



Structural Stability and Safety Factor Assessment Report

J.H. CAMPBELL GENERATING FACILITY

POND A STRUCTURAL STABILITY AND SAFETY FACTOR ASSESSMENT REPORT

West Olive, Michigan

Pursuant to 40 CFR 257.73(d, e)

Submitted To: Consumers Energy Company
1945 W. Parnall Road
Jackson, Michigan 49201

Submitted By: Golder Associates Inc.
15851 South US 27, Suite 50
Lansing, Michigan 48906

October 2016

1654923



**CERTIFICATION****Professional Engineer Certification Statement [40 CFR 257.73(d)(3) & 257.73(e)(2)]**

I hereby certify that, having reviewed the attached documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations Section 257.73 (40 CFR Part 257.73), I attest that this Structural Stability and Safety Factor Assessment Report is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of 40 CFR Part 257.73(d) periodic structural stability assessments and 40 CFR Part 257.73(e) periodic safety factor assessments.

Golder Associates Inc.


Signature

October 14, 2016

Date of Report Certification

Matthew Wachholz, PE

Name

6201047513

Professional Engineer Certification Number





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1.0 INTRODUCTION

1.1 Purpose

On April 17, 2015, the United States Environmental Protection Agency (EPA) issued the Coal Combustion Residual (CCR) Resource Conservation and Recovery Act (RCRA) Rule (40 CFR 257 Subpart D) ("CCR RCRA Rule") to regulate the beneficial use and disposal of CCR materials generated at coal-fired electrical power generating complexes. The CCR RCRA Rule requires that existing CCR surface impoundments meeting the requirements of Section 257.73(b) conduct initial and periodic structural stability assessments in accordance with Section 257.73(d) and safety factor assessments in accordance with Section 257.73(e). This report provides the initial structural stability assessment and the safety factor assessment for the Pond A surface impoundment (Pond A) at the J.H. Campbell Generating Facility (JH Campbell). A hazard potential classification was conducted for Pond A pursuant to Section 257.73, which resulted in a significant hazard potential classification, thereby requiring the 1000-year flood elevation to be used in the safety factor assessment.

1.2 Site Description and Background

JH Campbell is a coal-fired power generation facility located near West Olive, Michigan as presented on Figure 1 – Site Location Map. JH Campbell Pond A is a hydraulically active CCR surface impoundment which receives commingled CCRs and low-volume miscellaneous wastewaters and serves as a detention basin to settle suspended solids and CCRs until they are mechanically removed to maintain adequate storage capacity. Pond A is located along the southern end of the JH Campbell ash disposal area (Figure 2). Pond A has a primary 24-inch diameter corrugated metal pipe (CMP) outlet with a concrete energy dissipater, a 24-inch diameter primary high-density polyethylene (HDPE) inlet, a 30-inch diameter CMP overflow inlet, and a 24-inch diameter HDPE inlet. Topographic and bathymetric surveys were conducted for Pond A in May 2016 by Engineering & Environmental Solutions, LLC (E&ES), which were used to develop the assessments contained herein.

The discharge from Pond A flows through an internal ditch (South Ditch) and pond system and ultimately through National Pollutant Discharge Elimination System (NPDES) Outfall 002, regulated under JH Campbell's current NPDES permit.

1.3 Previous Evaluations

There are no certified records of previous slope stability analyses that have been performed for the Pond A embankments. A Probable Failure Mode Analysis (PFMA) was previously completed for the JH Campbell site (AECOM 2009a) to identify structural (geotechnical) and environmental risks. Additionally, previous site inspections have been conducted to observe and document the structural conditions of the embankment dikes. A list of reviewed documents pertinent to the structural stability assessment is provided in Table 1.3.1.

**Table 1.3.1 - Previous Reviewed Documents Related to Structural Stability Assessment**

Document	Date	Author
J.H. Campbell Pond A Annual RCRA CCR Surface Impoundment Inspection Report – January 2016	January 2016	Golder Associates Inc.
J.H. Campbell Ash Disposal Area Triennial Ash Dike Risk Assessment Report	December 2014	Barr Engineering
Resource Conservation and Recovery Act Vertical Expansion Feasibility Investigation -2012	December 2012	Engineering & Environmental Solutions, LLC
J.H. Campbell Ash Disposal Area 2012 Ash Dike Risk Assessment FINAL Inspection Report	July 2012	AECOM Technical Services, Inc.
Inspection Report J.H. Campbell Generating Facility Ash Dike Risk Assessment	November 2009	AECOM Technical Services, Inc.
Potential Failure Mode Analysis (PFMA) Report J.H. Campbell Generating Facility Ash Dike Risk Assessment	November 2009	AECOM Technical Services, Inc.



2.0 SUBSURFACE CONDITIONS

The site is located near the east shore of Lake Michigan. Quaternary deposits in the area primarily consist of eolian sands extending to depths of approximately 45 to 60 feet below natural ground surface. The sands are underlain by fine-grained silty clay and clayey silt soils which extend down to bedrock. Bedrock of the Coldwater Shale deposits and Marshall Formation consisting of shale, sandstone, limestone, and siltstone exists at depths of approximately 140 feet below natural ground surface (STS 1993).

Soil borings and laboratory testing programs were completed in 2012, 2015, and 2016 around Pond A to develop site specific stratigraphy and engineering material properties. The subsurface investigations and testing identified that the native soil beneath Pond A consists of sand underlain by silty clay. The May 2016 survey conducted by E&ES was used to develop the slope geometry in the stability analysis.



3.0 STRUCTURAL STABILITY ASSESSMENT [40 CFR 257.73(d)(1)(i-vii)]

The CCR RCRA Rule requires an initial and periodic structural stability assessment be conducted by a qualified professional engineer (QPE) to document whether design, construction, operation, and maintenance are consistent with recognized and generally accepted good engineering practices for the maximum volume of CCR and CCR wastewater that can be impounded therein. The following sections provide documentation on the initial structural stability assessment and rely mainly on the recent and historic annual inspections performed at the site as well as the weekly field inspections performed by Consumers Energy Company (CEC). The most recent inspection was completed by Golder Associates Inc. (Golder) in May 2016 for the initial structural stability assessment. The summary inspection checklist for the May 2016 site inspection is included in Appendix A.

