Initial Factor of Safety Assessment Report
Inactive CCR Surface Impoundment

City of Ames Steam Electric Plant

Ames Municipal Electric System
502 Carroll Avenue
Ames, Iowa 50010

SCS ENGINEERS

April 16, 2018

SCS Engineers
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Clive, Iowa 50325
515-631-6161

April 16, 2018
File No. 27217425.00

Mr. Brian Trower
Assistant Director – Electric Services
Ames Municipal Electric System
502 Carroll Avenue
Ames, Iowa 50010

Subject: Initial Factor of Safety Assessment Report
Inactive Coal Combustion Residuals (CCR) Surface Impoundment

Dear Mr. Trower:

SCS Engineers has prepared the Initial Factor of Safety Assessment Report for the Inactive CCR Surface Impoundment for the City of Ames Steam Electric Plant in accordance with the requirements set forth in §257.73(e) of the CCR Rule (40 CFR 257.50-107). SCS believes the factors of safety for the City of Ames Steam Electric Plant CCR Surface Impoundment meet the regulatory requirements set forth in §257.73(e)(i) to (iv) of the CCR rule.

If you have any questions regarding this document, please contact the undersigned.

Sincerely,

Patrick M. Goeke
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PE CERTIFICATION

Certification Statement 40 CFR §257.73(e) – Initial Factor of Safety Assessment

This Initial Factor of Safety Assessment Report for the City of Ames Steam Electric Plant CCR Inactive Surface Impoundment was prepared by SCS Engineers (SCS). The document and Certification are based on and limited to information that SCS has relied on from the City of Ames and others, but not independently verified, by SCS.

I, Christine L. Collier, hereby certify that this Initial Factor of Safety Assessment Report for the City of Ames Steam Electric Plant meets the requirements of §257.73(e) and that it was prepared by me or under my direct supervision, and that I am a duly licensed Professional Engineer under the laws of the State of Iowa.

Digitally signed by Christine Collier
Date: 2018.04.16 22:56:43 -05'00'

(signature) (date)

Christine L. Collier

(printed or typed name)

License number 17963

My license renewal date is December 31, 2019.

Pages or sheets covered by this seal:

Entire Document except Appendix A

1 INTRODUCTION

On April 17, 2015, the Environmental Protection Agency issued the final version of the federal Coal Combustion Residuals (CCR) Rule to regulate the disposal of CCR materials generated from the combustion of coal at electric utilities and independent power producers. Inactive power plant ash impoundments containing CCR are regulated under Section 257.100 of the Code of Federal Regulations (CFR) 40 Part 257.

The City of Ames (COA) Steam Electric Plant is subject to the CCR Rule and in accordance with the rule must document the Initial Factor of Safety Assessment as specified in Section §257.73(e) of the rule. This document provides the Initial Factor of Safety Assessment and documentation for the existing COA CCR Surface Impoundment.

The Initial Factor of Safety Assessment must document the factor of safety of the ash impoundment for various loading conditions required in 40 CFR §257.73(e)(i) to (iv) of the CCR rule.

2 BRIEF DESCRIPTION OF IMPOUNDMENT

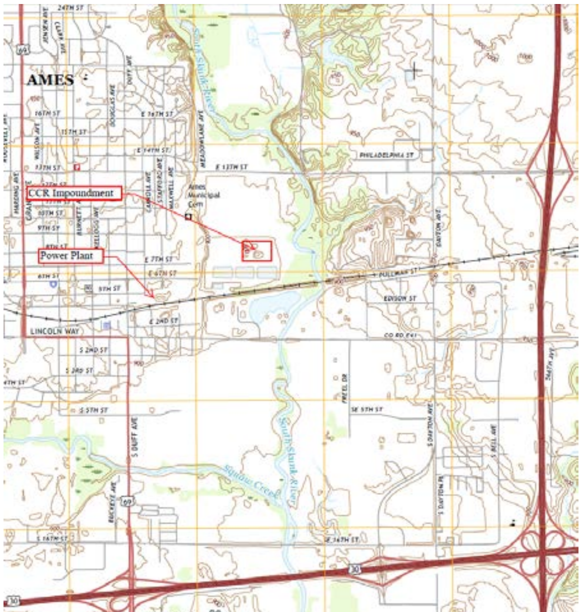


Figure 1 – USGS Topo Map - 2012

The City of Ames Steam Electric Plant is located at 200 East 5th Street, in Ames, Iowa. The City of Ames Steam Electric Plant disposed their CCR materials in a single CCR surface impoundment located approximately 3,000 feet northeast of the generating station in Section 1, Township 83 North, Range 24 West. The approximately 9.6 acre CCR impoundment is located adjacent to and to the east of the COA Water Treatment Plant's Lime Pond. The CCR surface impoundment is approximately 900 feet in length in the east-west direction and a maximum of 675 feet in length in the north-south direction. Based on the 2017 aerial image obtained from the COA and the parcel information found on the City of Ames Beacon™ geographic information system (GIS) site, the area to the north and immediate northeast of the impoundment is privately-owned crop land, to the northeast beyond the privately owned crop ground is the COA South River Valley Park, to the east (ranging from 450 to 950 feet) is the South Skunk River, to the south is COA property and the railroad embankment for the Union Pacific Railroad, and to the west is the lime pond.

The CCR impoundment was designed by Lutz, Daily & Brain Consulting Engineers in 1980 and was used for disposal of CCR until October 19, 2015. The embankments for the impoundment were constructed of clay soils obtained from an adjacent borrow area and from within the impoundment footprint. The bottom and interior side slopes of the impoundment were lined with a 3-foot thick impervious liner with a permeability ranging between 7.3×10^{-9} and 4×10^{-10} centimeters per second (cm/sec). Construction of the CCR surface impoundment was overseen by Lutz, Daily & Brain personnel. Density and permeability testing during construction was performed by Patzig Testing Laboratories Co., Inc.

The design plans indicated top of the impoundment liner in the bottom of the impoundment is city datum[1] elevation EL 59 (EL 882.5 MSL)[1], the top of the impoundment embankments is city datum EL 74 (EL 897.5 MSL) and the ground surface elevation around the impoundment ranged from EL 64 to 62 (EL 887.5 to 885.5 MSL). The maximum depth from the crest of the embankment to the base of the impoundment is 15 feet. The maximum exterior height of the embankment (12 feet) occurs in the southeast corner of the impoundment where the ground surface is city datum El is 62. The impoundment berms have a crest width ranging from 10 to 25 feet and 3 horizontal to 1 vertical (3:1) side slopes on both exterior and interior slopes of the impoundment. Two non-CCR impoundments (clear water basins) are located to the south of the CCR surface impoundment.

3 FACTOR OF SAFETY ASSESSMENT

3.1 SUBSURFACE INFORMATION

SCS reviewed existing subsurface geotechnical reports, construction reports, and previous stability analyses as part of this report. Reviewed documents included:

1. Wenck, Dike Stability Investigation Report, Revised March 2018
2. Patzig Testing Laboratory, Geotechnical Investigation Lagoon System and Borrow Area, 1980
3. Patzig Testing Laboratory, Ames Lagoon Permeability Testing, 1980
4. Patzig Testing Laboratory, Soil Investigation, 1980

In April 2016, Wenck Associates, Inc. of Maple Plain, Minnesota, completed a “Dike Stability Investigation Report” for the Ames Municipal Electric System. As part of the investigation, Wenck (and it’s subcontractor, Braun Intertec) completed four standard soil borings through the CCR and Lime Pond embankments, using hollow stem augers and split-spoon and Shelby tube samples. The borings were drilled to depths ranging from 30 to 70 feet. In addition, Wenck completed eight cone penetrometer test (CPT) soundings to characterize the embankment and foundation to depths ranging from 30 to 71 feet. Four of the CPT soundings were co-located with the soil borings.

Wenck selected four soil samples for index testing consisting of Atterberg limits (ASTM D4318) and grain size analysis (ASTM D422). Wenck selected two Shelby tube samples for strength testing using consolidated-undrained triaxial testing (ASTM D4767).

[1] City Datum = 823.55 MSL

In the April 2016 Wenck Dike Stability Investigation Report, Wenck selected the engineering soil parameters found in Table 1 below for the three main soils found at the site to be used in the embankment stability analyses.

Table 1. Soil Engineering Properties

Material Type	Unit Weight (pcf)	Effective Angle of Internal Friction, Phi' (degrees)	Cohesion, C' (psf)
Fill Material	115	30	50
Sandy Lean Clay (CL)	115	28	25
Poorly Graded Sand	110	30	0

3.2 METHODOLOGY

Wenck performed slope stability analyses on three cross sections using the SLOPE/W™ program developed by GEO-SLOPE International Ltd. Wenck evaluated each cross section (inboard and outboard) for two loading conditions: 1) static slope stability, and 2) seismic event slope stability. SCS reviewed the 2016 and 2018 Wenck stability analyses designed to meet the requirements of the CCR rule and that were consistent with the conditions at the site. SCS was provided the revised Wenck Dike Stability Investigation Report, Ames Municipal Electric System, Ames, IA in April 2018.

At the request of the COA, SCS was provided the SLOPE/W™ data files for SCS review. SCS reviewed the input and output data from the Wenck models. SLOPE/W™ solves two factor of safety (FS) equations: one satisfying force equilibrium and one satisfying moment equilibrium. The stability process involves passing a slip surface through the earth mass and dividing the inscribed portion into vertical slices. The slip surface may be circular, composite (i.e., combination of circular and linear portions), or consist of any shape defined by a series of straight lines (i.e., fully specified slip surface). SLOPE/W™ has undergone a rigorous validation and verification process, which can be accessed on the Geoslope International website (www.geo-slope.com).

Based on the SCS review of the construction drawings and available subsurface information, SCS determined the critical cross section to be located in the southeast corner of the CCR impoundment where the embankment height is the greatest due to the location of the lowest existing ground surface in that area. When determining the engineering parameters for the site, SCS selected the worst case strength data based on our review of the borings logs, test data, CPT soundings and historic data and reports. SCS conducted additional stability analyses utilizing additional failure surfaces and failure mechanisms, alternate soil strength parameters, and phreatic surfaces. It is SCS' professional opinion that the factors of safety calculated and presented in the Wenck report meet the requirements of the CCR regulations, and that, in SCS' opinion, the factors of safety are conservative estimates.

3.3 LONG TERM MAXIMUM STORAGE CONDITION

From the Wenck report:

The static load condition assumes steady state groundwater conditions with no seismic activity. The minimum calculated factors of safety (FS) for each cross section are summarized below:

Table 5: Static Loading Condition Analysis Results

Cross Section	Long Term Max. Pool Elevation 69.5 (ft) – MIN FS = 1.5		Max. Surcharge Pool Elevation 74.0 (ft) – MIN FS = 1.4	
	Inboard Slope FS	Outboard Slope FS	Inboard Slope FS	Outboard Slope FS
1	1.99	1.92	2.34	1.53
2	1.97	2.68	2.30	2.16
3	2.01	1.70	2.34	1.40

The calculated FS by Wenck for the long term maximum loading condition is 1.70, which exceeds the required 1.50 FS specified in the CCR rule.

3.4 END OF CONSTRUCTION CONDITION

Section 257.73(e)(1) does not require consideration of end-of-construction conditions for existing surface impoundments since sufficient time has generally passed that such any excess pore pressures caused by construction have dissipated, and materials can be characterized by their drained effective stress shear strength parameters. Therefore, this condition was not considered.

3.5 MAXIMUM SURCHARGE CONDITION

From the Wenck report:

The static load condition assumes steady state groundwater conditions with no seismic activity. The minimum calculated factors of safety (FS) for each cross section are summarized below:

Table 5: Static Loading Condition Analysis Results

Cross Section	Long Term Max. Pool Elevation 69.5 (ft) – MIN FS = 1.5		Max. Surcharge Pool Elevation 74.0 (ft) – MIN FS = 1.4	
	Inboard Slope FS	Outboard Slope FS	Inboard Slope FS	Outboard Slope FS
1	1.99	1.92	2.34	1.53
2	1.97	2.68	2.30	2.16
3	2.01	1.70	2.34	1.40

For details on the PMF storm routing, refer to the hydraulic and hydrologic storm water routing analysis include in the COA Initial Inflow Design Flood Control Plan.

The calculated FS by Wenck for the long term maximum loading condition is 1.40, which meets the required 1.40 FS specified in the CCR rule.

3.6 SEISMIC CONDITION

From the Wenck report:

The analysis considered both the inboard and outboard slopes at the Maximum Surcharge Pool Elevation to be conservative. Results of the analysis are as follows:

Table 7: Seismic Loading Condition Analysis Results

Cross Section Location	Inboard Slope FS	Outboard Slope	Minimum Required FS
1	1.65	1.31	1.00
2	1.63	1.70	1.00
3	1.65	1.20	1.00

The calculated FS by Wenck for the seismic condition is 1.20, which meets the required 1.00 FS specified in the CCR rule.

3.7 RAPID DRAWDOWN CONDITION

SCS does not believe rapid drawdown is applicable to the embankment because of the duration a water level from a flood event would be applied to the outboard embankment slope and the permeability of the embankment soils. Historically, the duration of past flood events have been too short to alter the phreatic surface inside the embankment.

Regardless, Wenck conducted a rapid drawdown analysis using a very conservative water level in the embankment resulting from the flood event. Wenck calculated a minimum factor of safety of 1.21, which equals or exceeds the recommended factor of safety of 1.0-1.2 taken from the United States Corps of Engineers (USACE), "Engineering Manual 1110-0-1913 Design and Construction of Levees".

3.8 LIQUIFACTION POTENTIAL

Section 257.73(e)(1)(iv) requires that the potential for liquefaction be evaluated when materials are present that may be susceptible to liquefaction. The minimum required factor of safety for liquefaction potential is 1.20. Liquefaction is a phenomenon where saturated cohesionless materials lose shear strength because of an increase in pore water pressures caused by seismic shaking. Factors impacting the liquefaction potential of soils are the material grain size characteristics, density, whether the material is saturated and the characteristics of the design seismic event.

SCS reviewed the liquefaction potential calculations conducted by Wenck using a method presented in a paper[2] by Robertson and Wride published in the Canadian Geotechnical Journal. The procedure used CPT data to estimate the cyclic resistance ration (CRR) of the soils with depth. The CRR

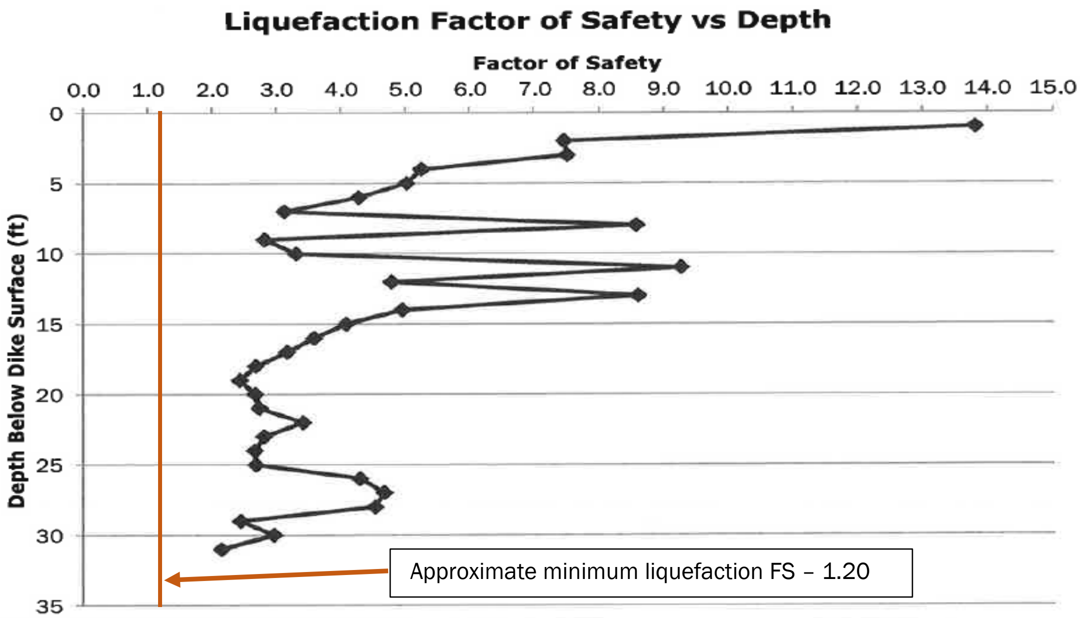
[2] "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test" by Robertson and Wride; Canadian Geotechnical Journal; 1998.

represents the resistance of the soil profile to liquefy during a seismic event. A cyclic stress ration (CSR) is calculated based on the expected peak horizontal ground surface acceleration (0.06g) and overburden stress. The result is a profile of soil stress and liquefaction potential with depth for the design seismic event.

A liquefaction factor of safety profile is calculated using the following equation:

$$FS(z) = CRR(z) / CSR(z)$$

The following graph is plot of the liquefaction factor of safety versus depth calculated for CPT-3 at the COA site. Wenck concluded the results for CPT-3 are representative of the entire site given the relative consistency of the subsurface across the site. Presented below is the Wenck derived liquefaction analysis profile.



The above graph shows that the liquefaction factor of safety versus depth exceeds the required minimum of 1.20 FS specified in the CCR rule.

4 SUMMARY OF SAFETY ASSESSMENT

The following table summarizes the required slope stability cases, pool elevation used in each slope stability case, and the target and calculated factor of safety. SCS Engineers reviewed the slope stability analyses prepared by Wenck Associates, Inc., Maple Plain, MN. SCS' evaluation of the stability analyses is that the factors of safety calculated by Wenck and presented in the Wenck report meet the requirements of the CCR regulations, and that, in SCS' opinion, the factors of safety are conservative estimates.

Table 2. Factors of Safety

Case	Pool Elevation[1]	Target FS	Calculated FS
Long Term Maximum Storage	69.5	1.5	**1.7**
Maximum Surcharge	74.0	1.4	**1.4**
Seismic	74.0	1.0	**1.2**
Liquefaction Potential	NA	1.2	**>1.2**

5 REVISIONS, RECORDKEEPING, AND REPORTING

The Factor of Safety Assessment Report is required to be updated every five years, from the date of placement of the previous assessment in to the operating record as required by §257.105(f)(12). The initial and subsequent reports must be certified by a qualified professional engineer stating that the Factor of Safety Assessment meet the requirements of §257.73(e).

The COA will place this initial Factor of Safety Assessment Report in the CCR Operating Record and on the COA's CCR Rule Compliance Data and Information website by April 17, 2018. The COA will notify the Iowa Department of Natural Resources (IDNR) that this report has been completed and placed in the facility's operating record and on the COA CCR Rule Compliance Data and Information website. Further, the COA will notify the IDNR of subsequent updates to the Factor of Safety Assessment Report.

Appendix A

Supporting Documents

WENCK File #B3349-0001
Revised March 2018

Dike Stability Investigation Report
Ames Municipal Electric System
Ames, IA

Prepared for:

Ames Municipal Electric System
Ames, IA

502 Carroll Avenue
Ames, Iowa 50010

Responsive partner.
Exceptional outcomes.

Prepared by:

WENCK Associates, Inc.
1800 Pioneer Creek Center
Maple Plain, MN 55359
763-479-4200

Dike Stability Investigation Report
Ames Municipal Electric System
Ames, IA

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Iowa.

Tony S. Rohs
Signature

3/27/18
Date

Tony Rohs, PE
Principal
License renewal date is 12/31/18
License No. 23988

WENCK
ASSOCIATES
Responsive partner. Exceptional outcomes.

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1.0 Introduction

The City of Ames, IA (City) operates a municipal power plant located at 502 Carroll Avenue in Ames, IA (see Figure 1). The power plant has historically generated electricity using two coal fired units. Ash from the coal burning process was sluiced to an ash pond impoundment onsite. In addition, the site operates a landfill area where coal combustion residuals (CCR) were stored. Figure 2 presents a layout of the pond and landfill areas. The plant currently has been converted to use natural gas as the fuel source. This conversion eliminated the use of coal.

