<u>Comments on Draft Report on Kentucky Utilities – Green River Station</u>

EPA:

Contractor did not rate Finishing Pond #3- taken out of service in 2010, but not officially closed out with the state- have contractor rate pond.

State: None

Company: See letter dated January 26, 2011

Generation Services

VIA OVERNIGHT DELIVERY

Mr. Stephen Hoffman
U.S. Environmental Protection Agency
Two Potomac Yard
2733 South Crystal Drive
Fifth Floor, N-5237
Arlington, VA 22202-2733

January 26, 2011

Re: Kentucky Utilities' Comments on
DRAFT Report of Geotechnical Investigation Dam Safety Assessment of Coal Combustion Surface Impoundments Kentucky Utilities, a Subsidiary of E.ON U.S. Green River Station, Central City, Kentucky

Dear Mr. Hoffman:

The U.S. Environmental Protection Agency (EPA) requested comments from Kentucky Utilities (KU) on a draft report regarding coal combustion residual (CCR) impoundments at KU's Green River Station. AMEC, an engineering contractor for EPA, prepared the draft report dated September 2010 to present results of their assessment of the structural stability of four CCR impoundments at Green River Station, commonly referred to as Ash Treatment Basin #1, Ash Treatment Basin #2, Scrubber Pond, and Coal Pile Runoff Pond.

The scope of AMEC's assessment included a site visit to perform visual observations of the impoundments and a review of documentation provided by KU. As part of the assessment, AMEC assigned a condition rating and a hazard rating to each impoundment using their engineering judgment and understanding of criteria developed by the EPA.

In conducting its assessment, AMEC utilized impoundment guidelines issued by the Mine Safety and Health Administration (MSHA). However, the MSHA guidelines are aimed at coal slurry ponds at mine sites, rather than the CCR impoundments found at a power plant. The MSHA standards are not legally applicable to our impoundments and in fact differ substantially from the standards that are applicable to our facilities. As you know, over the past two years EPA has assessed impoundments at several other facilities owned by KU or its affiliates. None of the EPA contractors conducting assessments of our facilities has utilized MSHA guidelines in preparing its reports. In fact, of the dozens of assessments of power plant impoundments that EPA has conducted across the nation, we are unaware of any EPA contractor other than AMEC utilizing MSHA guidelines in preparing its reports. Consequently, we object to the use of MSHA guidelines for inspection of our facilities because they are legally inapplicable, inappropriate from a technical standpoint, and inconsistent with past EPA practice. In the present situation, where EPA is conducting nation-wide assessments to determine whether CCR impoundments pose any significant risk to the public, it is particularly inappropriate for EPA to apply differing standards depending on the EPA contractor that conducts the assessment.

We disagree with the "poor" condition rating which AMEC has assigned to each of our impoundments. Based on AMEC's site inspection in August of 2010, AMEC found "no major operational or maintenance issues that needed to be addressed." However, AMEC determined to assign a poor condition rating based on the absence of certain information specified under the MSHA guidelines. It is entirely permissible under the MSHA guidelines to consider methods and procedures and other information that falls outside the gambit of the MSHA program to verify the safety of an impoundment.

According to the preface of MSHA's *Engineering and Design Manual Coal Refuse Disposal Facilities*, Second Edition, May 2009: "*The guidance presented in this Manual represents information, methods and procedures that are recommended for consideration by designers, coal operators, and regulators. The guidance presented in this Manual is not regulation and cannot be enforced as such. It is not intended to preclude the application of other credible methods and procedures or the use of other and new information that will result in a safe and reliable coal refuse disposal facility.*"

Kentucky has established a dam safety regulatory program under KRS Chapter 151 which involves permitting and inspection of impoundments. KRS 150.295 directs the Secretary of the Energy and Environment Cabinet (EEC) to inspect dams and reservoirs on a regular schedule. KRS 151.100 defines the word dam to mean any artificial barrier, including appurtenant works, which does or can impound or divert water and which either (a) is or will be 25 feet or more in height or (b) has or will have an impounding capacity at maximum water storage elevation of 50 acre-feet or more. All such dams are subject to the provisions of KRS Chapter 151 and are regulated by the EEC, Department for Environmental Protection (KY DEP).

The Secretary of the EPC is empowered by KRS 151 to administer and enforce the law using methods and procedures such as adopting rules and regulations, routinely inspecting dams, issuing permits and certificates of inspection, requiring owners to take action to protect life and property, and conducting studies and investigations as necessary to ensure compliance. KY DEP maintains an experienced technical staff to enforce regulations and administer the methods and procedures of the Secretary.

The EPC's regulations incorporate two technical publications that provide methods and procedures for the design, construction and safe operation of dams. These publications are *The Division of Water Engineering Memorandum No. 5* and *Guidelines for Geotechnical Investigation and Analysis of New and Existing Earth Dams.* Kentucky professional engineers have historically used these publications for the design and construction of numerous projects which have been determined to be safe and reliable. These publications provide appropriately conservative methods and procedures for the design, construction and operation of safe CCR impoundments. MSHA impoundment guidelines are designed to regulate a broader array of potential dam integrity issues and materials with differing physical properties than CCRs. KU does not consider the strict application of MSHA impoundment guidelines to be necessary or appropriate for CCR impoundments. Nor does KU interpret the MSHA guidelines as precluding reliance on relevant information available under the Kentucky Dam Safety program or otherwise available to EPA.

According to Kentucky regulations, the Green River CCR impoundments are classified as follows:

Ash Treatment Basin #1 – Class A, Low Hazard
Ash Treatment Basin #2 – Not Classified
Scrubber Pond - Class A, Low Hazard
Coal Pile Runoff Pond – Not Classified

Kentucky regulations define Class A, Low Hazard dams as "structures located such that failure would cause loss of the structure itself but little or no additional damage to other property". Ash Treatment Basin #2 and Coal Pile Runoff Pond are small impoundments that are not large enough to be classified as a dam per Kentucky regulations and do not present a hazard to life or property.

Out of an abundance of caution and to assist KY DEP, EPA and AMEC, KU has conducted additional studies and investigations to confirm the safety of impoundments at Green River Station. The studies and investigations included a suite of comprehensive geotechnical explorations, instrumentation programs, geological laboratory testing programs, slope stability analyses, hydrologic and hydraulic analyses, and recent engineering condition assessments by an independent registered professional engineer. These further studies concluded that all four CCR impoundments at Green River are in acceptable condition.

KU has included these additional studies, clerical and technical corrections to AMEC's draft report as the following attachments to this letter.

Attachment 1 – KU's Comments - clerical and technical corrections to *DRAFT Report of Geotechnical Investigation Dam Safety Assessment of Coal Combustion Surface Impoundments Kentucky Utilities, a Subsidiary of E.ON U.S. Green River Station, Central City, Kentucky*

Attachment 2 - *Report of Geotechnical Exploration and Slope Stability Analyses Kentucky Utilities (KU) Green River Power Station, No. 2 Pond/Coal Pile Runoff Pond and Scrubber Pond, South Carrolton, Muhlenberg County, Kentucky,* December 3, 2010, Mactec Engineering and Consulting, Inc.

Addendum A, Report of Geotechnical Exploration and Slope Stability Analyses Kentucky Utilities (KU) Green River Power Station, No. 2 Pond/Coal Pile Runoff Pond and Scrubber Pond, South Carrolton, Muhlenberg County, Kentucky, January 24, 2011, Mactec Engineering and Consulting, Inc.

Sheet Number 1, As-Built, Number 2 Pond Slope Armoring and Ditch Relocation, September 15, 2010, Associated Engineers, Inc.

Attachment 3 – *Addendum A - Assessment of Spillway Hydrologic Adequacy for the Coal Pile Pond, Ash Treatment Basin No. 2, and Scrubber Pond at Green River Generating Station,* January 25, 2011, Mactec Engineering and Consulting, Inc.

Attachment 4 – *Addendum A – Final Geotechnical Report, Main Ash Pond Slope Stability Analysis and Repair, Kentucky Utilities, Green River Station*, January 24, 2011, Associated Engineers, Inc.

Attachment 5 – Cover Pages, cover letter, appendices A and B of *2011 Pond Inspections Visual Site Assessment Report Six Impoundment Facilities*, January 25, 2011, ATC Associates, Inc.

KU respectfully requests that EPA direct AMEC, in finalizing the report, to refrain from applying MSHA guidelines and to consider all information available under the Kentucky Dam Safety Program as well as the additional studies and investigations performed by KU. KU believes that the additional information clearly shows the CCR impoundments at Green River Station are in acceptable condition.

Also, please note that on November 1, 2010, the name of E.ON U.S. LLC was changed to LG&E and KU Energy LLC. Consequently, any references to E.ON U.S. should be changed to LG&E and KU Energy.

We appreciate the opportunity to comment. If you have any questions regarding these comments, please contact me using the information provided below.

Sincerely,

David J. Millay

David Millay, PE
Civil Engineer, LG&E and KU Services Company
Phone 502-627-2468
david.millay@lge-ku.com

Attachments
Cc: James Kohler, PE, U.S. Environmental Protection Agency
Gary Wells, PE, Kentucky Department of Environmental Protection– Dam Safety Section
Michael Winkler, LG&E and KU Services Company
John Voyles, LG&E and KU Services Company

Attachment 1

KU Comments-clerical and technical corrections to
DRAFT Report of Geotechnical Investigation Dam Safety Assessment of Coal Combustion Surface Impoundments
Kentucky Utilities, a Subsidiary of E.ON U.S.
Green River Station, Central City, Kentucky,

AMEC Project No. 3-2106-0177.0003

Prepared by AMEC Earth & Environmental, Inc.,
September 2010

KU General comments:

In Kentucky, CCR impoundments are regulated by the Energy and Environmental Cabinet, Department of Environmental Protection, Division of Water. The U.S. Department of Labor, Mine Safety Health Administration (MSHA) does not regulate CCR impoundments in Kentucky. MSHA impoundment guidelines are designed to regulate a broader array of potential dam integrity issues and materials with differing physical properties than CCRs. KU does not consider the strict application of MSHA impoundment guidelines to be necessary or appropriate for CCR impoundments in Kentucky.

Inside of cover page

"Kentucky Utilities a wholly owned subsidiary of E.ON U.S., Green River Power Station…"

Page 1, *1.1 Introduction*
First paragraph, fourth line:
"…perform a site assessment of Kentucky Utilities (a wholly owned ~~S~~subsidiary of E.ON U.S.) Green River Power…"

Page 1, *Table 1. Site Visit Attendees*

E.ON U.S., Environmental Affairs Michael Winkler, Manager-Environmental Programs
Kentucky Utilities Travis Harper, Chemist III
~~*E.ON U.S.*~~ Kentucky Utilities Tom Troost, ~~*Plant*~~ General Manager, Green River Power Station
E.ON U.S., Generation Engineering David Millay, P.E., Civil Engineer

Page 2, section *1.2 Project Background*
Fifth paragraph

"Based on a site visit evaluation of the impoundments, AMEC engineers assigned a "Significant Hazard Potential" classification to the Ash Treatment Basin #1 or Main Pond, Ash Treatment Basin #2, Scrubber Pond, and the Former Ash Pond or Coal Runoff Pond… "

KU Notes: The Green River CCR impoundments do not qualify for any MSHA category because MSHA does not have jurisdictional authority to regulate the Green River CCR Impoundments.

KY DEP's staff of dam safety engineers conducted comprehensive design reviews and permitting for the Ash Treatment Basin #1 and the Scrubber Pond during the design, construction, and initial operation phase of these projects. Ash Treatment Basin #1 and the Scrubber Pond were permitted as low hazard dams, and are currently classified as low hazard dams.

KY DEP engineers have conducted numerous routine site inspections at Green River for Ash Treatment Basin #1 and the Scrubber Pond. KY DEP continues to classify Ash Treatment Basin #1 and the Scrubber Pond as Class A, Low Hazard dams. The Number 2 Pond and the Coal Runoff Pond remain exempt from Kentucky dam safety regulations because they are small and do not create a hazard to life or property.

Page 2, section *1.2 Project Background*
First, second and third paragraphs

KU Notes:

The Green River Ash Treatment Basin #1 and Scrubber Pond dams are classified as Class A, Low Hazard dams by Kentucky regulations. Low hazard classifications means that failure would cause loss of the structure itself but little or no additional damage to other property.

Refer to KRS 151.250

" 151.250 Plans for dams, levees, etc. to be approved and permit issued by cabinet -- Jurisdiction of Department for Natural Resources.

(1) Notwithstanding any other provision of law, no person and no city, county, or other political subdivision of the state, including levee districts, drainage districts, flood control districts or systems, or similar bodies, shall commence the construction, reconstruction, relocation or improvement of any dam, embankment, levee, dike, bridge, fill or other obstruction (except those constructed by the Department of Highways) across or along any stream, or in the floodway of any stream, unless the plans and specifications for such work have been submitted by the person or political subdivision responsible for the construction, reconstruction or improvement and such plans and specifications have been approved in writing by the cabinet and a permit issued. However, the cabinet by regulation may exempt those dams, embankments or other obstructions which are not of such size or type as to require approval by the cabinet in the interest of safety or retention of water supply."

The KU Green River Number 2 Pond and Coal Pile Runoff Pond are exempt from Kentucky dam safety regulations as they are not of such size to require approval by the cabinet in the interest of safety.

Page 2, section *1.2 Project Background*
Fourth paragraph, third and fourth line

"Copies of the ~~*ash*~~ CCW Impoundment Inspection Forms are provided in Appendix A. The CCW Impoundment Inspection…"

Page 3, section *1.2.1 State Issued Permits*
First paragraph

"The permit became effective of November 1, 2001 and expired on October 31, 2004. At the time of writing of this report, KDOW stated the KPDES permit for Green River Power Station was under review."

KU Note: The permit remains in effect under applicable state regulations.

Page 3, section *1.2.1 State Issued Permits*
Second paragraph

KU Note: Two engineers from KDOW Dam Safety Section inspected the Green River Ash Treatment Basin #1 and the Scrubber Pond on January 6, 2011. No safety issues were noted and KU expects KDOW will subsequently issue a Certificate of Inspection.

Page 4, section *1.4.1 Ash Handling and Flow Summary*
Second paragraph, first line

"Once-through cooling water flows are used for the ~~*main condenser*~~ Units 3 and 4 condensers and are not routed…"

Page 5, section *1.4.2 Ash Treatment Basin #1*
First paragraph, sixth and seventh lines

KU Note: The Green River Ash Treatment Basin #1 was constructed under the supervision of a professional engineer. James Flaig, Kentucky Professional Engineer number 6337 supervised the construction. Reference HC Nutting as built project drawings transmitted by KU to AMEC on July 30, 2010.

Page 5, section *1.4.2 Ash Treatment Basin #1*
Second paragraph

KU Note: The Green River Ash Treatment Basin #1 slope failures were shallow, maintenance type sloughs, commonly associated with earthen dams. KU promptly took action to repair these areas. Qualified KU staff routinely monitors these areas and the repairs have continued to perform satisfactorily.

Page 5, section *1.4.2 Ash Treatment Basin #1*
Fourth paragraph, second line

"…excavating and removing loose materials and reconstructing the slope with rock."

Page 5, section *1.4.2 Ash Treatment Basin #1*
Fourth paragraph, sixth line

"…requirements of Section 843, Type IV, of the current edition of the Kentucky ~~KOT~~ Transportation Cabinet..."

Page 7, section *1.4.5 Scrubber Pond*
First paragraph

KU Note: In December 2010, KU installed new pumps with automatic switches on the Scrubber Pond to provide automatic pool elevation control.

Page 7, section *1.4.5 Scrubber Pond*
Second paragraph, third line

"…~~2001~~ 2003 the Scrubber Pond has not received FGD residuals."

Page 8, section *1.5 Previously Identified Safety Issues*

KU Note: The Green River Ash Treatment Basin #1 slope failures were shallow, maintenance type sloughs, commonly associated with earthen dams. KU took action to repair these areas. Qualified KU staff routinely monitors these areas and the repairs have continued to perform satisfactorily. KU acted promptly to address the sloughs, but at no time were they considered a safety issue.

Page 10, section *2.2.1 Ash Treatment Basin #1 – Embankments and Crest*
First paragraph, line 12

"Two ~~rock~~ buttresses, reportedly installed…"

KU Note: The east buttress installed in 2010 is rock. The west buttress is constructed out of compacted soil.

Page 13, section *2.7 Monitoring Instrumentation*

KU Note: The Green River Ash Treatment Basin #1 and Ash Treatment Basin #2 were designed and constructed with weirbox structures and metal plate v-notch weirs at the ash pond flow measurement structure. Weirs are instruments used to measure and monitor flow.

Pages 18-22, section *3.2.1 Hydrologic and Hydraulic Study*

KU Notes: KU implemented various hydrologic and hydraulic (H&H) system improvements at the Ash Treatment Basin #2 (Number 2 Pond) and Scrubber Pond in 2010. MACTEC Engineering and Consulting updated the H&H model for these impoundments. See *Addendum A to Assessment of Spillway Hydrologic Adequacy for the Coal Pile Pond, Ash Treatment Basin No. 2, and Scrubber Pond at Green River Generating Station,* January 25, 2011.

Mactec's H&H model concluded that all four Green River CCR impoundments do not overtop during a 100 year, 6 hour precipitation event. Ash Treatment Basin #1 and the Scrubber Pond meet Kentucky H&H regulations for Class A, Low Hazard dams.

Because the Ash Treatment Basin #2 and the Coal Pile Runoff Pond are not large enough to meet Kentucky regulations for classification as a dam, Kentucky H&H regulations for a Class A, Low Hazard Dams do not apply. Ash Treatment Basin #2 and the Coal Pile Runoff Pond are smaller impoundments that do not present a hazard to life or property.

KU is continuing to evaluate the modeled H&H conditions at the Green River CCR impoundments and plans to implement any necessary operational adjustments.

Page 23, section *3.3 Structural Adequacy and Stability*

Table 7 heading "Minimum ~~*Required*~~ Dam Safety Factors"

KU suggests that AMEC should delete the word "required" as it does not apply to all three agencies published documents regarding minimum safety factors.

Page 30, section *3.5.1 Instrumentation*

KU Note: The Main Pond and Number 2 Pond were designed and constructed with weirbox structures and metal plate v-notch weirs at the principal spillway discharge structure. Weirs are instruments used to measure and monitor flow.

Pages 36-37 section *4.1 Acknowledgement of Management Unit Conditions*

KU Notes: KU has provided additional information that shows all four Green River CCR impoundments are not in poor condition. For the draft and final reports, KU suggests that AMEC adjust the assigned condition ratings to reflect the acceptable conditions.

Pages 39, 41, 43, 45 sections *4.2.4 – 4.5.4 Inspection Recommendations*

KU Notes: ATC Associates conducted an independent third party inspection of the four Green River CCR impoundments in January, 2011. ATC do not recognize any dam safety deficiencies and noted only routine minor maintenance items. KU is developing plans to address the priority maintenance items in 2011.

Pages 37-39, 40-42, 44, sections *4.2.2, 4.3.2, 4.4.2, 4.5.2 Geotechnical and Stability Recommendations*

KU Notes: A series of comprehensive geotechnical explorations and slope stability analyses for the Green River CCR impoundments were completed in December, 2010 and is included as attachment 2. The results of the analysis for Ash Treatment Basin #1 and the Scrubber Pond are summarized in Table 1.

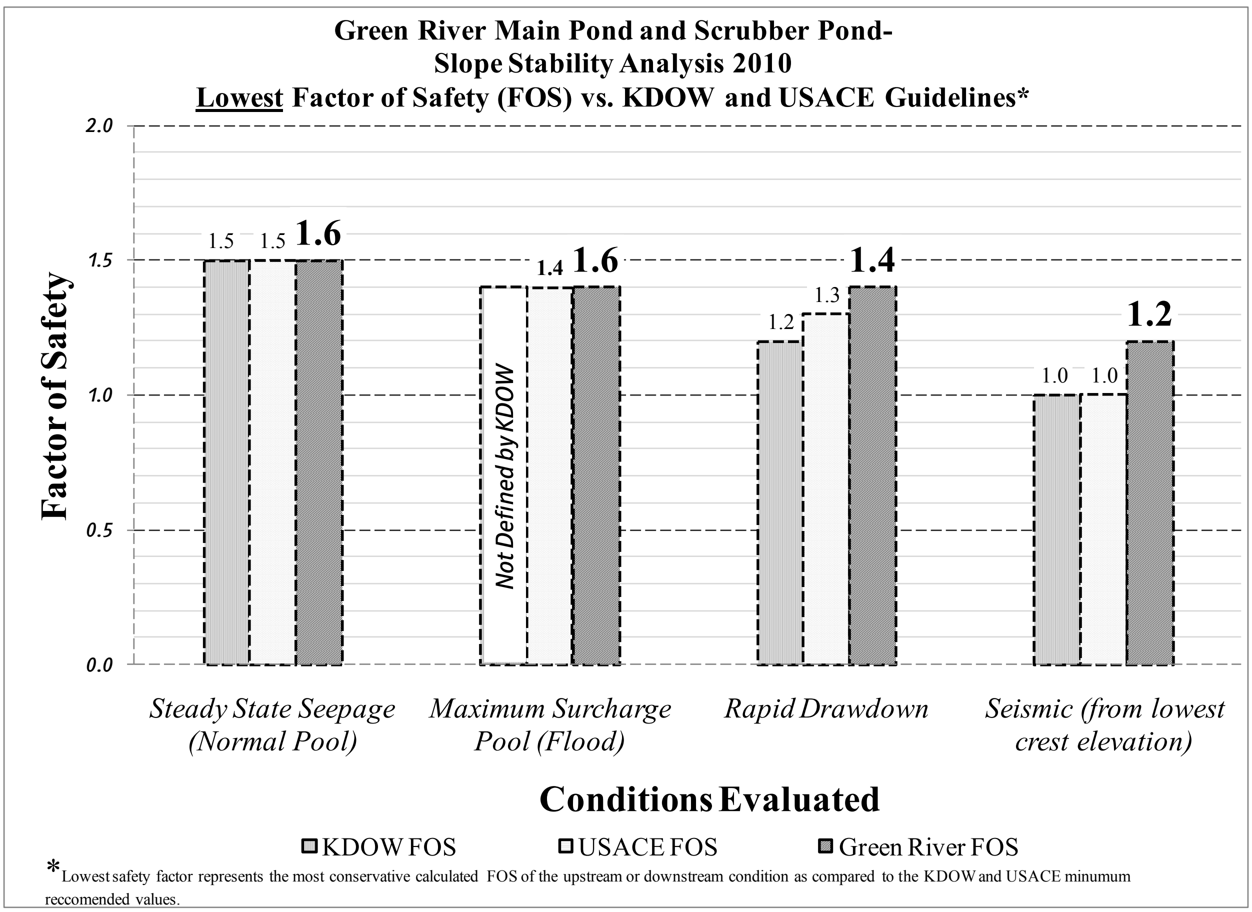
Because the Ash Treatment Basin #2 and the Coal Pile Runoff Pond are not large enough to meet Kentucky regulations for classification as a dam, Kentucky slope stability regulations do not apply. Ash Treatment Basin #2 and the Coal Pile Runoff Pond are smaller impoundments that do not present a hazard to life or property.

Slope stability analyses showed factors of safety below KY DEP recommended values at a cross section 1 of the Coal Pile Runoff Pond and a cross section 5 of the Ash Treatment Basin #2. These analyses concluded that the impoundment slopes are stable under steady-state conditions and did not conclude there was a safety concern.

For cross section 1 of the Coal Pile Runoff Pond, the downstream model for the steady-state/maximum surcharge pool conditions indicated a theoretical minimum FS of 1.4. Theoretical factors of safety above 1.0 indicate a stable slope under modeled conditions; therefore, the slopes are currently stable and should not be expected to fail under normal operating conditions. KU is currently evaluating the results of the analysis and plans to study options to improve the section if necessary to increase the factor of safety above KY DEP recommended values.

For Ash Treatment Basin #2, the modeled theoretical failure occurs under earthquake loading conditions. The theoretical failure occurs as a thin veneer within the impoundment ash inside the embankment and would not cause a release of material.

Table 1



Attachment 2

Report of Geotechnical Exploration and Slope Stability Analyses
Kentucky Utilities (KU) Green River Power Station
No. 2 Pond/Coal Pile Runoff Pond and Scrubber Pond
South Carrollton, Muhlenberg County, Kentucky

December 3, 2010
Mactec Engineering and Consulting, Inc.

Addendum A, Report of Geotechnical Exploration and Slope Stability Analyses
Kentucky Utilities (KU) Green River Power Station
No. 2 Pond/Coal Pile Runoff Pond and Scrubber Pond
South Carrolton, Muhlenberg County, Kentucky

January 24, 2011
Mactec Engineering and Consulting, Inc.

Sheet Number 1, As-Built, Number 2 Pond Slope Armoring and Ditch Relocation

September 15, 2010
Associated Engineers, Inc.

REPORT OF GEOTECHNICAL EXPLORATION AND SLOPE STABILITY ANALYSES

KENTUCKY UTILITIES (KU)
GREEN RIVER POWER STATION
NO. 2 POND/COAL PILE RUNOFF POND
AND SCRUBBER POND
SOUTH CARROLLTON, MUHLENBERG COUNTY, KENTUCKY

Prepared For:

LG&E and KU Services
220 West Main Street
Louisville, Kentucky 40202

LG&E and KU Contract No. 31528

Prepared By:

MACTEC ENGINEERING AND CONSULTING, INC.
13425 Eastpoint Centre Drive, Suite 122
Louisville, Kentucky 40222

MACTEC PROJECT NO. 3143-10-1317.02

December 3, 2010

MACTEC

engineering and constructing a better tomorrow

December 3, 2010

Mr. David J. Millay, P.E.
LG&E and KU Services
220 West Main Street
Louisville, Kentucky 40202
Phone: 502-627-2468
Facsimile: 502-217-2850
Electronic mail: David.Millay@eon-us.com

SUBJECT: Report of Geotechnical Exploration and Slope Stability Analyses
KU Green River Power Station
No. 2 Pond/Coal Pile Runoff Pond and Scrubber Pond
South Carrollton, Muhlenberg County, Kentucky
MACTEC Project No. 3143-10-1317.02

Dear Mr. Millay:

MACTEC Engineering and Consulting, Inc. (MACTEC) is pleased to submit this Report of Geotechnical Exploration and Slope Stability Analyses for the No. 2 Pond/Coal Pile Runoff Pond and the Scrubber Pond at the KU Green River Power Station in South Carrollton, Muhlenberg County, Kentucky. Our services were provided in general accordance with our Master Agreement No. 31528, Contract No. 495429 dated August 23, 2010, and our Proposal No. PROP10LVLE Task 162.

The attached report presents a review of the project information provided to us, a description of the site and subsurface conditions encountered, a summary of our slope stability analyses, and our findings and conclusions relative to the existing No. 2 Pond/Coal Pile Runoff Pond and the Scrubber Pond at the KU Green River Power Station. The Appendix to the report contains site and boring location plans, the results of our field and laboratory testing, and the results of our slope stability analyses.

MACTEC appreciates this opportunity to provide our services to you and we look forward to serving as your geotechnical consultant throughout this project. Please contact us if you have any questions regarding the information presented.

Sincerely,

MACTEC ENGINEERING AND CONSULTING, INC.

Sarah Shilley for Melany L. Brite w/ permission
Senior Professional

STATE OF KENTUCKY NICHOLAS G. SCHMITT 10311 LICENSED PROFESSIONAL ENGINEER
12/03/10

Nicholas G. Schmitt, P.E.
Senior Principal Engineer
Licensed Kentucky 10311

Attachment: Report of Geotechnical Exploration

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APPENDIX

1. EXECUTIVE SUMMARY

Kentucky Utilities (KU) retained MACTEC Engineering and Consulting, Inc. (MACTEC) to evaluate the stability of the existing No. 2 Pond/Coal Pile Runoff Pond embankments and Scrubber Pond embankments at their Green River Power Station in South Carrollton, Muhlenberg County, Kentucky. The goal of our services was to evaluate the stability of the upstream and downstream slopes at ten selected cross-sections (Section 1 through Section 10), under three conditions: steady-state/maximum surcharge pool, rapid drawdown, and dynamic (seismic) loading.

Our exploration included a total of 23 soil test borings and six groundwater piezometers. Two borings were drilled at each of 10 cross-sections (one crest boring and one downstream toe boring per cross-section). Three additional toe borings were drilled to further explore unanticipated conditions encountered at Section 2. The piezometers were installed in selected crest borings (three per pond). Our geotechnical laboratory testing included index tests, classification tests, and triaxial shear strength tests.

We developed slope stability models based on the geometric slope conditions (upstream and downstream slopes) and our interpretation of the subsurface soil strata and available groundwater data. We selected soil parameters for the slope stability analyses based on several resources, including the laboratory testing performed for this exploration, our field testing and observations, published information on similar soil and material types, and our experience.

Our analyses indicate that the embankment sections analyzed are structurally stable under steady-state conditions from a slope stability standpoint, and are not in danger of imminent failure. However, one slope under steady-state/maximum surcharge conditions (Section 1 Downstream) and one slope under seismic loading conditions (Section 5 Upstream) do not meet the target Factor of Safety (FS) criteria provided and referenced herein. Various methods are available for improving the minimum factor of safety of the Section 1 Downstream slope, as discussed in Section 5.6.2 of this report. The predicted failure of the Section 5 Upstream slope occurs as a thin veneer failure within the impounded ash behind the embankment and would have an insignificant impact on the embankment at this location. Therefore, improvements are not warranted for the Section 5 Upstream slope.

2. PURPOSE AND SCOPE OF EXPLORATION

The purpose of this exploration was to obtain site specific subsurface information for the development of slope models to analyze the stability of the existing No. 2 Pond/Coal Pile Runoff Pond and the Scrubber Pond at the KU Green River Power Station. The primary guidance documents for the development of our exploration and analyses included the Kentucky Environment and Energy Cabinet (KEEC), Water Infrastructure Branch, Dam Safety Division Guidelines (primarily Engineering Memorandum Number 5 and KAR 401:030 – Design Criteria for Dams and Associated Structures and "Guidelines for Geotechnical Investigation and Analysis of New and Existing Earth Dams") and the U.S. Army Corps of Engineers (USACE) Engineering Manual EM 1110-2-1902. In addition, the "Engineering and Design Manual" (dated May 2009) by the Mine Safety and Health Administration (MSHA) was referenced for seismic stability analyses.

KU retained MACTEC to provide geotechnical engineering consulting services for the Green River Power Station No. 2 Pond/Coal Pile Runoff Pond and the Scrubber Pond. This report presents a summary of our geotechnical exploration, the results of our slope stability analyses, and our conclusions pertinent to the pond embankments. Herein, the term "site" shall refer specifically to the No. 2 Pond/Coal Pile Runoff Pond and the Scrubber Pond at the KU Green River Power Station.

Our scope of services included reviewing documents including aerial photographs and construction drawings provided by KU, available geologic and topographic mapping, and explorations performed by others; performing a site reconnaissance, exploratory drilling, and laboratory testing; and performing slope stability analyses for the existing pond embankments. A total of 20 soil test borings were proposed to obtain subsurface data at ten cross-sections along the embankments at areas we judged to be "critical" based on the topography and nature of the exposed slope. The cross-sections are spaced on approximately 200 to 700 foot intervals along the existing embankments of the ponds to obtain subsurface data along the crest and toe. Three borings were added to further explore unanticipated conditions encountered in the Section 2 borings. Three piezometers were installed in the embankment crest at each pond (total of six piezometers) to monitor piezometric levels within the dams. Water levels in the piezometers were recorded on August 24 and October 14, 2010.

The assessment of site environmental conditions was beyond the scope of our geotechnical exploration.

3. PROJECT INFORMATION

Project information was provided by Mr. David J. Millay, P.E. and other representatives of KU during multiple telephone conversations, electronic mail transmittals, and a site meeting on August 9, 2010 between KU and MACTEC representatives. Copies of the following documents were provided to us:

- *KU Green River Mapping*, dated February 3, 2010, prepared by L. Robert Kimball & Associates, LLC
- Seven historic topographic maps, dated 1951 through 1993, provided by KU
- Several aerial images of Green River Power Station , untitled and undated, provided by KU
- Three bathymetric surveys titled, *Ash Pond Capacity Analysis – No. 2 Pond*, *Ash Pond Capacity Analysis – Coal Pile Runoff Pond*, and *Ash Pond Capacity Analysis – Scrubber Pond*, dated July 30, 2010, prepared by Associated Engineers, Inc.
- *Final Geotechnical Report, Main Ash Pond, Slope Stability Analysis and Repair, Green River Station*, dated July 16, 2010, prepared by Associated Engineers, Inc.

As previously noted, our services were requested relative to evaluation of the embankments retaining two ponds at the KU Green River Power Station facility in South Carrollton, Kentucky. The ponds are identified as the No. 2 Pond/Coal Runoff Pond and the Scrubber Pond. Information pertaining to the two ponds is summarized below.

<u>No. 2 Pond/Coal Pile Runoff Pond</u>. The No. 2 Pond/Coal Pile Runoff Pond has a collective surface area of approximately 32 acres and was constructed in two phases. The south embankment of the Coal Pile Runoff Pond (western cell) was constructed in the 1940s to create a runoff basin for the coal stockpile and a settling pond for sluiced ash and plant process water. In the early 1970s, the south embankment of the Coal Pile Runoff Pond was expanded to the east and a divider dike was constructed to create a two-cell pond. The east pond is referred to as the No. 2 Pond. This expansion included an embankment constructed to form the east limit of the No. 2 Pond which intersects a native hillside at the northern limit of the pond. The total length of constructed embankments for this complex is approximately 3,050 linear feet. The typical crest elevation for the Number 2 Pond is 400 feet National Geodetic Vertical Datum of 1929 (NGVD) with a typical crest width of about 10 feet.

Information provided indicates the bottom of pond design elevation was approximately 385 feet NGVD. However, we understand some local variations from the design bottom elevation may be expected. An as-built survey of the completed pond, prepared before the pond was put into service, is not available.

The downstream toe elevation varies, with the lowest toe elevation of 385 feet NGVD resulting in a maximum dam height of approximately 15 feet. Both the upstream and downstream embankment slope inclinations are nominally reported to be 2.5 Horizontal to 1 Vertical (2.5H:1V).

Scrubber Pond. The Scrubber Pond (also known as the SO_2 Removal Pond) has a surface area of approximately 9 acres and was constructed in the late 1970s to manage flue gas desulfurization (FGD) residuals for Green River Power Station Units 1 and 2. Both units were retired in 2003 and the Scrubber Pond has not received FGD residuals since that time. The impoundment consists of three embankments along the east, south and west sides of the pond. The north limits of the east and west embankments intersect a native hillside. The total length of constructed embankment is approximately 2,150 linear feet. The typical crest elevation is 405 feet NGVD with a typical crest width of about 10 feet.

Information provided indicates the bottom of pond design elevation was approximately 385 feet NGVD. However, we understand some local variations from the design bottom elevation may be expected. An as-built survey of the completed pond, prepared before the pond was put into service, is not available.

The downstream toe elevation varies, with the lowest toe elevation of 385 feet NGVD resulting in a maximum dam height of approximately 20 feet. Both the upstream and downstream embankment slope inclinations are nominally reported to be 2.5H:1V.

Representatives from KU and MACTEC were present on August 9, 2010 at the Green River Power Station in South Carrollton, Muhlenberg County, Kentucky. The purposes of the meeting were to discuss the No. 2 Pond/Coal Pile Runoff Pond and the Scrubber Pond, perform an initial reconnaissance of the facility, and discuss an exploration approach for obtaining the data required to evaluate the stability of the existing embankments.

The proposed drilling plan included 20 soil test borings, comprised of one boring on the crest and one boring at the downstream toe of 10 selected embankment sections. The ten proposed sections were spaced on approximately 200- to 700-foot intervals along the total embankment length of 5,200 feet. We judged this spacing interval acceptable to provide adequate initial coverage for the subsurface exploration. Further, the cross sections were selected at areas judged to be "critical" based on the topography and the nature of the exposed slope.

4. EXPLORATORY FINDINGS

4.1 SURFACE CONDITIONS

MACTEC conducted a site reconnaissance on August 12-14, 2010 during our drilling operations. The site surface conditions were observed and documented and the information gathered was used to help interpret the subsurface data, and to detect conditions which could affect our recommendations.

The KU Green River Power Station is situated along the northern bank of the Green River, about 1-1/2 miles east of US 431 in South Carrollton, Muhlenberg County, Kentucky. Access to the plant from US 431 is provided via Power Plant Road. The No. 2 Pond and the Scrubber Pond are located on the northeast side of the plant, about 1100 feet north of the river.

Surface cover along the crest of the embankments, which were used as access roads, consisted primarily of gravel. The downstream face of the southern and eastern embankments of the No. 2 Pond were covered with limestone rip rap, which we understand was placed to mitigate surface erosion. Otherwise, surface cover on the upstream and downstream slope faces and the toe of the embankments consisted of sparse to dense field grasses and weeds. Relatively dense vegetation was also observed in the southern portions of the No. 2 Pond and the Coal Pile Runoff Pond (i.e., within about 250 to 350 feet of the southern embankments), where the ash level was typically within a few feet of the dam crest elevation. Impounded water was not present immediately upstream of the embankments at these locations.

We observed soft, wet surface conditions at the toe of the southern embankments of both the No. 2 Pond and the Scrubber Pond. We understand this condition is typical for these areas.

4.2 SITE GEOLOGY

The *Geologic Map of the Central City East Quadrangle, Muhlenberg and Ohio Counties, Kentucky* (United States Geological Survey (USGS), 1972) indicates the site is underlain by alluvial deposits of Quaternary age and the Lisman Formation of the Upper Pennsylvanian group of Pennsylvanian age. Descriptions of these map units and their relative distribution on the site are provided below.

Quaternary Alluvium. Alluvial deposits (i.e., soils deposited by moving water) are mapped in the eastern site area. The alluvium consists of silt, clay, sand, and gravel, generally light brown to reddish brown, which has been deposited along the Green River and its tributaries. Alluvium thicknesses up to 100 feet are present in portions of the quadrangle, with thicknesses more than 50 feet common elsewhere in the quadrangle.

Lisman Formation. The Lisman Formation underlies the western portion of the site and consists of interbedded sandstone, siltstone, shale, limestone, coal, and underclay. The total thickness of the Lisman Formation is 115 to 170 feet.

4.3 SOIL SURVEY

Information obtained at the United States Department of Agriculture Natural Resource Conservation Service website indicates the surficial soils mapped at the subject site consist primarily of Dumps (Du) within the embankments and northern portions of the ponds, with Nolin silt loam (Nh) mapped south of the south embankments. The soil survey also included a map unit identified as Water (W) within the ponds.

Dumps are described as consisting of miscellaneous areas of stored fly ash from coal-burning electric plants and bottom land soils that have 1 to 8 feet of overwashed coal, gravel, and sandy materials from nearby coal mines. Because of their origin, detailed characteristics of these materials are not available.

Nolin silt loam is a well-drained soil located on flood plains on valleys. Slopes are 0 to 2 percent. The parent material consists of mixed fine silty alluvium. The depth to a root restrictive layer is greater than 60 inches. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very high. Shrink-swell potential is low. This soil is occasionally flooded, but not ponded. A seasonal zone of water saturation is at 45 inches during January, February, March, April, and December. Organic matter content in the surface horizon is about 2 percent. This soil does not meet hydric criteria. Published information indicates these soils have a rating class of “very limited” for construction of levees, dikes and embankments.

Water consists of areas such as lakes, ponds, rivers, and double-line streams covered with water year around and essentially devoid of vegetation.

The following map shows the distribution of the two primary soil series found in the project area (NRCS website).

Figure 1. USDA Soil Survey Map of Project Site
Source: Web Soil Survey – NRCS Website
Soil Survey Area: McLean & Muhlenberg Counties, Kentucky
Survey Area Data: Version 7, October 15, 2009
Date aerial image was photographed: August 6, 2004

4.4 SUBSURFACE CONDITIONS

4.4.1 Exploration Program

A comprehensive field exploration program was developed to obtain data for use in evaluating the stability of the existing embankments according to the scope of services developed by MACTEC and KU, the guidance documents previously referenced, and MACTEC's experience in the region. Exploratory drilling and piezometer installation was performed in August, 2010. Drilling was performed by Tri-State Drilling, LLC using a track-mounted, Diedrich D-50 Turbo drill rig and a truck-mounted, CME 55 drill rig, and by Hoosier Drilling Contractors, LLC using a truck-mounted CME 55 drill rig. Each drill rig was equipped with an automatic hammer. MACTEC engineers were on-site during the field work to direct drilling operations and to collect and classify samples. Drilling operations were performed in general accordance with ASTM procedures for subsurface explorations as presented in the Appendix.

A total of 23 soil test borings were drilled at the approximate locations indicated on Figure 2 in the Appendix. The boring depths ranged up to 40 feet. The boring numbers and suffixes indicate their general location with respect to section number and crest or toe (e.g., Boring B-1C was drilled on the crest at Section 1; Boring B-3T was drilled at the toe of Section 3). Ten borings were drilled along the embankment crest, as proposed. The borings drilled along the toe of the embankments included the original 10 proposed borings, plus three additional borings (B-1.5T, B-1.75-T, and B-2.5T) advanced east and west of Section 2. The three additional borings were advanced to obtain additional information relative to unanticipated conditions encountered in Boring B-2T.

Six piezometers were installed in completed crest borings (three piezometers per pond) to monitor piezometric levels within the embankments. The piezometer locations are indicated on Figure 2 in the Appendix. Groundwater level data obtained in the piezometers is discussed later in this report.

All borings (except borings in which piezometers were installed) were backfilled with Bentonite pellets and capped with cement mortar.

The planned boring locations were marked in the field by MACTEC using a handheld GPS unit. The surface elevation at the boring locations was interpolated from topographic mapping provided by KU. The boring locations and elevations discussed in this report and presented on the Appendix materials should be considered accurate to the degree implied by the method used. The boring locations, depths and elevations are summarized in Table 1 below.

Table 1
Boring Location Summary

Boring ID	Pond	Latitude	Longitude	Top of Ground Elevation (ft) (NGVD)	Boring Termination Depth (ft)	Bottom of Boring Elevation (ft) (NGVD)
B-1C	Coal Pile Runoff	37.365053	-87.119365	409.6	40.5	369.1
B-1T		37.365032	-87.119278	389.3	20.5	368.8
B-1.5T	No. 2	37.365809	-87.117931	392.0	10.5	381.5
B-1.75T		37.365988	-87.117585	390.0	11.0*****	379.0
B-2C		37.366317	-87.117264	399.7	35.5	364.2
B-2T		37.366180	-87.117181	388.8	30.5	358.3
B-2.5T		37.366513	-87.116546	388.0	20.5	367.5
B-3C		37.366780	-87.116331	399.4	35.5	363.9
B-3T		37.366772	-87.116215	384.8	20.5	364.3
B-4C		37.367835	-87.116844	399.1	35.5	363.6
B-4T		37.367881	-87.116755	389.0	20.5	368.5
B-5C		37.368460	-87.117143	399.5	27.0*****	372.5
B-5T		37.368485	-87.117049	387.2	20.5	366.7
B-6C	Scrubber	37.367897	-87.116257	404.7	35.5	369.2
B-6T		37.367839	-87.116456	390.9	25.5	365.4
B-7C		37.367072	-87.115444	404.7	35.5	369.2
B-7T		37.366913	-87.115360	387.2	40.5	346.7
B-8C		37.367384	-87.114825	404.5	40.5	364.0
B-8T		37.367322	-87.114772	387.4	20.5	366.9
B-9C		37.367951	-87.113765	403.9	35.5	368.4
B-9T		37.367970	-87.113646	387.3	20.5	366.8
B-10C		37.368586	-87.114286	403.9	35.5	368.4
B-10T		37.368638	-87.114179	391.9	25.5	366.4

***** Auger refusal depth

Prepared By: VM
Checked By: ALB

4.4.2 Stratigraphy

The subsurface conditions encountered at the test boring locations are indicated on the Test Boring Records in the Appendix. These Test Boring Records represent our interpretation of the subsurface conditions based on the field logs, visual examination of field samples by an engineer, and tests of selected field samples. The interface between strata depicted on the Test Boring Records represents the approximate interface location. In addition, the transition between strata may be gradual. Water levels reported on the Test Boring Records represent the conditions only at the time of the measurements.

Beneath surficial gravel or topsoil, the borings typically encountered four strata, designated as Stratum I through Stratum IV. These materials consisted of lean clay fill (Stratum I), coal combustion waste (Stratum II), lean clay alluvium (Stratum III), and weathered shale (Stratum IV). General descriptions of the materials encountered are provided below.

Surficial Materials. A surface layer of gravel was encountered in six crest borings (B-1C, B-3C through B-6C and B-10C). The gravel layer thickness ranged from about 1/2 foot to 1-1/2 feet. Surficial gravel was not encountered at other locations. The gravel consisted of well- to poorly-graded crushed stone, with fine to coarse grained sand, and trace amounts of organics.

Topsoil was encountered in two crest borings (B-8C and B-9C) and four toe borings (B-3T, B-4T, B-5T and B-7T). The topsoil thickness ranged from about 1/2 foot to 1 foot.

Stratum I – Lean Clay Fill**. –** Each of the borings encountered fill. The fill extended to depths ranging from approximately 9 to 23-1/2 feet in the crest borings and from 3 to 13 feet in the toe borings.

The fill generally consisted of orange-brown, brown, and gray, silty and sandy, lean clay with trace amounts of black oxides, fly ash, gravel, and organics. The standard penetration test values (N-values) in the fill ranged from 3 to 19 blows per foot (bpf).

Laboratory tests were performed on selected samples of the Stratum I fill soils. The natural moisture content of 55 Stratum I test samples ranged from 9 to 30 percent. Soil plasticity tests (Atterberg limits) performed on six samples indicated Liquid Limits of 30 to 48 and Plasticity Indices of 11 to 28. These values correspond to "CL" type soils, according to the Unified Soil Classification System (USCS). Grain size distribution tests performed on six samples indicated the samples consisted of approximately 0 to 1 percent gravel, 4 to 25 percent sand, and 74 to 96 percent silt and clay. Unit weight determinations performed on six Shelby tube samples indicated dry densities in the range of 96 to 143 pounds per cubic foot (pcf) and wet densities in the range of 120 to 167 pcf.

Stratum II – Coal Combustion Waste. Crest boring B-2C and toe borings B-1.5T, B-1.75T, B-2T and B-2.5T encountered ash underlying the Stratum I lean clay fill. The ash extended to a depth of 28 feet in Boring B-2C and 6 to 27 feet in the toe borings.

This material consisted of light to dark gray, Coal Combustion Waste (CCW) consisting of fly ash and bottom ash with some sand and silt. The SPT N-values in this material ranged from 0 to 10 bpf.

The natural moisture content of four fly ash samples ranged from 18 to 34 percent. The natural moisture content of five bottom ash samples ranged from 20 to 38 percent. Grain size distribution tests were performed on one fly ash sample and one bottom ash sample. These test results suggested USCS classifications of ML (silt) and SM (silty sand), respectively. Unit weight determinations on two Shelby tube samples indicated dry densities of 65 pcf (bottom ash) and 107 pcf (fly ash), with corresponding wet densities of 83 pcf and 136 pcf.

Stratum III – Lean Clay (Alluvium). The borings typically encountered lean clay alluvium beneath the Stratum I and Stratum II fill. This material extended to auger refusal on weathered shale in Borings B-1C, B-5C, and B-1.75T,and to boring termination at other locations. The alluvium typically consisted of gray, orange, and brown, silty lean clay with trace amounts of sand and weathered shale fragments. We visually classified an interval of alluvium in one boring (Boring B-10C) as silty sand (USCS CL-ML). The SPT N-values ranged from 0 to 21 bpf, indicating the consistency of this material ranged from very soft to very stiff.

The natural moisture content of Stratum III test samples ranged from 16 to 43 percent. Soil plasticity tests performed on seven samples indicated Liquid Limits of 27 to 40 and Plasticity Indices of 7 to 20. These values correspond to USCS "CL" type soils. Grain size distribution tests on seven samples indicated the samples consisted of approximately 3 to 24 percent sand and 76 to 97 percent silt and clay. Unit weight determination tests performed on four Shelby tube samples indicated dry densities in the range of 93 to 110 pcf and wet densities in the range of 118 to 129 pcf.

Consolidated-undrained (CU) triaxial shear test with pore pressure measurements were performed on five Shelby tube samples of Stratum III soils. The testing indicated total shear strength parameters ranging from about 130 to 1,800 pounds per square foot (psf) (cohesion, c) and 7 to 30 degrees (angle of internal friction, φ), and effective shear strength parameters ranging from about 0 to 1,370 psf (cohesion, c') and 16 to 34 degrees (angle of internal friction, φ').

Stratum IV – Weathered Shale. Gray to dark gray, highly weathered shale was encountered beneath Stratum III soils in three borings. The weathered shale extended to auger refusal depths of 11 and 27 feet in Borings B-1.75T and B-5C, respectively, and to the planned termination depth of about 40 feet in Boring B-1C. The SPT N-values in the weathered shale were 50 blows for 6 inches or less penetration. Based on the consistency of the recovered samples and the recorded penetration resistance values, we judged this material to be hard soil or very soft rock.

The natural moisture content of one test sample of weathered shale was 8 percent.

4.4.3 Groundwater

Groundwater levels were generally measured in each of the borings upon completion of drilling. Borings were left open, where possible, for the purpose of measuring 24-hour water levels. Some borings caved-in after completion of drilling, which precluded measurement of the groundwater level. Groundwater conditions at the time of drilling, and where available after 24 hours, as well as cave-in depths where applicable, are noted on the Test Boring Records in the Appendix.

Piezometers were installed in six embankment crest borings. Piezometers were installed in three No. 2 Pond crest borings (B-2C, B-3C, and B-4C) and three Scrubber Pond crest borings (B-6C, B-8C, and B-10C). The target depths for the piezometers were selected to gain an understanding the piezometric levels within and just below the embankment. We anticipate that groundwater within this zone would have the greatest impact on the stability of the embankments. The water level in the piezometers was checked upon completion of installation, and on two occasions following installation. The piezometer readings are summarized in Table 2 below and are also shown on the respective Test Boring Records in the Appendix.

Table 2
Summary of Piezometer Readings

Peizometer ID	Date of Installation	Screened Interval Depth (ft)	Top of Ground Elevation (ft) NGVD	Bottom of Piezometer Elevation (ft) NGVD	Date of Readings			
					8/24/10		10/14/10	
					Depth	Elevation	Depth	Elevation
					(ft)		(ft)	
B-2C	8/14/10	15-25	399.7	374.7	10.2	389.5	10.5	389.2
B-3C	8/13/10	25.5-35.5	399.4	363.9	12.6	386.8	12.6	386.8
B-4C	8/14/10	20-30	399.1	369.1	6.9	392.2	8.0	391.1
B-6C	8/14/10	15-25	404.7	379.7	11.5	393.2	12.6	392.1
B-8C	8/14/10	29-39	404.5	365.5	15.1	389.4	13.7	390.8
B-10C	8/13/10	15-25	403.9	378.9	25.3	378.6	26.4	377.5
Readings were taken from top of ground (TOG) level.								

Prepared By: _VM_
Checked By: _MLB_

4.5 POND CONDITIONS

According to the construction drawings provided by KU, topographic mapping (dated December 2009) shows a water surface elevation varying from 397.9 to 401.6 feet NGVD for the No. 2 Pond and 398.9 feet NGVD for the Scrubber Pond. Approximately one third of the No. 2 Pond (in two separate areas) and two thirds of the Scrubber Pond has free water. Ash is at elevations varying from 399.2 to 409.2 feet NGVD in the Number 2 Pond and from 400 to 400.5 feet NGVD in the Scrubber pond.

4.6 LABORATORY TESTING

Samples obtained during drilling operations were observed and visually classified in the field by a MACTEC engineer. The soils were described according to consistency or relative density (based on SPT N-values), color, and texture. These descriptions are included on our Test Boring Records in the Appendix. The classification method discussed above is primarily qualitative; for detailed soil classification, two laboratory tests are necessary: plasticity characteristics and grain size distribution. Using these test results, the soil can be classified according to the USCS (ASTM D2487).

Laboratory testing was performed on selected samples obtained from our borings. These tests included natural moisture content, Atterberg limits (plasticity), grain size distribution, specific gravity, and unit weight. The field classifications provided on the Test Boring Records were adjusted to reflect the results of our laboratory testing where warranted. In addition, more sophisticated laboratory testing was performed to evaluate the shear strength characteristics of the existing dike materials. Specifically, we performed the following tests:

133 Natural Moisture Content
18 Atterberg Limits
20 Grain Size Distribution
12 Specific Gravity
12 Unit Weight
8 Triaxial Shear with Pore Pressures Measurements

Detailed descriptions of these tests and the test results are included in the Appendix.

4.6.1 CLASSIFICATION TESTING RESULTS

The results of the natural moisture content, Atterberg limits, and grain size distribution testing were discussed in Section 4.4 Subsurface Conditions. Summarized in Table 3 below are the range of the specific gravity and unit weight values for Strata I, II, and III. Specific gravity and unit weight testing was not performed on samples from Stratum IV.

Table 3. Summary Results of Specific Gravity and Unit Weight Determinations

Stratum	Soil Description	Minimum Specific Gravity	Maximum Specific Gravity	Minimum Wet Unit Weight (pcf)	Maximum Wet Unit Weight (pcf)
I	CL (Fill)	2.67	2.75	120.3	167.3
II	CCW (Fill – bottom ash)	2.66		83.3	
II	CCW (Fill – fly ash)	2.45		135.9	
III	CL (Alluvium)	2.61	2.76	118.7	128.6

Prepared By: VM
Checked By: ALB

4.6.2 STRENGTH TEST RESULTS

Strength testing included consolidated undrained triaxial shear tests with pore pressure measurements. These tests were used to determine both total stress and effective stress parameters. Summarized in Table 4 are the ranges of the strength testing for Strata I and III. These tests were not conducted on the Stratum II CCW materials or Stratum IV Weathered Shale. Detailed descriptions of these tests and the results of our testing are included in the Appendix.

Table 4
Summary Results of Strength Testing

Stratum	Soil Description	Total Strength Parameters				Effective Strength Parameters			
		Minimum		Maximum		Minimum		Maximum	
		Cohesion, c (psf)	Internal Friction Angle, φ (degrees)	Cohesion, c (psf)	Internal Friction Angle, φ (degrees)	Cohesion, c' (psf)	Internal Friction Angle, φ' (degrees)	Cohesion, c' (psf)	Internal Friction Angle, φ' (degrees)
I	CL (Fill)	129	0	2,827	30	0	0.2	2,812	34
III	CL (Alluvium)	799	7	1,799	23	0	16	1,370	33

Prepared By: *VM*
Checked By: *ALB*

5. SLOPE STABILITY ANALYSIS

5.1 INTRODUCTION

Slope stability analysis is used to evaluate the resistance of a natural or man-made slope to failure by sliding or collapsing. When the forces tending to cause a slope to fail (i.e., driving forces) are equal to the forces tending to prevent the slope from failing (i.e., restoring forces), the slope is said to be in equilibrium. When the restoring forces exceed the driving forces, there is a Factor of safety against failure. The Factor of Safety (FS) against failure is the ratio of the sum of the resisting forces to the sum of the driving forces:

$$FS = \frac{\Sigma \text{ resisting forces}}{\Sigma \text{ driving forces}}$$

Using the above equation, a slope in equilibrium (i.e., a slope with the resisting forces equal to the driving forces) would have a Factor of Safety of 1.0. Slopes with a Factor of Safety less than 1.0 (i.e., slopes with the resisting forces less than the driving forces) are predicted to fail under the conditions used to perform the analysis.

Although a slope with a Factor of Safety against failure equal to 1.0 is in equilibrium and therefore technically meets the minimum criteria for stability, various organizations, including state and federal agencies, such as the US Army Corps of Engineers and others, have proposed minimum target Factors of Safety for slopes which are greater than 1.0. The purpose of these minimum factors of safety is to add a level of protection against failure. The target minimum factor of safety varies with project location (e.g., federal, state, or municipal jurisdiction), project type (e.g., impoundment or roadway), and conditions analyzed (e.g., end of construction, steady state, maximum flood, rapid drawdown, and seismic loading). The target factors of safety considered for this project are discussed further below.

We used the data gathered during our exploration, survey data provided by KU, and our experience with CCW impoundments to prepare a cross-sectional model at each target section for stability analysis. Both the upstream slope and the downstream slope of each target section were analyzed. We compared the results of our analyses with the Factors of Safety recommended in the regulatory guidelines for this type of impoundment to check for cross-sections where remedial repairs to increase the minimum Factor of Safety may be required. The guidance documents referenced previously suggest the following minimum acceptable Factors of Safety:

Table 5
Minimum Factors of Safety

Condition Analyzed	Agency		
	KEEC	USACE	MSHA
Long-term, steady-state using maximum storage/surcharge pool	1.5	1.4	1.5
Rapid drawdown	1.2	1.1-1.3	1.2
Seismic	1.0	1.0	1.2

Prepared By: *MLB*
Checked By: *NGS*

Slope stability analyses were performed using the computer program STABL6H, developed by Harald Van Aller, P.E. The program uses a two-dimensional limit equilibrium method of analysis and calculates the factor of safety based on the Modified Bishop Method of Slices. Our analyses were performed to model the overall stability of the upstream and downstream faces of the existing embankment under three conditions: steady-state/maximum surcharge pool (flood) conditions, rapid drawdown conditions, and seismic (dynamic) conditions. The locations of the ten cross-sections (Sections 1 through 10) analyzed are indicated on the Boring Location Plan and Stability Sections drawing provided in the Appendix.

5.2 GEOMETRY

The slope stability models are based on the geometric slope conditions (upstream and downstream slopes) and our interpretation of the subsurface soil strata. The reported bottom of pond elevation of 385 feet NGVD was used in our analyses, unless specific boring data suggested a lower bottom of pond elevation was appropriate.

Both the upstream and downstream slope faces were nominally reported to be 2.5H:1V. The cross-sections generated from the topographic survey provided suggest the upstream slope inclinations range from 1.9H:1V to 5H:1V, and the downstream slope inclinations range from 2H:1V to 4H:1V. The upstream slopes below the current water or ash levels were projected from the available topographic data. The configuration of the impounded ash was interpreted from bathymetric survey data provided by KU.

In addition to the embankment slope and crest configuration, the geometry (layering) of the subsurface soil strata were developed for modeling purposes. Layering of the subsurface soils was based on the borings advanced at each cross-section location. At a minimum, one crest boring and one toe boring was used to extrapolate the geometry of the soil layers. Generally, the embankments were reportedly constructed of clay fill excavated from the incised portion of the pond and placed overlying existing lean clay alluvial soils. Descriptions of the embankment and foundation soils are summarized in Section 4.4 of this report and detailed descriptions at each cross-section analyzed are shown on the Test Boring Records in the Appendix.

5.3 SOIL PARAMETER SELECTION

We selected strength and unit weight parameters for each of the soil layers, including moist unit weight, saturated unit weight, effective cohesion, and effective internal angle of friction. The soil parameters selected for the slope stability analyses (see in Table 6 below) were chosen based on several resources, including the laboratory testing performed for this exploration, our field testing and observations, published information on similar soil and material types, and our experience. The soil strength parameters selected for each cross-section analyzed are shown on the respective STABL6H plots included in the Appendix.

For the purposes of our analyses, we did not assign separate shear strength parameters for lean clay fill and alluvial lean clay. This is because the embankments were reportedly constructed using the on-site alluvial soil, which was assumed to have been excavated and placed using typical construction and compaction techniques. Therefore, for modeling purposes, the soil strata identified in Section 4 were categorized into layers based on consistency, as interpreted from the boring data. Additionally, based on our past experience with CCWs, rip rap, and published data, we assigned classification and strength test values for the CCW (both fly ash and bottom ash) and rip rap.

Technically, limestone rip rap such as that used to armor the downstream slope of Sections 2, 3, 7, and 8 does not exhibit any effective cohesion in laboratory testing. However, using an effective cohesion equal to zero for the rip rap at these sections causes two conflicts within the computer model:

1. It indicates shallow sloughing critical circles; and
2. It prevents the model from adequately analyzing deeper critical circles.

To overcome this shortcoming in the stability model, we assigned a nominal effective cohesion (100 psf) to the rip rap. This technique is typically used throughout the consulting industry and allows for more thorough evaluation of the stability of each cross section analyzed.

Table 6
Soil Parameters

Soil Description	Unit Weight		Effective Stress Shear Strength	
	Moist (pcf)	Saturated (pcf)	Cohesion, c' (psf)	Internal Friction Angle, φ' (degrees)
CL (very soft, very soft/soft)	118	123	80	15
CL (soft, soft/firm)	122	127	100	16
CL (firm)	125	130	200	25
CL (firm/very stiff)	125	130	300	25
CL (stiff)	129	134	300	25
Weathered shale	126	131	6	32
CCW – fly ash	90	95	0	20
CCW – bottom ash	108	113	0	28
Rip Rap	140	145	100	45

Prepared By: MLB
Checked By: NGS

5.4 PIEZOMETRIC SURFACES

For modeling purposes, we estimated the piezometric surface at each target section based on a water level at the crest elevation on the upstream side and a water level at the toe elevation on the downstream side, to simulate a "worst case" condition. We supplemented our estimated piezometric surface with piezometers data where available.

The unit weight of water was modeled as 62.4 pounds per cubic foot (pcf). The long-term, steady-state/maximum surcharge pool conditions were modeled using a pool elevation coincident with the crest elevation at each section, except at Section 1. The maximum pool elevation at Section 1 was modeled at 405.2 feet NGVD, which is the crest elevation of the adjoining divider dike between the Coal Pile Runoff Pond and the No. 2 Pond. This elevation is lower than the crest elevation at Section 1 (approximately 408.7 feet NGVD), and therefore controls the maximum pool elevation at Section 1. While the scenario described above is unlikely to occur, it conservatively models a flood condition. For the rapid drawdown condition, we modeled the pool elevation dropping rapidly from the long-term, steady-state condition (maximum operating pool) to the bottom of pond elevation. Finally, for the seismic (dynamic) condition, we used the maximum operating pool elevation described above in our analyses.