In accordance with the CCR RCRA Rule, in any calendar year in which both the periodic inspection by a QPE and the quinquennial (occurring every five years) structural stability assessment by a QPE required by Sections 257.73(d) are required to be completed, the annual inspection is not required. If the annual inspection is not conducted in a year as provided by this paragraph, the deadline for completing the next annual inspection is one year from the date of completing the quinquennial structural stability assessment. As a result, a certified annual inspection report for Pond A will not be required until October 2017.

3.1 Foundations and Abutments [40 CFR 257.73(d)(1)(i)]

Certified issued for construction (IFC) drawings were available on the original design of the Pond A embankments from 1979. The foundation soils consist of native sand soils. There has been no indication of foundational or abutment instability or movement in recent or historic site inspections and; therefore, the foundation soils and abutments are considered stable.

3.2 Slope Protection [40 CFR 257.73(d)(1)(ii)]

The downstream slopes of the embankments for Pond A are protected from erosion and deterioration by the establishment of a vegetative cover. Existing slopes are inspected weekly for erosion, signs of seepage, animal burrows, sloughing, and plants that could negatively impact the embankment. The May 2016 inspection did not identify items relating to slope protection that required investigation or repair, and the downstream slopes of Pond A are not subjected to wave or sudden drawdown effects. The existing slope protection measures are considered adequate to provide protection against surface erosion, wave action, and adverse effects of sudden drawdown.

3.3 Dikes (Embankment) [40 CFR 257.73(d)(1)(iii)]

Based on the IFC drawings and subsurface investigation information reviewed, it is understood that the perimeter dike was constructed with standard earthwork equipment and consists of sand fill that was compacted to 90 percent of the optimum density achieved by the Standard Proctor (ASTM D698), as



specified in the embankment construction drawings. Results of the safety factor assessment detailed in Section 4.0 provide additional details on the stability of the external dike. Based on the relative density of the material encountered during the subsurface investigations, historic inspections, recent observations, and results of the stability analysis; the embankment dikes are considered sufficient to withstand the range of loading conditions in Pond A.

3.4 Vegetated Slopes [40 CFR 257.73(d)(1)(iv)]

The EPA has vacated the requirement that vegetative cover on surface impoundment dikes be maintained at no more than six inches. A new rule establishing requirements relating to the use of vegetation as slope protection for CCR surface impoundments is still pending.

3.5 Spillways [40 CFR 257.73(d)(1)(v)]

There are no spillways on Pond A. Flow is conveyed in and out of Pond A via pipes as described in Section 3.6.

3.6 Hydraulic Structures [40 CFR 257.73(d)(1)(v)]

Pond A has a primary outlet which consists of a 24-inch diameter asbestos bonded CMP with square anti-seep collars and a concrete energy dissipater. Pond A has three inlets: a 24-inch diameter primary HDPE inlet located in the northwest corner, a 30-inch diameter CMP overflow pipe inlet located in the southwest corner, and a 24-inch HDPE pipe inlet located in the southwest corner. The discharge from Pond A flows through the South Ditch and pond system and ultimately through the site's NPDES Outfall 002, regulated under the site's current NPDES permit.

These four pipes were identified as the only hydraulic structures that underlie the base or pass through the external dike of Pond A. Three of these pipes were reported to be in good or good to fair condition in the 2014 Triennial Ash Dike Risk Assessment Report (Barr 2014a), which was based on a closed circuit television (CCTV) inspection of the hydraulic structures. The 24-inch diameter HDPE inlet pipe located in the southwest corner was not included in the 2014 CCTV inspection although the May 2016 inspection did not identify that the inlet required repair or investigation. Additionally, no change to the condition of the three pipes that were CCTV inspected in 2014 were noted in the May 2016 inspection by Golder.

Based on review of the Barr Triennial Ash Dike Assessment Report and May 2016 inspection, three of the four hydraulic structures that underlie the base or pass through the external dike were inspected and are free of significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, and debris which may negatively affect the operation of the hydraulic structure. Based on the May 2016 inspection, one of the four hydraulic structures that underlie the base or pass through the external dike were inspected and are free of significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, and debris which may negatively affect the operation of the hydraulic structure.



3.7 Downstream Slopes Adjacent to Water Body [40 CFR 257.73(d)(1)(vii)]

The downstream slopes of Pond A are not adjacent to water bodies and; therefore, rapid-drawdown was not considered a potential mechanism for structural instability in the exterior slope.

3.8 Structural Stability Deficiencies [40 CFR 257.73(d)(2)]

Based on the 2016 site inspection and structural stability assessment contained herein, no structural stability deficiencies were identified.



4.0 SAFETY FACTOR ASSESSMENT [40 CFR 257.73(e)]

According to Section 257.73(e)(1) of the CCR RCRA Rule, periodic safety factor assessments must be conducted for each CCR unit. The safety factor assessment must document the calculated factor of safety for the dike slopes under the following scenarios:

- Maximum Pool Storage - Section 257.73(e)(1)(i) – Defined as the long-term, maximum storage pool (or operating) elevation and equal to the upstream outlet elevation [elevation = 615.5 feet (NGVD29)] for this facility; static factor of safety must equal or exceed 1.50
- Maximum Pool Surcharge - Section 257.73(e)(1)(ii) – Defined as the temporary raised pond level above the maximum pool storage elevation due to an inflow design flood [619.0 feet (NGVD29)]; static factor of safety must equal or exceed 1.40
- Seismic Loading Conditions - Section 257.73(e)(1)(iii) – Seismic factor of safety must equal or exceed 1.00
- Liquefaction Potential - Section 257.73(e)(1)(iv) – Only necessary for dikes constructed of soils that have susceptibility to liquefaction; factor of safety must equal or exceed 1.20

The following sections provide details on the factor of safety assessment and methods used to calculate the slope factor of safety and results of the analysis.