The City is required to evaluate the structural integrity of the ash pond impoundment dikes to comply with Rule 257.73 of Federal Regulation 40 CFR 257 Subpart D. The rule requires minimum safety factors (FS) for the following impoundment dike loading conditions:

- Long-term maximum storage pool loading condition (min. static FS = 1.50)
- Maximum surcharge pool loading condition (min. static FS = 1.40)
- Seismic loading resulting from an event with a peak ground acceleration that has a 2% probability of exceedance in 50 years (min. FS = 1.00)
- For CCR units with downstream slopes which can be inundated by the pool of an adjacent water body, such as a river, stream or lake, downstream slopes that maintain structural stability during low pool of the adjacent water body or sudden drawdown of the adjacent water body
- Evaluation of sediments with liquefaction potential (min. FS = 1.20)

This report summarizes the results of a geotechnical field investigation of the surface impoundment dikes, laboratory testing of soil samples collected from the site, and slope stability analysis of the pond dikes to evaluate safety factors under the loading conditions listed above.

2.0 Previous Work

Existing information regarding pond dike construction and previous site evaluations were used to supplement this report. Pond dike construction drawings provided by the Ames Municipal Electric System were used to provide the topography shown in the pond dike cross sections. The pond dike drawings are included in Appendix A.

A report entitled, *Coal Combustion Residue Impoundment, Round 12- Dam Assessment Report* was previously prepared by Dewberry and Davis, LLC for the US Environmental Protection Agency (Dewberry and Davis, 2014). The report provided an initial assessment of the stability and functionality of the surface impoundments at the site. Information from Dewberry and Davis 2014 Final report regarding potential seismic event magnitudes was referenced for the seismic stability evaluation in this report. The 2014 final version of the Dewberry and Davis report is included in Appendix A for reference. It is important to note that the Final version of the Dewberry report predates the 2015 final issuance date of Rule 257.73 of Federal Regulation 40 CFR 257 Subpart D, commonly referred to as the "CCR Rules or Standards".

3.0 Field Investigation

3.1 SOIL BORINGS AND SOUNDINGS

Standard Penetration Test (SPT) soil borings were completed in four locations as shown on Figure 2. Soil sampling was conducted with a split spoon sampler at 2.5-foot intervals to 30 feet, then at 5-ft intervals to the termination depth of each borehole. Soil from each split-spoon was field classified by manual-visual methods and then collected and labeled in containers for laboratory classification. In addition, Shelby Tube samples of cohesive material encountered were collected for potential laboratory testing.

The Cone Penetration Test CPT soundings are performed by pushing a cone-shaped instrument through the subsurface. The instrument measures tip resistance, sleeve friction and pore pressure at approximately 20 cm intervals. The measurements are correlated to a pre-defined range of soil behavior types to produce a relatively high-resolution estimate of the subsurface composition. In this investigation, CPT soundings were completed in eight locations. Four of the locations corresponded with the SPT boring locations. The remaining CPT soundings were performed in independent locations, as shown on Figure 2. Borehole and sounding depths and soil sample types collected are given in Table 1 below:

Table 1: Borehole and Sounding Depths and Soil Sample Types

Borehole ID	Proposed Depth	Completed Depth	Sampling
SPT-1	30	27.5	Split-Spoons, Shelby Tubes
SPT-2	70	60	Split-Spoons, Shelby Tubes
SPT-3	30	30	Split-Spoons, Shelby Tubes
SPT-4	70	70	Split-Spoons, Shelby Tubes
CPT-1	30	30	--
CPT-2	70	65	--
CPT-3	30	31	--
CPT-4	70	70	--
CPT-5	30	41	--
CPT-6	70	71	--
CPT-7	30	31	--
CPT-8	70	71	--

3.2 SUMMARY OF GEOLOGIC AND HYDROGEOLOGIC CONDITIONS

The subsurface materials encountered in the pond dikes during this investigation were consistent throughout the site. Fill material was generally encountered from the surface to approximately 12 feet below the surface. The fill material was composed of dark gray to brown lean clay with trace organics and lenses of sand and fat clay. The fill material was generally underlain by undisturbed sandy lean clay alluvium to a depth of approximately 16-21 feet below top of dike. This material was dark brown in color, medium stiff to stiff, and dry to moist. Course grained alluvium ranging from poorly graded sand with trace gravel to poorly graded sand with silt or trace clay was generally encountered below the sandy lean clay alluvium to the end of the borehole. The sand was brown, fine to coarse grained, loose to medium dense, and wet. The groundwater table was generally encountered between 18 and 22 feet below the top of dike in the course grained alluvium.

Subsurface information collected from the SPT borings was used to create boring logs representing the subsurface conditions encountered at each SPT borehole location. The subsurface geology described above can be referenced on these boring logs which are included in Attachment B.

The subsurface conditions indicated by the CPT soundings corresponding to boreholes SPT-1, SPT-2, SPT-3 and SPT-4 (see Figure2) indicated good agreement with the conditions shown on the SPT boring logs. The CPT soundings at locations CPT-6, CPT-7, and CPT-8 indicated similar subsurface conditions to those encountered in locations 1, 2, 3, and 4. The sounding at location CPT-5 indicated fine-grained material from approximately 23 feet below top of dike to the end of the sounding at approximately 40 feet below top of dike. This differs from the coarse-grained alluvium encountered at this depth interval at other locations. Appendix C contains the SPT sounding logs.

3.3 SOIL SAMPLE TESTING

Soil samples collected during the investigation were reviewed and representative samples were selected for laboratory testing. Selected samples were tested at the Braun Intertec Corporation soils laboratory in Cedar Rapids, IA for the following:

- Atterberg Limit Tests (ASTM D 4318)
- Grain Size Analysis (sieves through #200) (ASTM D 422)
- Tri-Axial Compression Testing, Consolidated-Undrained (ASTM D 4767)

Test results are presented in Appendix D. The test results were used to verify field soil classifications and estimate soil engineering properties. The Atterberg Limit and grain size analysis (index parameter) test results are summarized in the table below:

Table 2: Summary of Index Parameter Test Results

Borehole ID	Sample Depths (ft)	Material Classification	%Sand	%Silt	%Clay	LL	PL	PI
STP-1	18-20	Sandy Lean Clay (CL)	11.7	62.5	25.8	38	17	21
STP-2	8-10	Sandy Lean Clay (CL)	41.4	32.7	25.8	27	12	15
STP-3	16-18	Sandy Lean Clay (CL)	32.9	46.2	20.9	27	17	10
STP-4	11-13	Sandy Lean Clay (CL)	16.0	49.4	34.4	52	22	30

Tri-axial compression tests (consolidated-undrained) were performed on two soil samples from the pond dikes to evaluate the shear strength of the material. The test results were then used to estimate the soil engineering properties described in Section 3.4. The results of the tri-axial compression tests are shown below:

Table 3: Summary of Tri-Axial Compression Test (CU) Results

Borehole ID	Sample Depths (ft)	Material Classification	Effective Friction (degrees)	Effective Cohesion (tsf)	Total Friction (degrees)	Total Cohesion (tsf)
STP-2	8-10	Sandy Lean Clay (CL)	28.3	0	26.6	0.23
STP-3	16-18	Sandy Lean Clay (CL)	30.4	0	18.1	0.12

3.4 SOIL ENGINEERING PROPERTIES

Soil engineering properties for the surface impoundment dike materials and native subsoils were estimated from SPT test results collected during the field investigation and the tri-axial compression test results. Effective angle of internal friction was estimated for each soil type from N-values corrected for overburden pressure using a correlation proposed by Peck, Hanson and Thornburn (1974) as given in a publication by T.F. Wolff (1989). These values were compared to the tri-axial compression test results and conservative peak strength values were assigned to each soil type. The table below gives the engineering properties for the main material types found at the site:

Table 4: Soil Engineering Properties

Material Type	Unit Weight (pcf)	Effective Angle of Internal Friction, phi' (Degrees)	Cohesion, c' (psf)
Fill Material	115	30	50
Sandy Lean Clay (CL)	115	28	25
Poorly Graded Sand	110	30	0

4.0 Geotechnical Modeling

4.1 SLOPE STABILITY MODELING METHODOLOGY

The stability of the existing surface impoundment dikes was evaluated using a slope stability software program called Slope/W, developed by Geo-Slope International. The program uses a limit-equilibrium approach to calculate a factor of safety for potential failure surface locations. The minimum calculated factor of safety is compared to the minimum factors of safety for each load case outlined in Section 1.0.

Stability analysis was performed along three cross sections through the ash pond dikes as shown in Figure 2. Cross sections 1, 2, and 3 were aligned with SPT and CPT soil boring locations completed during the field investigation to allow the use of site specific subsurface geologic and groundwater observations.

The ash ponds remain active and operate at a normal pool site elevation of approximately 69.5. Although the CPT data indicated lenses of elevated pore pressures in the lean silty clay layer near the pond water elevation, these sediments are not likely completely saturated to the water level of the pond. However, modeling them as such represents the conservative case. Each cross section was evaluated for the following loading conditions:

- Static slope stability (2 cases)
  - Long-term maximum storage pool loading condition (min. static FS = 1.50)
  - Maximum surcharge pool loading condition (min. static FS = 1.40)
- Rapid draw down analysis following a 500-yr flood event in the adjacent Skunk River
- Seismic event slope stability (min. FS = 1.00)

Both the inside and outside surface impoundment dike slopes were analyzed for the static and seismic load conditions. Only the outside dike slope was analyzed for the rapid draw down loading condition. The results of the analysis for each condition are discussed below.

4.2 STATIC LOADING CONDITIONS

The static load condition assumes steady state groundwater conditions with no seismic activity. The minimum calculated factors of safety (FS) for each cross section are summarized below:

Table 5: Static Loading Condition Analysis Results

Cross Section	Long Term Max. Pool Elevation 69.5 (ft) – MIN FS = 1.5		Max. Surcharge Pool Elevation 74.0 (ft) – MIN FS = 1.4	
	Inboard Slope FS	Outboard Slope FS	Inboard Slope FS	Outboard Slope FS
1	1.99	1.92	2.34	1.53
2	1.97	2.68	2.30	2.16
3	2.01	1.70	2.34	1.40

The analysis indicates that calculated minimum factors of safety exceed the minimum required factors of safety for both the long term maximum storage elevation case (EL 69.5 ft) and the maximum surcharge pool elevation case (74.0 ft).

4.3 RAPID DRAWDOWN (RDD) ANALYSIS

The site has the potential to experience a rapid drawdown (RDD) scenario due to the presence of the Lower Skunk River approximately 400 ft to the east of the ash pond at its closest point.

A review of FEMA flood mapping data and historical flood data for the area indicates the 500-year flood event corresponds to a site elevation of approximately 69.5 ft. Based on the above, the following factors of safety were determined on the outboard slopes only at each of the 3 cross sections evaluated.

The CCR standard does not establish a minimum FS for the RDD condition, therefore the minimum FS shown below was taken from the United States Corps of Engineers (USACE), "Engineering Manual 1110-0-1913 Design and Construction of Levees", which is the same Min factor of safety range being used in the planned Fargo-Moorhead Diversion project, where technical requirements are established by the USACE

Table 6: Rapid Drawdown Loading Condition Results

Cross Section Location	Calculated RDD FS	Recommended Minimum FS
1	1.31	1.0-1.2
2	1.93	1.0-1.2
3	1.21	1.0-1.2

4.4 SEISMIC EVENT LOADING CONDITION

The report by Dewberry and Davis (2012) indicated that the estimated peak ground acceleration for an earthquake with a 2% probability of exceedance in a 50-year period for the Ames, IA area is 0.06g. This value was used in SLOPE/W to perform a pseudo-seismic analysis of each cross section to evaluate slope stability during a seismic event. In a pseudo-seismic analysis, SLOPE/W imparts a horizontal and vertical force on the dike materials equal to the product of the material unit weight times the specified peak ground acceleration. The slope stability of the dike is then evaluated with these forces applied. The analysis considered both the inboard and outboard slopes at the Maximum Surcharge Pool Elevation to be conservative. Results of the analysis are as follows:

Table 7: Seismic Loading Condition Analysis Results

Cross Section Location	Inboard Slope FS	Outboard Slope	Minimum Required FS
1	1.65	1.31	1.00
2	1.63	1.70	1.00
3	1.65	1.20	1.00

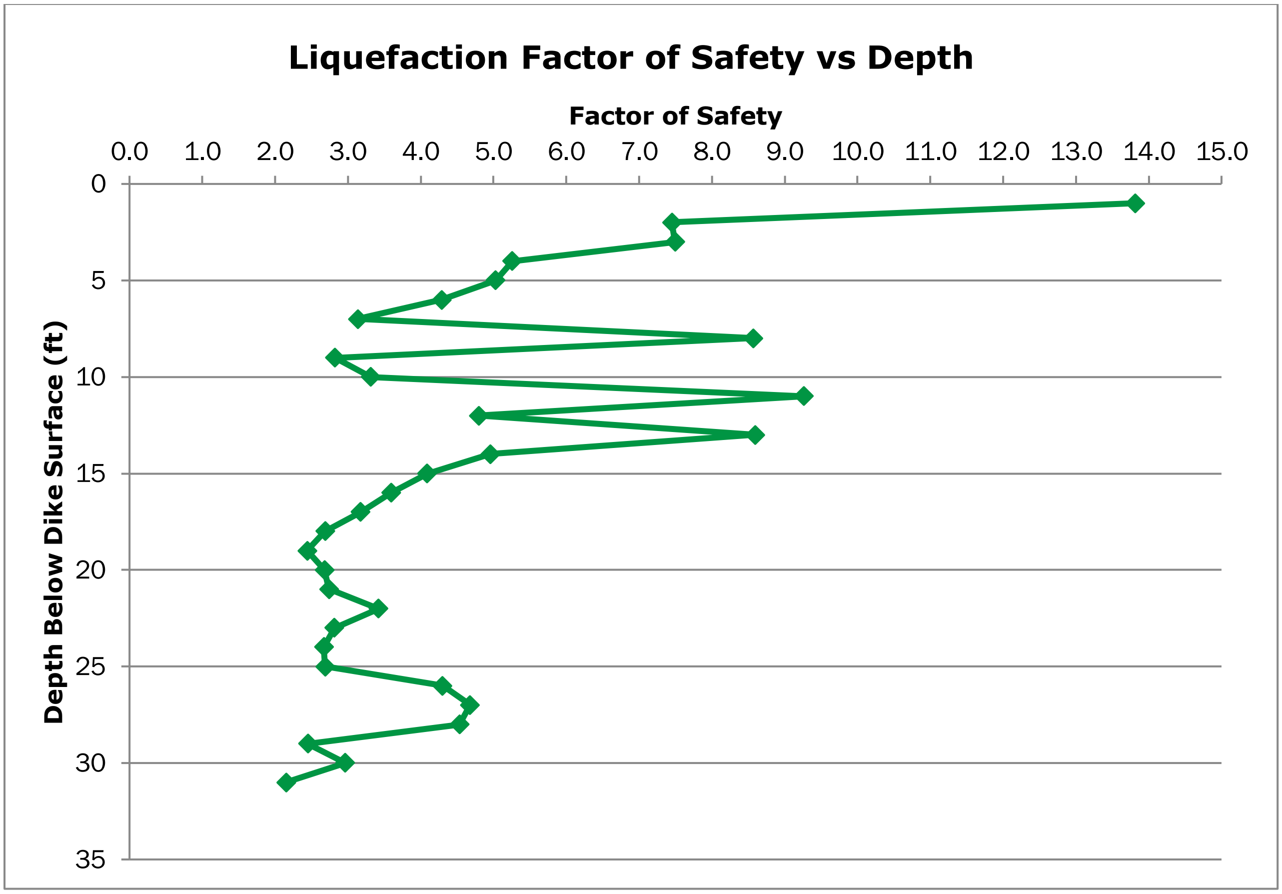
The analysis indicates that calculated minimum factors of safety exceed the minimum required factor of safety of 1.00 in all cases.

Appendix E contains the various slope stability analyses results.

4.5 LIQUEFACTION POTENTIAL

The liquefaction potential of the materials in and below the surface impoundment dikes was evaluated according to a procedure described in paper published in the Canadian Geotechnical Journal entitled, *Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test*, by Robertson and Wride (1998). The procedure uses CPT data to estimate the cyclic resistance ratio (CRR) of soils with depth. The CRR represents the resistance of the soil profile to liquefaction due to cyclic acceleration during a seismic event. A cyclic stress ratio (CSR) is also calculated based on expected peak horizontal ground surface acceleration and overburden stresses. The CSR represents the cyclic stress placed on the soil profile during a specified seismic event. For this analysis, the CSR profile was calculated using the expected peak ground surface acceleration for the site (0.06g) given in Dewberry and Davis (2012).

The result is a profile of soil stress and liquefaction resistance with depth for a given seismic event. A liquefaction factor of safety profile is calculated as the quotient of the cyclic resistance ratio to the cyclic stress ratio with depth (FS(z) = CRR(z)/CSR(z)). A liquefaction factor of safety profile was calculated for location CPT-3 at the Ames Utility site to evaluate liquefaction potential of the site soils. As the graph below indicates, the factor of safety exceeded the minimum criteria of FS = 1.20 for all depths. Given the relative consistency of the subsurface across the site, these results may be considered representative of the liquefaction potential of the site.