5.5 SEISMIC CONDITIONS

Seismic conditions for this site were modeled under dynamic loading conditions using a peak horizontal ground acceleration of 0.10g for a 10 percent probability of exceedance in 50 years. We developed this value based on information from the following references:

- Earthquake magnitude data published in the USGS National Seismic Hazard Mapping Project (NSHMP) database
- *East Coast Seismicity, Ground Motions, and Liquefaction Evaluation Seminar*, April 25, 200, Dulles, Virginia, Center for Geotechnical Practice and Research (CGPR) & Virginia Polytechnic Institute and University Division of Continuing Education
- *2006 International Building Code,* International Code Council, 2006
- *Minimum Design Loads for Buildings and Other Structures, ASCE/SEI 7-05*, American Society of Civil Engineers, 2005

5.6 RESULTS OF ANALYSES

5.6.1 Background

The results of the analyses for each slope are provided on the *Minimum Factor of Safety Summary* table included in the Appendix to this report. In addition, the STABL6H Plots showing the models and probable failure circles are also included in the Appendix. Our analyses, performed using the geometry and parameters described herein, indicate all slope sections meet or exceed the target minimum FS, except Section 1 Downstream for steady-state/maximum surcharge pool conditions, and Section 5 Upstream for seismic conditions.

The slopes with minimum FS which do not meet the target FS criteria are discussed further in Section 5.6.2. However, we believe it is important to note that the minimum FS for all the slopes analyzed under steady-state/maximum surcharge pool conditions exceeded 1.0. Therefore, these slopes are currently stable under steady-state conditions and should not be expected to fail under normal operating conditions. However, some treatment may be required at Section 1 Downstream to increase the minimum FS under steady-state/maximum surcharge conditions, to meet the target FS.

It is also important to note that although the analyses suggest the Section 5 Upstream slope has a minimum FS less than 1.0 under seismic loading conditions, which predicts failure of the slope under seismic loading, seismic loads would have to be imposed on the slope to induce the failure predicted by the analyses. The minimum FS under seismic loading is not an indicator of potential performance under conditions without seismic loading, such as steady-state. In addition, the critical slip circle with a FS lower than the target value is confined to a thin veneer within the CCW. This type of failure would not impact the integrity of the embankment.

5.6.2 Discussion

The paragraphs below present discussions of each of the slopes with an FS below the target FS, as noted in Section 5.6.1.

Section 1. The Section 1 Downstream model for the steady-state/maximum surcharge pool conditions indicated a minimum FS of 1.4. The location and shape of the predicted critical slip circle would impact the embankment, and would occur within the soft fill and alluvium located between approximately Elevation 385 and 371 feet NGVD. Various methods are available for improving the minimum factor of safety such as installation of a rock buttress on the downstream slope to provide more sliding resistance along the predicted slip circle.

Section 5. The Section 5 Upstream model indicated a minimum FS of 0.8 under seismic loading conditions. The predicted failure occurs as a thin veneer failure within the impounded ash behind the embankment and would have an insignificant impact on the embankment.

6. CONCLUSIONS

Based on the results of our stability analyses, we have concluded that the embankment sections analyzed are structurally stable under steady-state conditions from a slope stability standpoint, and are not in danger of imminent failure. However, one slope under steady-state/maximum surcharge conditions (Section 1 Downstream) and one slope under seismic loading conditions (Section 5 Upstream) do not meet the target FS criteria provided and referenced herein. Various methods are available for improving the minimum factor of safety of the Section 1 Downstream slope, as discussed in the preceding section. The predicted failure of the Section 5 Upstream slope occurs as a thin veneer failure within the impounded ash behind the embankment and would have an insignificant impact on the embankment at this location. Therefore, improvements are not warranted for the Section 5 Upstream slope.

Altering any of the conditions or geometry used in our analyses, including dredging ash from behind the embankments, raising the embankment crest, or raising or lowering of the water level, could potentially change the stability of the embankment, including reducing the minimum FS against failure. We recommend that we be consulted to analyze any proposed changes to the embankment conditions before the proposed changes are implemented, and suggest measures to improve the minimum FS against failure, if warranted.

7. BASIS FOR CONCLUSIONS

The conclusions provided are based in part on project information provided to MACTEC and only apply to the specific project and site discussed in this report. If the project information section in this report contains incorrect information or if additional information is available, you should convey the correct or additional information to us and retain us to review our conclusions. We can then modify our conclusions if they are inappropriate for the project.

The assessment of site environmental conditions for the presence or potential presence of contaminants in the soil, rock, surface water, groundwater, or air of the site was beyond the scope of this exploration.

Regardless of the thoroughness of a geotechnical exploration, there is always a possibility that conditions between borings will be different from those at specific boring locations.

We wish to remind you that our exploration services include storing the samples collected and making them available for inspection for 60 days. The samples are then discarded unless you request otherwise.

APPENDIX:

Site Location Map

Boring Location Plan and Slope Stability Sections

Field Testing Procedures

Key to Symbols and Descriptions

Test Boring Records

Laboratory Testing Procedures

Summary of Laboratory Test Data

Atterberg Limit Test Results

Grain Size Distribution Test Results

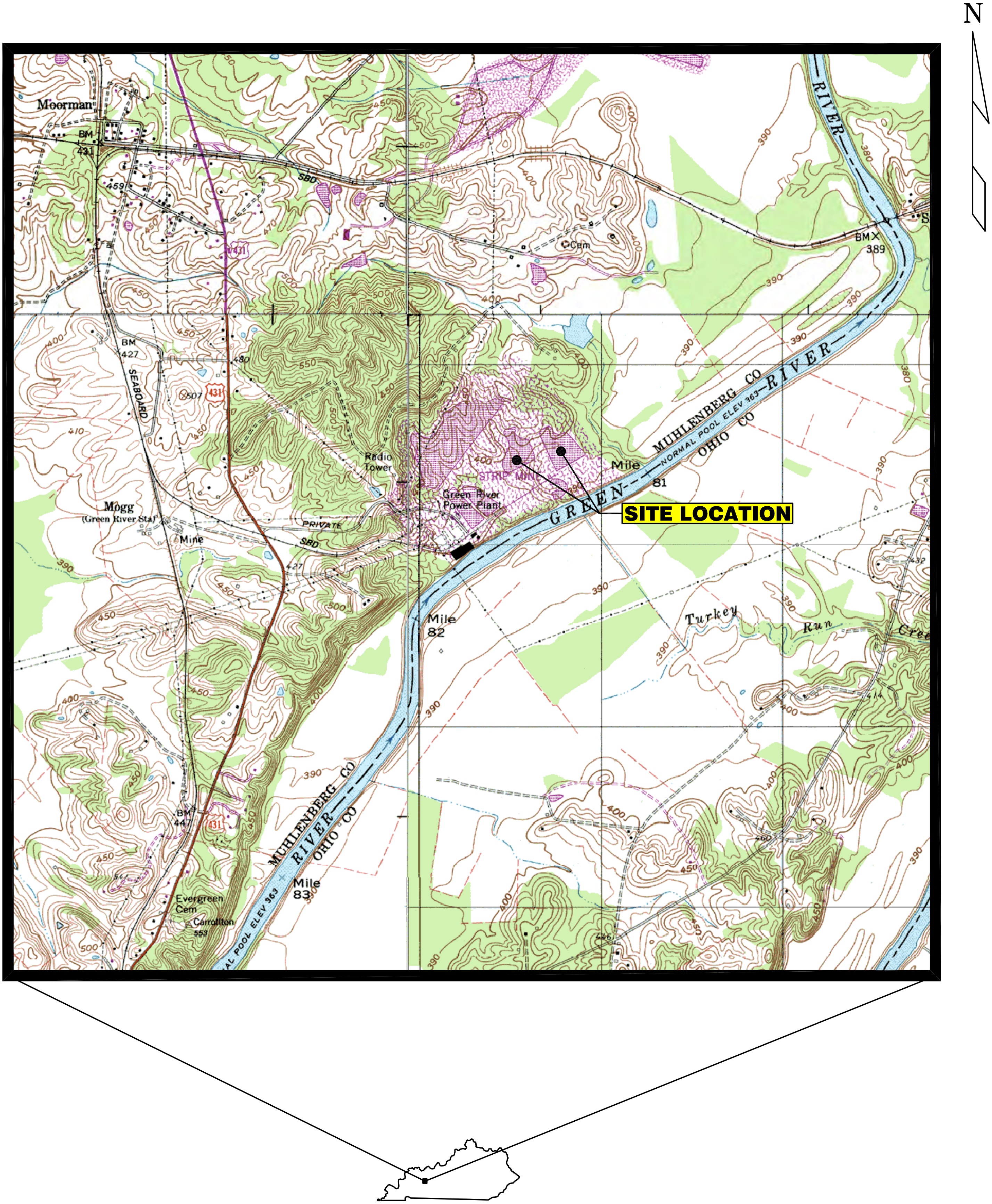
Triaxial Shear Test Results

Summary of Slope Stability Results

PCSTABL Plots

SITE LOCATION MAP

SOURCE: MAPTECH TERRAIN NAVIGATOR, CENTRAL CITY EAST QUADRANGLE, AERIAL SURVEY 1967, PHOTOINSPECTED 1984.



E.ON U.S. SERVICES, INC.
KENTUCKY UTILITIES
220 WEST MAIN STREET
LOUISVILLE, KENTUCKY 40202
PROJECT NO. 3143-10-1317-02

MACTEC
13425 Eastpoint Centre Drive, Ste 122
Louisville, KY. 40223
Phone: 502-253-2500 Fax: 502-253-2501

CHECKED BY: A.BRENNEMAN PREPARED BY: G.HAYS

SITE LOCATION MAP
GREEN RIVER POWER STATION
MUHLENBURG COUNTY, KENTUCKY

CADD FILE:101317-02_SLM.dwg
PLOT DATE: 8/26/10

FIGURE 1

BORING LOCATION PLAN AND SLOPE STABILITY SECTIONS

Source: Original drawing provided by Kimball Corp.

REV	DATE	BY	DESCRIPTION

SEAL

DESIGNED A.BRENNEMAN
DRAWN G.HAYS
CHECKED A.BRENNEMAN
IN CHARGE N.SCHMITT
DATE 8/10/10

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BORING LOCATION PLAN AND SLOPE STABILITY SECTIONS
GREEN RIVER POWER STATION
SOUTH CARROLTON
MUHLENBURG COUNTY, KENTUCKY

SCALE GRAPHIC
MACTEC PROJECT NO. 3143-10-1317-02
DWG. NO. 2

CADD FILE: 101317-02_Green River.dwg
PLOT DATE: 8/10/10

FIELD TESTING PROCEDURES

KEY TO SYMBOLS AND DESCRIPTIONS

TEST BORING RECORDS

FIELD TESTING PROCEDURES

Field Operations: The general field procedures employed by MACTEC are summarized in ASTM D420 which is entitled "Investigating and Sampling Soils and Rocks for Engineering Purposes." This recommended practice lists recognized methods for determining soil and rock distribution and ground water conditions. These methods include geophysical and in situ methods as well as borings.

Borings are drilled to obtain subsurface samples using one of several alternative techniques depending upon the subsurface conditions. These techniques are:

a. Continuous 2½ or 3¼ inch inside diameter (I.D.) hollow stem augers;
b. Wash borings using roller cone or drag bits (using drilling mud or water);
c. Continuous flight augers (ASTM D1425).

These drilling methods are not capable of penetrating through material designated as "refusal materials." Refusal, thus indicated, may result from hard cemented soil, soft weathered rock, coarse gravel or boulders, thin rock seams, or the upper surface of sound continuous rock. Core drilling procedures are required to determine the character and continuity of refusal materials.

The subsurface conditions encountered during drilling are reported on a field test boring record by the chief driller. The record contains information concerning the boring method, samples attempted and recovered, indications of the presence of various materials such as coarse gravel, cobbles, etc., and observations between samples. Therefore, these boring records contain both factual and interpretive information. The field boring records are on file in our office.

The soil and rock samples plus the field boring records are reviewed by a geotechnical engineer. The engineer classifies the soils in general accordance with the procedures outlined in ASTM D2488 and prepares the final boring records which are the basis for all evaluations and recommendations.

The final boring records represent our interpretation of the contents of the field records based on the results of the engineering examinations and tests of the field samples. These records depict subsurface conditions at the specific locations and at the particular time when drilled. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the subsurface soil and ground water conditions at these boring locations. The lines designating the interface between soil or refusal materials on the records and on profiles represent approximate boundaries. The transition between materials may be gradual. The final boring records are included with this report.

The detailed data collection methods used during this exploration are discussed below.

Soil Test Borings: Soil test borings were made at the site at locations shown on the attached Boring Plan. Soil sampling and penetration testing were performed in accordance with ASTM D1586.

The borings were made by mechanically twisting a hollow stem steel auger into the soil. At regular intervals, soil samples obtained with a standard 1.4 inch I.D., 2 inch outside diameter (O.D.), split tube sampler. The sampler was first seated 6 inches to penetrate any loose cuttings, then driven an additional foot with blows of a 140-pound hammer free falling 30 inches. The number of hammer blows required to drive the sampler the final foot was recorded and is designated the "penetration resistance". The penetration resistance, when properly evaluated, is an index to the soil strength and foundation supporting capability.

Representative portions of the soil samples, thus obtained, were placed in glass jars and transported to the laboratory. In the laboratory, the samples were examined to verify the driller's field classifications. Test Boring Records are attached which graphically show the soil descriptions and penetration resistances.

Undisturbed Sampling: Split tube samples are suitable for visual examination and classification tests but are not sufficiently intact for quantitative laboratory testing. For quantitative testing, relatively undisturbed samples are obtained by pushing sections of 3 inch O.D., 16 gauge, steel or brass tubing (Shelby tube) into the soil at the desired sampling levels. This procedure is described by ASTM D1587. Each tube, together with the encased soil, is carefully removed from the ground, made airtight and transported to the laboratory. Locations and depths of undisturbed samples are shown on the Test Boring Record.

Water Level Readings: Water table readings are normally taken in conjunction with borings and are recorded on the "Test Boring Records". These readings indicate the approximate location of the hydrostatic water table at the time of our field investigation. Where impervious (more clayey) soils are encountered the amount of water seepage into the boring is small, and it is generally not possible to establish the location of the hydrostatic water table through water level readings. The ground water table may also be dependent upon the amount of precipitation at the site during a particular period of time. Fluctuations in the water table should be expected with variations in precipitation, surface run-off, evaporation and other factors.

The time of boring, water level reported on the boring records is determined by field crews as the drilling tools are advanced. The time of boring water level is detected by changes in the drilling rate, soil samples obtained, or by measurement after the drilling tools are withdrawn. Additional water table readings may be obtained after the borings are completed. A time lag of 24 hours may allow stabilization of the ground water table which has been disrupted by the drilling operations. The readings are taken by dropping a weighted line down the boring or using an electrical probe to detect the water level surface.

Occasionally, the borings will cave-in, preventing water level readings from being obtained or trapping drilling water above the caved-in zone. The cave-in depth is also measured and recorded on the boring records.

Piezometers: Water level readings taken during the field operations do not provide information on the long term fluctuations of the water table. When this information is required, piezometers are necessary to prevent the borings from caving. The piezometers are constructed by inserting 1.5-inch-diameter PVC plastic pipe to the desired depth in the borings. A slotted PVC well screen is attached to the bottom of the plastic pipe to allow subsurface water to enter the piezometer. Clean sand is backfilled around the bottom of the well screen. The remainder of the hole is backfilled with an impervious material, using a bentonite cap to seal out surface water. The top of the PVC pipe has a removable cover to seal out rainwater.

MACTEC KEY TO SYMBOLS AND DESCRIPTIONS

Group Symbols	Typical Names
GW	Well graded gravels, gravel - sand mixtures, little or no fines.
GP	Poorly graded gravels or gravel - sand mixtures, little or no fines.
GM	Silty gravels, gravel - sand - silt mixtures.
GC	Clayey gravels, gravel - sand - clay mixtures.
SW	Well graded sands, gravelly sands, little or no fines.
SP	Poorly graded sands or gravelly sands, little or no fines.
SM	Silty sands, sand - silt mixtures
SC	Clayey sands, sand - clay mixtures.
ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts and with slight plasticity.
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
OL	Organic silts and organic silty clays of low plasticity.
MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
CH	Inorganic clays of high plasticity, fat clays
CL-CH	Inorganic clays ranging from low to high plasticity (combination of CL and CH above)
OH	Organic clays of medium to high plasticity
PT	Peat and other highly organic soils.
Top-Soil	The upper portion of a soil, usually dark colored and rich in organic material.
FILL	Fill soils are materials that have been transported to their present location by man.
Lime-stone	A sedimentary rock consisting predominantly of calcium carbonate
Sand-stone	A sedimentary rock consisting of sand consolidated with some cement (clay or quartz etc.)
Silt-stone	A fine-grained rock of consolidated silt.
Shale	A fine-grained sedimentary rock consisting of compacted and hardened clay, silt, or mud.
PWR	Partially Weathered Rock

Boundary Classifications:
Soils possessing characteristics of two groups are designated by combinations of group symbols.

	Undisturbed Sample (UD or SH)		Auger Cuttings (AU)
	Split Spoon Sample (SS or SPT)		Bulk Sample (BK) or Grab Sample (GS)
	Rock Core (RC)		No Recovery (NR)
	Water Table at time of drilling		Water Table after drilling
	WOH - Weight of Hammer	C	Cave Depth

Correlation of Penetration Resistance (N) with Relative Density and Consistency

SAND & GRAVEL		SILT & CLAY	
Relative Density	No. of Blows	Consistency	No. of Blows
Very Loose	0 to 4	Very Soft	0 to 1
Loose	5 to 10	Soft	2 to 4
Firm	11 to 20	Firm	5 to 8
Very Firm	21 to 30	Stiff	9 to 15
Dense	31 to 50	Very Stiff	16 to 30
Very Dense	Over 50	Hard	Over 30

Standard Penetration Resistance The Number of Blows of a 140 lb. Hammer Falling 30 in. Required to Drive a 1.4 in. I.D. Split Spoon Sampler 1 Foot. As Specified in ASTM D-1586. Also commonly referred to as an "N" value.

Estimated Relative Moisture Condition

Visual classification relative to assumed optimum moisture content (OMC) of standard proctor

Dry:	Air dry to dusty
Slightly Moist:	Dusty to approximately -2% OMC
Moist:	Approximately between ±2% OMC
Very Moist:	From approximately +2% to nearly saturated
Wet:	Contains free water or nearly saturated

Relative Hardness of Rock

Very Soft:	Can be broken with fingers
Soft:	Can be scratched with fingernail; Only edges can be broken with fingers
Moderately Hard:	Can be easily scratched with knife; Cannot be scratched with fingernail
Hard:	Difficult to scratch with knife; Hard hammer blow to break specimen
Very Hard:	Cannot be scratched with knife; Several hard hammer blows to break specimen

Rock Continuity

Core Recovery	Description
0 - 40%	Incompetent
40 - 70%	Competent
70 - 90%	Fairly Continuous
90 - 100%	Continuous

Rock Quality Designation

RQD	Rock Quality Classification
< 25%	Very Poor
25 - 50%	Poor
50 - 75%	Fair
75 - 90%	Good
90 - 100%	Very Good

REC Recovery - Total Length of Rock Recovered in the Core Barrel Divided by the Total Length of the Core Run Times 100%

RQD Rock Quality Designation - Total Length of Sound Rock Segments Recovered that are Longer Than or Equal to 4" (mechanical breaks excluded) Divided by the Total Length of the Core Run Times 100%.

SILT OR CLAY	SAND			GRAVEL		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

No.200 No.40 No.10 No.4 3/4" 3" 12"

U.S. STANDARD SIEVE SIZE

Reference: The Unified Soil Classification System, Corps of Engineers, U.S. Army Technical Memorandum No. 3-357, Vol. 1, March, 1953 (Revised April, 1960)

Depth (ft)	Description	Elev. MSL (ft)	Sample Number	Sample Type	Recov (in.)	N-Count (1st 6" 2nd 6" 3rd 6") / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	Remarks
0	GRAVEL; FILL	409.6										SURFACE COVER: GRAVEL
	STIFF to FIRM, Brown and gray, silty and sandy, lean CLAY (CL), moist; FILL		SS-1		10	5-5-6 (N = 11)	12.1					
5		404.6	UD-1		18		17.1	45	20		91	
10		399.6	SS-2		6	5-5-6 (N = 11)	13.4					
15		394.6	SS-3		16	3-3-5 (N = 8)	22.4					
	FIRM to STIFF, Gray to bluish gray, silty, lean CLAY (CL), with organics, moist; ALLUVIUM											
20		389.6	UD-2		20							
25		384.6	SS-4		14	3-6-7 (N = 13)	23.4					
30		379.6	UD-3		20		27.2	40	21		89	
35		374.6	SS-5		18	2-2-3 (N = 5)	24.1					
	HARD, Gray, weathered SHALE											
40		369.6	SS-6		12	40-45-50/5" (N = 50/5")	8.1					
	BORING TERMINATED AT 40.5 FEET											BORING DRY UPON COMPLETION OF DRILLING
45		364.6										

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

Note: *No information on the borings should be used without considering the entire content of the main document.*

START DATE: 8/14/2010
CONTRACTOR: Hoosier Drilling
DRILLER: Gary Taylor
EQUIPMENT: CME750
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature]
Boring No.: B-1C

MACTEC

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV MSL (ft)	Sample Number	Sample Type	RECOV (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS (Note: *No information on the borings should be used without considering the entire content of the main document.*)
0	FIRM to SOFT, Mottled Grayish brown, silty and sandy, lean CLAY (CL), organics, trace amounts of black oxides, moist; (FILL)	389.3	SS-1		15	4-3-3 (N = 6)	20.3					SURFACE COVER: GRASS
5		384.3	SS-2		7	2-2-2 (N = 4)	30.2					
	SOFT to STIFF, Mottled Reddish brown and gray, silty and sandy, lean CLAY (CL), with reddish brown shale fragments, moist; ALLUVIUM		UD-1		20							
10		379.3	SS-3		7	2-1-1 (N = 2)	25.5					
15		374.3	SS-4		16	1-3-1 (N = 4)	25.5					
			UD-2		22							
20		369.3	SS-5		18	3-5-5 (N = 10)	22.1					
	BORING TERMINATED AT 20.5 FEET											BORING DRY UPON COMPLETION OF DRILLING
25		364.3										

START DATE: 8/11/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature]
Boring No.: B-1T

MACTEC

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	LEGEND	ELEV MSL (ft)	Sample Number	Sample Type	RECOV (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS (Note: No information on the borings should be used without considering the entire content of the main document.)
0	FIRM, Orange brown and gray, silty and sandy, lean clay (CL), with trace amounts of fly ash and organics, moist; FILL		392.0	SS-1		18	5-3-3 (N = 6)	19.0					SURFACE COVER: GRASS AND STRAW
	VERY LOOSE, Gray to dark gray, SILT, SAND, CCW (FLY ASH) mixture, wet; FILL												WATER ON DRILLING TOOLS AT 3.5 FEET
5			387.0	SS-2		5	2-1-2 (N = 3)	21.3					
	STIFF, Orange brown, silty and sandy, lean CLAY (CL), with gray shale fragments, moist; ALLUVIUM												
10			382.0	SS-3		15	2-5-8 (N = 13)	18.0					
	BORING TERMINATED AT 10.5 FEET												
15			377.0										
20			372.0										
25			367.0										

START DATE: 8/13/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-1.5T**

MACTEC

MACTEC SOIL-ROCK (SITE MAP) 3143101317.02.GPJ MACTEC DATABASE TEMPLATE 01.GDT 9/21/10

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	LEGEND	ELEV MSL (ft)	Sample Number	Sample Type	RECOV (in.)	N-COUNT (1st 6" 2nd 6" 3rd 6") RQD / % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS (Note: *No information on the borings should be used without considering the entire content of the main document.*)
0	STIFF, Orange brown, silty and sandy, lean CLAY (CL), moist; FILL		390.0	SS-1		10	4-5-6 (N = 11)	16.5					SURFACE COVER: GRASS AND STRAW
	LOOSE, Gray to black, CCW (FLY ASH), very moist to wet; FILL			SS-2		10	2-4-6 (N = 10)	17.6					
5			385.0										
	STIFF, Gray to dark gray, silty, lean CLAY (CL), moist to very moist; ALLUVIUM												WATER ON DRILLING TOOLS AT 6.5 FEET
				UD-1		18		17.4	35	18		76	
	HARD, Gray to dark gray, highly weathered, silty SHALE, moist			SS-3		7	16-50/4" (N = 50/4")						
10			380.0										
	AUGER REFUSAL AT 11.0 FEET												BORING DRY UPON COMPLETION OF DRILLING
15			375.0										
20			370.0										
25			365.0										

START DATE: 8/13/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-1.75T**

MACTEC

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	LEGEND	ELEV MSL (ft)	Sample Number	Sample Type	RECOV (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS (Note: *No information on the borings should be used without considering the entire content of the main document.*)
0	STIFF to FIRM, Orange brown, silty, lean CLAY (CL), with organics and black oxides, dry to moist; FILL		399.7										SURFACE COVER: GRAVEL
				SS-1		14	4-5-6 (N = 11)	15.7					
5			394.7	SS-2		16	4-3-3 (N = 6)	19.5					WATER ON DRILLING TOOLS AT 4.0 FEET
10	SOFT to FIRM, Mottled Orange brown and gray, silty, lean CLAY (CL), with organics, moist to wet; FILL		389.7	SS-3		16	2-2-2 (N = 4)	29.6					DEPTH OF WATER IN PZ AT 10.0 FEET ON 08/24/10
				UD-1		20							
15			384.7	SS-4		14	2-3-3 (N = 6)	23.1					
	LOOSE to VERY LOOSE, Black, fine to coarse grained, CCW (BOTTOM ASH), wet; FILL												
20			379.7	SS-5		14	3-3-3 (N = 6)	25.8					
	▽			UD-2		18		27.8				19	
25			374.7	SS-6		6	10-3-1 (N = 4)	19.5					PIEZOMETER INSTALLED WITH SCREENED INTERVAL FROM 15-25 FEET
	SOFT, Gray, silty, lean CLAY (CL), moist to wet; ALLUVIUM												
30			369.7	SS-7		18	1-1-1 (N = 2)	28.7					
	STIFF, Mottled Gray and orange-brown, lean CLAY (CL), moist; ALLUVIUM												
35			364.7	SS-8		16	3-4-5 (N = 9)	21.0					
	BORING TERMINATED AT 35.5 FEET												
40			359.7										
45			354.7										

START DATE: 8/14/2010
CONTRACTOR: Hoosier Drilling
DRILLER: Gary Taylor
EQUIPMENT: CME750
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: AGS
Boring No.: B-2C

MACTEC

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV MSL (ft)	Sample Number	Sample Type	RECOV (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS (Note: *No information on the borings should be used without considering the entire content of the main document.*)
0	STIFF, Mottled Gray and brown, silty and sandy, lean CLAY (CL), with organics, moist; FILL	388.8	SS-1		15	4-5-4 (N = 9)	16.6					SURFACE COVER: STRAW
5		383.8	UD-1		20							
	VERY LOOSE, Gray to black, fine to coarse grained, CCW (BOTTOM ASH), wet; FILL											WATER ON DRILLING TOOLS AT 6.5 FEET
10		378.8	SS-2		16	3-2-1 (N = 3)	32.6					
	VERY SOFT, Gray to black, CCW (FLY ASH), with organics, wet; FILL											
15		373.8	UD-2		22		27.5				60	
20		368.8	SS-3		18	WH-WH-WH (N = WH)	33.9					
25		363.8	UD-3		24							
	VERY STIFF, Gray, silty, lean CLAY (CL), wet; ALLUVIUM											
30		358.8	SS-5		14	15-15-50/3" (N = 50/3")						
	BORING TERMINATED AT 30.5 FEET											
35		353.8										

START DATE: 8/11/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-2T**

MACTEC

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV MSL (ft)	Sample Number	Sample Type	RECOV (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS (Note: *No information on the borings should be used without considering the entire content of the main document.*)
0	FIRM, Gray and brown, silty, lean CLAY (CL), with organics, moist; FILL	388.0	SS-1		15	3-3-4 (N = 7)	18.9					SURFACE COVER: STRAW; WATER ON DRILLING TOOLS AT 3.0 FEET
4	SOFT, Gray and brown, silty, lean CLAY (CL), with black oxide nodules, very moist; FILL											
5		383.0	SS-2		18	2-2-2 (N = 4)	25.3					
6.5	VERY LOOSE, Gray to black, fine to coarse grained, CCW (BOTTOM ASH), wet; FILL											
10		378.0	SS-3		12	1-1-1 (N = 2)	38.0					
14	FIRM, Brownish gray, lean CLAY (CL), trace FLY ASH, wet; FILL											
15		373.0	SS-4		15	2-2-3 (N = 5)	28.1					
18	FIRM, Mottled Gray and brown, lean CLAY (CL), with black oxide nodules, moist; ALLUVIUM											
20		368.0	SS-5		16	3-3-5 (N = 8)	24.6					
20.5	BORING TERMINATED AT 20.5 FEET											
25		363.0										

START DATE: 8/13/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature]
Boring No.: B-2.5T

MACTEC

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

DEPTH (ft)	DESCRIPTION	ELEV MSL (ft)	Sample Number	RECOV (in.)	N-COUNT (1st 6" 2nd 6" 3rd 6") / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS
0	GRAVEL; FILL	399.4									SURFACE COVER: GRAVEL
	SOFT to FIRM, Orange brown and gray, silty and sandy, lean CLAY (CL), moist; FILL		SS-1	0	3-2-2 (N = 4)						
5		394.4	SS-2	0	3-2-3 (N = 5)						
10		389.4	SS-3	12	3-3-2 (N = 5)	21.0					
	FIRM, Orange brown, sandy, lean CLAY (CL), with fine gravel, moist to very moist; FILL										DEPTH OF WATER IN PZ AT 12.4 FEET ON 08/24/10
15		384.4	UD-1	18		24.5	37	19		87	
	STIFF, Orange brown, sandy, lean CLAY (CL), with fine gravel, moist to very moist; ALLUVIUM										
20		379.4	SS-4	18	4-6-7 (N = 13)	23.9					
25		374.4	UD-2	24							
	STIFF to FIRM, Gray brown and orange brown, sandy, lean CLAY (CL), wet; ALLUVIUM										WATER ON DRILLING TOOLS AT 27.5 FEET
30		369.4	SS-5	18	4-5-7 (N = 12)	23.6					
35		364.4	SS-6	18	3-4-4 (N = 8)	24.8					
	BORING TERMINATED AT 35.5 FEET										PIEZOMETER INSTALLED WITH SCREENED INTERVAL FROM 25.5-35.5 FEET
40		359.4									
45		354.4									

Note: *No information on the borings should be used without considering the entire content of the main document.*

START DATE: 8/13/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-3C**

MACTEC

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV MSL (ft)	Sample Number	RECOV (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS (Note: *No information on the borings should be used without considering the entire content of the main document.*)
0	TOPSOIL; FILL	384.8									SURFACE COVER: GRASS AND STRAW
	STIFF, Gray and brown, silty and sandy, lean CLAY (CL), with organics, moist; (FILL)										
			UD-1	17		19.3	48	20		85	
5		379.8	SS-1	16	3-5-5 (N = 10)	23.5					
			UD-2	24							
10		374.8	SS-2	17	3-4-6 (N = 10)	24.5					
			UD-3	24							
	FIRM to SOFT, Gray and brown, silty and sandy, lean CLAY (CL), with black oxide nodules, very moist; ALLUVIUM										
15		369.8	SS-3	18	3-3-3 (N = 6)	23.7					
20		364.8	SS-4	18	2-2-2 (N = 4)	25.0					
	BORING TERMINATED AT 20.5 FEET										BORING DRY UPON COMPLETION OF DRILLING
25		359.8									

START DATE: 8/12/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-3T**

MACTEC

MACTEC SOIL-ROCK (SITE MAP) 314310131702.GPJ MACTEC DATABASE TEMPLATE 01.GDT 9/21/10

DEPTH (ft)	DESCRIPTION SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	ELEV MSL (ft)	Sample Number	REC (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS **Note:** *No information on the borings should be used without considering the entire content of the main document.*
0	GRAVEL; FILL	399.1									SURFACE COVER: GRAVEL
	SOFT to STIFF, Orange brown, silty and sandy, lean CLAY (CL), with organics, moist; FILL										
			UD-1	24							
5		394.1	SS-1	16	1-2-2 (N = 4)	19.8					
											DEPTH OF WATER IN PZ AT 6.5 FEET ON 08/24/10
10		389.1	SS-2	17	2-5-5 (N = 10)	15.7					
			UD-2	24							
	STIFF to FIRM, Gray brown and orange brown, silty and sandy, lean CLAY (CL), with black oxides, moist to wet; ALLUVIUM										
15		384.1	SS-3	16	3-3-6 (N = 9)	21.5					
											WATER ON DRILLING TOOLS AT 17.5 FEET
20		379.1	SS-4	18	2-3-3 (N = 6)	23.2					PIEZOMETER INSTALLED WITH SCREENED INTERVAL FROM 20-30 FEET
			UD-3	20							
	STIFF to VERY STIFF, Gray brown and orange brown, silty and sandy, lean CLAY (CL), with coarse sand and trace amounts of fine gravel, wet; ALLUVIUM										
25		374.1	SS-5	18	3-5-5 (N = 10)	22.2					
			UD-4	24							
30		369.1	SS-6	18	3-6-9 (N = 15)	22.4					
35		364.1	SS-7	18	6-9-9 (N = 18)	20.7					
	BORING TERMINATED AT 35.5 FEET										
40		359.1									

START DATE: 8/12/2010
CONTRACTOR: Tri-State
DRILLER: Tracy Braizer
EQUIPMENT: CME-55
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-4C**

MACTEC

DEPTH (ft)	DESCRIPTION SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	ELEV MSL (ft)	Sample Number	Sample Type	RECOV (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS *Note: No information on the borings should be used without considering the entire content of the main document.*
0	TOPSOIL; FILL	389										SURFACE COVER: GRASS AND STRAW
			SS-1		16	2-5-2 (N = 7)	18.4					
	FIRM , Gray and brown, silty and sandy, lean CLAY (CL), with trace amounts of organics and black oxides, moist; FILL											
5		384	UD-1		20							
10		379	SS-2		18	2-3-3 (N = 6)	22.8					
	FIRM, Orange gray, silty and sandy, lean CLAY (CL), very moist; ALLUVIUM											
			UD-1		18		24.5	37	17		97	
15		374	SS-3		12	3-3-5 (N = 8)	24.0					
20		369	SS-4		16	3-2-4 (N = 6)	19.2					
	BORING TERMINATED AT 20.5 FEET											BORING DRY UPON COMPLETION OF DRILLING
25		364										

START DATE: 8/12/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-4T**

MACTEC

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV MSL (ft)	Sample Number	RECOV (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS
0	GRAVEL; FILL	399.5									SURFACE COVER: GRAVEL
	FIRM to SOFT, Mottled Orange brown and gray, silty and sandy, lean CLAY (CL), with trace amounts or organics and gravel, moist; FILL		SS-1	12	3-3-3 (N = 6)	22.2					
5		394.5	SS-2	12	2-2-2 (N = 4)	24.8					
	STIFF to VERY STIFF, Orange brown and gray, silty and sandy, lean CLAY (CL), with coarse sand and fine gravel, moist to wet; ALLUVIUM										
10		389.5	SS-3	16	4-4-4 (N = 8)	20.3					
15		384.5	UD-1	14							
20		379.5	SS-4	18	5-9-10 (N = 19)	17.6					
25		374.5	SS-5	16	5-4-4 (N = 8)	43.4					WATER ON DRILLING TOOLS AT 25.0 FEET
	HARD, Dark gray, highly weathered, SHALE		SS-6	5	50/5" (N = 50/5")						
	AUGER REFUSAL AT 27.0 FEET										
30		369.5									
35		364.5									
40		359.5									

Note: *No information on the borings should be used without considering the entire content of the main document.*

START DATE: 8/14/2010
CONTRACTOR: Hoosier Drilling
DRILLER: Gary Taylor
EQUIPMENT: CME750
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-5C**

MACTEC

DESCRIPTION

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

Note: *No information on the borings should be used without considering the entire content of the main document.*

Depth (ft)	Description	Elev MSL (ft)	Sample Number	Recov (in.)	N-Count (1st 6" 2nd 6" 3rd 6") / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	Remarks
0	TOPSOIL; FILL	387.2									SURFACE COVER: STRAW
	SOFT to FIRM, Grayish brown, silty and sandy, lean CLAY (CL), with organics, moist; FILL		SS-1	12	3-2-2 (N = 4)	19.3					
5		382.2	SS-2	16	3-4-4 (N = 8)	18.6					
			UD-1	24							
	SOFT, Grayish brown, silty and sandy, lean CLAY (CL), with organics, wet; FILL										
10		377.2	SS-3	18	WH-WH-4 (N = 4)	24.4					WATER ON DRILLING TOOLS AT 9.0 FEET
	STIFF to HARD, Orange brown, silty and sandy, lean CLAY (CL), with fine gravel, very moist to wet; ALLUVIUM										
			UD-2	20							
15		372.2	SS-4	18	4-5-7 (N = 12)	23.2					
20		367.2	SS-5	3	50/3" (N = 50/3")						
	BORING TERMINATED AT 20.5 FEET										BORING DRY UPON COMPLETION OF DRILLING
25		362.2									

START DATE: 8/12/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-5T**

MACTEC

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV MSL (ft)	Sample Number	RECOV (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS (Note: *No information on the borings should be used without considering the entire content of the main document.*)
0	GRAVEL; FILL	404.7									SURFACE COVER: GRAVEL
	VERY STIFF to STIFF, Brown and light gray, sandy, lean CLAY (CL), with fine to coarse gravel, moist to wet; FILL		SS-1	0	5-6-10 (N = 16)						
5		399.7	UD-1	0							WATER ON DRILLING TOOLS AT 3.5 FEET
			SS-2	8	5-7-9 (N = 16)	16.0					
10		394.7	SS-3	14	4-5-6 (N = 11)	17.5					DEPTH OF WATER IN PZ AT 11.5 FEET ON 08/24/10
15	FIRM to VERY STIFF, Mottled dark orange brown and gray, silty and sandy, lean CLAY (CL), with coarse sand and fine gravel, wet; ALLUVIUM	389.7	UD-2	24							
20		384.7	SS-4	15	4-5-5 (N = 10)	21.6					
25		379.7	SS-5	15	3-2-3 (N = 5)	23.2					PIEZOMETER INSTALLED WITH SCREENED INTERVAL FROM 15-25 FEET
30		374.7	SS-6	13	5-7-8 (N = 15)	19.3					
35		369.7	SS-7	15	5-9-12 (N = 21)	21.6					
	BORING TERMINATED AT 35.5 FEET										
40		364.7									

START DATE: 8/14/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: CME750
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-6C**

MACTEC

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV MSL (ft)	Sample Number	RECOV (in.)	N-COUNT (1st 6" / 2nd 6" / 3rd 6") RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS (Note: No information on the borings should be used without considering the entire content of the main document.)
0	FIRM to STIFF, Light grayish brown, silty and sandy, lean CLAY (CL), moist; FILL	390.9									SURFACE COVER: GRAVEL
			SS-1	0	3-3-4 (N = 7)						
			UD-1	24							
5		385.9	SS-2	12	5-5-5 (N = 10)	20.3					
10		380.9	SS-3	16	3-4-5 (N = 9)	22.5					
			UD-2	24							
	FIRM to STIFF; Orange brown, silty and sandy, lean CLAY (CL), with trace amounts of fine gravel, moist to wet; ALLUVIUM										WATER ON DRILLING TOOLS AT 13.0 FEET
15		375.9	SS-4	15	2-3-3 (N = 6)	25.9					
			UD-3	24							
20		370.9	SS-5	12	3-4-6 (N = 10)	21.3					
25		365.9	SS-6	16	3-5-5 (N = 10)						
	BORING TERMINATED AT 25.5 FEET										BORING DRY UPON COMPLETION OF DRILLING
30		360.9									

START DATE: 8/12/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: [signature] **Boring No.: B-6T**

MACTEC

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	LEGEND	ELEV MSL (ft)	Sample Number	Sample Type	RECOV (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS (Note: *No information on the borings should be used without considering the entire content of the main document.*)
0	VERY STIFF to FIRM, Light brown and tan, silty and sandy, lean CLAY (CL), with trace amounts of organics and fine gravel, dry to moist; FILL		404.7	SS-1		10	9-9-8 (N = 17)	9.3					SURFACE COVER: GRASS AND GRAVEL
5			399.7	SS-2		12	3-3-4 (N = 7)	17.7					
10			394.7	UD-1		22							
15			389.7	SS-3		16	4-5-7 (N = 12)	19.4					
	STIFF to FIRM, Orange brown and gray, silty, lean CLAY (CL), with pockets of coarse sand, moist to very moist; ALLUVIUM												
20			384.7	SS-4		0	3-4-6 (N = 10)						
25			379.7	SS-5		12	3-4-5 (N = 9)	23.2					
30			374.7	UD-2		24							
35			369.7	SS-6		18	3-4-4 (N = 8)	26.4					
	BORING TERMINATED AT 35.5 FEET												BORING DRY UPON COMPLETION OF DRILLING
40			364.7										

START DATE: 8/14/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature]
Boring No.: B-7C

MACTEC

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV MSL (ft)	Sample Number	REC (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS (Note: *No information on the borings should be used without considering the entire content of the main document.*)
0	TOPSOIL; FILL	387.2									SURFACE COVER: GRASS AND STRAW
	STIFF, Dark brown, silty and sandy, lean CLAY (CL), with organics, moist; FILL		SS-1	18	5-5-4 (N = 9)	20.1					
	SOFT to STIFF, Light grayish brown to orange brown, silty and sandy, lean CLAY (CL), moist to very moist; ALLUVIUM										
5		382.2	SS-2	18	2-1-3 (N = 4)	25.0					
			UD-1	24							
10		377.2	SS-3	16	4-4-5 (N = 9)	22.2					
15		372.2	SS-4	14	2-2-2 (N = 4)	25.9					
			UD-2	24							
20		367.2	SS-5	18	2-2-3 (N = 5)	26.0					
	VERY SOFT to VERY STIFF, Gray to dark gray, sandy, lean CLAY (CL), wet; ALLUVIUM										WATER ON DRILLING TOOLS AT 23.0 FEET
25		362.2	SS-6	18	WH-WH-WH (N = WH)	27.5					
30		357.2	SS-7	18	WH-WH-WH (N = WH)	26.2					
35		352.2	SS-8	18	3-3-5 (N = 8)	23.4					
40		347.2	SS-9	18	5-8-9 (N = 17)	21.1					
	BORING TERMINATED AT 40.5 FEET										
45		342.2									

START DATE: 8/12/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-7T**

MACTEC

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

Note: No information on the borings should be used without considering the entire content of the main document.

Depth (ft)	Description	Elev MSL (ft)	Sample Number	Recov (in.)	N-Count (1st 6" / 2nd 6" / 3rd 6") / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	Remarks
0	TOPSOIL; FILL	404.5									SURFACE COVER: GRASS AND STRAW
	FIRM to STIFF, Grayish brown and orange brown, silty, lean CLAY (CL), with trace amounts of organics, sand and fine gravel, moist; FILL		SS-1	10	3-4-4 (N = 8)						
5		399.5	SS-2	18	3-4-4 (N = 8)	21.3					
10		394.5	SS-3	12	3-4-5 (N = 9)	21.1					
	FIRM, Grayish brown, silty, lean CLAY (CL), with trace amounts of black oxides, moist to very moist; FILL										
15		389.5	SS-4	14	2-2-3 (N = 5)	21.8					DEPTH OF WATER IN PZ AT 14.7 FEET ON 08/24/10
20		384.5	SS-5	14	2-2-4 (N = 6)	24.2					
	FIRM to STIFF, Mottled Gray, brown and dark orange, silty and sandy, lean CLAY (CL), with coarse sand and fine gravel, very moist to wet; ALLUVIUM										
25		379.5	UD-1	24							
30		374.5	SS-6	12	2-3-3 (N = 6)	26.2					
35		369.5	SS-7	16	2-3-3 (N = 6)	26.7					
40		364.5	SS-8	15	3-4-6 (N = 10)	26.4					PIEZOMETER INSTALLED WITH SCREEN INTERVAL FROM 29.0-39.0 FEET; BORING DRY UPON COMPLETION OF DRILLING
	BORING TERMINATED AT 40.5 FEET										
45		359.5									

START DATE: 8/14/2010
CONTRACTOR: Tri-State
DRILLER: Tracy Braizer
EQUIPMENT: CME-55
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-8C**

MACTEC

TEST BORING RECORD

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

Note: *No information on the borings should be used without considering the entire content of the main document.*

Depth (ft)	Description	Elev. MSL (ft)	Sample Number	Sample Type	Recov (in.)	N-Count (1st 6" / 2nd 6" / 3rd 6") RQD / % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	Remarks
0	STIFF, Brown to gray, silty, lean CLAY (CL), with organics and black oxides, dry to moist; FILL	387.4	SS-1	SS	16	4-8-7 (N = 15)	14.6					SURFACE COVER: GRASS AND STRAW
4	FIRM, Grayish blue, silty, lean CLAY (CL), with sand, moist; ALLUVIUM		SS-2	SS	13	1-2-3 (N = 5)	20.3					
5		382.4										
			UD-1	UD	24							
9	SOFT, Mottled Gray to brown, silty, lean CLAY (CL), with black oxides, moist to wet; ALLUVIUM		SS-3	SS	18	2-2-2 (N = 4)	24.8					
10		377.4										WATER ON DRILLING TOOLS AT 12.0 FEET
14	VERY SOFT, Moddled Gray to brown, silty, lean CLAY (CL), with black oxides, wet; ALLUVIUM		SS-4	SS	16	WH-WH-1 (N = 1)	26.2					
15		372.4										
17	FIRM, Mottled Gray to brown, silty, lean CLAY (CL), moist; ALLUVIUM		UD-2	UD	24		25.2	29	17		83	
			SS-5	SS	18	3-4-4 (N = 8)	22.4					
20		367.4										
20.5	BORING TERMINATED AT 20.5 FEET											
25		362.4										

START DATE: 8/13/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-8T**

MACTEC

DEPTH (ft)	DESCRIPTION SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	ELEV MSL (ft)	Sample Number	RECOV (in.)	N-COUNT (1st 6" 2nd 6" 3rd 6") / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS Note: *No information on the borings should be used without considering the entire content of the main document.*
0	TOPSOIL; FILL VERY STIFF, Orange brown, silty, lean CLAY (CL), with organics, moist; FILL	403.9									SURFACE COVER: GRASS AND GRAVEL
			SS-1	15	5-8-8 (N = 16)	12.4					
5		398.9	UD-1	14		17.2	39	19		74	
	STIFF to FIRM, Grayish brown and orange brown, silty and sandy, lean CLAY (CL), with trace amounts of organics, moist to very moist; FILL										
10		393.9	SS-2	16	4-6-7 (N = 13)	21.5					
15		388.9	UD-2	18							
20		383.9	SS-3	12	3-3-4 (N = 7)						
	STIFF to SOFT, Orange brown, lean CLAY (CL), with sand pockets, very moist; ALLUVIUM										
25		378.9	SS-4	18	4-5-5 (N = 10)	19.4					
30		373.9	SS-5	18	1-1-2 (N = 3)						
35		368.9	SS-6	18	4-5-6 (N = 11)	25.4					
	BORING TERMINATED AT 35.5 FEET										BORING DRY UPON COMPLETION OF DRILLING
40		363.9									
45		358.9									

START DATE: 8/13/2010
CONTRACTOR: Tri-State
DRILLER: Tracy Braizer
EQUIPMENT: CME-55
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature]
Boring No.: B-9C

MACTEC

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV MSL (ft)	Sample Number	RECOV (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS (Note: No information on the borings should be used without considering the entire content of the main document.)
0	STIFF, Mottled Gray and brown, lean CLAY (CL), with organics and black oxides, dry to moist; FILL	387.3	SS-1	16	3-5-6 (N = 11)	16.0					SURFACE COVER: GRASS
			UD-1	14		17.5	30	19		86	
	STIFF, Mottled Gray and brown, lean CLAY (CL), with organics and black oxides, dry to moist; ALLUVIUM		SS-2	14	4-5-5 (N = 10)	19.2					
5		382.3									
	STIFF to FIRM, Mottled Gray and brown, lean CLAY (CL), with organics and black oxides, moist to wet; ALLUVIUM		SS-3	12	3-4-6 (N = 10)	23.0					
10		377.3									
			UD-2	24							
			SS-4	18	2-3-3 (N = 6)	23.8					
15		372.3									WATER ON DRILLING TOOLS AT 15.0 FEET
	FIRM, Mottled Gray and brown, silty, lean CLAY (CL), moist; ALLUVIUM		SS-5	18	3-3-5 (N = 8)	22.8					
20		367.3									
	BORING TERMINATED AT 20.5 FEET										BORING DRY UPON COMPLETION OF DRILLING
25		362.3									

START DATE: 8/13/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-9T**

MACTEC

Depth (ft)	Description	Elev MSL (ft)	Sample Number	Recov (in.)	N-Count (1st 6" 2nd 6" 3rd 6") / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	Remarks
0	GRAVEL; FILL	403.9									SURFACE COVER: GRAVEL
	STIFF, Orange brown and gray, silty and sandy, lean CLAY (CL), with trace amounts of fine gravel, moist; FILL		SS-1	16	5-5-5 (N = 10)	16.4					
5		398.9	SS-2	18	4-5-8 (N = 13)	16.9					
			UD-1	16		17.1	40	16		91	
10		393.9	SS-3	14	5-6-7 (N = 13)	17.0					
	STIFF to FIRM, Orange brown and gray, silty CLAY (CL-ML), with sand, with trace amounts of organics, moist to very moist; ALLUVIUM ▼										
15		388.9	SS-4	12	3-5-5 (N = 10)	20.2					
											WATER ON DRILLING TOOLS AT 17.5 FEET
20		383.9	SS-5	14	3-4-5 (N = 9)	20.0					
			UD-2	24							
25		378.9	SS-6	15	2-3-4 (N = 7)	22.6					PIEZOMETER INSTALLED WITH SCREENED INTERVAL FROM 15-25 FEET
	FIRM to STIFF, Orange brown and gray, silty and sandy, lean CLAY (CL), with coarse sand and trace amounts of fine gravel, wet; ALLUVIUM										DEPTH OF WATER IN PZ AT 25.0 FEET ON 08/24/10
30		373.9	SS-7	16	2-2-3 (N = 5)	27.2					
35		368.9	SS-8	18	3-4-5 (N = 9)	19.9					
	BORING TERMINATED AT 35.5 FEET										BORING DRY UPON COMPLETION OF DRILLING
40		363.9									

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

Note: *No information on the borings should be used without considering the entire content of the main document.*

START DATE: 8/13/2010
CONTRACTOR: Tri-State
DRILLER: Tracy Braizer
EQUIPMENT: CME-55
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature] **Boring No.: B-10C**

MACTEC

MACTEC SOIL-ROCK (SITE MAP) 3143101317.02.GPJ MACTEC DATABASE TEMPLATE 01.GDT 9/21/10

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV MSL (ft)	Sample Number	Sample Type	RECOV (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS (Note: No information on the borings should be used without considering the entire content of the main document.)
0	VERY STIFF, Mottled Gray and brown, silty, lean CLAY (CL), with organics and black oxides, dry; FILL	391.9	SS-1		18	10-11-8 (N = 19)	11.4					SURFACE COVER: GRASS
	VERY STIFF to STIFF, Mottled Gray and brown, silty, lean CLAY (CL), with organics and black oxides, dry to moist; ALLUVIUM		SS-2		16	7-9-13 (N = 22)	16.7					
5		386.9										
10		381.9	SS-3		16	3-5-6 (N = 11)	20.7					
			UD-1		24							
												WATER ON DRILLING TOOLS AT 13.0 FEET
	FIRM, Mottled Gray and brown, silty, lean CLAY (CL), with organics and black oxides, wet; ALLUVIUM		SS-4		18	2-3-3 (N = 6)	24.6					
15		376.9										
	FIRM to STIFF, Mottled Gray and brown, silty, lean CLAY (CL), with organics and black oxides, moist, ALLUVIUM		SS-5		14	2-2-3 (N = 5)	24.1					
20		371.9										
25		366.9	SS-6		16	4-5-7 (N = 12)	21.2					
	BORING TERMINATED AT 25.5 FEET											
30		361.9										

START DATE: 8/13/2010
CONTRACTOR: Tri-State
DRILLER: Shannon Snow
EQUIPMENT: Diedrich D-50 Turbo
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Automatic
LOGGED BY: Vandana Muddu
PREPARED BY: Sarah Sheilley
REMARKS:

TEST BORING RECORD

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature]
Boring No.: B-10T

MACTEC

LABORATORY TESTING PROCEDURES

SUMMARY OF LABORATORY TEST DATA

LABORATORY TESTING PROCEDURES

Soil Classification: Soil classifications provide a general guide to the engineering properties of various soil types and enable the engineer to apply past experience to current situations. In our investigations, samples obtained during drilling operations are examined in our laboratory and visually classified by an engineer. The soils are classified according to consistency (based on number of blows from standard penetration tests), color and texture. These classification descriptions are included on our "Test Boring Records."

The classification system discussed above is primarily qualitative and for detailed soil classification two laboratory tests are necessary: grain size tests and plasticity tests. Using these test results the soil can be classified according to the AASHTO or Unified Classification Systems (ASTM D2487). Each of these classification systems and the in-place physical soil properties provide an index for estimating the soil's behavior. The soil classification and physical properties determined are presented in this report.

Atterberg Limits: Portions of the samples are taken for Atterberg Limits testing to determine the plasticity characteristics of the soil. The plasticity index (PI) is the range of moisture content over which the soil deforms as a plastic material. It is bracketed by the liquid limit (LL) and the plastic limit (PL). The liquid limit is the moisture content at which the soil becomes sufficiently "wet" to flow as a heavy viscous fluid. The plastic limit is the lowest moisture content at which the soil is sufficiently plastic to be manually rolled into tiny threads. The liquid limit and plastic limit are determined in accordance with ASTM D4318.

Grain Size Tests: Grain Size Tests are performed to determine the soil classification and the grain size distribution. The soil samples are prepared for testing according to ASTM D421 (dry preparation) or ASTM D2217 (wet preparation). The grain size distribution of soils coarser than a number 200 sieve (0.074 mm opening) is determined by passing the samples through a standard set of nested sieves. Materials passing the number 200 sieve are suspended in water and the grain size distribution calculated from the measured settlement rate. These tests are conducted in accordance with ASTM D422.

Moisture Content: The Moisture Content is determined according to ASTM D2216.

Physical Soil Properties: The in-place physical properties are described by the specific gravity, wet unit weight, moisture content, dry unit weight, void ratio, and percent saturation of the soil. The specific gravity and moisture content are determined according to ASTM D854 and D2216, respectively. The wet unit weight is found by obtaining a known volume of the soil and dividing the wet sample weight by the known volume. The dry unit weight, void ratio and percent saturation are calculated values.

Triaxial Shear Tests: Triaxial shear tests are used to determine the strength characteristics and friction angle of a given soil sample. Triaxial tests are also used to determine the elastic properties of the soil specimen. Triaxial shear tests are performed on several sections of a relatively undisturbed sample extruded from the sampling tube. The samples are trimmed into cylinders 1.4 to 2.8 inches in diameter and encased in rubber membranes. Each is then placed in a compression chamber and confined by all around water pressure. Samples are then subjected to additional axial and/or lateral loads, depending on the soil and the field conditions to be simulated. The test results are typically presented in tabular form or in the form of stress-strain curves and Mohr envelopes or p-q plots.

LABORATORY TESTING PROCEDURES (continued)

Three types of triaxial tests are normally performed. The most suitable type of triaxial test is determined by the loading conditions imposed on the soil in the field and the soil characteristics.

1. Consolidated-Undrained (designated as a CU or R Test).
2. Consolidated-Drained (designated as a CD or S Test).
3. Unconsolidated-Undrained (designated as a UU or Q Test).