4.1 Slope Stability Analysis

Slope stability analyses were performed to evaluate the factor of safety for each of the maximum pool storage, maximum pool surcharge, and seismic loading scenarios. In the Preamble to Sections 257 and 261 of the CCR RCRA Rule *General Safety Factor Assessment Considerations* [VI (E)(3)(b)(ii)(a)], limit equilibrium methods are identified as conventional analysis procedures for calculating the factor of safety and specific common methods are identified, including the Morgenstern and Price method of slices (Abramson et al. 2002), which was used for this stability analysis.

4.1.1 Cross Section Analyzed

The critical section of the exterior dike was determined by using the existing topography (2016), the interpreted soil profile from the subsurface investigations, and the interpreted phreatic surface based on observations. The critical cross section is anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions.

The critical section used for the safety factor assessment was located along the southern dike and is shown as Section A-A' in Figure 2.



4.1.2 Geotechnical Material Properties

Based on the subsurface investigations and laboratory testing, representative material properties were selected for use in the safety factor assessment. Applicable engineering material properties were developed for four separate material units: 1) dike fill consisting of sand; 2) sand (native foundation soil); 3) clay (native foundation soil); and 4) drainage channel gravel.

4.1.3 Pond Elevation and Phreatic Surface/Groundwater

The phreatic surface for the stability models was developed based on water level measurements from standpipe piezometers installed within the embankment. Two upstream water boundary conditions were considered in the analyses; the maximum pool storage and the maximum pool surcharge conditions. The maximum pool surcharge scenario considers the temporary rise of the pond water elevation due to rainfall and collection of site stormwater runoff during the design event. Pond water elevations were calculated for the 1000-year storm event, resulting in an increase in pond elevations to 617.90 feet (NGVD29) as provided in Golder's J.H. Campbell Generating Facility Pond A, Inflow Design Flood Control System Plan (Golder 2016b).

Downstream water boundary condition was set to groundwater elevation of approximately 596.0 feet (NGVD29). For the maximum pool storage scenario, upstream water boundary condition was set to pond water surface elevation of 615.5 feet (NGVD29) based on the primary outlet upstream invert elevation. For the maximum pool surcharge scenario, upstream water boundary condition was set to pond water surface elevation of 619.0 feet (NGVD29) based on the 1000-year storm pond water elevation.

The phreatic surface was estimated inside the embankment by using piezometer water level measurements with known pond elevations to calibrate the model.

4.1.4 Vehicle Loading

The crest of the embankments are periodically used by maintenance vehicles as access roads around the ponds and; therefore, a vehicle load was applied to the critical cross section for the maximum pool storage and maximum pool surcharge cases to model the loading effects of vehicle traffic. The vehicle load was applied based on American Association of State Highway and Transportation Officials (AASHTO) recommended loading for truck loads acting perpendicular to traffic (AASHTO 2012).

4.1.5 Seismic Loading Conditions

Factors of safety for stability under seismic conditions were calculated using the pseudo-static method. The peak ground acceleration (PGA) based on the 2008 United States Geological Survey (USGS) seismic hazard maps (Peterson et al. 2008) with a two percent probability of exceedance in 50 years (2,475-year return period) is 0.033g; however, the Natural Resources Conservation Service (NRCS) recommends a



minimum seismic coefficient of 0.05g for Michigan, so a seismic coefficient of 0.05g was used in seismic analyses.

4.2 Stability Analysis Results

Slope stability analyses were performed for long-term static conditions for the critical cross section considered under maximum pool storage and maximum pool surcharge scenarios as well as pseudo-static seismic conditions. The results of the slope stability analyses cases are presented in Table 4.2.1, and critical failure surface result outputs are contained in Appendix B. The results indicate that Pond A exterior slopes meet or exceed the required safety factors under all considered loading scenarios.

Table 4.2.1 - Slope Stability Analysis Results

Scenarios	Maximum Pool Storage	Maximum Pool Surcharge	Seismic
Required Safety Factor	1.50	1.40	1.00
Section	Calculated Safety Factor		
Section A-A'	1.63	1.63	1.43

4.3 Liquefaction Potential Assessment

Embankment and foundation soils were screened for seismically-induced liquefaction susceptibility using methods recommended by the National Center for Earthquake Research (NCEER), which uses Cone Penetrometer Test (CPT) data (Youd et al. 2001; Robertson and Wride 1998). The calculated factor of safety against seismically-induced liquefaction is shown in Appendix C and was calculated to be greater than 1.20 throughout the depth of the embankments and underlying foundation in the evaluated CPT soundings for the considered earthquake loading. These screening-level results indicate that the embankments and foundation soils for Ponds A are not susceptible to seismically-induced liquefaction for the seismic loading considered.



5.0 SUMMARY

Based on our review of the information provided by CEC, onsite observations, and the results of the structural stability assessment; no structural stability deficiencies were identified for the Pond A surface impoundment during this assessment. Based on this same information and on our safety factor assessment, the calculated factor of safety through the critical cross section in the Pond A surface impoundment meets or exceeds the minimum values listed in Section 257.73(e)(1)(i-iv).



6.0 CLOSING

This report summarizes the results of the structural stability and factor of safety assessment to fulfill the provisions of Title 40 of the Code of Federal Regulations Section 257.73 (40 CFR Part 257.73) for Pond A at JH Campbell.

GOLDER ASSOCIATES INC.

A handwritten signature in blue ink, appearing to read "Jeff Piaskowski".

Jeffrey Piaskowski, P.E.
Project Engineer

A handwritten signature in blue ink, appearing to read "Jeff Schneider".

Jeffrey Schneider, P.E.
Senior Project Engineer

A handwritten signature in black ink, appearing to read "Matt Wachholz".

