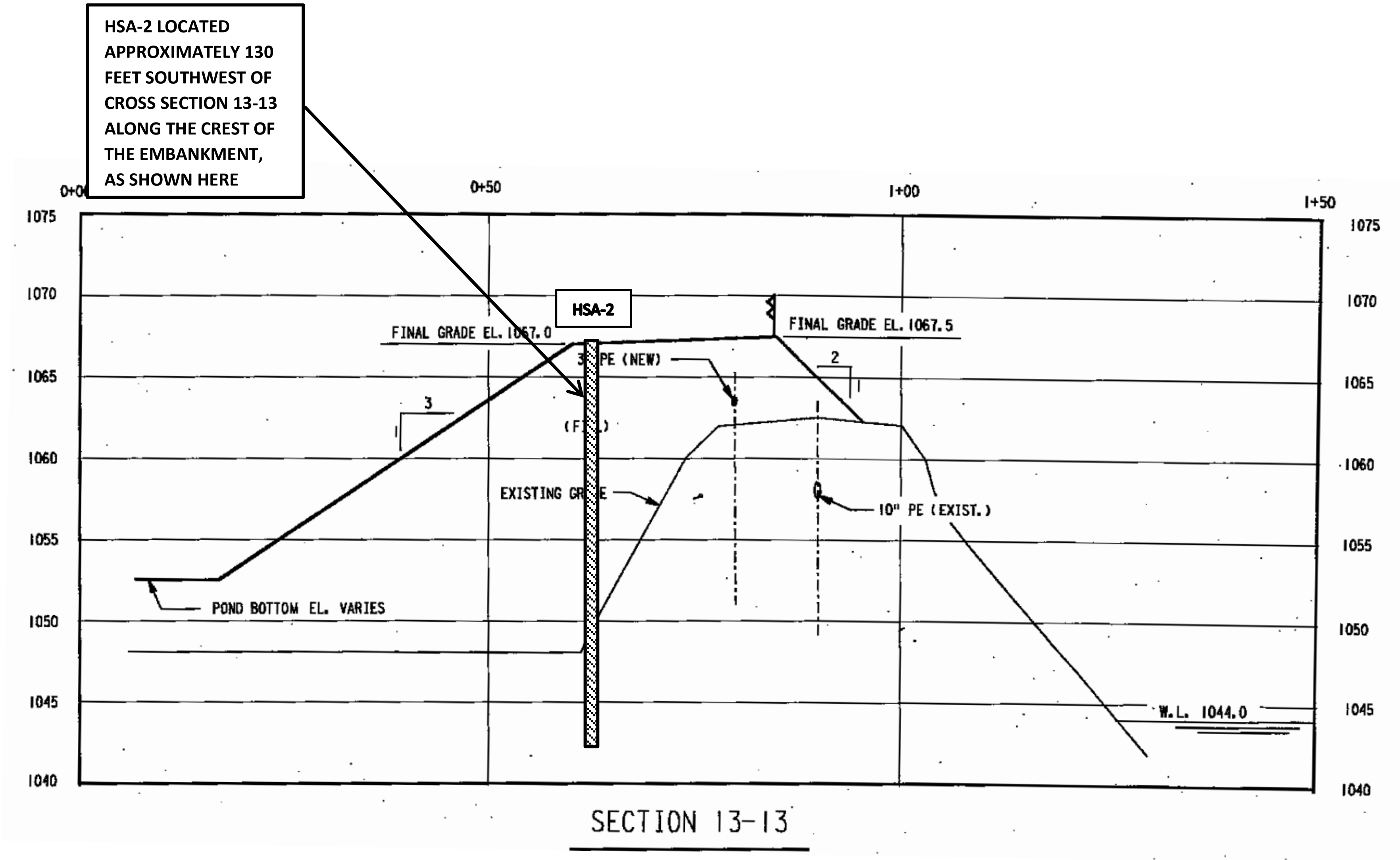

Figure 2 – Cross Section 13-13 of the Northwest Berm of Ash Pond A

APPENDIX A

PHOTOGRAPHIC RECORD

GEOSYNTEC CONSULTANTS Photographic Record			
Client:	NRG, Inc.	Project Number:	ME0903
Site Name:	Shawville Power Station	Site Location:	Shawville, Pennsylvania

Photograph 1

Date: 12/18/2012

Location: Ash Pond A

Ash Pond A as viewed from the north corner, looking south. The valve structure for the emergency overflow pipe is visible in the foreground.

Photograph 2

Date: 12/18/2012

Location: Ash Pond A

View of the northeast berm of Ash Pond A. Walkway on the right leads to the decant structure. The water treatment facility appears on the left side of the photo.

GEOSYNTEC CONSULTANTS Photographic Record			
Client:	NRG, Inc.	Project Number:	ME0903
Site Name:	Shawville Power Station	Site Location:	Shawville, Pennsylvania

Photograph 3

Date: 12/18/2012

Location: Ash Pond A

Picture of the dividing berm between Ash Pond A and Ash Pond B. Picture is from the northwest berm of Ash Pond A, looking south.

Photograph 4

Date: 12/18/2012

Location: Ash Pond B

Picture of the dividing berm from the Ash Pond B side, looking southeast.

GEOSYNTEC CONSULTANTS
Photographic Record

Client:	NRG, Inc.	Project Number:	ME0903
Site Name:	Shawville Power Station	Site Location:	Shawville, Pennsylvania

Photograph 5

Date: 12/18/2012

Location: River Bank

Outer slope (i.e. northwest slope) of Ash Pond A, looking southwest along the bank of the West Branch Susquehanna River. Large boulders, trees, and grass line the slopes.

Photograph 6

Date: 12/18/2012

Location: Ash Pond B

View of the southwest slope of Ash Pond B, looking southeast. Berm is relatively short (less than ten feet high, and a natural counterweight exists to the other side of the incised ditch shown here.

GEOSYNTEC CONSULTANTS
Photographic Record

Client: NRG, Inc.		Project Number: ME0903	
Site Name: Shawville Power Station		Site Location: Shawville, Pennsylvania	

Photograph 5

Date: 12/18/2012

Location: River Bank

Outer slope (i.e. northwest slope) of Ash Pond B, looking northeast along the bank of the West Branch Susquehanna River. Boulders, trees, and grass line the slopes.

Photograph 6

Date: 12/18/2012

Location: South Slope

Outer slope (i.e. northwest slope) of Ash Pond B, looking southwest along the bank of the West Branch Susquehanna River. Large boulders, trees, and grass line the slopes.

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 AND LABORATORY DATA

BORING LOG

Geosyntec consultants
engineers | scientists | innovators

Boring ID	HSA-1		
Logged By	W. Tyner	Elevation	N/A
Date	12/18/2012	Northing	N/A
Project No.	ME0903	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 / Mike Williams	Cave Depth	N/A
Rig Type	Track Mounted HSA	Depth to Water	25 feet BGS

Elevation	Depth (ft)	Blow Counts				N- Value	Material Description	USCS	Sample No.	Recovery
	0-2	-	-	-	-		Gravel road base with well graded sand	GW/SW	1	
	2-4	-	-	-	-					
	4-6	4	6	8	8	14	Yellowish orange fine silt (hit geotextile in anchor trench)	ML	2	50%
	6-8	4	8	20	20	28	Yellowish orange to greenish gray silt	ML	3	
	8-10	4	10	13	13	23	Yellowish orange to greenish gray silt with 5% gravel	ML	4	100%
	10-12	9	10	8	8	18	Light brown sandy silt with a ~2 inch thick layer of crushed limerock at about 11 feet BGS	ML	5	70%
	12-14	4	4	6	5	10	Transitioning to brown to light gray plastic silt with 25% gravel	MH/GP	6	75%
	14-16	7	5	4	4	9	Brown plastic silt with some caved in material in the top of the split-spoon (poor recovery)	ML/MH	7	30%
	16-18	4	3	4	4	7	Brown clayey sand with 5% gravel	SC	8	100%
	18-20	4	3	4	3	7	Crushed sandstone	Rock	9	10%
	20-22	4	6	6	5	12	Brown clayey sand with gravel (sandstone)	SC	10	60%
	22-24	5	5	4	2	9	Loamy soil with 15% gravel (moist - groundwater at approximately 25 feet BGS)	Loam	11	30%
	24-26	2	4	5	4	9	Silty fine sand - slightly plastic Boring terminated at 26 feet BGS. Backfilled with cuttings and three buckets of coated bentonite pellets.	SM/ML	12	100%

BORING LOG

Geosyntec consultants
engineers | scientists | innovators

Boring ID	HSA-2		
Logged By	W. Tyner	Elevation	N/A
Date	12/18/2012	Northing	N/A
Project No.	ME0903	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 / Mike Williams	Cave Depth	N/A
Rig Type	Track Mounted HSA	Depth to Water	22 feet BGS

Elevation	Depth (ft)	Blow Counts				N- Value	Material Description	USCS	Sample No.	Recovery
	0-2	-	-	-	-		Gravel road base and fine silt for first four feet of augering (as witnessed in cuttings - no samples collected)			
	2-4	-	-	-	-					
	4-6	4	6	10	10	16	Yellowish orange sandy silt and gravel	SM	1	50%
	6-8	14	18	18	18	36	silt with 35% gravel	GP-SM	2	100%
	8-10	12	11	11	14	22	Silty sand with 1/2" diameter gravel pieces (~50% gravel)	GP-SM	3	70%
	10-12	8	11	7	5	18	Silty sand with 1/2" diameter gravel pieces (~50% gravel)	GP-SM	4	50%
	12-14	3	3	3	2	6	Transitions to silty to clayer sand at 13 feet BGS	ML-SC	5	40%
	14-16	8	5	8	10	13	Silt transitioning to crushed sandstone at 15.5 feet BGS	ML-Rock	6	50%
	16-18	4	4	6	8	10	Clayey sand transitioning back to crushed sandstone	SC-Rock	7	60%
	18-20	8	8	5	3	13	Crushed sandstone transitions to loamy soil	Loam	8	50%
	20-22	6	3	2	4	5	Brown sandy clay	CL	9	50%
	22-24	2	1	1	2	2	Brown sandy clay below water table	CL	10	40%
	24-26	3	3	2	3	5	Sandy Clay Boring terminated at 26 feet BGS and backfilled with cuttings and three buckets of coated bentonite pellets.	CL	11	60%
							Lab Results for composite sample from 20' - 26' BGS: LL = 33; PL = 19; 61.7% Fines; 38.3% Sand			

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BORING LOG

Boring ID	HSA-3		
Logged By	W. Tyner	Elevation	N/A
Date	12/18/2012	Northing	N/A
Project No.	ME0903	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 / Mike Williams	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	-	-	-	-		Gravel road base and fine silt for first four feet of augering (as witnessed in cuttings - no samples collected)			
	2-4	-	-	-	-					
	4-6	8	9	16	5	25	Gravelly silt	GP	1	50%
	6-8	4	5	45	12	50	Gravelly silt, transitions to crushed sandstone at 7.5 ft BGS	GP-SM	2	40%
	8-10	15	12	15	7	27	Dry crushed sandstone with some silt	GP	3	50%
	10-12	6	5	4	6	9	Crushed sandstone transitions to sandy clay at 11 ft BGS	SC-CL	4	40%
	12-14	2	7	8	5	15	Clayey sand	SC-CL	5	80%
	14-16	4	2	6	6	8	Silty fine sand (brown)	SM	6	25%
	16-18	4	5	6	7	11	Silty fine sand	SM	7	75%
	18-20	6	>30	27	19	>57	Transition at 18.5 ft BGS to crushed sandstone with silt	GP	8	75%
	20-22	6	9	14	14	23	Brown silt	ML	9	50%
	22-24	10	13	16	20	29	Brown silt with 15% gravel	ML	10	60%
	24-26	9	10	13	13	23	Gray silt with 15% gravel	ML	11	80%
	26-28	10	12	14	12	26	Gray silty sand	SM	12	90%
	28-30	11	25	26	50	51	Sandstone at 29.5 feet BGS (no groundwater encountered) Boring terminated at 30 ft BGS. Backfilled with cutting and four buckets of coated bentonite pellets.			

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BORING LOG

Boring ID	HSA-4		
Logged By	W. Tyner	Elevation	N/A
Date	12/18/2012	Northing	N/A
Project No.	ME0903	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 / Mike Williams	Cave Depth	N/A
Rig Type	Track Mounted HSA	Depth to Water	*25 feet (possibly perched)*

Elevation	Depth (ft)	Blow Counts				N- Value	Material Description	USCS	Sample No.	Recovery
	0-2 2-4	- -	- -	- -	- -		Gravel road base and fine silt for first four feet of augering (as witnessed in cuttings - no samples collected)			
	4-6	7	10	13	11	23	Yellowish orange silt with 15% gravel	SM	1	90%
	9-11	2	4	4	3	8	Mix of silt with 10% gravel, interspersed with gravel from shale and sandstone	ML	2	40%
	14-16	8	10	8	6	18	Brown silt with 10% gravel transitioning to sandstone at 15 feet BGS	ML	3	50%
	19-21	7	7	6	4	13	Limerock gravel	GP	4	10%
	24-26	1	4	9	9	13	Sandstone at 25.5 feet BGS with what appears to be perched water just above the stone. Below the sandstone (bottom of spoon), is a tight gray silt that appears to be dry.	ML/ Rock/ ML	5	
							Possible groundwater (maybe perched) at 25 feet BGS. Terminated boring at 26 feet BGS and backfilled with cuttings and four buckets of coated bentonite pellets.			