Borehole	Depth	Sample Type	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Limit	Atterberg Limits: Plasticity Index	USCS Class-ification	Natural Moisture Content (%)	Unconfined Compress. Strength (Soil-psf)	Unconfined Compress. Strength (Rock-psi)	Unit Weight (pcf): Dry Density	Unit Weight (pcf): Wet Density	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Specific Gravity	Rock Core: RQD	Rock Core: Percent Recovery	% Finer #200
B-1.5T	0.0	SS					19.0										
B-1.5T	4.0	SS					21.3										
B-1.5T	9.0	SS					18.0										
B-1.75T	0.0	SS					16.5										
B-1.75T	4.0	SS					17.6										
B-1.75T	7.0	UD	35	18	17	CL	17.4			109.6	128.6			2.75			76
B-10C	1.0	SS					16.4										
B-10C	4.0	SS					16.9										
B-10C	7.0	UD	40	16	24	CL	17.1			111.4	130.5			2.71			91
B-10C	9.0	SS					17.0										
B-10C	14.0	SS					20.2										
B-10C	19.0	SS					20.0										
B-10C	24.0	SS					22.6										
B-10C	29.0	SS					27.2										
B-10C	34.0	SS					19.9										
B-10T	0.0	SS					11.4										
B-10T	4.0	SS					16.7										
B-10T	9.0	SS					20.7										
B-10T	14.0	SS					24.6										
B-10T	19.0	SS					24.1										
B-10T	24.0	SS					21.2										
B-1C	1.0	SS					12.1										
B-1C	4.0	UD	45	20	25	CL	17.1			142.9	167.3			2.75			91
B-1C	9.0	SS					13.4										
B-1C	14.0	SS					22.4										
B-1C	24.0	SS					23.4										

Remarks:

* SPT/SS = Split-spoon BG = Bulk / bag sample
UD/SH = Undisturbed sample RC = Rock core

Summary of Laboratory Results

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature]

MACTEC

MACTEC_LAB-SUMMARY LANDSCAPE (SP GRAV) 3143101317.02.GPJ MACTEC DATABASE TEMPLATE 01.GDT 9/21/10

Borehole	Depth	Sample Type	Atterberg Limits			USCS Class-ification	Natural Moisture Content (%)	Unconfined Compress. Strength (Soil-psf)	Unconfined Compress. Strength (Rock-psi)	Unit Weight (pcf)		Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Specific Gravity	Rock Core		% Finer #200
			Liquid Limit	Plastic Limit	Plasticity Index					Dry Density	Wet Density				RQD	Percent Recovery	
B-1C	29.0	UD	40	21	19	CL	27.2			93.3	118.7			2.63			89
B-1C	34.0	SS					24.1										
B-1C	39.0	SS					8.1										
B-1T	0.0	SS					20.3										
B-1T	4.0	SS					30.2										
B-1T	9.0	SS					25.5										
B-1T	14.0	SS					25.5										
B-1T	19.0	SS					22.1										
B-2.5T	0.0	SS					18.9										
B-2.5T	4.0	SS					25.3										
B-2.5T	9.0	SS					38.0										
B-2.5T	14.0	SS					28.1										
B-2.5T	19.0	SS					24.6										
B-2C	1.0	SS					15.7										
B-2C	4.0	SS					19.5										
B-2C	9.0	SS					29.6										
B-2C	14.0	SS					23.1										
B-2C	19.0	SS					25.8										
B-2C	20.5	UD				SM	27.8			65.1	83.3			2.66			19
B-2C	24.0	SS					19.5										
B-2C	29.0	SS					28.7										
B-2C	34.0	SS					21.0										
B-2T	0.0	SS					16.6										
B-2T	9.0	SS					32.6										
B-2T	14.0	UD				ML	27.5			106.6	135.9			2.45			60
B-2T	19.0	SS					33.9										

Remarks:

* SPT/SS = Split-spoon BG = Bulk / bag sample
UD/SH = Undisturbed sample RC = Rock core

Summary of Laboratory Results

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By:

MACTEC

Borehole	Depth	Sample Type	Atterberg Limits			USCS Class-ification	Natural Moisture Content (%)	Unconfined Compress. Strength (Soil-psf)	Unconfined Compress. Strength (Rock-psi)	Unit Weight (pcf)		Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Specific Gravity	Rock Core		% Finer #200
			Liquid Limit	Plastic Limit	Plasticity Index					Dry Density	Wet Density				RQD	Percent Recovery	
B-3C	9.0	SS					21.0										
B-3C	14.0	UD	37	19	18	CL	24.5			96.6	120.3			2.67			87
B-3C	19.0	SS					23.9										
B-3C	29.0	SS					23.6										
B-3C	34.0	SS					24.8										
B-3T	1.0	UD	48	20	28	CL	19.3			105.8	126.3			2.74			85
B-3T	4.0	SS					23.5										
B-3T	9.0	SS					24.5										
B-3T	14.0	SS					23.7										
B-3T	19.0	SS					25.0										
B-4C	5.0	SS					19.8										
B-4C	9.0	SS					15.7										
B-4C	14.0	SS					21.5										
B-4C	19.0	SS					23.2										
B-4C	24.0	SS					22.2										
B-4C	29.0	SS					22.4										
B-4C	34.0	SS					20.7										
B-4T	0.0	SS					18.4										
B-4T	9.0	SS					22.8										
B-4T	10.5	UD	37	17	20	CL	24.5			102.0	126.9			2.76			97
B-4T	14.0	SS					24.0										
B-4T	19.0	SS					19.2										
B-5C	0.0	SS					22.2										
B-5C	4.0	SS					24.8										
B-5C	9.0	SS					20.3										
B-5C	19.0	SS					17.6										

Remarks:

* SPT/SS = Split-spoon BG = Bulk / bag sample
UD/SH = Undisturbed sample RC = Rock core

Summary of Laboratory Results

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: ________

MACTEC

Borehole	Depth	Sample Type	Atterberg Limits			USCS Class-ification	Natural Moisture Content (%)	Unconfined Compress. Strength (Soil-psf)	Unconfined Compress. Strength (Rock-psi)	Unit Weight (pcf)		Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Specific Gravity	Rock Core		% Finer #200
			Liquid Limit	Plastic Limit	Plasticity Index					Dry Density	Wet Density				RQD	Percent Recovery	
B-5C	24.0	SS					43.4										
B-5T	0.0	SS					19.3										
B-5T	4.0	SS					18.6										
B-5T	9.0	SS					24.4										
B-5T	14.0	SS					23.2										
B-6C	6.0	SS					16.0										
B-6C	9.0	SS					17.5										
B-6C	19.0	SS					21.6										
B-6C	24.0	SS					23.2										
B-6C	29.0	SS					19.3										
B-6C	34.0	SS					21.6										
B-6T	4.0	SS					20.3										
B-6T	9.0	SS					22.5										
B-6T	14.0	SS					25.9										
B-6T	19.0	SS					21.3										
B-6T	24.0	SS															
B-7C	0.0	SS					9.3										
B-7C	4.0	SS					17.7										
B-7C	14.0	SS					19.4										
B-7C	24.0	SS					23.2										
B-7C	34.0	SS					26.4										
B-7T	0.0	SS					20.1										
B-7T	4.0	SS					25.0										
B-7T	9.0	SS					22.2										
B-7T	14.0	SS					25.9										
B-7T	19.0	SS					26.0										

Remarks:

* SPT/SS = Split-spoon BG = Bulk / bag sample
UD/SH = Undisturbed sample RC = Rock core

Summary of Laboratory Results

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature]

MACTEC

Borehole	Depth	Sample Type	Atterberg Limits			USCS Class-ification	Natural Moisture Content (%)	Unconfined Compress. Strength (Soil-psf)	Unconfined Compress. Strength (Rock-psi)	Unit Weight (pcf)		Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Specific Gravity	Rock Core		% Finer #200
			Liquid Limit	Plastic Limit	Plasticity Index					Dry Density	Wet Density				RQD	Percent Recovery	
B-7T	24.0	SS					27.5										
B-7T	29.0	SS					26.2										
B-7T	34.0	SS					23.4										
B-7T	39.0	SS					21.1										
B-8C	1.0						17.7										
B-8C	4.0	SS					21.3										
B-8C	9.0	SS					21.1										
B-8C	14.0	SS					21.8										
B-8C	19.0	SS					24.2										
B-8C	29.0	SS					26.2										
B-8C	34.0	SS					26.7										
B-8C	39.0	SS					26.4										
B-8T	0.0	SS					14.6										
B-8T	4.0	SS					20.3										
B-8T	9.0	SS					24.8										
B-8T	14.0	SS					26.2										
B-8T	17.0	UD	29	17	12	CL	25.2			101.9	127.7			2.61			83
B-8T	19.0	SS					22.4										
B-9C	1.0	SS					12.4										
B-9C	4.0	UD	39	19	20	CL	17.2			114.0	133.7			2.70			74
B-9C	9.0	SS					21.5										
B-9C	19.0	SS															
B-9C	24.0	SS					19.4										
B-9C	34.0	SS					25.4										
B-9C	39.0						26.6										
B-9T	0.0	SS					16.0										

Remarks:

* SPT/SS = Split-spoon   BG = Bulk / bag sample
UD/SH = Undisturbed sample   RC = Rock core

Summary of Laboratory Results

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By: [signature]

MACTEC

Borehole	Depth	Sample Type	Atterberg Limits			USCS Class-ification	Natural Moisture Content (%)	Unconfined Compress. Strength (Soil-psf)	Unconfined Compress. Strength (Rock-psi)	Unit Weight (pcf)		Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Specific Gravity	Rock Core		% Finer #200
			Liquid Limit	Plastic Limit	Plasticity Index					Dry Density	Wet Density				RQD	Percent Recovery	
B-9T	2.0	UD	30	19	11	CL	17.5			110.5	129.8			2.70			86
B-9T	4.0	SS					19.2										
B-9T	9.0	SS					23.0										
B-9T	14.0	SS					23.8										
B-9T	19.0	SS					22.8										

Remarks:

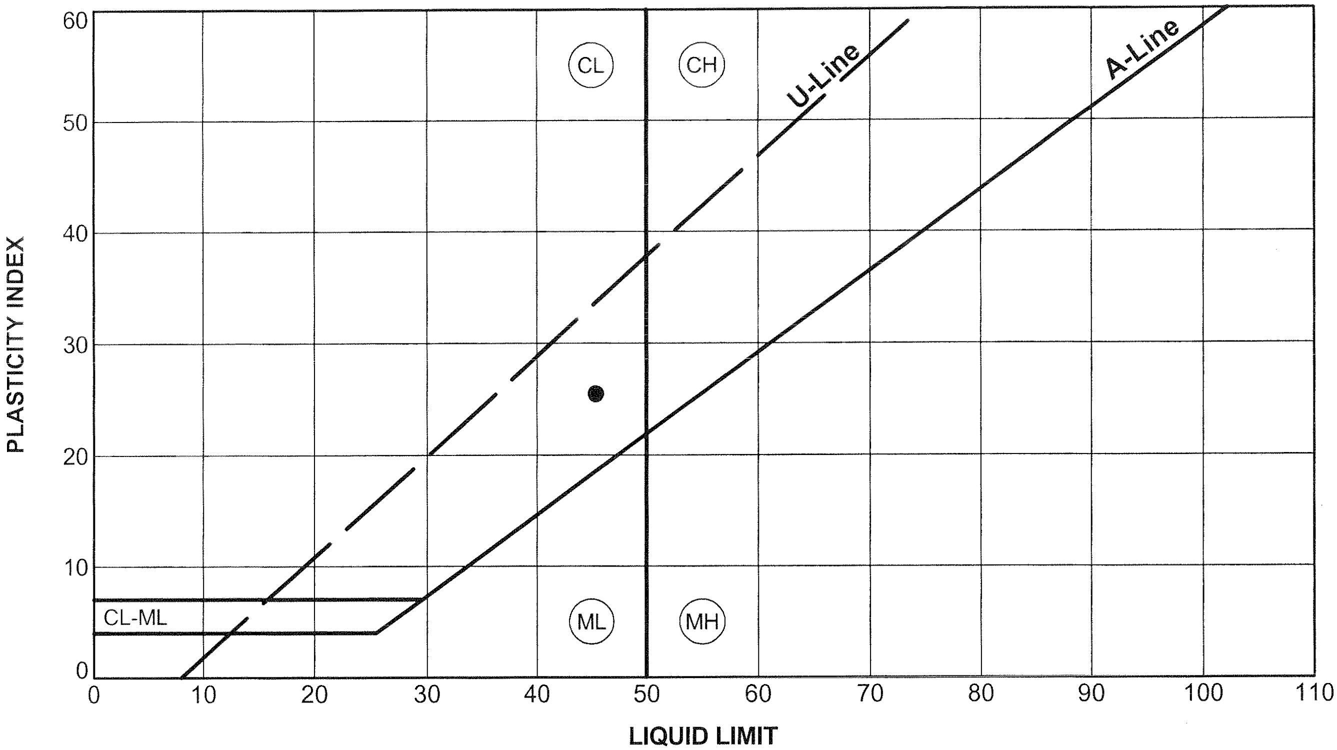
* SPT/SS = Split-spoon   BG = Bulk / bag sample
UD/SH = Undisturbed sample   RC = Rock core

Summary of Laboratory Results

Project: E.ON U.S. - Green River Power Station
Project No: 3143-10-1317.02
Checked By:

MACTEC

ATTERBERG LIMITS TEST RESULTS



Symbol	Location	Depth, feet	LL	PL	PI	Natural Moisture Content, %	LI	USCS	Soil Classification
●	B-1C	4.0-6.0	45	20	25	17.1	-0.1	CL	Grayish black, lean CLAY

Remarks:

Test Method - ASTM D4318

LL=Liquid Limit; PL= Plastic Limit; PI=Plasticity Index; LI=Liquidity Index

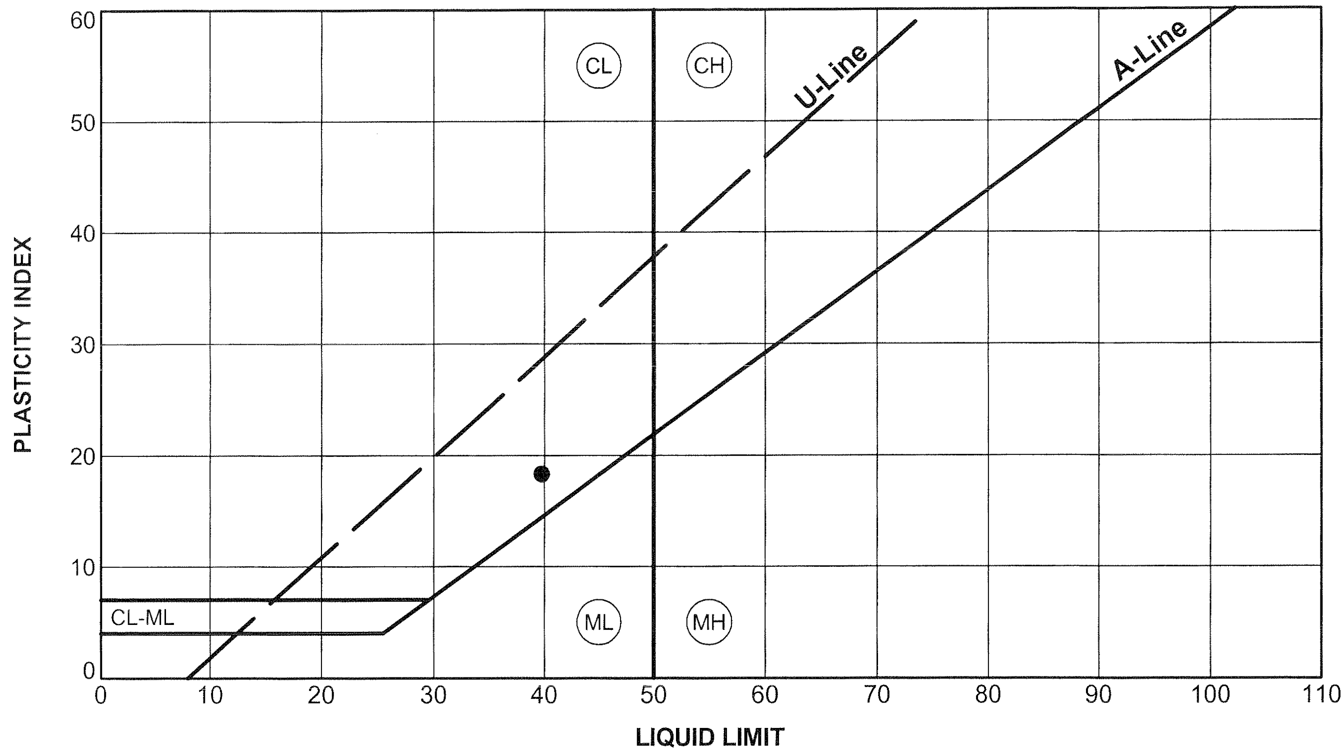
ATTERBERG LIMITS RESULTS

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: [signature]

MACTEC



Symbol	Location	Depth, feet	LL	PL	PI	Natural Moisture Content, %	LI	USCS	Soil Classification
●	B-1C	29.0-31.0	40	21	19	27.2	0.3	CL	Gray to brown, lean CLAY

Remarks:

Test Method - ASTM D4318

LL=Liquid Limit; PL= Plastic Limit; PI=Plasticity Index; LI=Liquidity Index

ATTERBERG LIMITS RESULTS

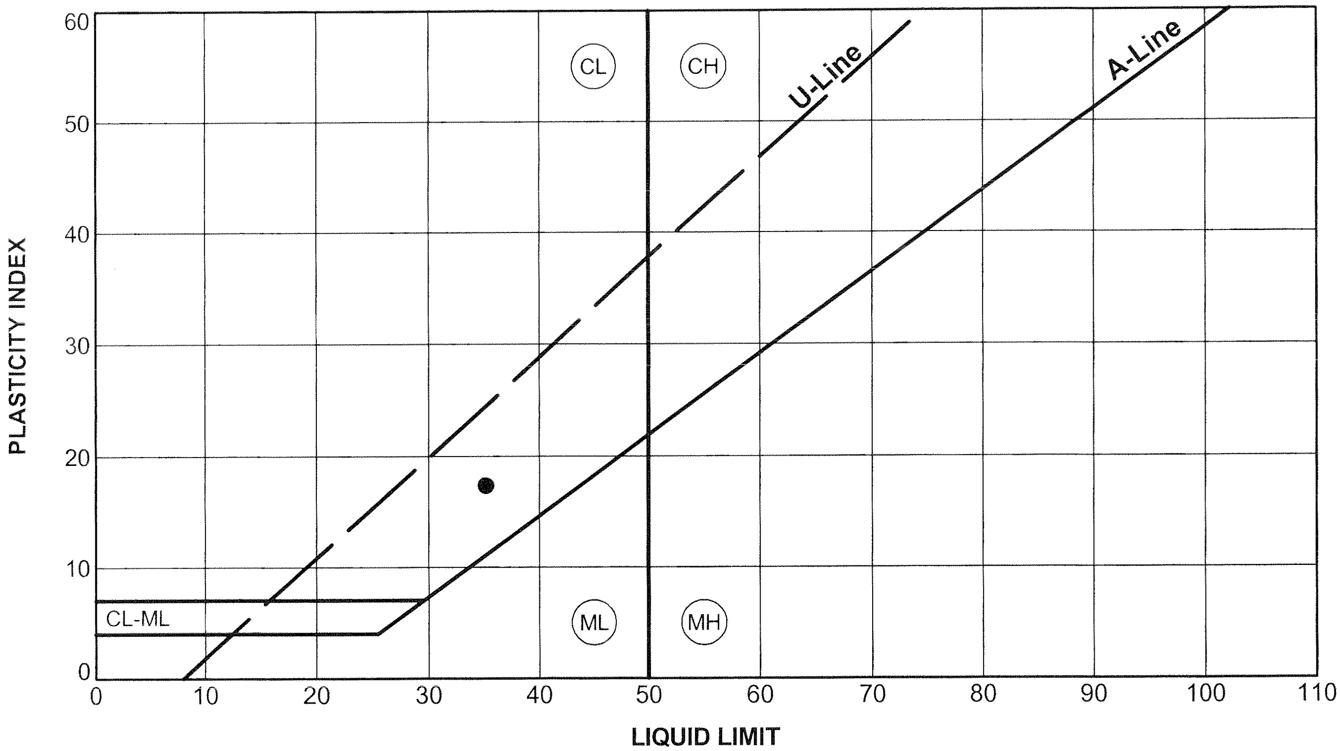
Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: [signature]

MACTEC

MACTEC_ATTERBERG_LIMITS 3143101317.02.GPJ MACTEC DATABASE TEMPLATE 01.GDT 9/1/10



Symbol	Location	Depth, feet	LL	PL	PI	Natural Moisture Content, %	LI	USCS	Soil Classification
●	B-1.75T	7.0-9.0	35	18	17	17.4	0.0	CL	Brownish black, lean CLAY

Remarks:

Test Method - ASTM D4318

LL=Liquid Limit; PL= Plastic Limit; PI=Plasticity Index; LI=Liquidity Index

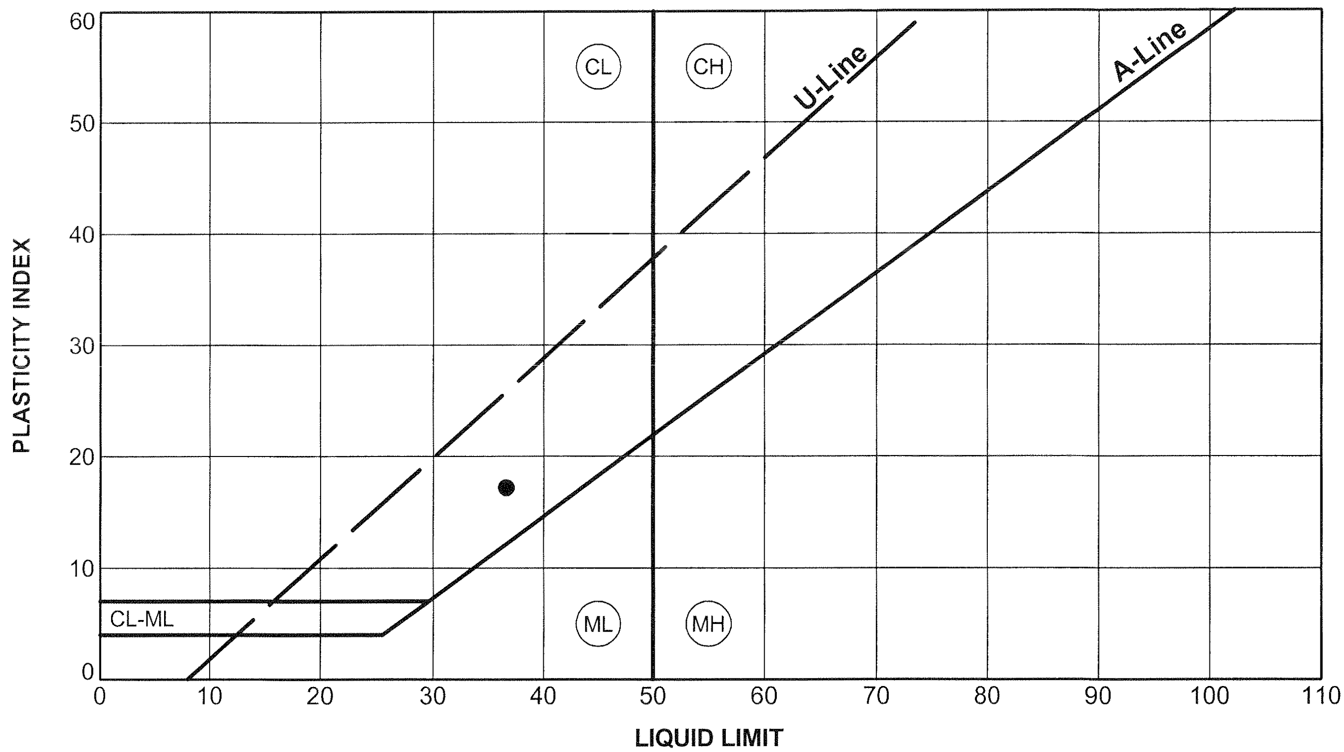
ATTERBERG LIMITS RESULTS

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: [signature]

MACTEC



Symbol	Location	Depth, feet	LL	PL	PI	Natural Moisture Content, %	LI	USCS	Soil Classification
●	B-3C	14.0-16.0	37	19	18	24.5	0.3	CL	Brown, lean CLAY

Remarks:

Test Method - ASTM D4318

LL=Liquid Limit; PL= Plastic Limit; PI=Plasticity Index; LI=Liquidity Index

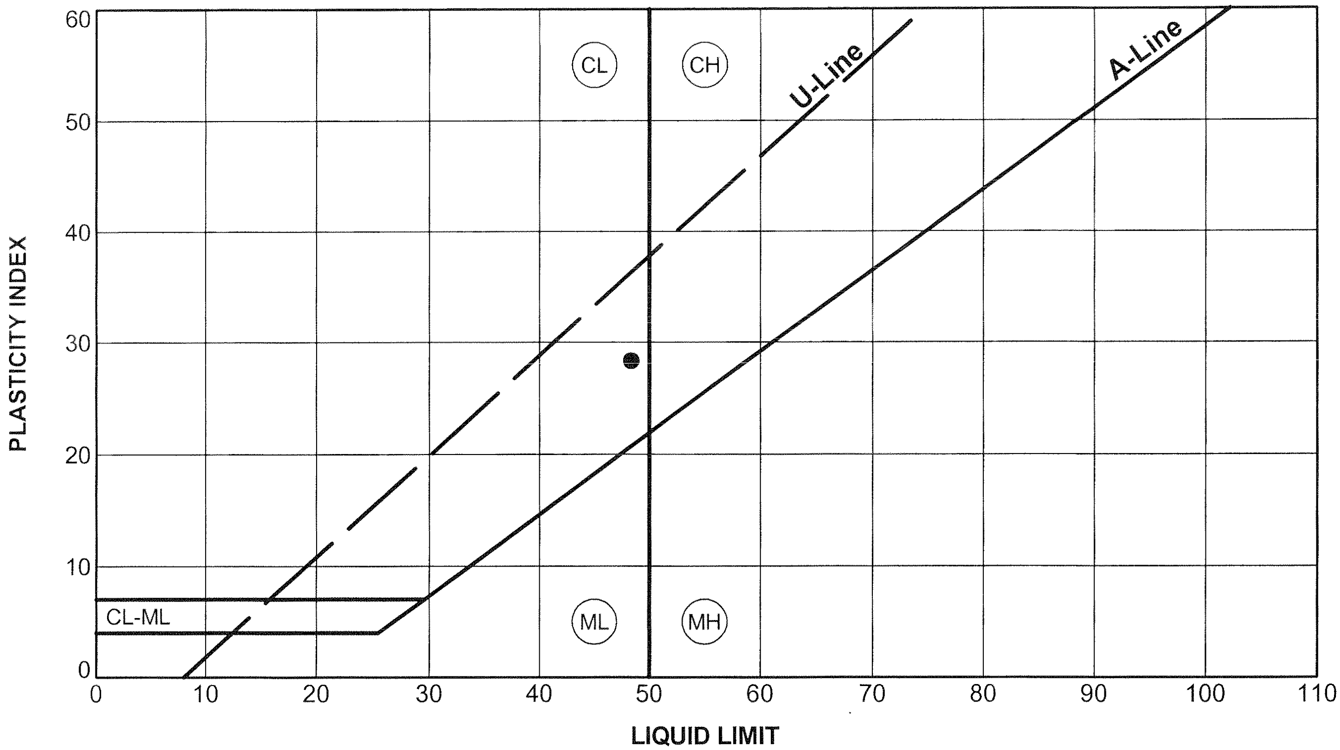
ATTERBERG LIMITS RESULTS

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: ______

MACTEC



Symbol	Location	Depth, feet	LL	PL	PI	Natural Moisture Content, %	LI	USCS	Soil Classification
●	B-3T	1.0-3.0	48	20	28	19.3	0.0	CL	Yellowish brown, lean CLAY

Remarks:

Test Method - ASTM D4318

LL=Liquid Limit; PL= Plastic Limit; PI=Plasticity Index; LI=Liquidity Index

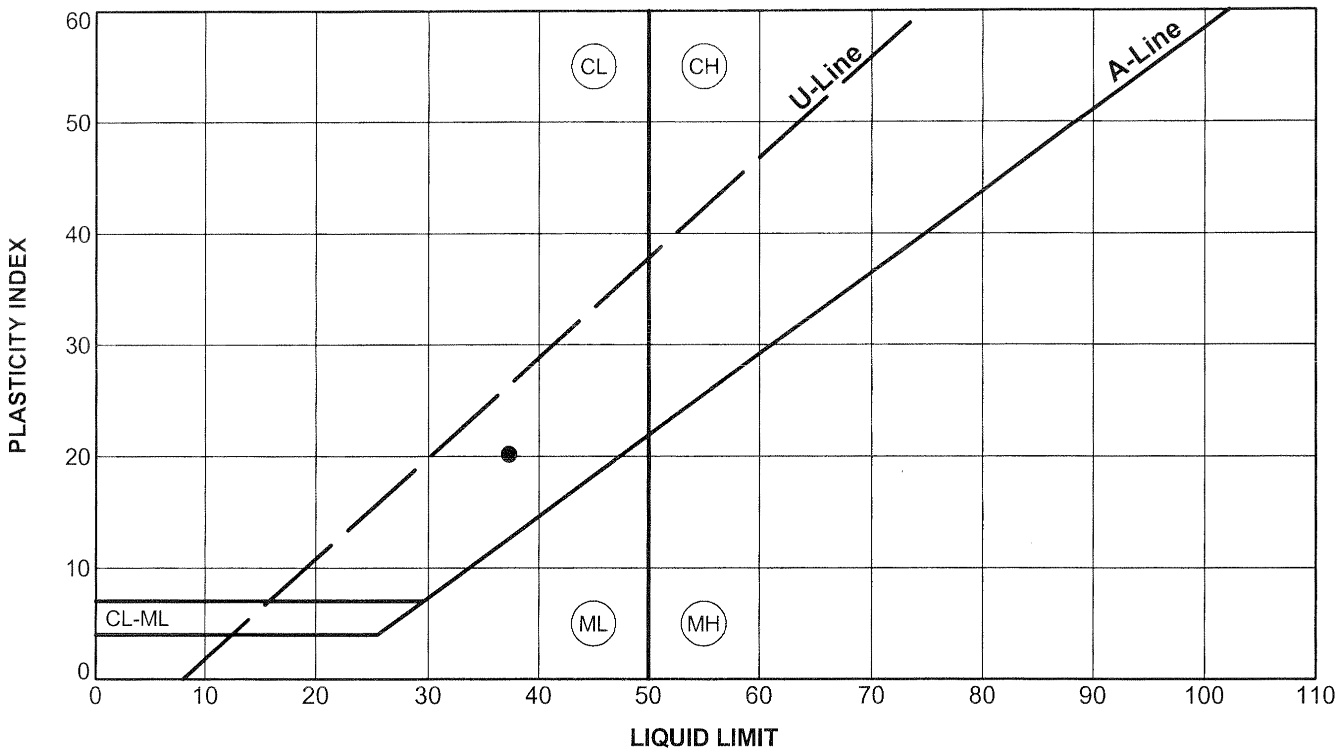
ATTERBERG LIMITS RESULTS

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: ____

MACTEC



Symbol	Location	Depth, feet	LL	PL	PI	Natural Moisture Content, %	LI	USCS	Soil Classification
●	B-4T	10.5-12.5	37	17	20	24.5	0.4	CL	Brown, lean CLAY

Remarks:

Test Method - ASTM D4318

LL=Liquid Limit; PL= Plastic Limit; PI=Plasticity Index; LI=Liquidity Index

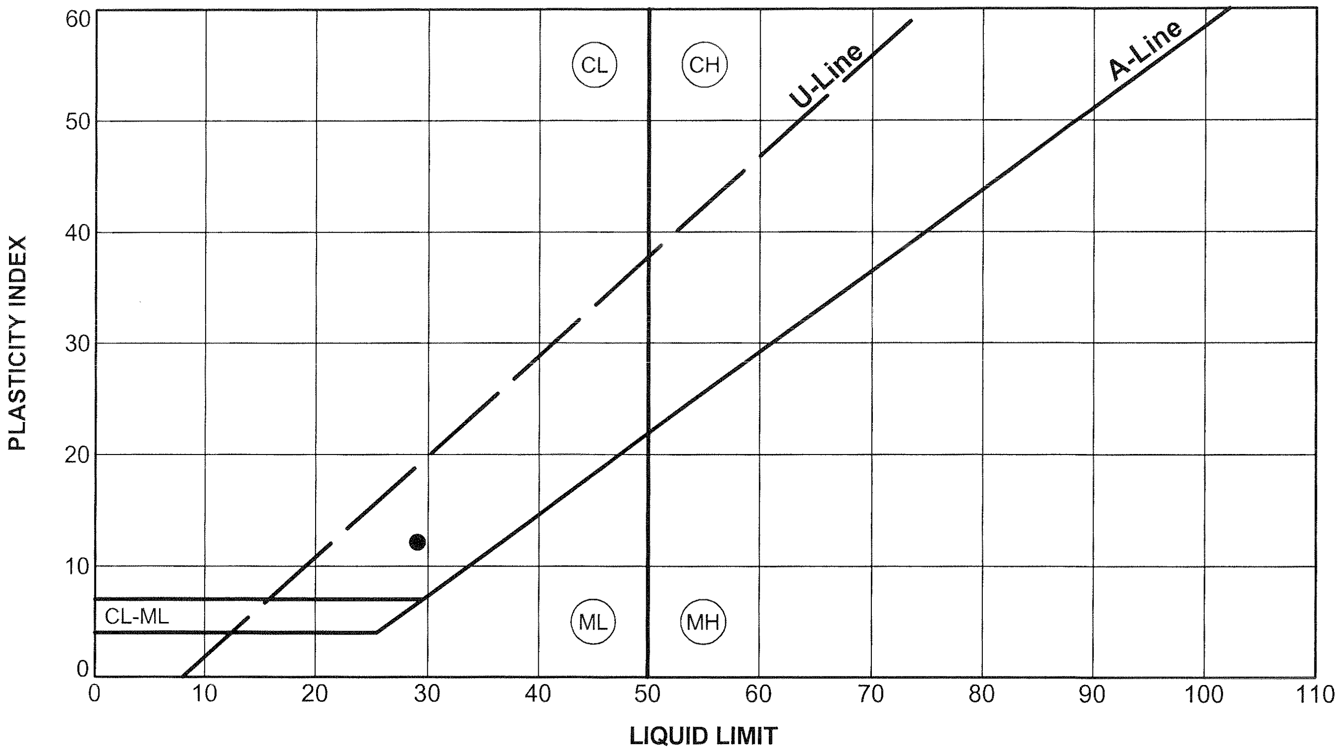
ATTERBERG LIMITS RESULTS

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: AdS

MACTEC



Symbol	Location	Depth, feet	LL	PL	PI	Natural Moisture Content, %	LI	USCS	Soil Classification
●	B-8T	17.0-19.0	29	17	12	25.2	0.7	CL	Brown, lean CLAY

Remarks:

Test Method - ASTM D4318

LL=Liquid Limit; PL= Plastic Limit; PI=Plasticity Index; LI=Liquidity Index

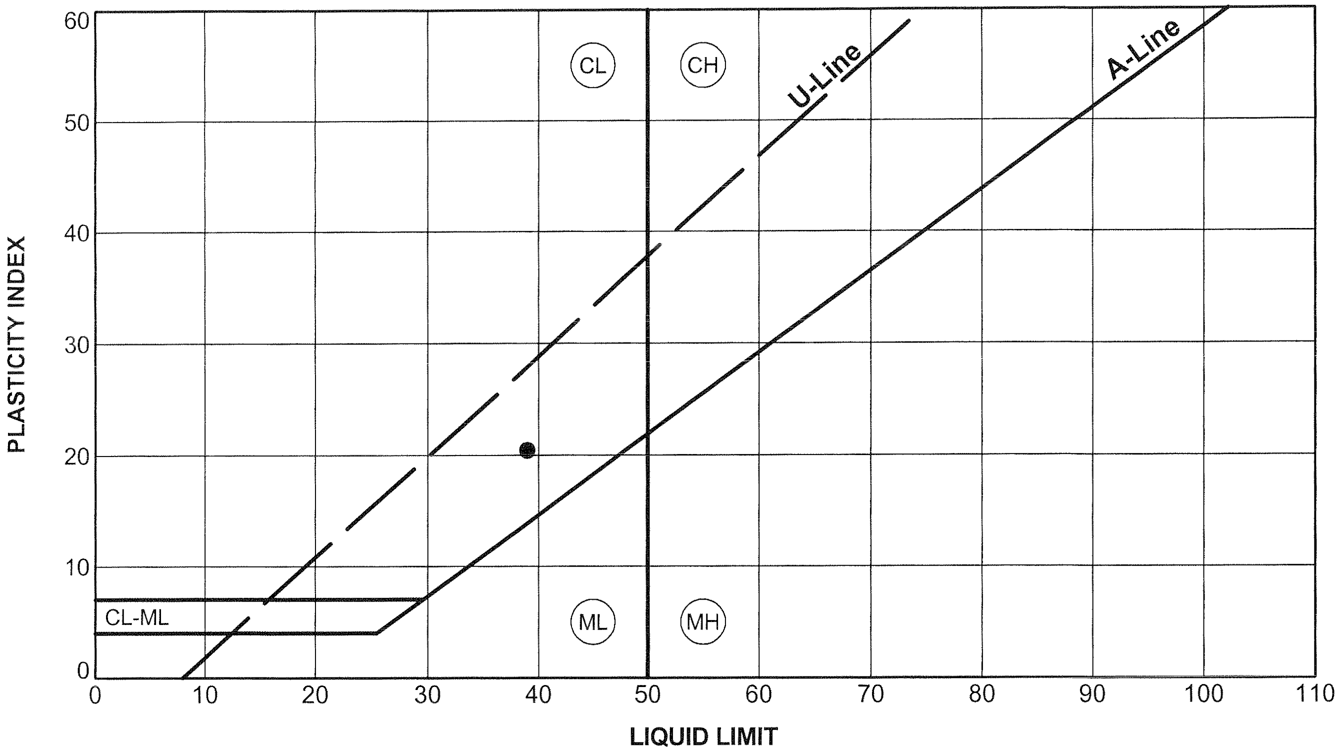
ATTERBERG LIMITS RESULTS

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: ______

MACTEC



Symbol	Location	Depth, feet	LL	PL	PI	Natural Moisture Content, %	LI	USCS	Soil Classification
●	B-9C	4.0-6.0	39	19	20	17.2	-0.1	CL	Reddish brown, lean CLAY

Remarks:

Test Method - ASTM D4318

LL=Liquid Limit; PL= Plastic Limit; PI=Plasticity Index; LI=Liquidity Index

ATTERBERG LIMITS RESULTS

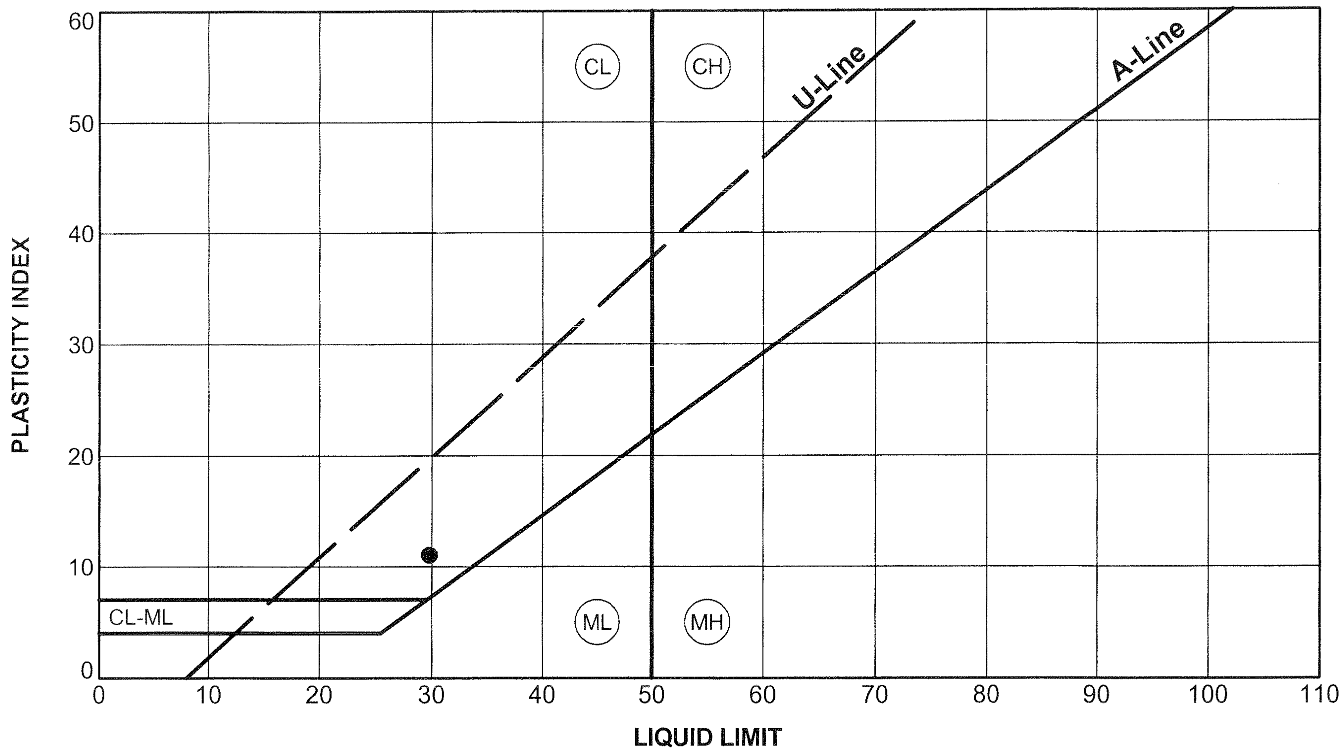
Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: ____

MACTEC

MACTEC_ATTERBERG_LIMITS 3143101317.02.GPJ MACTEC DATABASE TEMPLATE 01.GDT 9/1/10



Symbol	Location	Depth, feet	LL	PL	PI	Natural Moisture Content, %	LI	USCS	Soil Classification
●	B-9T	2.0-4.0	30	19	11	17.5	-0.1	CL	Brown, lean CLAY

Remarks:

Test Method - ASTM D4318

LL=Liquid Limit; PL= Plastic Limit; PI=Plasticity Index; LI=Liquidity Index

ATTERBERG LIMITS RESULTS

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: [signature]

MACTEC

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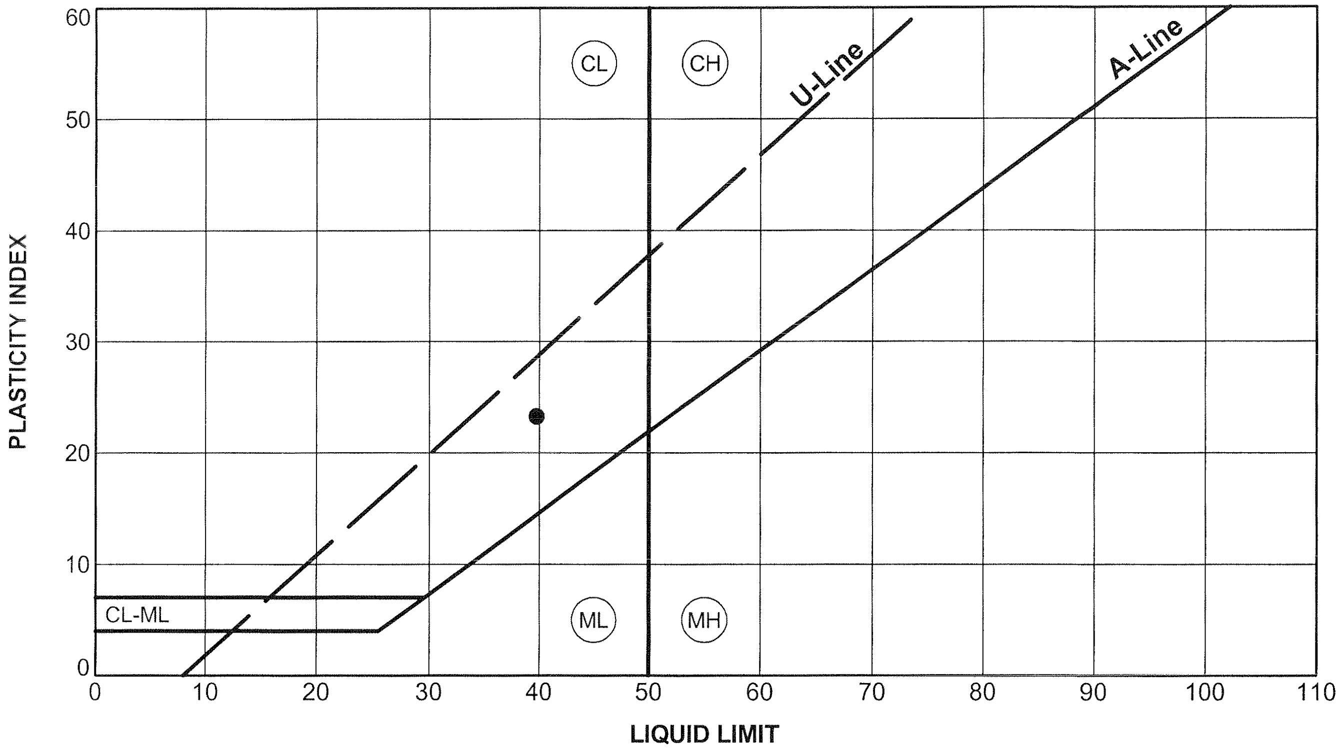


Symbol	Location	Depth, feet	LL	PL	PI	Natural Moisture Content, %	LI	USCS	Soil Classification
●	B-10C	7.0-9.0	40	16	24	17.1	0.0	CL	Yellowish brown, lean CLAY

Remarks:

Test Method - ASTM D4318

LL=Liquid Limit; PL= Plastic Limit; PI=Plasticity Index; LI=Liquidity Index

ATTERBERG LIMITS RESULTS

Project: E.ON U.S. - Green River Power Station

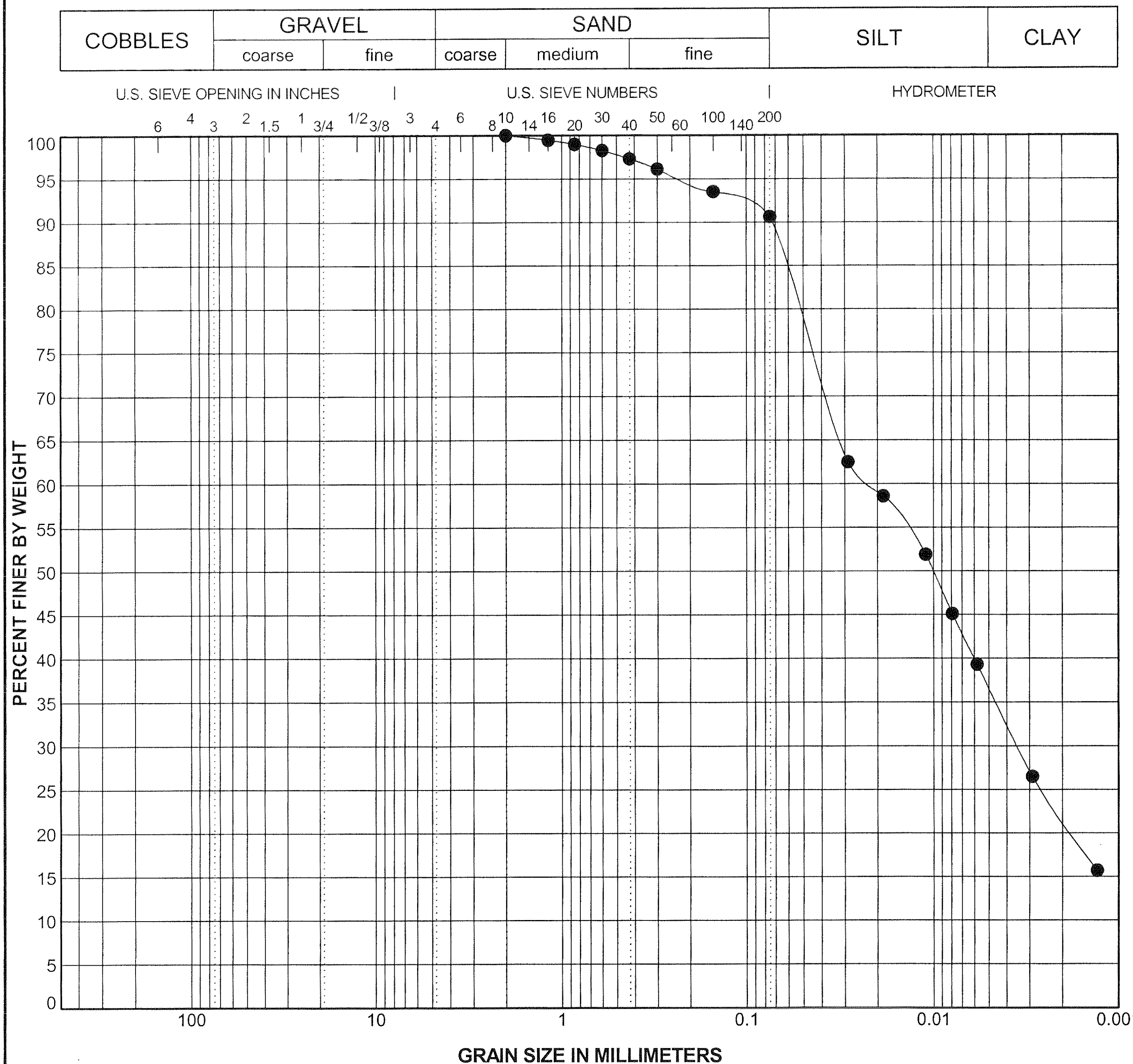
Project No: 3143-10-1317.02

Checked By: ________

MACTEC

MACTEC_ATTERBERG_LIMITS 3143101317.02.GPJ MACTEC DATABASE TEMPLATE 01.GDT 9/1/10

GRAIN SIZE DISTRIBUTION TEST RESULTS



Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	B-1C	4.0-6.0	Grayish black, lean CLAY	CL	2	0.022	0.004			

MACTEC_GRAIN_SIZE 3143101317.02.GPJ LAW_GIBB.GDT 9/1/10

Remarks:

Test Method - ASTM D422

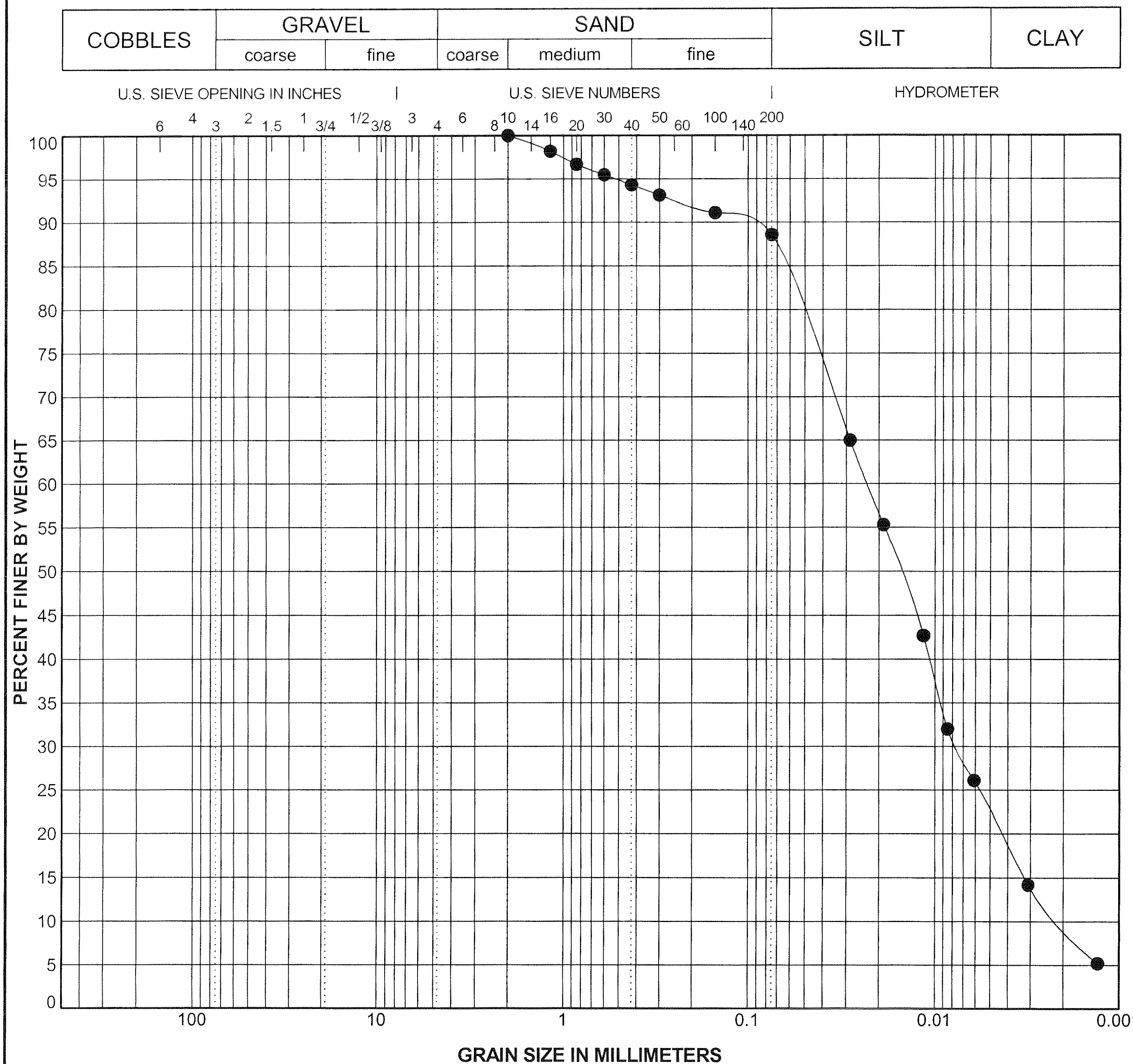
GRAIN SIZE DISTRIBUTION

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: [signature]

MACTEC



Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	B-1C	29.0-31.0	Gray to brown, lean CLAY	CL	2	0.023	0.008	0.002	1.21	11.18

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

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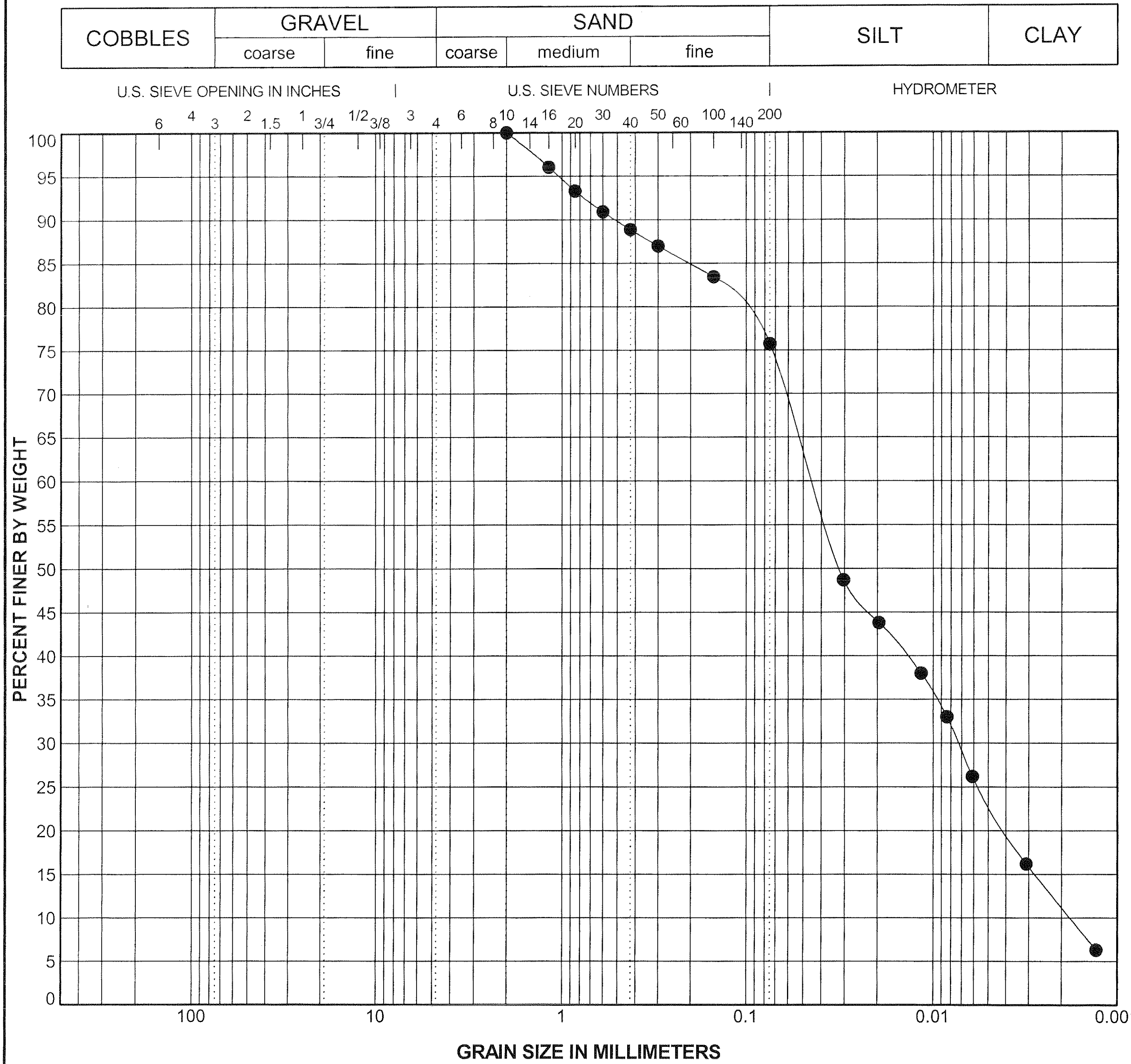
MACTEC

MACTEC_GRAIN_SIZE 3143101317.02.GPJ LAW_GIBB.GDT 9/1/10



Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	B-1.75T	7.0-9.0	Brownish black, lean CLAY	CL	2	0.044	0.007	0.002	0.67	24.65

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: ________

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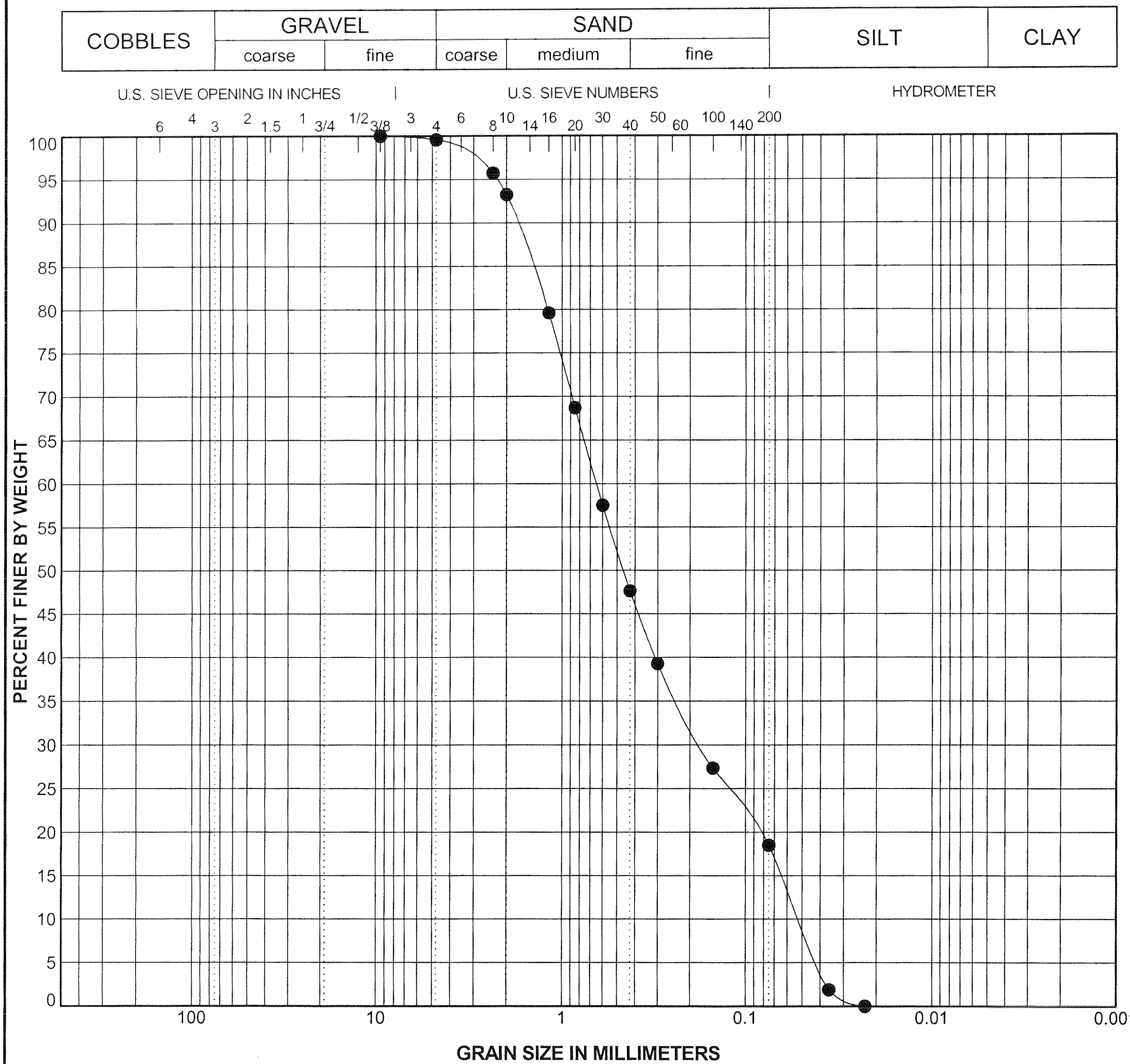
MACTEC_GRAIN_SIZE 3143101317.02.GPJ LAW_GIBB.GDT 9/1/10



Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	B-2C	20.5-22.5	Black, CCW (BOTTOM ASH)	SM	9.5	0.648	0.175	0.051	0.92	12.61

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

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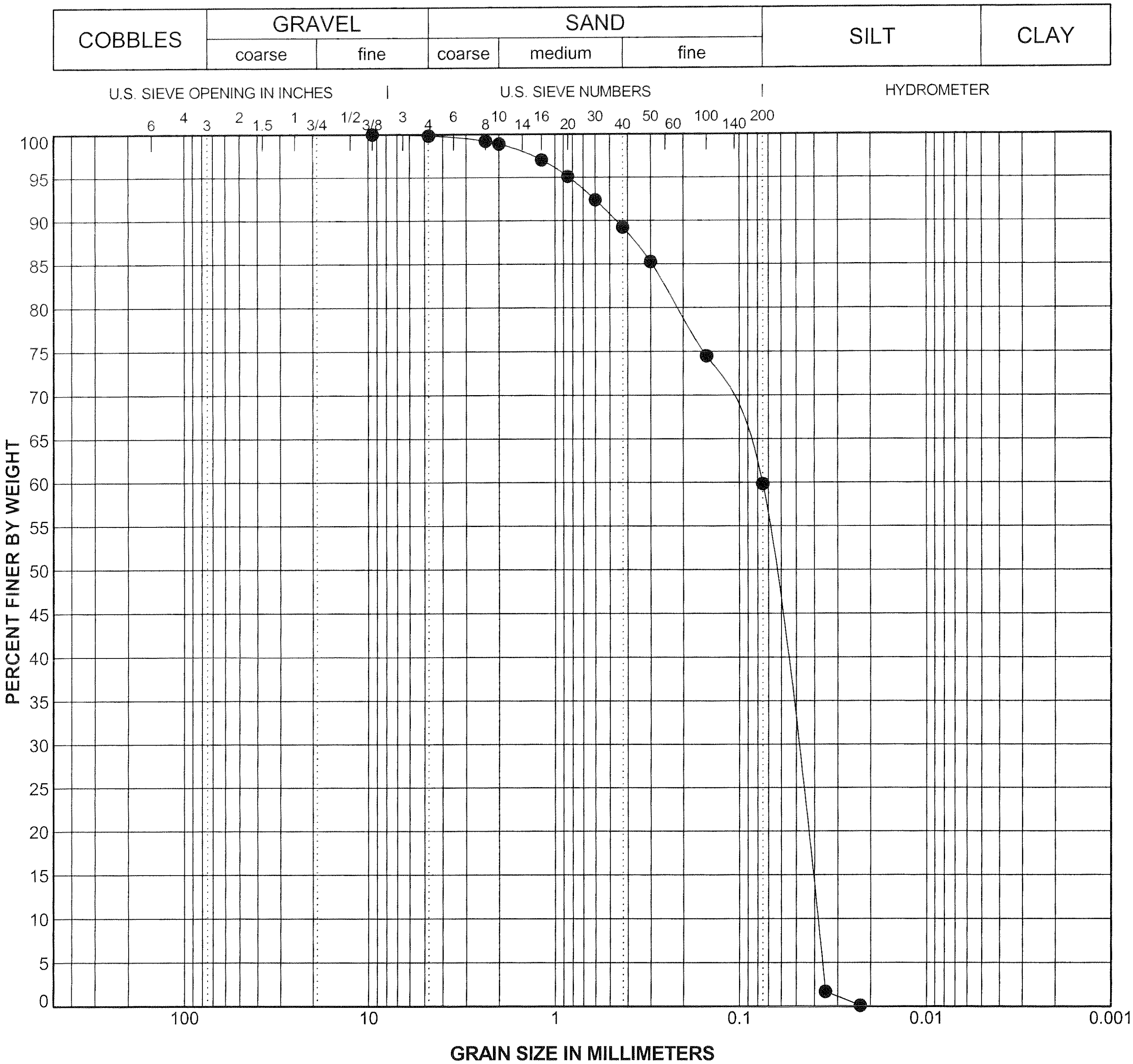
MACTEC_GRAIN_SIZE 3143101317.02.GPJ LAW_GIBB.GDT 9/1/10



Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	B-2T	14.0-16.0	Black, CCW (FLY ASH)	ML	9.5	0.076	0.051	0.039	0.87	1.94

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

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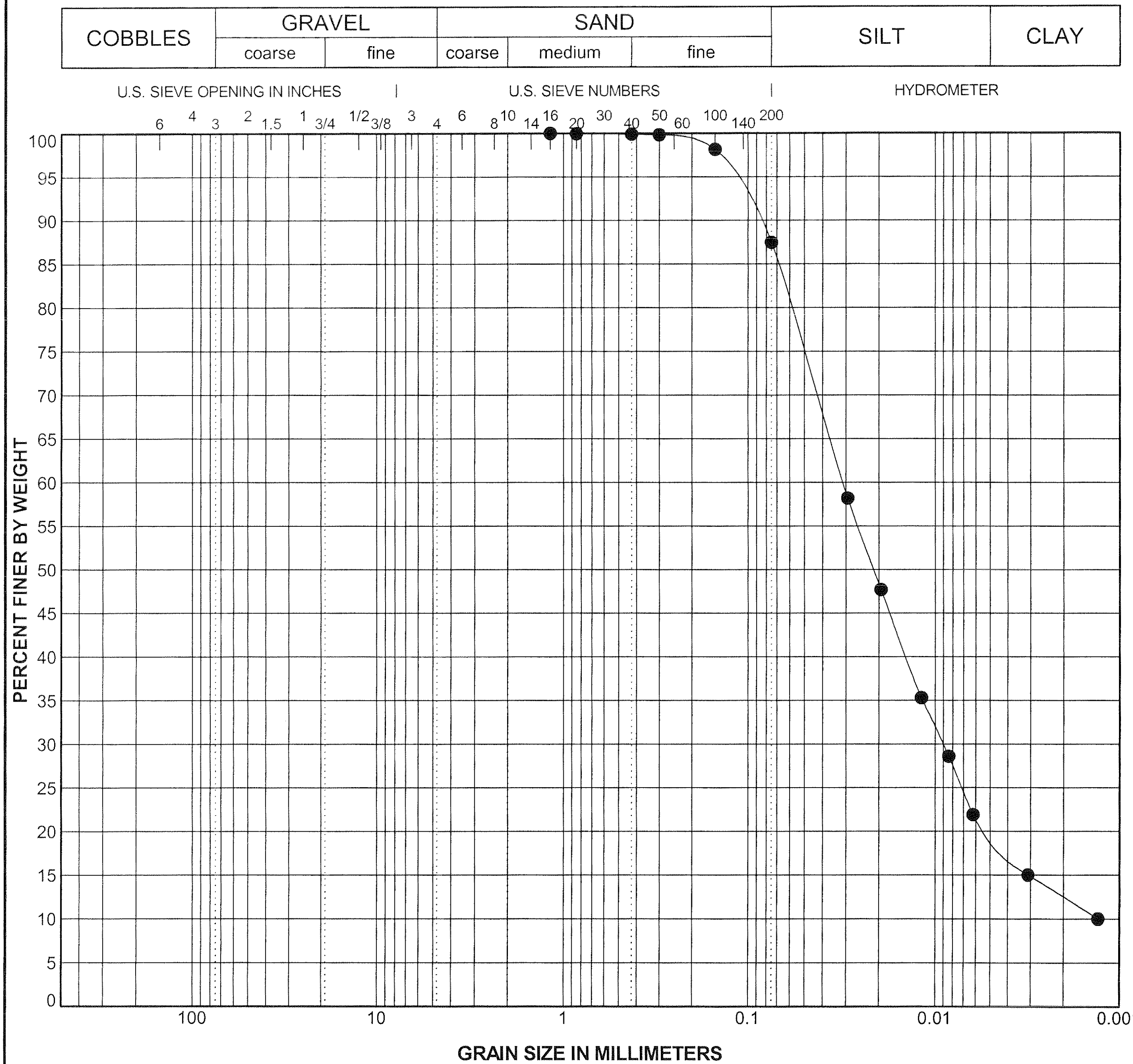
MACTEC