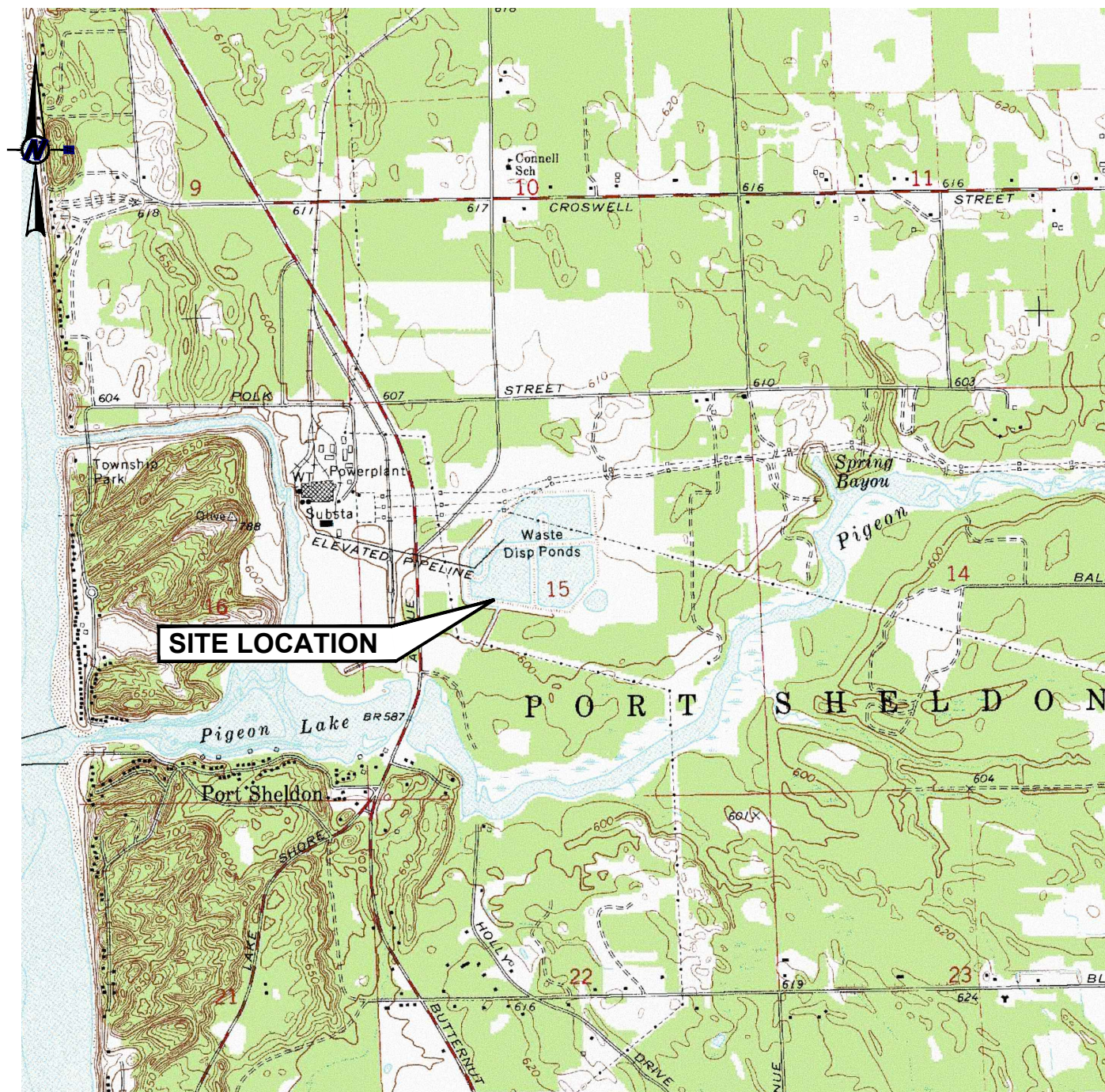
Matt Wachholz, P.E.
Senior Engineer



7.0 REFERENCES

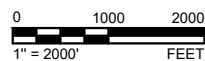
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FIGURES



REFERENCE(S)

1. BASE MAP TAKEN FROM 7.5 MINUTE U.S.G.S. QUADRANGLES OF PORT SHELDON MICHIGAN, DOWNLOADED FROM MICHIGAN DNR WEBSITE JUNE 2016.



CLIENT
CONSUMERS ENERGY COMPANY
17000 CROSWELL ST.
WEST OLIVE, MI 49460

CONSULTANT



YYYY-MM-DD 2016-06-06

DESIGNED JS

PREPARED ARM

REVIEWED DJS

APPROVED MAB

PROJECT
2016 RCRA COMPLIANCE STRUCTURAL STABILITY & SAFETY
FACTOR ASSESSMENT

TITLE

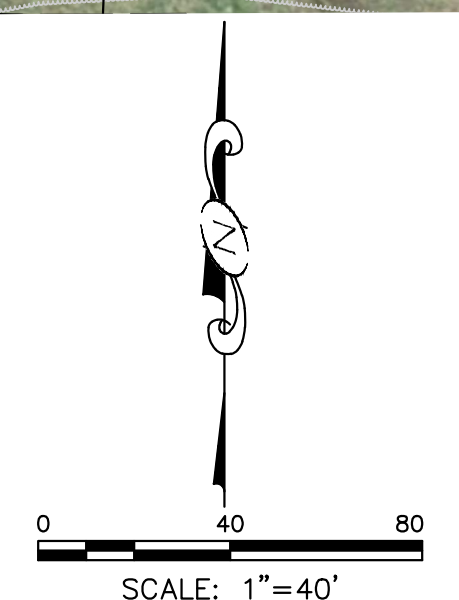
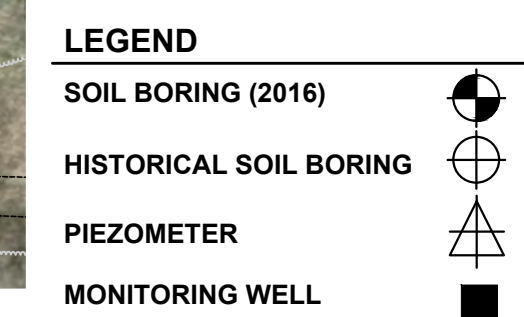
SITE LOCATION MAP