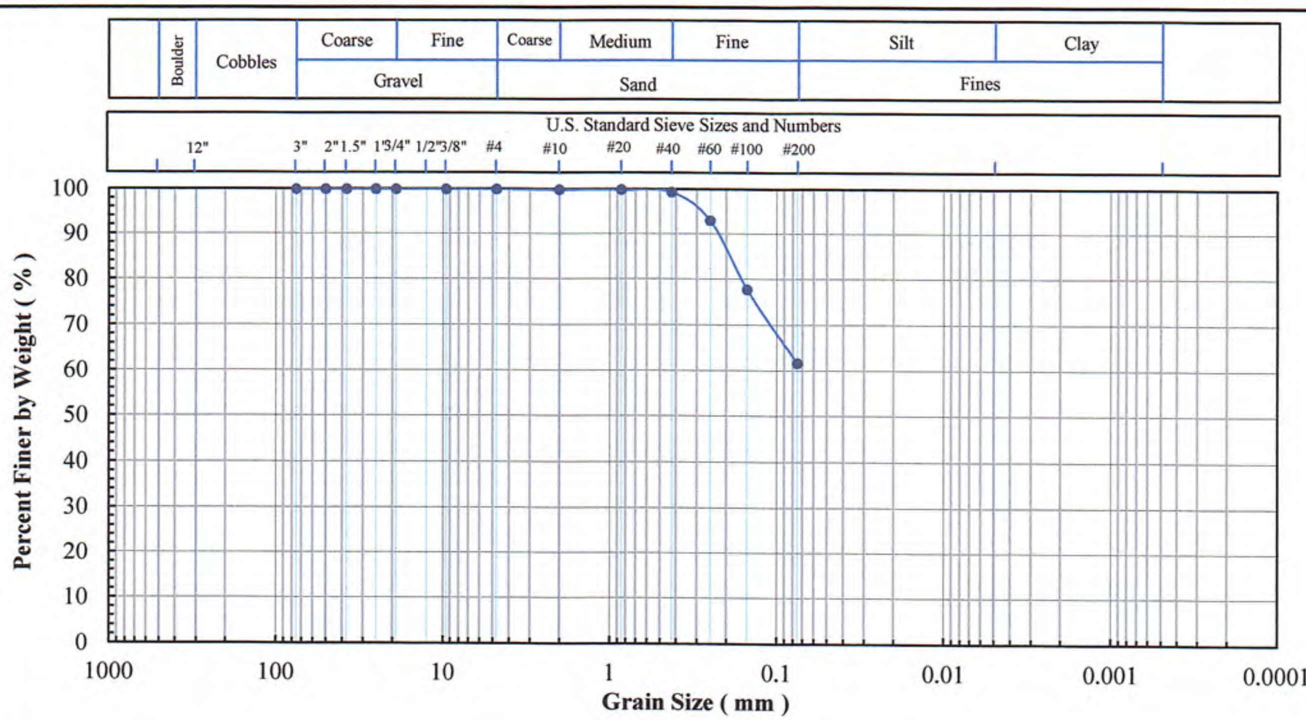
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
953 Forrest Street, Roswell, Georgia 30075
Tel: (770) 910 7537 Fax: (770) 910 7538

Project Name:	Shawville Ash Ponds
Project No:	580
Client Sample ID:	HSA-2 (20-26')
Lab Sample No:	13A025

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



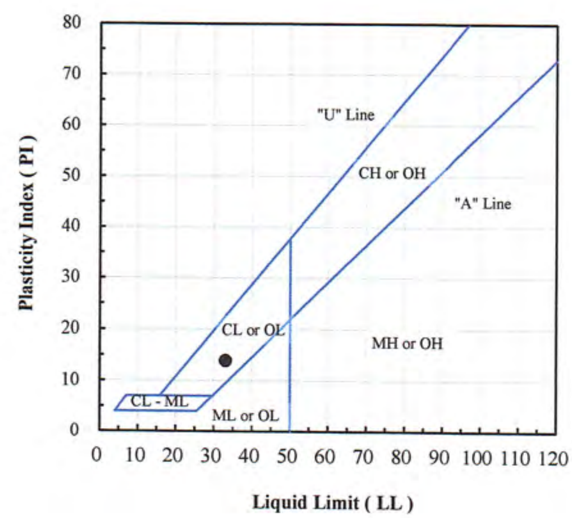
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.9
#20	0.850	99.9
#40	0.425	99.4
#60	0.250	93.0
#100	0.150	77.7
#200	0.075	61.7

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	38.3
Fines (%):	61.7
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
HSA-2 (20-26')	13A025	24.9	61.7	33	19	14	CL - Sandy lean clay

Note(s):

1-14-13
NJB

APPENDIX D

STABILITY ANALYSIS

Geosyntec
consultants

COMPUTATION COVER SHEET

Client: NRG **Project:** Shawville BAP Stability **Project/Proposal #:** ME0903 **Task #:** 02

TITLE OF COMPUTATIONS Stability Analysis for BAPs at Shawville Power Station

COMPUTATIONS BY:
Signature [signature] 2/21/2013
DATE
Printed Name Chunling Li
and Title Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY:
(Peer Reviewer)
Signature [signature] 2/21/2013
DATE
Printed Name Lucas de Melo
and Title Senior Engineer

COMPUTATIONS CHECKED BY:
Signature [signature] 2/21/2013
DATE
Printed Name Lucas de Melo
and Title Senior Engineer

COMPUTATIONS BACKCHECKED BY:
(Originator)
Signature [signature] 2/21/2013
DATE
Printed Name Chunling Li
and Title Engineer

APPROVED BY:
(PM or Designate)
Signature [signature] 2/21/2013
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 ASH POND AT SHAWVILLE 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 Shawville Power Station in Shawville, Pennsylvania. A slope stability analysis is conducted as a part of the review. The details of this analysis are presented in this calculation package.

2. BACKGROUND

Currently, there are two BAPs (denoted as Ash Pond A and Ash Pond B) at the Shawville facility. The embankments for Ash Pond A were constructed in prior to 1957, and later vertically raised to the current elevation in the late 1980's (placed into service in October 1989). The embankments for Ash Pond B were constructed concurrent with the vertical expansion of the Ash Pond A embankments. A liner system and decanting structures were also installed at the time of expansion. As a part of this pond stability assessment project, Geosyntec drilled four borings at the site, including two borings at each one of the ponds. The goal of this investigation was to collect samples and characterize the subsurface soils. Borings were advanced from the interior edge of the access road at the top of the pond embankments to a depth of approximately 26 to 30 feet at locations shown in Figure 1. The pond geometry was obtained from drawings by prepared Gilbert/Commonwealth, Inc. dated August 1987, and made available by NRG.

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 approximate mid-point of the northern embankment of Ash Pond A, as shown in Figure 1.

This section was selected because the embankment height at this location is the highest and has the weakest foundation soil layer based on standard penetration test blow counts (SPT-N) obtained during the field investigation (approximately 2 blows/ft.). Therefore, the selected analysis location at Ash Pond A likely represents the most critical condition.

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 Shawville facility site is estimated to be 0.091g (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 to account for the stiffness of soil material overlying the bedrock, which is represented by a site classification in the International Building Code. Using the International Building Code (IBC) 2006 soil classification table, the Shawville lithology classifies as a site classification D (stiff soil profile). This classification is selected based on the average standard penetration resistance (N-value) within a upper 100 foot 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. Based on the site coefficient and the PGA in rock, the PGA in soil site is estimated to be 0.146g.

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 0.146g, a seismic coefficient of 0.073 was used in this analysis.

6. STRATIGRAPHY AND MATERIAL PARAMETERS

The stratigraphy and material parameters used for the slope stability analysis are selected based on the results of boring investigation, which are described below:

Fill

The embankment is constructed by enlarging a pre-existing berm using fill material. Based on the boring logs, it appears that the fill materials in the upper and lower portion of the berm have different material properties.

The fill material in the upper 10 to 12 ft is generally granular and contains significant portion of gravel. This material generally classifies as poorly graded gravel (GP) or gravelly silty sand (SM-GP), according to the unified soil classification system (USCS). The SPT-N ranges from 16 to 50 blows/ft, with an average of 27 blows/ft. Using the empirical correlations between SPT-N and friction angle [Kulhawy and Mayne, 1990] (see Figure 5), the upper portion of the fill material is assumed to have a friction angle of 36 degrees and no cohesion.

The lower portion of the fill material generally contains some fines and is typically classified as silt (ML), clayey sand (SC) or silty sand (SM). The SPT-N values are typically within the range of 6 to 13 blows/ft. This material is assumed to have a friction angle of 32 degree, using the empirical correlation with SPT-N. The assumed friction angles are also comparable with the typical material properties of compacted soil provided by NAVFAC (see Figure 6).

Pre-Existing Embankment (prior to pond expansion)

Due to the alignment of the pre-existing embankment and the location of the utilities, it is unclear whether soil data from the pre-existing embankment in Ash Pond A was obtained. The cross section provided in Figure 2 depicts the typical location of the borings in relation to pre-existing embankment and the underground power lines that are located within the embankments. As shown in this cross section, the borings may have missed the inside toe of the pre-existing berm, but likely encountered the native material that formed the bottom of the unlined ash pond that later became Ash Pond A. Because the pond was constructed as a combination diked/incised pond, it is assumed that the pre-existing embankment was constructed using the material removed from the excavation of the pond. Based on the boring logs for HSA-1 and HSA-2, the native material is likely to be either a sandy clay (CL) or low-plasticity silt (ML). Hence, Geosyntec considered two different soil properties for the pre-existing soil berm in the analyses:

(i) the soil in the pre-existing berm is considered a low-plasticity silt (ML) based on the information collected from HSA-1. The SPT blow counts ranged from 7 to 28 (blow/ft), with an average of 15 blows/ft.

(ii) the soil in the pre-existing berm berm is conservatively assumed to consist of low-plasticity clay, with an SPT-N of 5 blows/ft (i.e., lower range of SPT-N found in the fill material).

The material properties for the silt (i.e., first scenario) are selected based on typical material properties for compacted soil provided by NAVFAC (See Figure 6). Additionally, the typical undrained shear strength provided is verified using the empirical correlations with SPT-N value [Kulhawy and Wayne, 1990]:

$$S_u/P_a = 0.06\ \mathrm{N}$$

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 5 and 15 blows/ft, the undrained shear strength is estimated to be 600 and 1,900 psf, which are lower or comparable with the typical value provided by NAVFAC.

Foundation Soil

During the boring investigation, the soils underlying the pond embankment is consisted of clayey sand (SC), silt (ML) or sandy clay (CL). A composite soil sample composed of soils collected at HAS-2 boring between depths of 10 and 16 feet below ground surface (ft-bgs) was sent to the laboratory and classified according to the Unified Soil Classification system. Laboratory test results show that the material is a CL with a plasticity index (PI) of 14 (Attachment 1). The SPT-N of that material are generally between 2 and 9 blows/ft, and may be greater than 20 blows/ft at locations close to bedrock (HSA-3), where crushed sandstone was encountered. Using the lower bound of SPT-N, the foundation clay is assumed to have an undrained shear strength of 250 psf. Under drained condition, this clay is conservatively assumed to be normally-consolidated with a friction angle of 33.5, estimated using the empirical correlation between critical void ratio friction angle and plasticity index (see Figure 7). The cohesion of the foundation soil is conservatively neglected in this analysis.

Bedrock

The bedrock present at the site was estimated to be sandstone which typically has very high shear strength. However, the depth to the sound bedrock was not confirmed by the borings. However, the material at a depth greater than 30 ft consist of rock pieces and silt/clay, which is considered to derived from rock weathering process. For this analysis, the weathered bedrock was conservatively assumed to have a friction angle of 25 degree and a cohesion of 500 psf.

Table 1 summaries the material properties used in the slope stability analysis. The analyzed cross section is shown in Figure 8.

Table 1. Material Properties Used in Slope Stability Analyses

Material	Moist Unit Weight (lb/ft^3)	Saturated Unit Weight (lb/ft^3)	Drained Shear Strength		Undrained Shear Strength (psf)
			Cohesion (psf)	Friction Angle (deg)	
Fill (upper)	120	-	0	36	-
Fill (lower)	120	-	0	32	-
Pre-Existing Berm (silt)	125	-	190	32	600
Pre-Existing Berm (clay)	125	-	270	28	1,900
Foundation	125	130	0	33.5	250
Weathered rock	135	135	500	25	-

7. GROUNDWATER CONDITION

The groundwater table in the area is connected to the water level of the Susquehanna River located to the north of the ponds, which is estimated to be at elevation 1,044 ft-msl. In the analysis, a groundwater table at elevation 1044 ft-msl was assigned to the foundation soils.

For this analysis, the water level in the pond is assumed to be at elevation 1,064 ft-msl, which is the high water level as presented in the drawings by prepared Gilbert/Commonwealth, Inc . The water in the lined pond is modeled as material with no shear strength in the analysis.

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.