MACTEC_GRAIN_SIZE 3143101317.02.GPJ LAW_GIBB.GDT 9/1/10



Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	B-3C	14.0-16.0	Brown, lean CLAY	CL	1.18	0.031	0.009	0.001	2.01	23.96

MACTEC_GRAIN_SIZE 3143101317.02.GPJ LAW_GIBB.GDT 8/27/10

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

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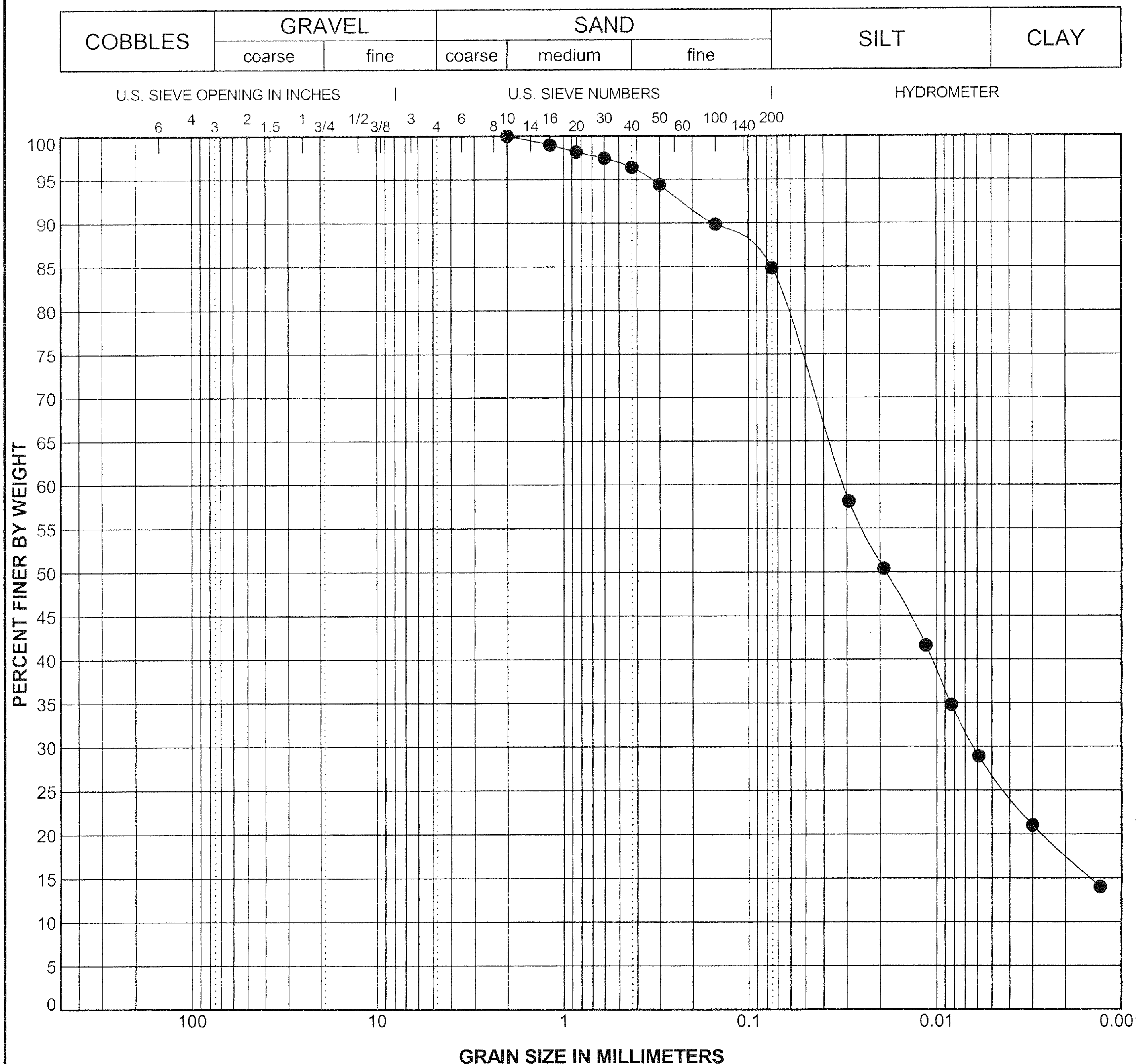

Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	B-3T	1.0-3.0	Yellowish brown, lean CLAY	CL	2	0.031	0.006			

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

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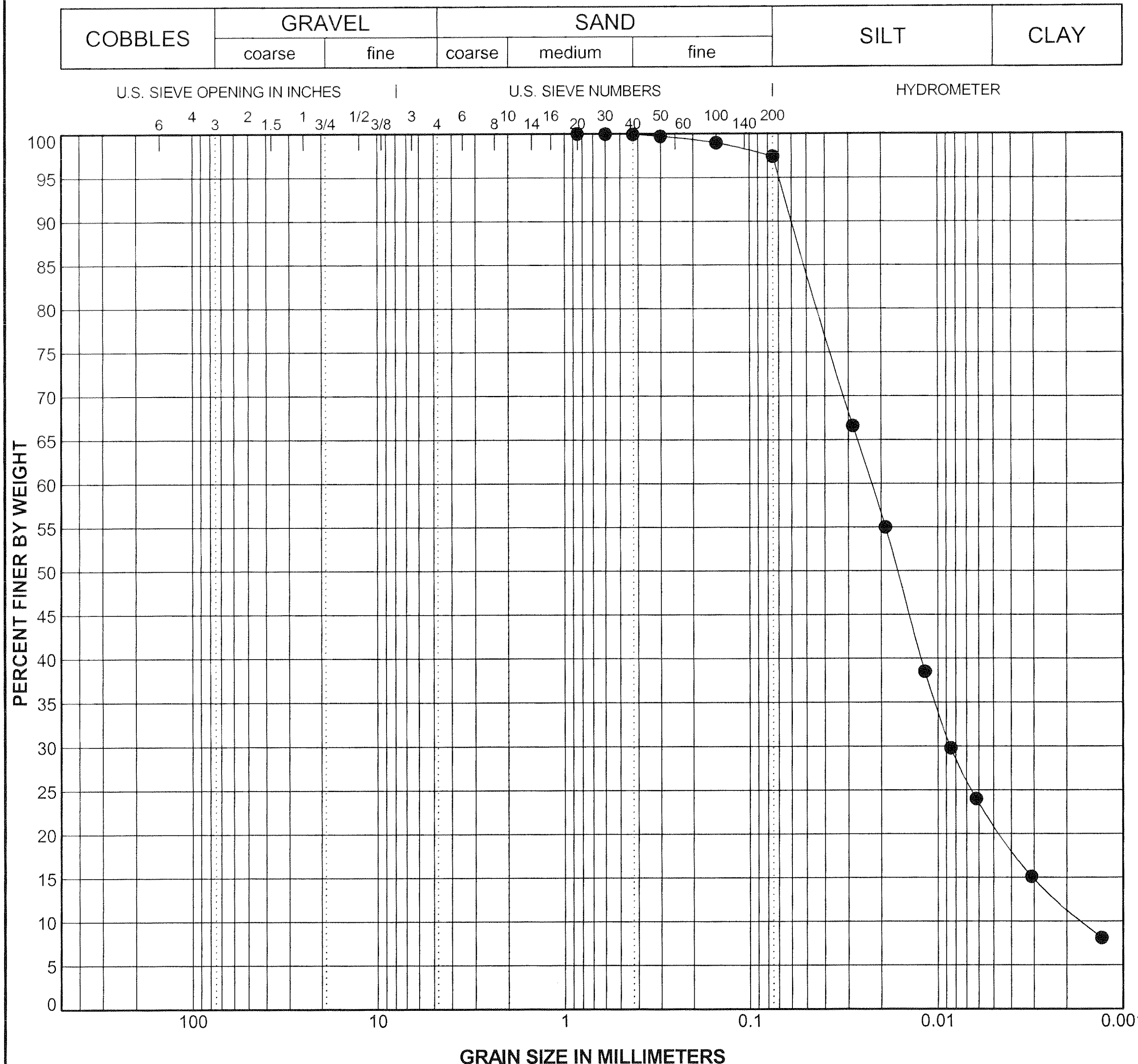
MACTEC

MACTEC_GRAIN_SIZE 3143101317.02.GPJ LAW_GIBB.GDT 8/27/10



Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	B-4T	10.5-12.5	Brown, lean CLAY	CL	0.85	0.023	0.009	0.002	1.97	13.73

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

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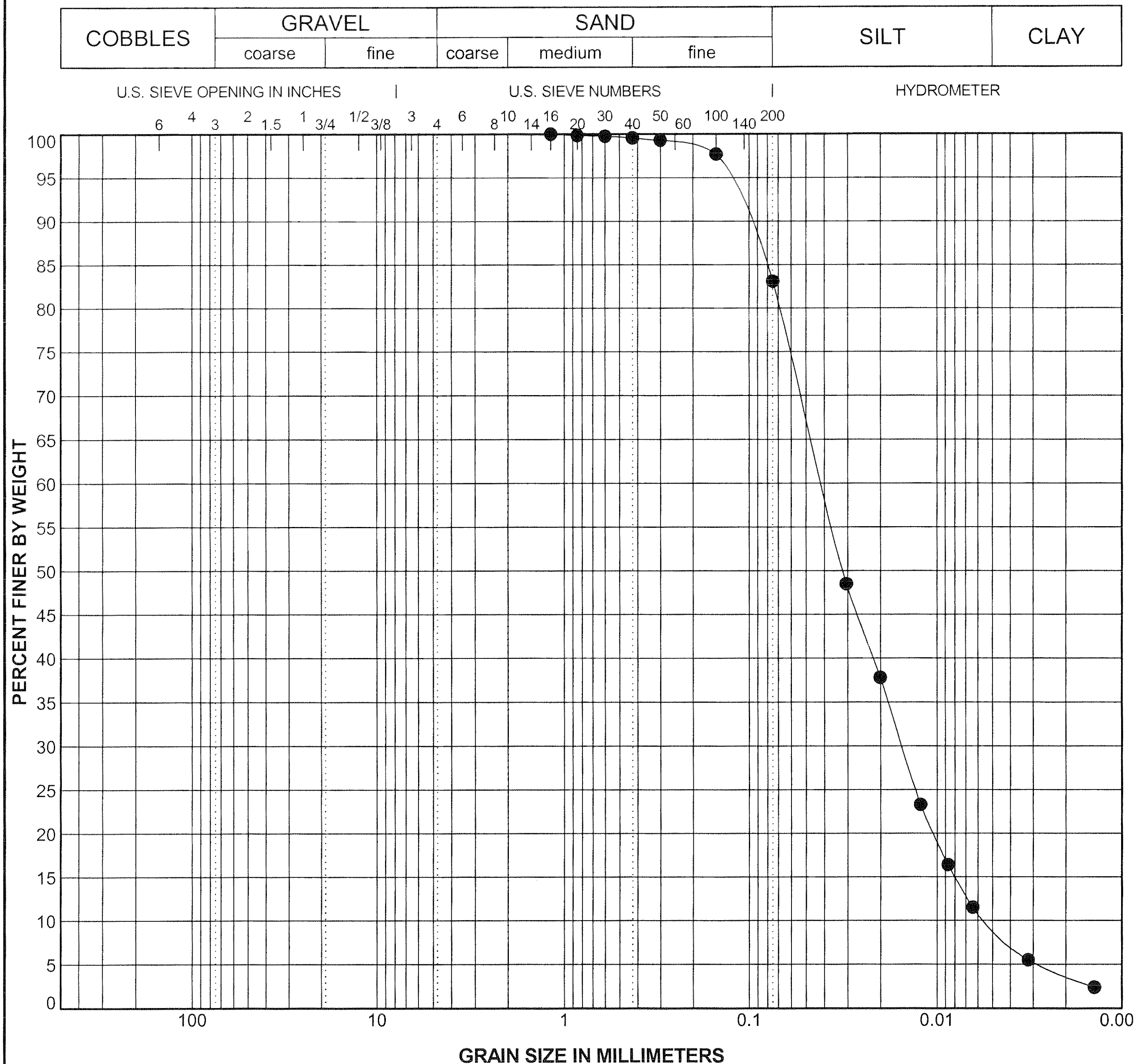

Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	B-8T	17.0-19.0	Brown, lean CLAY	CL	1.18	0.041	0.015	0.005	1.07	7.64

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: [signature]

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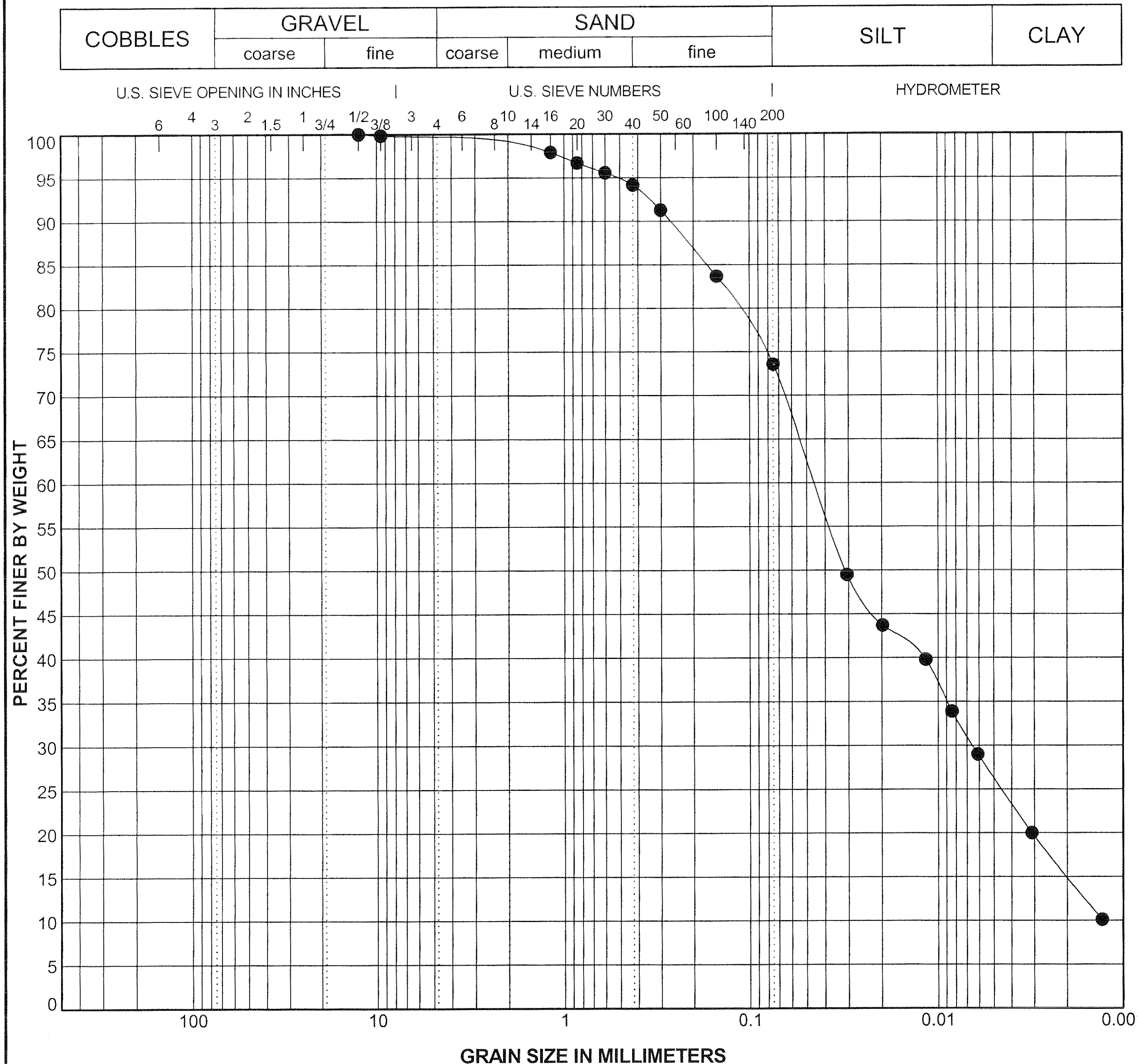


Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	B-9C	4.0-6.0	Reddish brown, lean CLAY	CL	12.5	0.045	0.007			

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

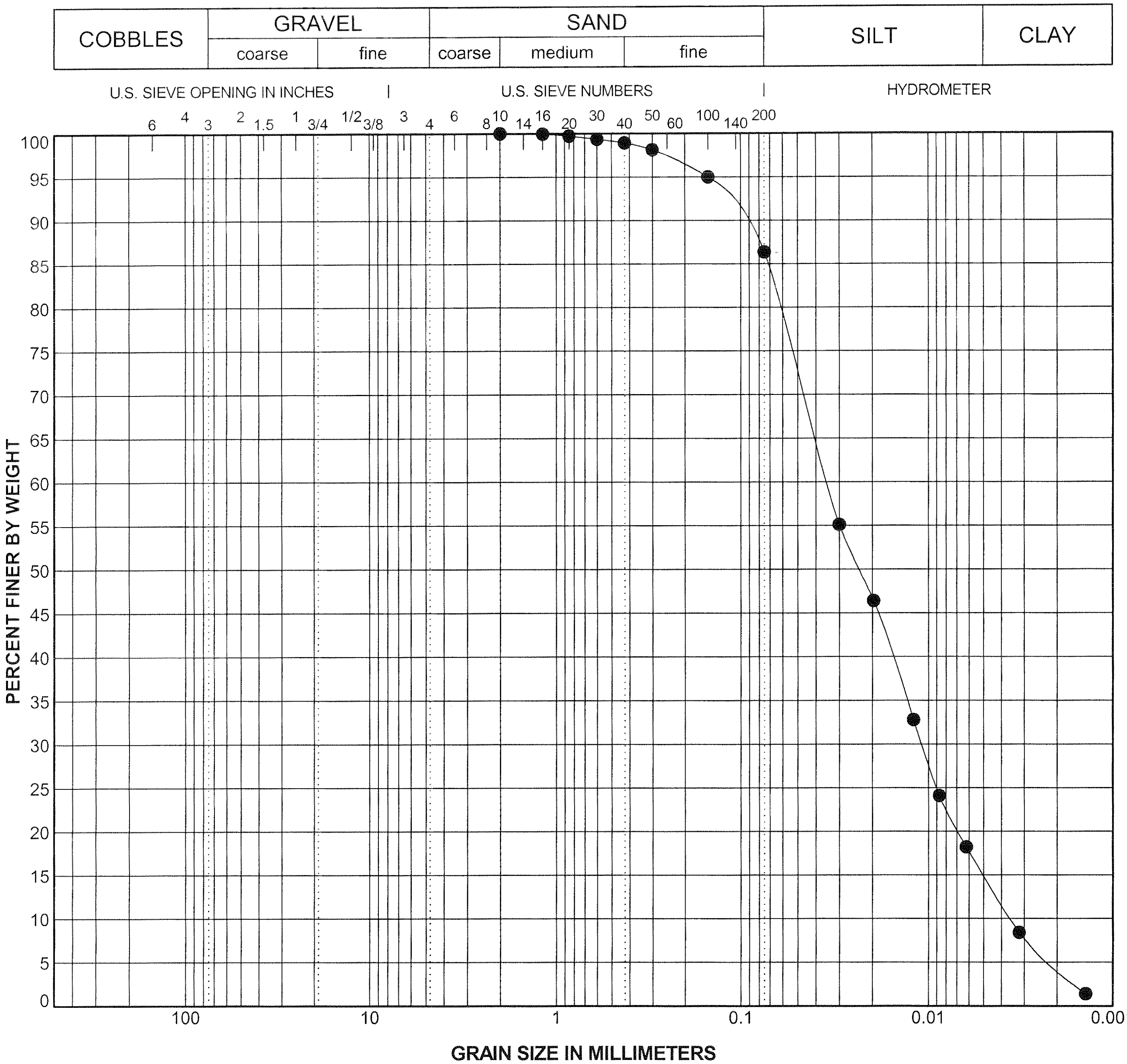
Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: [signature]

MACTEC

MACTEC_GRAIN_SIZE 3143101317.02.GPJ LAW_GIBB.GDT 8/27/10



Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	B-9T	2.0-4.0	Brown, lean CLAY	CL	2	0.035	0.011	0.004	0.95	9.72

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

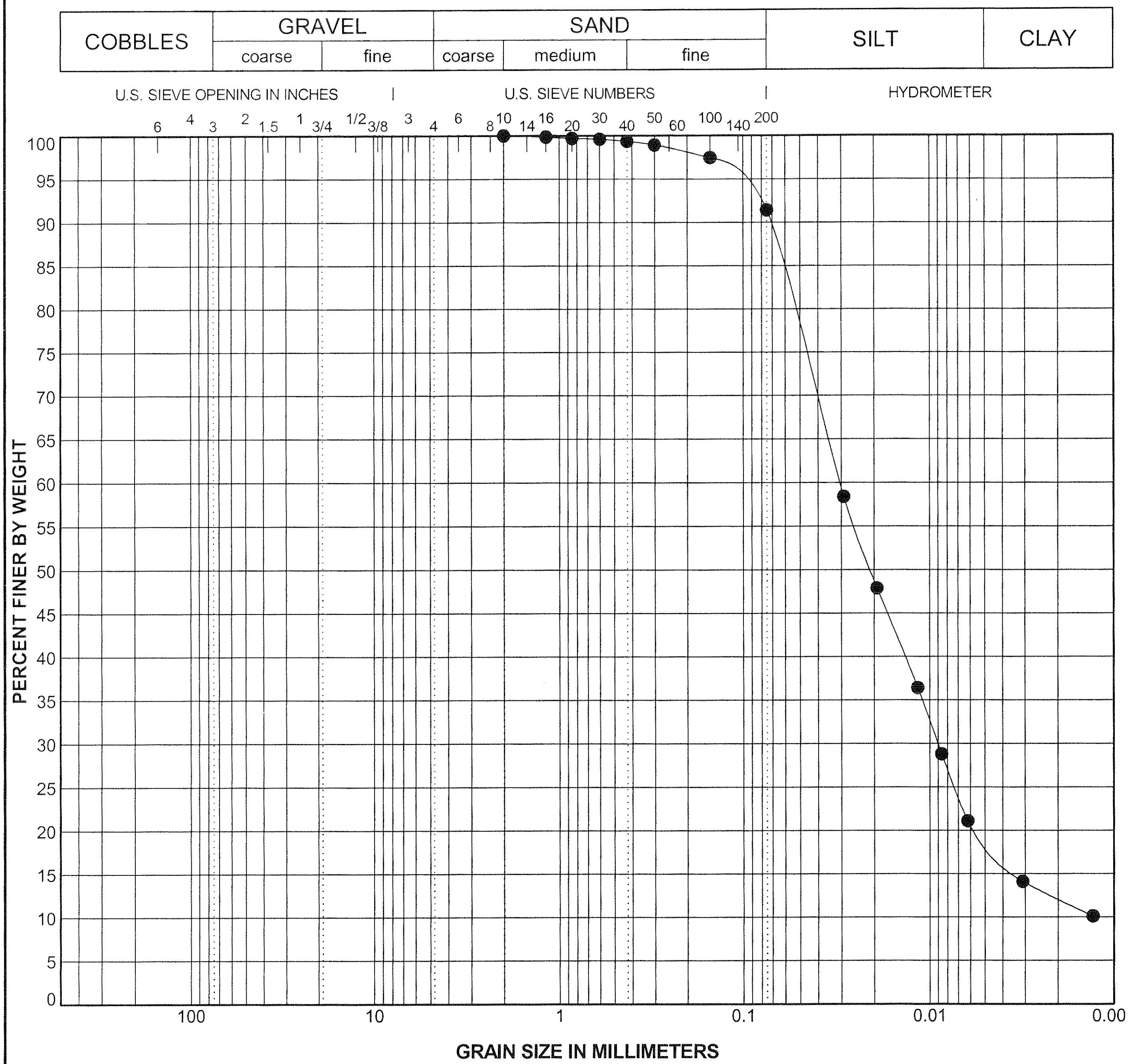
Project: E.ON U.S. - Green River Power Station

Project No: 3143-10-1317.02

Checked By: [signature]

MACTEC

MACTEC_GRAIN_SIZE 3143101317.02.GPJ LAW_GIBB.GDT 8/30/10



Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	B-10C	7.0-9.0	Yellowish brown, lean CLAY	CL	2	0.03	0.009			

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

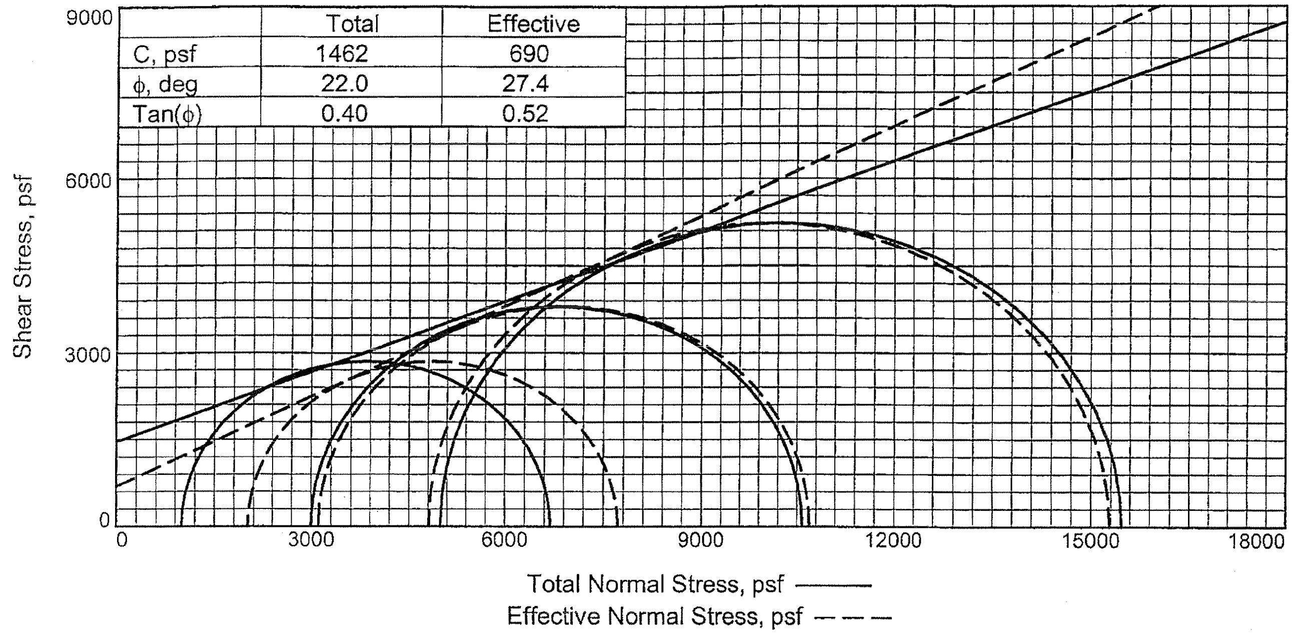
Project: E.ON U.S. - Green River Power Station

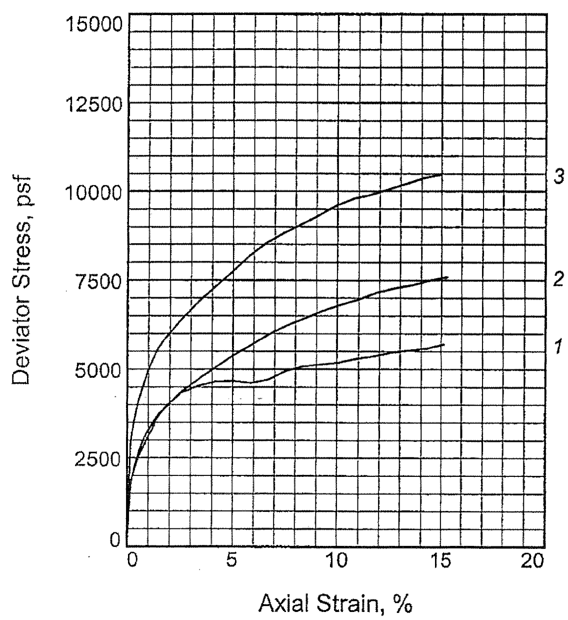
Project No: 3143-10-1317.02

Checked By: ____

MACTEC

TRIAXIAL SHEAR TEST RESULTS





Sample No.		1	2	3
Initial	Water Content, %	24.7	24.7	23.8
	Dry Density, pcf	99.8	99.5	100.6
	Saturation, %	99.7	98.6	97.8
	Void Ratio	0.6570	0.6631	0.6447
	Diameter, in.	2.85	2.85	2.83
	Height, in.	6.08	6.00	6.14
At Test	Water Content, %	24.6	24.0	23.2
	Dry Density, pcf	100.1	101.1	102.5
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.6532	0.6370	0.6136
	Diameter, in.	2.88	2.85	2.82
	Height, in.	5.96	5.89	6.04
Strain rate, in./min.		0.01	0.01	0.01
Back Pressure, psf		8640	8640	8640
Cell Pressure, psf		9634	11635	13637
Fail. Stress, psf		5701	7591	10469
Total Pore Pr., psf		7618	8525	8827
Ult. Stress, psf				
Total Pore Pr., psf				
$\bar{\sigma}_1$ Failure, psf		7717	10702	15279
$\bar{\sigma}_3$ Failure, psf		2016	3110	4810

Type of Test:
CU with Pore Pressures
Sample Type: Undisturbed
Description: Lean Clay

LL= 37 **PL=** 19 **PI=** 18
Assumed Specific Gravity= 2.65
Remarks:

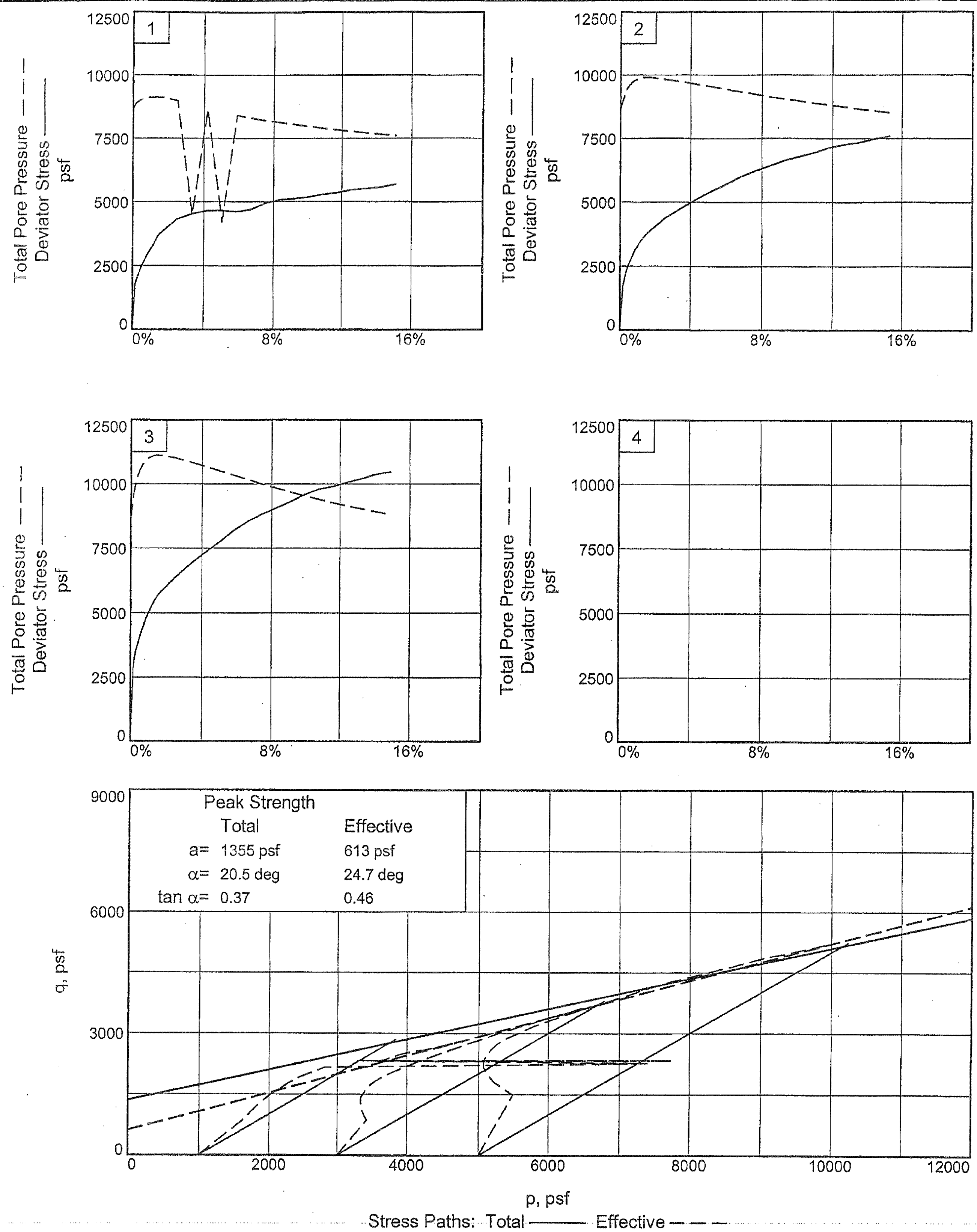
Client: E. ON U.S. Services, Inc.

Project: Green River Power Station

Location: B-3T
Depth: 5.5-7.5
Proj. No.: 314310131702 **Date Sampled:** 9-7-10

TRIAXIAL SHEAR TEST REPORT
MACTEC Engineering and Consulting, Inc.
Charlotte, North Carolina

Tested By: J Alexander **Checked By:** D Kopitsky



Peak Strength

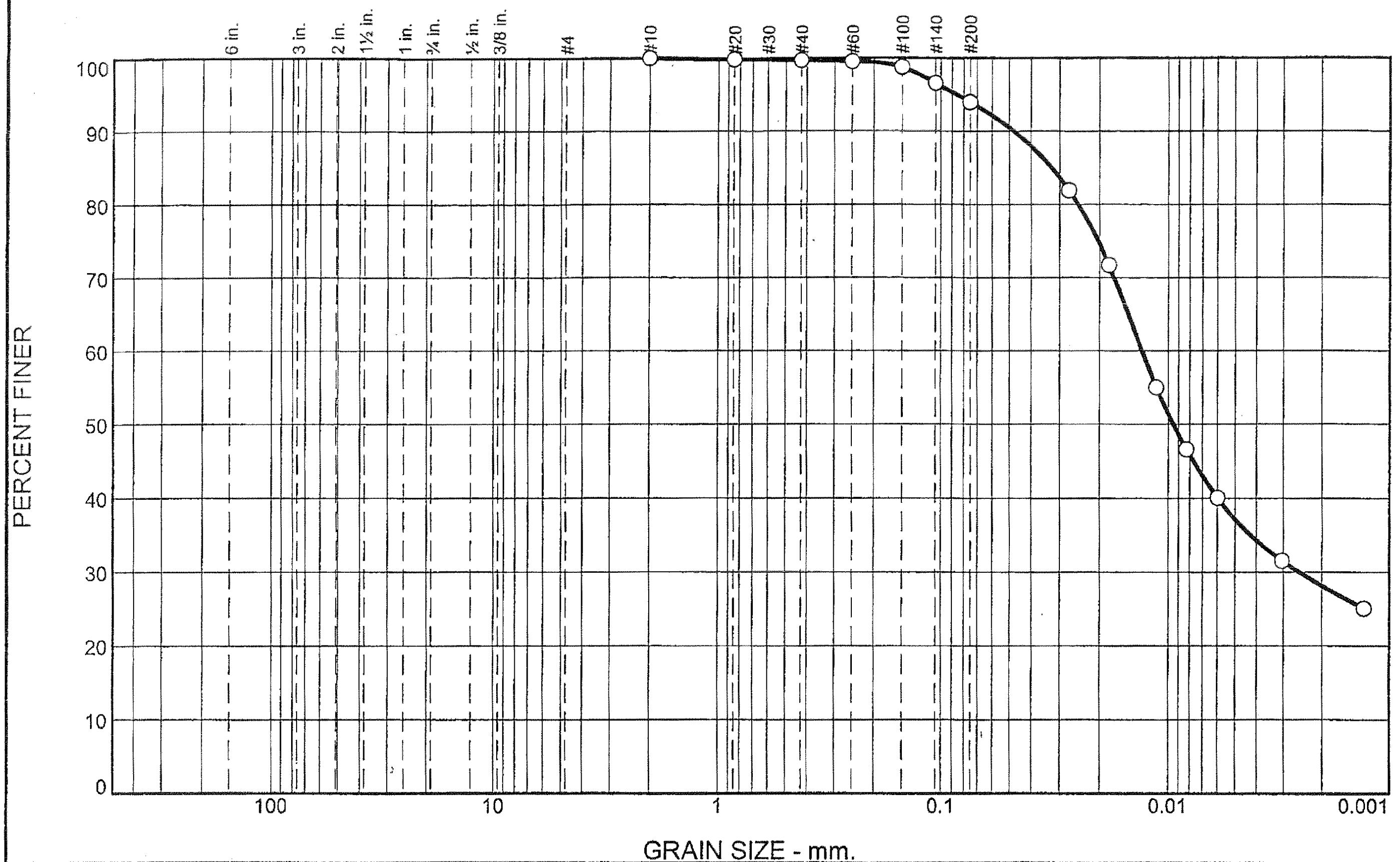
	Total	Effective
a=	1355 psf	613 psf
α=	20.5 deg	24.7 deg
tan α=	0.37	0.46

Client: E. ON U.S. Services, Inc.
Project: Green River Power Station
Location: B-3T **Depth:** 5.5-7.5
Project No.: 314310131702

MACTEC Engineering and Consulting, Inc.

Tested By: J Alexander **Checked By:** D Kopitsky

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.3	5.7	56.8	37.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.9		
#40	99.7		
#60	99.6		
#100	98.8		
#140	96.6		
#200	94.0		
0.0273 mm.	82.0		
0.0182 mm.	71.7		
0.0113 mm.	55.0		
0.0083 mm.	46.6		
0.0060 mm.	40.1		
0.0030 mm.	31.6		
0.0013 mm.	25.1		

* (no specification provided)

Soil Description

Lean Clay

Atterberg Limits

PL= 19 LL= 37 PI= 18

Coefficients

D_{90}= 0.0476 D_{85}= 0.0324 D_{60}= 0.0131
D_{50}= 0.0095 D_{30}= 0.0025 D_{15}=
D_{10}= C_u= C_c=

Classification

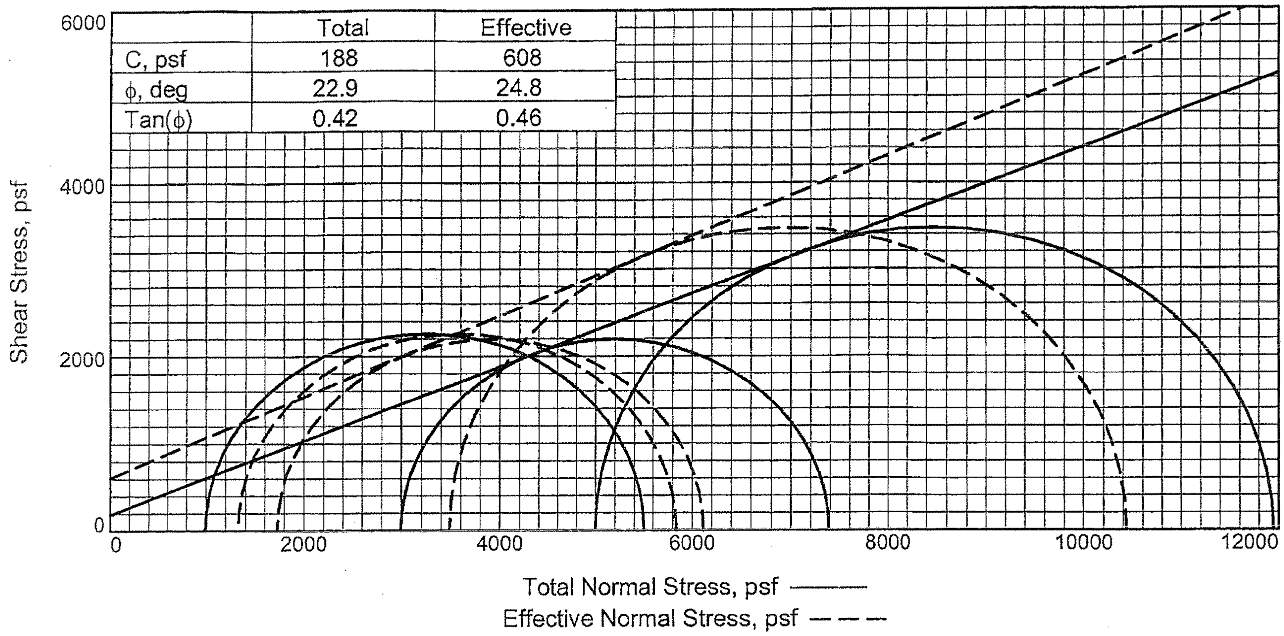
USCS= CL AASHTO= A-6(17)

Remarks

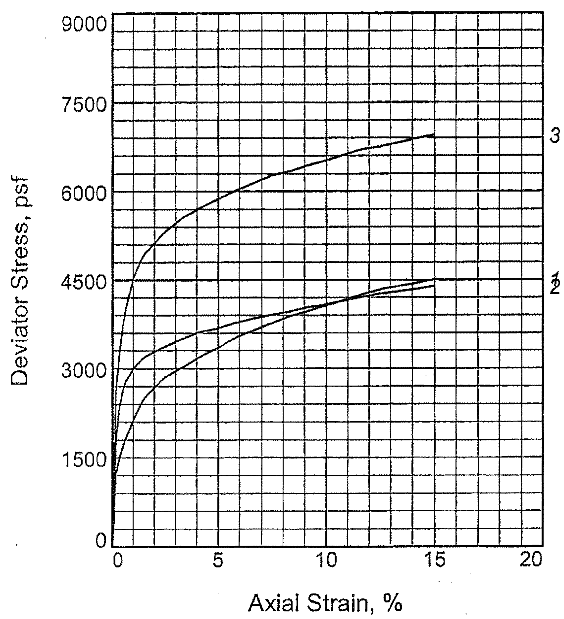
Location: B-3T
Depth: 5.5-7.5
Date: 9-7-10

MACTEC Engineering and Consulting, Inc. Charlotte, North Carolina	**Client:** E. ON U.S. Services, Inc. **Project:** Green River Power Station **Project No:** 314310131702

Tested By: J Alexander **Checked By:** D Kopitsky



	Total	Effective
C, psf	188	608
ϕ, deg	22.9	24.8
Tan(ϕ)	0.42	0.46



	Sample No.	1	2	3
Initial	Water Content, %	19.9	26.6	21.7
	Dry Density, pcf	107.4	96.4	103.3
	Saturation, %	97.7	98.6	95.5
	Void Ratio	0.5401	0.7154	0.6010
	Diameter, in.	2.83	2.84	2.82
	Height, in.	6.02	6.13	6.13
At Test	Water Content, %	20.6	23.4	21.3
	Dry Density, pcf	107.1	102.1	105.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5452	0.6195	0.5647
	Diameter, in.	2.85	2.78	2.81
	Height, in.	5.96	6.03	6.02
	Strain rate, in./min.	0.01	0.01	0.01
	Back Pressure, psf	8640	8640	8640
	Cell Pressure, psf	9634	11635	13637
	Fail. Stress, psf	4512	4390	6951
	Total Pore Pr., psf	8309	9907	10152
	Ult. Stress, psf			
	Total Pore Pr., psf			
	$\bar{\sigma}_1$ Failure, psf	5837	6118	10436
	$\bar{\sigma}_3$ Failure, psf	1325	1728	3485

Type of Test:
CU with Pore Pressures

Sample Type: Undisturbed

Description: Lean Clay

LL= 41 **PL=** 18 **PI=** 23

Assumed Specific Gravity= 2.65

Remarks:

Client: E. ON U.S. Services, Inc.

Project: Green River Power Station

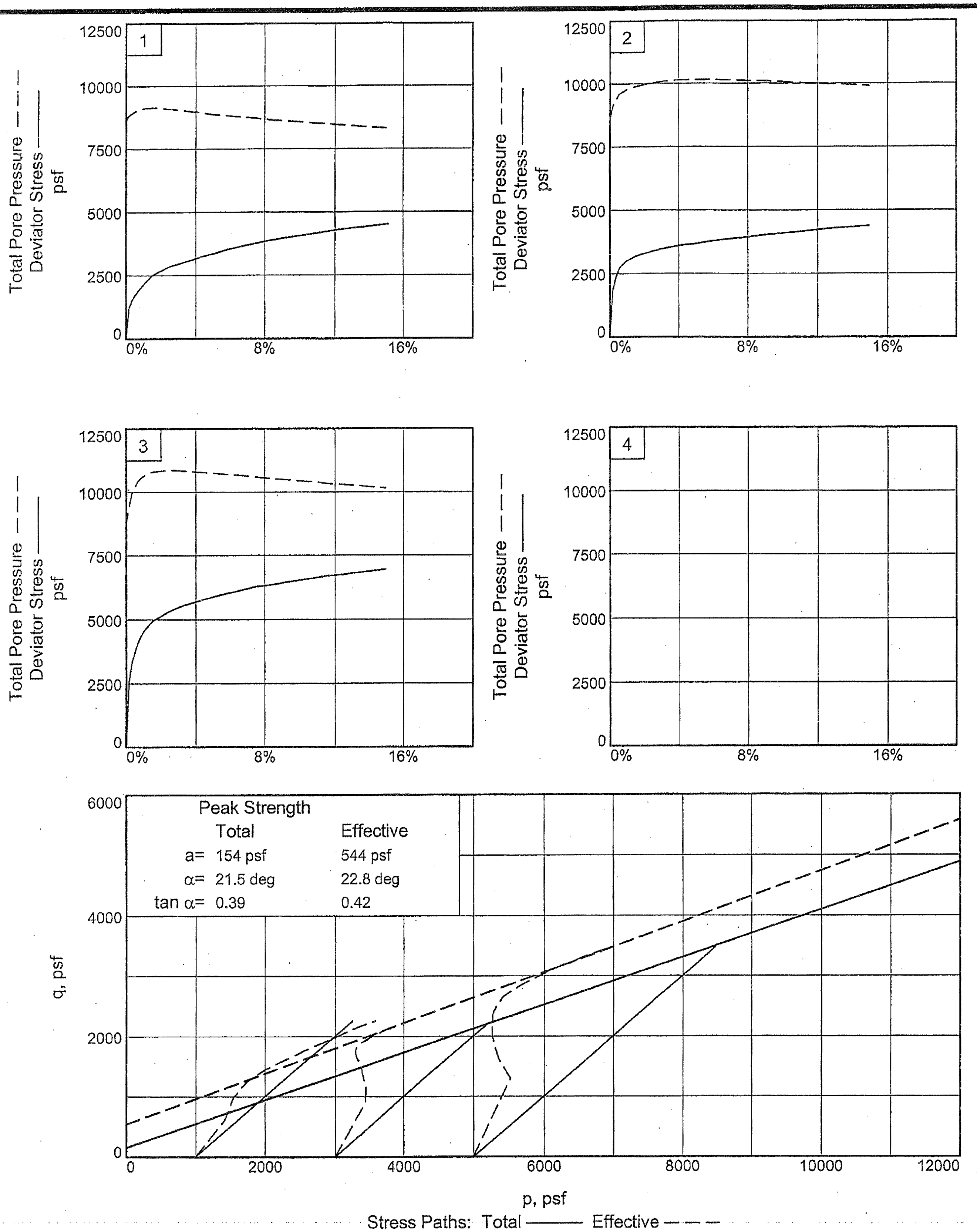
Location: B-4C

Depth: 3-5

Proj. No.: 314310131702 **Date Sampled:** 9-7-10

TRIAXIAL SHEAR TEST REPORT
MACTEC Engineering and Consulting, Inc.
Charlotte, North Carolina

Tested By: J Alexander **Checked By:** D Kopitsky

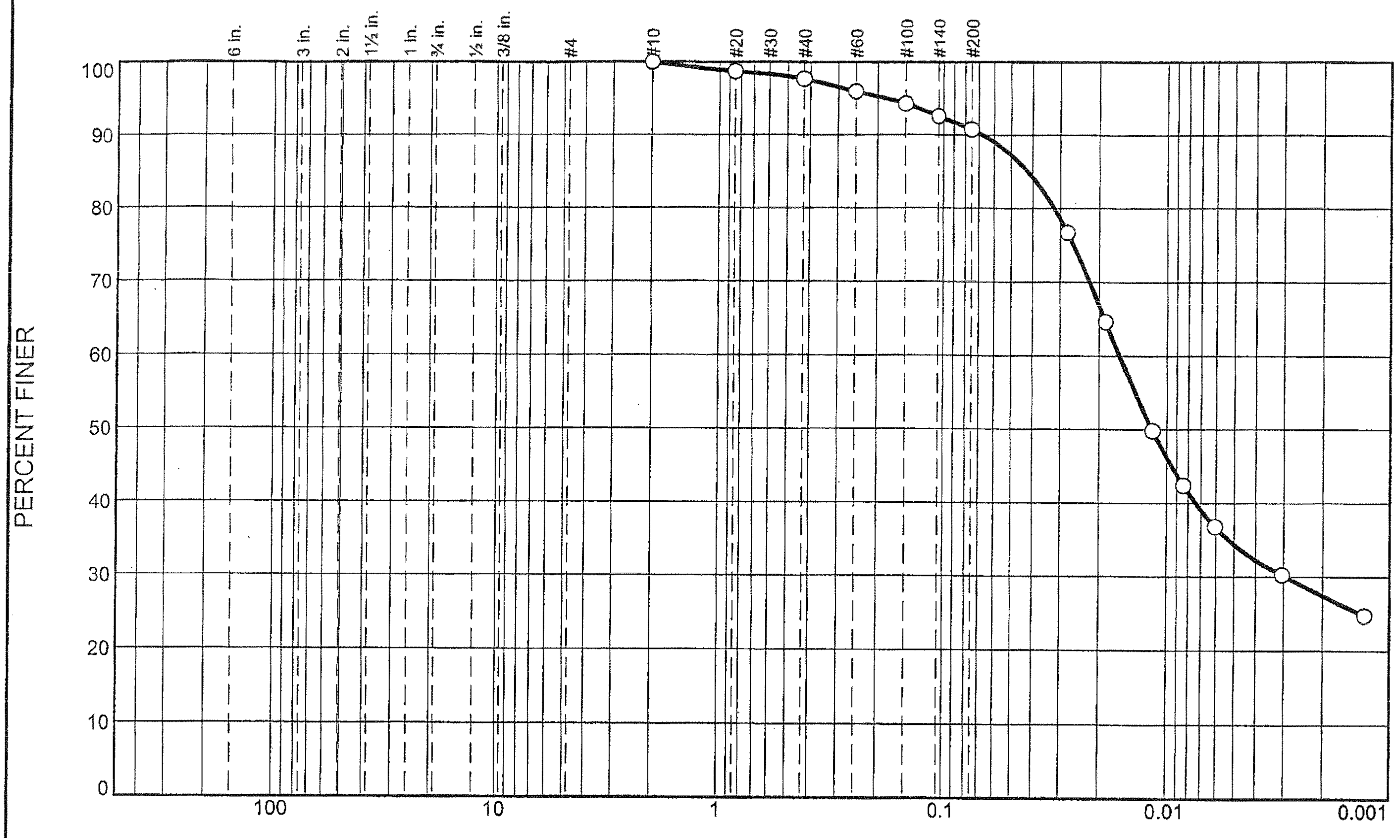


Client: E. ON U.S. Services, Inc.
Project: Green River Power Station
Location: B-4C **Depth:** 3-5
Project No.: 314310131702

MACTEC Engineering and Consulting, Inc.

Tested By: J Alexander **Checked By:** D Kopitsky

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	2.3	6.9	56.4	34.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	98.7		
#40	97.7		
#60	96.0		
#100	94.3		
#140	92.6		
#200	90.8		
0.0278 mm.	76.7		
0.0187 mm.	64.6		
0.0115 mm.	49.8		
0.0084 mm.	42.4		
0.0061 mm.	36.8		
0.0031 mm.	30.3		
0.0013 mm.	24.8		

* (no specification provided)

Soil Description

Lean Clay

Atterberg Limits

PL= 18 LL= 41 PI= 23

Coefficients

D_{90}= 0.0670 D_{85}= 0.0420 D_{60}= 0.0162
D_{50}= 0.0116 D_{30}= 0.0029 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-7-6(21)

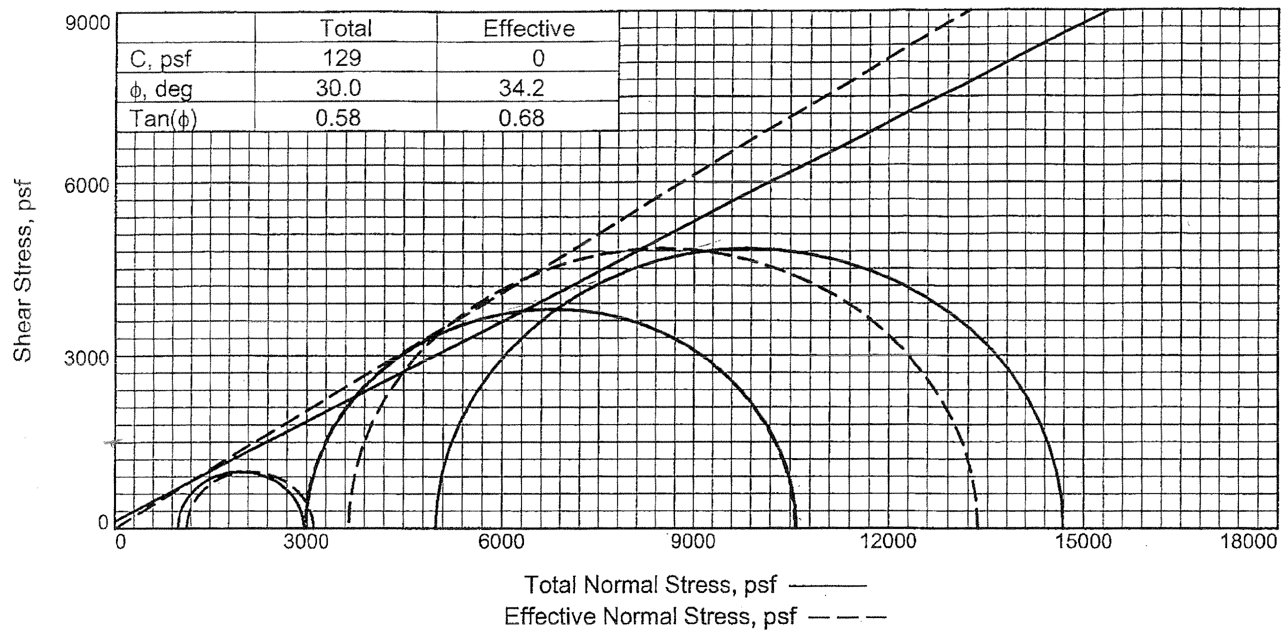
Remarks

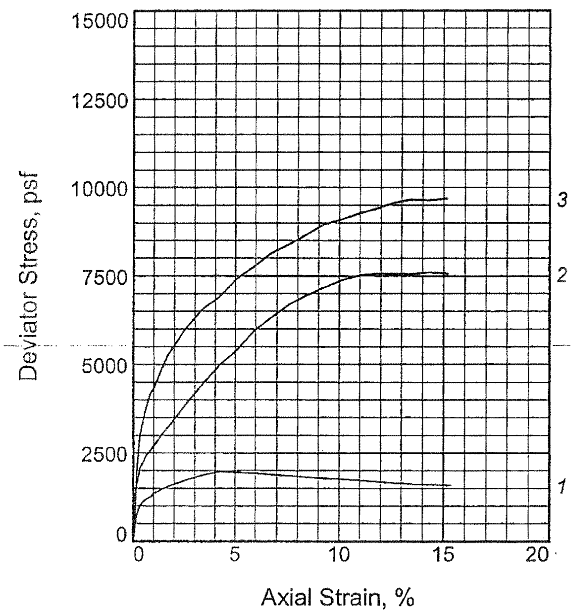
Location: B-4C
Depth: 3-5

Date: 9-7-10

MACTEC Engineering and Consulting, Inc. Charlotte, North Carolina	**Client:** E. ON U.S. Services, Inc. **Project:** Green River Power Station **Project No:** 314310131702

Tested By: J Alexander **Checked By:** D Kopitsky





Sample No.		1	2	3
Initial	Water Content, %	23.8	18.6	19.4
	Dry Density, pcf	101.5	110.3	108.5
	Saturation, %	100.0	98.5	97.8
	Void Ratio	0.6296	0.4997	0.5250
	Diameter, in.	2.84	2.84	2.83
	Height, in.	6.03	6.03	6.06
At Test	Water Content, %	24.0	18.4	18.1
	Dry Density, pcf	101.1	111.1	111.8
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.6362	0.4885	0.4804
	Diameter, in.	2.89	2.86	2.82
	Height, in.	5.87	5.92	5.94
Strain rate, in./min.		0.00	0.00	0.00
Back Pressure, psf		8640	8640	8640
Cell Pressure, psf		9634	11635	13637
Fail. Stress, psf		1972	7603	9690
Total Pore Pr., psf		8496	8654	9979
Ult. Stress, psf				
Total Pore Pr., psf				
$\bar{\sigma}_1$ Failure, psf		3109	10584	13348
$\bar{\sigma}_3$ Failure, psf		1138	2981	3658

Type of Test: CU with Pore Pressures

Sample Type: Undisturbed

Description: lean clay

LL= 45 **PL=** 20 **PI=** 25

Assumed Specific Gravity= 2.65

Remarks:

Client: E. ON U.S. Services, Inc.