PROJECT NO.
1654923

REV.
#

FIGURE
1

1. CONTOURS SHOWN ARE FROM MAY 2016 GROUND SURVEY.



							10/6/2016	FILED IN OWNER'S OPERATING RECORD		AM	DS	JP	
REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	BY	CHK	APP	REV	DATE	DESCRIPTION	BY	CHK	APP	



J.H. CAMPBELL ASH STORAGE FACILITY

**2016 RCRA COMPLIANCE FACTOR OF SAFETY ASSESSMENT
POND A-BOREHOLE LOCATION & CROSS SECTION MAP**

				UNIT#
SCALE	1" = 40'	DRAWING NO.	FIGURE	REV.
JOB	1654923	----	2	A

APPENDIX A
SUMMARY INSPECTION CHECKLIST

CCR SURFACE IMPOUNDMENT VISUAL INSPECTION CHECKLIST

Facility Name: J.H. Campbell Pond A

Owner: Consumers Energy Company

Purpose of Facility: Detention of process water from the generating facility

County, State: Ottawa County, Michigan

Inspected By: Tiffany Johnson

Inspection Date: 5/19/16

Weather: Clear, 75-degrees F

ITEM	Acceptable	Monitor/Maintain	Investigate	Repair	REMARKS
1. General Conditions					
a. Year Minimum Water Elevation					615.5 feet NGVD
b. Year Average Water Elevation					615.5 feet NGVD
c. Year Maximum Water Elevation					615.5 feet NGVD
d. Current water level					615.5 feet NGVD
e. Current storage capacity					Volume: 237,000 CY (See Note 1)
f. Current volume of impounded water and CCR					Volume: 119,000 CY (See Note 1)
g. Alterations	X				
h. Development of downstream plain	X				
i. Grass cover	X				
j. Settlement/misalignment/cracks	X				
k. Sudden drops in water level?					NA – No drop in water level observed.
2. Inflow Structure			X		See Note 2 below.
a. Settlement	X				
b. Cracking	X				
c. Corrosion	X				
d. Obstacles in inlet	X				
e. Riprap/erosion control		X			Observed surficial erosion around inlet, maintain erosion controls. See Note 5.
3. Outflow Structure			X		See Note 3 below.
a. Settlement	X				
b. Cracking	X				
c. Corrosion	X				
d. Obstacles in outlet	X				
e. Riprap/erosion control	X				
f. Seepage	X				
4. Upstream slope					Upstream slope is considered the northern, eastern, and western slopes that are bounded by the inactive landfill.
a. Erosion	X				
b. Rodent burrows	X				No new burrows noted during inspection.
c. Vegetation		X			Areas of sparse vegetation on northwest corner. See Note 5.
d. Cracks/settlement	X				
e. Riprap/other erosion protection		X			Erosion and gullies on southern and northern upstream slopes. See Note 5.
f. Slide, Slough, Scarp	X				
5. Crest					
a. Soil condition					
b. Comparable to width from previous inspection					NA
c. Vegetation	X				Observed surficial erosion at crest of slope, maintain erosion controls. See Note 5.
d. Rodent burrows	X				No new burrows noted during inspection.
e. Exposed to heavy traffic	X				Heavy traffic is minimized across Pond A crest.
f. Damage from vehicles/machinery	X				
6. Downstream slope					Downstream slope is considered the southern slope of Pond A.
a. Erosion		X			Observed erosion on areas of sparse vegetation, maintain vegetation and erosion controls. See Note 3.
b. Vegetation		X			See Note 3.
c. Rodent burrows	X				No new burrows noted during inspection. See Note 5.
d. Slide, Slough, Scarp		X			See Note 4.
e. Drain conditions	X				
f. Seepage	X				No active or historical seeps observed during inspection. See Note 5.
7. Toe					
a. Vegetation	X				
b. Rodent burrows	X				No new burrows noted during inspection. See Note 5.
c. Settlement	X				

ITEM		Acceptable	Monitor/Maintain	Investigate	Repair	REMARKS
d.	Drainage conditions	X				
e.	Seepage	X				No active or historical seeps observed during inspection. See Note 5.

Notes:

1) Current storage capacity is based on an approximate bottom elevation of 600.0 feet NGVD29 and two feet of freeboard measured from a topographic survey collected in May of 2016. Volume of impounded water and CCR are based on an approximate bottom elevation of 600.0 feet NGVD29 and pond operating level (615.5 feet NGVD29) based on a topographic survey collected in May of 2016.

2) One inflow structure for Pond A is located in southwest corner and consists of a 24-inch HDPE pipe. There is no record of CCTV inspection and pipe is of unknown condition.

Action: Golder recommends that the 24-inch HDPE inlet be inspected to verify that the hydraulic structure does not have deficiencies.

3) The outflow structure for Pond A is a 24-inch CMP and includes a 90-degree bend and was inspected with a camera in 2014 up to the bend. Given the material type and bend, CEC should monitor the outflow pipe weekly, as per the SMP.

Action: Golder recommends an inspection be conducted on the remaining portion of the structure that conveys flows from the southeast corner of the pond to the outlet pipe.

4) Surficial erosion was observed along the south slope of Pond A due to sparse vegetation. CEC should monitor areas, per the SMP, and maintain erosion and vegetation controls. This is not a deficiency or release as classified under 40 CFR 257.83(b)(5).

5) A historic slough was observed on the south slope of Pond A. Location was documented by CEC personnel and will be monitored weekly, as per the SMP. This is not a deficiency or release as classified under 40 CFR 257.83(b)(5).

6) Items 2 and 3 observed and documented in this checklist are considered a deficiency or release as classified under 40 CFR 257.83(b)(5) and Golder recommends the hydraulic structures are inspected as soon as feasible and their condition documented.