9. 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

Case of Analysis	Loading Conditions	Failure Mode	Calculated F.S.	Target F.S.
Case 1 (assume silt in pre-existing soil berm)	Static	Circular	1.51	1.5
		Block	1.59	1.5
	Seismic	Circular	1.27	1.2
		Block	1.33	1.2
Case 2 (assume clay in pre-existing soil berm)	Static	Circular	1.53	1.5
		Block	1.60	1.5
	Seismic	Circular	1.28	1.2
		Block	1.34	1.2

10. SUMMARY

The stability of the two BAPs at the Shawville facility was evaluated for several scenarios. Based on material properties derived from empirical correlations or typical material properties, the results of these analyses show factors of safety exceeding the minimum recommended factors of safety. Thus, the two BAPs at the Shawville facility are considered stable.

11. REFERENCES

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FIGURES

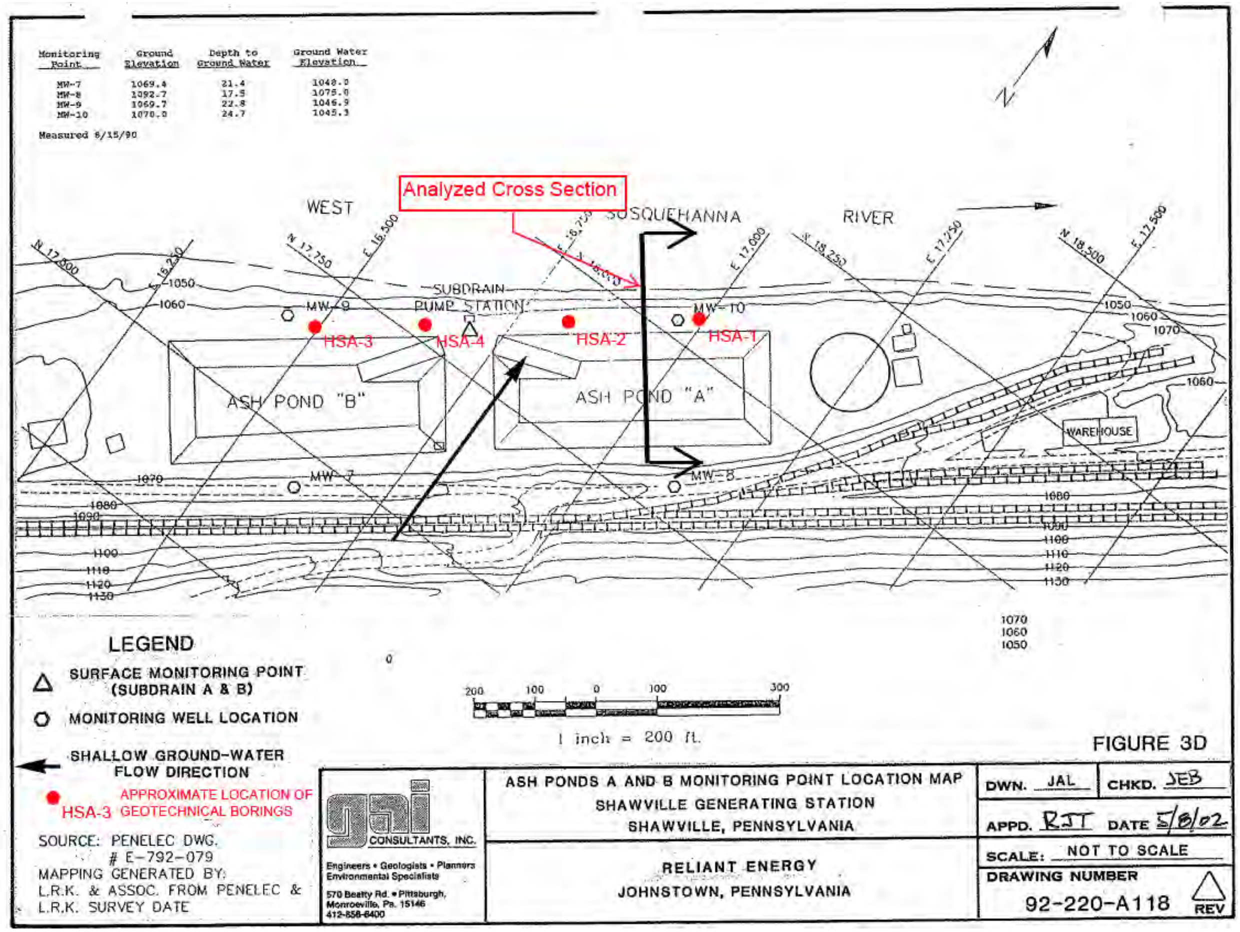
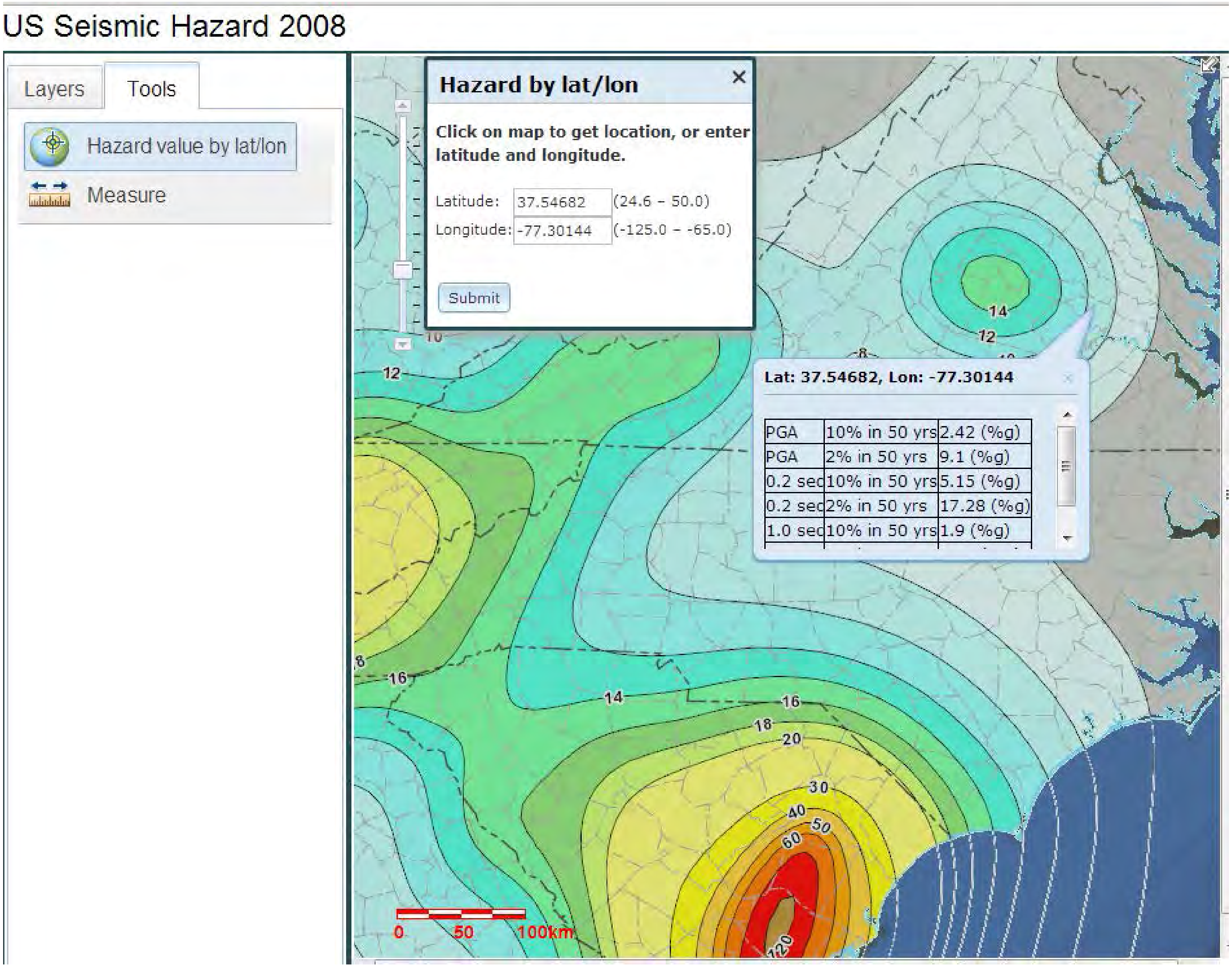


Figure 1. Location of Geotechnical Borings and Analyzed Cross Section



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

Table 4-3

N VERSUS $\bar{\phi}_{tc}$ RELATIONSHIPS

	N Value (blows/ft or 305 mm)	Relative Density	Approximate $\bar{\phi}_{tc}$ (degrees) (a)	(b)
	0 to 4	very loose	< 28	< 30
Fill (lower) →	4 to 10	loose	28 to 30	30 to 35
Fill (upper) →	10 to 30	medium	30 to 36	35 to 40
	30 to 50	dense	36 to 41	40 to 45
	> 50	very dense	> 41	> 45

a - Source: Peck, Hanson, and Thornburn (12), p. 310.
b - Source: Meyerhof (13), p. 17.

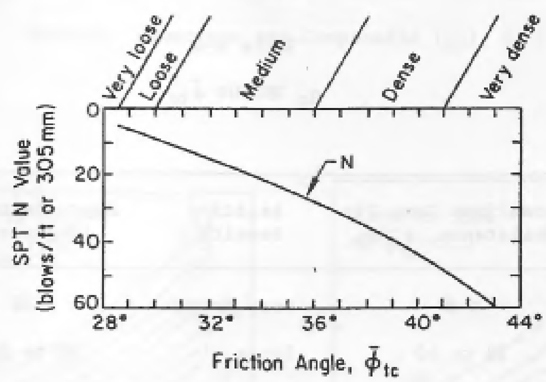


Figure 4-12. N versus $\bar{\phi}_{tc}$

Source: Peck, Hanson, and Thornburn (12), p. 310.

Reproduced from Kulhawy and Mayne [1990]

Figure 5 Empirical Correlation between SPT-N and Friction Angle

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: At 1.4 tsf (20 psi)	Typical Value of Compression: At 3.6 tsf (50 psi)	Typical Strength Characteristics: Cohesion (as compacted) psf	Typical Strength Characteristics: Cohesion (saturated) psf	Typical Strength Characteristics: PHI (Effective Stress Friction Angle Degrees)	Typical Strength Characteristics: Tan PHI	Typical Coefficient of Permeability ft/min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in
				Percent of Original Height								
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 6. Typical Shear Strength of Compacted Soils

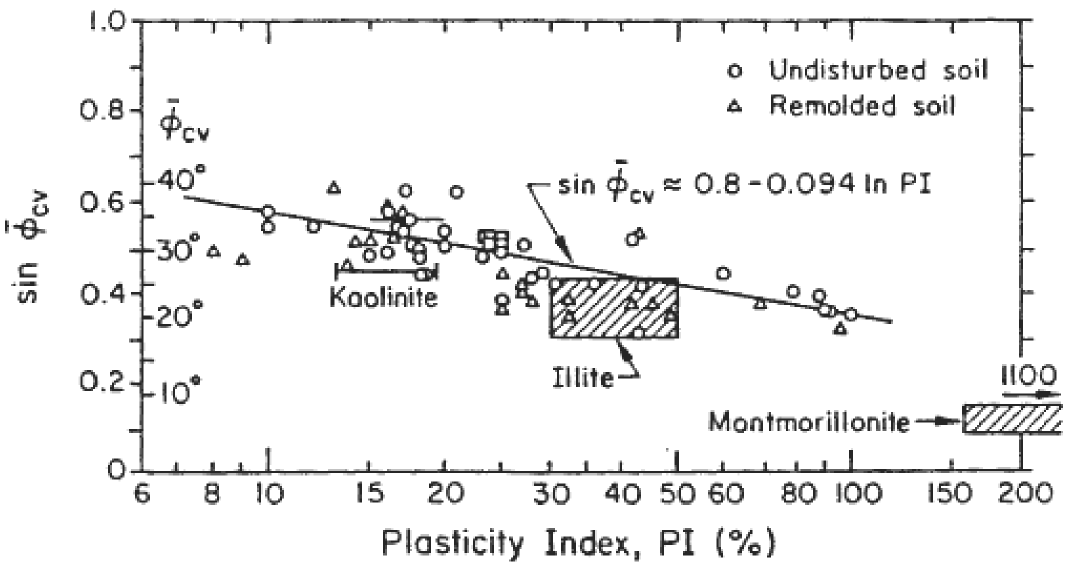


Figure 4-20. $\bar{\phi}_{cv}$ for NC Clays versus PI

Source: Mitchell (22), p. 284.