Project: Green River Power Station

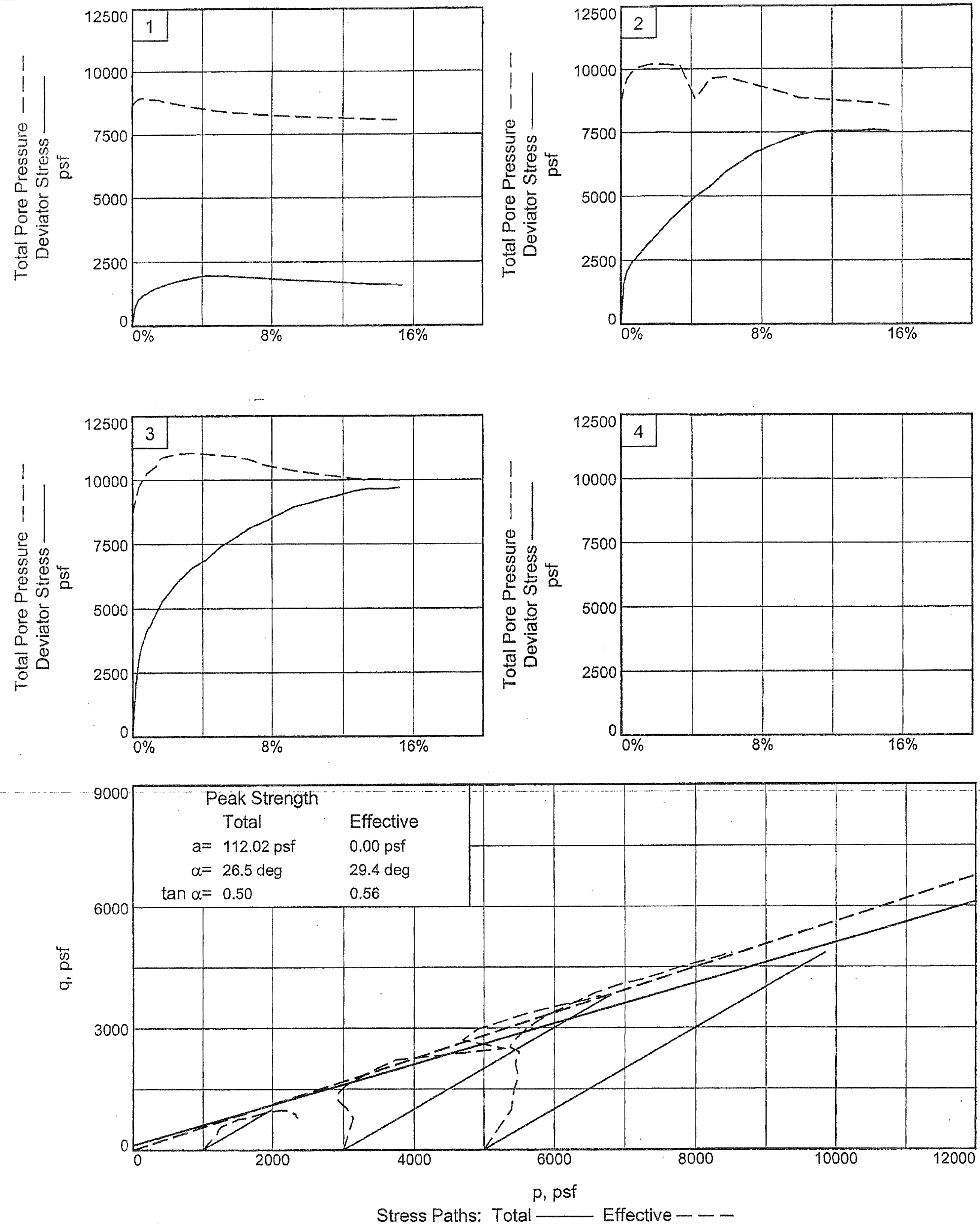
Location: B-4C

Depth: 10.5-12.5

Proj. No.: 314310131702 **Date Sampled:** 8-18-10

TRIAXIAL SHEAR TEST REPORT
MACTEC Engineering and Consulting, Inc.
Charlotte, North Carolina

Tested By: J. Alexander **Checked By:** D. Kopitsky

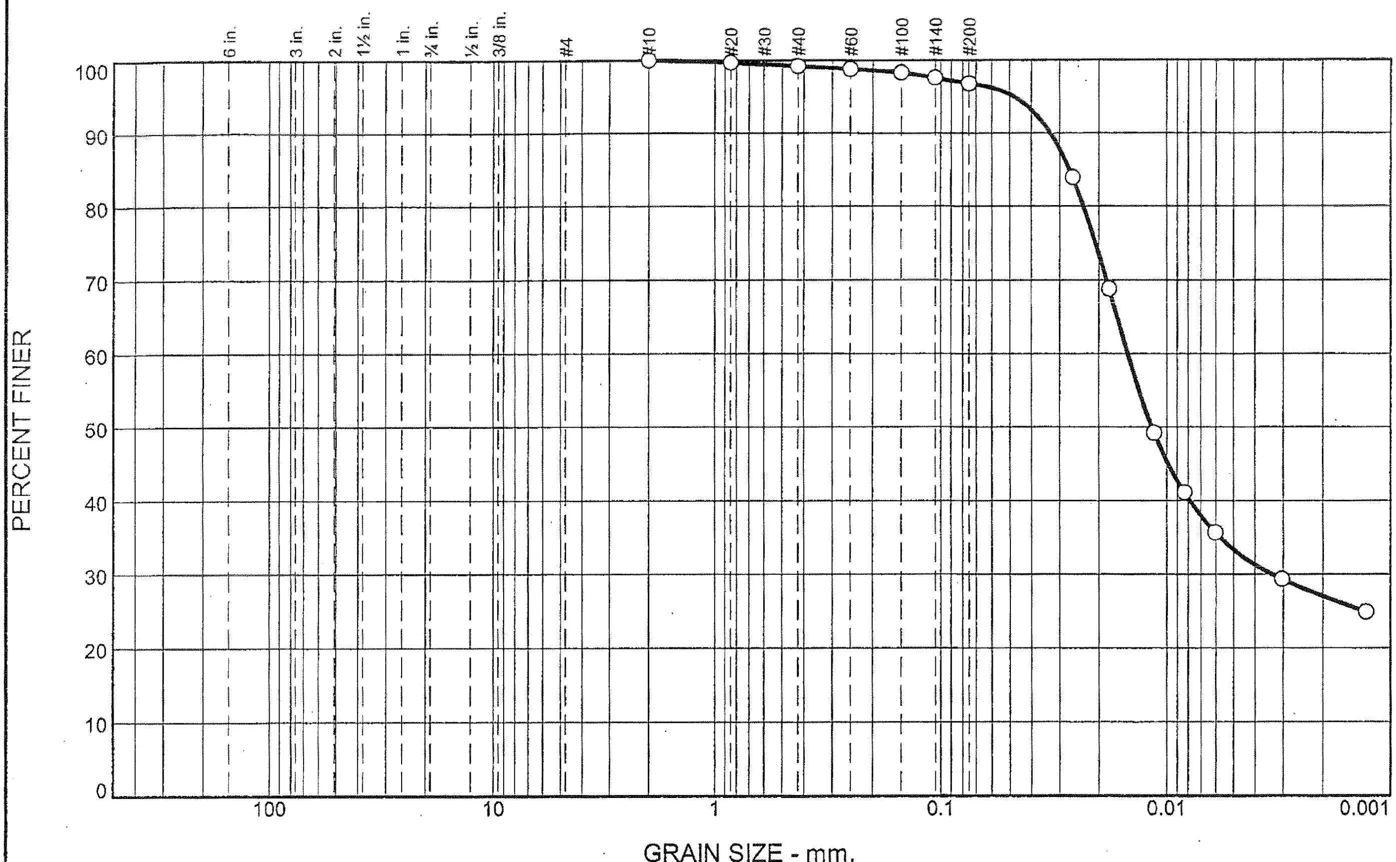


Client: E. ON U.S. Services, Inc.
Project: Green River Power Station
Location: B-4C **Depth:** 10.5-12.5
Project No.: 314310131702

MACTEC Engineering and Consulting, Inc.

Tested By: J. Alexander **Checked By:** D. Kopitsky

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.8	2.4	63.4	33.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.7		
#40	99.2		
#60	98.8		
#100	98.3		
#140	97.6		
#200	96.8		
0.0262 mm.	84.0		
0.0180 mm.	68.8		
0.0114 mm.	49.2		
0.0083 mm.	41.2		
0.0060 mm.	35.7		
0.0030 mm.	29.4		
0.0013 mm.	24.9		

* (no specification provided)

Soil Description

lean clay

Atterberg Limits

PL= 20 LL= 45 PI= 25

Coefficients

D_{90}= 0.0329 D_{85}= 0.0270 D_{60}= 0.0148
D_{50}= 0.0116 D_{30}= 0.0033 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-7-6(26)

Remarks

Location: B-4C
Depth: 10.5-12.5

Date: 8-18-10

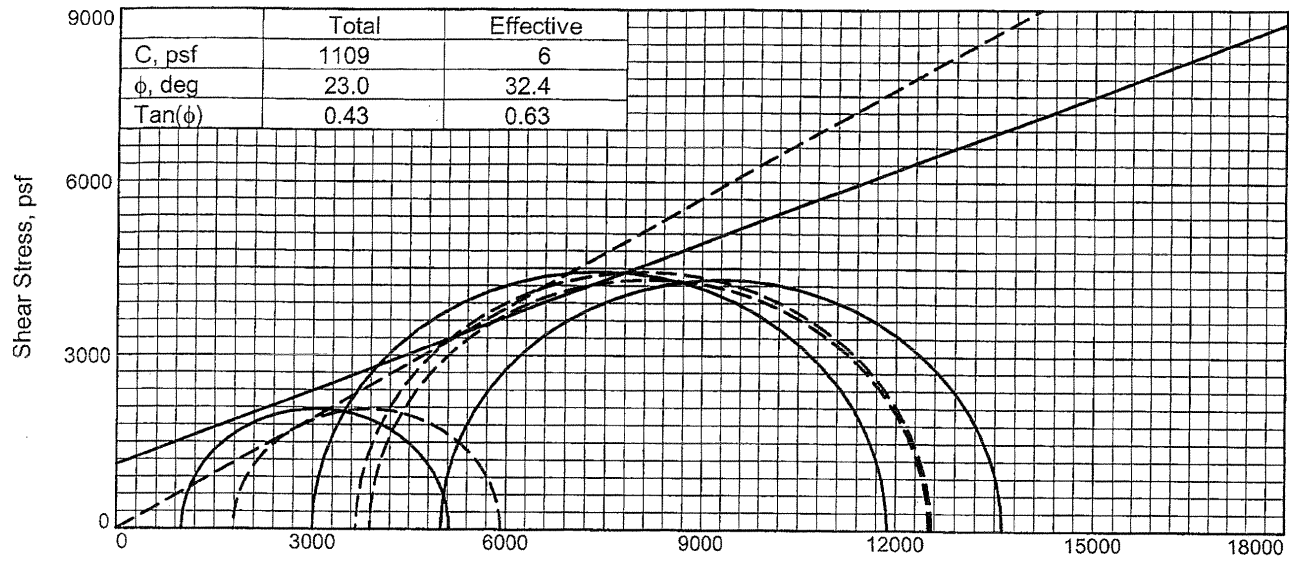
MACTEC Engineering and Consulting, Inc.

Charlotte, North Carolina

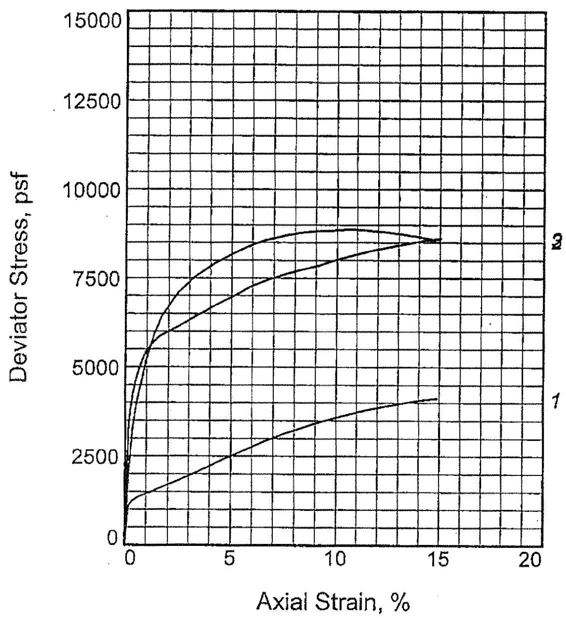
Client: E. ON U.S. Services, Inc.
Project: Green River Power Station
Project No: 314310131702

Tested By: J. Alexander Checked By: D. Kopitsky

8/23/10



	Total	Effective
C, psf	1109	6
ϕ, deg	23.0	32.4
Tan(ϕ)	0.43	0.63



	Sample No.	1	2	3
Initial	Water Content, %	22.3	20.1	19.9
	Dry Density, pcf	102.7	107.3	106.2
	Saturation, %	96.7	98.4	94.7
	Void Ratio	0.6108	0.5419	0.5570
	Diameter, in.	2.88	2.87	2.89
	Height, in.	6.09	6.15	6.04
At Test	Water Content, %	20.7	19.0	18.7
	Dry Density, pcf	106.8	110.1	110.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5486	0.5028	0.4947
	Diameter, in.	2.83	2.84	2.84
	Height, in.	6.04	6.11	5.99
	Strain rate, in./min.	0.00	0.00	0.01
	Back Pressure, psf	7200	7200	7200
	Cell Pressure, psf	8194	10195	12197
	Fail. Stress, psf	4134	8877	8617
	Total Pore Pr., psf	6408	6523	8309
	Ult. Stress, psf			
	Total Pore Pr., psf			
	$\bar{\sigma}_1$ Failure, psf	5919	12549	12505
	$\bar{\sigma}_3$ Failure, psf	1786	3672	3888

Type of Test:
CU with Pore Pressures

Sample Type: Undisturbed

Description: lean clay

LL= 29 **PL=** 16 **PI=** 13

Assumed Specific Gravity= 2.65

Remarks:

Client: E. ON U.S. Services, Inc.

Project: Green River Power Station

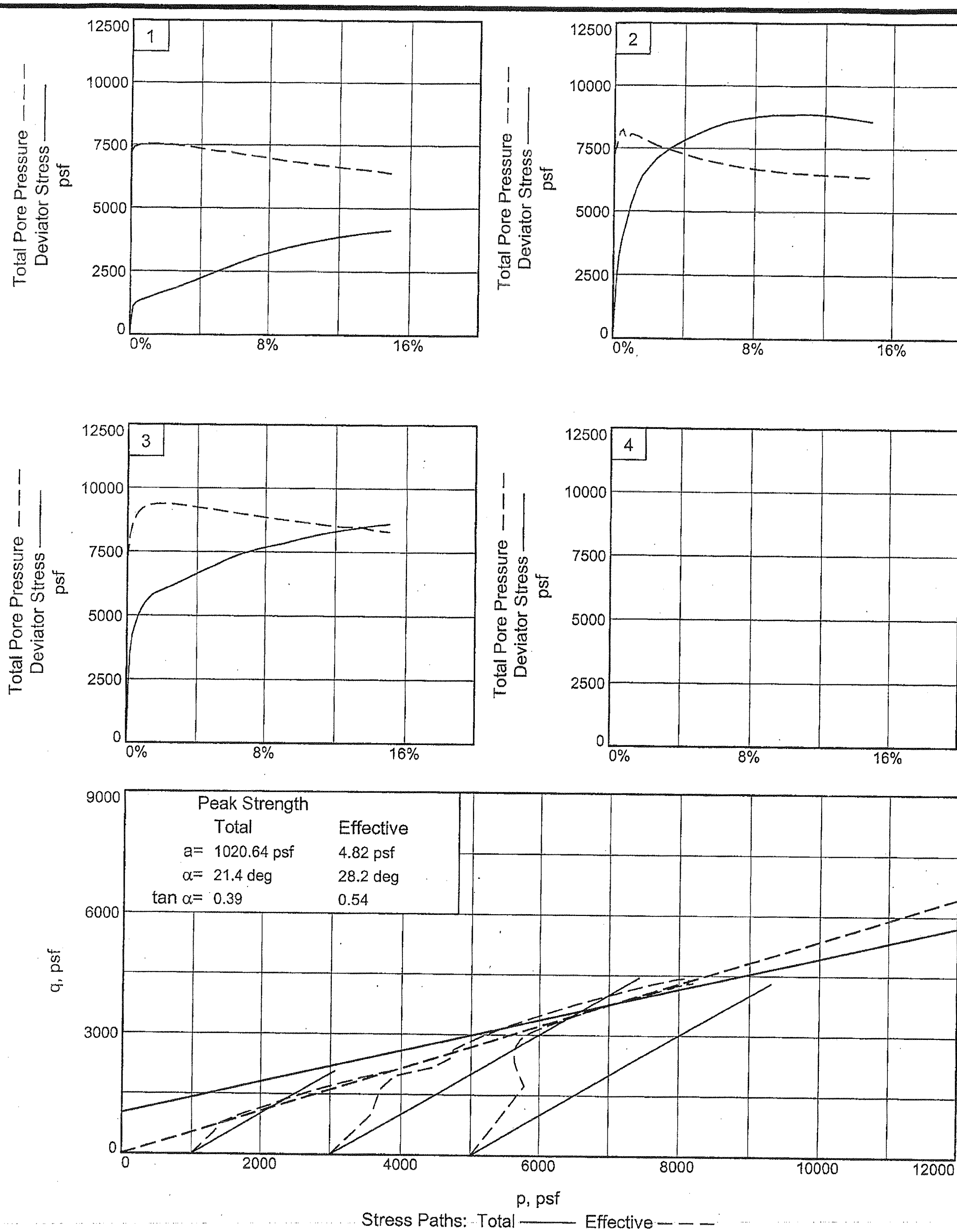
Location: B-4C

Depth: 25.5-27.5

Proj. No.: 314310131702 **Date Sampled:** 8-18-10

TRIAXIAL SHEAR TEST REPORT
MACTEC Engineering and Consulting, Inc.
Charlotte, North Carolina

Tested By: J. Alexander **Checked By:** D. Kopitsky

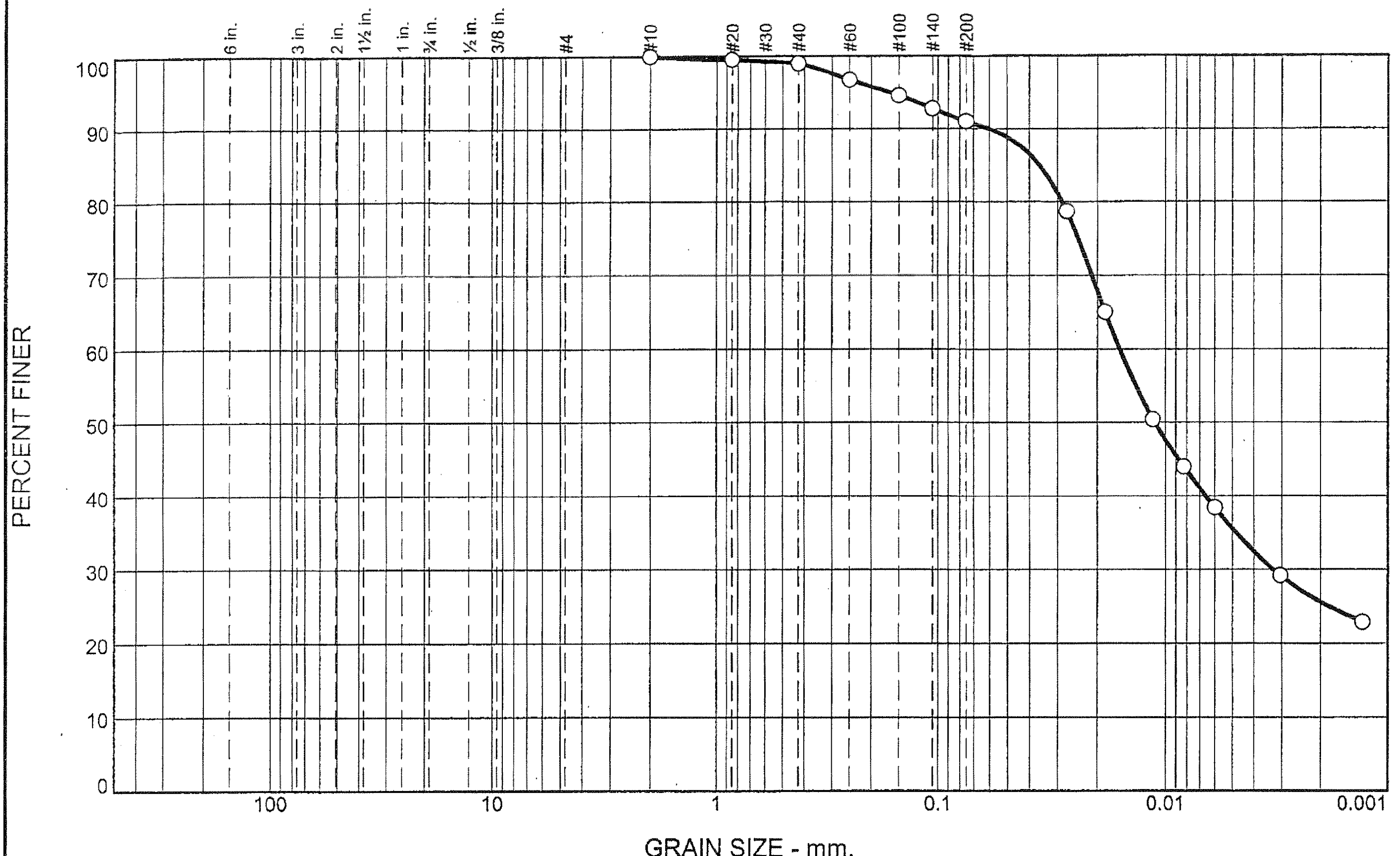


Client: E. ON U.S. Services, Inc.
Project: Green River Power Station
Location: B-4C **Depth:** 25.5-27.5
Project No.: 314310131702

MACTEC Engineering and Consulting, Inc.

Tested By: J. Alexander **Checked By:** D. Kopitsky

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.0	8.0	55.4	35.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.5		
#40	99.0		
#60	96.8		
#100	94.6		
#140	92.8		
#200	91.0		
0.0273 mm.	78.7		
0.0185 mm.	65.0		
0.0114 mm.	50.5		
0.0083 mm.	44.0		
0.0060 mm.	38.4		
0.0030 mm.	29.2		
0.0013 mm.	22.9		

* (no specification provided)

Soil Description

lean clay

Atterberg Limits

PL= 16 LL= 29 PI= 13

Coefficients

D_{90}= 0.0600 D_{85}= 0.0360 D_{60}= 0.0159
D_{50}= 0.0111 D_{30}= 0.0033 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(10)

Remarks

Location: B-4C
Depth: 25.5-27.5

Date: 8-18-10

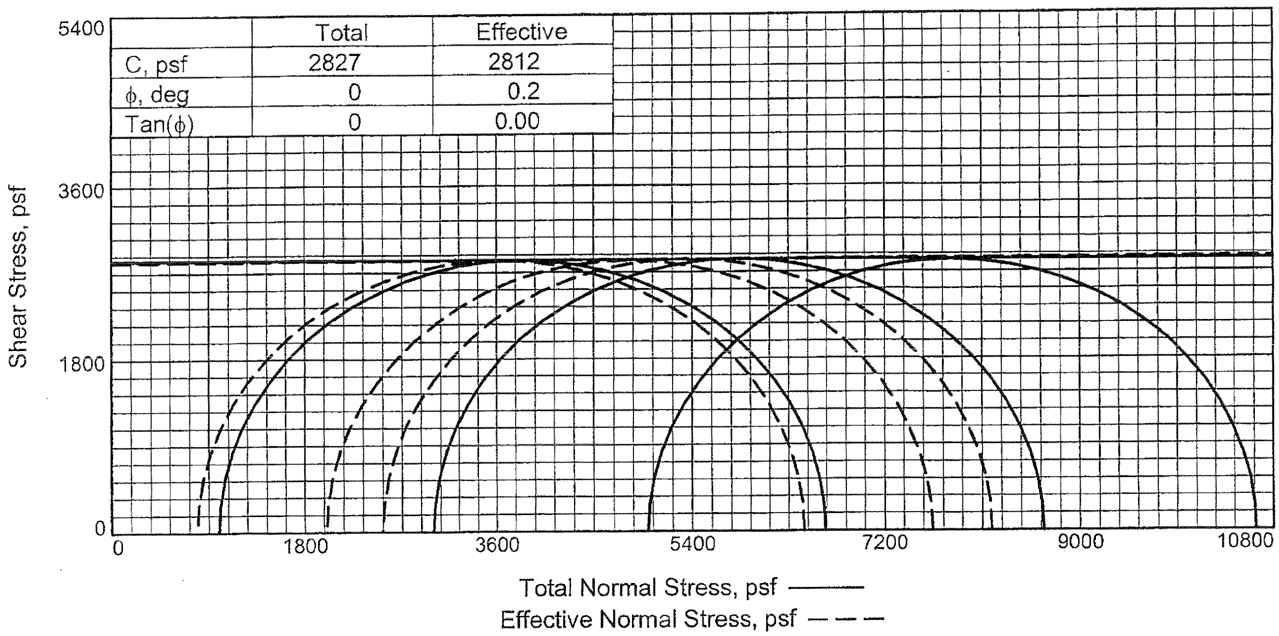
MACTEC Engineering and Consulting, Inc.

Charlotte, North Carolina

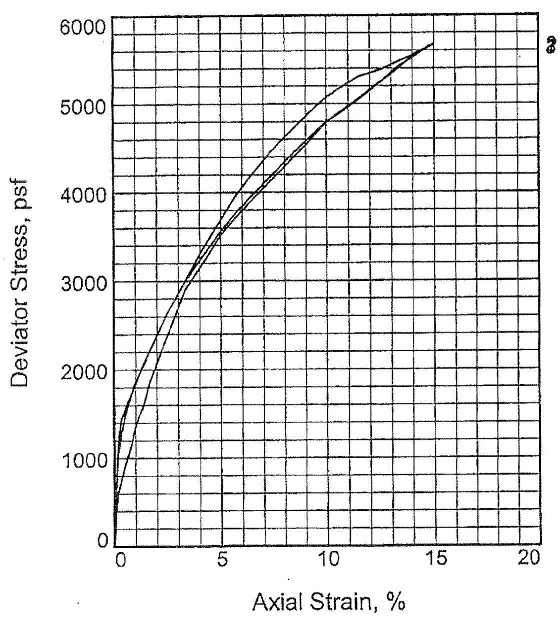
Client: E. ON U.S. Services, Inc.
Project: Green River Power Station
Project No: 314310131702

Tested By: D. Kopitsky **Checked By:** J. Alexander

DMB 8/23/10



	Total	Effective
C, psf	2827	2812
ϕ, deg	0	0.2
Tan(ϕ)	0	0.00



	Sample No.	1	2	3
Initial	Water Content, %	18.6	19.7	20.3
	Dry Density, pcf	110.1	108.7	107.5
	Saturation, %	98.1	100.0	99.8
	Void Ratio	0.5027	0.5220	0.5387
	Diameter, in.	2.84	2.82	2.84
	Height, in.	6.14	6.18	6.16
At Test	Water Content, %	19.0	19.8	19.7
	Dry Density, pcf	110.0	108.5	108.6
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5043	0.5248	0.5232
	Diameter, in.	2.86	2.87	2.84
	Height, in.	6.08	6.01	6.09
	Strain rate, in./min.	0.01	0.01	0.01
	Back Pressure, psf	8640	8640	8640
	Cell Pressure, psf	9634	11635	13637
	Fail. Stress, psf	5652	5669	5641
	Total Pore Pr., psf	8842	9115	11635
	Ult. Stress, psf			
	Total Pore Pr., psf			
	$\bar{\sigma}_1$ Failure, psf	6444	8189	7643
	$\bar{\sigma}_3$ Failure, psf	792	2520	2002

Type of Test:
CU with Pore Pressures

Sample Type: Undisturbed

Description: Lean Clay

LL= 35 **PL=** 19 **PI=** 16

Assumed Specific Gravity= 2.65

Remarks:

Client: E. ON U.S. Services, Inc.

Project: Green River Power Station

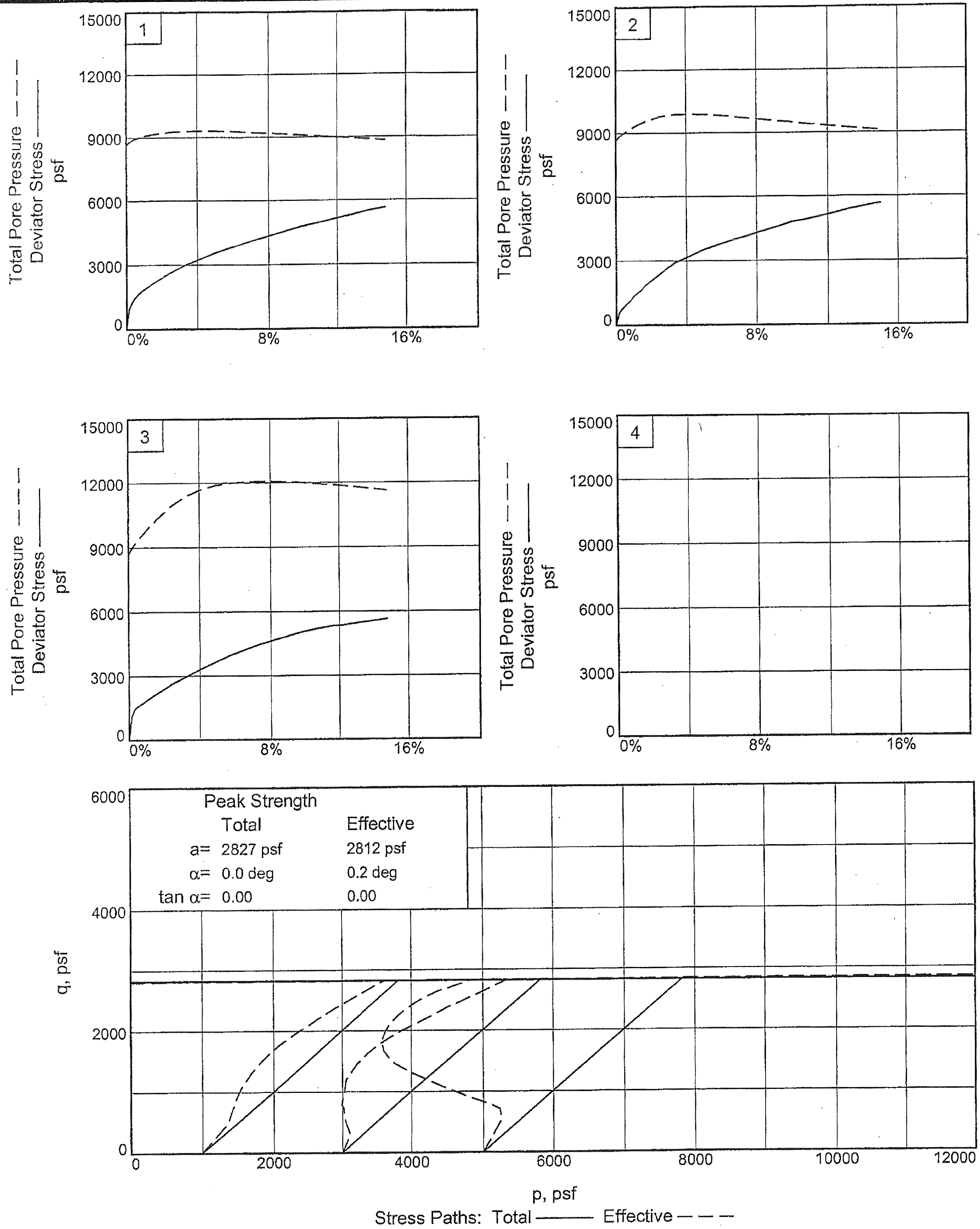
Location: B-7C

Depth: 9-11

Proj. No.: 314310131702 **Date Sampled:** 8-30-10

TRIAXIAL SHEAR TEST REPORT
MACTEC Engineering and Consulting, Inc.
Charlotte, North Carolina

Tested By: J Alexander **Checked By:** D Kopitsky

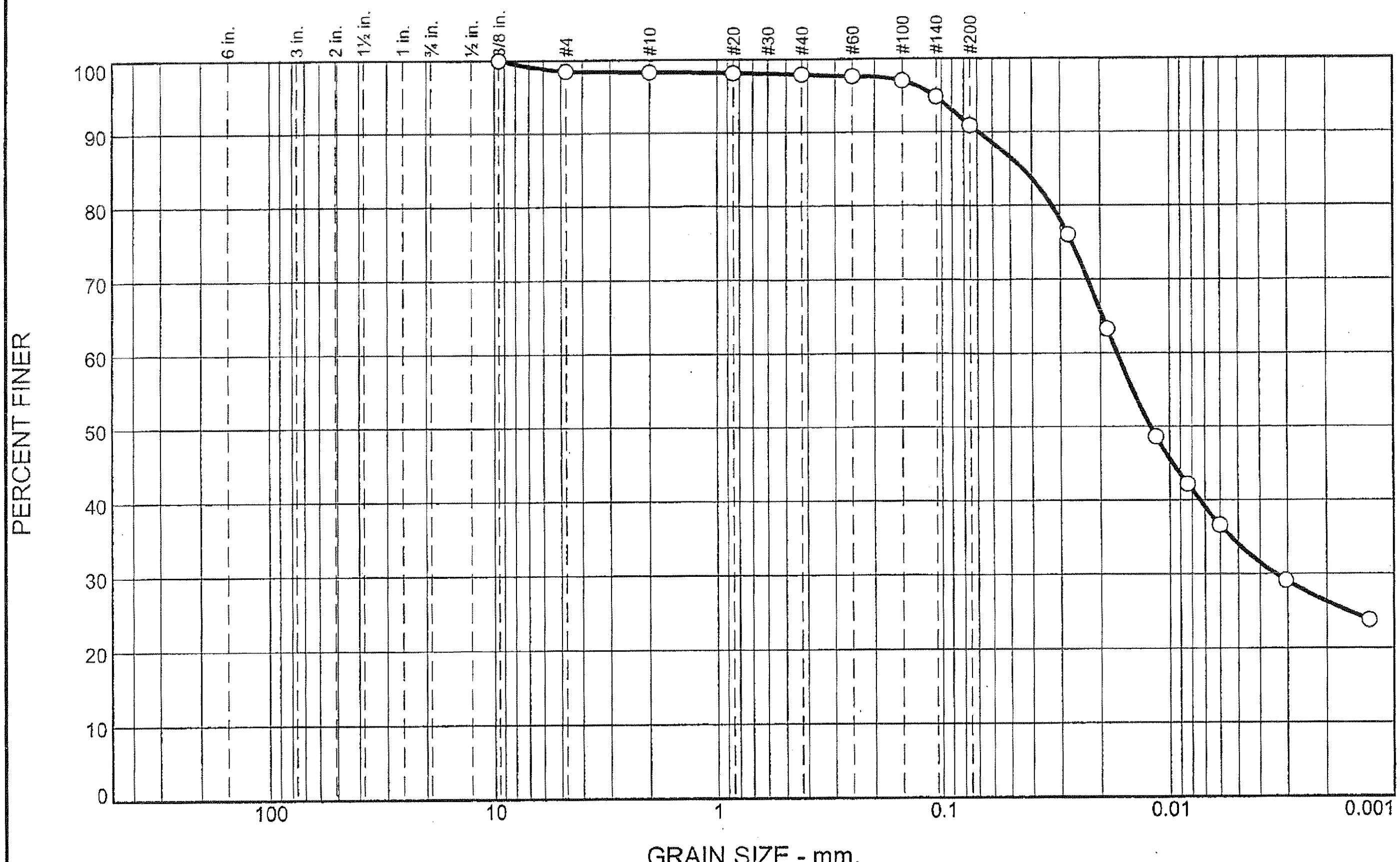


Client: E. ON U.S. Services, Inc.
Project: Green River Power Station
Location: B-7C **Depth:** 9-11
Project No.: 314310131702

MACTEC Engineering and Consulting, Inc.

Tested By: J Alexander **Checked By:** D Kopitsky

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.5	0.2	0.3	7.1	56.9	34.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8"	100.0		
#4	98.5		
#10	98.3		
#20	98.2		
#40	98.0		
#60	97.6		
#100	97.0		
#140	94.8		
#200	90.9		
0.0277 mm.	76.1		
0.0186 mm.	63.3		
0.0115 mm.	48.6		
0.0083 mm.	42.2		
0.0060 mm.	36.7		
0.0031 mm.	29.2		
0.0013 mm.	23.8		

* (no specification provided)

Soil Description

Lean Clay

Atterberg Limits

PL= 19 LL= 35 PI= 16

Coefficients

D_{90}= 0.0689 D_{85}= 0.0438 D_{60}= 0.0169
D_{50}= 0.0121 D_{30}= 0.0034 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(14)

Remarks

Location: B-7C
Depth: 9-11

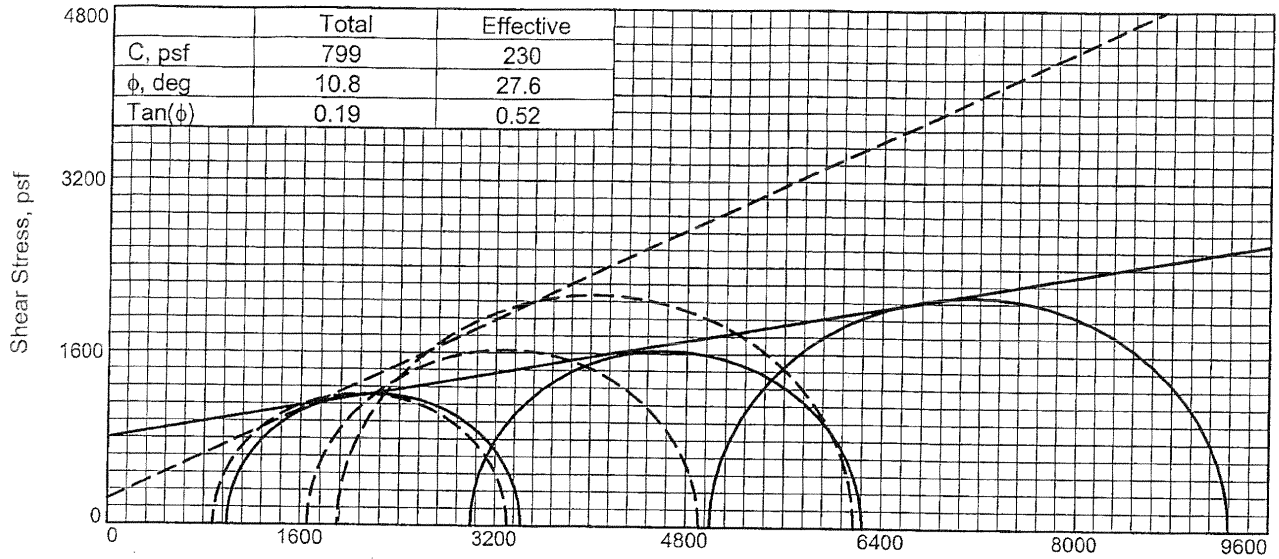
Date: 8-30-10

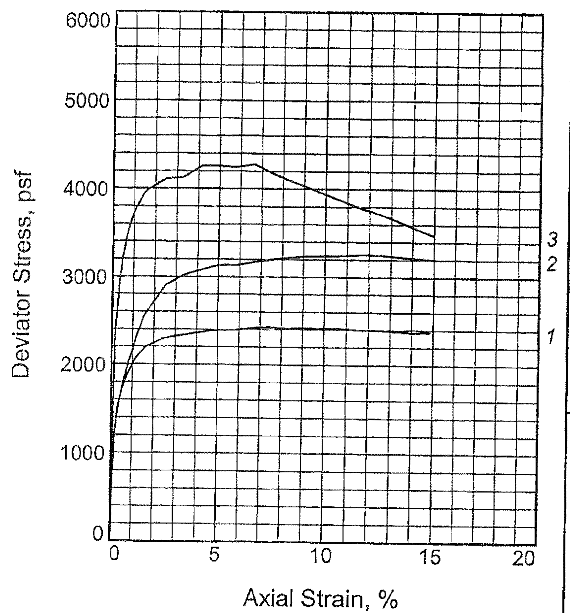
MACTEC Engineering and Consulting, Inc.

Charlotte, North Carolina

Client: E. ON U.S. Services, Inc.
Project: Green River Power Station
Project No: 314310131702

Tested By: D Kopitsky **Checked By:** J Alexander





Sample No.		1	2	3
Initial	Water Content, %	26.4	25.8	25.5
	Dry Density, pcf	96.9	98.3	97.9
	Saturation, %	99.0	99.9	98.1
	Void Ratio	0.7064	0.6830	0.6901
	Diameter, in.	2.85	2.85	2.85
	Height, in.	6.13	6.04	6.14
At Test	Water Content, %	25.5	24.4	23.3
	Dry Density, pcf	98.7	100.5	102.3
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.6767	0.6465	0.6164
	Diameter, in.	2.84	2.83	2.81
	Height, in.	6.06	5.97	6.02
Strain rate, in./min.		0.00	0.00	0.00
Back Pressure, psf		8640	8640	8640
Cell Pressure, psf		9634	11635	13637
Fail. Stress, psf		2426	3252	4278
Total Pore Pr., psf		8755	9979	11736
Ult. Stress, psf				
Total Pore Pr., psf				
$\bar{\sigma}_1$ Failure, psf		3304	4908	6179
$\bar{\sigma}_3$ Failure, psf		878	1656	1901

Type of Test:
CU with Pore Pressures

Sample Type: Undisturbed

Description: lean clay

LL= 34 **PL=** 19 **PI=** 15

Assumed Specific Gravity= 2.65

Remarks:

Client: E. ON U.S. Services, Inc.

Project: Green River Power Station

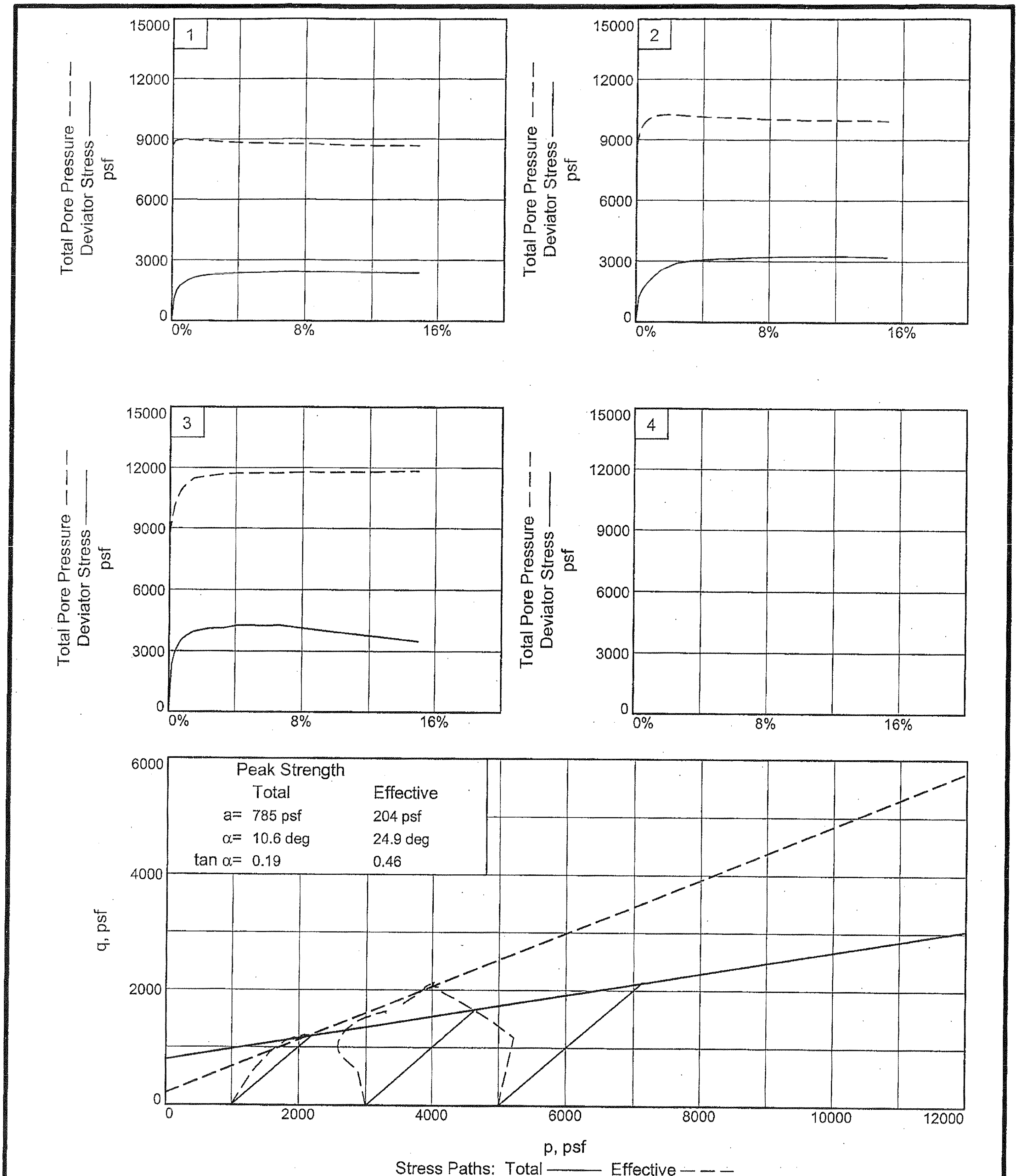
Location: B-7T

Depth: 15.5-17.5

Proj. No.: 314310131702 **Date Sampled:** 8-30-10

TRIAXIAL SHEAR TEST REPORT
MACTEC Engineering and Consulting, Inc.
Charlotte, North Carolina

Tested By: J Alexander **Checked By:** D Kopitsky

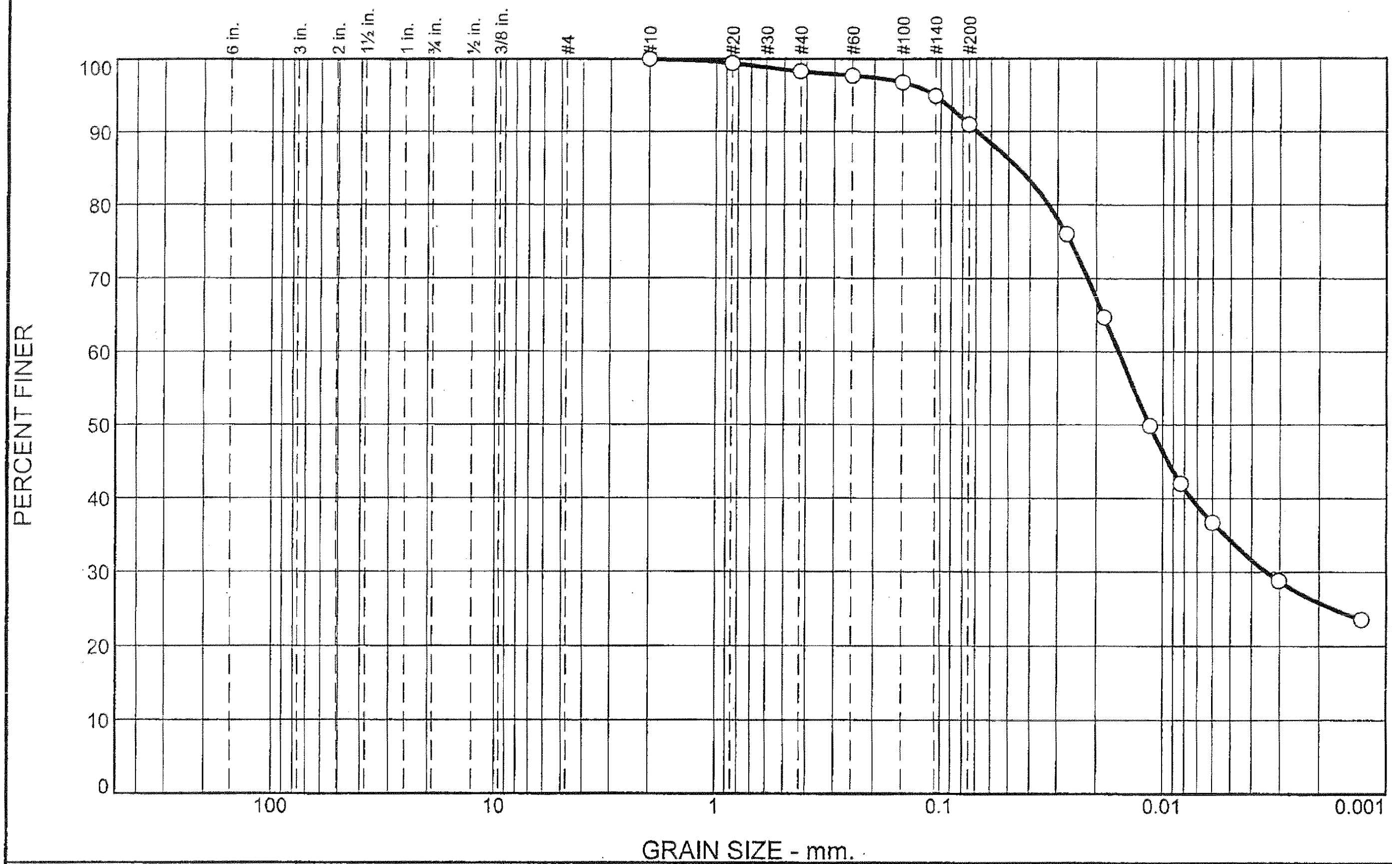


Client: E. ON U.S. Services, Inc.
Project: Green River Power Station
Location: B-7T **Depth:** 15.5-17.5
Project No.: 314310131702

MACTEC Engineering and Consulting, Inc.

Tested By: J Alexander **Checked By:** D Kopitsky

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.7	7.3	56.7	34.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.4		
#40	98.3		
#60	97.7		
#100	96.8		
#140	94.9		
#200	91.0		
0.0274 mm.	76.1		
0.0184 mm.	64.7		
0.0114 mm.	49.9		
0.0083 mm.	42.0		
0.0060 mm.	36.7		
0.0030 mm.	28.8		
0.0013 mm.	23.6		

* (no specification provided)

Soil Description

lean clay

Atterberg Limits

PL= 19 LL= 34 PI= 15

Coefficients

D_{90}= 0.0690 D_{85}= 0.0452 D_{60}= 0.0158
D_{50}= 0.0114 D_{30}= 0.0034 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(13)

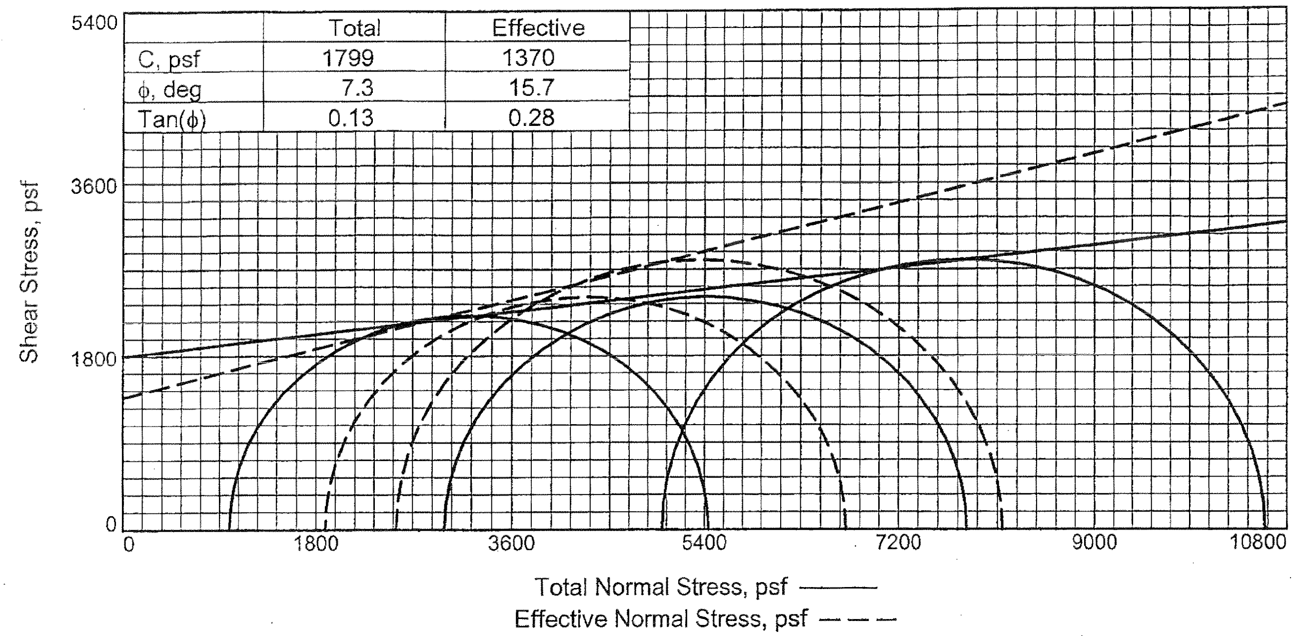
Remarks

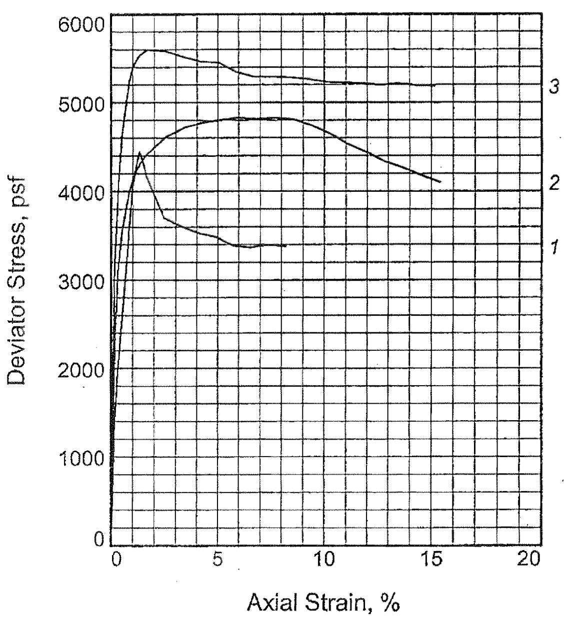
Location: B-7T
Depth: 15.5-17.5

Date: 8-30-10

MACTEC Engineering and Consulting, Inc.	**Client:** E. ON U.S. Services, Inc.
	Project: Green River Power Station
Charlotte, North Carolina	**Project No:** 314310131702

Tested By: J. Alexander **Checked By:** D. Kopitsky





Sample No.		1	2	3
Initial	Water Content, %	22.2	23.2	23.3
	Dry Density, pcf	100.1	97.6	99.0
	Saturation, %	90.1	88.6	92.2
	Void Ratio	0.6531	0.6945	0.6705
	Diameter, in.	2.83	2.87	2.84
	Height, in.	6.13	5.99	6.07
At Test	Water Content, %	24.0	24.5	24.3
	Dry Density, pcf	101.2	100.4	100.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.6355	0.6479	0.6427
	Diameter, in.	2.82	2.86	2.85
	Height, in.	6.09	5.85	5.94
Strain rate, in./min.		0.01	0.01	0.01
Back Pressure, psf		8640	8640	8640
Cell Pressure, psf		9634	11635	13637
Fail. Stress, psf		4444	4828	5601
Total Pore Pr., psf		8640	9749	11088
Ult. Stress, psf				
Total Pore Pr., psf				
$\bar{\sigma}_1$ Failure, psf		5438	6714	8149
$\bar{\sigma}_3$ Failure, psf		994	1886	2549

Type of Test:
CU with Pore Pressures
Sample Type: Undisturbed
Description: lean clay with sand

LL= 33 **PL=** 18 **PI=** 15
Assumed Specific Gravity= 2.65
Remarks:

Client: E. ON U.S. Services, Inc.

Project: Green River Power Station

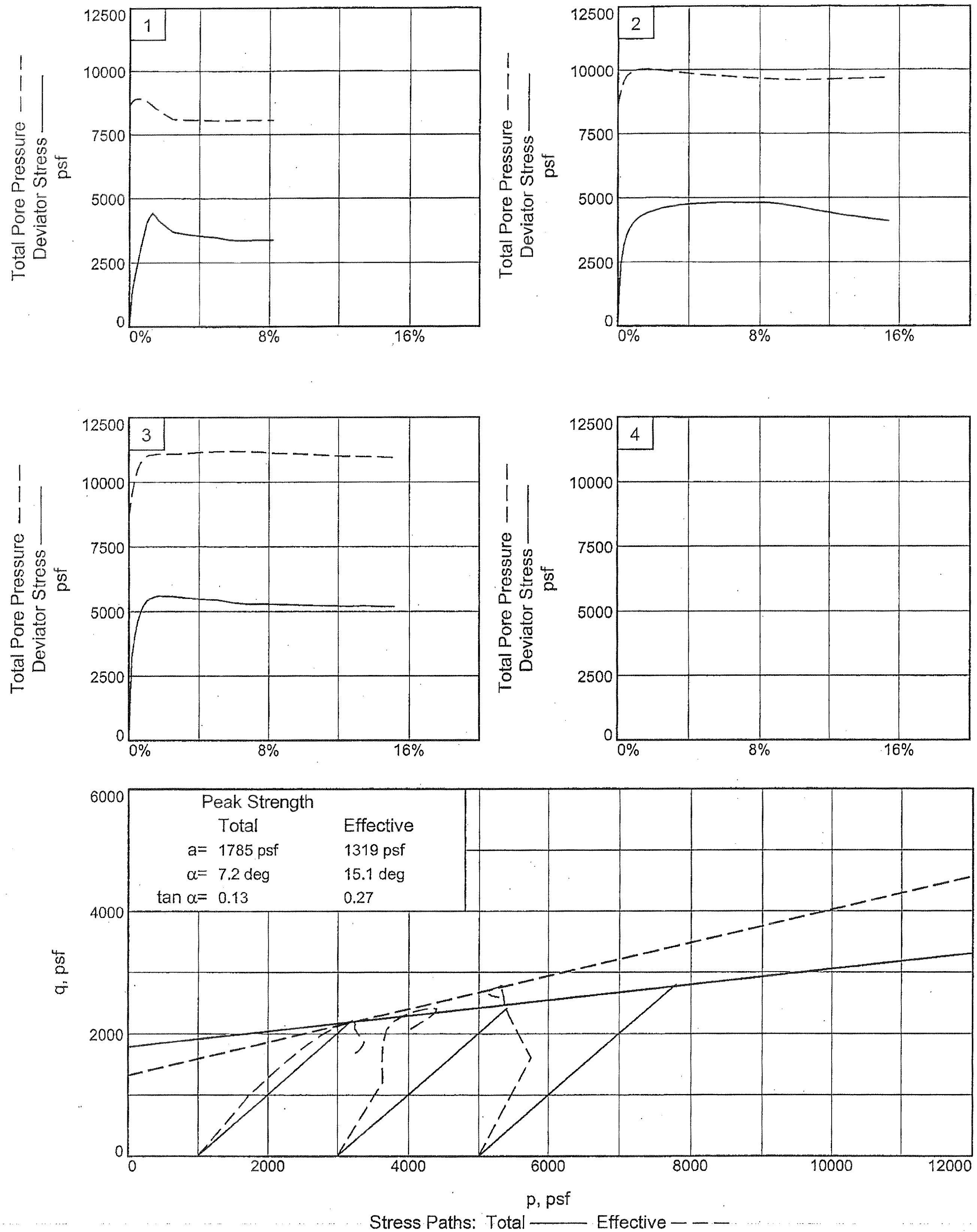
Location: B-8T

Depth: 7-9

Proj. No.: 314310131702 **Date Sampled:** 8-30-10

TRIAXIAL SHEAR TEST REPORT
MACTEC Engineering and Consulting, Inc.
Charlotte, North Carolina

Tested By: J Alexander **Checked By:** D Kopitsky

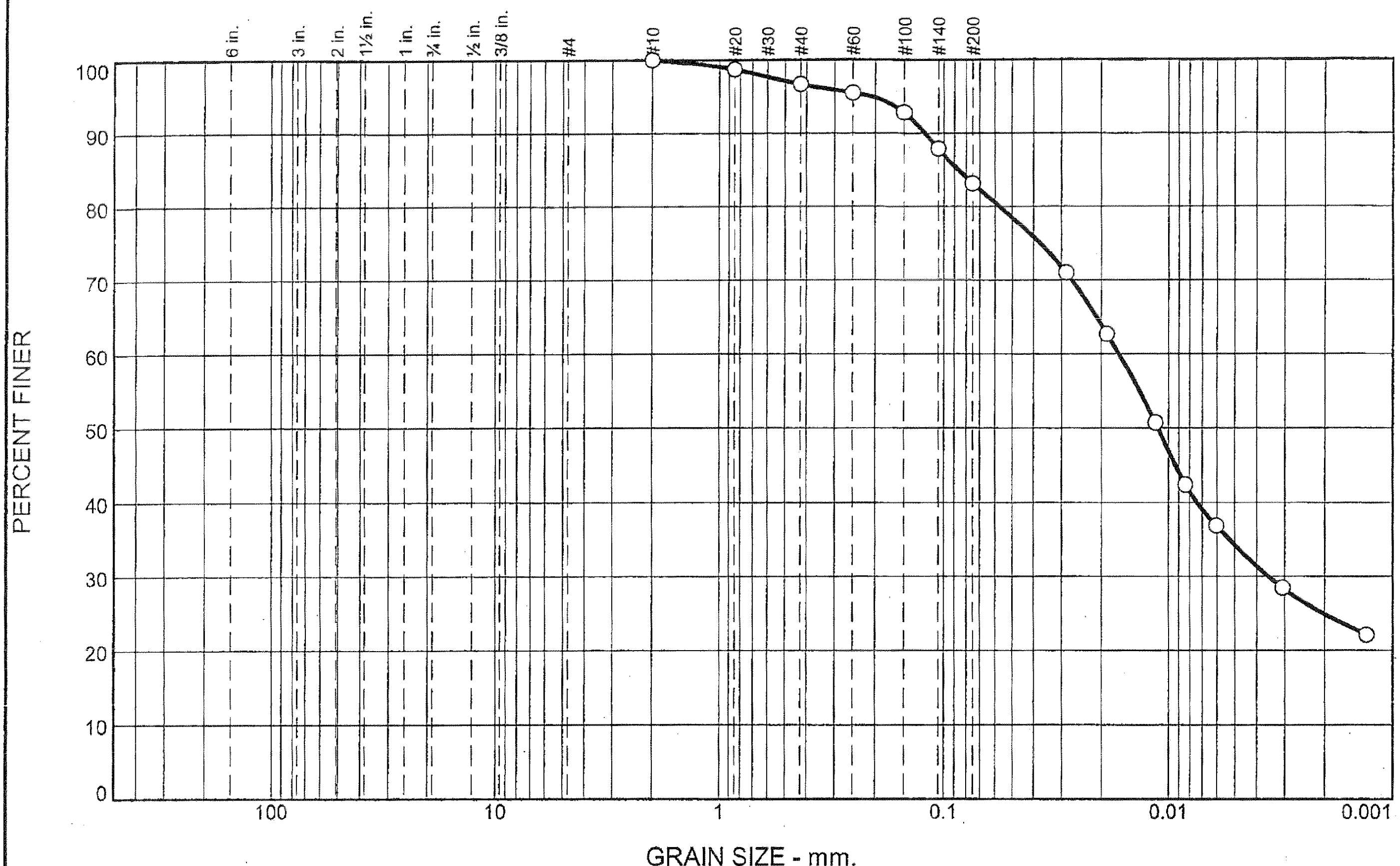


Client: E. ON U.S. Services, Inc.
Project: Green River Power Station
Location: B-8T **Depth:** 7-9
Project No.: 314310131702

MACTEC Engineering and Consulting, Inc.