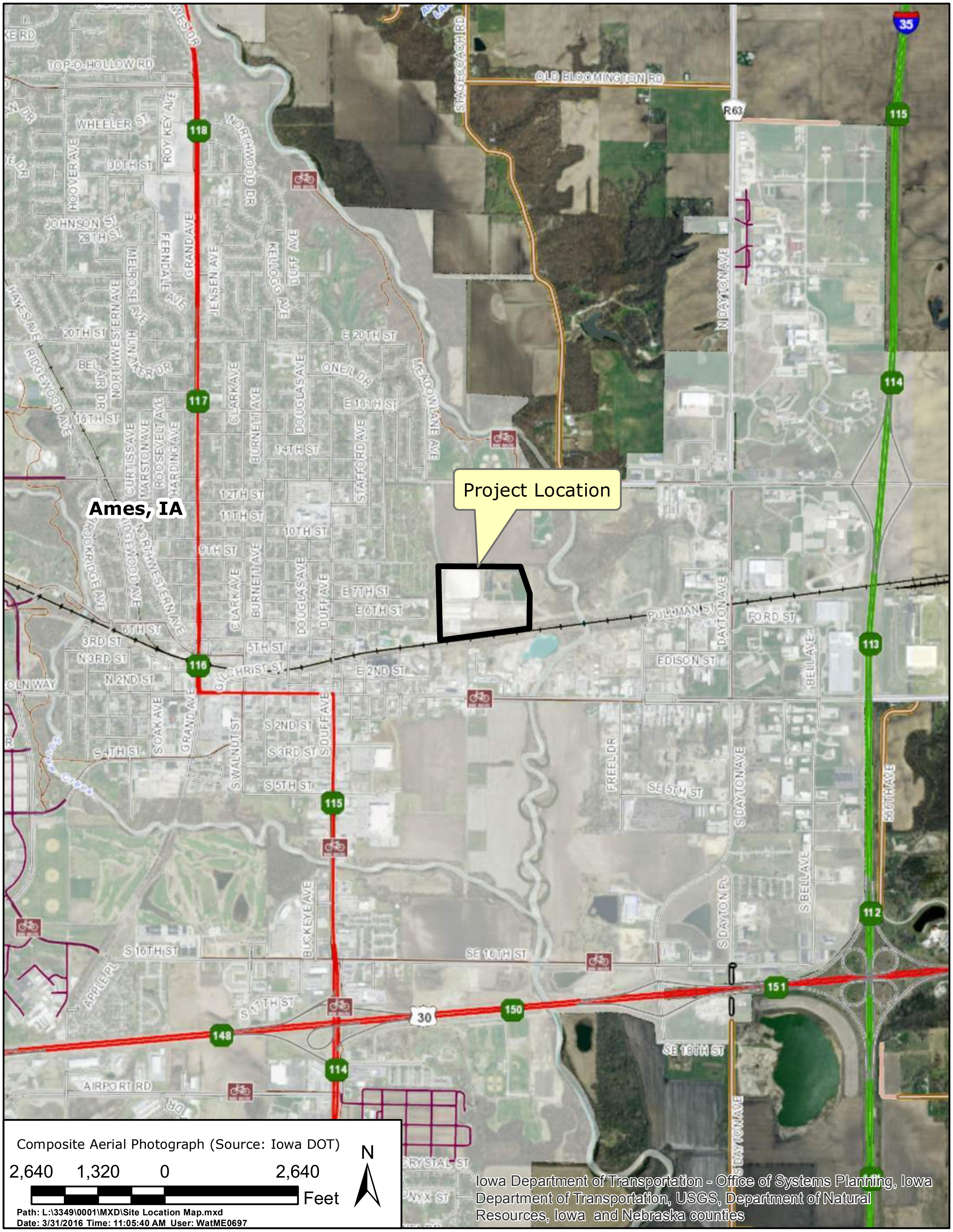
Liquefaction Factor of Safety vs Depth
Factor of Safety
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0
Depth Below Dike Surface (ft)
0 5 10 15 20 25 30 35

5.0 Summary and Conclusions

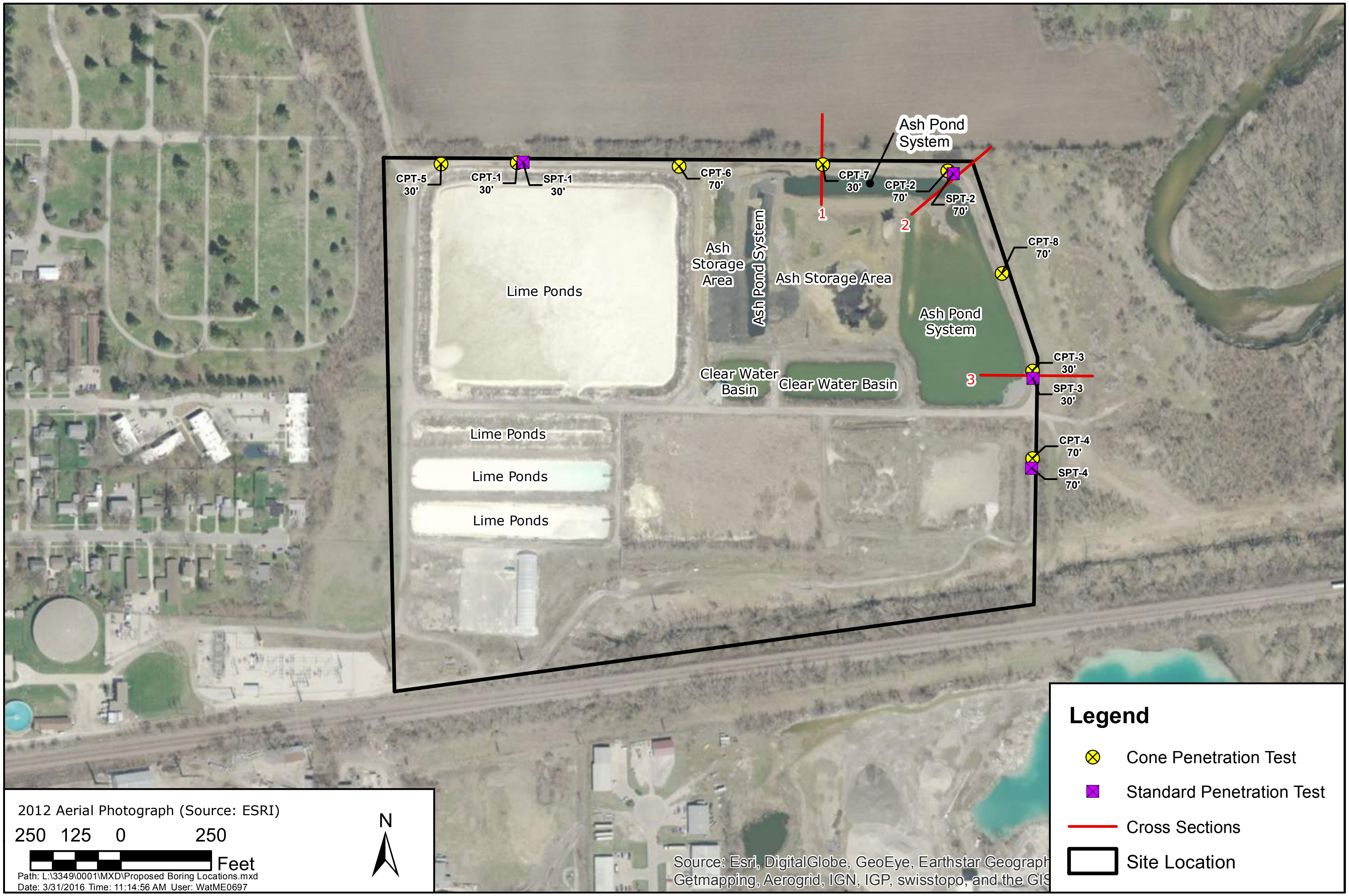
Based on the site's implementation appropriate maintenance activities (tree removal, planned riprap placement to minimize erosion potential due to wave action, and increased inspection frequency) the design, construction, operation, and maintenance of the CCR unit is consistent with recognized and generally accepted good engineering practices for the maximum volume of CCR and CCR wastewater which can be impounded therein.

The subsurface data collected during this investigation compares well with information collected previously at the site. The SPT and CPT data collected were in close agreement and indicated relatively uniform subsurface conditions across the site. Our analysis of the data indicates that the surface impoundment dikes have acceptable factors of safety for all loading conditions considered.

Figures



AMES MUNICIPAL ELECTRIC SYSTEM	WENCK ASSOCIATES Responsive partner. Exceptional outcomes.	MAR 2016
Site Location Map		Figure 1



AMES MUNICIPAL ELECTRIC SYSTEM	WENCK ASSOCIATES	MAR 2016
Soil Boring and Cross Section Locations	Responsive partner. Exceptional outcomes.	Figure 2

Appendix A

Final Dewberry and Davis Report (2014)

FINAL

Removed from 2018 Factor of Safety Assessment Report due to size. Available on EPA's website.

Coal Combustion Residue Impoundment

Round 12 - Dam Assessment Report

City of Ames Power Plant

Lime and Ash Pond
City of Ames
Ames, Iowa

Prepared for:

United States Environmental Protection Agency
Office of Resource Conservation and Recovery

Prepared by:

Dewberry Consultants, LLC
Fairfax, Virginia

Under Contract Number: EP-09W001727
March 2014

Appendix B

SPT Boring Logs

BRAUN INTERTEC

LOG OF BORING

Braun Project B1510576 Geotechnical Evaluation Ames Municipal Electric Ames, Iowa	BORING: **STP-1** LOCATION: See Attached Sketch

DRILLER: K. Elliott/K. Simpson	METHOD: 3 1/4" HSA, Autohammer	DATE: **11/2/15**	SCALE: **1" = 4.4'**

Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
	FILL	FILL: Lean Clay trace Organics, with Sand and pockets of Fat Clay, dark gray and brown, dry-to-moist	(7) (9) (8) (8)		
13.0	CL	SANDY LEAN CLAY trace Gravel, dark brown, moist, soft to medium (Alluvium)	(5) (3)		PP= 1.0 tsf
21.0	SP-SC	POORLY GRADED SAND with CLAY trace Gravel, fine- to coarse- grained, brown, moist, very loose to medium (Alluvium)	(5) (2) (13)	∇	
27.5		END OF BORING. Water observed at 22 feet while drilling. Boring then backfilled.			

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\CEDARRAPIDS\2015\B1510576.GPJ BRAUN_V8_CURRENT.GDT 12/9/15 17:08

LOG OF BORING

Braun Project B1510576
Geotechnical Evaluation
Ames Municipal Electric
Ames, Iowa

BORING: **STP-2**
LOCATION: See Attached Sketch

DRILLER: K. Elliott/K. Simpson | METHOD: 3 1/4" HSA, Autohammer | DATE: **11/4/15** | SCALE: **1" = 4.4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
	FILL	FILL: Lean Clay trace Organics, with Sand and pockets of Fat Clay, dark brown and gray, dry-to-moist	(12) (9) (11)		
10.5	CL	SANDY LEAN CLAY trace Organics, dark brown, dry-to-moist, medium to rather stiff (Alluvium)	(10) (7)		
16.0	SP	POORLY GRADED SAND trace Gravel, fine- to coarse-grained, brown, dry-to-wet, very loose to medium (Alluvium)	(3) (6) (13)	▽	
27.0	SP-SM	POORLY GRADED SAND with SILT trace Gravel, fine- to medium- grained, brown-gray, wet, medium (Alluvium)	(12) (13)		

LOG OF BORING N:\GINT\PROJECTS\CEDARRAPIDS\2015\B1510576.GPJ BRAUN_V8_CURRENT.GDT 12/9/15 17:08

BRAUN INTERTEC

LOG OF BORING

Braun Project B1510576 **Geotechnical Evaluation** **Ames Municipal Electric** **Ames, Iowa**	BORING: **STP-2 (cont.)** LOCATION: See Attached Sketch

DRILLER: K. Elliott/K. Simpson	METHOD: 3 1/4" HSA, Autohammer	DATE: **11/4/15**	SCALE: **1" = 4.4'**

Depth feet 35.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
		POORLY GRADED SAND with SILT trace Gravel, fine- to medium- grained, brown-gray, wet, medium (Alluvium) *(continued)*	(19)		
41.0	SP	POORLY GRADED SAND with Gravel, fine- to coarse- grained, gray, dry-to-wet, medium to dense (Alluvium)	(15)		
			(20)		
			(53)		
60.0		END OF BORING. Water observed at 20 feet while drilling. Boring then backfilled.			

(See Descriptive Terminology sheet for explanation of abbreviations)

BRAUN INTERTEC

LOG OF BORING

Braun Project B1510576
Geotechnical Evaluation
Ames Municipal Electric
Ames, Iowa

BORING: **STP-3**
LOCATION: See Attached Sketch

DRILLER: K. Elliott/K. Simpson	METHOD: 3 1/4" HSA, Autohammer	DATE: **11/3/15**	SCALE: **1" = 4.4'**

Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
11.0	FILL	FILL: Lean Clay trace Organics, with Sand and pockets of Fat Clay, dark gray and brown, dry-to-moist	(7) (10) (12) (11)		
18.0	CL	SANDY LEAN CLAY trace Organics, dark brown, moist, medium to stiff (Alluvium)	(14) (8)		
30.0	SP-SC	POORLY GRADED SAND with CLAY trace Gravel, fine- to coarse- grained, brown, wet, very loose to medium (Alluvium)	(3) (6) (6) (12) (17)	▽	
		END OF BORING. Water observed at 19 feet while drilling. Boring then backfilled.			

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\CEDARRAPIDS\2015\B1510576.GPJ BRAUN_V8_CURRENT.GDT 12/9/15 17:08

BRAUN INTERTEC

LOG OF BORING

Braun Project B1510576 Geotechnical Evaluation Ames Municipal Electric Ames, Iowa	BORING: **STP-4** LOCATION: See Attached Sketch
DRILLER: K. Elliott/K. Simpson — METHOD: 3 1/4" HSA, Autohammer	DATE: **11/3/15** — SCALE: **1" = 4.4'**

Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
	FILL	FILL: Lean Clay trace Organics, with Sand and pockets of Fat Clay, dark brown and gray, moist	(4)		
			(8)		
			(9)		
8.5	CL	SANDY LEAN CLAY trace Organics, dark brown to brown gray, moist, medium to rather stiff (Alluvium)	(9)		
					PP=2.0 tsf
			(9)		
			(7)	▽	
19.0	SP-SM	POORLY GRADED SAND with SILT trace Gravel, fine- to medium- grained, gray, wet, loose (Alluvium)	(6)		
			(6)		
			(8)		
26.0	SP	POORLY GRADED SAND with Gravel, fine- to coarse- grained, gray, wet, loose to medium (Alluvium)	(14)		
			(14)		
			(11)		

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\CEDARRAPIDS\2015\B1510576.GPJ BRAUN_V8_CURRENT.GDT 12/9/15 17:08

Braun Project B1510576
Geotechnical Evaluation
Ames Municipal Electric
Ames, Iowa

BORING: **STP-4 (cont.)**
LOCATION: See Attached Sketch

DRILLER: K. Elliott/K. Simpson	METHOD: 3 1/4" HSA, Autohammer	DATE: **11/3/15**	SCALE: **1" = 4.4'**

Depth feet 35.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
		POORLY GRADED SAND with Gravel, fine- to coarse- grained, gray, wet, loose to medium (Alluvium) *(continued)*			
			(17)		
			(14)		
			(18)		
			(18)		
			(9)		
			(22)		
70.0			(18)		

(See Descriptive Terminology sheet for explanation of abbreviations)

Braun Project B1510576 Geotechnical Evaluation Ames Municipal Electric Ames, Iowa	BORING: STP-4 (cont.) LOCATION: See Attached Sketch
DRILLER: K. Elliott/K. Simpson — METHOD: 3 1/4" HSA, Autohammer	DATE: 11/3/15 — SCALE: 1" = 4.4'

Depth feet 70.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
		END OF BORING. Water observed at 18 feet while drilling. Boring then backfilled.			

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\CEDARRAPIDS\2015\B1510576.GPJ BRAUN_V8_CURRENT.GDT 12/9/15 17:08

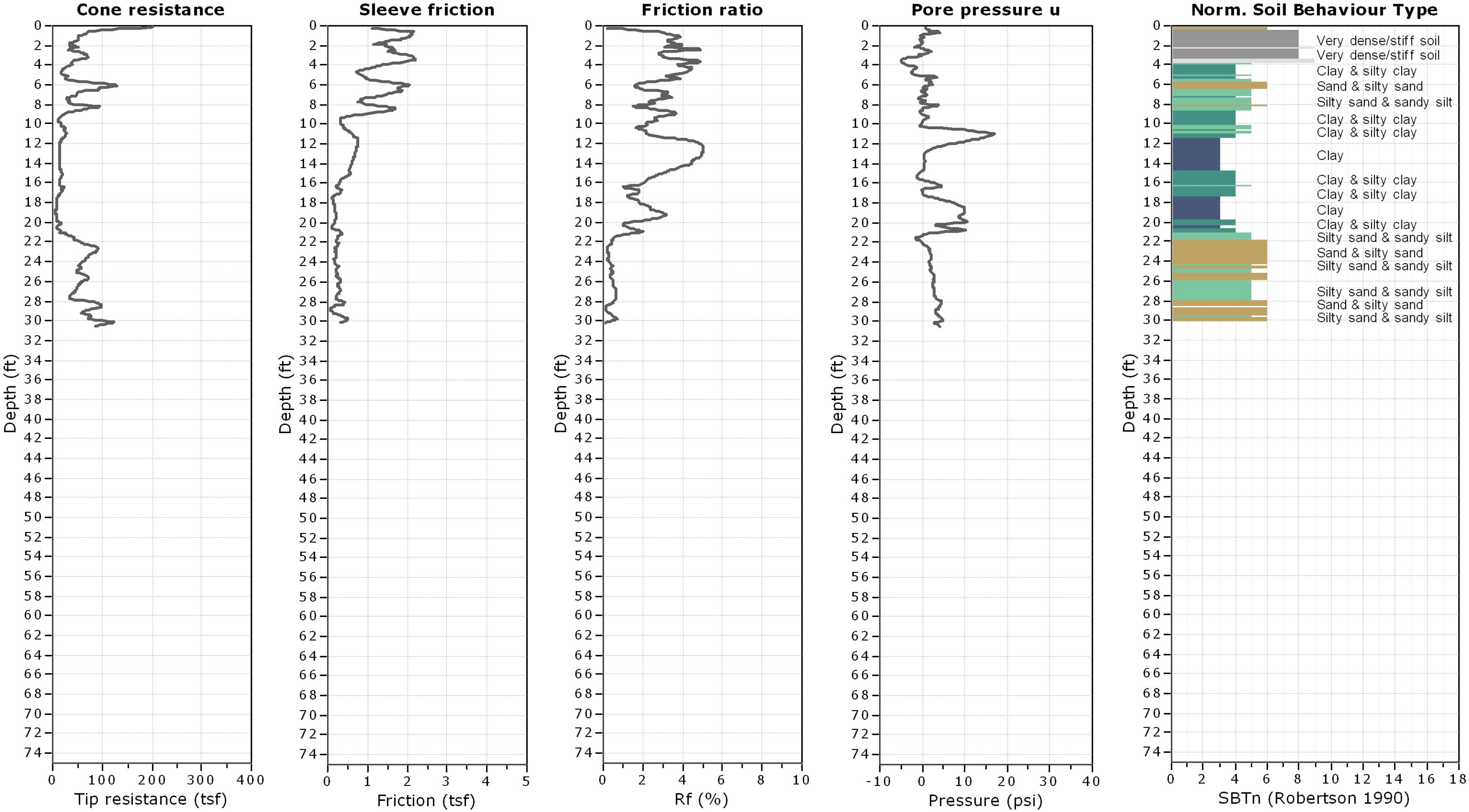
Appendix C

CPT Sounding Results

Braun Intertec Corporation
11001 Hampshire Ave S
Minneapolis, MN 55438
952-995-2000

CPT: CPT-1
Total depth: 30.56 ft, Date: 11/5/2015
Cone Type: SCPTu
Cone Operator: Holmbo

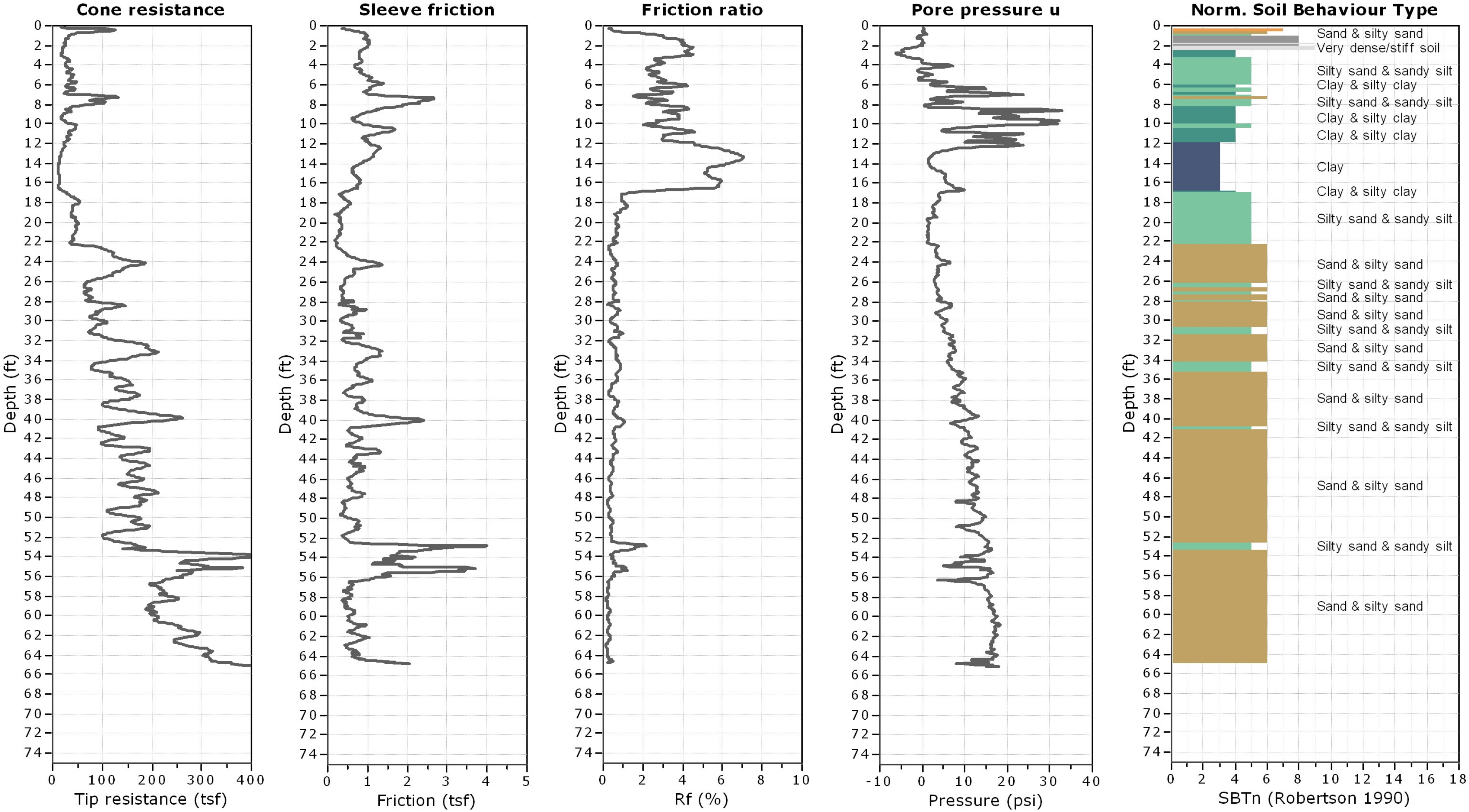
Project: **Ames Municipal Electrical System**
Location: **Ames, IA** **Project Number: B1510576**