Reproduced from Kulhawy and Mayne [1990]

Figure 7. Empirical Correlations between Critical Void Ratio Friction Angle and Plasticity Index

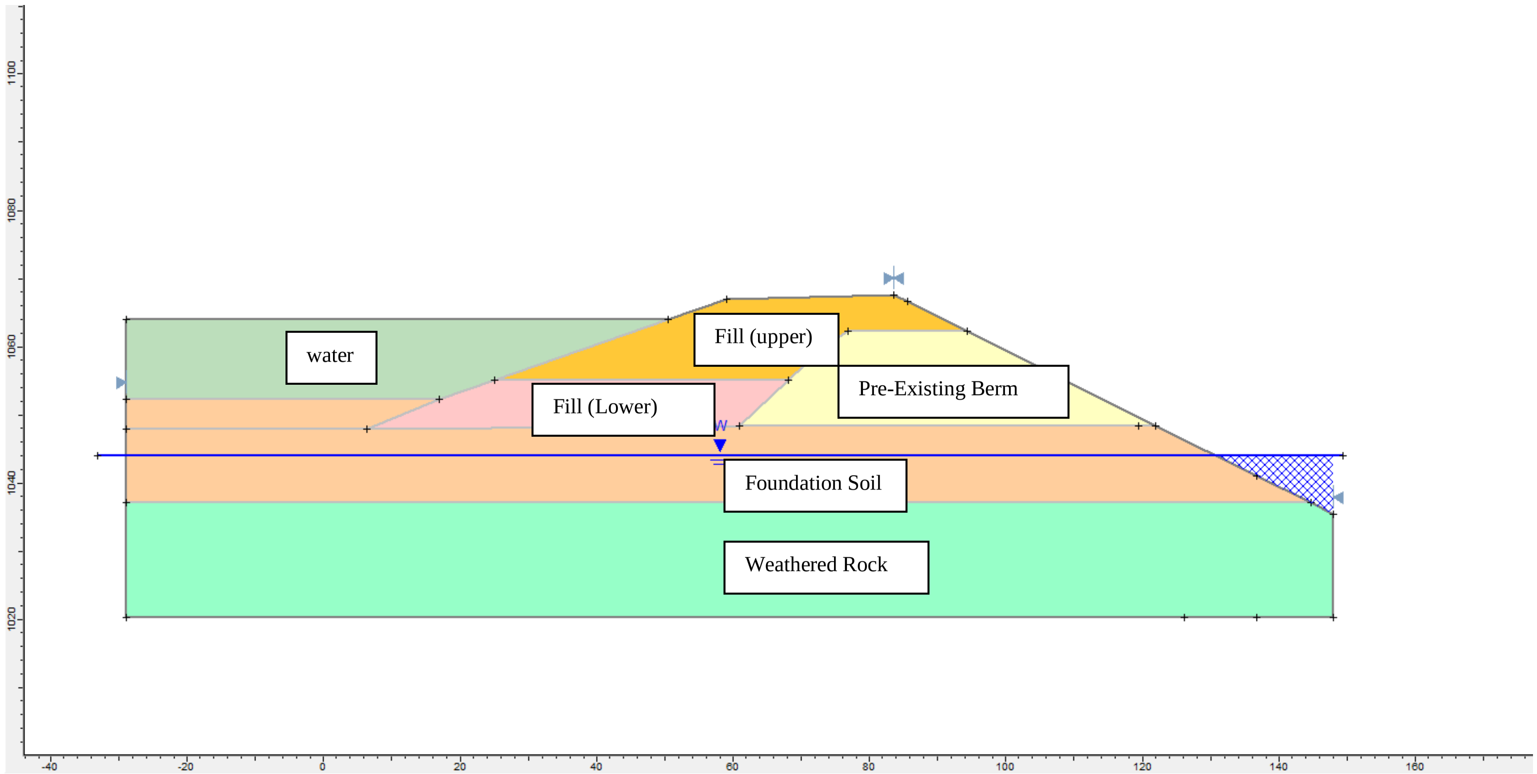


Figure 8. Analyzed Cross Section

Attachment 1

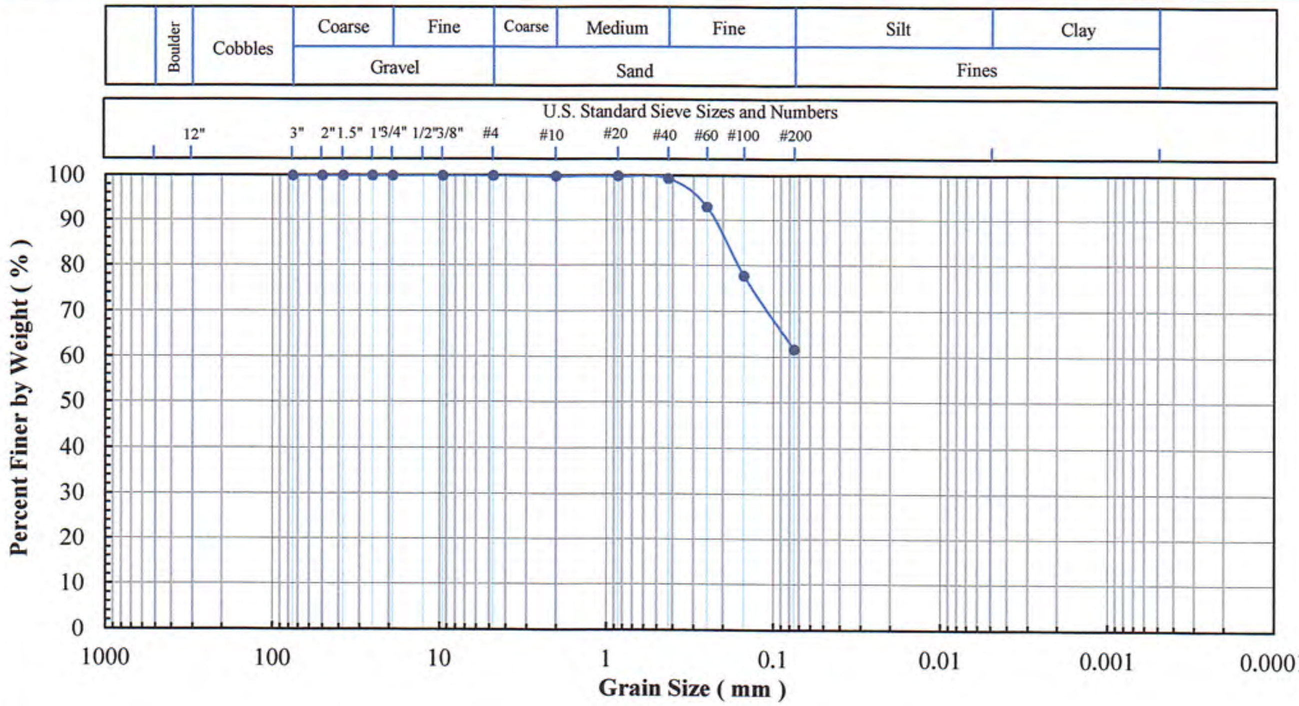
Laboratory Results

Excel Geotechnical Testing, Inc. "Excellence in Testing" 953 Forrest Street, Roswell, Georgia 30075 Tel: (770) 910 7537 Fax: (770) 910 7538	
Project Name:	Shawville Ash Ponds
Project No:	580
Client Sample ID:	HSA-2 (20-26')
Lab Sample No:	13A025

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



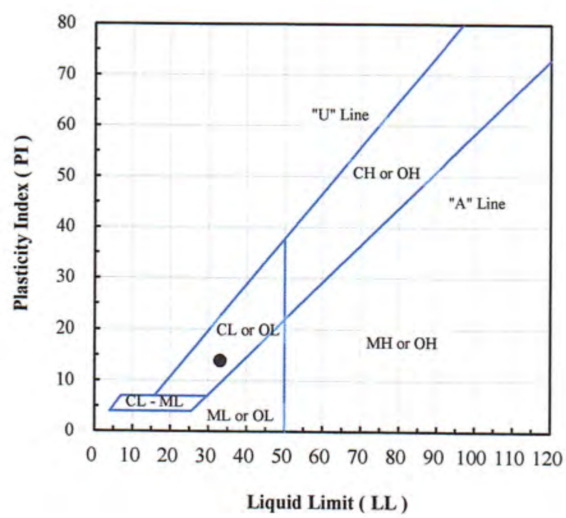
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.9
#20	0.850	99.9
#40	0.425	99.4
#60	0.250	93.0
#100	0.150	77.7
#200	0.075	61.7

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	38.3
Fines (%):	61.7
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



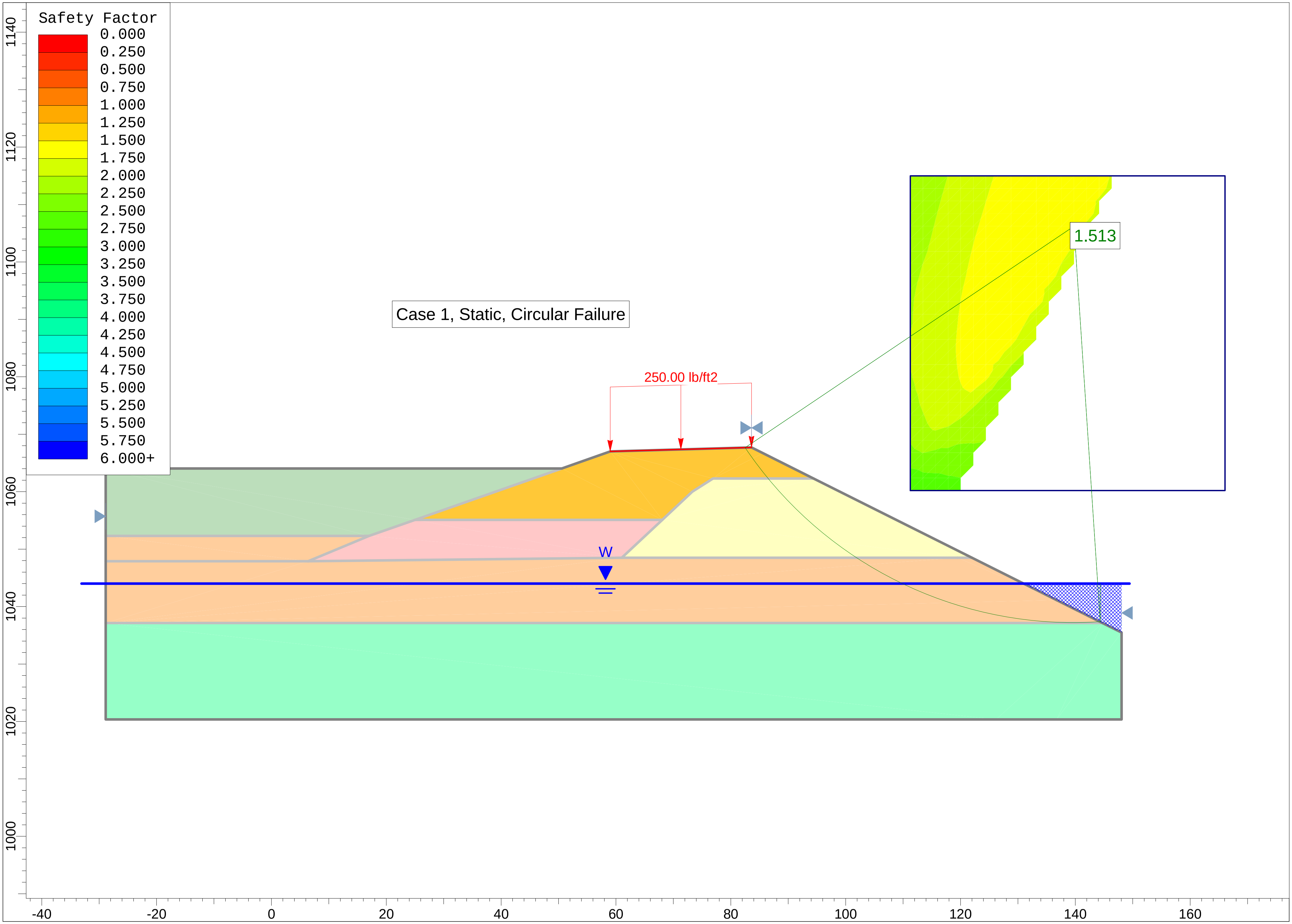
Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
HSA-2 (20-26')	13A025	24.9	61.7	33	19	14	CL - Sandy lean clay

Note(s):

1-14-13 NJR

Attachment 2

SLIDE Output


Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Case 1, Static, Circular Failure
250.00 lb/ft2
1.513
W
1140
1120
1100
1080
1060
1040
1020
1000
-40
-20
0
20
40
60
80
100
120
140
160

Slide Analysis Information

Document Name

File Name: shawville_circular.sli

Project Settings

Project Title:
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: On
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

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: 1

Loading

1 Distributed Load present:
Distributed Load Constant Distribution, Orientation: Vertical, Magnitude: 250 lb/ft2

Material Properties

Material: Previous Berm
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 190 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: water
Strength Type: No strength
Unit Weight: 62.4 lb/ft3

Material: Foundation soil
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 125 lb/ft3
Saturated Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 33.5 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (upper)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 37 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (lower)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: whethered rock
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 135 lb/ft3
Saturated Unit Weight: 135 lb/ft3
Cohesion: 500 psf
Friction Angle: 25 degrees
Water Surface: Water Table
Custom Hu value: 1

Global Minimums

Method: bishop simplified
FS: 1.512190
Center: 141.946, 1112.800
Radius: 75.655
Left Slip Surface Endpoint: 81.253, 1067.633
Right Slip Surface Endpoint: 144.615, 1037.193
Left Slope Intercept: 81.253 1067.633
Right Slope Intercept: 144.615 1044.006
Resisting Moment=2.54185e+006 lb-ft
Driving Moment=1.68091e+006 lb-ft

Method: janbu simplified
FS: 1.433130
Center: 133.180, 1097.460

Radius: 60.192
Left Slip Surface Endpoint: 80.903, 1067.623
Right Slip Surface Endpoint: 142.889, 1038.056
Left Slope Intercept: 80.903 1067.623
Right Slope Intercept: 142.889 1044.006
Resisting Horizontal Force=33545.3 lb
Driving Horizontal Force=23407.1 lb