Tested By: J Alexander **Checked By:** D Kopitsky

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	3.3	13.5	48.9	34.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	98.7		
#40	96.7		
#60	95.5		
#100	92.8		
#140	87.9		
#200	83.2		
0.0287 mm.	71.0		
0.0189 mm.	62.7		
0.0115 mm.	50.7		
0.0084 mm.	42.4		
0.0060 mm.	36.9		
0.0031 mm.	28.5		
0.0013 mm.	22.1		

* (no specification provided)

Soil Description

lean clay with sand

Atterberg Limits

PL= 18 LL= 33 PI= 15

Coefficients

D_{90}= 0.1217 D_{85}= 0.0866 D_{60}= 0.0167
D_{50}= 0.0112 D_{30}= 0.0035 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(11)

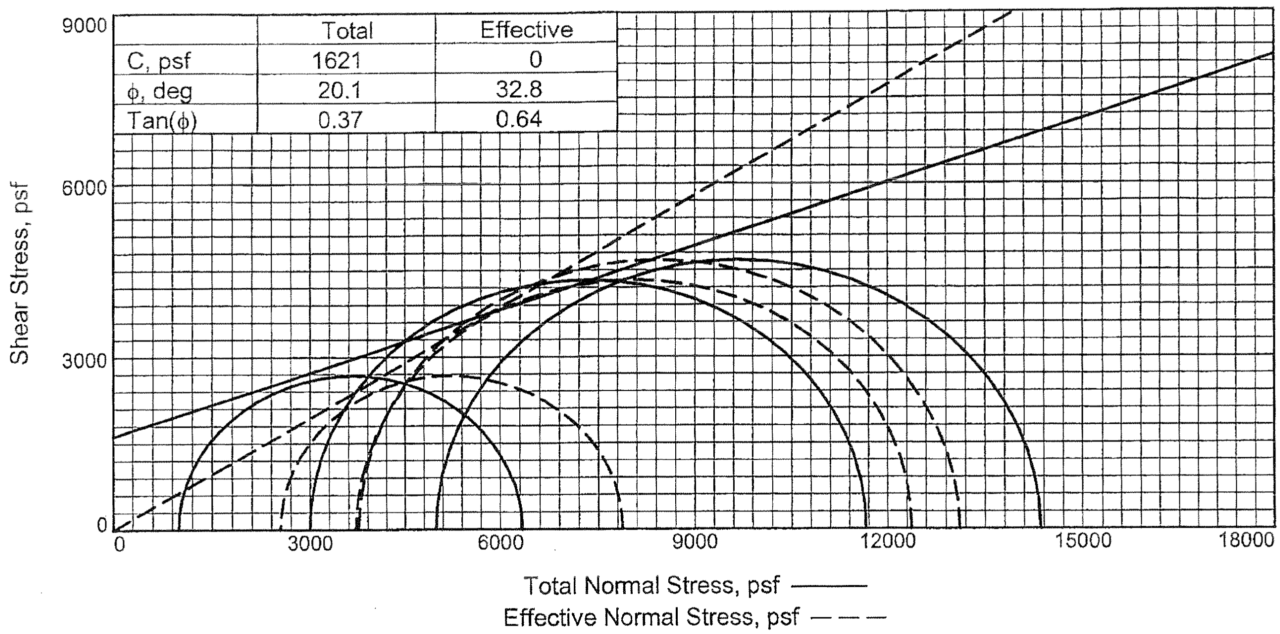
Remarks

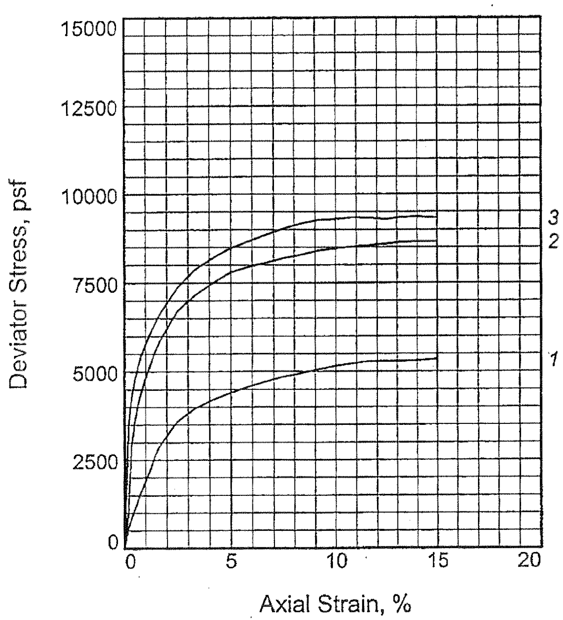
Location: B-8T
Depth: 7-9
Date: 8-30-10

MACTEC Engineering and Consulting, Inc. Charlotte, North Carolina	**Client:** E. ON U.S. Services, Inc. **Project:** Green River Power Station **Project No:** 314310131702

Tested By: J. Alexander **Checked By:** D. Kopitsky

	Total	Effective
C, psf	1621	0
ϕ, deg	20.1	32.8
Tan(ϕ)	0.37	0.64





Sample No.		1	2	3
Initial	Water Content, %	20.8	22.3	22.2
	Dry Density, pcf	104.4	103.4	102.9
	Saturation, %	94.5	98.4	96.8
	Void Ratio	0.5845	0.6000	0.6074
	Diameter, in.	2.82	2.83	2.82
	Height, in.	6.13	6.11	6.13
At Test	Water Content, %	22.1	21.8	21.2
	Dry Density, pcf	104.4	104.8	106.0
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5853	0.5785	0.5609
	Diameter, in.	2.84	2.84	2.80
	Height, in.	6.04	6.01	6.03
Strain rate, in./min.		0.01	0.01	0.01
Back Pressure, psf		8640	8640	8640
Cell Pressure, psf		9634	11635	13637
Fail. Stress, psf		5343	8666	9353
Total Pore Pr., psf		7099	7920	9878
Ult. Stress, psf				
Total Pore Pr., psf				
$\bar{\sigma}_1$ Failure, psf		7877	12381	13111
$\bar{\sigma}_3$ Failure, psf		2534	3715	3758

Type of Test:
CU with Pore Pressures

Sample Type: Undisturbed

Description: Silty Clay with Sand

LL= 27 **PL=** 20 **PI=** 7

Assumed Specific Gravity= 2.65

Remarks:

Client: E. ON U.S. Services, Inc.

Project: Green River Power Station

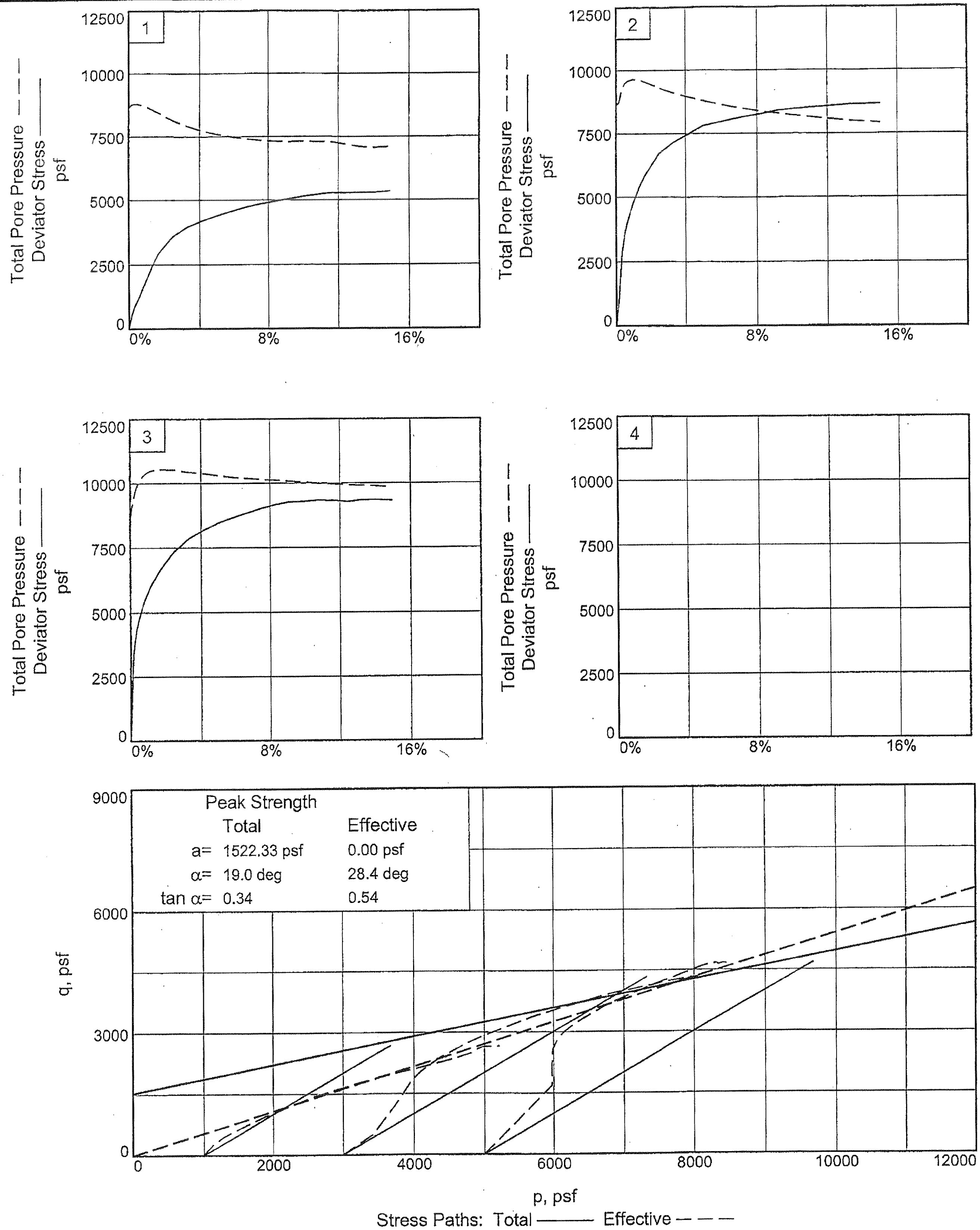
Location: B-10C

Depth: 21.5-23.5

Proj. No.: 314310131702 **Date Sampled:** 8-31-10

TRIAXIAL SHEAR TEST REPORT
MACTEC Engineering and Consulting, Inc.
Charlotte, North Carolina

Tested By: J Alexander **Checked By:** D Kopitsky

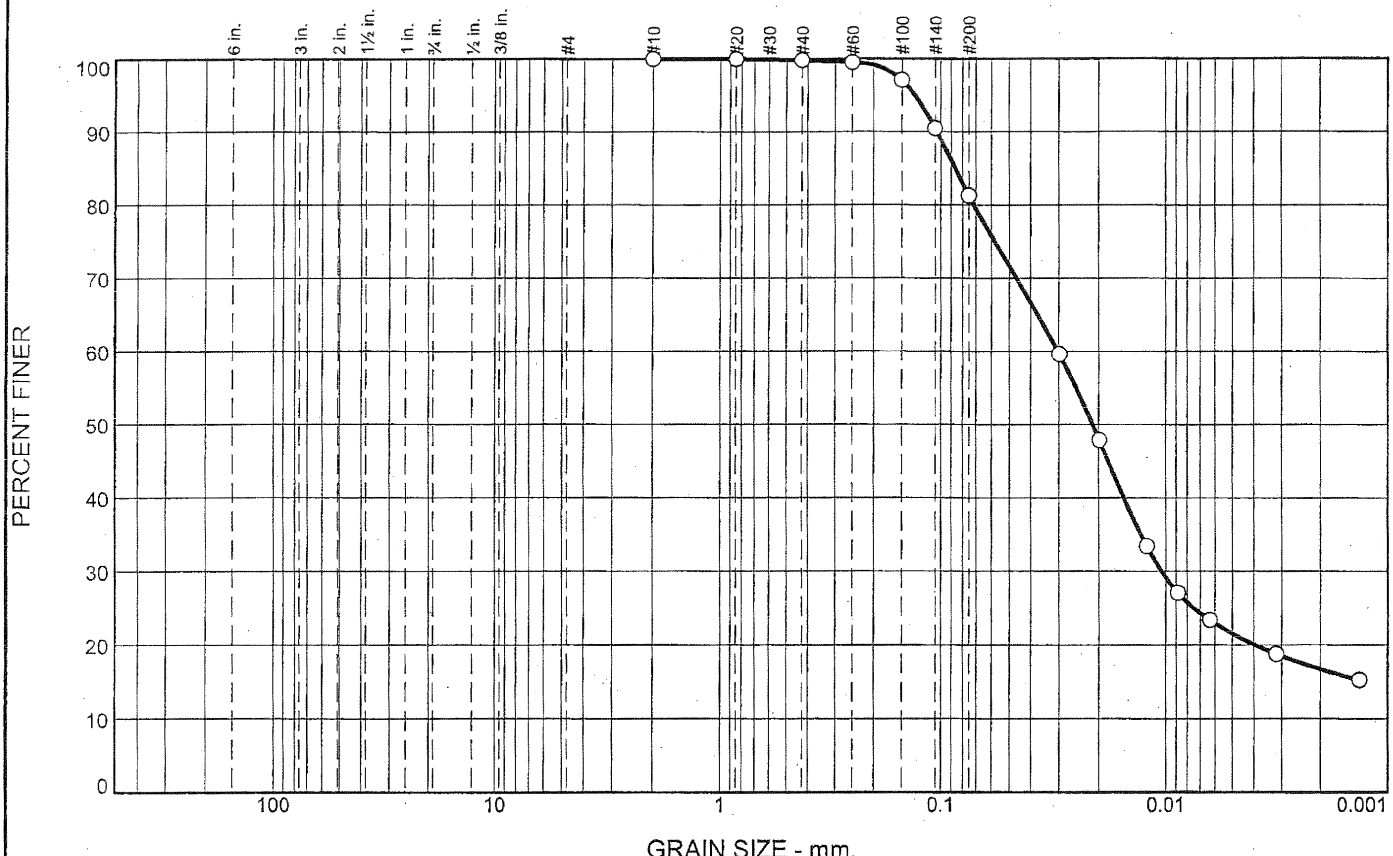


Client: E. ON U.S. Services, Inc.
Project: Green River Power Station
Location: B-10C **Depth:** 21.5-23.5
Project No.: 314310131702

MACTEC Engineering and Consulting, Inc.

Tested By: J Alexander **Checked By:** D Kopitsky

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.2	18.5	59.7	21.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	99.8		
#60	99.6		
#100	97.1		
#140	90.5		
#200	81.3		
0.0299 mm.	59.6		
0.0199 mm.	47.9		
0.0122 mm.	33.4		
0.0088 mm.	27.1		
0.0063 mm.	23.4		
0.0032 mm.	18.8		
0.0013 mm.	15.2		

* (no specification provided)

Soil Description

Silty Clay with Sand

Atterberg Limits

PL= 20 LL= 27 PI= 7

Coefficients

D_{90}= 0.1041 D_{85}= 0.0861 D_{60}= 0.0303
D_{50}= 0.0213 D_{30}= 0.0104 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL-ML AASHTO= A-4(4)

Remarks

Location: B-10C
Depth: 21.5-23.5

Date: 8-31-10

MACTEC Engineering and Consulting, Inc.

Charlotte, North Carolina

Client: E. ON U.S. Services, Inc.
Project: Green River Power Station
Project No: 314310131702

Tested By: D Kopitsky **Checked By:** J Alexander

SUMMARY OF SLOPE STABILITY RESULTS

PCSTABL PLOTS

MACTEC

Green River Power Station			
3143-10-1317.02			
MLB		Date:	12/2/2010
NGS		Date:	12/2/2010

Minimum Factor of Safety Summary
Green River Power Station
No. 2 Pond/Coal Pile Runoff Pond & Scrubber Pond

Target Section	Slope	Long-Term Steady State/Max Surcharge		Rapid Drawdown		Seismic	
		Target FS(1)	Min FS	Target FS(1)	Min FS	Target FS(1)	Min FS
1	Upstream	1.5	4.1	2.3	4.1	1.0	2.0
	Downstream		1.4		1.6		1.0
2	Upstream		6.7		8.2		1.3 (2)
	Downstream		2.3		2.3		1.3
3	Upstream		6.2		7.8		1.3 (2)
	Downstream		2.0		2.0		1.3
4	Upstream		3.6		1.9		1.0
	Downstream		2.4		2.4		1.5
5	Upstream		2.5		1.5		0.8
	Downstream		2.0		2.0		1.2
6	Upstream		5.1		3.2		2.2
	Downstream		2.5		2.5		1.8
7	Upstream		3.6		2.7		1.5
	Downstream		1.9		1.9		1.2
8	Upstream		6.0		3.6		1.9
	Downstream		1.6		1.6		1.2
9	Upstream		3.5		2.4		1.8
	Downstream		2.3		1.4		1.6
10	Upstream		6.1		3.6		3.3
	Downstream		1.7		1.7		1.2

x.x Highlighted value does not meet the target minimum FS criteria

(1) Target Factor of Safety References:
Design Criteria for Dams & Associated Structures (401 KAR 4:030, KAR 4:040)
USACE EM 1110-2-1902: Slope Stability
MSHA Engineering and Design Manual

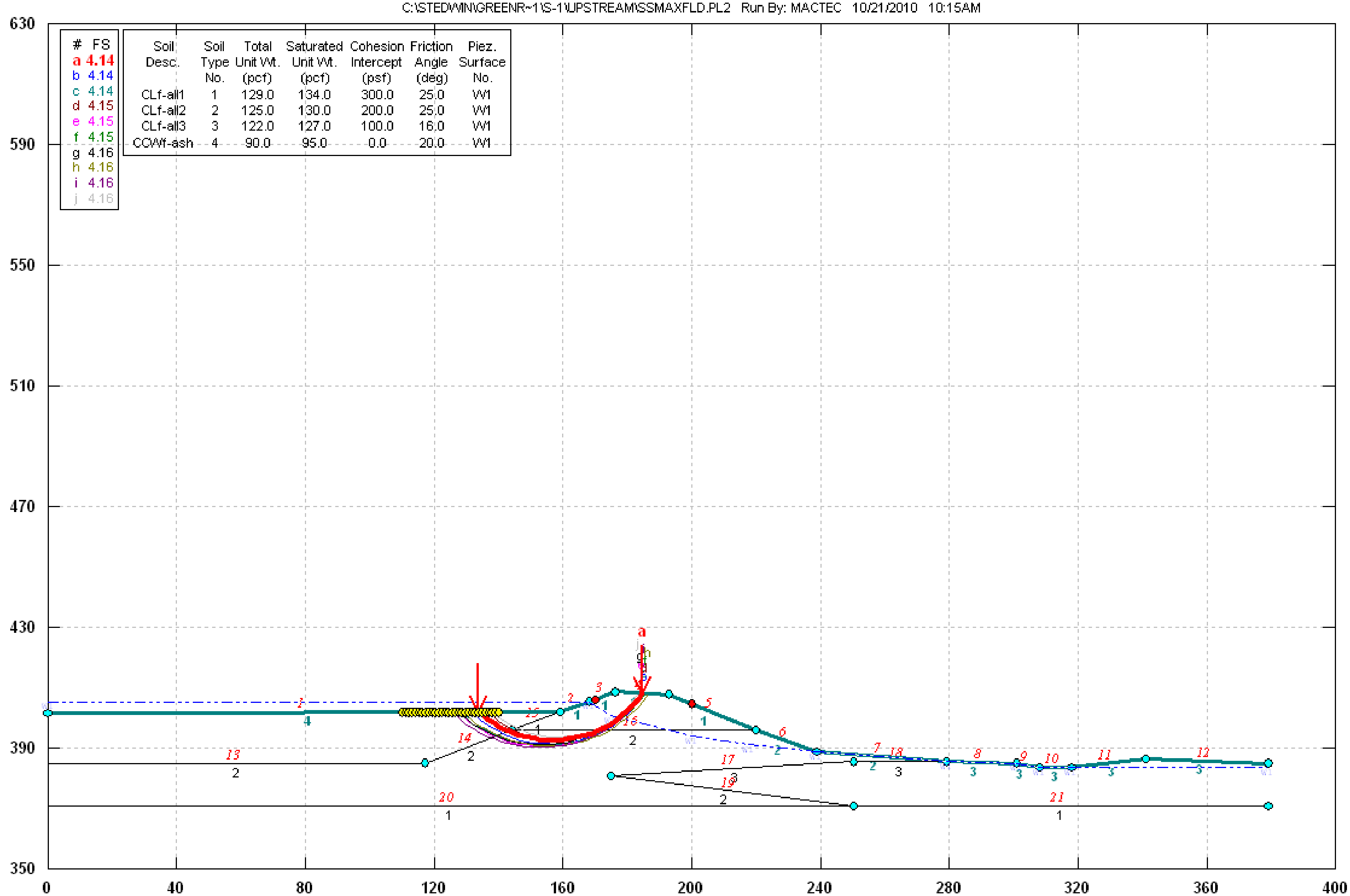
(2) Shallow surface sloughing failure - top of ash at dam crest elevation at this cross-section

3143-10-1317 Green River Power Station Section 1: Upstream - SS/Max Flood

C:\STEDWIN\GREENR~1\S-1\UPSTREAM\SSMAXFLD.PL2 Run By: MACTEC 10/21/2010 10:15AM

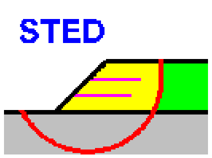
#	FS
a	4.14
b	4.14
c	4.14
d	4.15
e	4.15
f	4.15
g	4.16
h	4.16
i	4.16
j	4.16

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CLf-all1	1	129.0	134.0	300.0	25.0	W1
CLf-all2	2	125.0	130.0	200.0	25.0	W1
CLf-all3	3	122.0	127.0	100.0	16.0	W1
CCWf-ash	4	90.0	95.0	0.0	20.0	W1



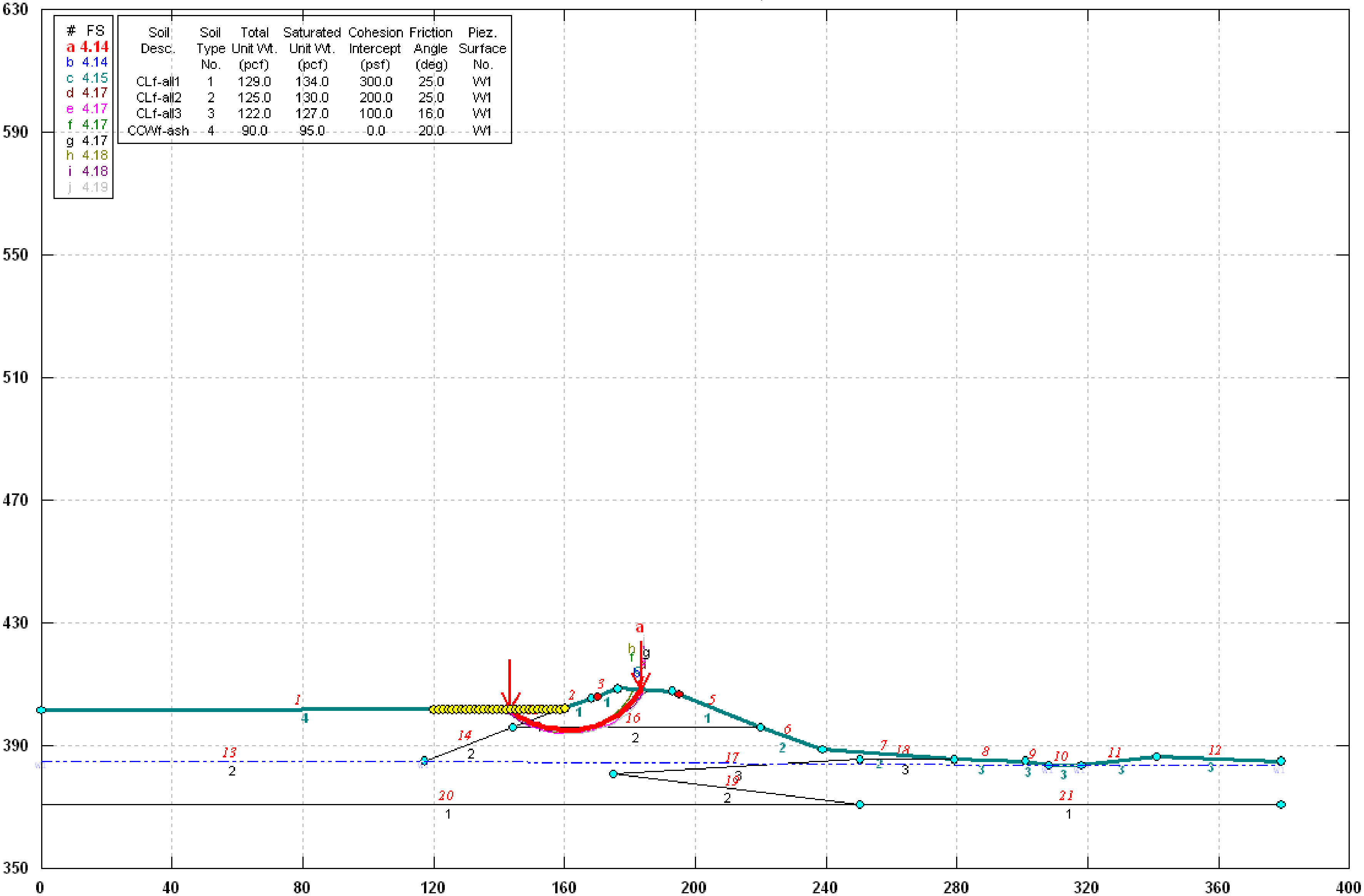
STABL6H FSmin=4.14

Safety Factors Are Calculated By The Modified Bishop Method



3143-10-1317 Green River Power Station Section 1: Upstream - Rapid Drawdown

C:\STEDWIN\GREENR~1\S-1\UPSTREAM\RDD.PL2 Run By: MACTEC 10/21/2010 10:48AM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CLf-all1	1	129.0	134.0	300.0	25.0	W1
CLf-all2	2	125.0	130.0	200.0	25.0	W1
CLf-all3	3	122.0	127.0	100.0	16.0	W1
CCWf-ash	4	90.0	95.0	0.0	20.0	W1

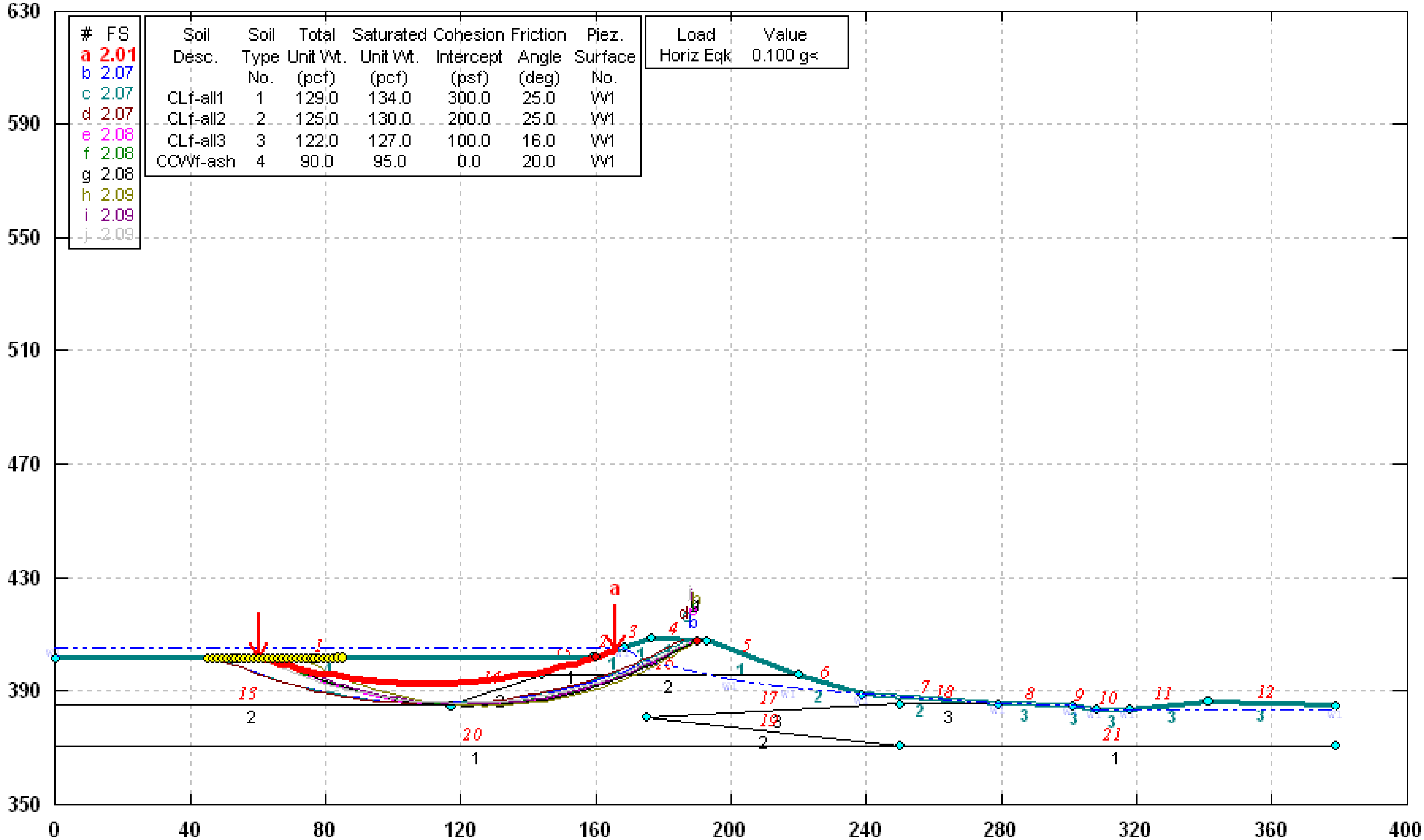
STABL6H FSmin=4.14

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 1: Upstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-1\UPSTREAM\SEISMIC.PL2   Run By: MACTEC   12/2/2010   12:00PM



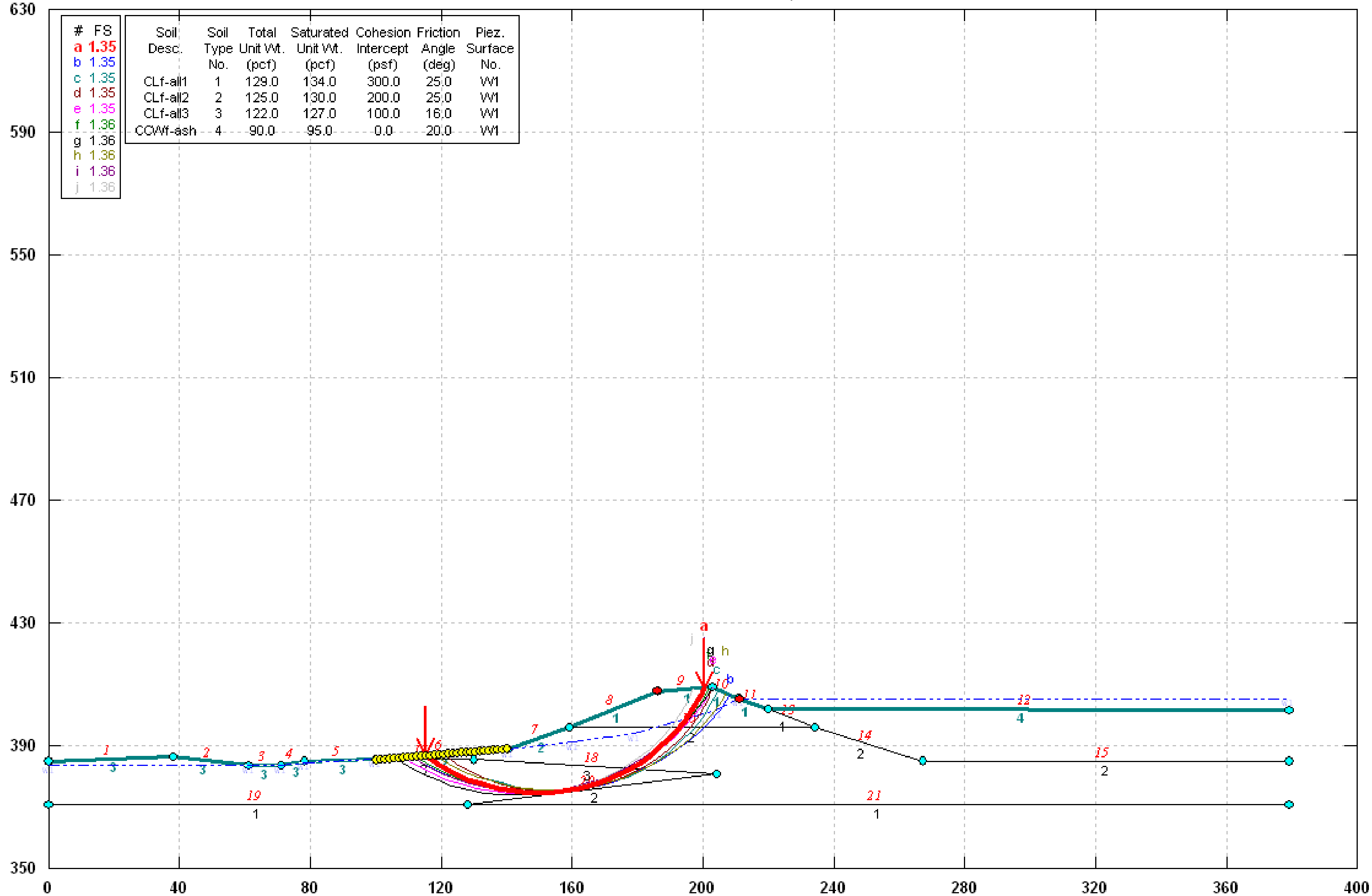
STABL6H FSmin=2.01

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 1: Downstream - SS/Max Flood

C:\STEDWIN\GREENR~1\S-1\DOWNST~1\SSMAXFLD.PL2 Run By: MACTEC 10/21/2010 11:10AM



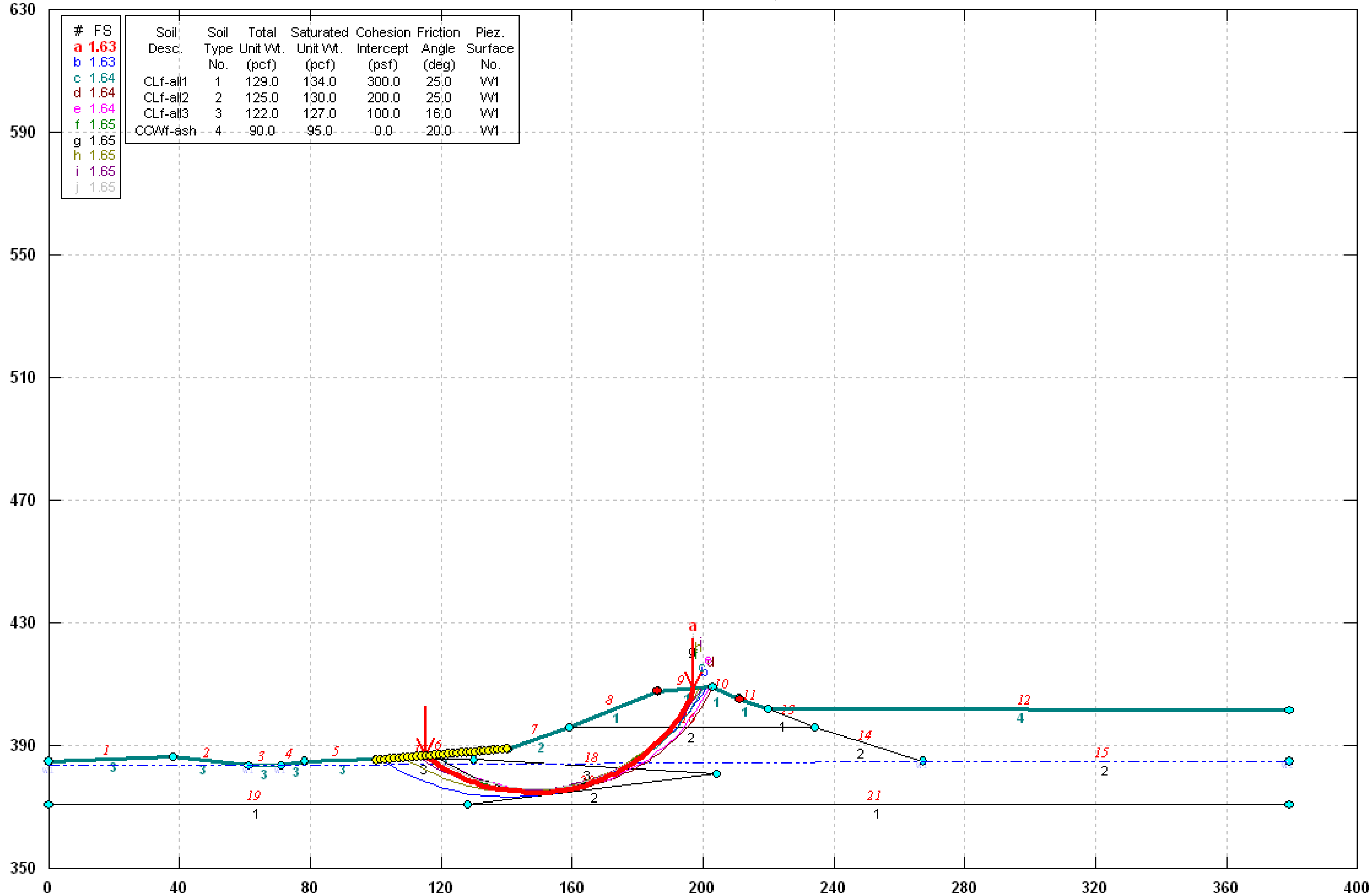
STABL6H FSmin=1.35

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 1: Downstream - Rapid Drawdown

C:\STEDWIN\GREENR~1\S-1\DOWNST~1\RDD.PL2 Run By: MACTEC 10/21/2010 2:19PM



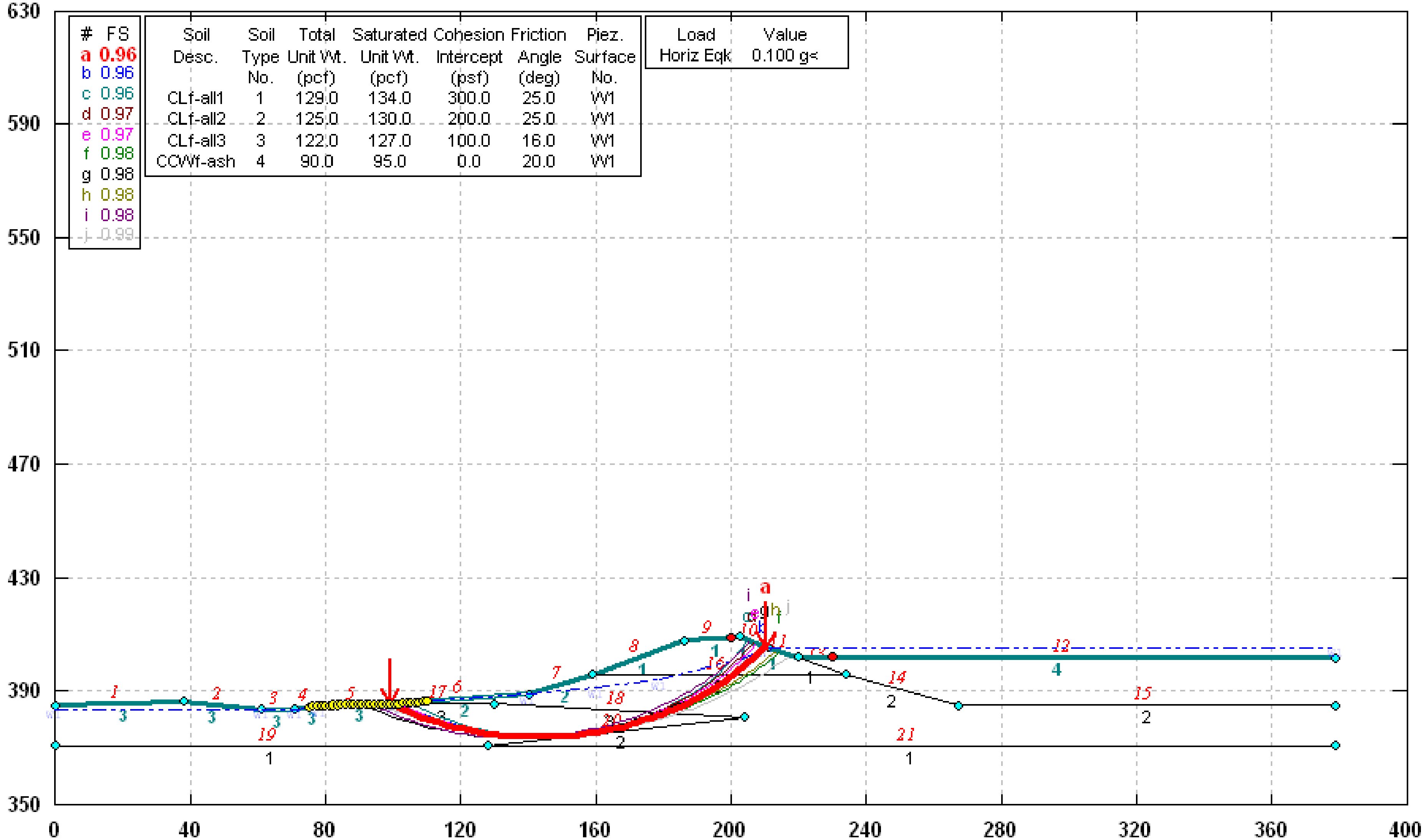
STABL6H FSmin=1.63

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 1: Downstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-1\DOWNST~1\SEISMIC.PL2 Run By: MACTEC 12/2/2010 11:59AM

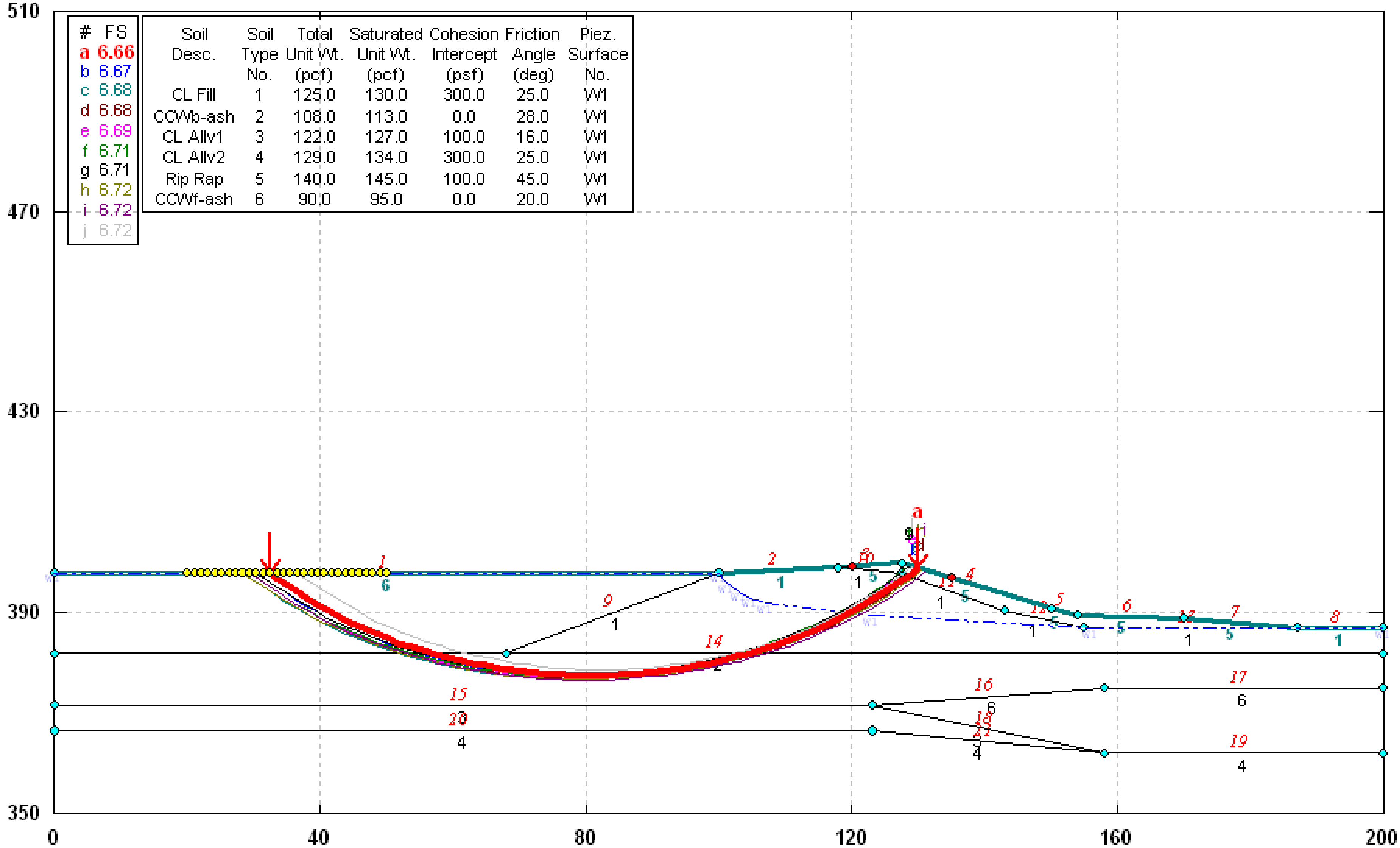


STABL6H FSmin=0.96

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 2: Upstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-2\UPSTREAM\SSMAXFLD.PL2 Run By: MACTEC 10/26/2010 3:41PM

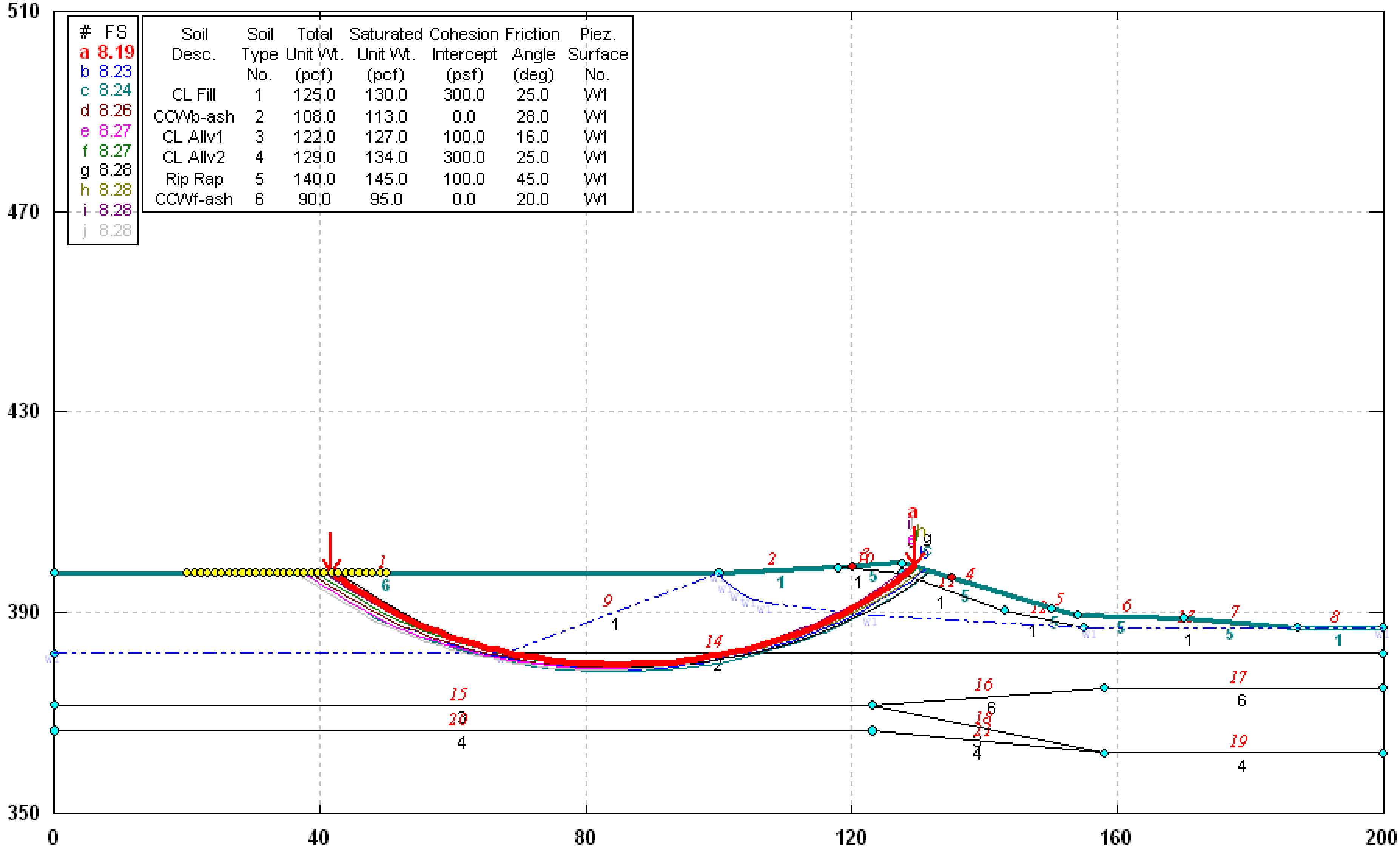


STABL6H FSmin=6.66

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 2: Upstream - Rapid Drawdown

C:\STEDWIN\STEDWIN\GREENR~1\S-2\UPSTREAM\RDD.PL2 Run By: MACTEC 10/26/2010 3:52PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CL Fill	1	125.0	130.0	300.0	25.0	W1
CCWb-ash	2	108.0	113.0	0.0	28.0	W1
CL Allv1	3	122.0	127.0	100.0	16.0	W1
CL Allv2	4	129.0	134.0	300.0	25.0	W1
Rip Rap	5	140.0	145.0	100.0	45.0	W1
CCWf-ash	6	90.0	95.0	0.0	20.0	W1

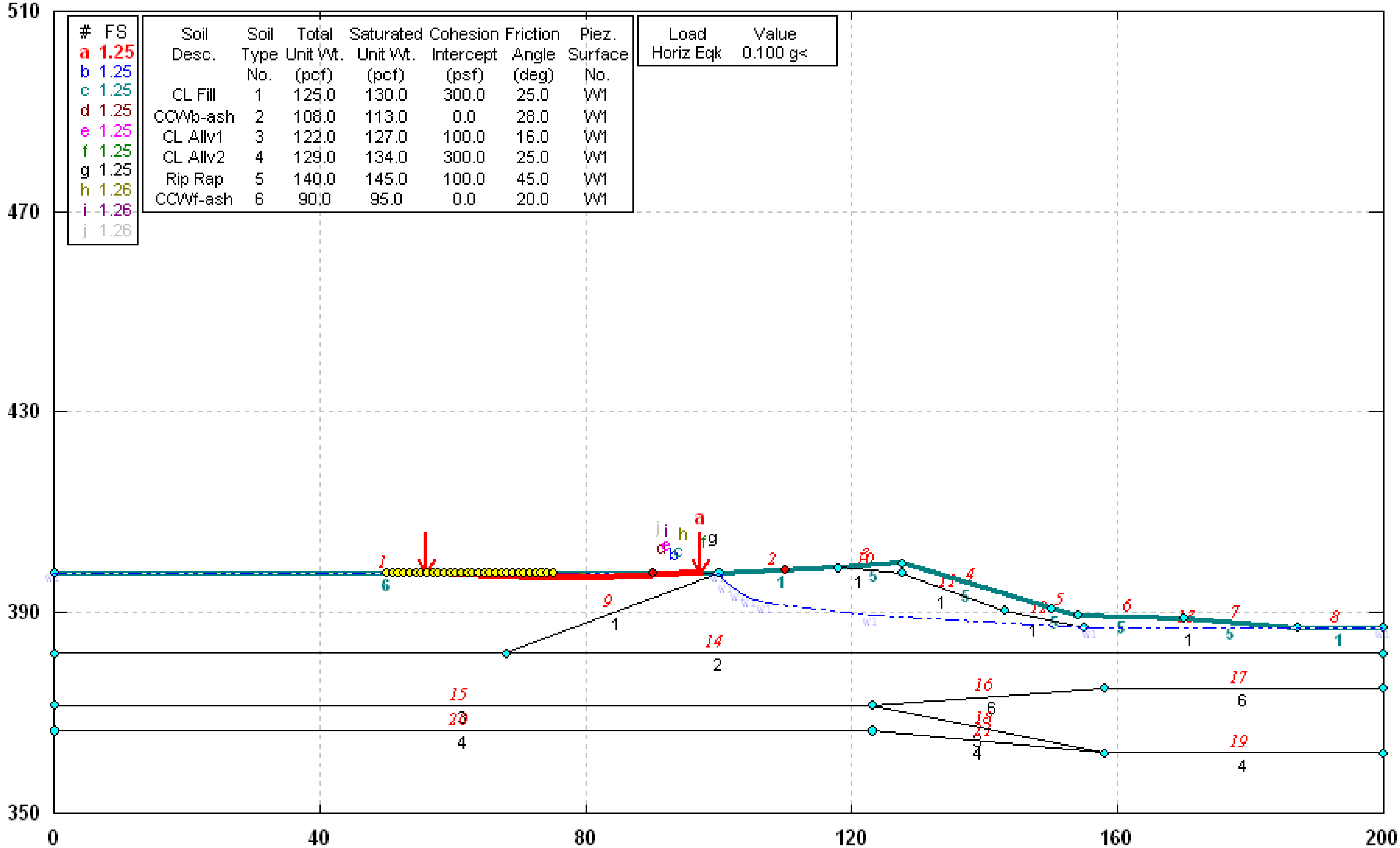
STABL6H FSmin=8.19

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 2: Upstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-2\UPSTREAM\SEISMIC.PL2 Run By: MACTEC 12/2/2010 12:41PM

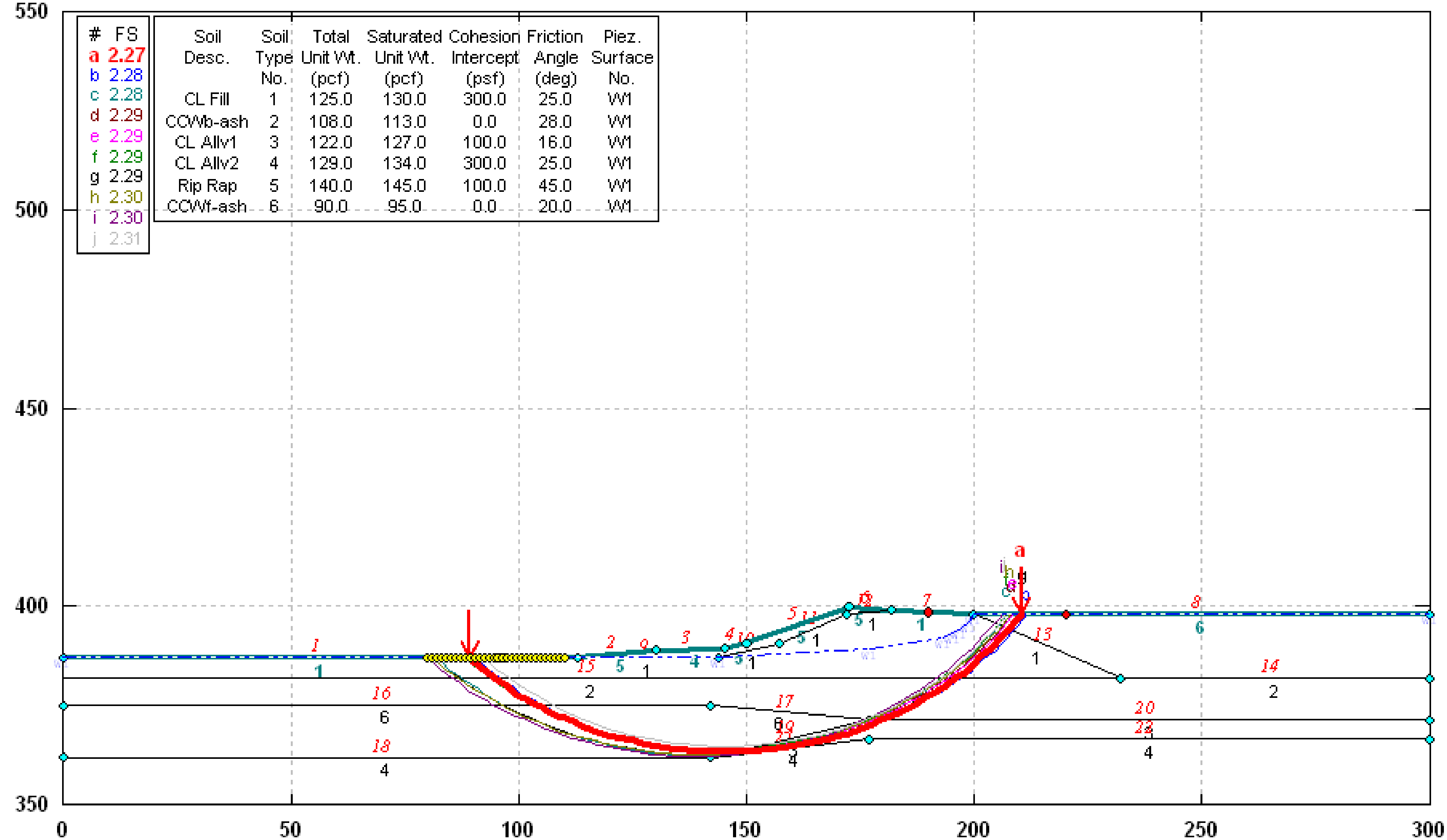


STABL6H FSmin=1.25

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 2: Downstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-2\DOWNST~1\SSMAXFLD.PL2 Run By: MACTEC 10/26/2010 4:34PM

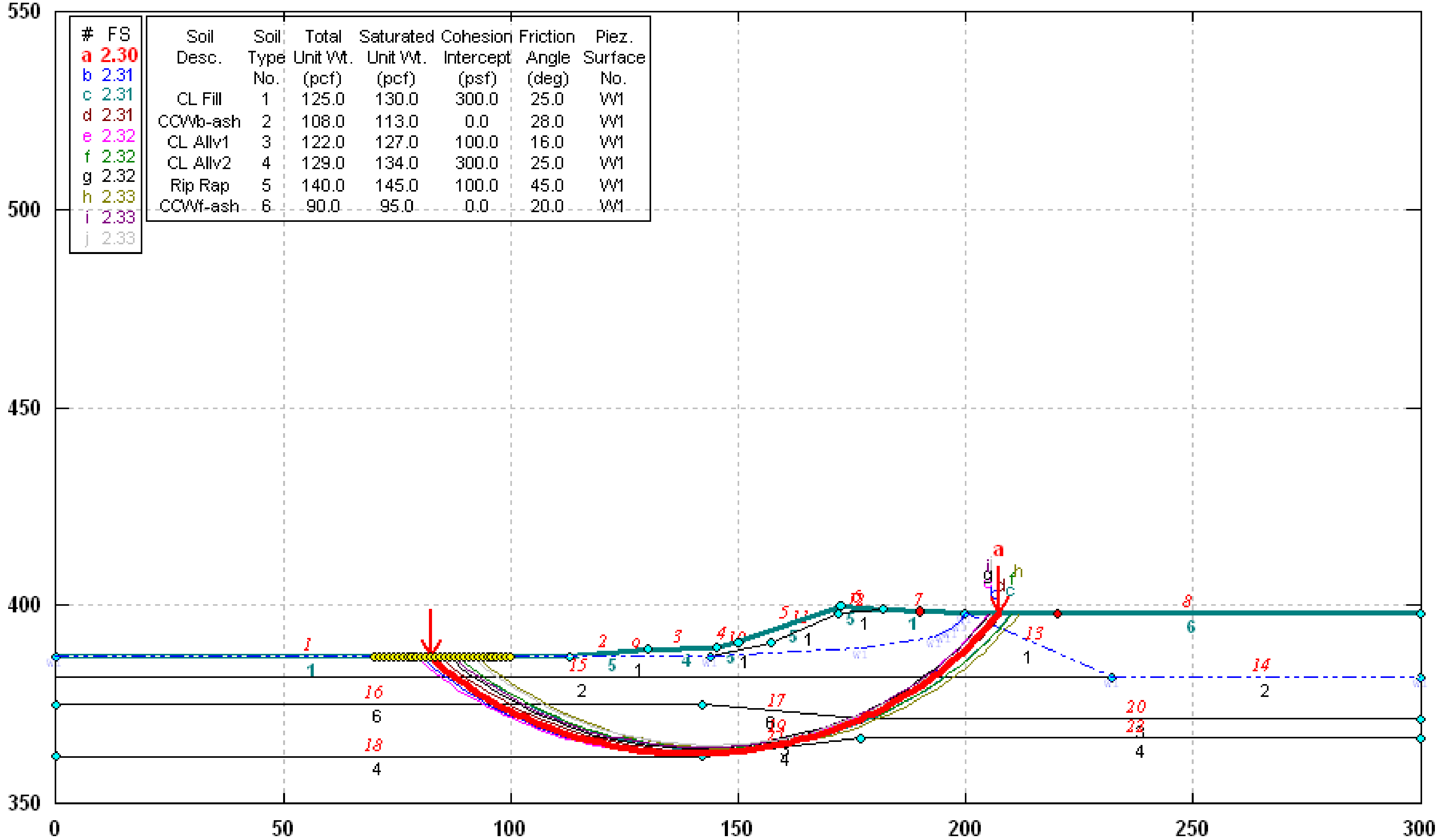


STABL6H FSmin=2.27

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 2: Downstream - Rapid Drawdown