Braun Intertec Corporation
11001 Hampshire Ave S
Minneapolis, MN 55438
952-995-2000

CPT: CPT-2
Total depth: 65.11 ft, Date: 11/5/2015
Cone Type: SCPTu
Cone Operator: Holmbo

Project: **Ames Municipal Electrical System**
Location: **Ames, IA** **Project Number: B1510576**

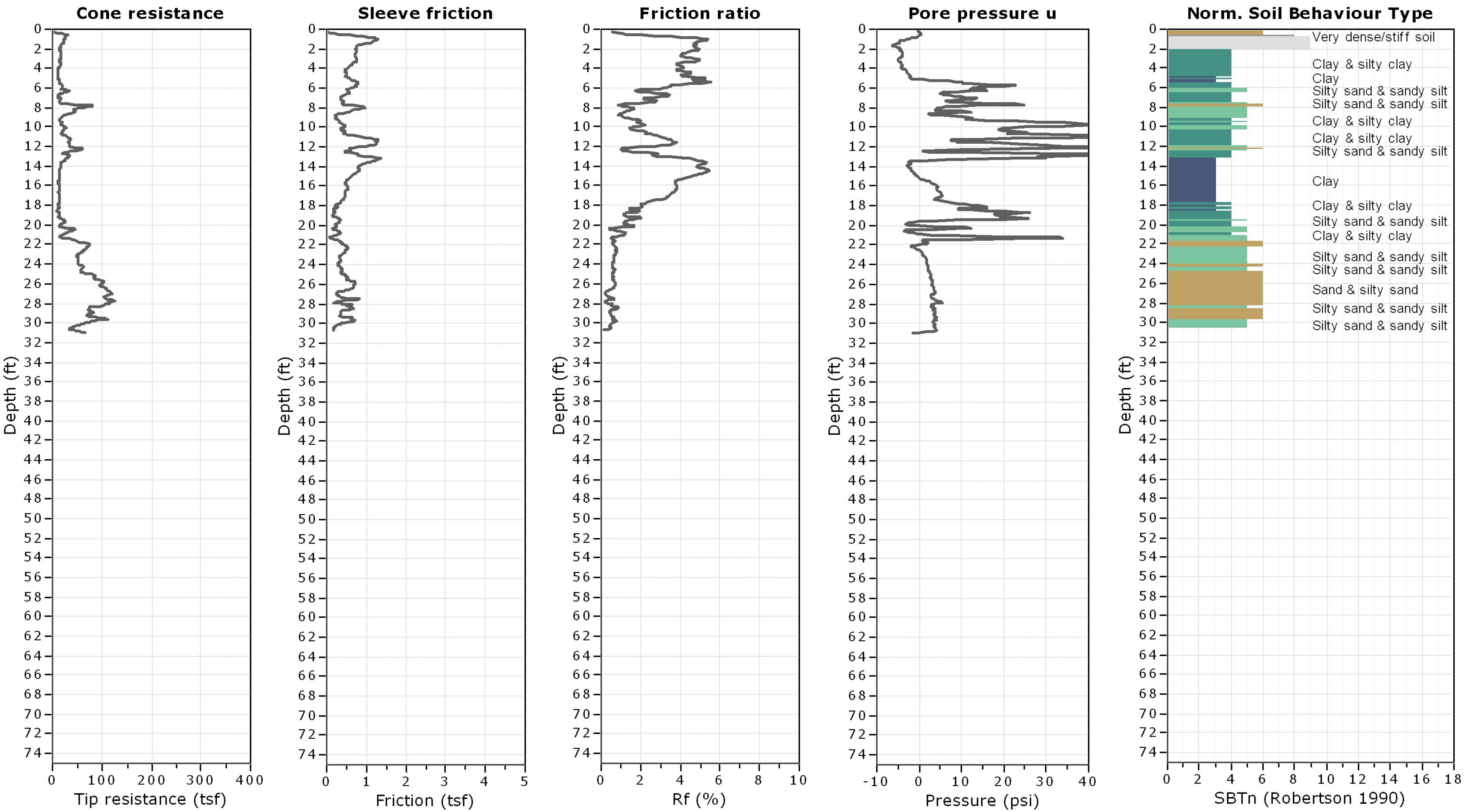


BRAUN INTERTEC

Braun Intertec Corporation
11001 Hampshire Ave S
Minneapolis, MN 55438
952-995-2000

CPT: CPT-3
Total depth: 31.04 ft, Date: 11/5/2015
Cone Type: SCPTu
Cone Operator: Holmbo

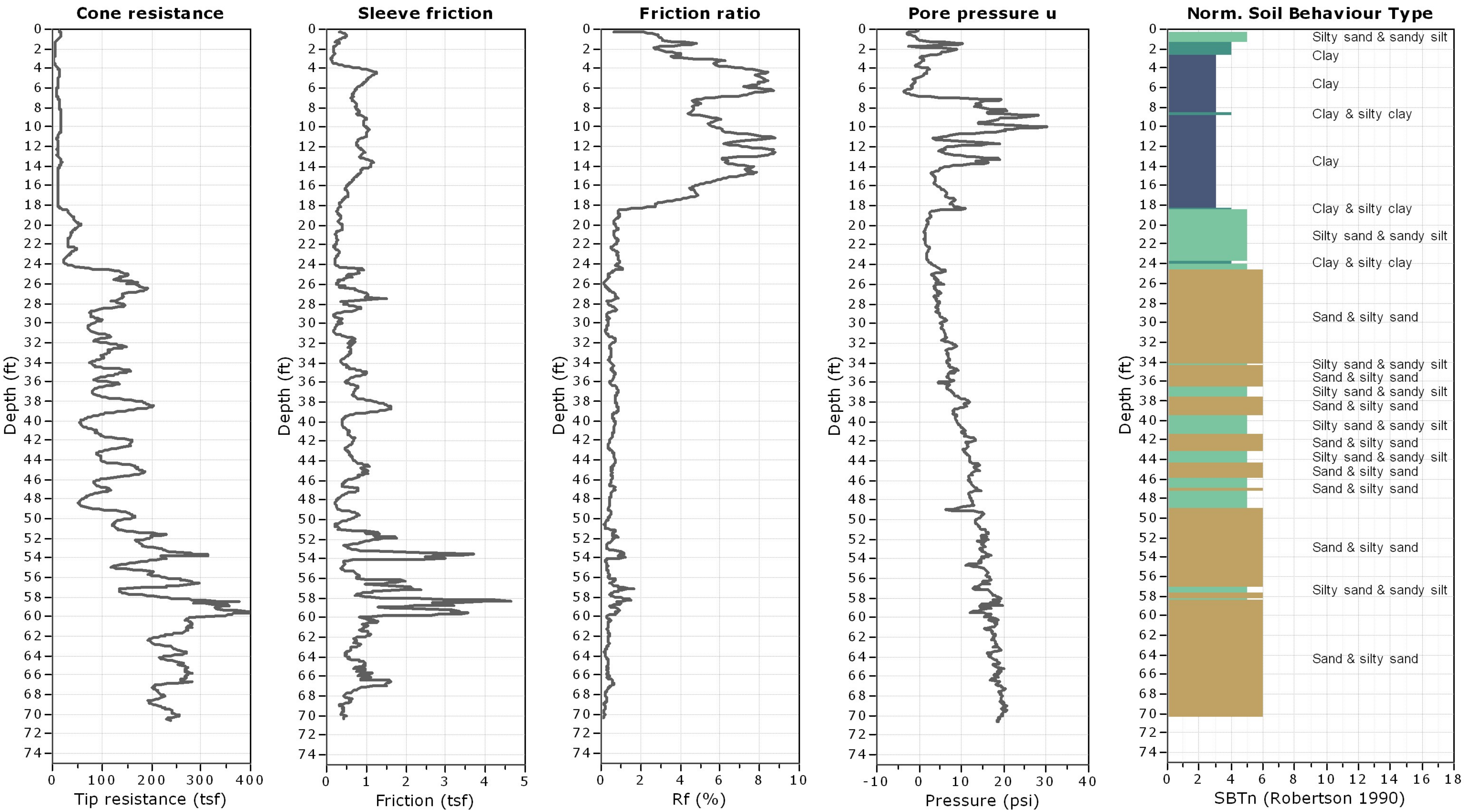
Project: **Ames Municipal Electrical System**
Location: **Ames, IA** **Project Number: B1510576**



Braun Intertec Corporation
11001 Hampshire Ave S
Minneapolis, MN 55438
952-995-2000

Project: **Ames Municipal Electrical System**
Location: **Ames, IA** **Project Number: B1510576**

CPT: CPT-4
Total depth: 70.67 ft, Date: 11/5/2015
Cone Type: SCPTu
Cone Operator: Holmbo



Braun Intertec Corporation
11001 Hampshire Ave S
Minneapolis, MN 55438
952-995-2000

CPT: CPT-5

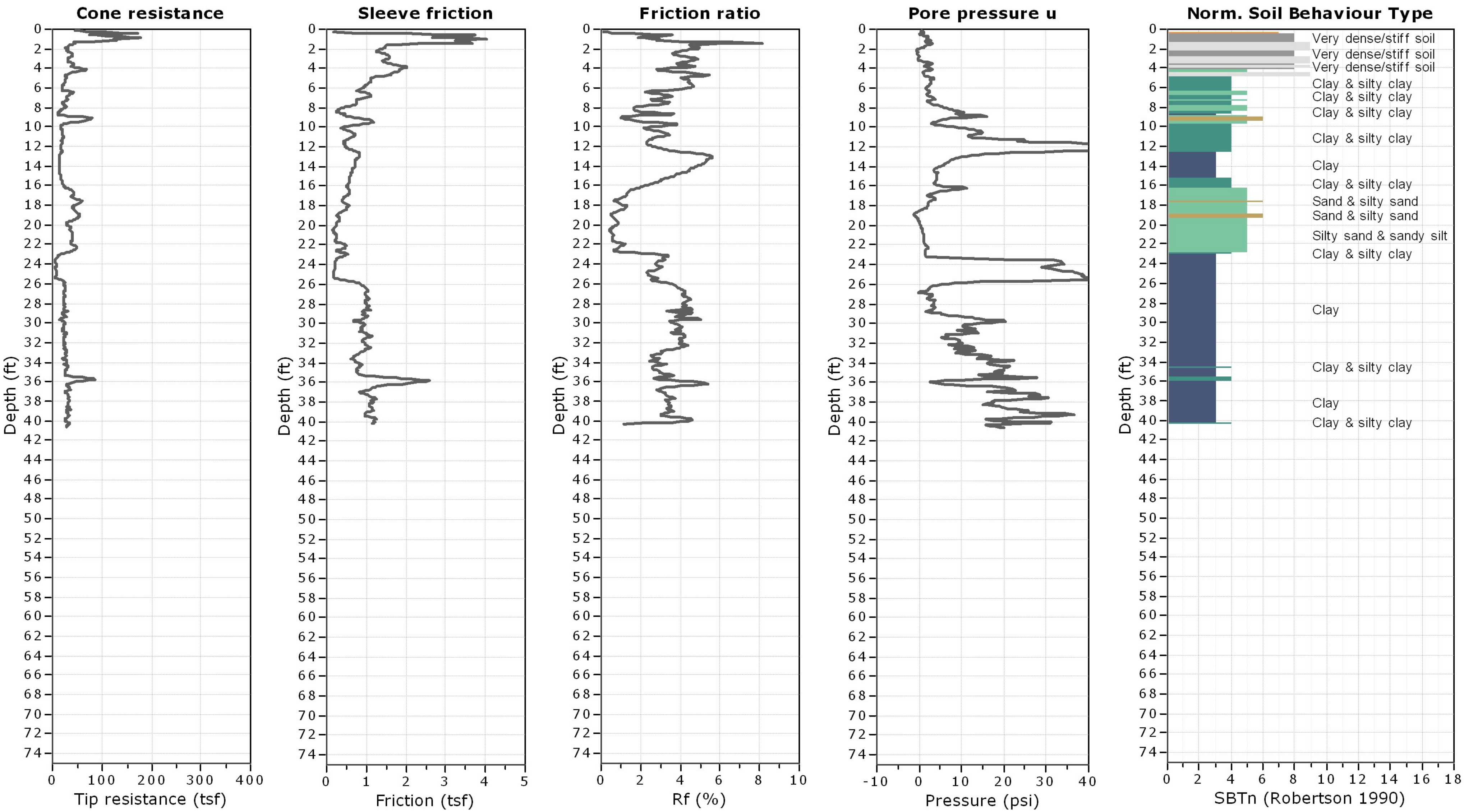
Total depth: 40.58 ft, Date: 11/5/2015

Cone Type: SCPTu

Cone Operator: Holmbo

Project: **Ames Municipal Electrical System**

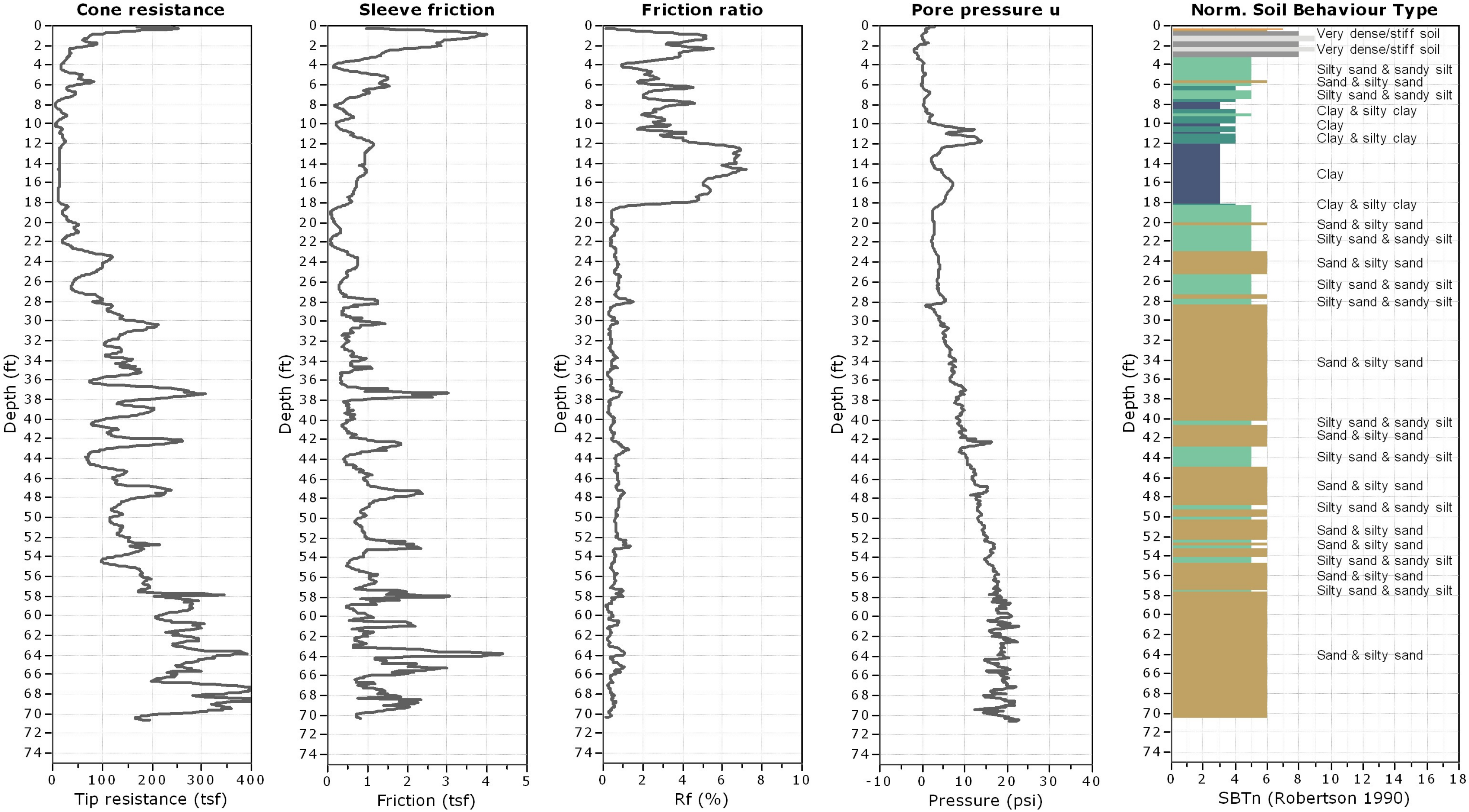
Location: **Ames, IA** **Project Number: B1510576**



Braun Intertec Corporation
11001 Hampshire Ave S
Minneapolis, MN 55438
952-995-2000

CPT: CPT-6
Total depth: 70.62 ft, Date: 11/5/2015
Cone Type: SCPTu
Cone Operator: Holmbo

Project: **Ames Municipal Electrical System**
Location: **Ames, IA** **Project Number: B1510576**