PROFESSIONAL ENGINEER SEAL

Name of Engineer: Tiffany D. Johnson, P.E.

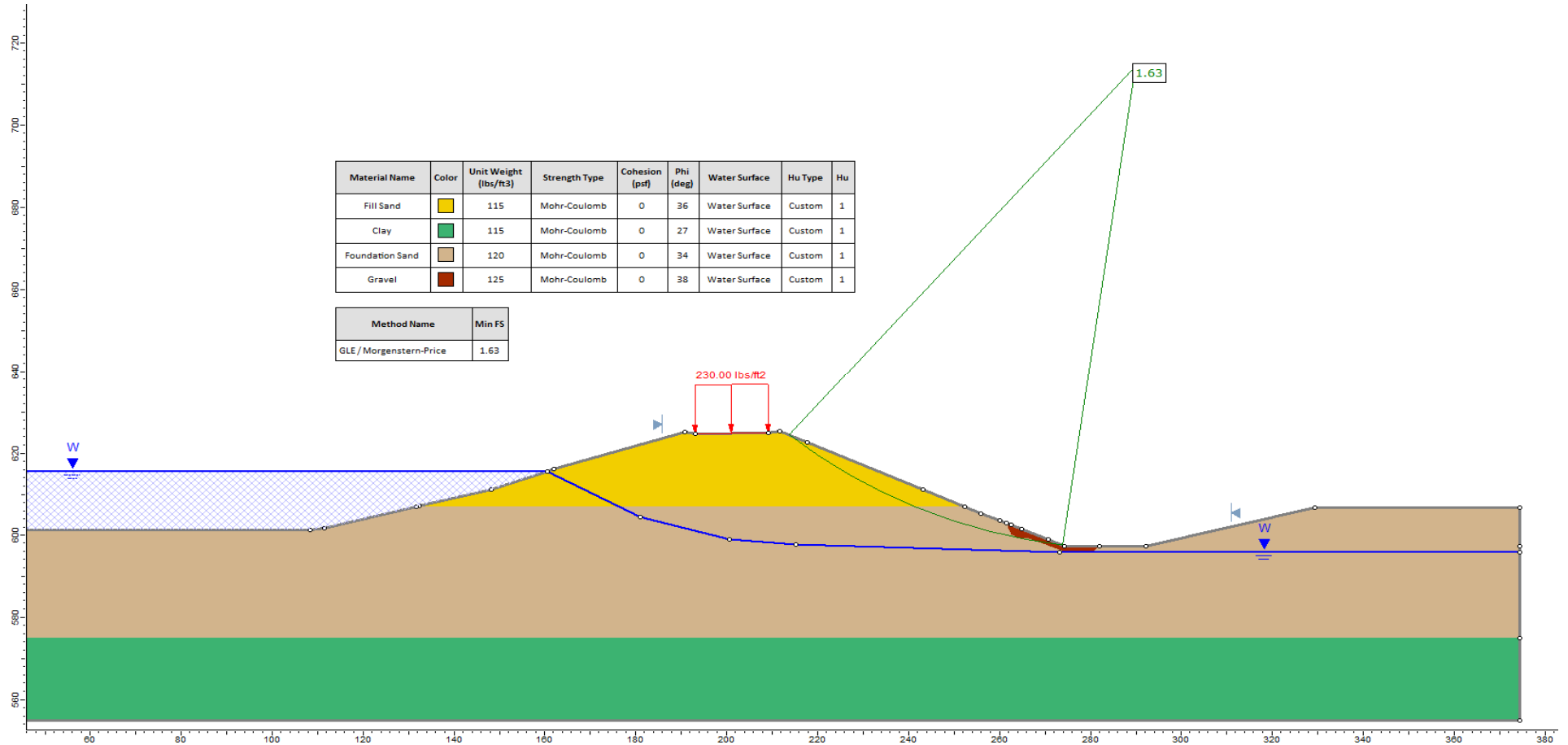
Date: 10/14/16

Engineering Firm: Golder Associates Inc.

Signature:



APPENDIX B
SLOPE STABILITY ANALYSIS RESULTS



SCALE AS SHOWN
DATE Aug 2016
MADE BY AK
CAD -

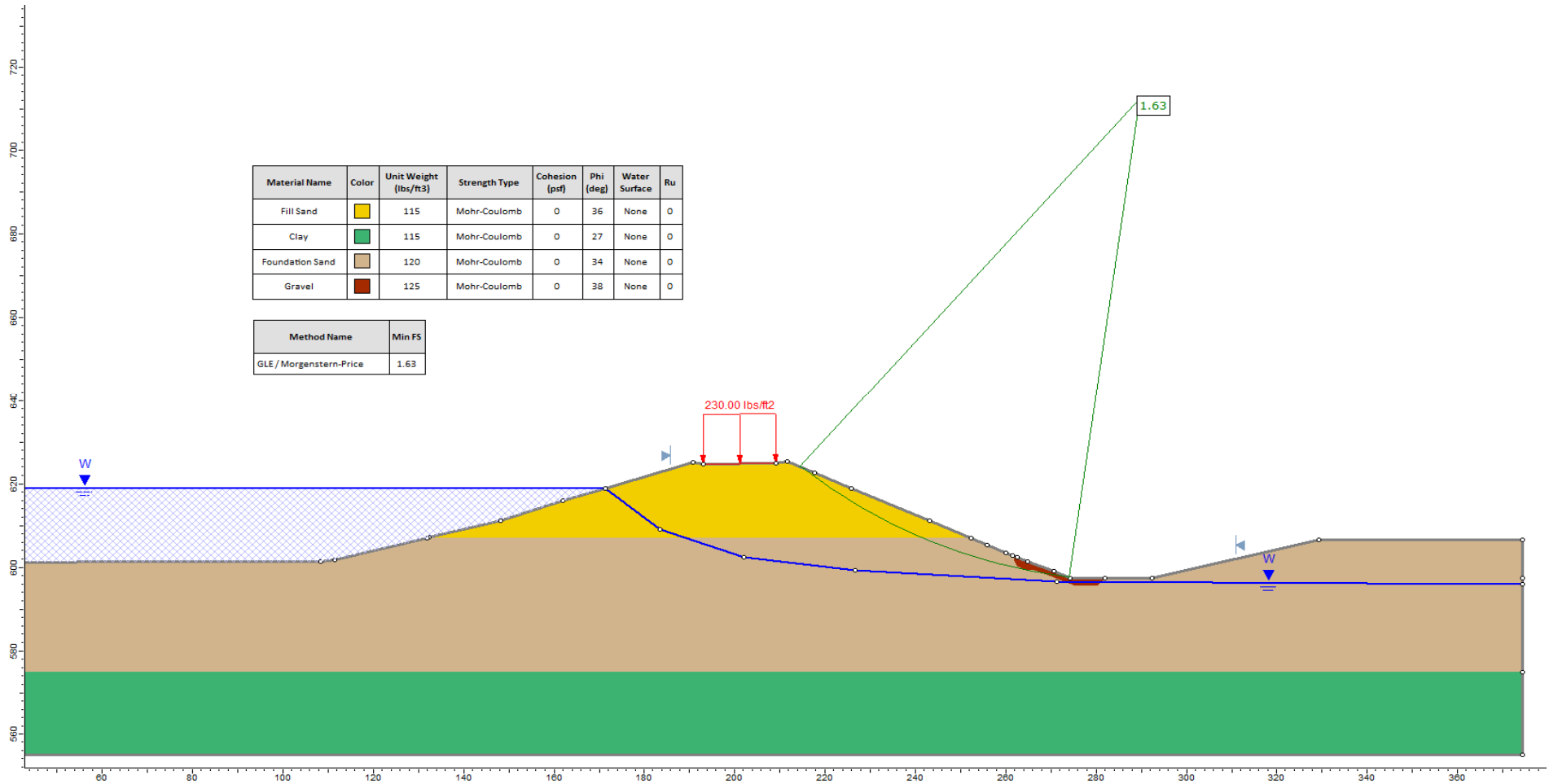
PROJECT J.H. Campbell Structural Stability Assessments
TITLE Pond A Section A-A'
Slope Factor of Safety
Max Pool Storage Scenario

FILE Campbell_Pond_A_Stability
PROJECT No. 1654923 REV. 0

CHECK JMS
REVIEW MJW

CLIENT Consumers Energy Company

FIGURE B-A1



SCALE AS SHOWN
 DATE Aug 2016
 MADE BY AK
 CAD -

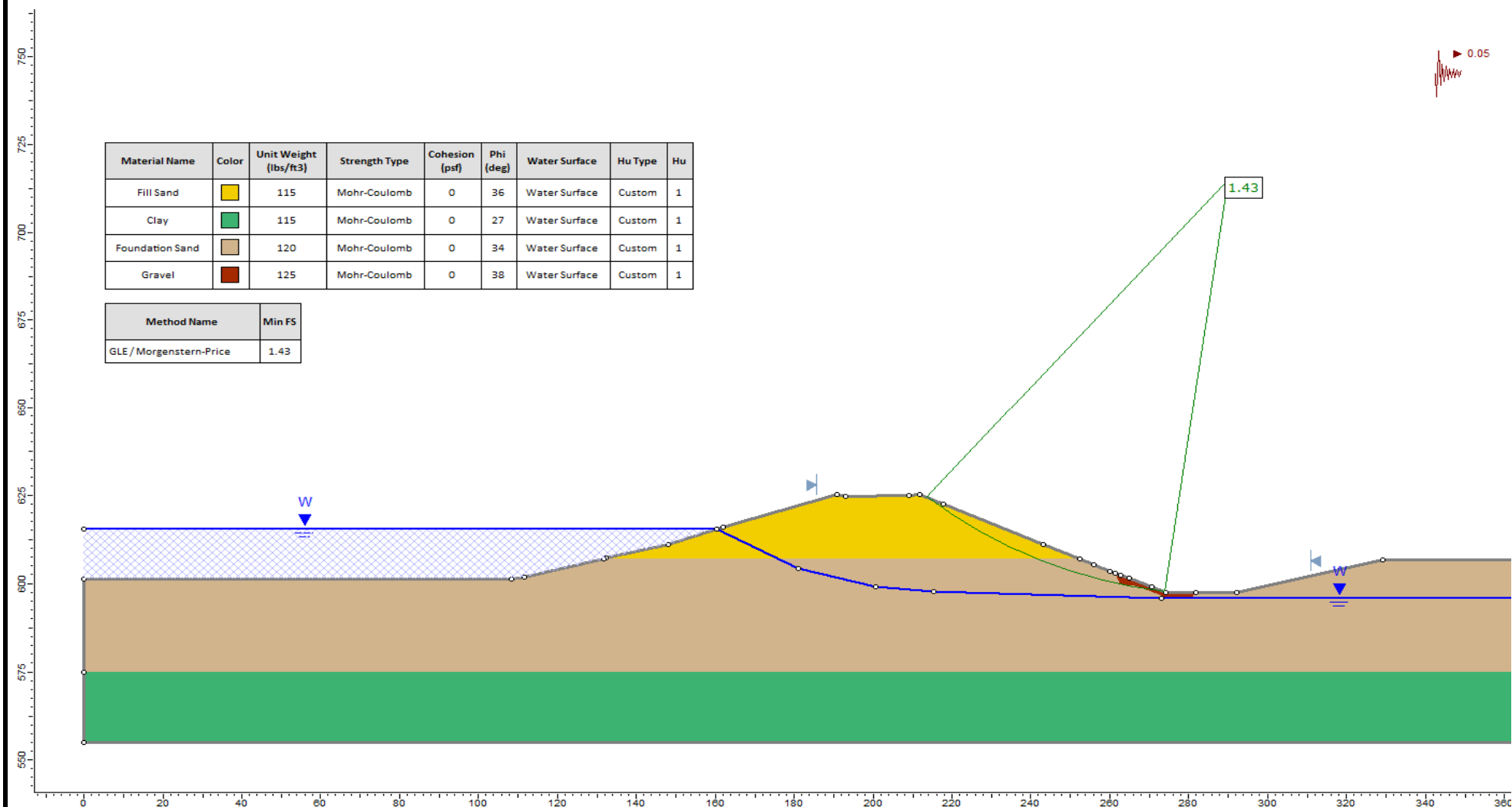
PROJECT J.H. Campbell Structural Stability Assessments
 TITLE Pond A Section A-A'
 Slope Factor of Safety
 Max Pool Surge Scenario