C:\STEDWIN\STEDWIN\GREENR~1\S-2\DOWNST~1\RDD.PL2 Run By: MACTEC 10/26/2010 4:45PM



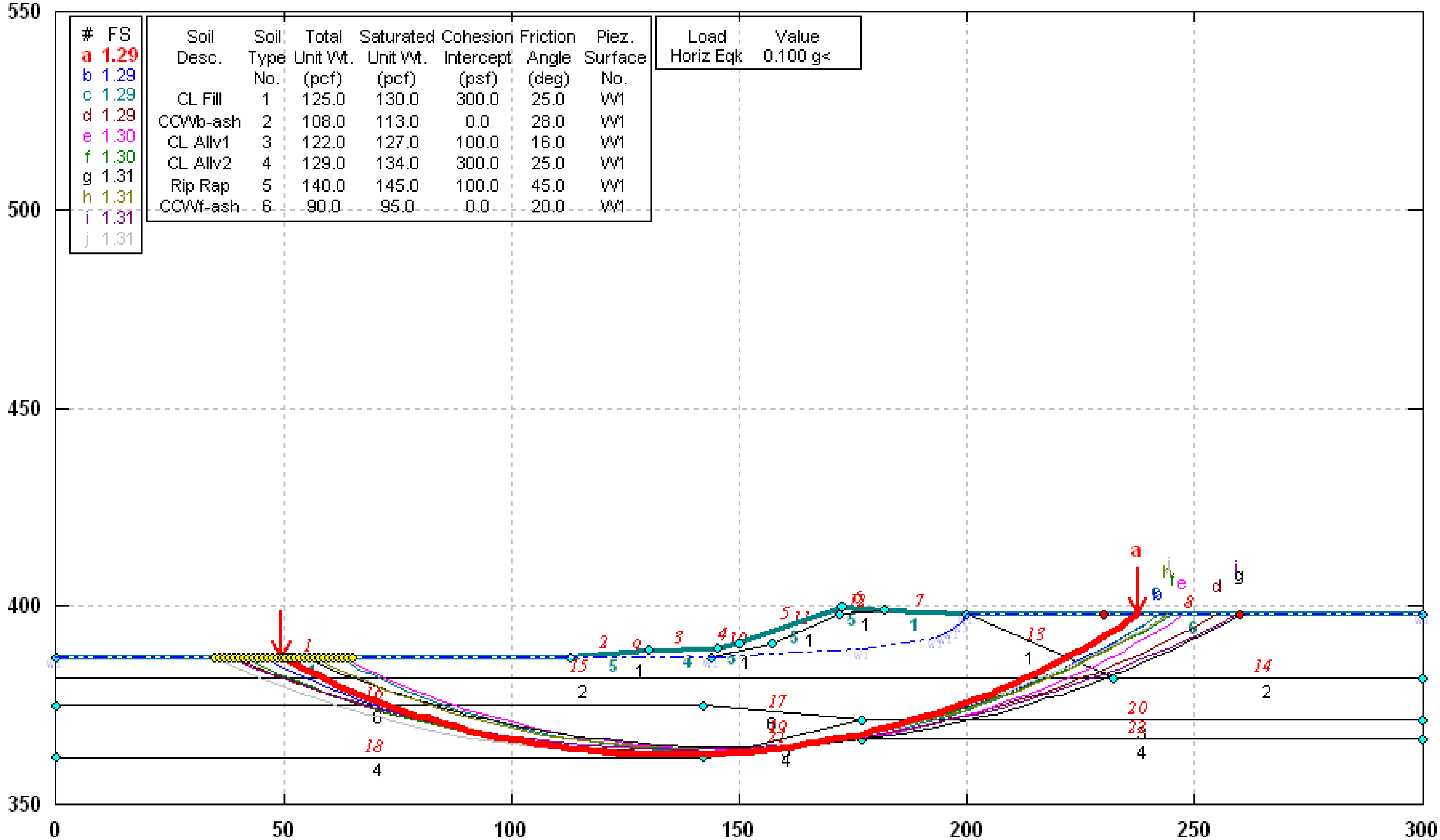
STABL6H FSmin=2.30

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 2: Downstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-2\DOWNST~1\SEISMIC.PL2 Run By: MACTEC 12/2/2010 12:04PM

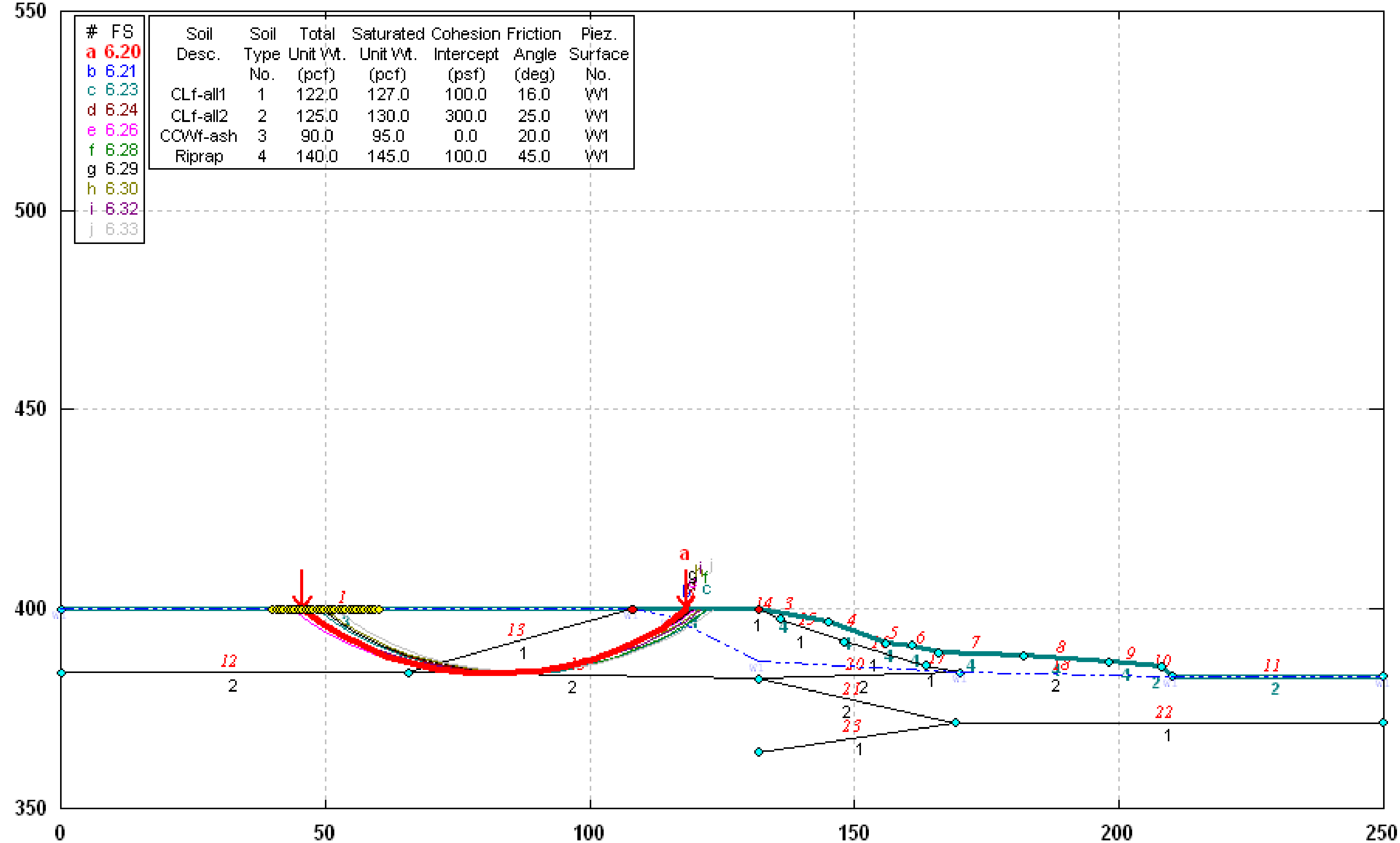


STABL6H FSmin=1.29

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 3: Upstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-3\UPSTREAM\SSMAXFLD.PL2 Run By: MACTEC 10/15/2010 3:57PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CLf-all1	1	122.0	127.0	100.0	16.0	W1
CLf-all2	2	125.0	130.0	300.0	25.0	W1
CCWf-ash	3	90.0	95.0	0.0	20.0	W1
Riprap	4	140.0	145.0	100.0	45.0	W1

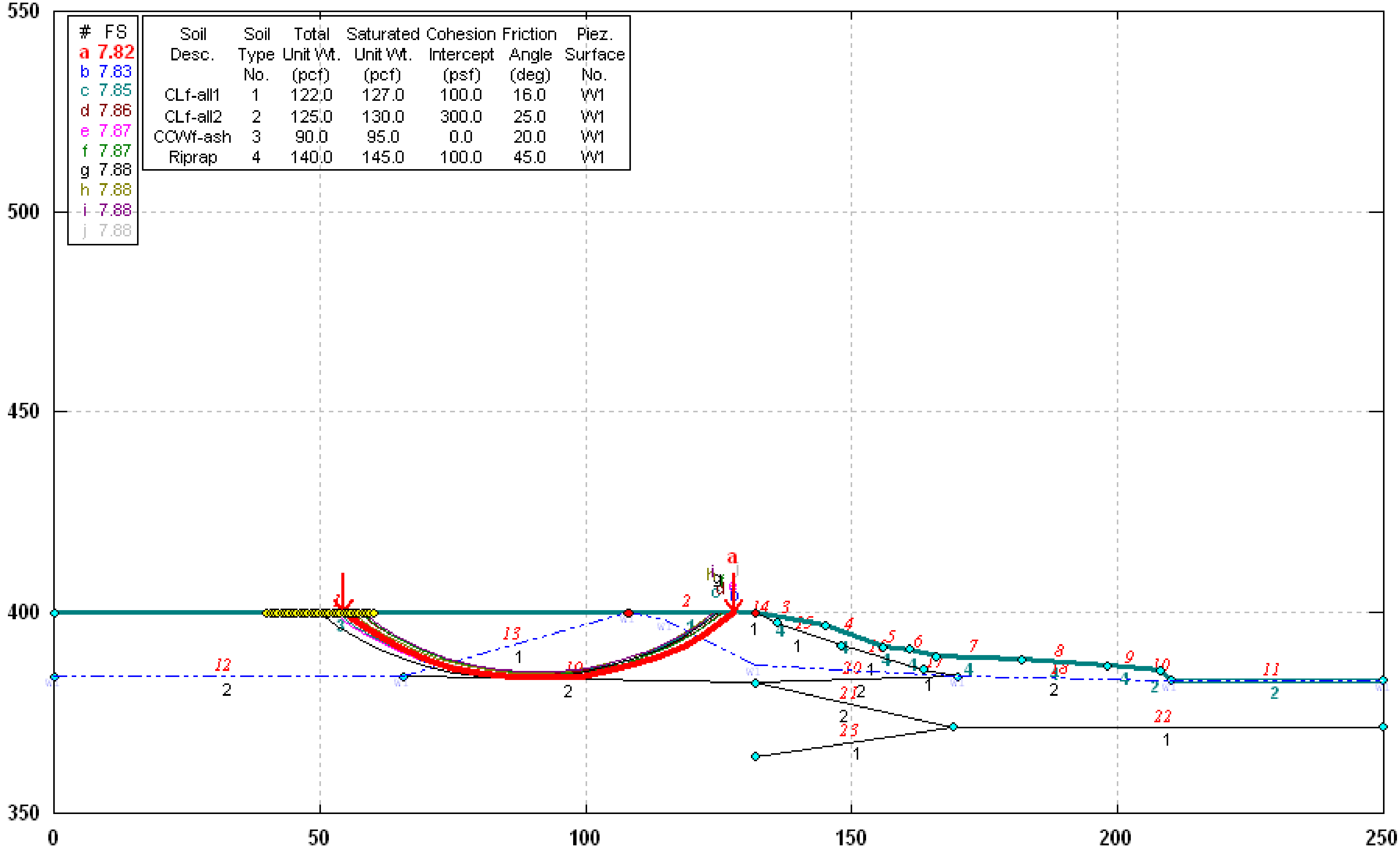
STED

STABL6H FSmin=6.20

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 3: Upstream - Rapid Drawdown

C:\STEDWIN\STEDWIN\GREENR~1\S-3\UPSTREAM\RDD.PL2 Run By: MACTEC 10/15/2010 4:02PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CLf-all1	1	122.0	127.0	100.0	16.0	W1
CLf-all2	2	125.0	130.0	300.0	25.0	W1
CCWf-ash	3	90.0	95.0	0.0	20.0	W1
Riprap	4	140.0	145.0	100.0	45.0	W1

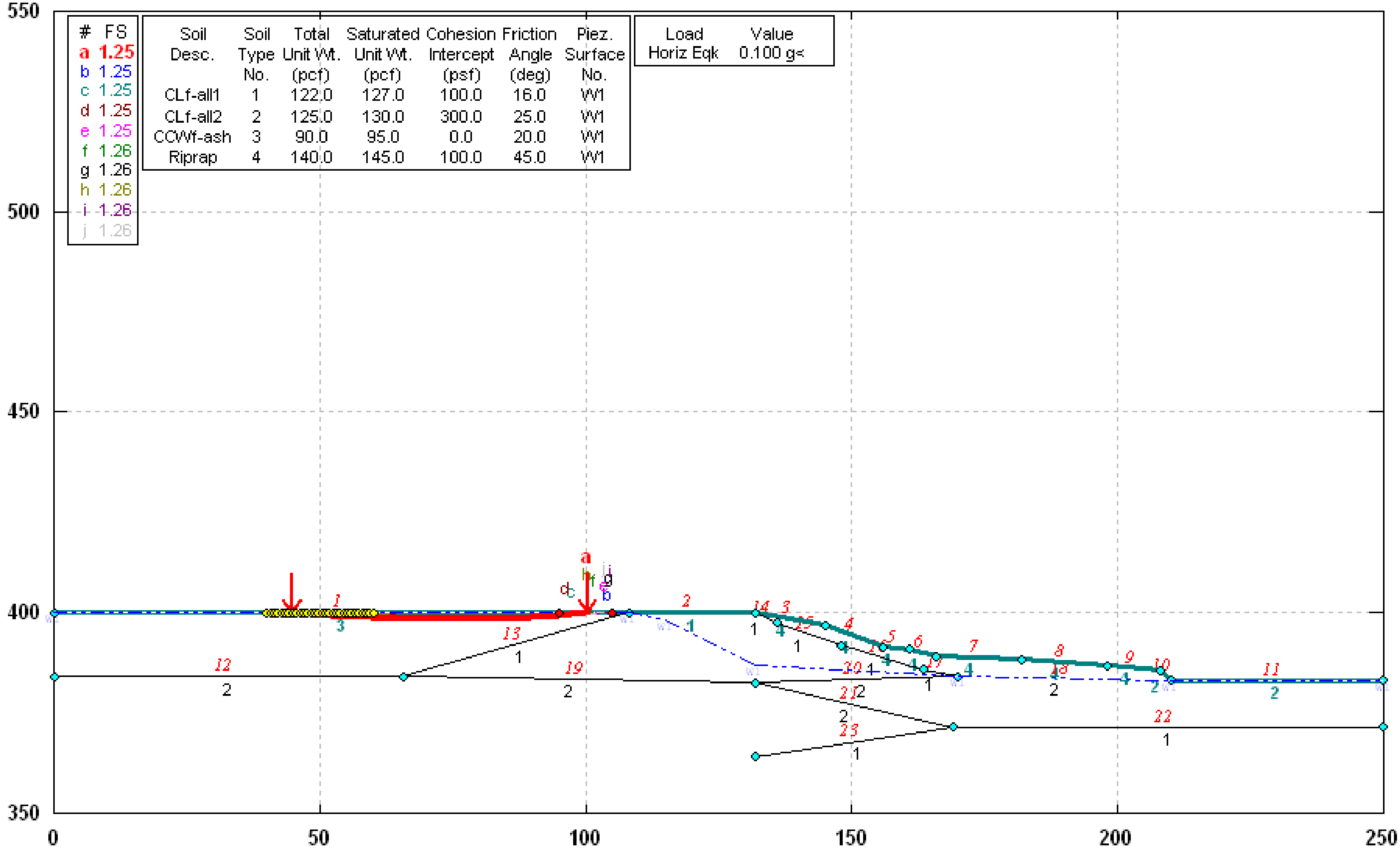
STABL6H FSmin=7.82

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 3: Upstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-3\UPSTREAM\SEISMIC.PL2 Run By: MACTEC 12/2/2010 11:06AM

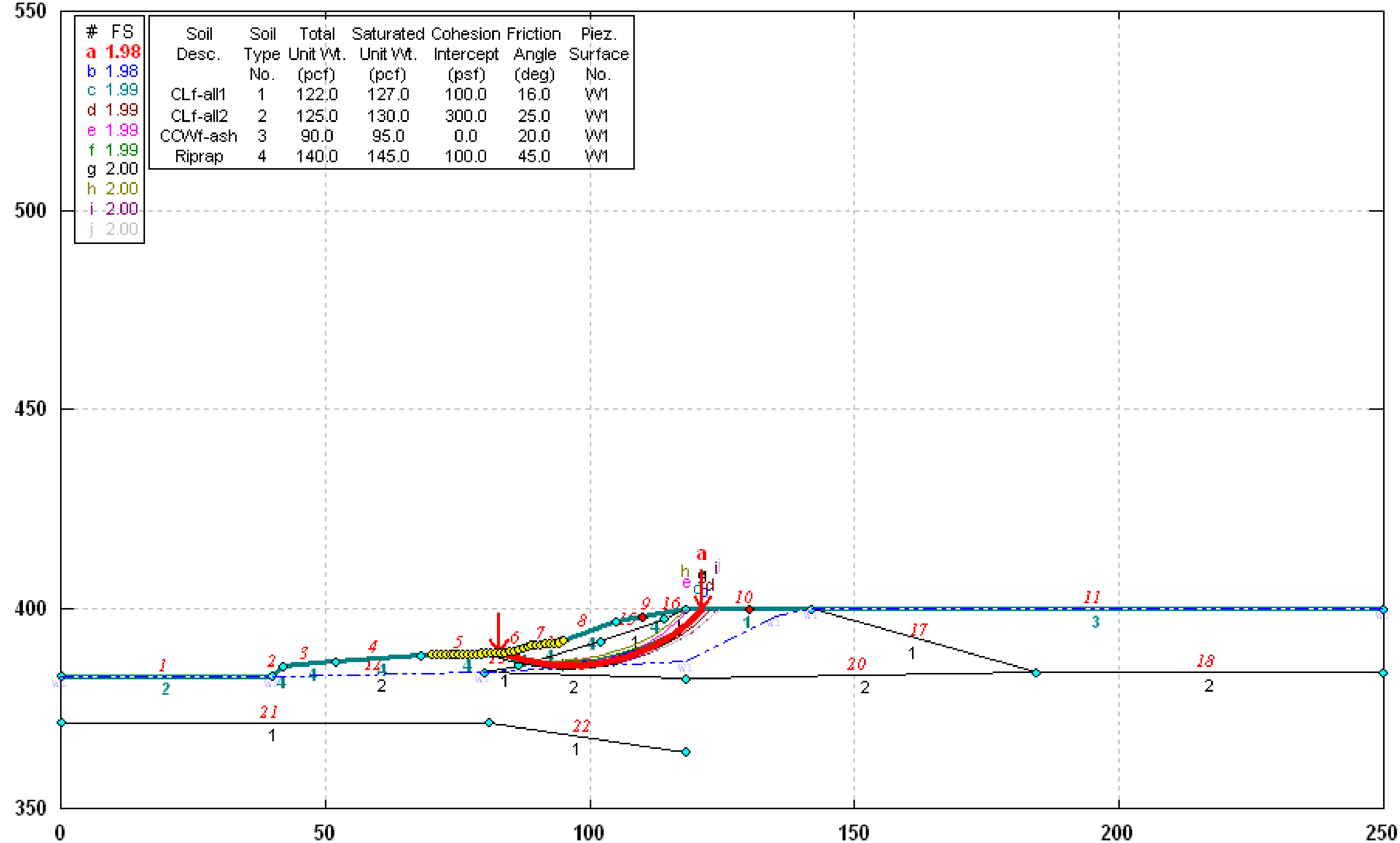


STABL6H FSmin=1.25

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 3: Downstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-3\DOWNST~1\SSMAXFLD.PL2   Run By: MACTEC   10/15/2010   4:26PM

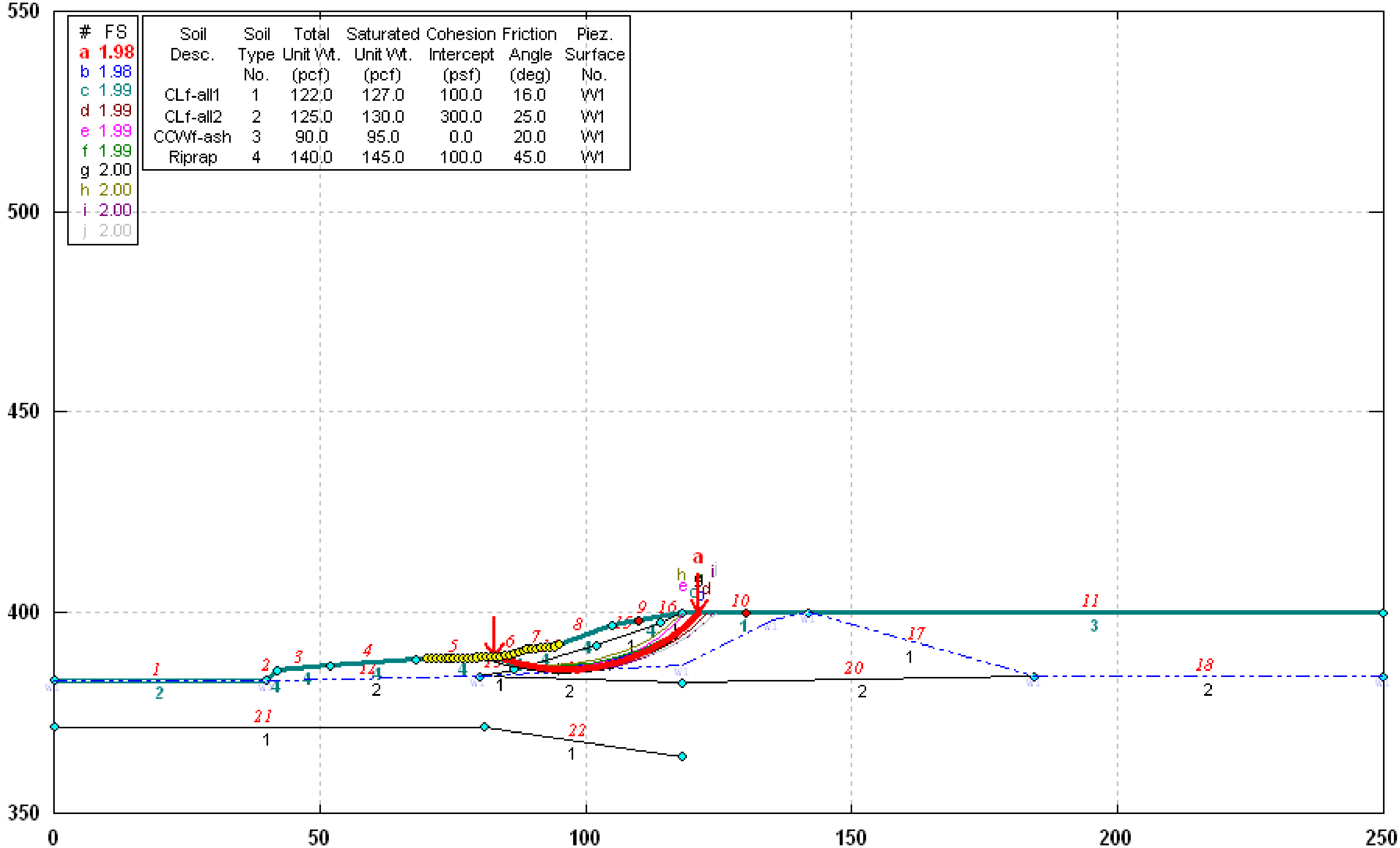


STABL6H FSmin=1.98
Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 3: Downstream - Rapid Drawdown

C:\STEDWIN\STEDWIN\GREENR~1\S-3\DOWNST~1\RDD.PL2 Run By: MACTEC 10/15/2010 4:21PM

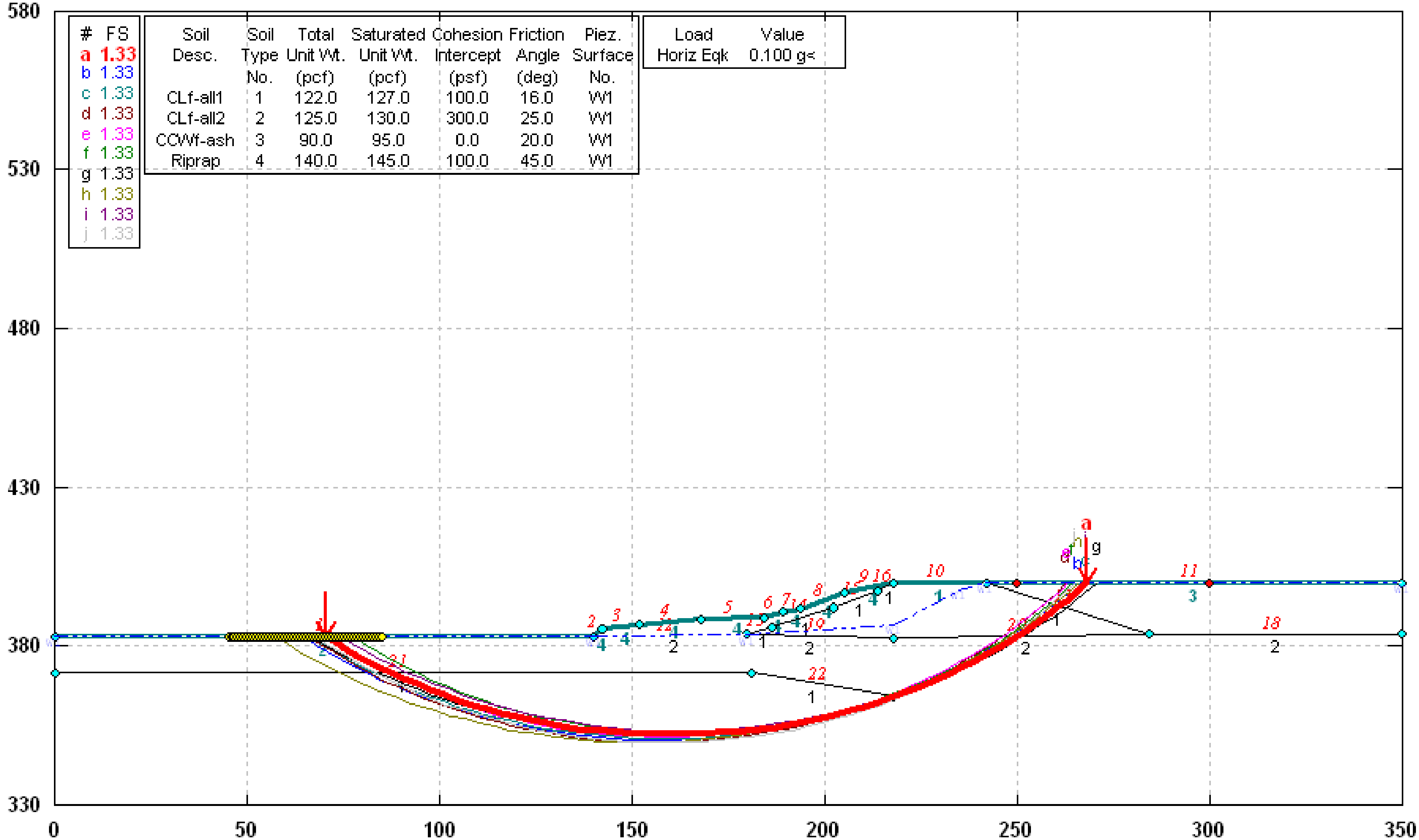


STABL6H FSmin=1.98

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 3: Downstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-3\DOWNST~1\SEISMIC.PL2 Run By: MACTEC 12/2/2010 12:18PM

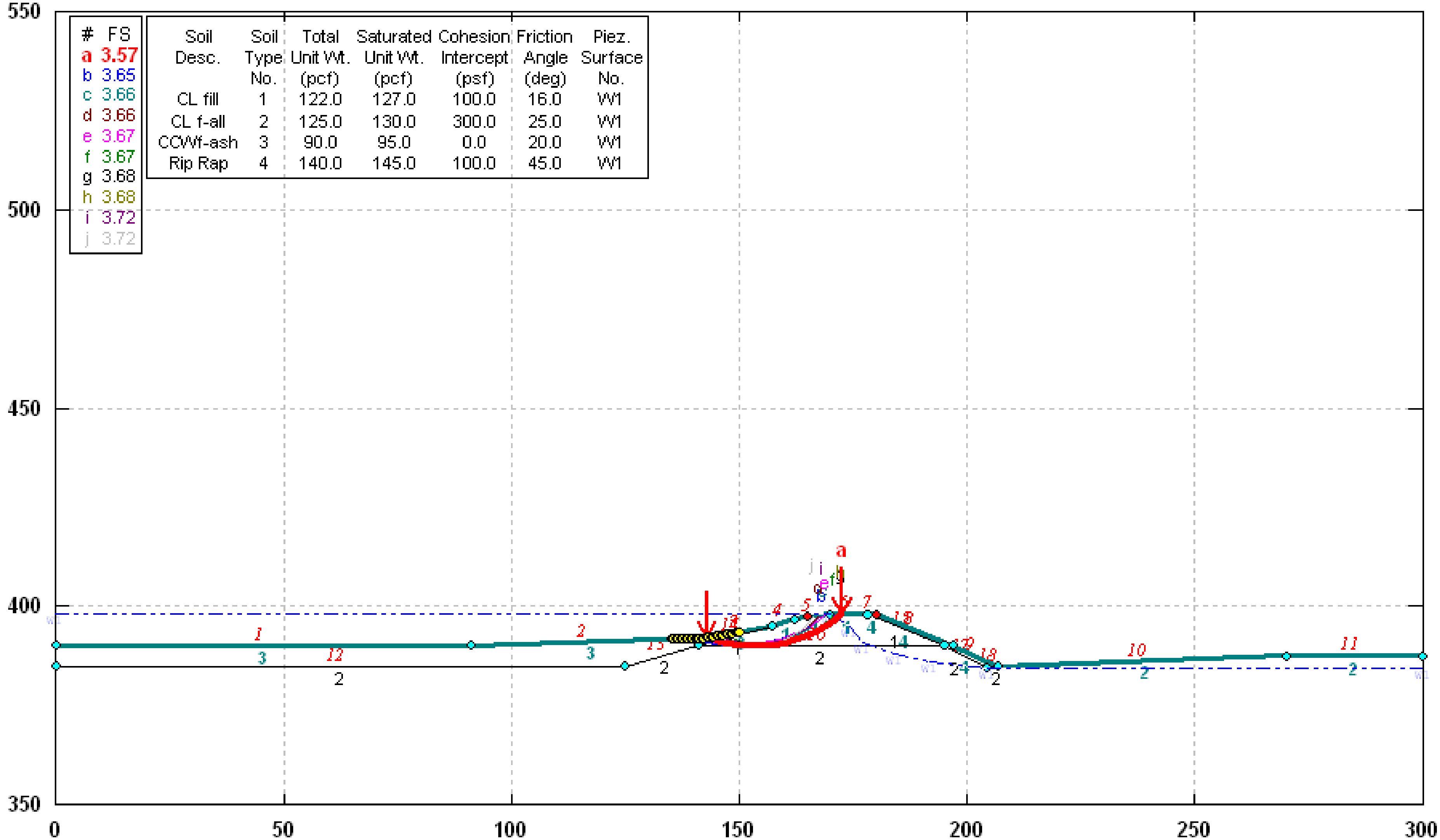


STABL6H FSmin=1.33

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Sta Section 4: Upstream - SS/Max Flood

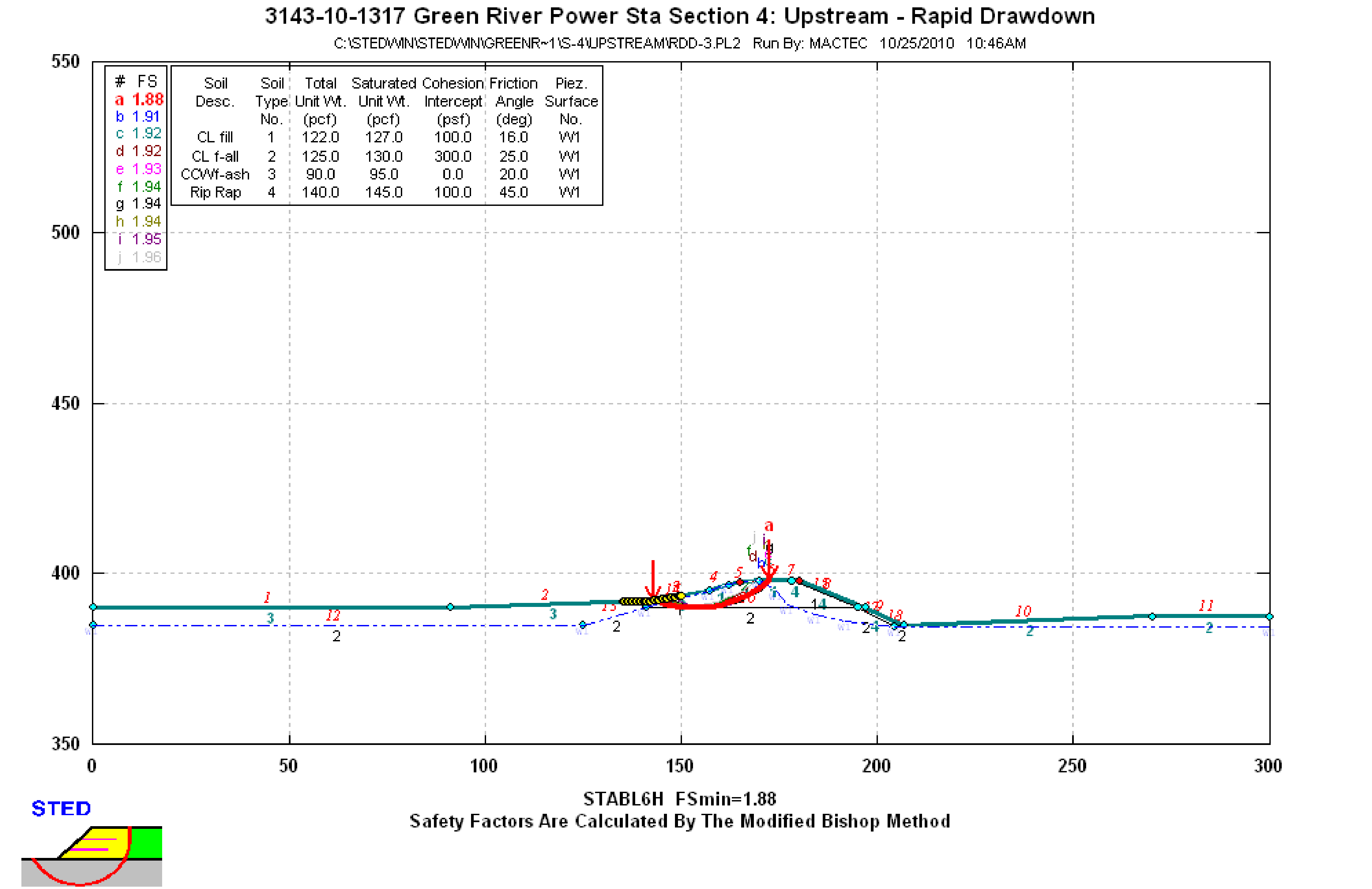
C:\STEDWIN\STEDWIN\GREENR~1\S-4\UPSTREAM\SSMXFL-3.PL2 Run By: MACTEC 10/25/2010 10:36AM



STABL6H FSmin=3.57

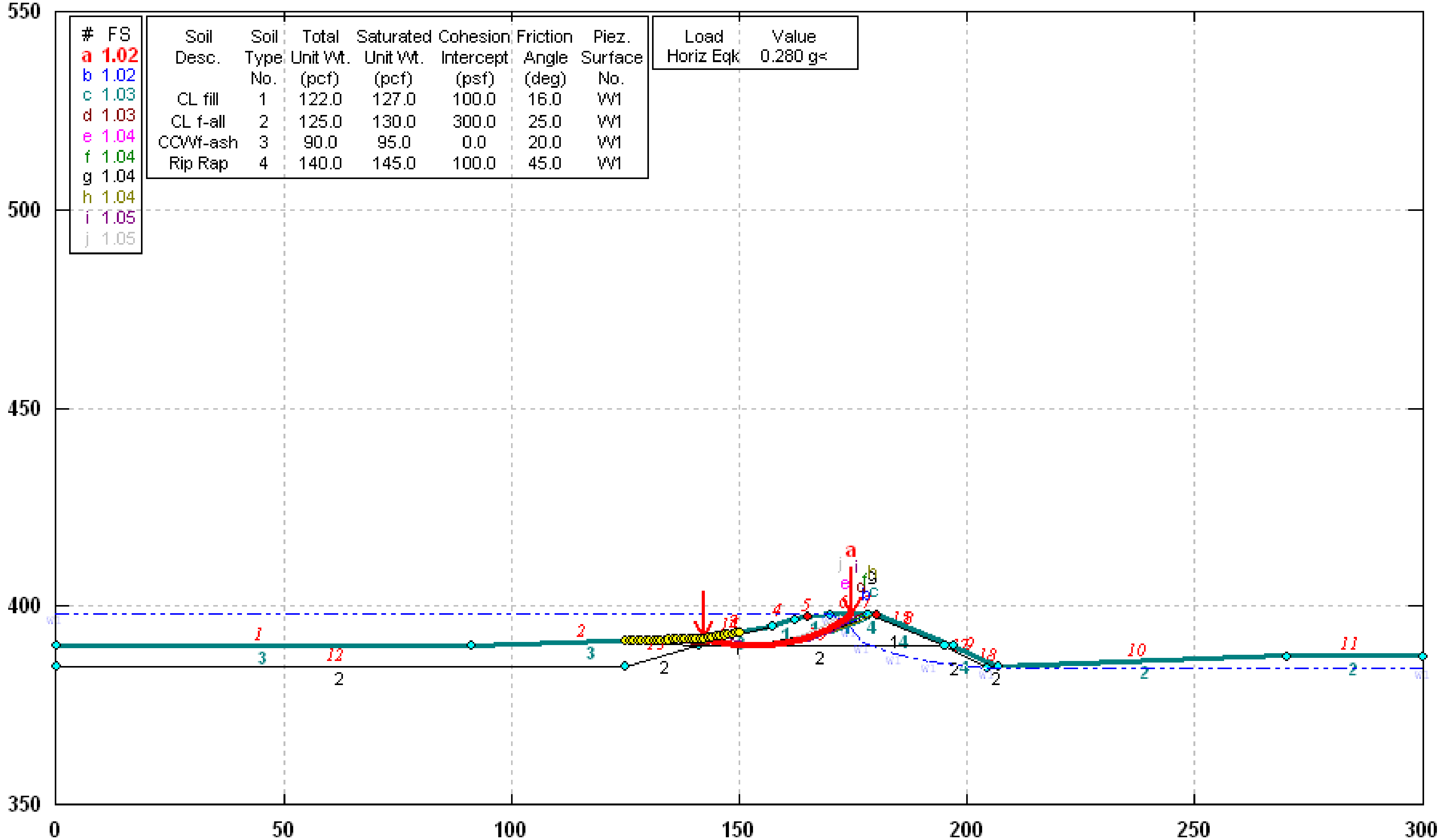
Safety Factors Are Calculated By The Modified Bishop Method

STED


3143-10-1317 Green River Power Sta Section 4: Upstream - Rapid Drawdown
C:\STEDWIN\STEDWIN\GREENR~1\S-4\UPSTREAM\RDD-3.PL2 Run By: MACTEC 10/25/2010 10:46AM
FS
a 1.88
b 1.91
c 1.92
d 1.92
e 1.93
f 1.94
g 1.94
h 1.94
i 1.95
j 1.96
Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Piez. Surface No.
CL fill 1 122.0 127.0 100.0 16.0 W1
CL f-all 2 125.0 130.0 300.0 25.0 W1
CCWf-ash 3 90.0 95.0 0.0 20.0 W1
Rip Rap 4 140.0 145.0 100.0 45.0 W1
550
500
450
400
350
0
50
100
150
200
250
300
STABL6H FSmin=1.88
Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Sta Section 4: Upstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-4\UPSTREAM\QUAKE-3.PL2 Run By: MACTEC 12/2/2010 12:19PM



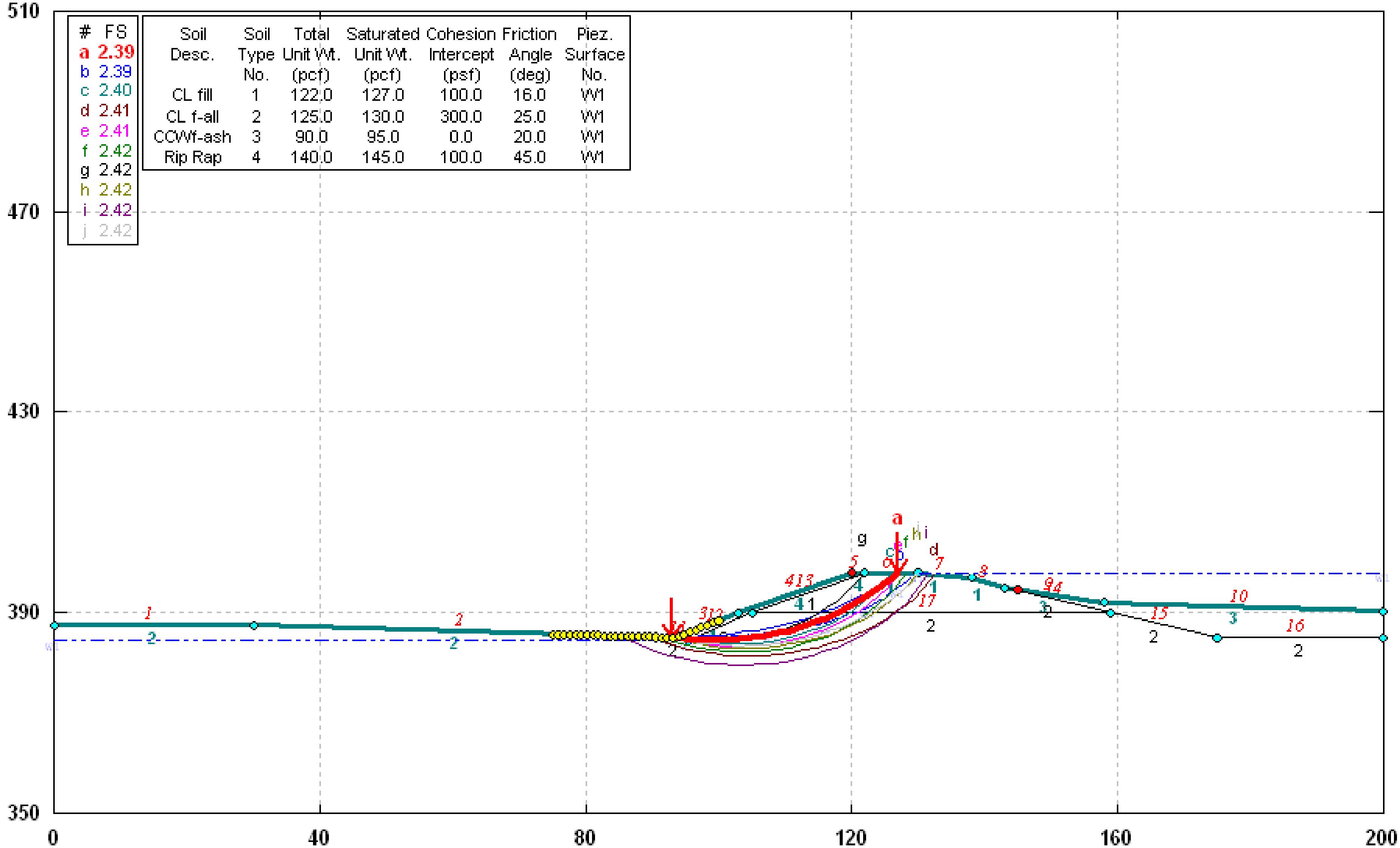
STABL6H FSmin=1.02

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Sta Section 4: Downstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-4\DOWNST~1\SSMXFL-3.PL2 Run By: MACTEC 10/25/2010 12:19PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CL fill	1	122.0	127.0	100.0	16.0	W1
CL f-all	2	125.0	130.0	300.0	25.0	W1
CCWf-ash	3	90.0	95.0	0.0	20.0	W1
Rip Rap	4	140.0	145.0	100.0	45.0	W1

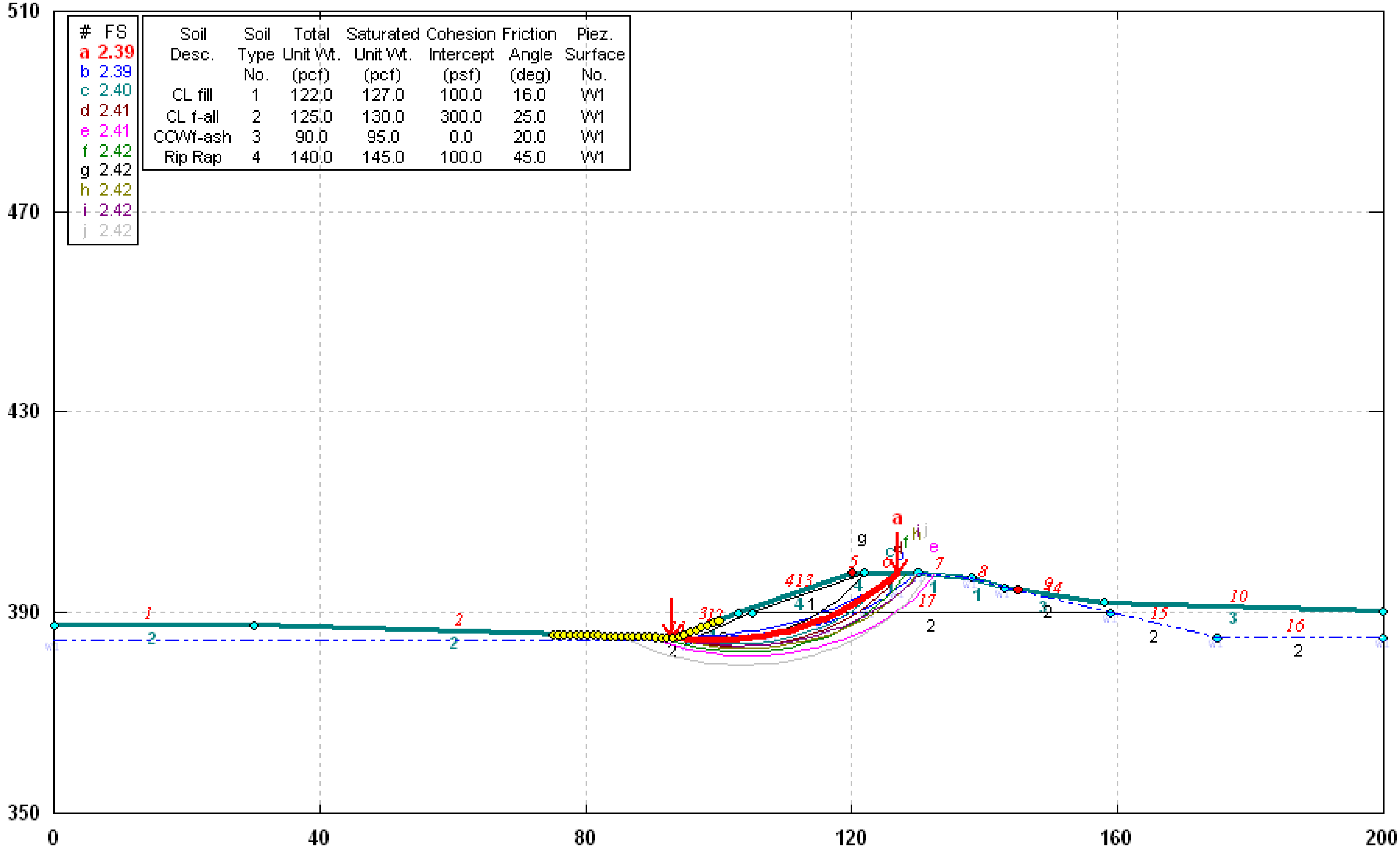
STED

STABL6H FSmin=2.39

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Sta Section 4: Downstream - Rapid Drawdown

C:\STEDWIN\STEDWIN\GREENR~1\S-4\DOWNST~1\RDD-3.PL2 Run By: MACTEC 10/25/2010 12:23PM



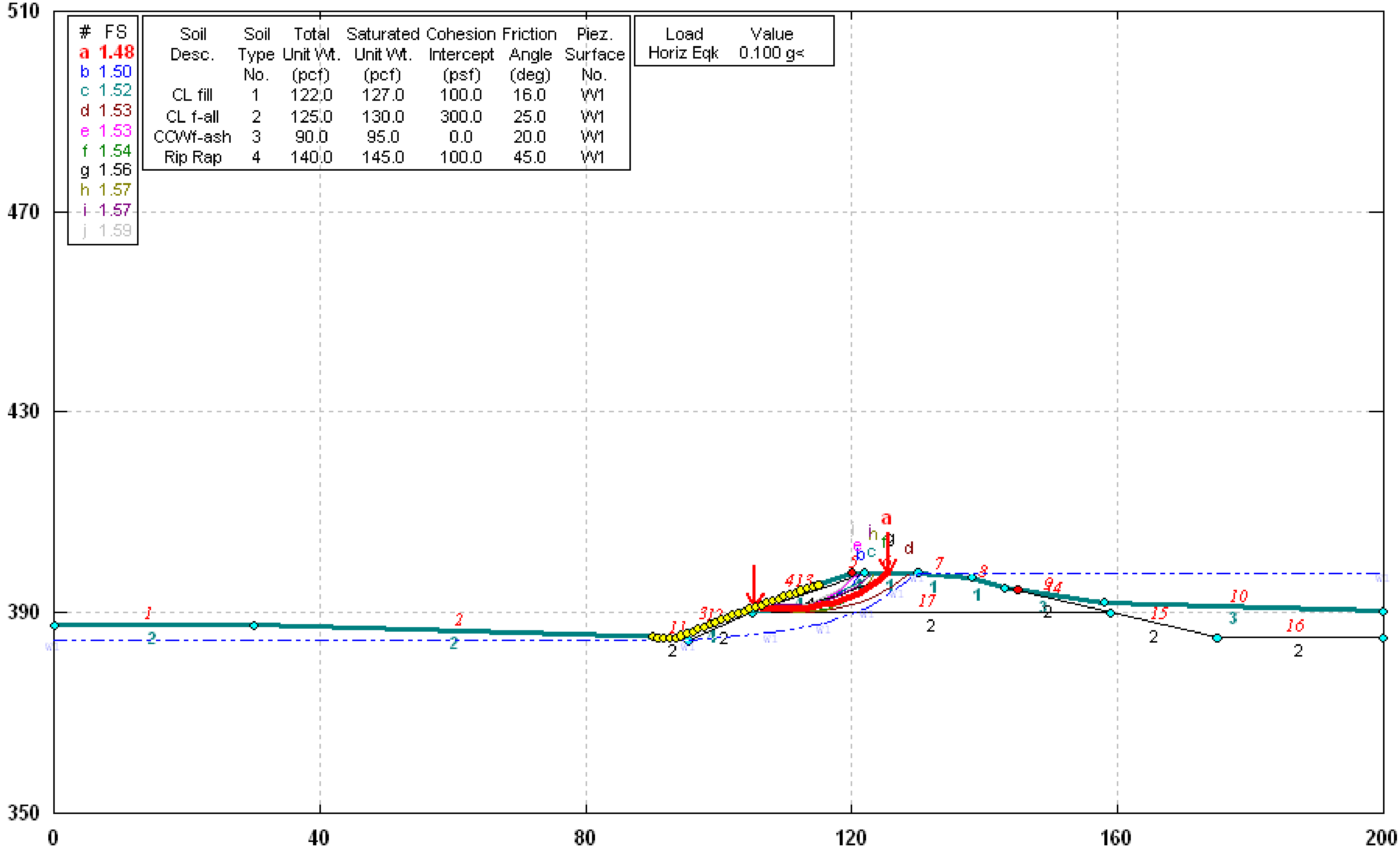
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CL fill	1	122.0	127.0	100.0	16.0	W1
CL f-all	2	125.0	130.0	300.0	25.0	W1
CCWf-ash	3	90.0	95.0	0.0	20.0	W1
Rip Rap	4	140.0	145.0	100.0	45.0	W1

STABL6H FSmin=2.39

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Sta Section 4: Downstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-4\DOWNST~1\QUAKE-3.PL2 Run By: MACTEC 12/2/2010 12:06PM

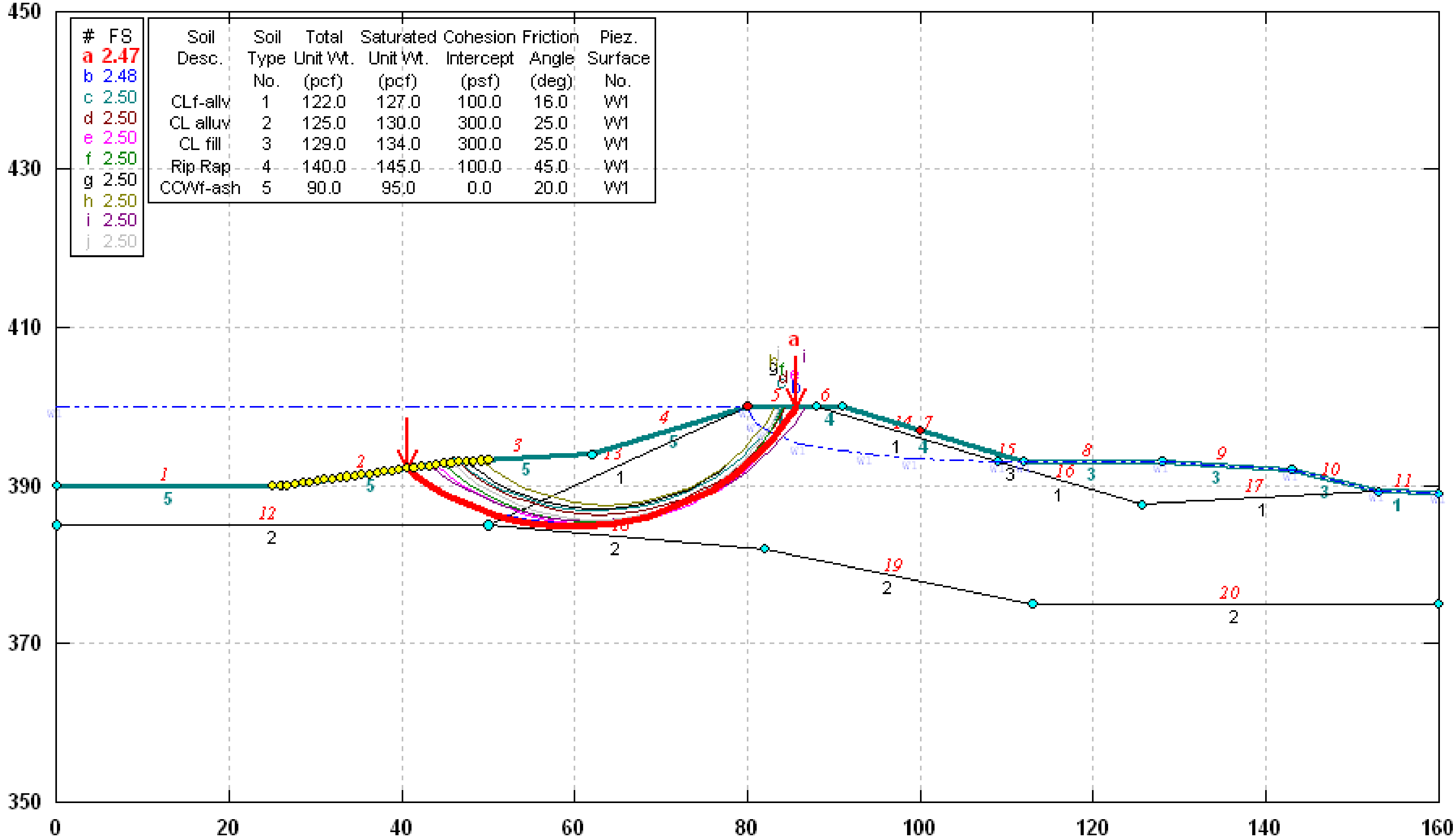


STABL6H FSmin=1.48

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 5: Upstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-5\UPSTREAM\SSMXFL-2.PL2 Run By: MACTEC 10/26/2010 12:33PM



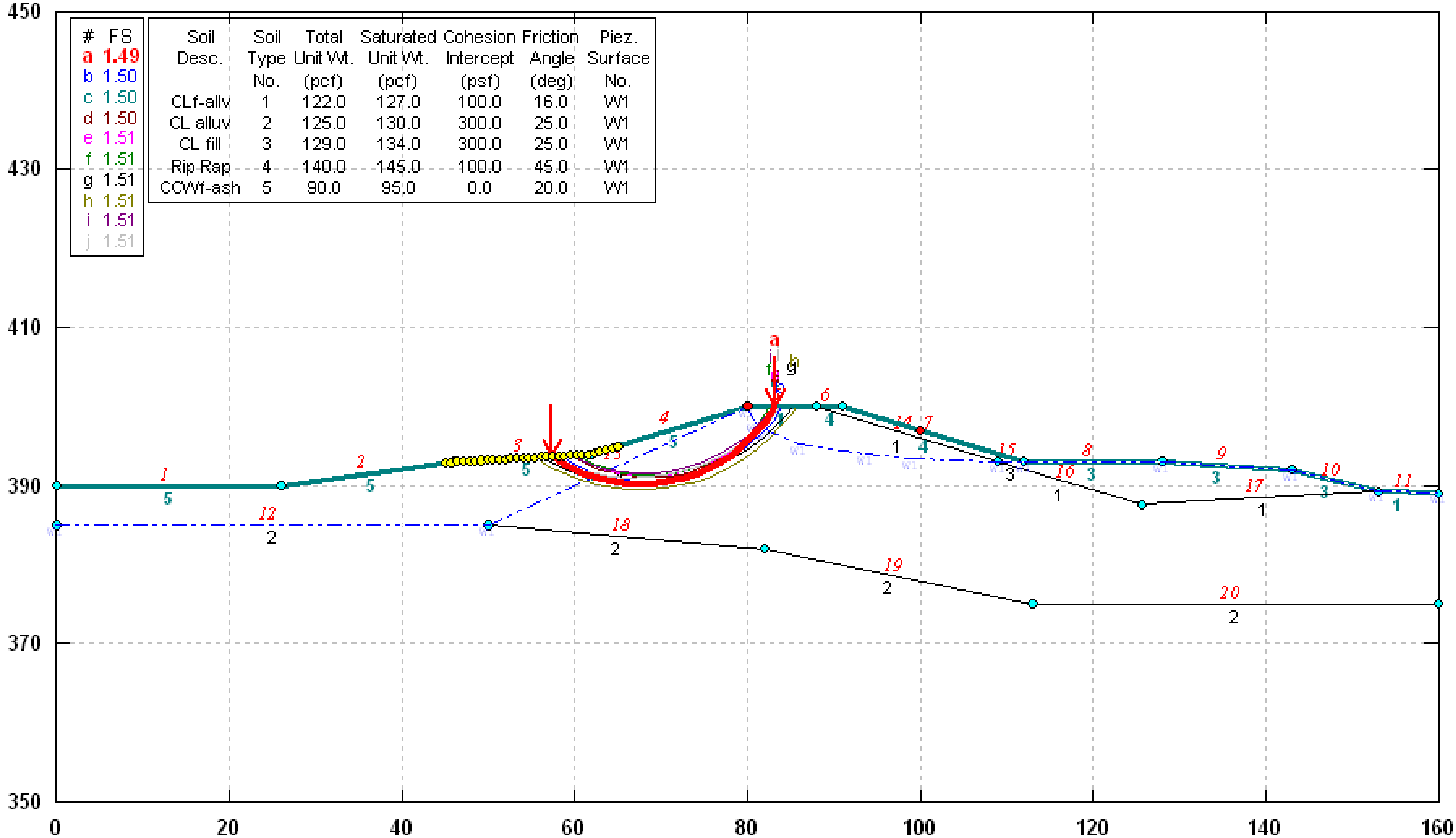
STABL6H FSmin=2.47

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 5: Upstream - Rapid Drawdown

C:\STEDWIN\STEDWIN\GREENR~1\S-5\UPSTREAM\RDD-2.PL2 Run By: MACTEC 10/26/2010 12:39PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CLf-allv	1	122.0	127.0	100.0	16.0	W1
CL alluv	2	125.0	130.0	300.0	25.0	W1
CL fill	3	129.0	134.0	300.0	25.0	W1
Rip Rap	4	140.0	145.0	100.0	45.0	W1
CCWf-ash	5	90.0	95.0	0.0	20.0	W1

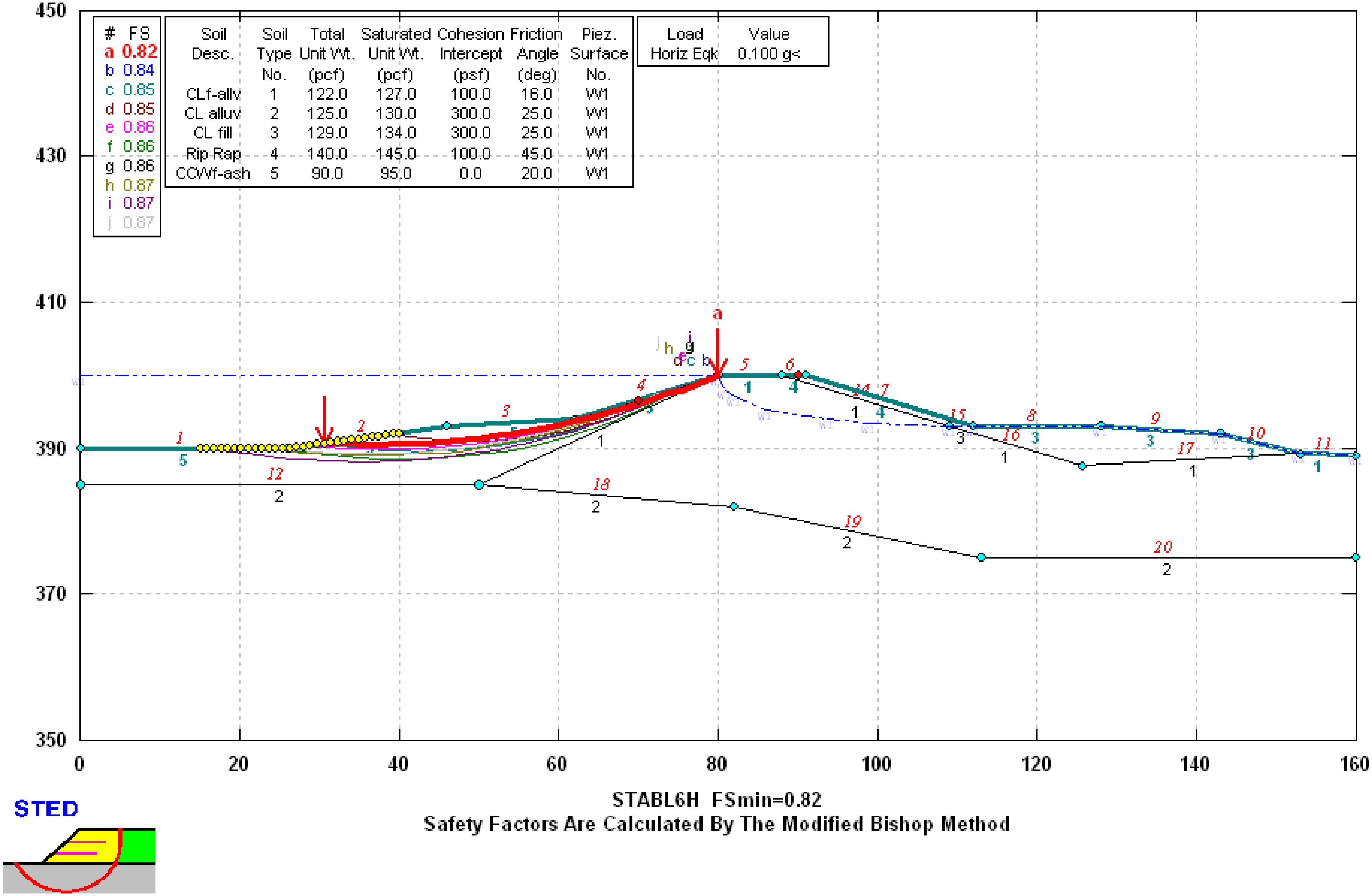
STABL6H FSmin=1.49

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 5: Upstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-5\UPSTREAM\SEISMC-2.PL2 Run By: MACTEC 12/2/2010 11:57AM