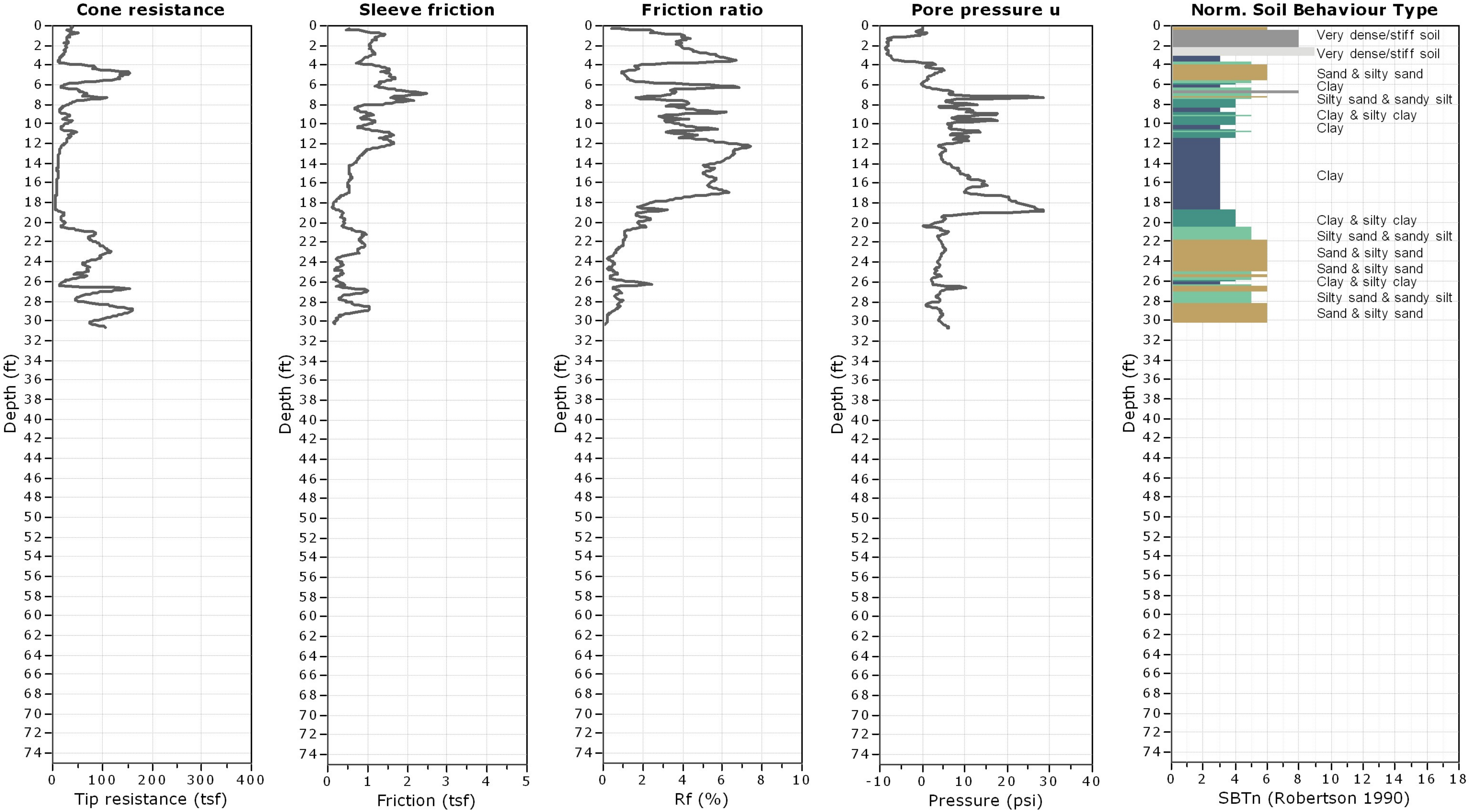


BRAUN INTERTEC

Braun Intertec Corporation
11001 Hampshire Ave S
Minneapolis, MN 55438
952-995-2000

CPT: CPT-7
Total depth: 30.67 ft, Date: 11/5/2015
Cone Type: SCPTu
Cone Operator: Holmbo

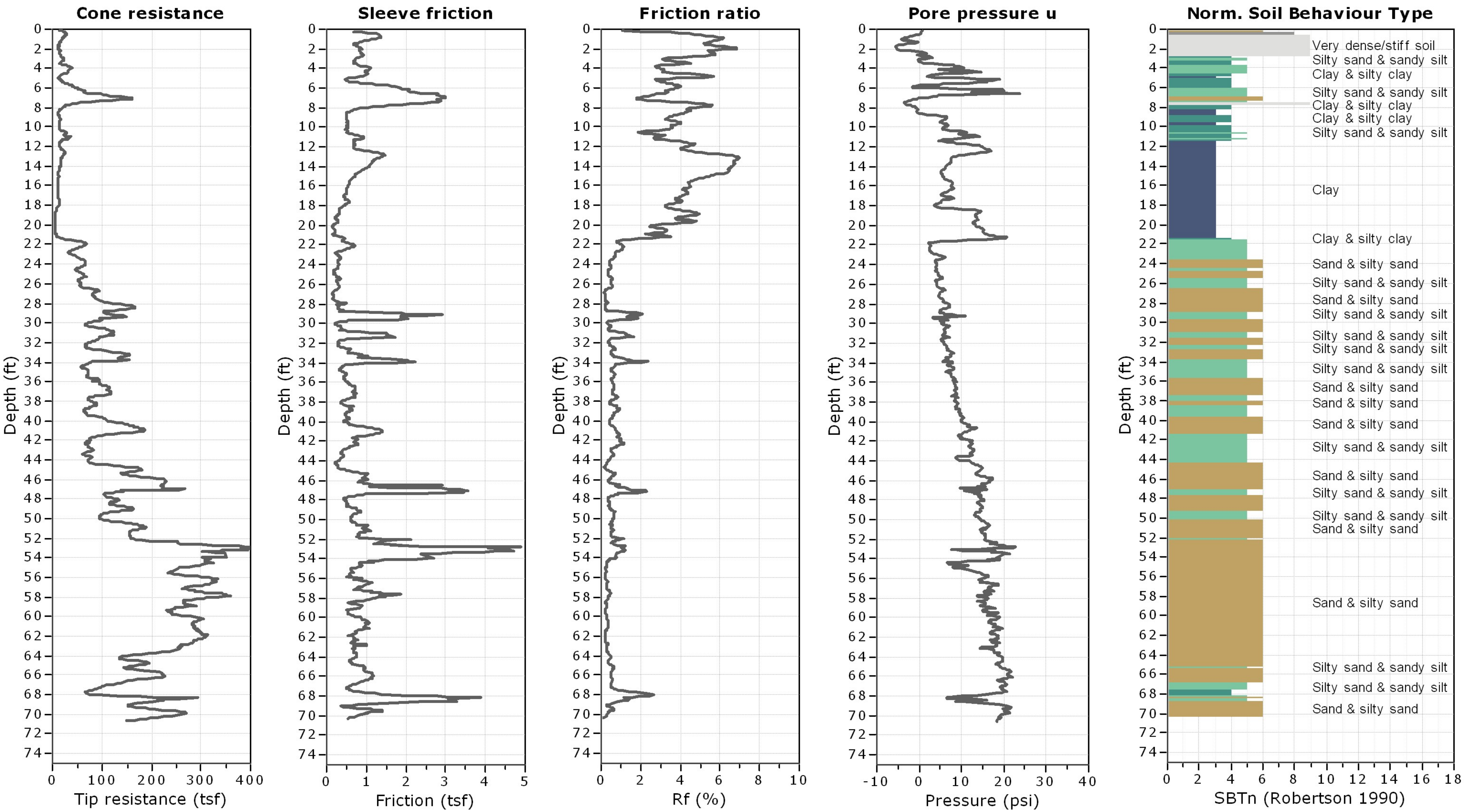
Project: **Ames Municipal Electrical System**
Location: **Ames, IA** **Project Number: B1510576**



Braun Intertec Corporation
11001 Hampshire Ave S
Minneapolis, MN 55438
952-995-2000

CPT: CPT-8
Total depth: 70.62 ft, Date: 11/5/2015
Cone Type: SCPTu
Cone Operator: Holmbo

Project: **Ames Municipal Electrical System**
Location: **Ames, IA** **Project Number: B1510576**



Appendix D

Soil Sample Laboratory Test Results

BRAUN INTERTEC

Braun Intertec Corporation
5915 4th Street SW, Suite 100
Cedar Rapids, IA 52404
Phone: 319.365.0961

Material Test Report

Report No: MAT:W15-011214-S1
Issue No: 1

Client: Jason Warne
Wenck Associates, Inc.
1800 Pioneer Creek Center
Maple Plain, MN, 55359
Project: B1510576
Ames Municipal Electric System
200 E. 5th St.
Ames, IA, 50010
TR: Jeremy Elkin, jelkin@braunintertec.com

Jeremy Elkin
Operations Supervisor
Date of Issue: 1/15/2016

Sample Details

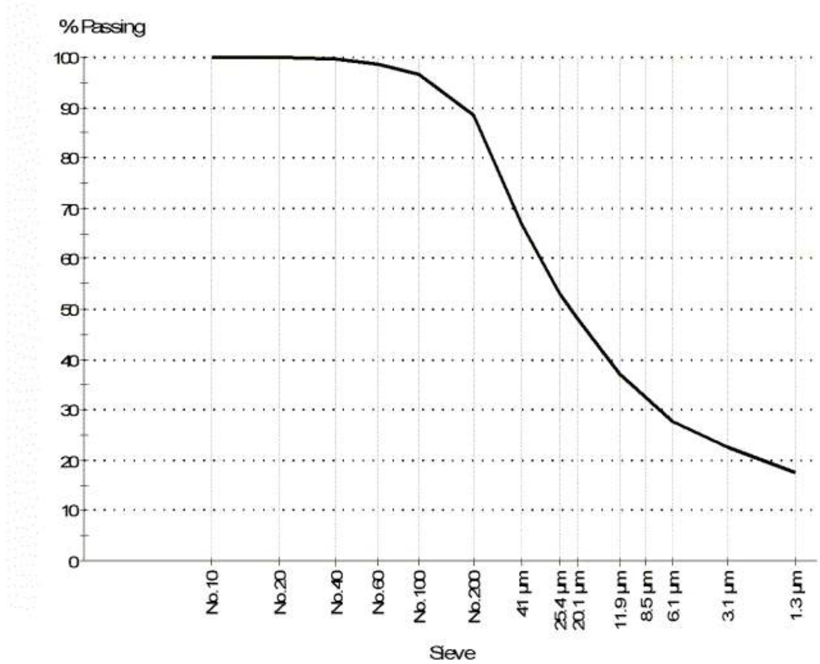
Sample ID:	W15-011214-S1
Alternate Sample ID:	STP-1 (18-20)
Sampled By:	
Sampling Method:	
Date Sampled:	
Date Submitted:	
Specification:	General Gradation
Source:	
Material Type:	
Sample Location:	

Atterberg Limit:

Liquid Limit: 38
Plastic Limit: 17
Plasticity Index: 21
Linear Shrinkage (%): N/A

Sample Description:

Particle Size Distribution



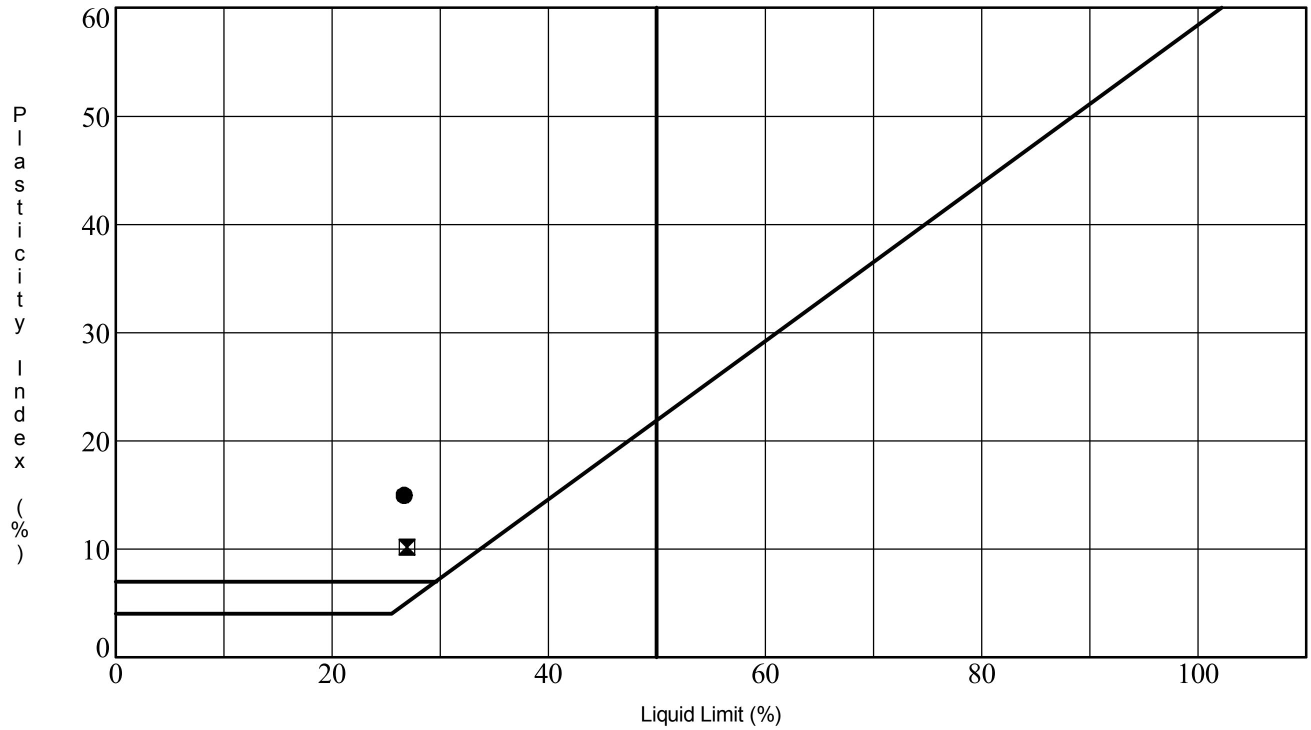
COBBLES	GRAVEL		SAND			FINES	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
(0.0%)	(0.0%)	(0.0%)	(0.0%)	(0.3%)	(11.4%)	(62.5%)	(25.8%)

Grading: ASTM D 422 - 07

Drying by: Oven
Date Tested: 1/15/2016

Sieve Size	% Passing	Limits
No.10 (2.0mm)	100	
No.20 (850µm)	100	
No.40 (425µm)	100	
No.60 (250µm)	99	
No.100 (150µm)	97	
No.200 (75µm)	88	
41.0 µm	66.9	
25.4 µm	53.1	
20.1 µm	47.9	
11.9 µm	37.1	
8.5 µm	32.4	
6.1 µm	27.6	
3.1 µm	22.8	
1.3 µm	17.4	

D85: 0.0682 **D60:** 0.0323 **D50:** 0.0221
D30: 0.0072 **D15:** 0.0009 **D10:** 0.0004



	Specimen Identification		LL	PL	PI	Fines	Classification
●	STP-2	8.0'-10.0'	27	12	15	59	SANDY LEAN CLAY(CL)
⧗	STP-3	16.0'-18.0'	27	17	10	67	SANDY LEAN CLAY(CL)

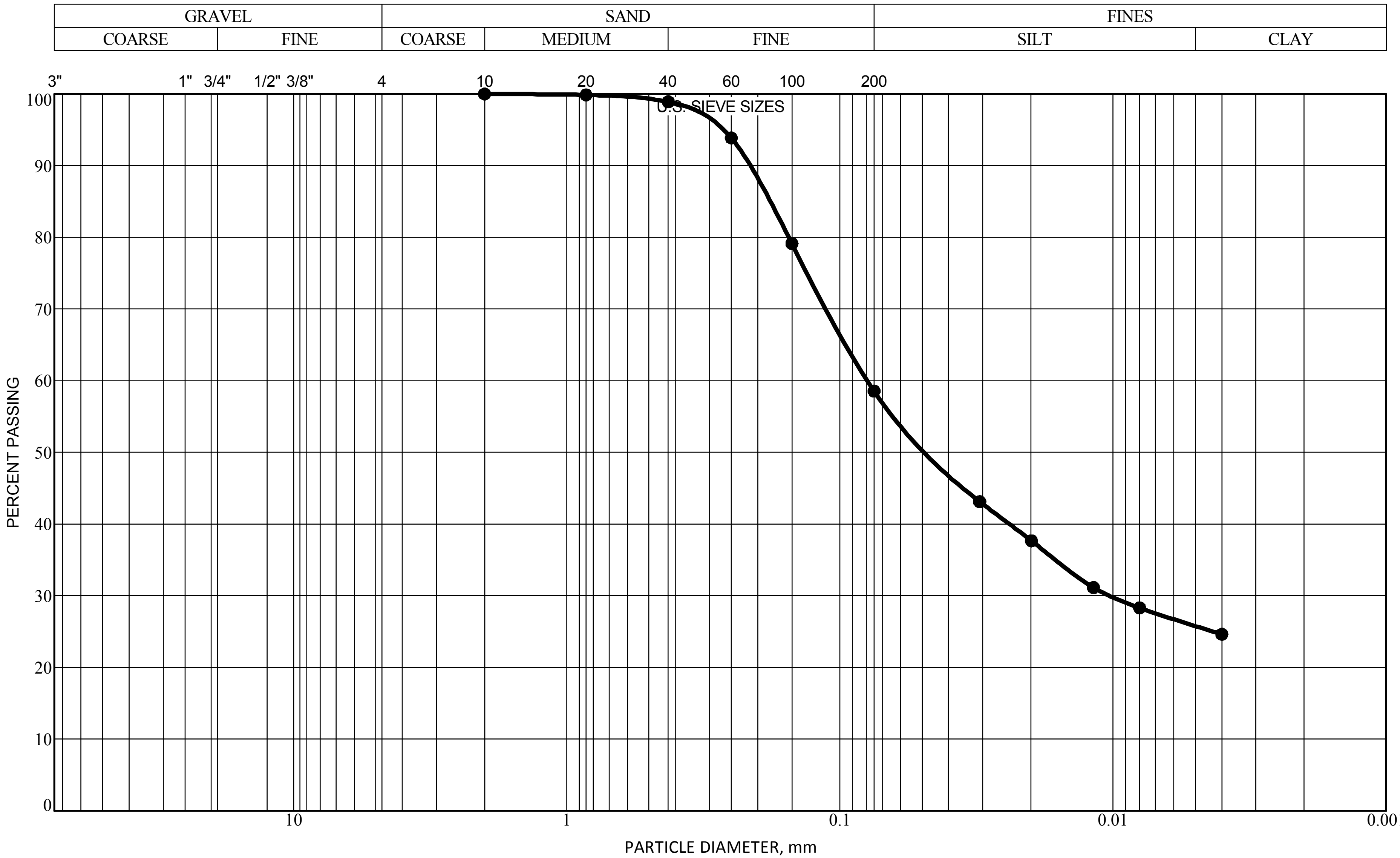
Braun Project B1510576
Ames Municipal Electric System
200 E. 5th St.
Ames, IA

ATTERBERG LIMITS RESULTS

BRAUN INTERTEC

ATTERBERG LIMITS N:\GINT\PROJECTS\X-GEOLAB\1-GINT FILES\AX PROJECTS GEO LAB\2015\B1510576.GPJ BRAUN_V8_CURRENT.GDT 12/22/15 15:38

GRAIN SIZE ACCUMULATION CURVE (ASTM)