FILE Campbell_Pond_A_Stability
 PROJECT No. 1654923 REV. 0

CHECK JMS
 REVIEW MJW

CLIENT Consumers Energy Company

FIGURE B-A2



SCALE AS SHOWN
DATE Aug 2016
MADE BY AK
CAD -

PROJECT J.H. Campbell Structural Stability Assessments

TITLE Pond A Section A-A'
Slope Factor of Safety
Seismic Scenario

FILE Campbell_Pond_A_Stability

CHECK JMS

CLIENT

Consumers Energy Company

PROJECT No. 1654923 REV. 0

REVIEW MJW

FIGURE

B-A3

APPENDIX C
LIQUIFACTION POTENTIAL ANALYSIS RESULTS

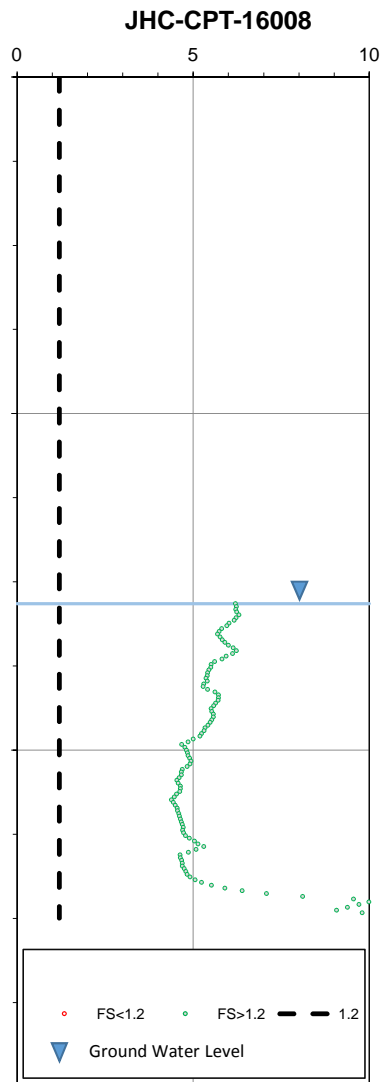
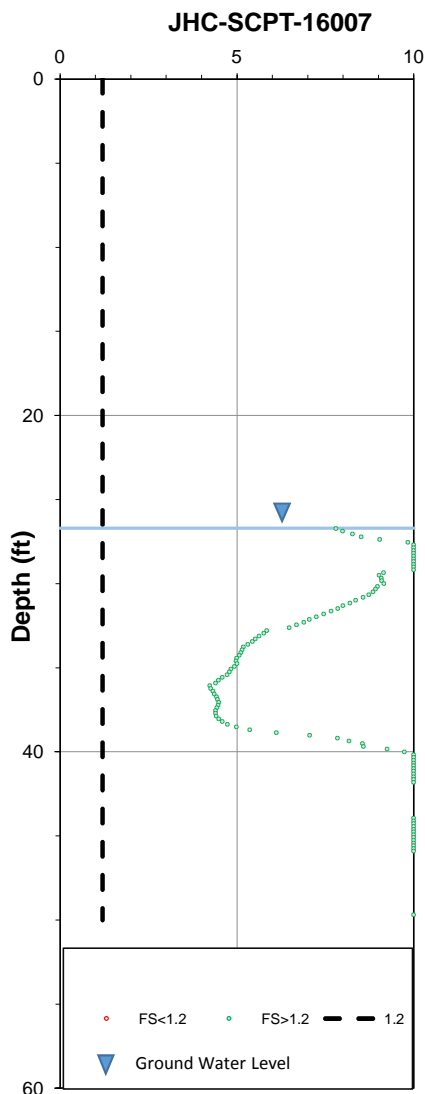
Project:	JH Campbell RCRA	Test Type:	CPTU	Golder Eng:	AK	Design EQ 1	
Location:	West Olive, MI	Device:	15 cm ² , Type 2 filter	Check	AF	Magnitude:	6.4
Client:	CEC	Standard:	ASTM D5778	Review:	JS		
Proj No.:	1654923	Push Co.:	ConeTec	Max Depth:	50.0 ft		
Area:	Pond A	Operator:	Thomas Carpenter	Termination:	Target Depth		



CPT ID: JHC-SCPT-16007
Test Date: 5/17/2016
Northing: 517541
Easting: 12635327
Elevation: 624.7 ft
a_{max}: 0.05 g
Water Table: 26.7 ft

CPT ID: JHC-CPT-16008
Test Date: 5/17/2016
Northing: 517559
Easting: 12635886
Elevation: 628.9 ft
a_{max}: 0.05 g
Water Table: 31.3 ft

FACTOR OF SAFETY AGAINST LIQUEFACTION



Notes: Factors of safety (FS) greater than 10 are shown equal to 10.

NCEER (2001) method was used to calculate factors of safety against liquefaction.

The ground water levels shown here are the interpreted ground water levels at the time of CPT investigation.

No liquefaction assumed to be possible above the water table or if $qc1Ncs > 160$.

Established in 1960, Golder Associates is a global, employee-owned organization that helps clients find sustainable solutions to the challenges of finite resources, energy and water supply and management, waste management, urbanization, and climate change. We provide a wide range of independent consulting, design, and construction services in our specialist areas of earth, environment, and energy. By building strong relationships and meeting the needs of clients, our people have created one of the most trusted professional services organizations in the world.

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