Method: spencer
FS: 1.512860
Center: 139.754, 1106.226
Radius: 69.040
Left Slip Surface Endpoint: 82.484, 1067.668
Right Slip Surface Endpoint: 144.325, 1037.337
Left Slope Intercept: 82.484 1067.668
Right Slope Intercept: 144.325 1044.006
Resisting Moment=2.27075e+006 lb-ft
Driving Moment=1.50096e+006 lb-ft
Resisting Horizontal Force=28420.8 lb
Driving Horizontal Force=18786.2 lb

Valid / Invalid Surfaces

Method: bishop simplified
Number of Valid Surfaces: 3097
Number of Invalid Surfaces: 4339
Error Codes:
Error Code -101 reported for 16 surfaces
Error Code -103 reported for 19 surfaces
Error Code -115 reported for 14 surfaces
Error Code -1000 reported for 4290 surfaces

Method: janbu simplified
Number of Valid Surfaces: 3097
Number of Invalid Surfaces: 4339
Error Codes:
Error Code -101 reported for 16 surfaces
Error Code -103 reported for 19 surfaces
Error Code -115 reported for 14 surfaces
Error Code -1000 reported for 4290 surfaces

Method: spencer
Number of Valid Surfaces: 3088
Number of Invalid Surfaces: 4348
Error Codes:
Error Code -101 reported for 16 surfaces
Error Code -103 reported for 19 surfaces
Error Code -111 reported for 9 surfaces
Error Code -115 reported for 14 surfaces
Error Code -1000 reported for 4290 surfaces

Error Codes

The following errors were encountered during the computation:

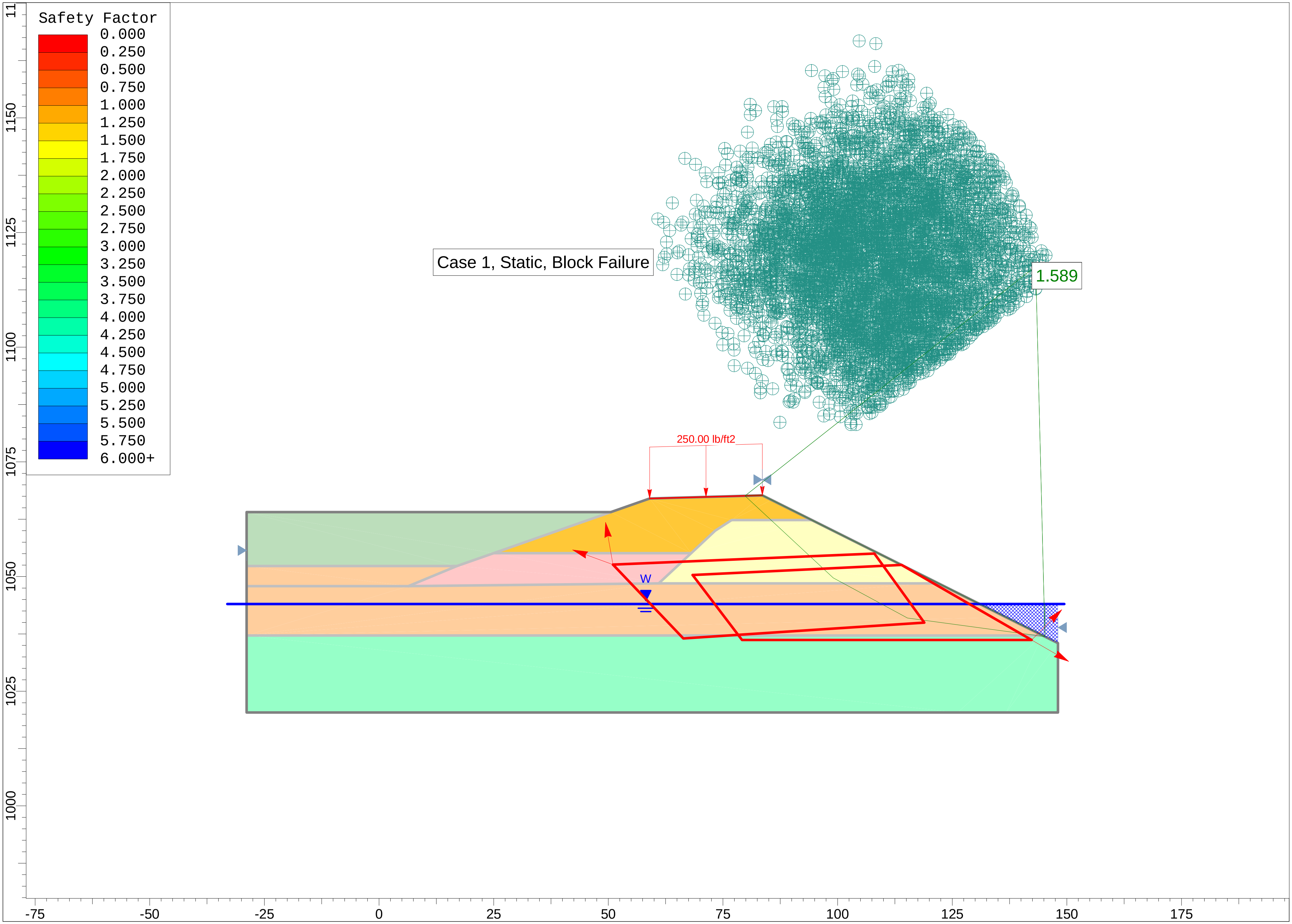
-101 = Only one (or zero) surface / slope intersections.

-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.

-111 = safety factor equation did not converge

-115 = Surface too shallow, below the minimum depth.

-1000 = No valid slip surfaces are generated at a grid center. Unable to draw a surface.



Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Case 1, Static, Block Failure
1.589
250.00 lb/ft2
W
1150
1125
1100
1075
1050
1025
1000
-75
-50
-25
0
25
50
75
100
125
150
175

Slide Analysis Information

Document Name

File Name: shawville_block.sli

Project Settings

Project Title:
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: On
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

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): 100
Left Projection Angle (End Angle): 160
Right Projection Angle (Start Angle): -30
Right Projection Angle (End Angle): 45
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

1 Distributed Load present:
Distributed Load Constant Distribution, Orientation: Vertical, Magnitude: 250 lb/ft2

Material Properties

Material: Previous Berm
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 190 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: water
Strength Type: No strength
Unit Weight: 62.4 lb/ft3

Material: Foundation soil
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 125 lb/ft3
Saturated Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 33.5 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (upper)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 37 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (lower)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: whethered rock
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 135 lb/ft3
Saturated Unit Weight: 135 lb/ft3
Cohesion: 500 psf
Friction Angle: 25 degrees
Water Surface: Water Table
Custom Hu value: 1

Global Minimums

Method: bishop simplified
FS: 1.567390
Axis Location: 141.797, 1114.331
Left Slip Surface Endpoint: 81.441, 1067.639
Right Slip Surface Endpoint: 142.937, 1038.031
Left Slope Intercept: 81.441 1067.639
Right Slope Intercept: 142.937 1044.006
Resisting Moment=2.41367e+006 lb-ft
Driving Moment=1.53993e+006 lb-ft

Method: janbu simplified

FS: 1.512330
Axis Location: 141.797, 1114.331
Left Slip Surface Endpoint: 81.441, 1067.639
Right Slip Surface Endpoint: 142.937, 1038.031
Left Slope Intercept: 81.441 1067.639
Right Slope Intercept: 142.937 1044.006
Resisting Horizontal Force=27132.9 lb
Driving Horizontal Force=17941.1 lb

Method: spencer
FS: 1.589190
Axis Location: 143.208, 1117.648
Left Slip Surface Endpoint: 79.807, 1067.592
Right Slip Surface Endpoint: 145.212, 1036.894
Left Slope Intercept: 79.807 1067.592
Right Slope Intercept: 145.212 1044.006
Resisting Moment=2.83683e+006 lb-ft
Driving Moment=1.78508e+006 lb-ft
Resisting Horizontal Force=30703 lb
Driving Horizontal Force=19319.9 lb

Valid / Invalid Surfaces

Method: bishop simplified
Number of Valid Surfaces: 4595
Number of Invalid Surfaces: 405
Error Codes:
Error Code -107 reported for 35 surfaces
Error Code -108 reported for 201 surfaces
Error Code -111 reported for 82 surfaces
Error Code -112 reported for 87 surfaces

Method: janbu simplified
Number of Valid Surfaces: 4357
Number of Invalid Surfaces: 643
Error Codes:
Error Code -107 reported for 35 surfaces
Error Code -108 reported for 405 surfaces
Error Code -111 reported for 133 surfaces
Error Code -112 reported for 70 surfaces

Method: spencer
Number of Valid Surfaces: 3160
Number of Invalid Surfaces: 1840
Error Codes:
Error Code -107 reported for 35 surfaces
Error Code -108 reported for 1439 surfaces
Error Code -111 reported for 276 surfaces
Error Code -112 reported for 90 surfaces

Error Codes

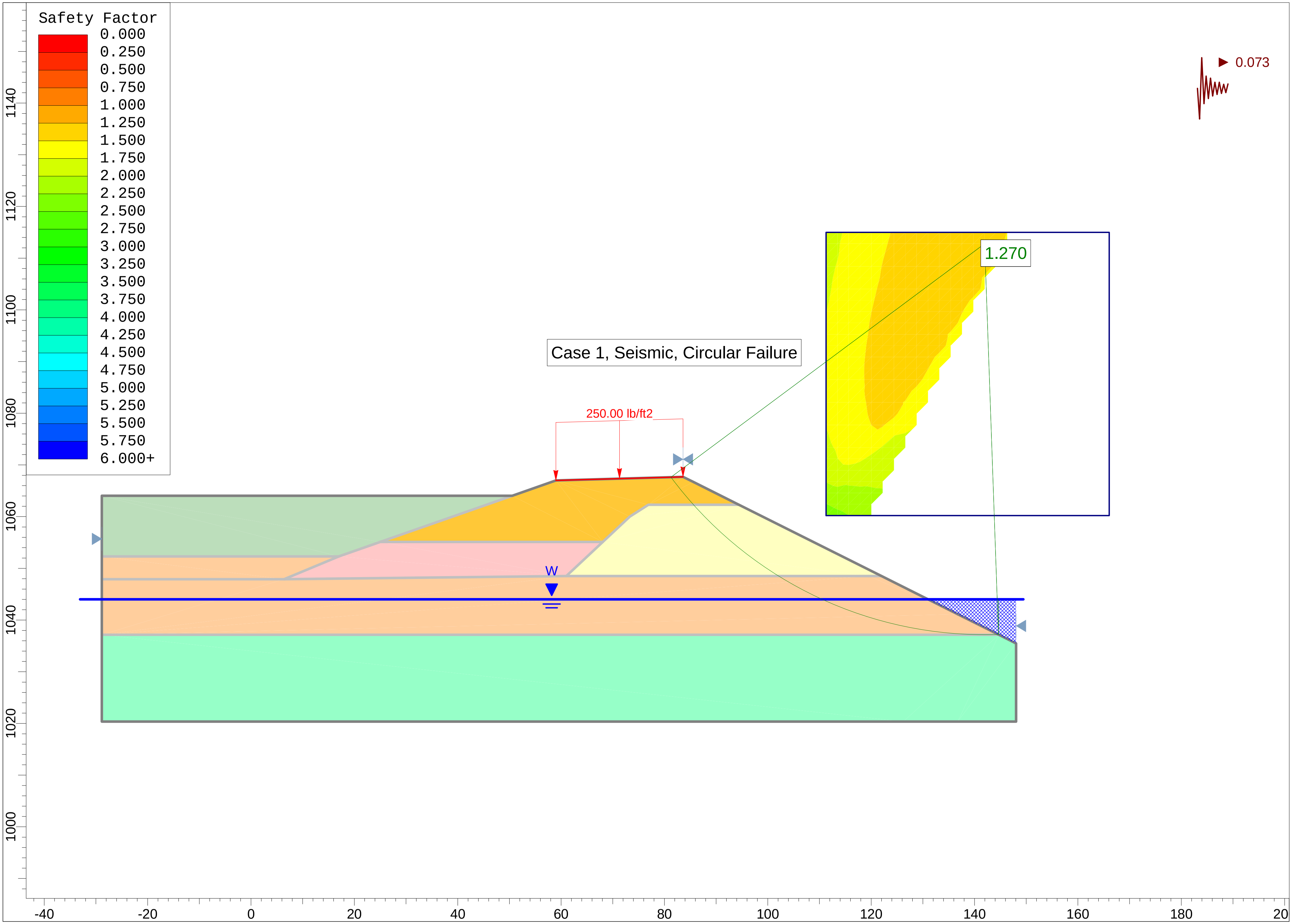
The following errors were encountered during the computation:

-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.


Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
0.073
1.270
Case 1, Seismic, Circular Failure
250.00 lb/ft2
W
1140
1120
1100
1080
1060
1040
1020
1000
-40
-20
0
20
40
60
80
100
120
140
160
180
20

Slide Analysis Information

Document Name

File Name: shawville_circular_seismic.sli

Project Settings

Project Title:
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: On
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

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: 1

Loading

Seismic Load Coefficient (Horizontal): 0.073
1 Distributed Load present:
Distributed Load Constant Distribution, Orientation: Vertical, Magnitude: 250 lb/ft2

Material Properties

Material: Previous Berm
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 190 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: water
Strength Type: No strength
Unit Weight: 62.4 lb/ft3

Material: Foundation soil
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 125 lb/ft3
Saturated Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 33.5 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (upper)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 37 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (lower)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: whethered rock
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 135 lb/ft3
Saturated Unit Weight: 135 lb/ft3
Cohesion: 500 psf
Friction Angle: 25 degrees
Water Surface: Water Table
Custom Hu value: 1

Global Minimums

Method: bishop simplified
FS: 1.263250
Center: 141.946, 1112.800
Radius: 75.655
Left Slip Surface Endpoint: 81.253, 1067.633
Right Slip Surface Endpoint: 144.615, 1037.193
Left Slope Intercept: 81.253 1067.633
Right Slope Intercept: 144.615 1044.006
Resisting Moment=2.45094e+006 lb-ft
Driving Moment=1.94018e+006 lb-ft

Method: janbu simplified
FS: 1.195320

Center: 133.180, 1097.460
Radius: 60.192
Left Slip Surface Endpoint: 80.903, 1067.623
Right Slip Surface Endpoint: 142.889, 1038.056
Left Slope Intercept: 80.903 1067.623
Right Slope Intercept: 142.889 1044.006
Resisting Horizontal Force=32380 lb
Driving Horizontal Force=27088.9 lb

Method: spencer
FS: 1.270020
Center: 141.946, 1112.800
Radius: 75.655
Left Slip Surface Endpoint: 81.253, 1067.633
Right Slip Surface Endpoint: 144.615, 1037.193
Left Slope Intercept: 81.253 1067.633
Right Slope Intercept: 144.615 1044.006
Resisting Moment=2.46408e+006 lb-ft
Driving Moment=1.94018e+006 lb-ft
Resisting Horizontal Force=28232.2 lb
Driving Horizontal Force=22229.7 lb

Valid / Invalid Surfaces

Method: bishop simplified
Number of Valid Surfaces: 3097
Number of Invalid Surfaces: 4339
Error Codes:
Error Code -101 reported for 16 surfaces
Error Code -103 reported for 19 surfaces
Error Code -115 reported for 14 surfaces
Error Code -1000 reported for 4290 surfaces

Method: janbu simplified
Number of Valid Surfaces: 3097
Number of Invalid Surfaces: 4339
Error Codes:
Error Code -101 reported for 16 surfaces
Error Code -103 reported for 19 surfaces
Error Code -115 reported for 14 surfaces
Error Code -1000 reported for 4290 surfaces

Method: spencer
Number of Valid Surfaces: 3095
Number of Invalid Surfaces: 4341
Error Codes:
Error Code -101 reported for 16 surfaces
Error Code -103 reported for 19 surfaces
Error Code -111 reported for 2 surfaces
Error Code -115 reported for 14 surfaces
Error Code -1000 reported for 4290 surfaces

Error Codes

The following errors were encountered during the computation:

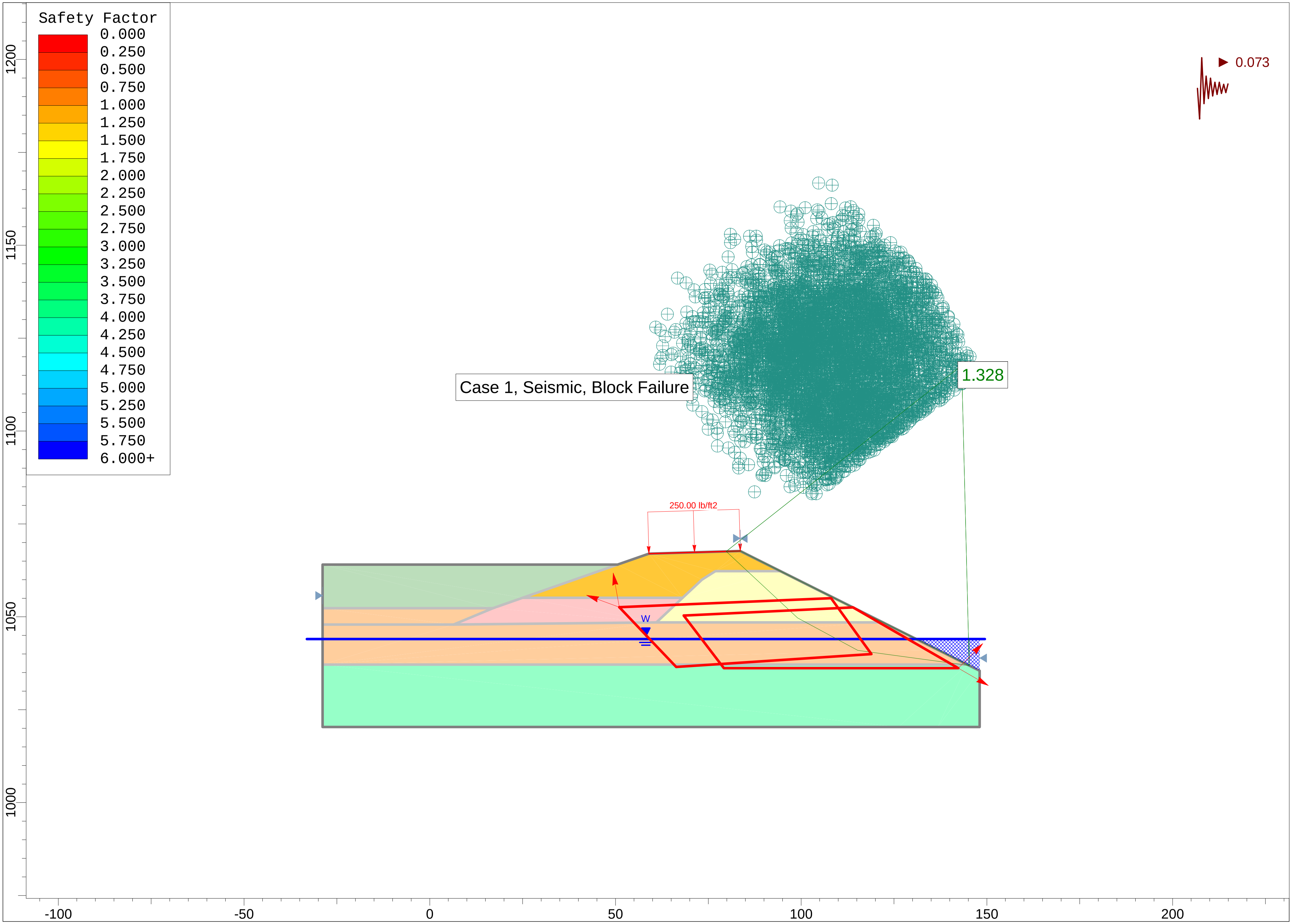
-101 = Only one (or zero)
surface / slope intersections.

-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.

-111 = safety factor equation did not converge

-115 = Surface too shallow, below the minimum depth.

-1000 = No valid slip surfaces are generated
at a grid center. Unable to draw a surface.


Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
0.073
Case 1, Seismic, Block Failure
1.328
250.00 lb/ft2
W
1200
1150
1100
1050
1000
-100
-50
0
50
100
150
200

Slide Analysis Information

Document Name

File Name: shawville_block_seismic.sli

Project Settings

Project Title:
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: On
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

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): 100
Left Projection Angle (End Angle): 160
Right Projection Angle (Start Angle): -30
Right Projection Angle (End Angle): 45
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

Seismic Load Coefficient (Horizontal): 0.073
1 Distributed Load present:
Distributed Load Constant Distribution, Orientation: Normal to boundary, Magnitude: 250 lb/ft2

Material Properties

Material: Previous Berm
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 190 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: water
Strength Type: No strength
Unit Weight: 62.4 lb/ft3

Material: Foundation soil
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 125 lb/ft3
Saturated Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 33.5 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (upper)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 37 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (lower)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: whethered rock
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 135 lb/ft3
Saturated Unit Weight: 135 lb/ft3
Cohesion: 500 psf
Friction Angle: 25 degrees
Water Surface: Water Table
Custom Hu value: 1

Global Minimums

Method: bishop simplified
FS: 1.312250
Axis Location: 141.797, 1114.331
Left Slip Surface Endpoint: 81.441, 1067.639
Right Slip Surface Endpoint: 142.937, 1038.031
Left Slope Intercept: 81.441 1067.639
Right Slope Intercept: 142.937 1044.006
Resisting Moment=2.33174e+006 lb-ft
Driving Moment=1.77691e+006 lb-ft

<u>Method: janbu simplified</u>
FS: 1.264180
Axis Location: 141.797, 1114.331
Left Slip Surface Endpoint: 81.441, 1067.639
Right Slip Surface Endpoint: 142.937, 1038.031
Left Slope Intercept: 81.441 1067.639
Right Slope Intercept: 142.937 1044.006
Resisting Horizontal Force=26232 lb
Driving Horizontal Force=20750.2 lb

<u>Method: spencer</u>
FS: 1.327950
Axis Location: 143.208, 1117.648
Left Slip Surface Endpoint: 79.807, 1067.592
Right Slip Surface Endpoint: 145.212, 1036.894
Left Slope Intercept: 79.807 1067.592
Right Slope Intercept: 145.212 1044.006
Resisting Moment=2.73671e+006 lb-ft
Driving Moment=2.06085e+006 lb-ft
Resisting Horizontal Force=29751.9 lb
Driving Horizontal Force=22404.4 lb

Valid / Invalid Surfaces

<u>Method: bishop simplified</u>
Number of Valid Surfaces: 4650
Number of Invalid Surfaces: 350
Error Codes:
Error Code -107 reported for 3 surfaces
Error Code -108 reported for 165 surfaces
Error Code -111 reported for 87 surfaces
Error Code -112 reported for 95 surfaces

<u>Method: janbu simplified</u>
Number of Valid Surfaces: 4444
Number of Invalid Surfaces: 556
Error Codes:
Error Code -107 reported for 3 surfaces
Error Code -108 reported for 346 surfaces
Error Code -111 reported for 120 surfaces
Error Code -112 reported for 87 surfaces

<u>Method: spencer</u>
Number of Valid Surfaces: 3116
Number of Invalid Surfaces: 1884
Error Codes:
Error Code -107 reported for 3 surfaces
Error Code -108 reported for 1298 surfaces
Error Code -111 reported for 488 surfaces
Error Code -112 reported for 95 surfaces

Error Codes

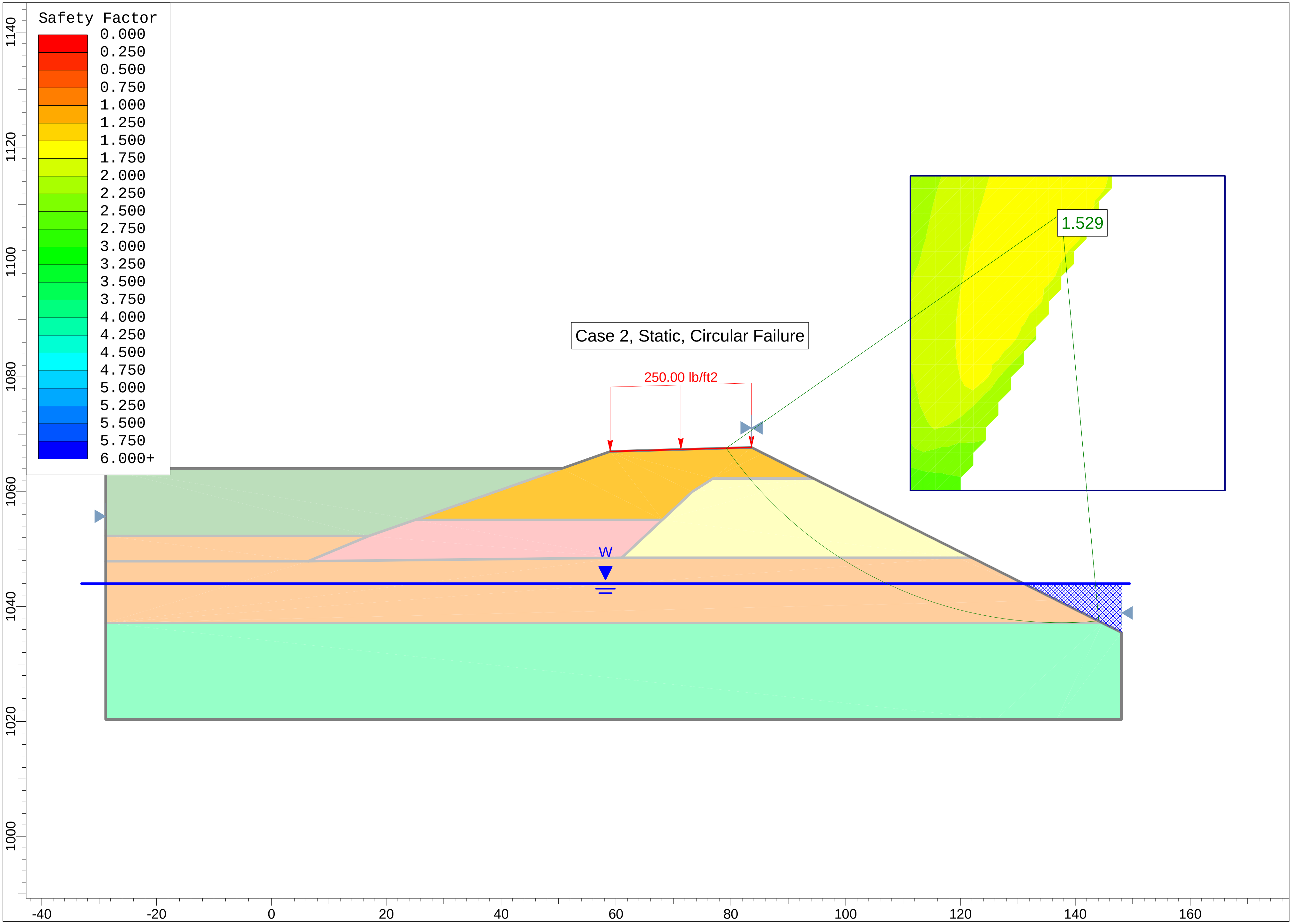
The following errors were encountered during the computation:

-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.



Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Case 2, Static, Circular Failure
250.00 lb/ft2
1.529
W
1140
1120
1100
1080
1060
1040
1020
1000
-40
-20
0
20
40
60
80
100
120
140
160

Slide Analysis Information

Document Name

File Name: shawville_circular2.sli

Project Settings

Project Title:
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: On
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

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: 1

Loading

1 Distributed Load present:
Distributed Load Constant Distribution, Orientation: Vertical, Magnitude: 250 lb/ft2

Material Properties

Material: Previous Berm
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 270 psf
Friction Angle: 28 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: water
Strength Type: No strength
Unit Weight: 62.4 lb/ft3

Material: Foundation soil
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 125 lb/ft3
Saturated Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 33.5 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (upper)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 37 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (lower)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: whethered rock
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 135 lb/ft3
Saturated Unit Weight: 135 lb/ft3
Cohesion: 500 psf
Friction Angle: 25 degrees
Water Surface: Water Table
Custom Hu value: 1

Global Minimums

Method: bishop simplified
FS: 1.522330
Center: 137.563, 1108.417
Radius: 71.255
Left Slip Surface Endpoint: 79.175, 1067.574
Right Slip Surface Endpoint: 144.079, 1037.461
Left Slope Intercept: 79.175 1067.574
Right Slope Intercept: 144.079 1044.006
Resisting Moment=2.85533e+006 lb-ft
Driving Moment=1.87563e+006 lb-ft

Method: janbu simplified
FS: 1.441410
Center: 133.180, 1099.651

Radius: 62.429
Left Slip Surface Endpoint: 79.614, 1067.587
Right Slip Surface Endpoint: 143.001, 1037.999
Left Slope Intercept: 79.614 1067.587
Right Slope Intercept: 143.001 1044.006
Resisting Horizontal Force=35603.6 lb
Driving Horizontal Force=24700.5 lb

Method: spencer
FS: 1.528830
Center: 137.563, 1108.417
Radius: 71.255
Left Slip Surface Endpoint: 79.175, 1067.574
Right Slip Surface Endpoint: 144.079, 1037.461
Left Slope Intercept: 79.175 1067.574
Right Slope Intercept: 144.079 1044.006
Resisting Moment=2.86753e+006 lb-ft
Driving Moment=1.87563e+006 lb-ft
Resisting Horizontal Force=34780.7 lb
Driving Horizontal Force=22749.8 lb

Valid / Invalid Surfaces

Method: bishop simplified
Number of Valid Surfaces: 3097
Number of Invalid Surfaces: 4339
Error Codes:
Error Code -101 reported for 16 surfaces
Error Code -103 reported for 19 surfaces
Error Code -115 reported for 14 surfaces
Error Code -1000 reported for 4290 surfaces

Method: janbu simplified
Number of Valid Surfaces: 3097
Number of Invalid Surfaces: 4339
Error Codes:
Error Code -101 reported for 16 surfaces
Error Code -103 reported for 19 surfaces
Error Code -115 reported for 14 surfaces
Error Code -1000 reported for 4290 surfaces

Method: spencer
Number of Valid Surfaces: 3092
Number of Invalid Surfaces: 4344
Error Codes:
Error Code -101 reported for 16 surfaces
Error Code -103 reported for 19 surfaces
Error Code -111 reported for 5 surfaces
Error Code -115 reported for 14 surfaces
Error Code -1000 reported for 4290 surfaces

Error Codes

The following errors were encountered during the computation:

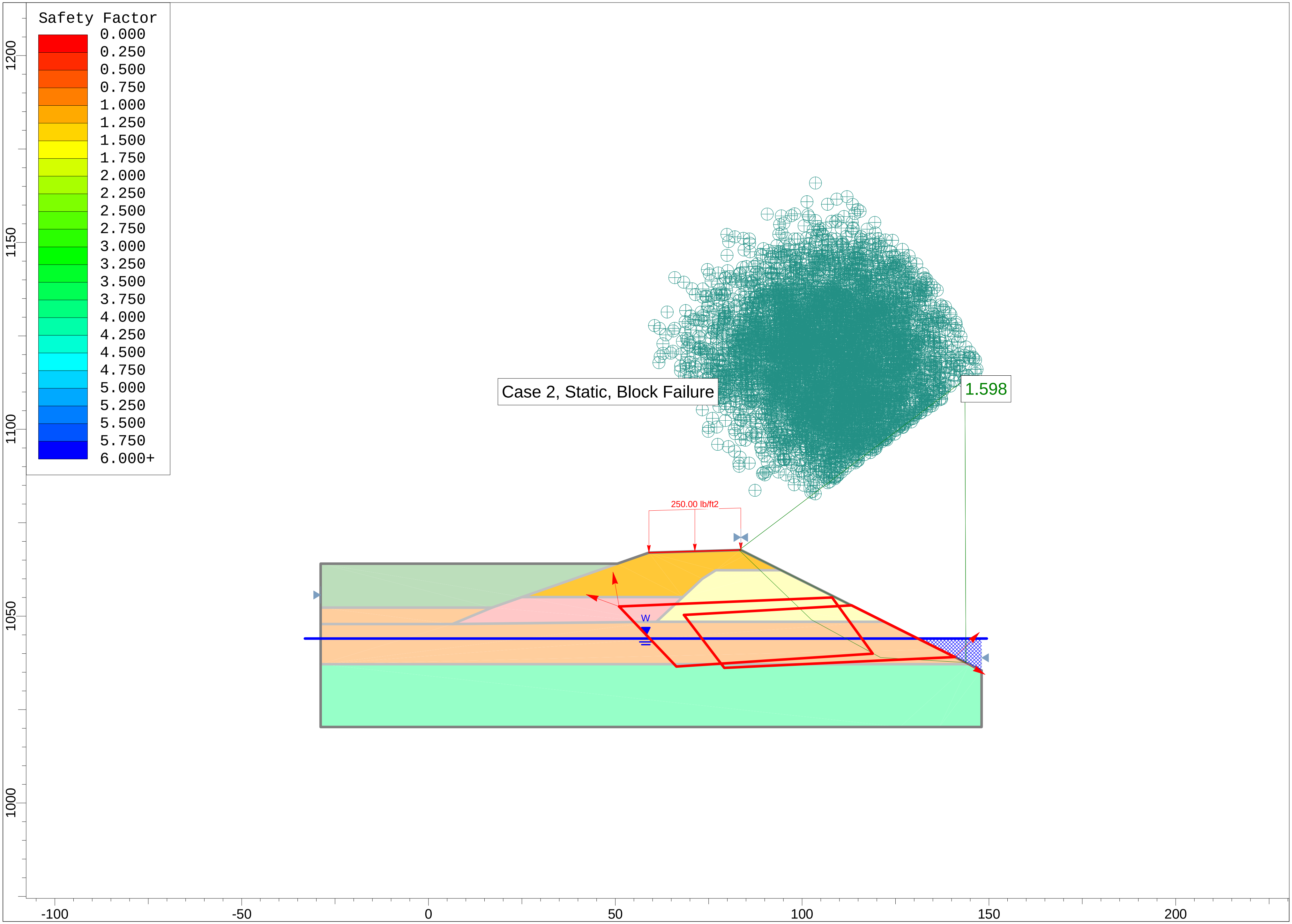
-101 = Only one (or zero) surface / slope intersections.

-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.

-111 = safety factor equation did not converge

-115 = Surface too shallow, below the minimum depth.

-1000 = No valid slip surfaces are generated at a grid center. Unable to draw a surface.



Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Case 2, Static, Block Failure
1.598
250.00 lb/ft2
W
1200
1150
1100
1050
1000
-100
-50
0
50
100
150
200

Slide Analysis Information

Document Name

File Name: shawville_block2.sli

Project Settings

Project Title:
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: On
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

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): 100
Left Projection Angle (End Angle): 160
Right Projection Angle (Start Angle): -30
Right Projection Angle (End Angle): 45
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

1 Distributed Load present:
Distributed Load Constant Distribution, Orientation: Vertical, Magnitude: 250 lb/ft2

Material Properties

Material: Previous Berm
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 270 psf
Friction Angle: 28 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: water
Strength Type: No strength
Unit Weight: 62.4 lb/ft3

Material: Foundation soil
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 125 lb/ft3
Saturated Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 33.5 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (upper)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 37 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (lower)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: whethered rock
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 135 lb/ft3
Saturated Unit Weight: 135 lb/ft3
Cohesion: 500 psf
Friction Angle: 25 degrees
Water Surface: Water Table
Custom Hu value: 1

Global Minimums

Method: bishop simplified
FS: 1.565900
Axis Location: 143.570, 1113.340
Left Slip Surface Endpoint: 83.121, 1067.686
Right Slip Surface Endpoint: 143.823, 1037.588
Left Slope Intercept: 83.121 1067.686
Right Slope Intercept: 143.823 1044.006
Resisting Moment=2.22067e+006 lb-ft
Driving Moment=1.41814e+006 lb-ft

Method: janbu simplified

FS: 1.522380
Axis Location: 143.570, 1113.340
Left Slip Surface Endpoint: 83.121, 1067.686
Right Slip Surface Endpoint: 143.823, 1037.588
Left Slope Intercept: 83.121 1067.686
Right Slope Intercept: 143.823 1044.006
Resisting Horizontal Force=24765 lb
Driving Horizontal Force=16267.3 lb

Method: spencer
FS: 1.597890
Axis Location: 143.570, 1113.340
Left Slip Surface Endpoint: 83.121, 1067.686
Right Slip Surface Endpoint: 143.823, 1037.588
Left Slope Intercept: 83.121 1067.686
Right Slope Intercept: 143.823 1044.006
Resisting Moment=2.23288e+006 lb-ft
Driving Moment=1.39739e+006 lb-ft
Resisting Horizontal Force=25187.4 lb
Driving Horizontal Force=15762.9 lb

Valid / Invalid Surfaces

Method: bishop simplified
Number of Valid Surfaces: 4598
Number of Invalid Surfaces: 402
Error Codes:
Error Code -107 reported for 36 surfaces
Error Code -108 reported for 197 surfaces
Error Code -111 reported for 87 surfaces
Error Code -112 reported for 82 surfaces

Method: janbu simplified
Number of Valid Surfaces: 4345
Number of Invalid Surfaces: 655
Error Codes:
Error Code -107 reported for 36 surfaces
Error Code -108 reported for 412 surfaces
Error Code -111 reported for 140 surfaces
Error Code -112 reported for 67 surfaces

Method: spencer
Number of Valid Surfaces: 3118
Number of Invalid Surfaces: 1882
Error Codes:
Error Code -107 reported for 36 surfaces
Error Code -108 reported for 1442 surfaces
Error Code -111 reported for 319 surfaces
Error Code -112 reported for 85 surfaces