BRAUN INTERTEC

Braun Project B1510576
Ames Municipal Electric System
200 E. 5th St.
Ames, IA

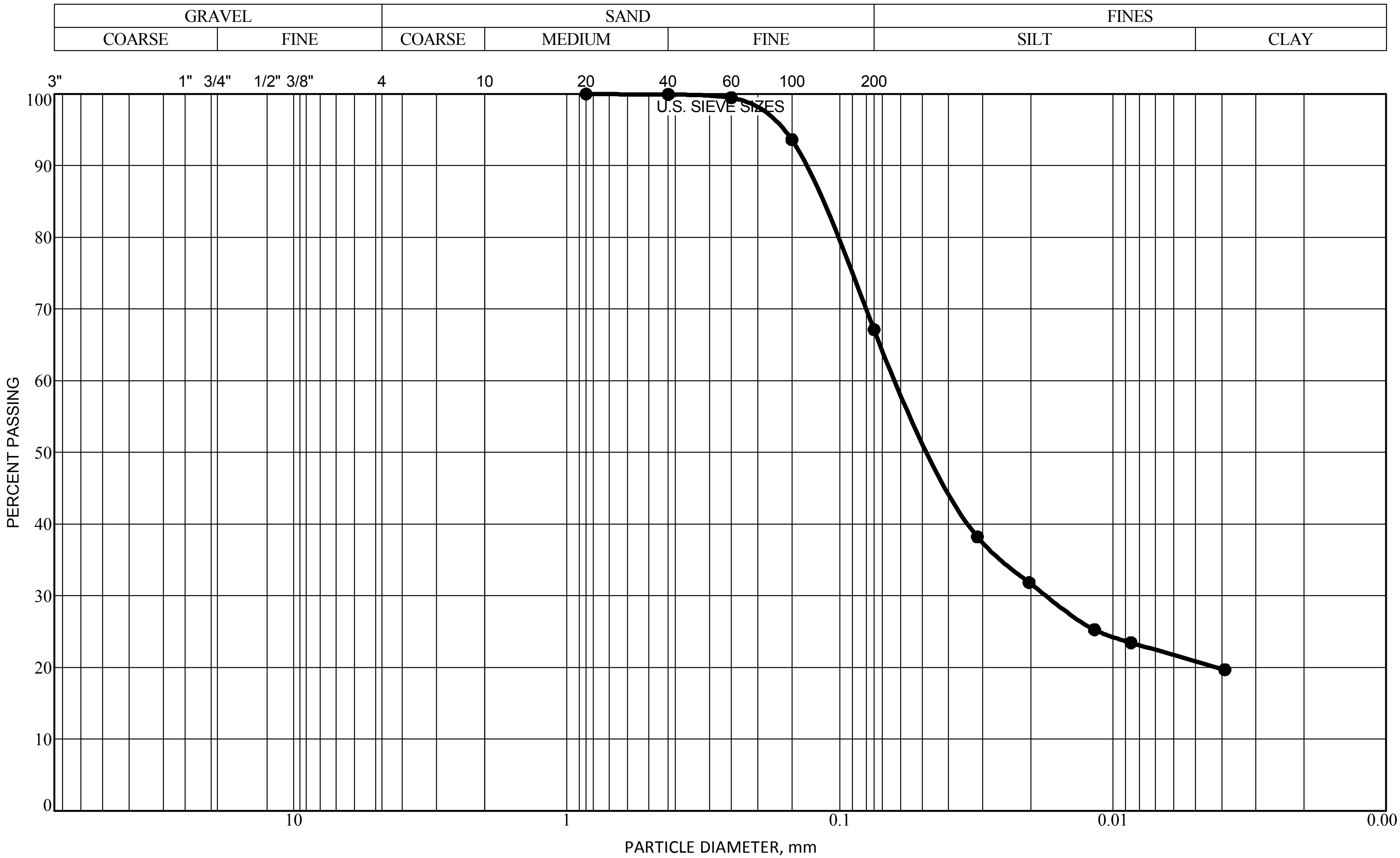
BORING: STP-2 DEPTH: 8.0'-10.0'

GRAVEL	0.0%
SAND	41.4%
SILT	32.7%
CLAY	25.8%
D60=0.079	Cu=
D30=0.010	Cc=
D10=	

CLASSIFICATION:
SANDY LEAN CLAY(CL)

GS ASTM N:\GINT\PROJECTS\X-GEOLAB\1-GINT FILES\AX PROJECTS GEO LAB\2015\B1510576.GPJ BRAUN_V8_CURRENT.GDT 12/22/15 15:38

GRAIN SIZE ACCUMULATION CURVE (ASTM)



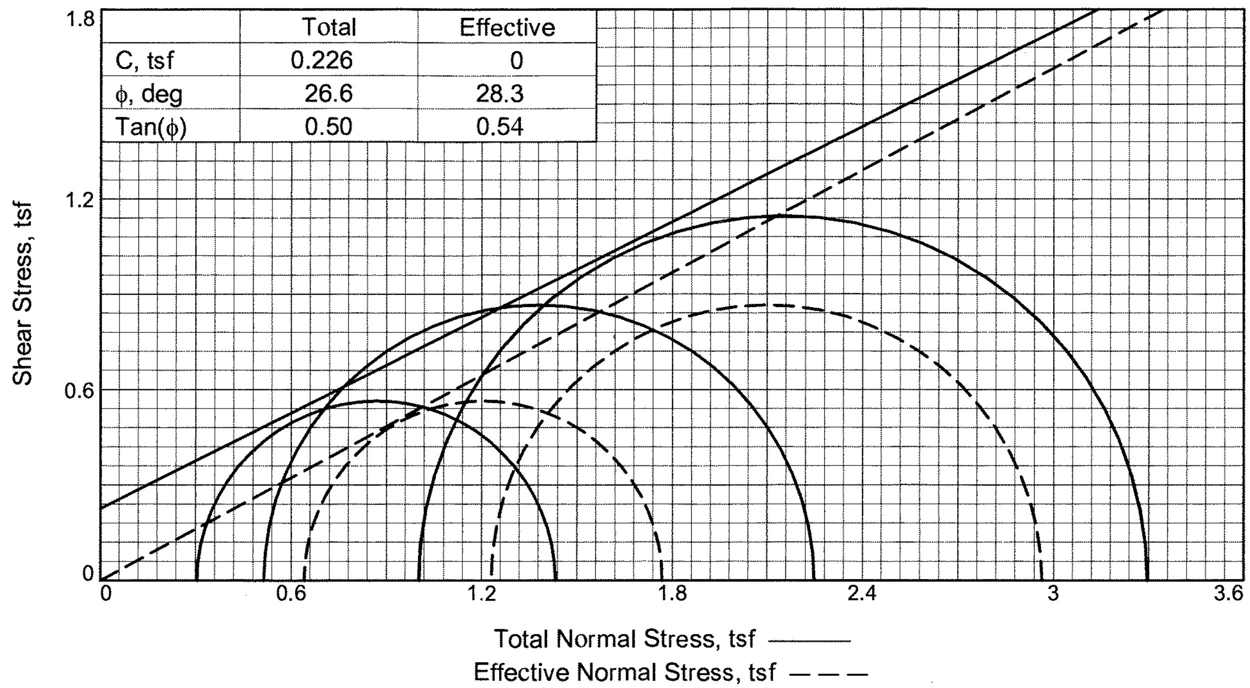
BRAUN INTERTEC

Braun Project B1510576
Ames Municipal Electric System
200 E. 5th St.
Ames, IA

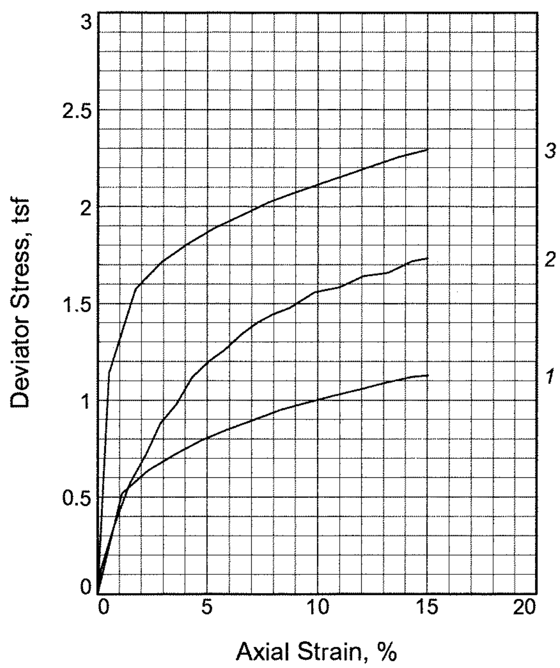
BORING: STP-3 DEPTH: 16.0'-18.0'

GRAVEL	0.0%
SAND	32.9%
SILT	46.2%
CLAY	20.9%
D60=0.061	
D30=0.017	Cu=
D10=	Cc=

CLASSIFICATION:
SANDY LEAN CLAY(CL)



	Total	Effective
C, tsf	0.226	0
φ, deg	26.6	28.3
Tan(φ)	0.50	0.54



Sample No.		1	2	3
Initial	Water Content, %	19.1	13.6	15.8
	Dry Density, pcf	108.7	117.2	113.8
	Saturation, %	93.5	83.7	88.9
	Void Ratio	0.5502	0.4380	0.4810
	Diameter, in.	1.418	1.420	1.407
	Height, in.	2.795	2.794	2.790
At Test	Water Content, %	20.1	15.7	17.5
	Dry Density, pcf	109.3	118.5	114.4
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5419	0.4226	0.4731
	Diameter, in.	1.415	1.415	1.404
	Height, in.	2.790	2.784	2.785
	Pore Pressure Parameter B	1.0	1.0	1.0
	Consolidation Pressure, tsf	0.31	0.52	1.00
	Back Pressure, tsf	6.82	6.62	6.13
	Cell Pressure, tsf	7.13	7.14	7.13
	Peak Deviator Stress, tsf	1.13	1.73	2.29
	Total Pore Pr., tsf	6.49	5.90	6.13
	Ultimate Deviator Stress, tsf	1.13	1.73	2.29
	Total Pore Pr., tsf	6.49	5.90	6.13
	Maj. Eff. Stress at Ultimate, tsf	1.77	2.96	3.30
	Min. Eff. Stress at Ultimate, tsf	0.64	1.23	1.00

Type of Test:
CU with Pore Pressures

Sample Type: Thinwall

Description: SANDY LEAN CLAY, brown (CL)

Assumed Specific Gravity= 2.70

Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Figure CU Triax ASTM D 4767

Client: Wenck Associates, Inc.

Project: Ames Municipal Electric System
200 E. 5th St., Ames, IA

Sample Number: STP-2 **Depth:** 8-10'

Proj. No.: B1510576 **Date Sampled:**

BRAUN℠
INTERTEC

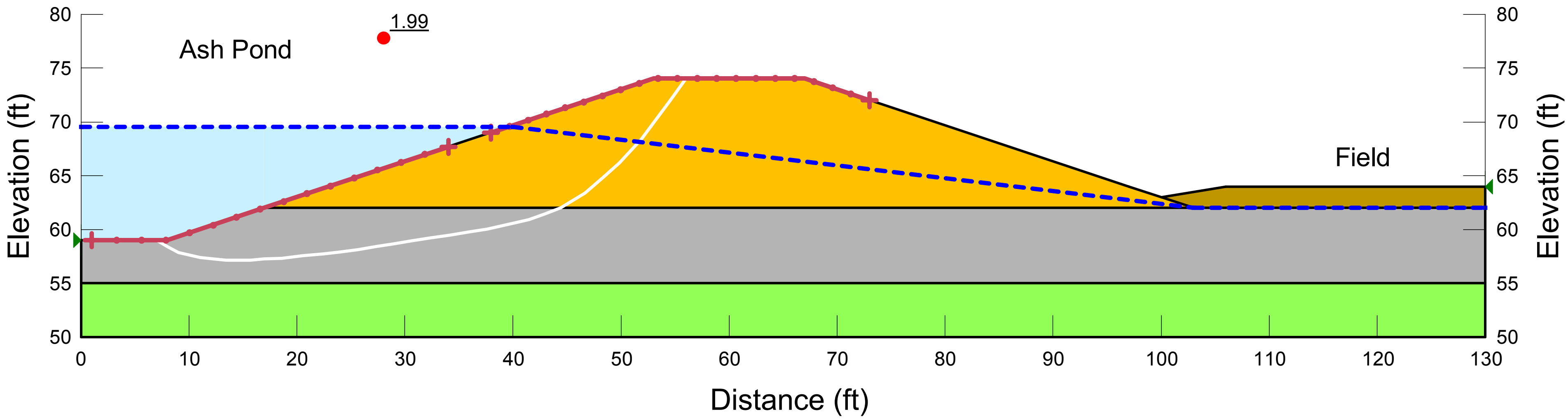
Appendix E

Slope Stability Analysis Results

Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 1
Static Analysis
Ash Pond Level: 69.5 ft

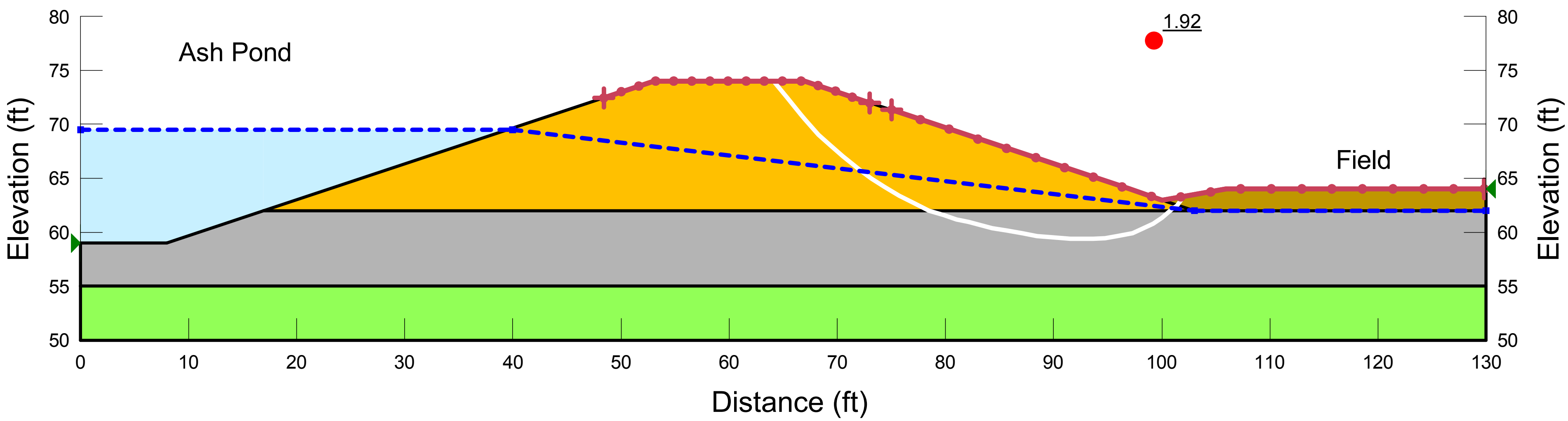
Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
Green	Poorly Graded Sand with trace Gravel (SP)	110	0	30
Orange	Lean Clay with Trace Organics (Fill)	115	50	30
Gray	Sandy Lean Clay with Organics (CL)	115	25	28
Brown	Topsoil	100	0	26



Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 1
Static Analysis
Ash Pond Level: 69.5 ft

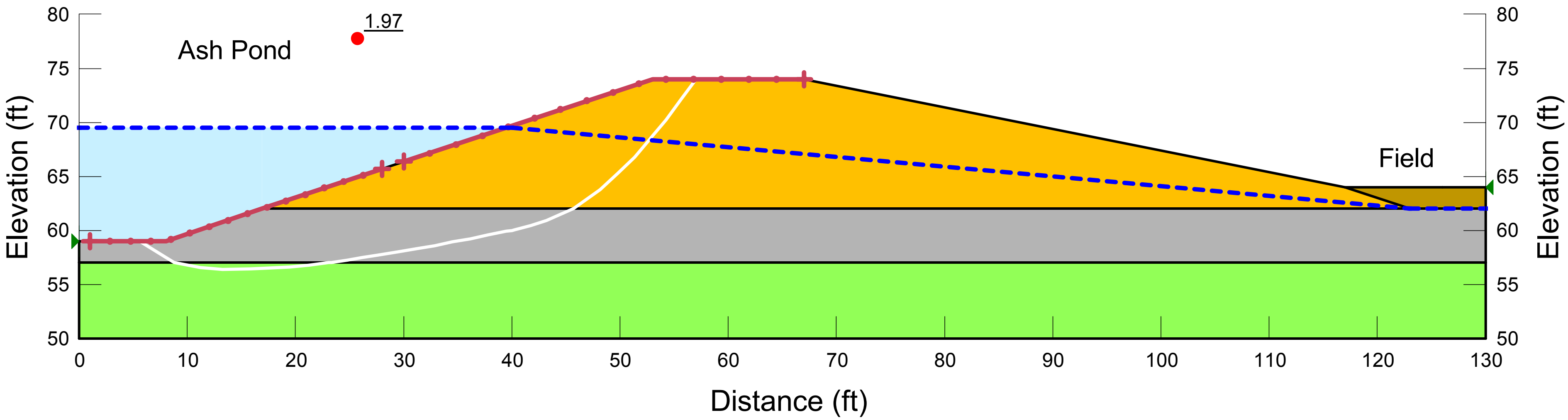
Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
(green)	Poorly Graded Sand with trace Gravel (SP)	110	0	30
(orange)	Lean Clay with Trace Organics (Fill)	115	50	30
(gray)	Sandy Lean Clay with Organics (CL)	115	25	28
(brown)	Topsoil	100	0	26



Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 2
Static Analysis
Ash Pond Level: 69.5 ft

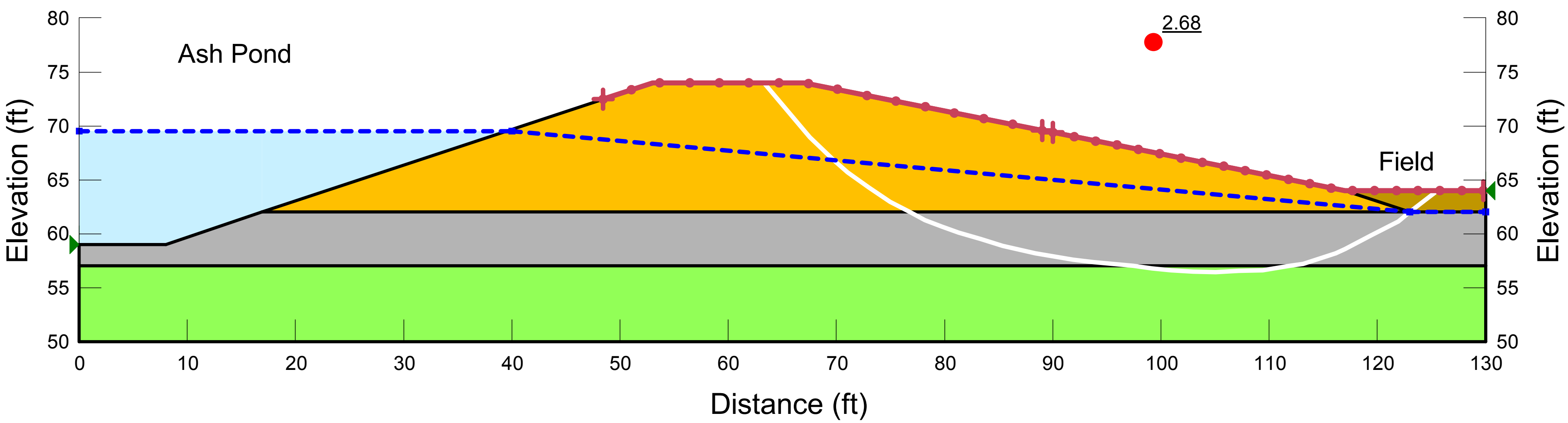
Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Poorly Graded Sand with trace Gravel (SP)	110	0	30
	Lean Clay with Trace Organics (Fill)	115	50	30
	Sandy Lean Clay with Organics (CL)	115	25	28
	Topsoil	100	0	26



Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 2
Static Analysis
Ash Pond Level: 69.5 ft

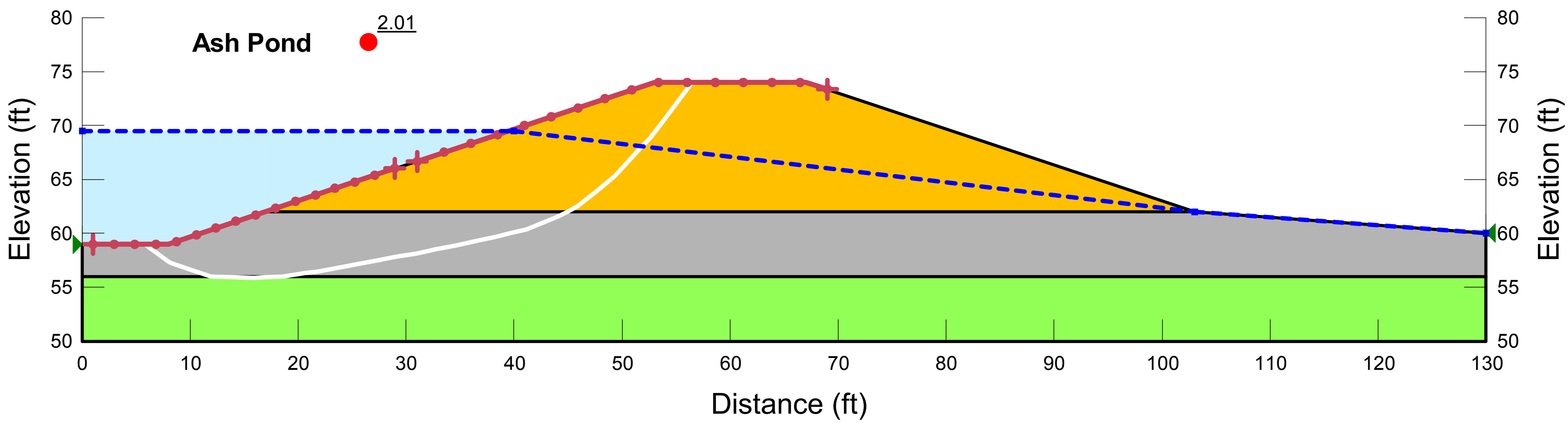
Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Poorly Graded Sand with trace Gravel (SP)	110	0	30
	Lean Clay with Trace Organics (Fill)	115	50	30
	Sandy Lean Clay with Organics (CL)	115	25	28
	Topsoil	100	0	26



Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 3
Static Analysis
Ash Pond Level: 69.5 ft

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
(green)	Poorly Graded Sand with Clay (SP-SC)	110	0	30
(orange)	Lean Clay with Trace Organics (Fill)	115	50	30
(grey)	Sandy Lean Clay with Organics (CL)	115	25	28



Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 3
Static Analysis
Ash Pond Level: 69.5 ft

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Poorly Graded Sand with Clay (SP-SC)	110	0	30
	Lean Clay with Trace Organics (Fill)	115	50	30
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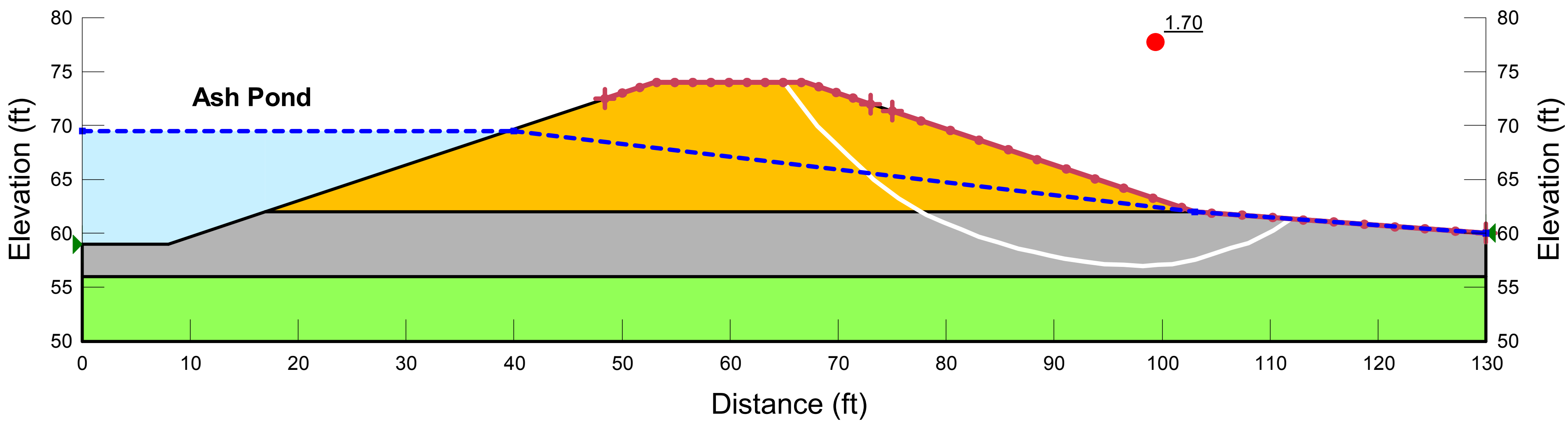
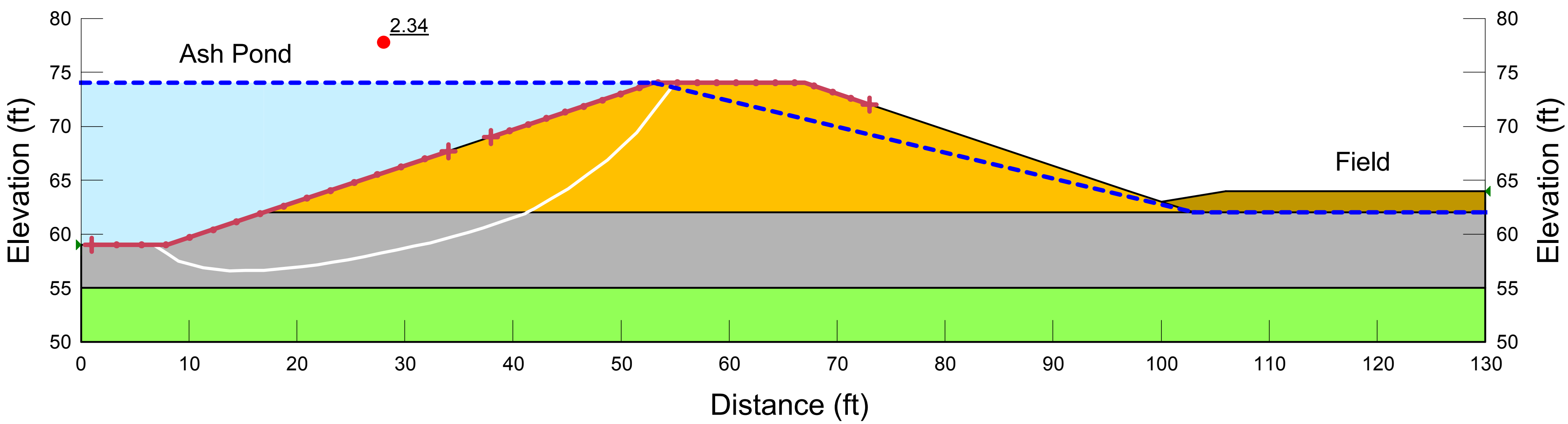


Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 1
Static Analysis
Ash Pond Level: 74.0 ft

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Poorly Graded Sand with trace Gravel (SP)	110	0	30
	Lean Clay with Trace Organics (Fill)	115	50	30
	Sandy Lean Clay with Organics (CL)	115	25	28
	Topsoil	100	0	26



Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 1
Static Analysis
Ash Pond Level: 74.0 ft

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
(green)	Poorly Graded Sand with trace Gravel (SP)	110	0	30
(orange)	Lean Clay with Trace Organics (Fill)	115	50	30
(gray)	Sandy Lean Clay with Organics (CL)	115	25	28
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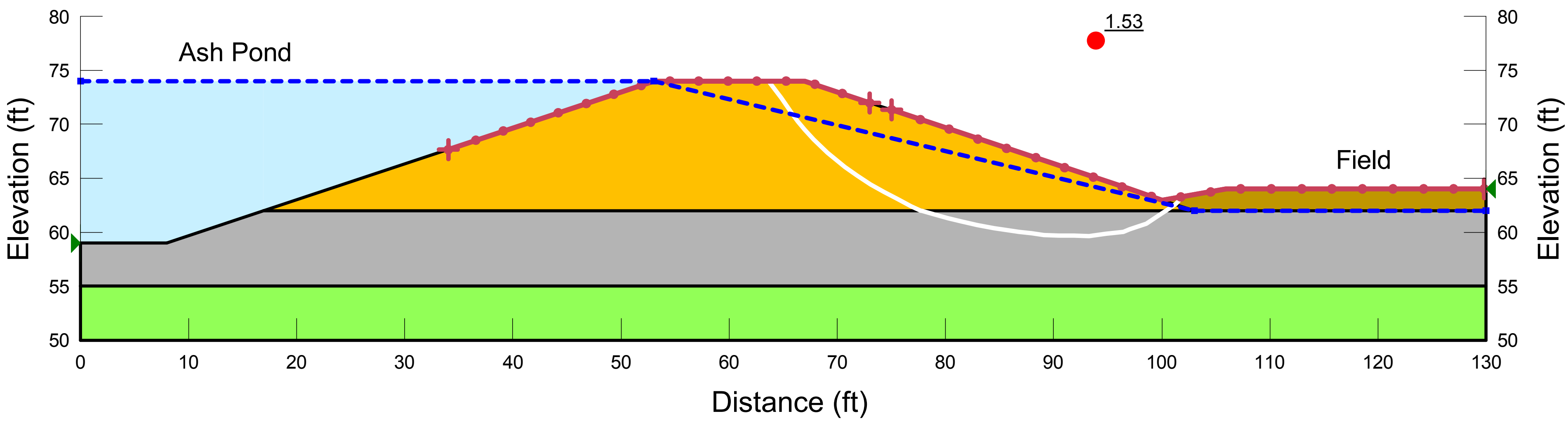

Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 2
Static Analysis
Ash Pond Level: 74.0 ft

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
(green)	Poorly Graded Sand with trace Gravel (SP)	110	0	30
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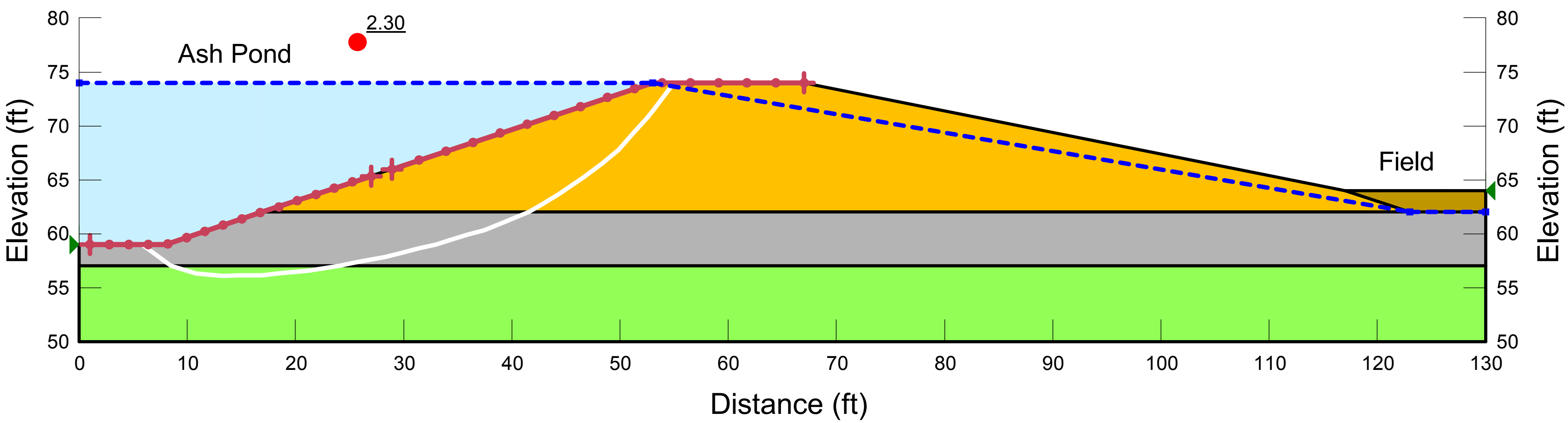

Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 2
Static Analysis
Ash Pond Level: 74.0 ft

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Poorly Graded Sand with trace Gravel (SP)	110	0	30
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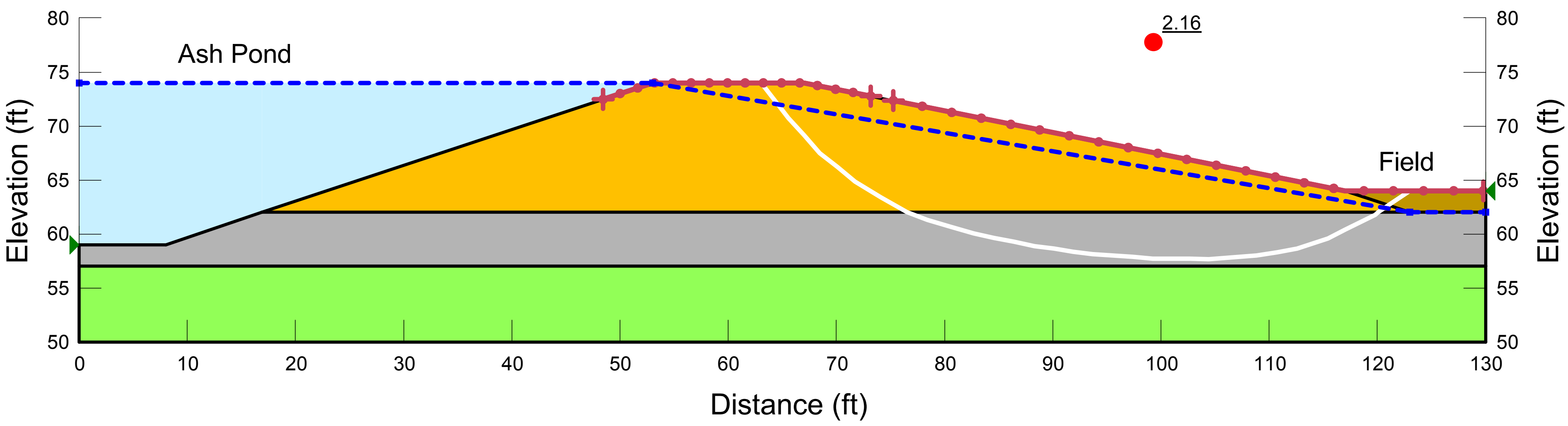

Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 3
Static Analysis
Ash Pond Level: 74.0 ft

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Poorly Graded Sand with Clay (SP-SC)	110	0	30
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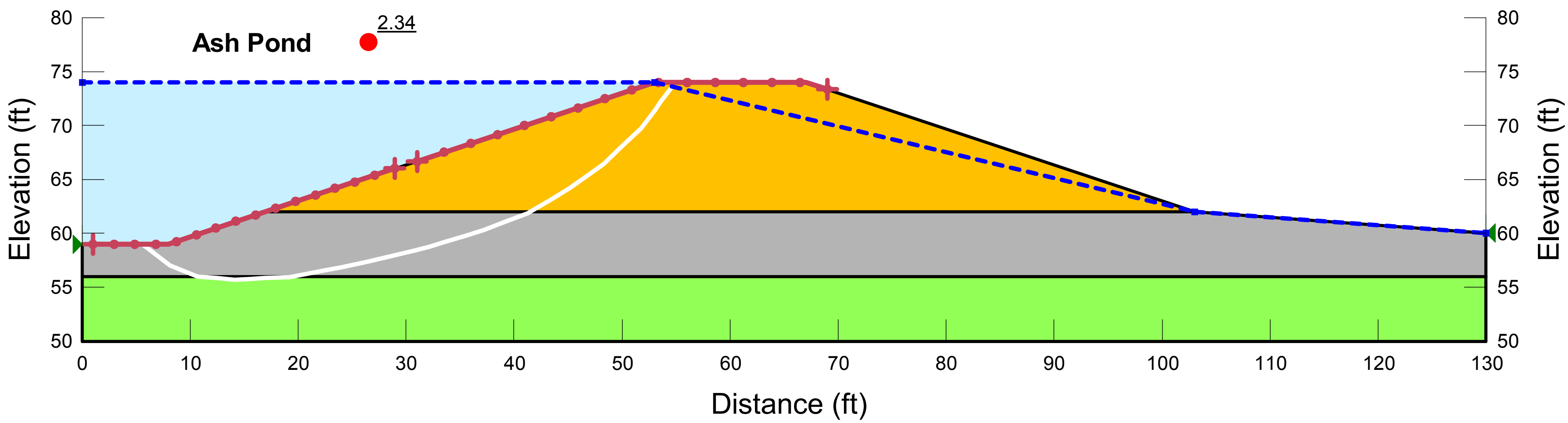

Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 3
Static Analysis
Ash Pond Level: 74.0 ft

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
Green	Poorly Graded Sand with Clay (SP-SC)	110	0	30
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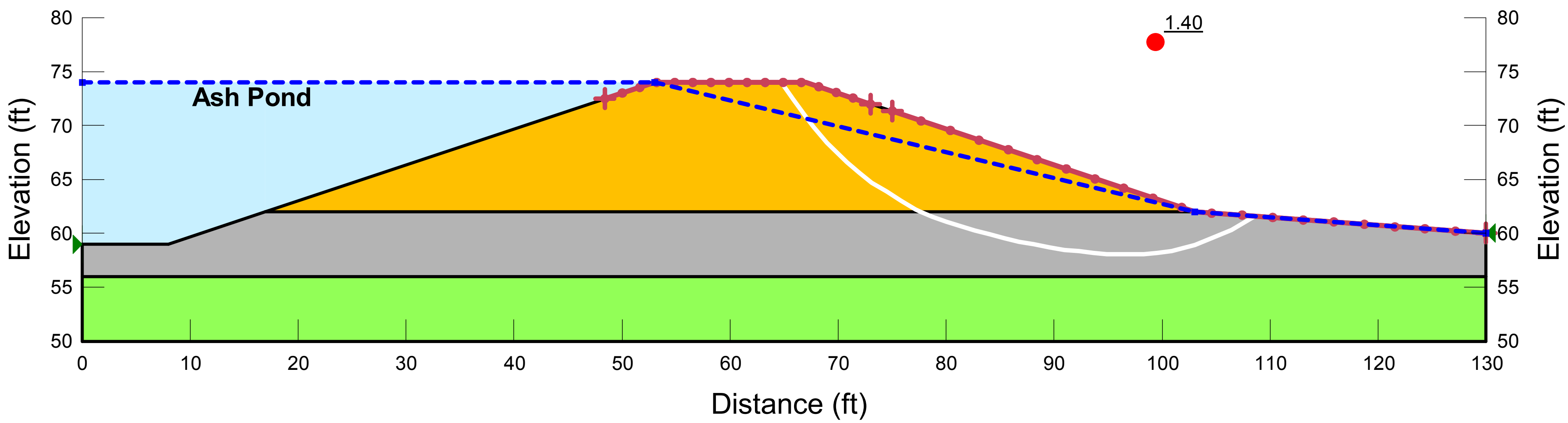
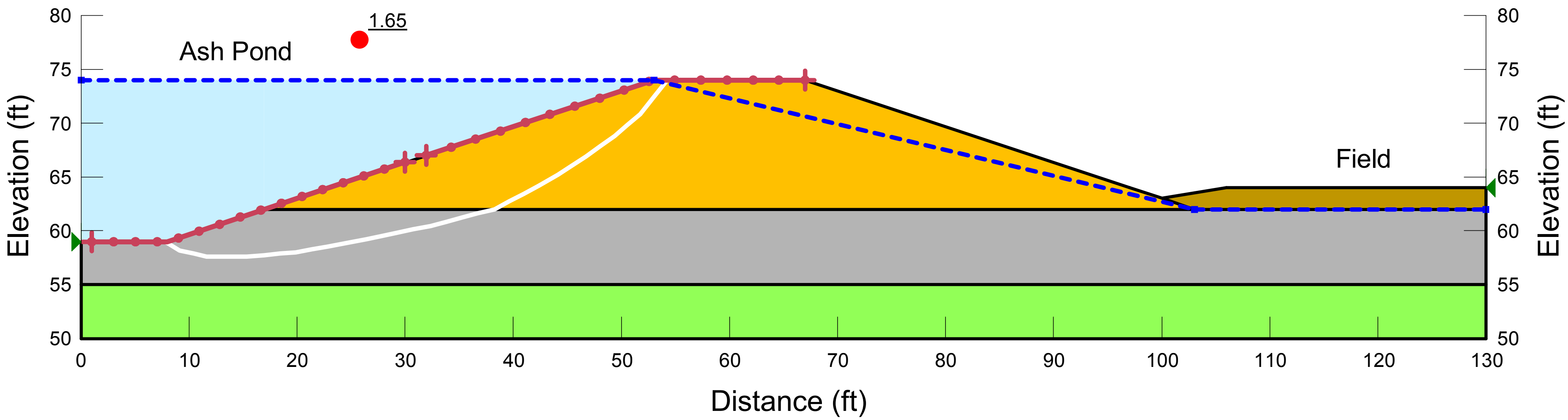


Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 1
Pseudo-Seismic Analysis
Kh, Kv = 0.06g
Ash Pond Level: 74.0 ft

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Poorly Graded Sand with trace Gravel (SP)	110	0	30
	Lean Clay with Trace Organics (Fill)	115	50	30
	Sandy Lean Clay with Organics (CL)	115	25	28
	Topsoil	100	0	26



Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 1
Pseudo-Seismic Analysis
Kh, Kv = 0.06g
Ash Pond Level: 74.0 ft

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
Green	Poorly Graded Sand with trace Gravel (SP)	110	0	30
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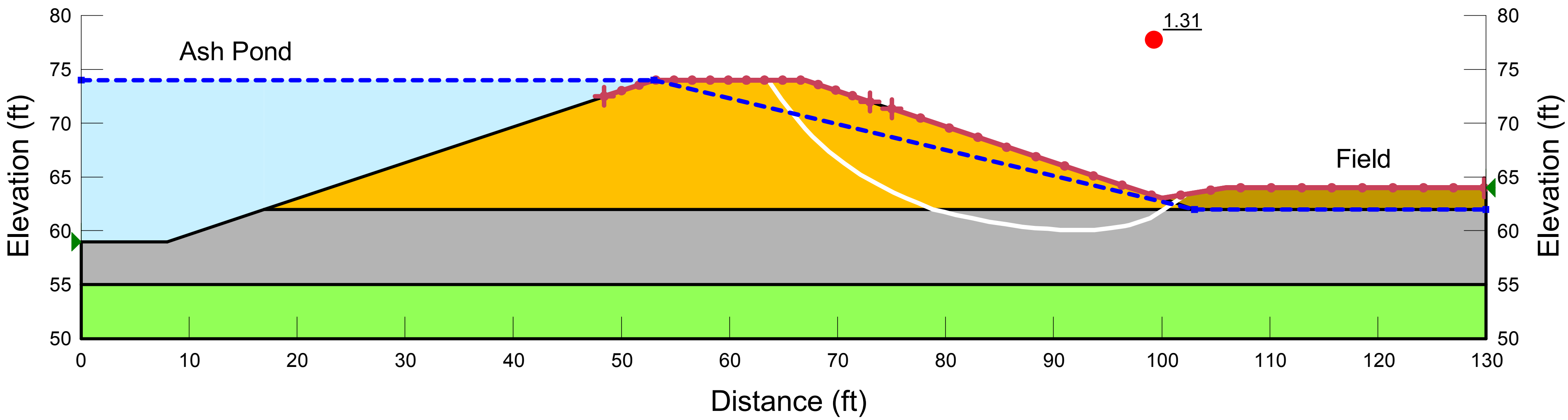

Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 2
Pseudo-Seismic Analysis
Kh, Kv = 0.06g
Ash Pond Level: 74.0 ft

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
(green)	Poorly Graded Sand with trace Gravel (SP)	110	0	30
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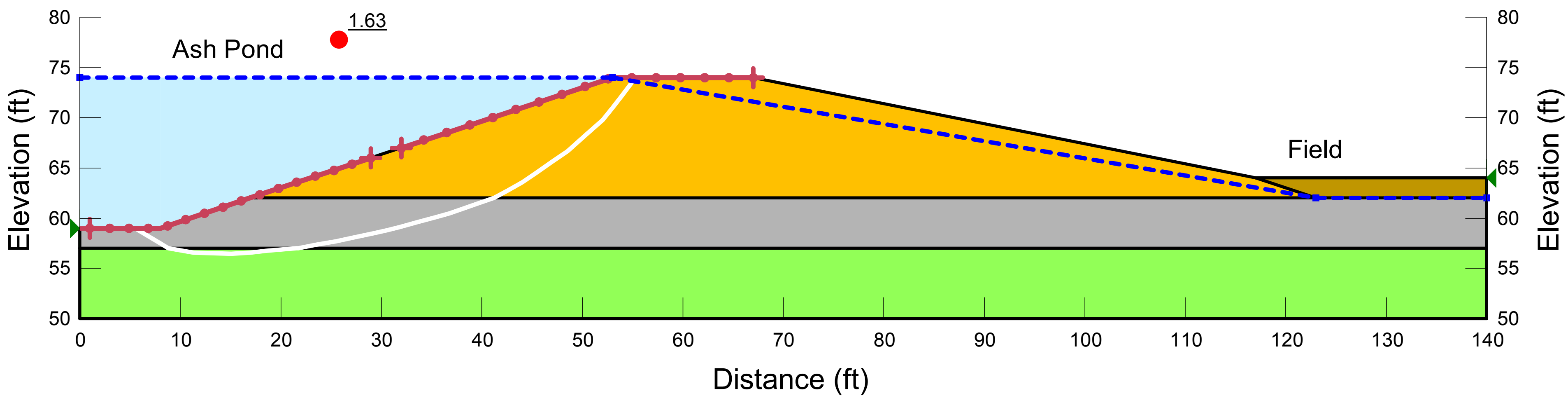

Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 2
Pseudo-Seismic Analysis
Kh, Kv = 0.06g
Ash Pond Level: 74.0 ft

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Poorly Graded Sand with trace Gravel (SP)	110	0	30
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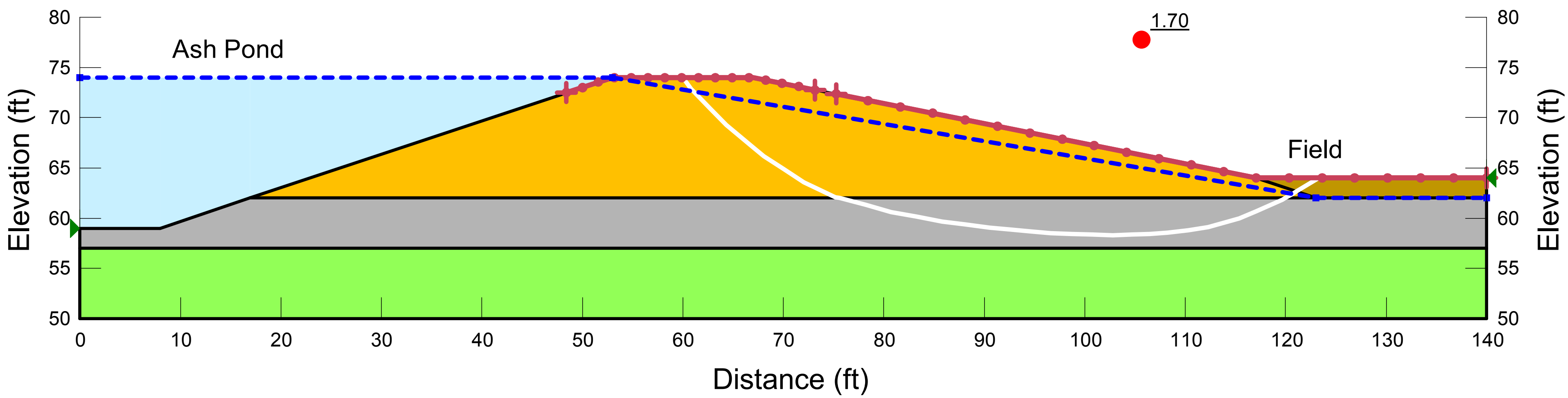
	Topsoil	100	0	26



Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 3
Pseudo-Seismic Analysis
Kh,Kv = 0.06g
Ash Pond Level: 74.0 ft

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Poorly Graded Sand with Clay (SP-SC)	110	0	30
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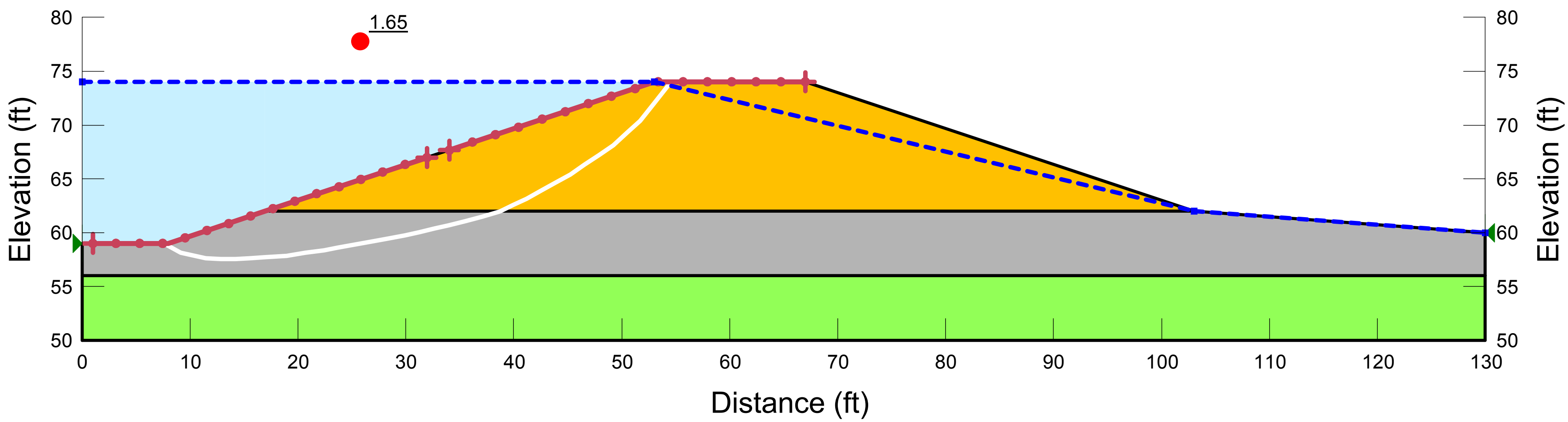

Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 3
Pseudo-Seismic Analysis
Kh,Kv = 0.06g
Ash Pond Level: 74.0 ft

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
Green	Poorly Graded Sand with Clay (SP-SC)	110	0	30
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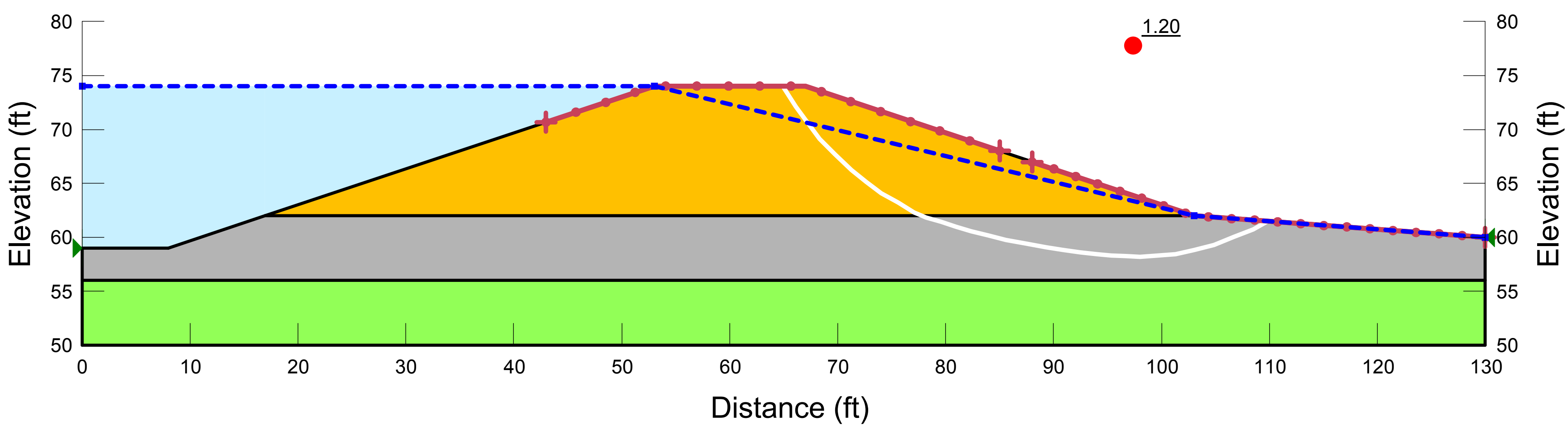
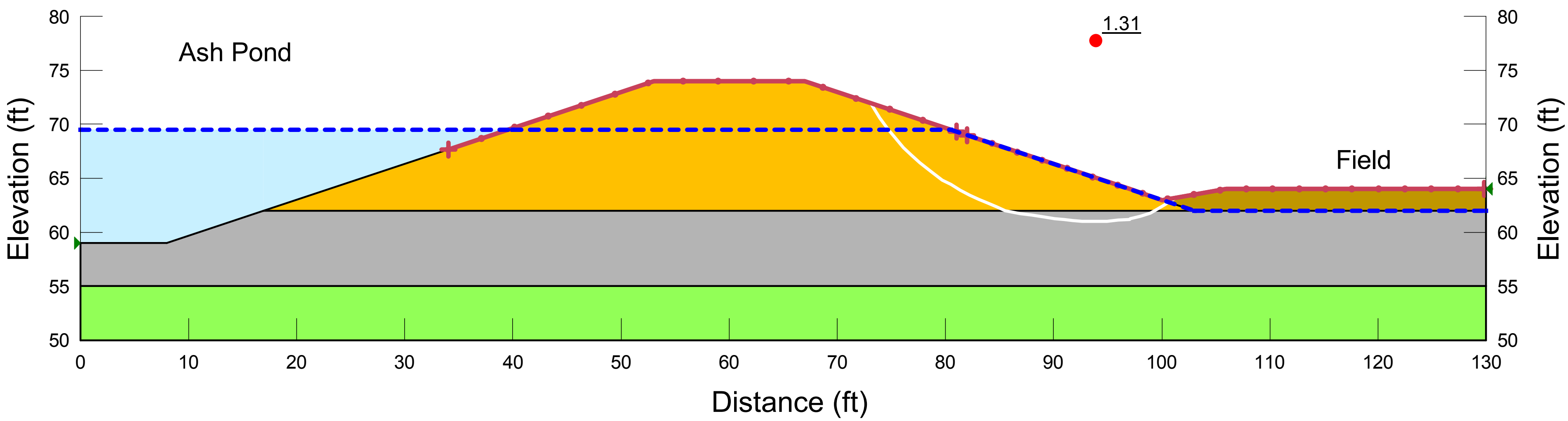


Rapid Drawdown (RDD)

Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 1
Static Analysis
Ash Pond Level: 69.5 ft
Rapid Drawdown Conditions on Outside Slope

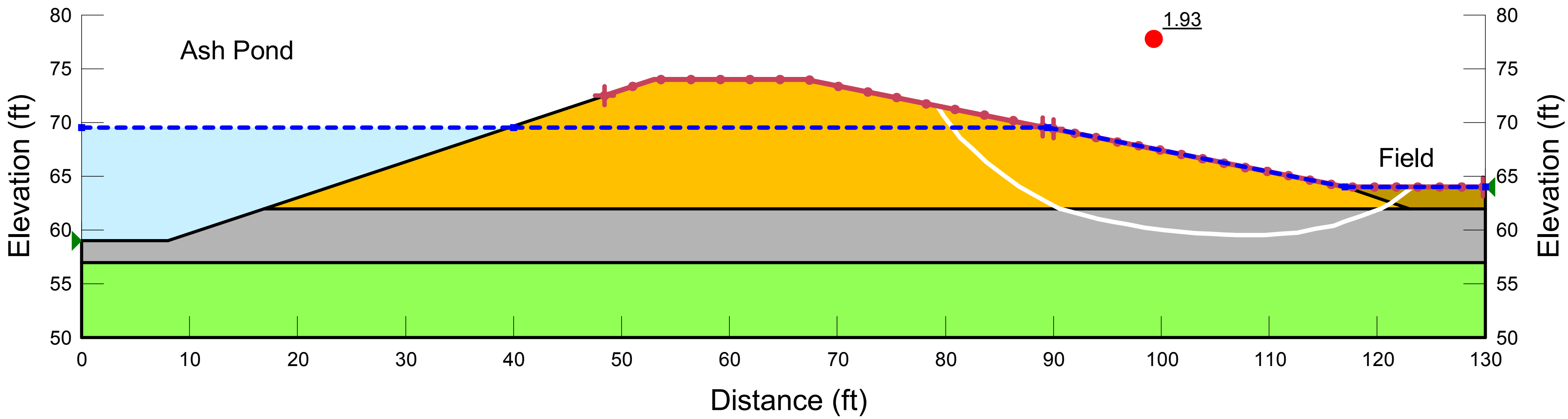
Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Poorly Graded Sand with trace Gravel (SP)	110	0	30
	Lean Clay with Trace Organics (Fill)	115	50	30
	Sandy Lean Clay with Organics (CL)	115	25	28
	Topsoil	100	0	26



Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 2
Static Analysis
Ash Pond Level: 69.5 ft
Rapid Drawdown Conditions on Outside Slope

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Poorly Graded Sand with trace Gravel (SP)	110	0	30
	Lean Clay with Trace Organics (Fill)	115	50	30
	Sandy Lean Clay with Organics (CL)	115	25	28
	Topsoil	100	0	26



Ash Pond Dike Evaluation
Ames Municipal Utility
City of Ames, IA

Cross Section 3
Static Analysis
Ash Pond Level: 69.5 ft
Rapid Drawdown Conditions on Outside Slope

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
Green	Poorly Graded Sand with Clay (SP-SC)	110	0	30
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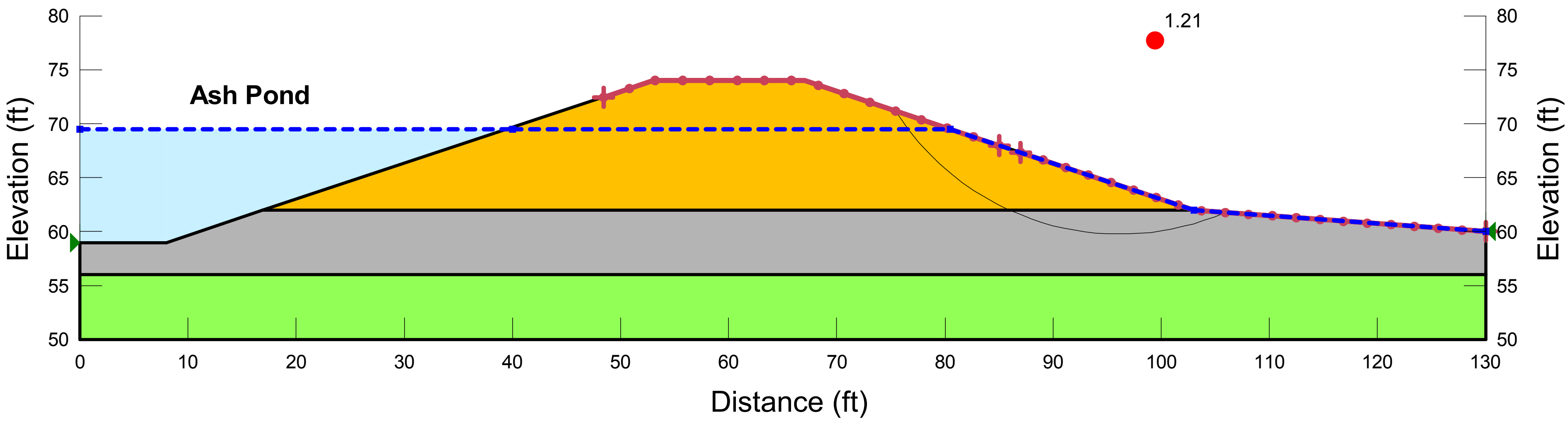

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