Error Codes

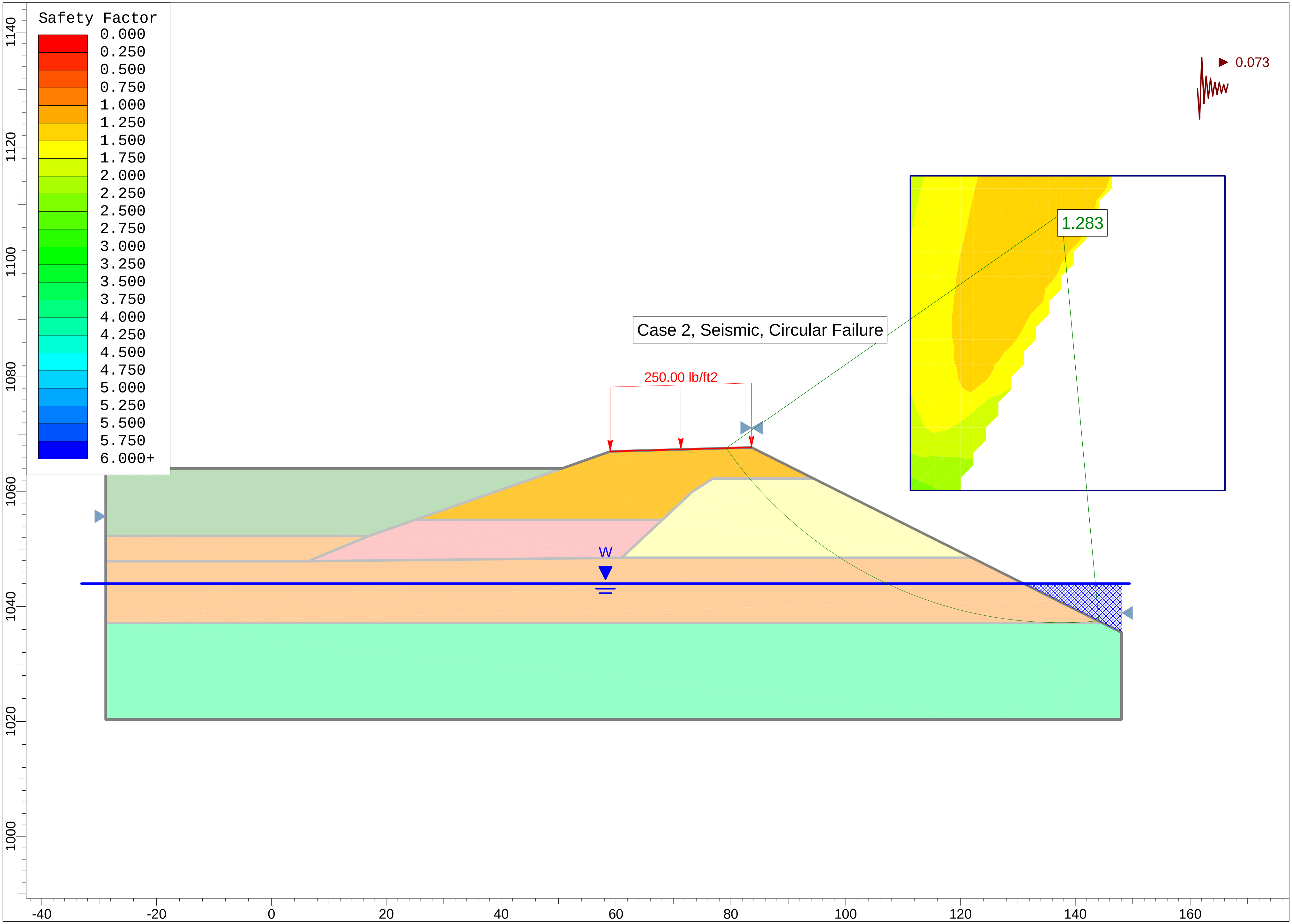
The following errors were encountered during the computation:

-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.


Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
0.073
1.283
Case 2, Seismic, Circular Failure
250.00 lb/ft2
W
1140
1120
1100
1080
1060
1040
1020
1000
-40
-20
0
20
40
60
80
100
120
140
160

Slide Analysis Information

Document Name

File Name: shawville_circular2_seismic.sli

Project Settings

Project Title:
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: On
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

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: 1

Loading

Seismic Load Coefficient (Horizontal): 0.073
1 Distributed Load present:
Distributed Load Constant Distribution, Orientation: Vertical, Magnitude: 250 lb/ft2

Material Properties

Material: Previous Berm
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 270 psf
Friction Angle: 28 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: water
Strength Type: No strength
Unit Weight: 62.4 lb/ft3

Material: Foundation soil
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 125 lb/ft3
Saturated Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 33.5 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (upper)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 37 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (lower)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: whethered rock
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 135 lb/ft3
Saturated Unit Weight: 135 lb/ft3
Cohesion: 500 psf
Friction Angle: 25 degrees
Water Surface: Water Table
Custom Hu value: 1

Global Minimums

Method: bishop simplified
FS: 1.276730
Center: 137.563, 1108.417
Radius: 71.255
Left Slip Surface Endpoint: 79.175, 1067.574
Right Slip Surface Endpoint: 144.079, 1037.461
Left Slope Intercept: 79.175 1067.574
Right Slope Intercept: 144.079 1044.006
Resisting Moment=2.76215e+006 lb-ft
Driving Moment=2.16345e+006 lb-ft

Method: janbu simplified
FS: 1.206510

Center: 133.180, 1099.651
Radius: 62.429
Left Slip Surface Endpoint: 79.614, 1067.587
Right Slip Surface Endpoint: 143.001, 1037.999
Left Slope Intercept: 79.614 1067.587
Right Slope Intercept: 143.001 1044.006
Resisting Horizontal Force=34445.9 lb
Driving Horizontal Force=28550.2 lb

Method: spencer
FS: 1.283190
Center: 137.563, 1108.417
Radius: 71.255
Left Slip Surface Endpoint: 79.175, 1067.574
Right Slip Surface Endpoint: 144.079, 1037.461
Left Slope Intercept: 79.175 1067.574
Right Slope Intercept: 144.079 1044.006
Resisting Moment=2.77612e+006 lb-ft
Driving Moment=2.16345e+006 lb-ft
Resisting Horizontal Force=33822.3 lb
Driving Horizontal Force=26358 lb

Valid / Invalid Surfaces

Method: bishop simplified
Number of Valid Surfaces: 3097
Number of Invalid Surfaces: 4339
Error Codes:
Error Code -101 reported for 16 surfaces
Error Code -103 reported for 19 surfaces
Error Code -115 reported for 14 surfaces
Error Code -1000 reported for 4290 surfaces

Method: janbu simplified
Number of Valid Surfaces: 3097
Number of Invalid Surfaces: 4339
Error Codes:
Error Code -101 reported for 16 surfaces
Error Code -103 reported for 19 surfaces
Error Code -115 reported for 14 surfaces
Error Code -1000 reported for 4290 surfaces

Method: spencer
Number of Valid Surfaces: 3095
Number of Invalid Surfaces: 4341
Error Codes:
Error Code -101 reported for 16 surfaces
Error Code -103 reported for 19 surfaces
Error Code -111 reported for 2 surfaces
Error Code -115 reported for 14 surfaces
Error Code -1000 reported for 4290 surfaces

Error Codes

The following errors were encountered during the computation:

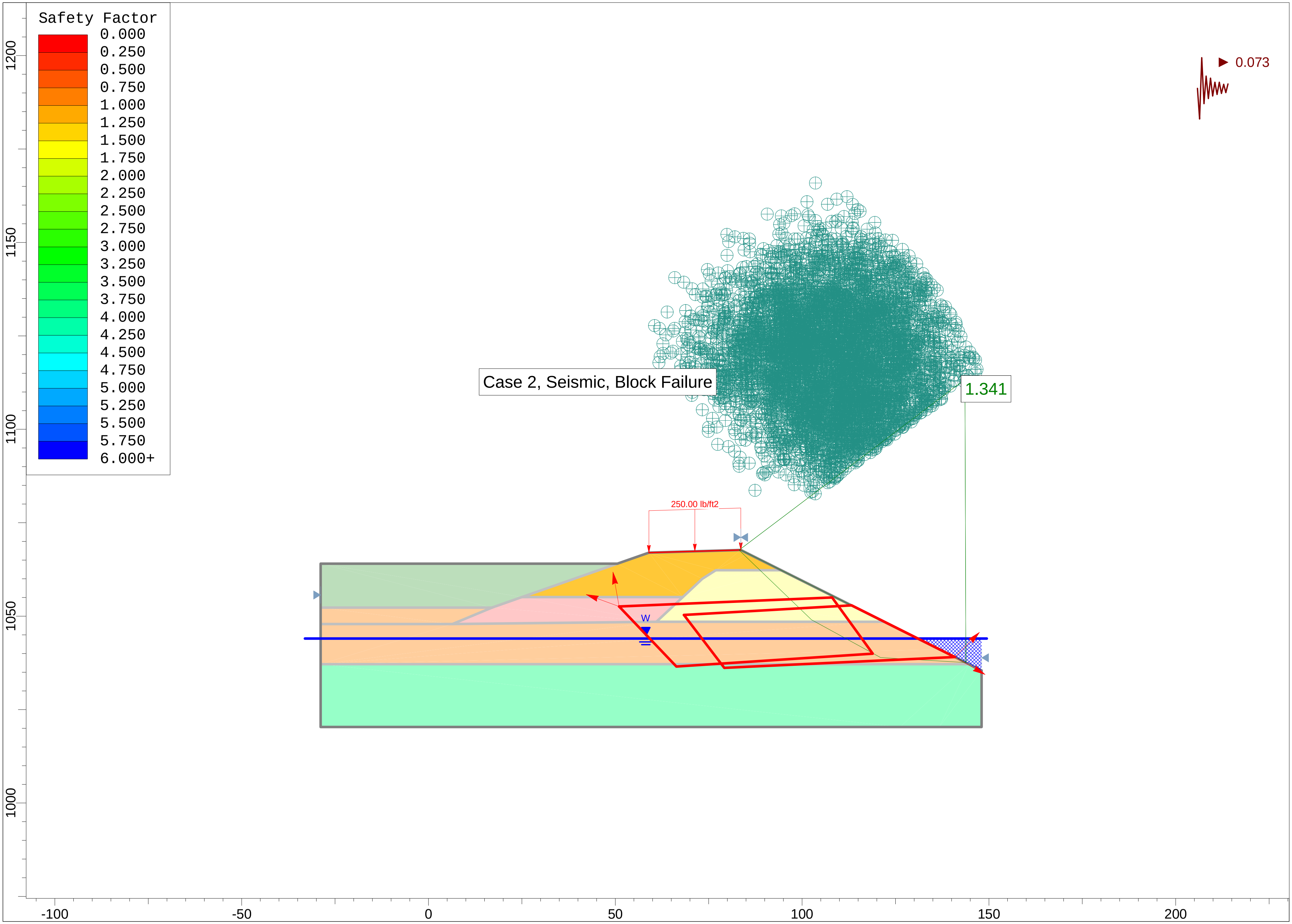
-101 = Only one (or zero)
surface / slope intersections.

-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.

-111 = safety factor equation did not converge

-115 = Surface too shallow, below the minimum depth.

-1000 = No valid slip surfaces are generated
at a grid center. Unable to draw a surface.



Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
0.073
Case 2, Seismic, Block Failure
1.341
250.00 lb/ft2
W
1200
1150
1100
1050
1000
-100
-50
0
50
100
150
200

Slide Analysis Information

Document Name

File Name: shawville_block2_seismic.sli

Project Settings

Project Title:
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: On
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Janbu simplified
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

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): 100
Left Projection Angle (End Angle): 160
Right Projection Angle (Start Angle): -30
Right Projection Angle (End Angle): 45
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

Seismic Load Coefficient (Horizontal): 0.073
1 Distributed Load present:
Distributed Load Constant Distribution, Orientation: Vertical, Magnitude: 250 lb/ft2

Material Properties

Material: Previous Berm
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 270 psf
Friction Angle: 28 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: water
Strength Type: No strength
Unit Weight: 62.4 lb/ft3

Material: Foundation soil
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 125 lb/ft3
Saturated Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 33.5 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (upper)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 37 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Fill (lower)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: whethered rock
Strength Type: Mohr-Coulomb
Unsaturated Unit Weight: 135 lb/ft3
Saturated Unit Weight: 135 lb/ft3
Cohesion: 500 psf
Friction Angle: 25 degrees
Water Surface: Water Table
Custom Hu value: 1

Global Minimums

Method: bishop simplified
FS: 1.310050
Axis Location: 143.570, 1113.340
Left Slip Surface Endpoint: 83.121, 1067.686
Right Slip Surface Endpoint: 143.823, 1037.588
Left Slope Intercept: 83.121 1067.686
Right Slope Intercept: 143.823 1044.006
Resisting Moment=2.14731e+006 lb-ft
Driving Moment=1.6391e+006 lb-ft

Method: janbu simplified
FS: 1.272900
Axis Location: 143.570, 1113.340
Left Slip Surface Endpoint: 83.121, 1067.686
Right Slip Surface Endpoint: 143.823, 1037.588
Left Slope Intercept: 83.121 1067.686
Right Slope Intercept: 143.823 1044.006
Resisting Horizontal Force=23946.3 lb
Driving Horizontal Force=18812.5 lb

Method: spencer
FS: 1.340820
Axis Location: 143.570, 1113.340
Left Slip Surface Endpoint: 83.121, 1067.686
Right Slip Surface Endpoint: 143.823, 1037.588
Left Slope Intercept: 83.121 1067.686
Right Slope Intercept: 143.823 1044.006
Resisting Moment=2.164e+006 lb-ft
Driving Moment=1.61393e+006 lb-ft
Resisting Horizontal Force=24490.6 lb
Driving Horizontal Force=18265.3 lb

Valid / Invalid Surfaces

Method: bishop simplified
Number of Valid Surfaces: 4656
Number of Invalid Surfaces: 344
Error Codes:
Error Code -107 reported for 3 surfaces
Error Code -108 reported for 171 surfaces
Error Code -111 reported for 82 surfaces
Error Code -112 reported for 88 surfaces

Method: janbu simplified
Number of Valid Surfaces: 4441
Number of Invalid Surfaces: 559
Error Codes:
Error Code -107 reported for 3 surfaces
Error Code -108 reported for 355 surfaces
Error Code -111 reported for 120 surfaces
Error Code -112 reported for 81 surfaces

Method: spencer
Number of Valid Surfaces: 3098
Number of Invalid Surfaces: 1902
Error Codes:
Error Code -107 reported for 3 surfaces
Error Code -108 reported for 1329 surfaces
Error Code -111 reported for 480 surfaces
Error Code -112 reported for 90 surfaces

Error Codes

The following errors were encountered during the computation:

-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.