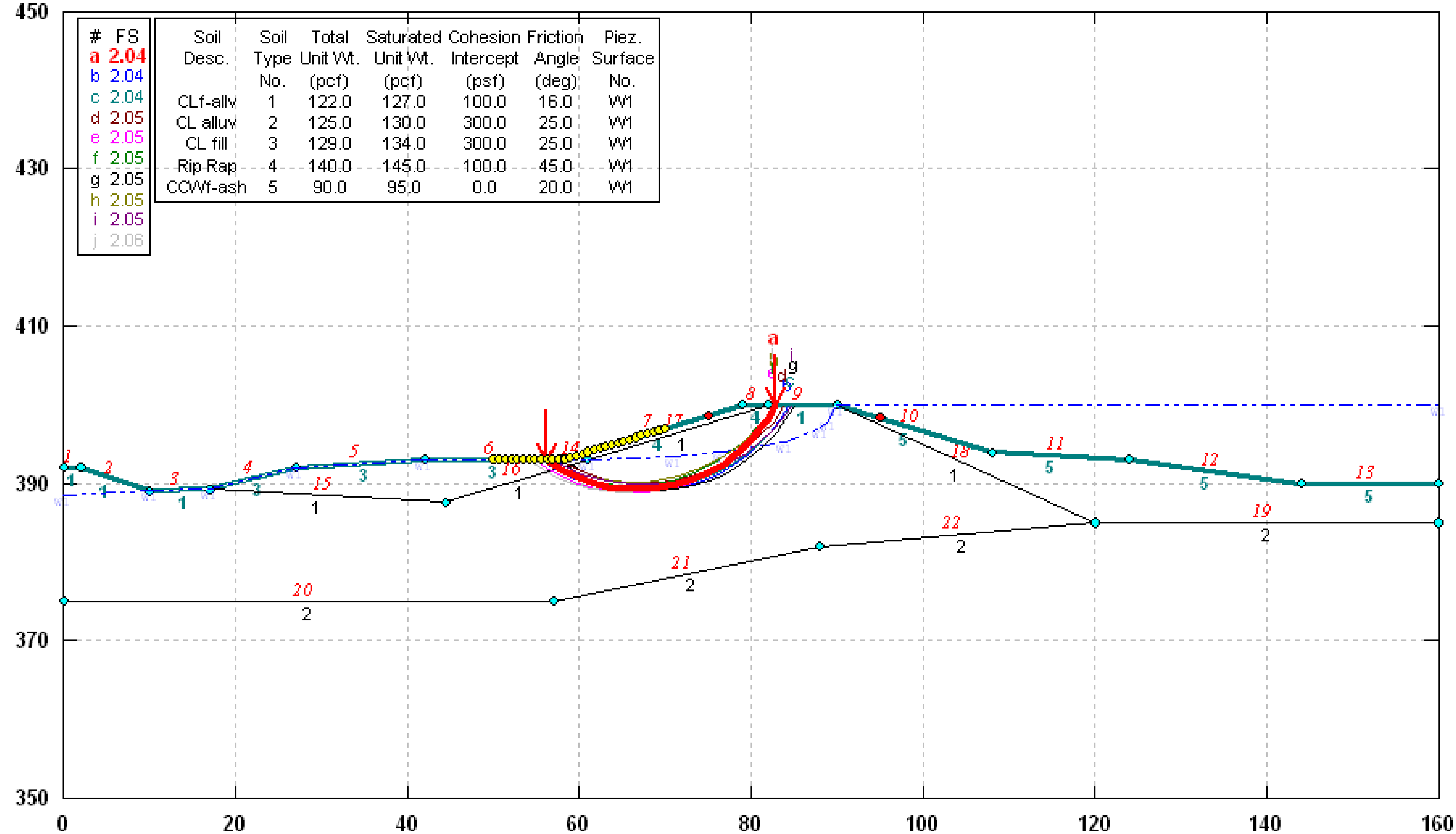


STABL6H FSmin=0.82

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 5: Downstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-5\DOWNST~1\SSMXFL-2.PL2 Run By: MACTEC 10/26/2010 10:26AM



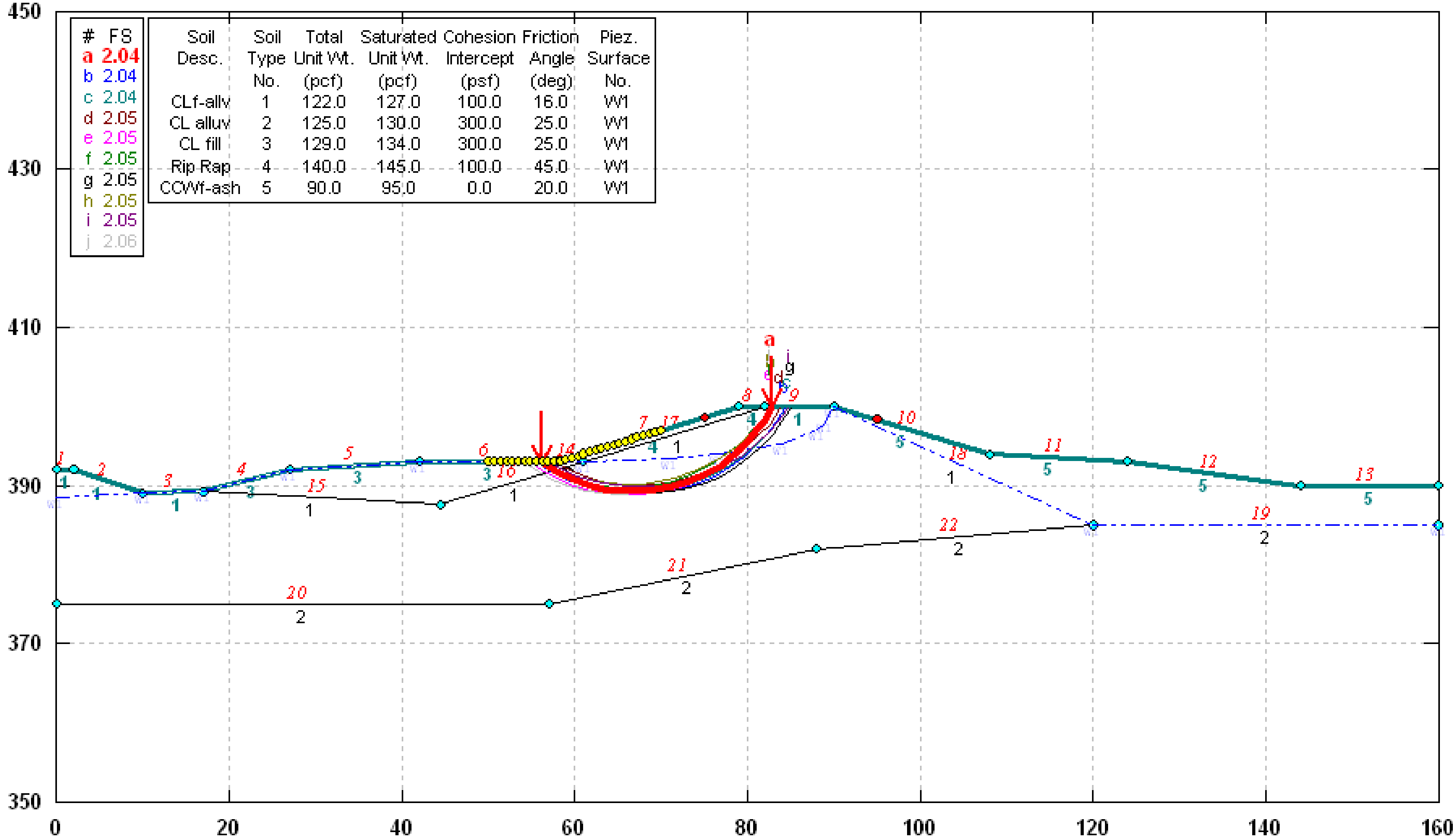
STABL6H FSmin=2.04

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 5: Downstream - Rapid Drawdown

C:\STEDWIN\STEDWIN\GREENR~1\S-5\DOWNST~1\RDD-2.PL2 Run By: MACTEC 10/26/2010 10:30AM



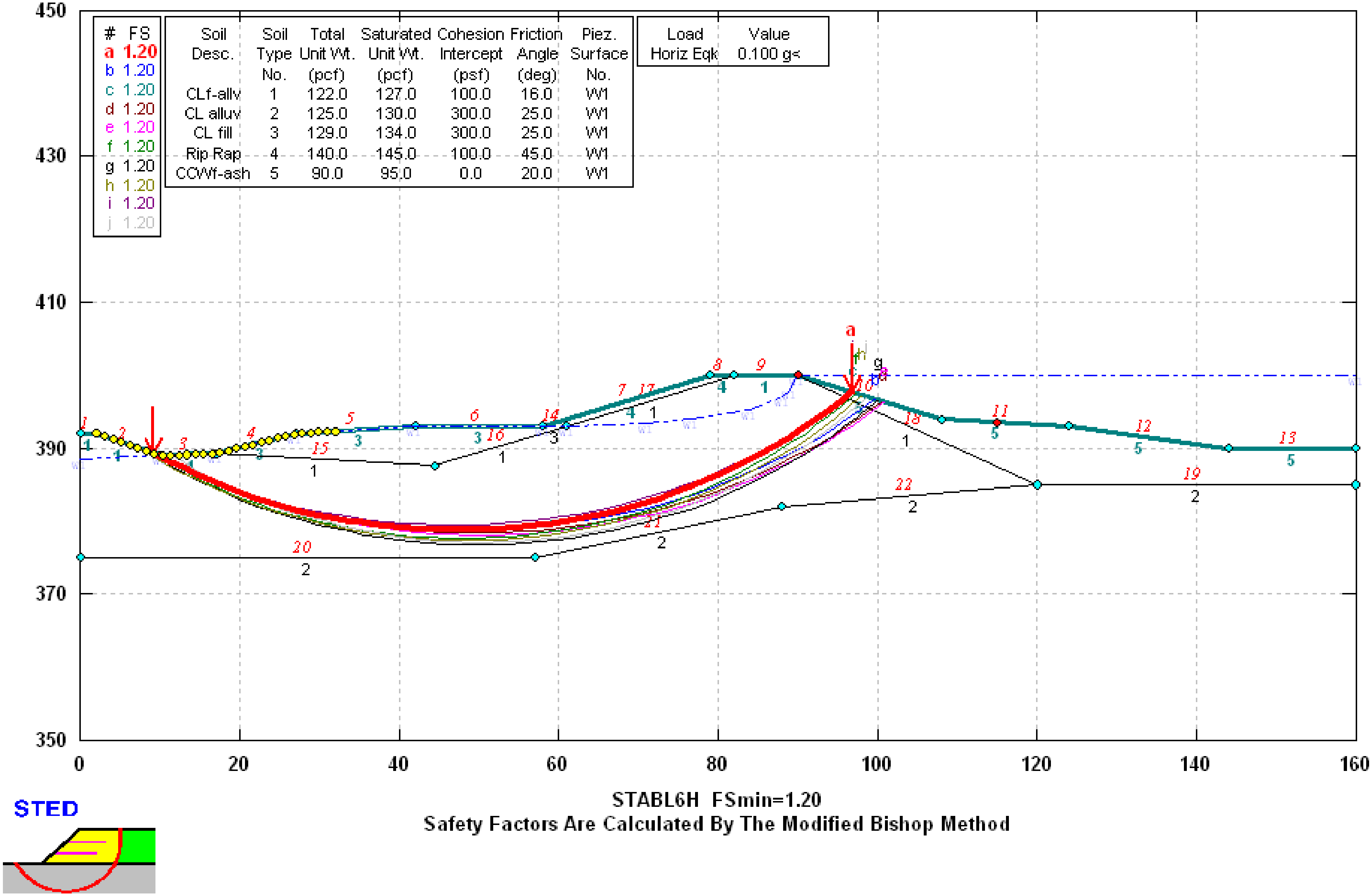
STABL6H FSmin=2.04

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 5: Downstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-5\DOWNST~1\SEISMC-2.PL2 Run By: MACTEC 12/2/2010 12:22PM

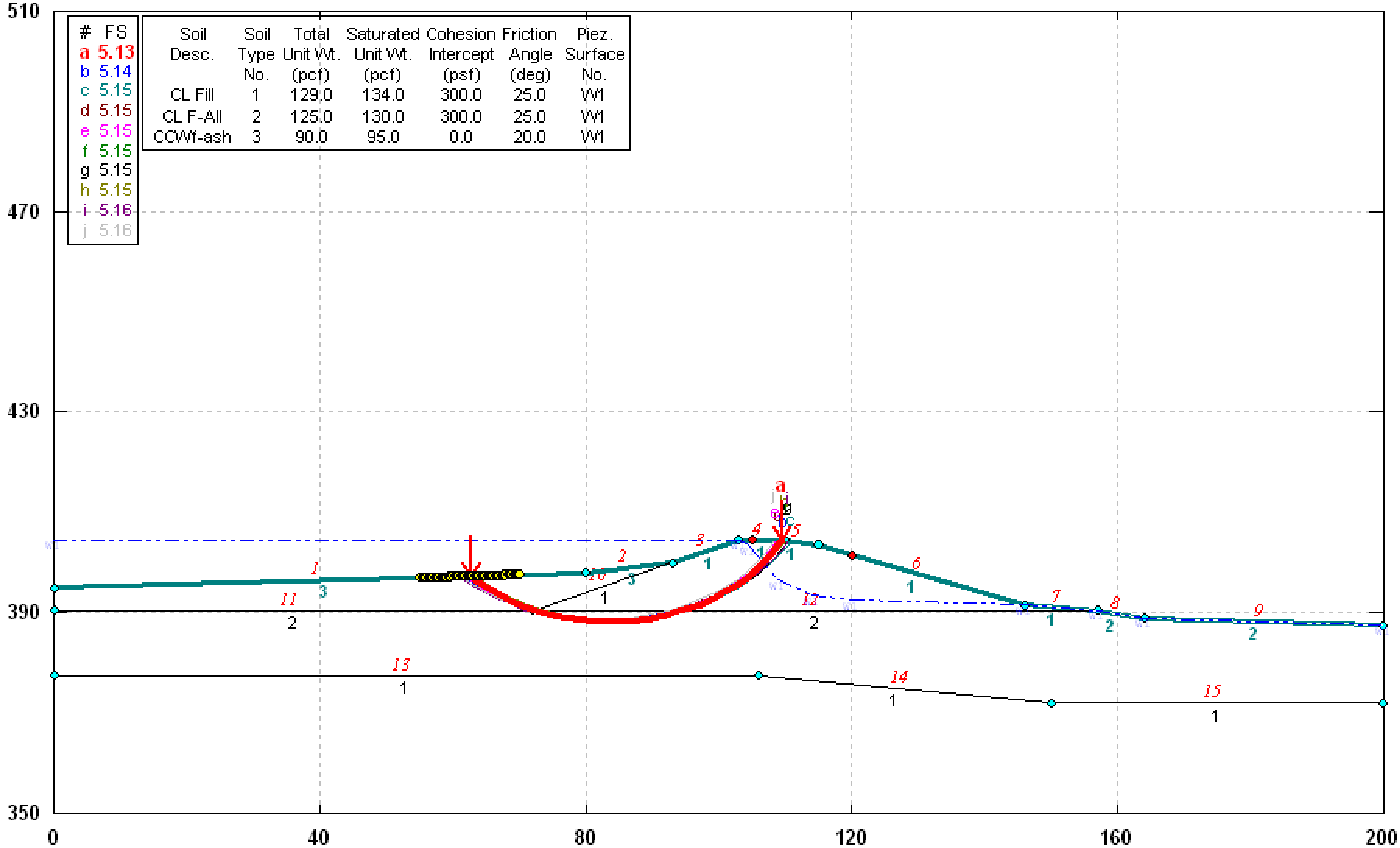


STABL6H FSmin=1.20

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 6: Upstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-6\UPSTREAM\SSMXFLD4.PL2 Run By: MACTEC 10/15/2010 2:56PM



STABL6H FSmin=5.13

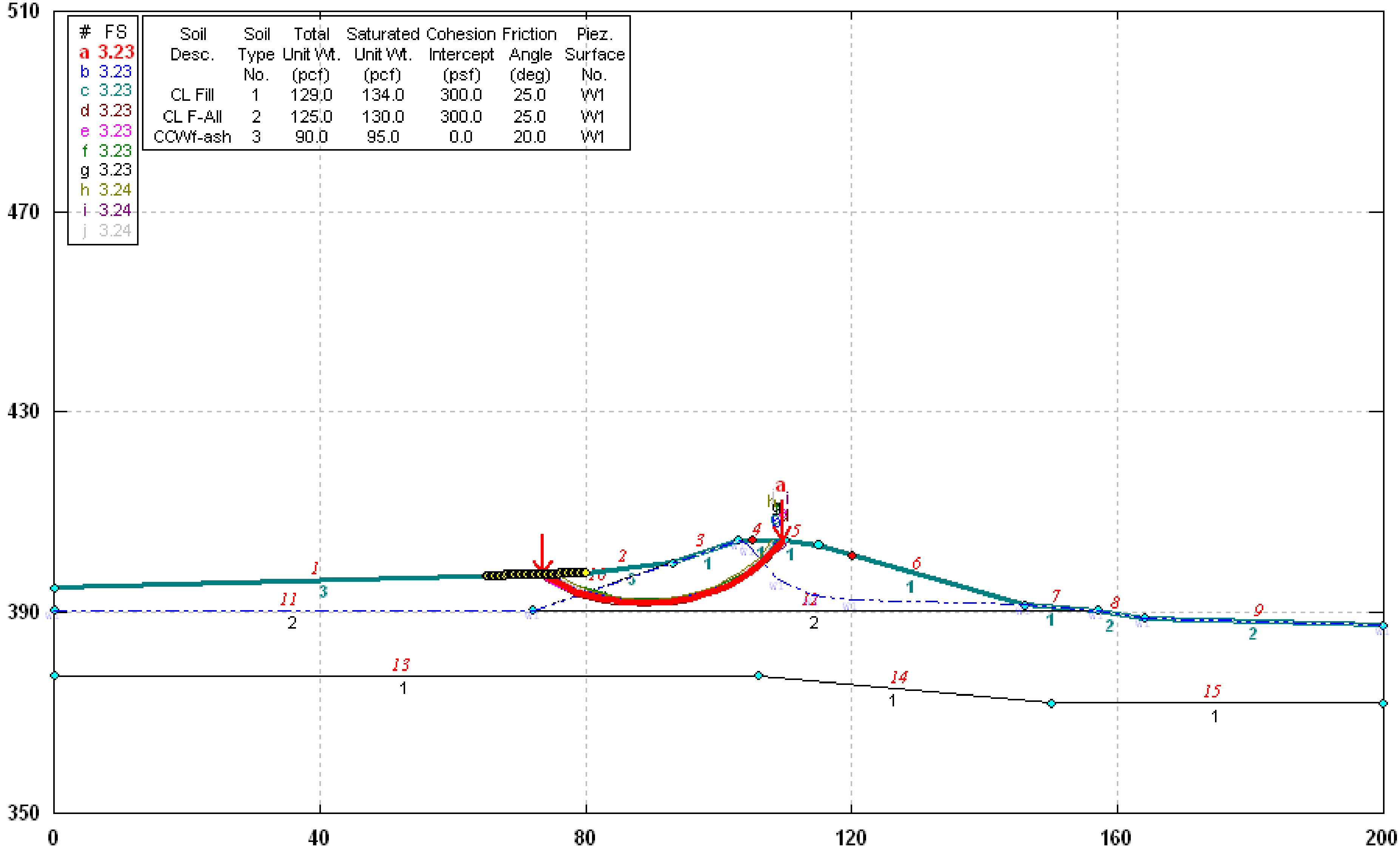
Safety Factors Are Calculated By The Modified Bishop Method

STED

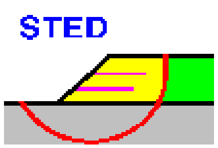
3143-10-1317 Green River Power Station Section 6: Upstream - Rapid Drawdown

C:\STEDWIN\STEDWIN\GREENR~1\S-6\UPSTREAM\RDD.PL2 Run By: MACTEC 10/15/2010 2:55PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CL Fill	1	129.0	134.0	300.0	25.0	W1
CL F-All	2	125.0	130.0	300.0	25.0	W1
CCWf-ash	3	90.0	95.0	0.0	20.0	W1

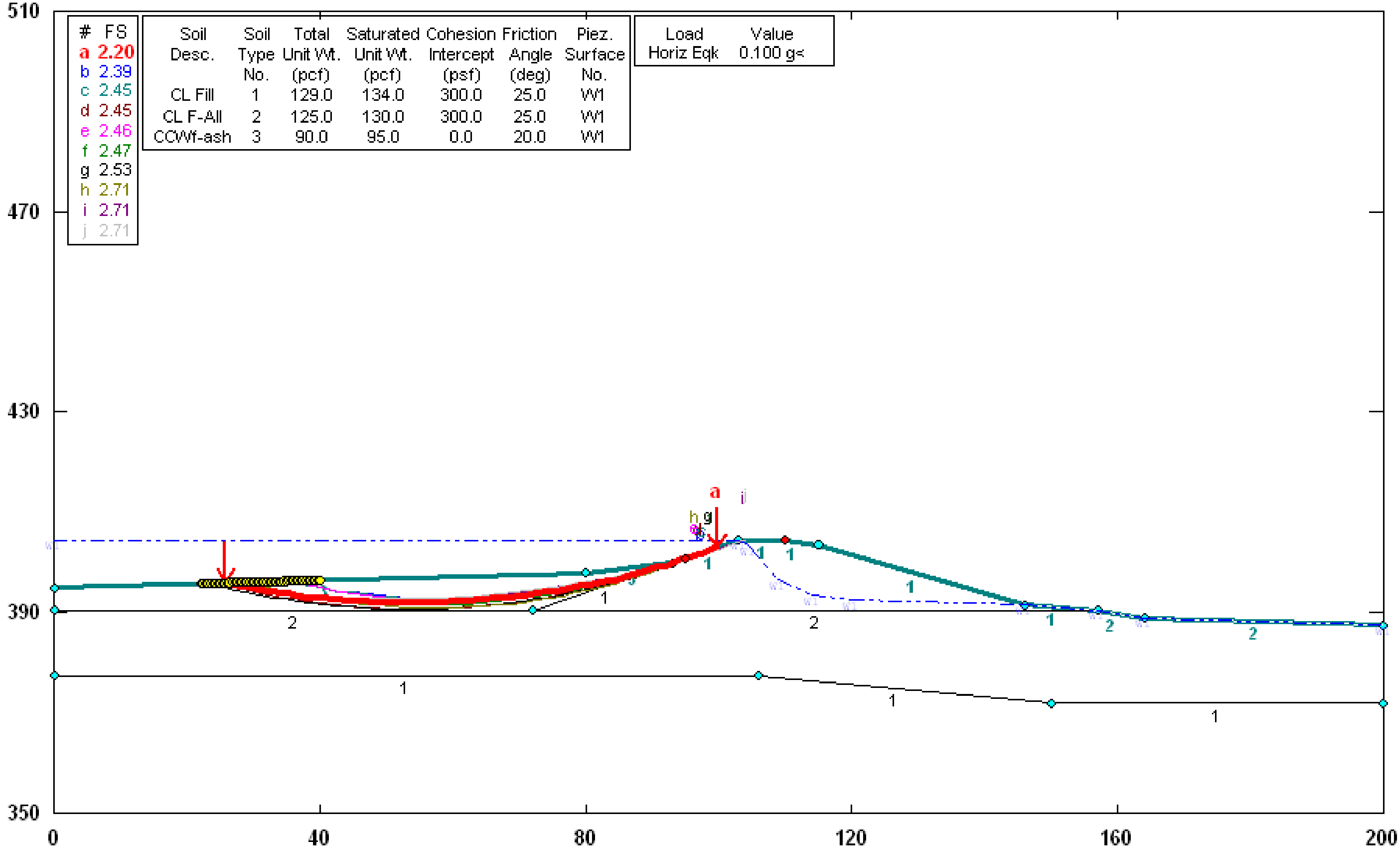


STABL6H FSmin=3.23
Safety Factors Are Calculated By The Modified Bishop Method



3143-10-1317 Green River Power Station Section 6: Upstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-6\UPSTREAM\SEISMIC.PL2 Run By: MACTEC 12/2/2010 11:03AM

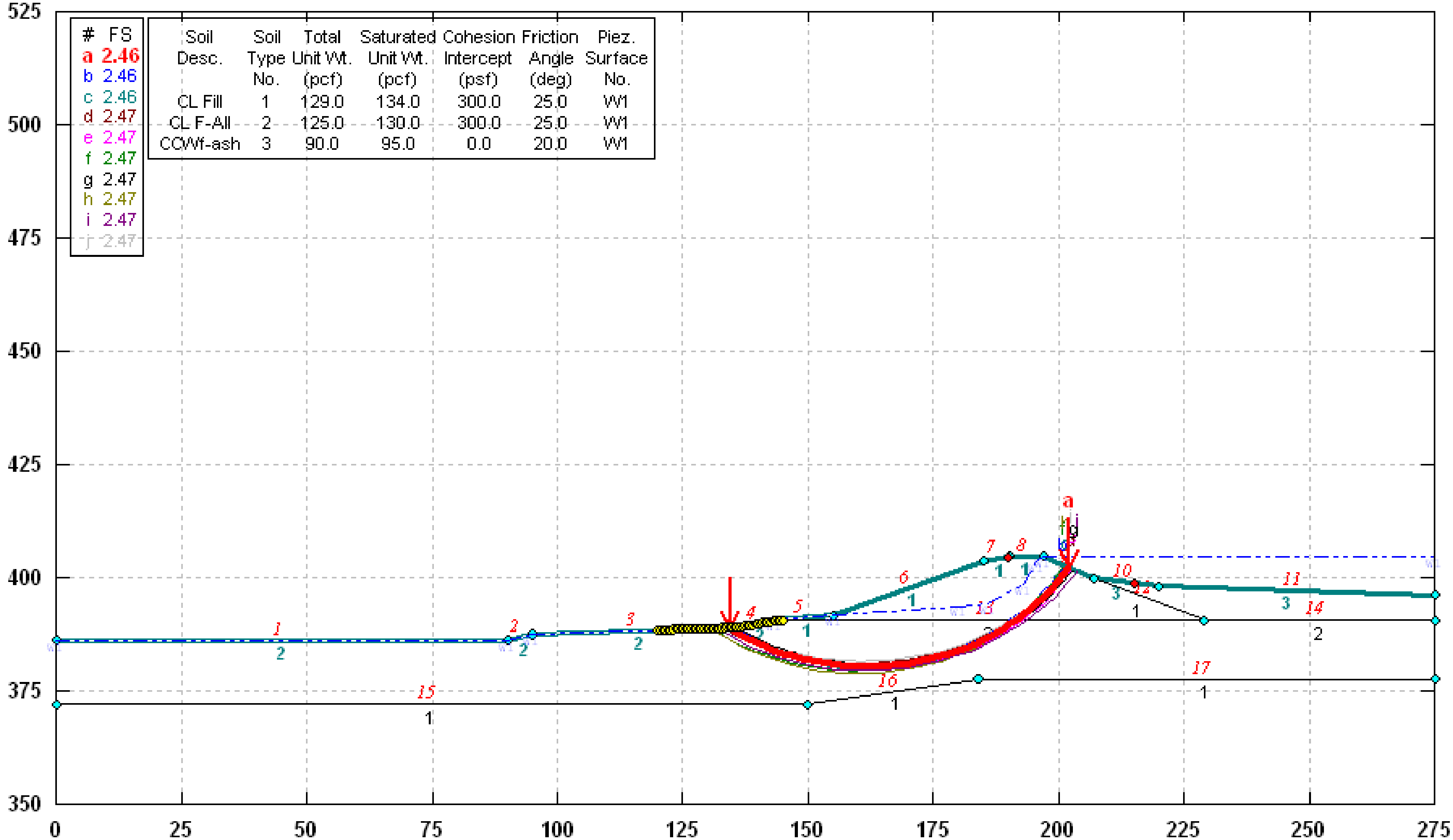


STABL6H FSmin=2.20

Safety Factors Are Calculated By The Modified Bishop Method

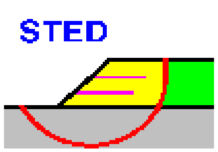
3143-10-1317 Green River Power Station Section 6: Downstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-6\DOWNST~1\SSMXFLD.PL2 Run By: MACTEC 10/15/2010 3:26PM



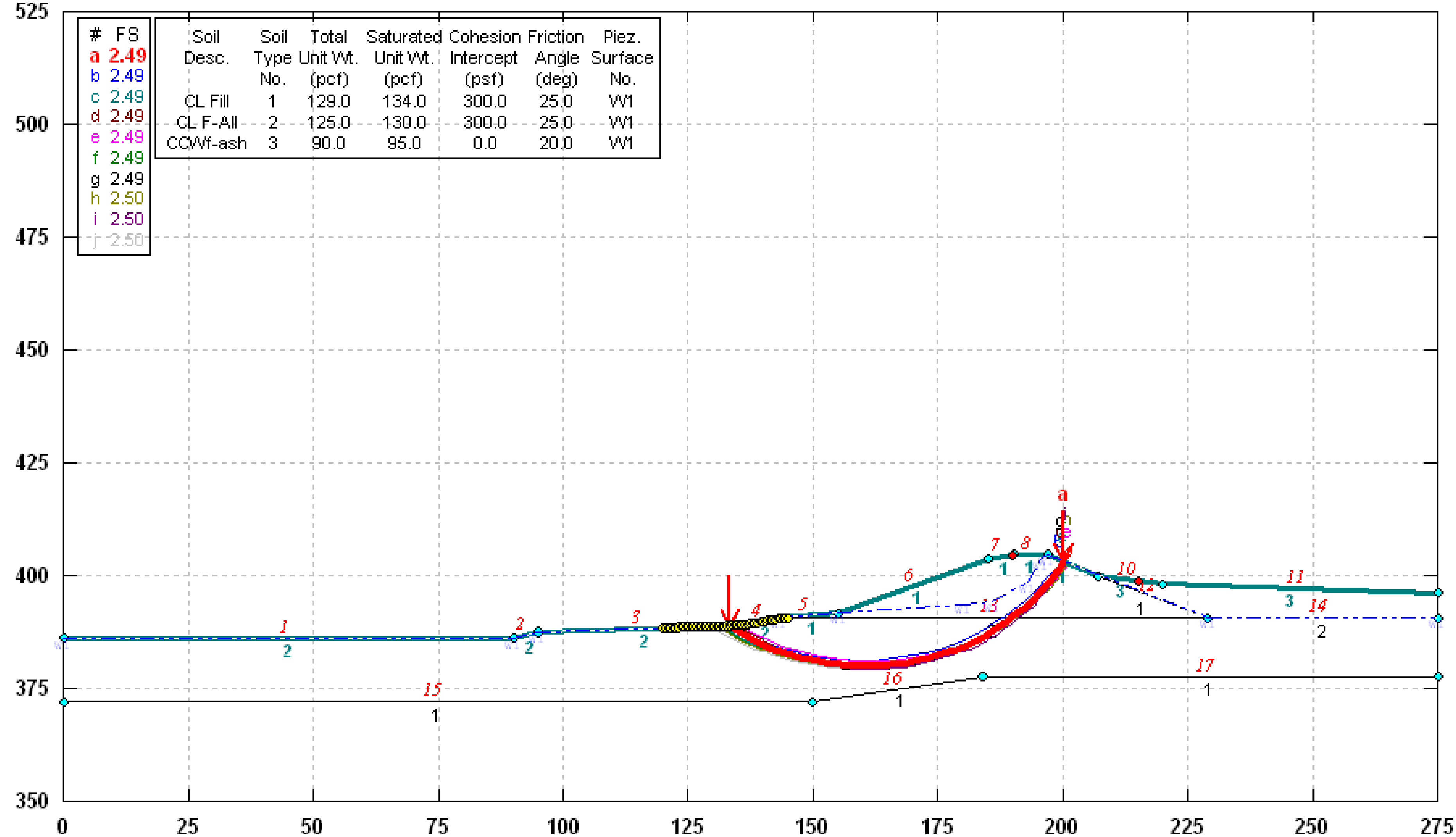
STABL6H FSmin=2.46

Safety Factors Are Calculated By The Modified Bishop Method



3143-10-1317 Green River Power Station Section 6: Downstream - Rapid Drawdown

C:\STEDWIN\STEDWIN\GREENR~1\S-6\DOWNST~1\RDD.PL2 Run By: MACTEC 10/15/2010 3:25PM

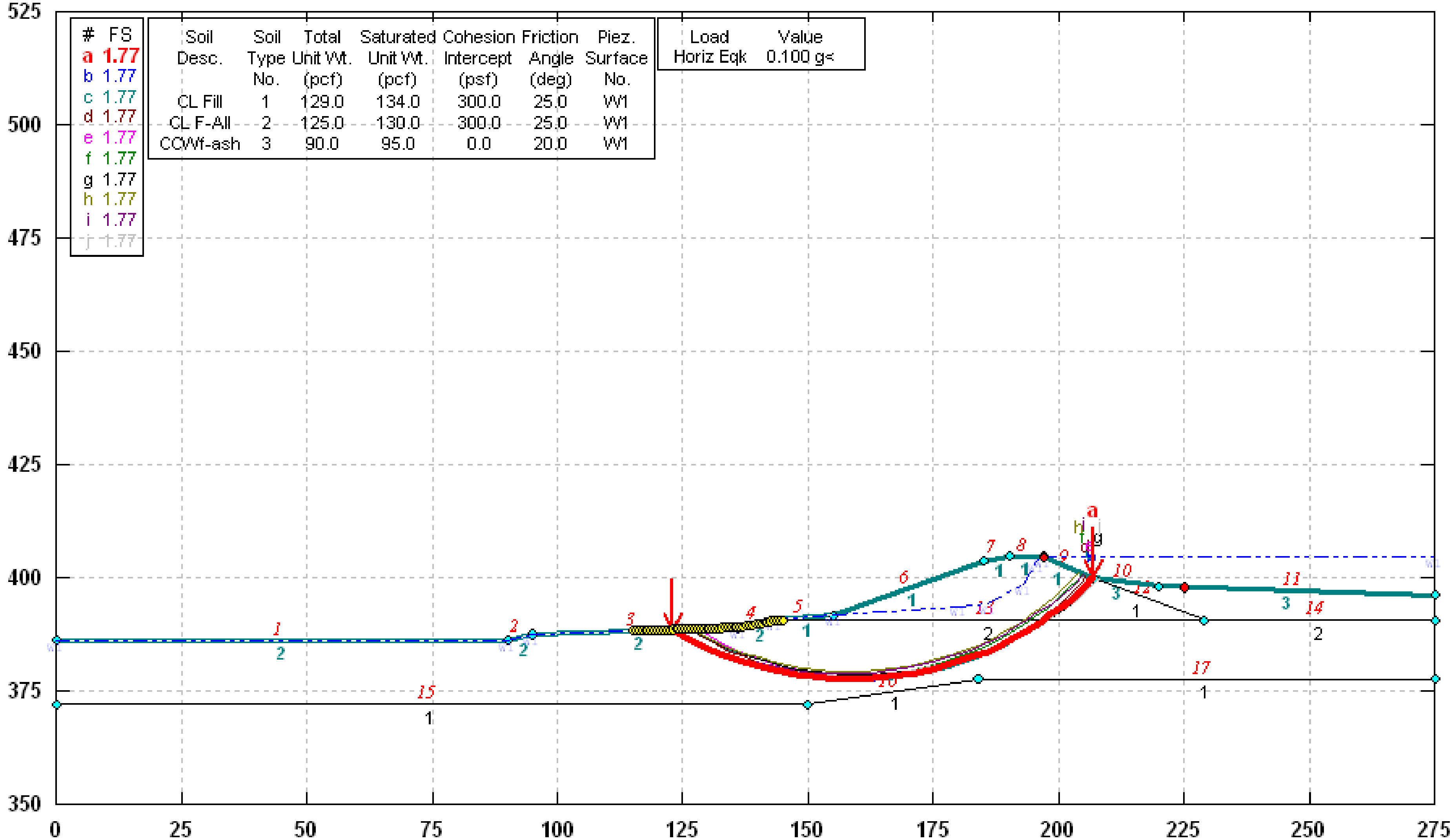


STABL6H FSmin=2.49

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 6: Downstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-6\DOWNST~1\SEISMIC.PL2 Run By: MACTEC 12/2/2010 12:27PM



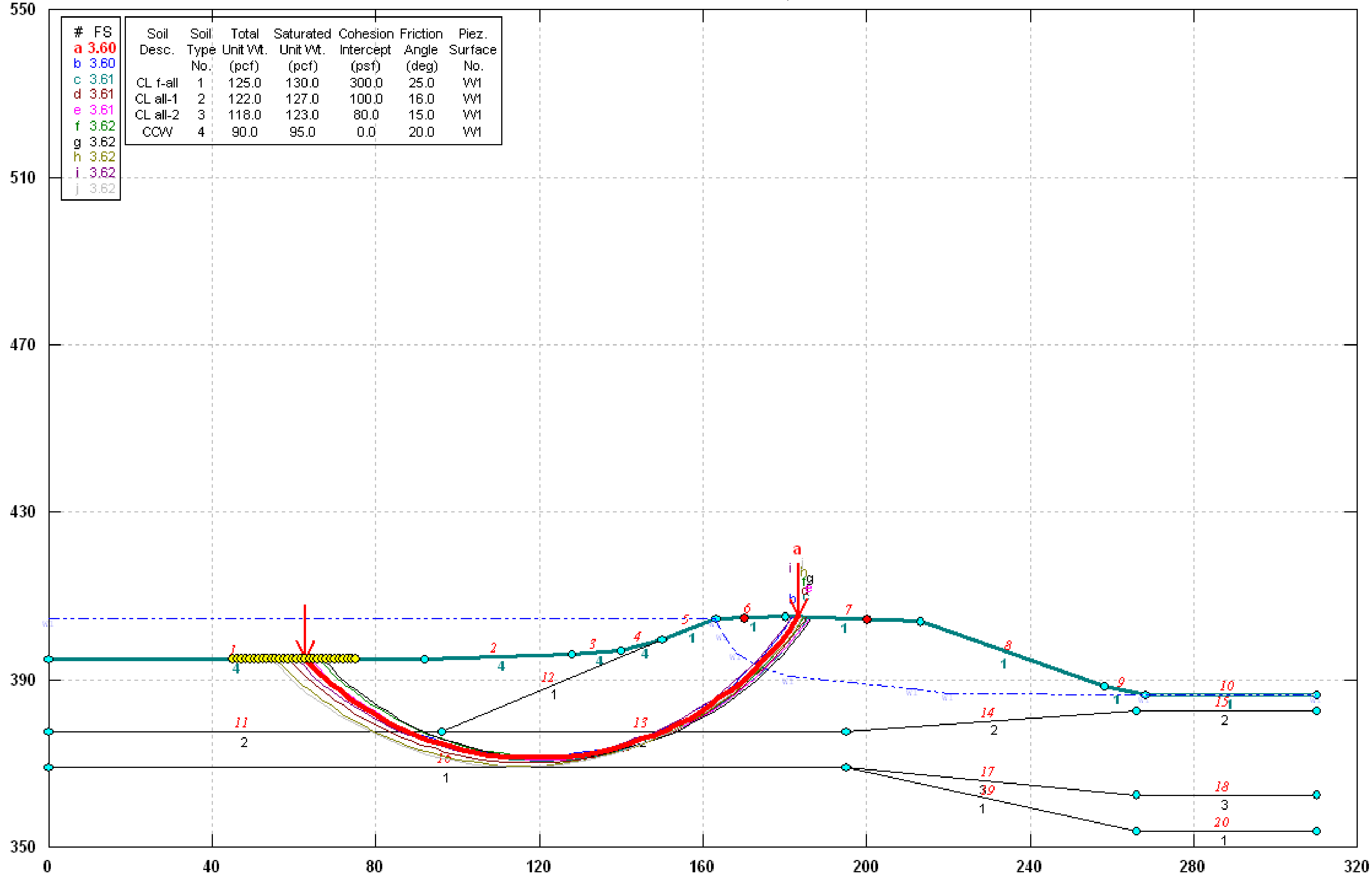
STABL6H FSmin=1.77

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Sta Section 7: Upstream - SS/Max Flood

C:\STEDWIN\GREENR~1\S-7\UPSTREAM\SSMXFL-3.PL2 Run By: MACTEC 10/29/2010 10:34AM



STABL6H FSmin=3.60

Safety Factors Are Calculated By The Modified Bishop Method

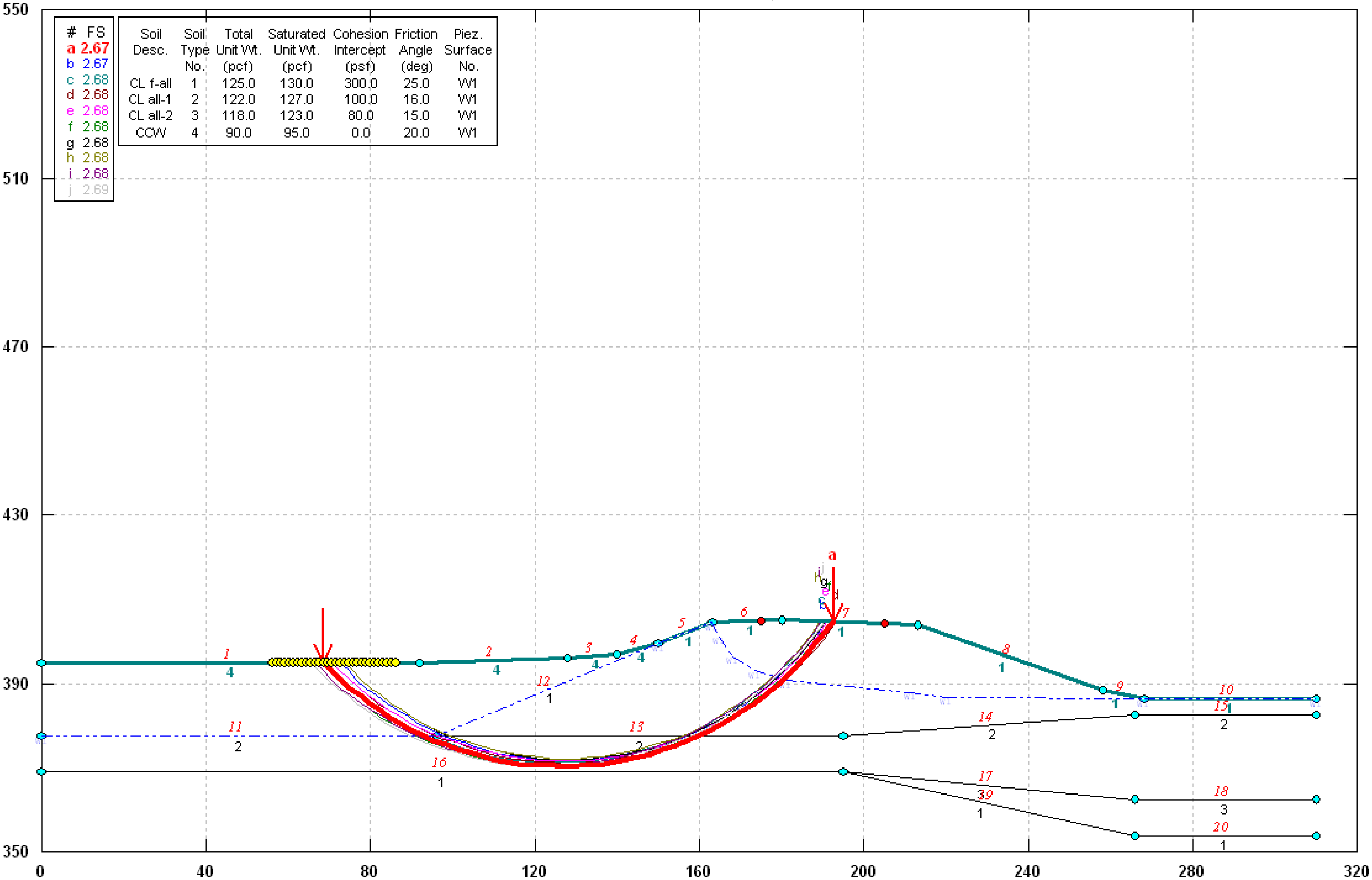
STED

3143-10-1317 Green River Power Sta Section 7: Upstream - Rapid Drawdown

C:\STEDWIN\GREENR~1\S-7\UPSTREAM\RDD-3.PL2 Run By: MACTEC 10/29/2010 10:38AM

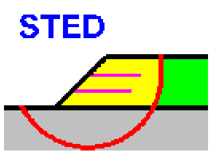
#	FS
a	2.67
b	2.67
c	2.68
d	2.68
e	2.68
f	2.68
g	2.68
h	2.68
i	2.68
j	2.69

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CL f-all	1	125.0	130.0	300.0	25.0	W1
CL all-1	2	122.0	127.0	100.0	16.0	W1
CL all-2	3	118.0	123.0	80.0	15.0	W1
CCW	4	90.0	95.0	0.0	20.0	W1



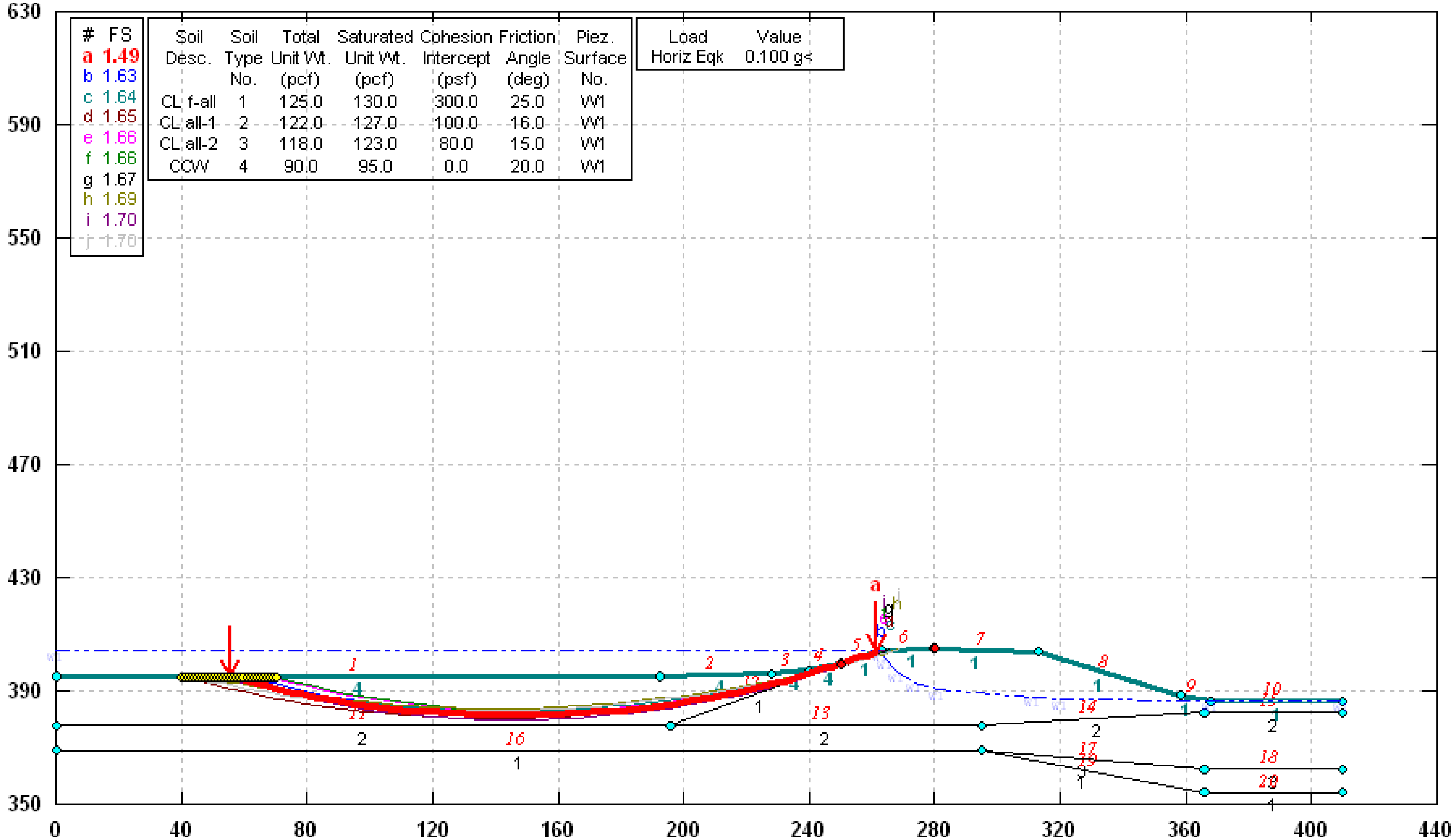
STABL6H FSmin=2.67

Safety Factors Are Calculated By The Modified Bishop Method



3143-10-1317 Green River Power Sta Section 7: Upstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-7\UPSTREAM\QUAKE-3.PL2 Run By: MACTEC 12/2/2010 12:10PM



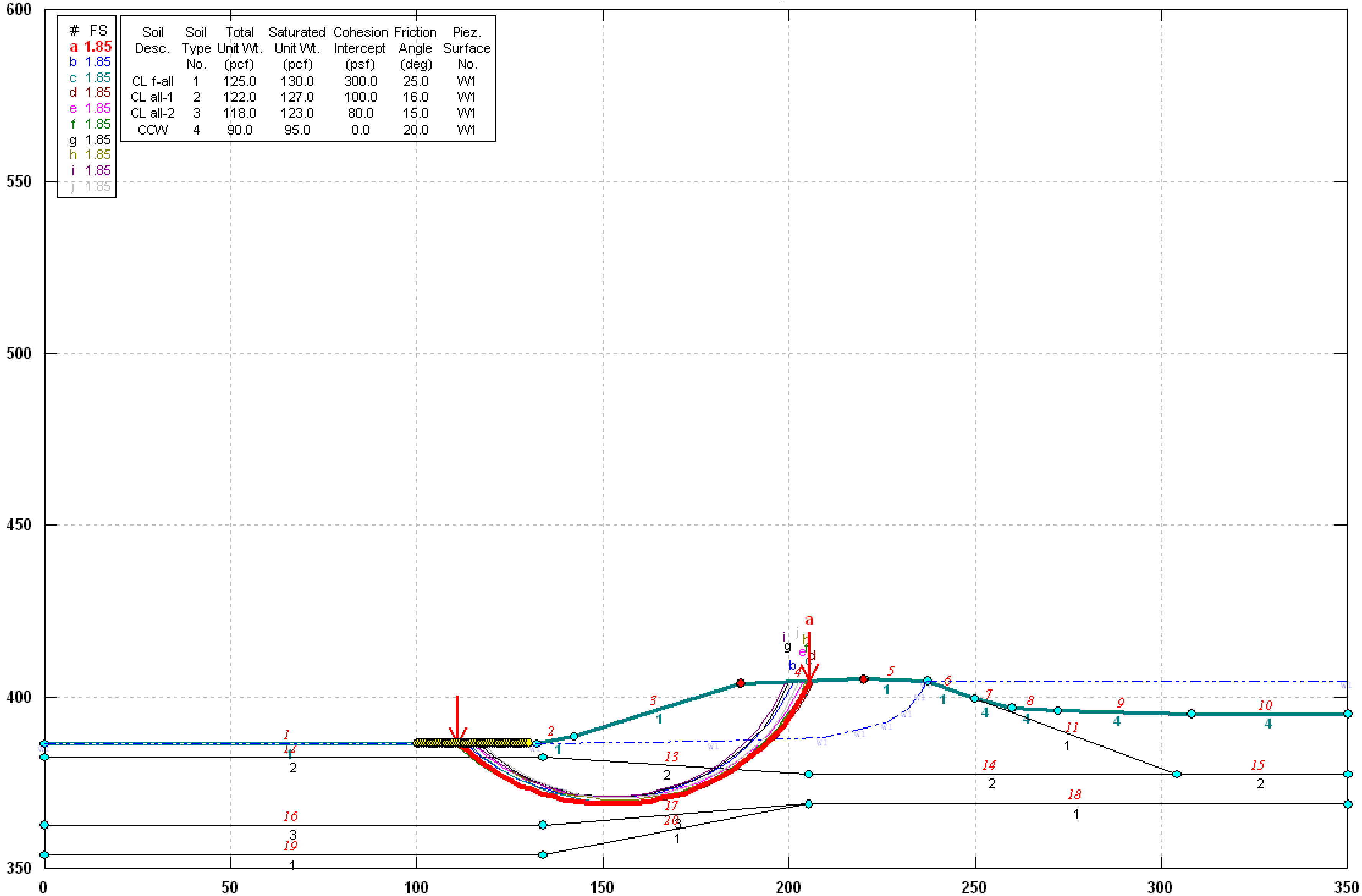
STABL6H FSmin=1.49

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Sta Section 7: Downstream - SS/Max Flood

C:\STEDWIN\GREENR~1\S-7\DOWNST~1\SSMXFL-3.PL2 Run By: MACTEC 10/29/2010 10:19AM



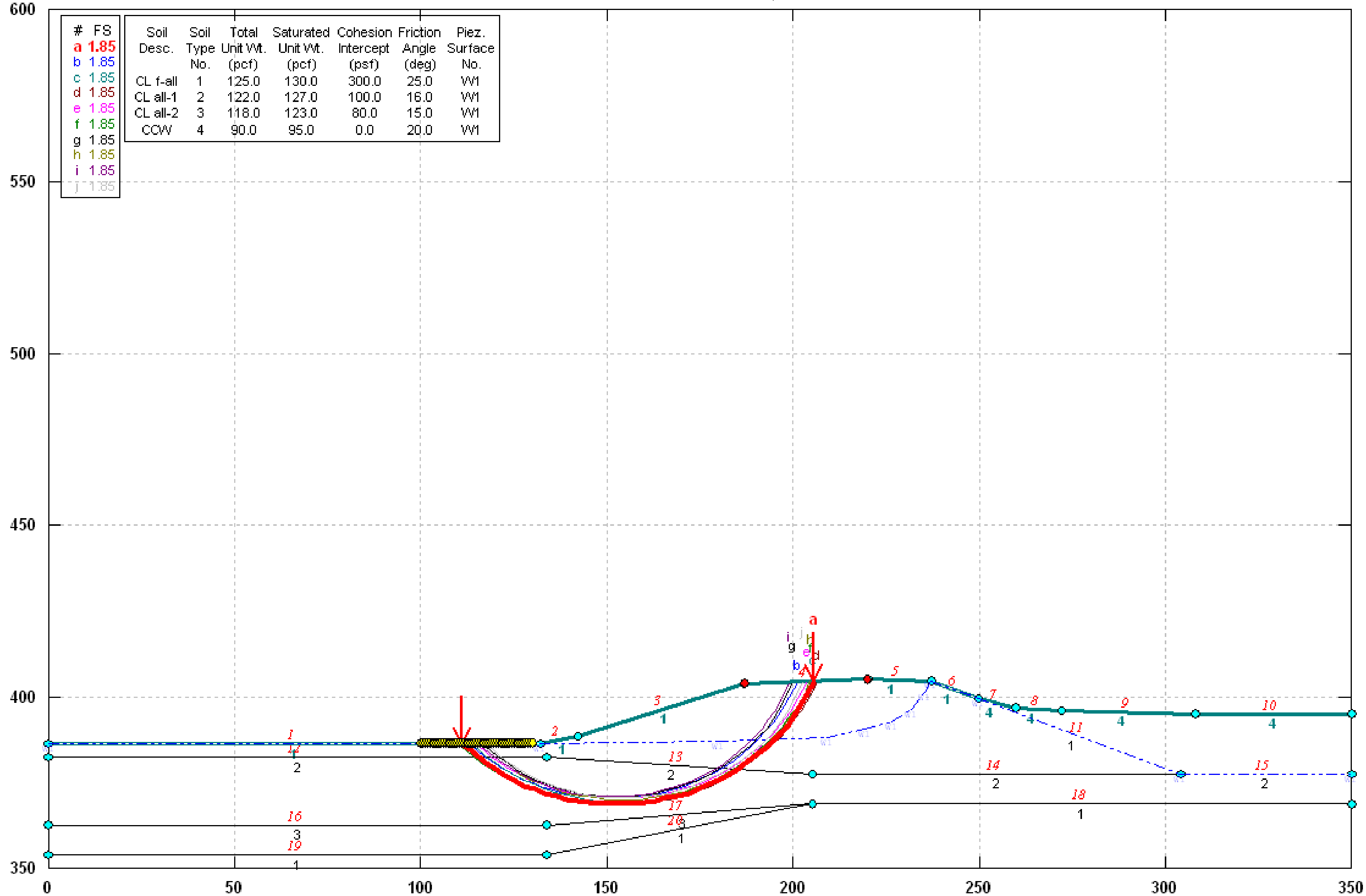
STABL6H FSmin=1.85

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Sta Section 7: Downstream - Rapid Drawdown

C:\STEDWIN\GREENR~1\S-7\DOWNST~1\RDD-3.PL2 Run By: MACTEC 10/29/2010 10:22AM



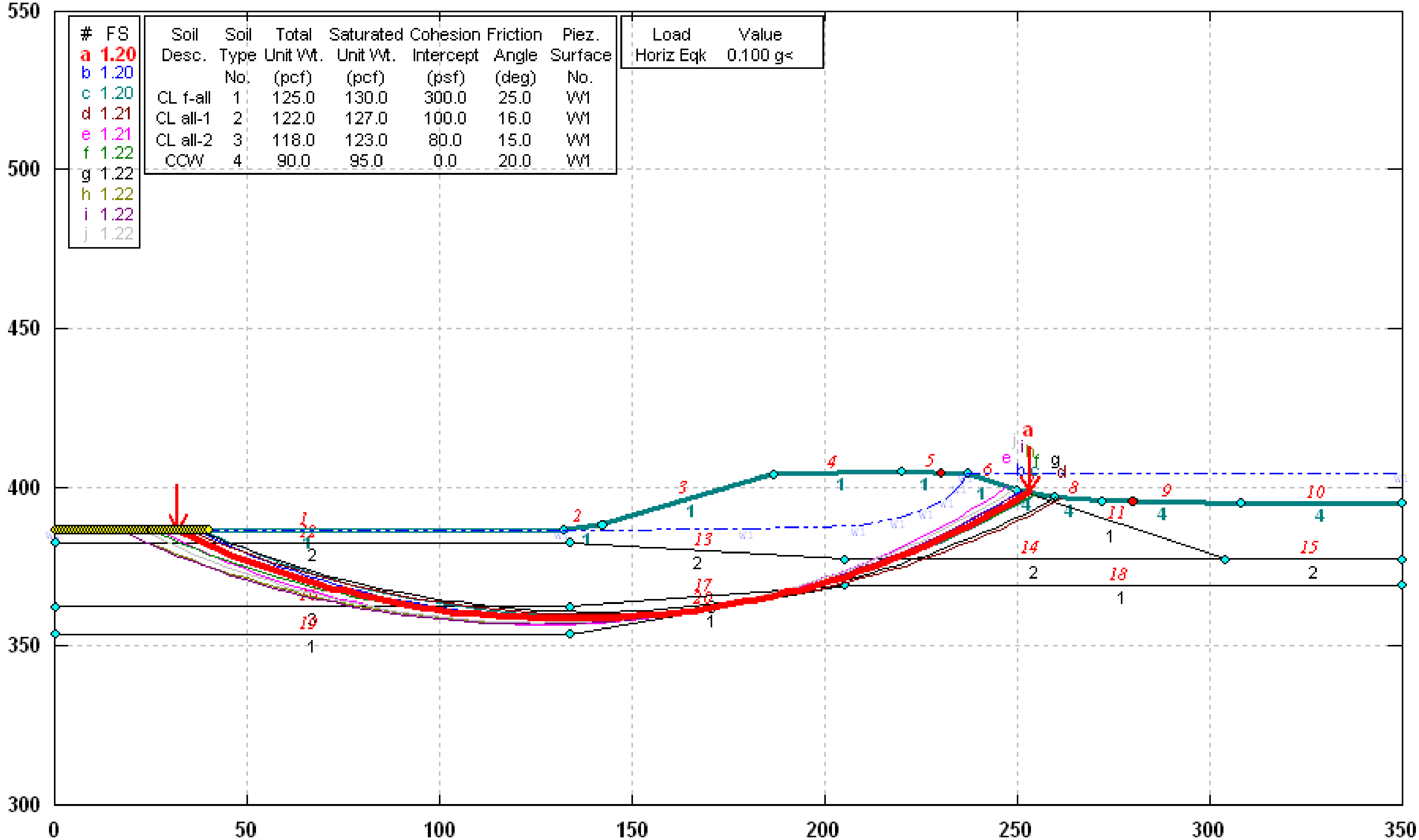
STABL6H FSmin=1.85

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Sta Section 7: Downstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-7\DOWNST~1\QUAKE3.PL2 Run By: MACTEC 12/2/2010 12:08PM



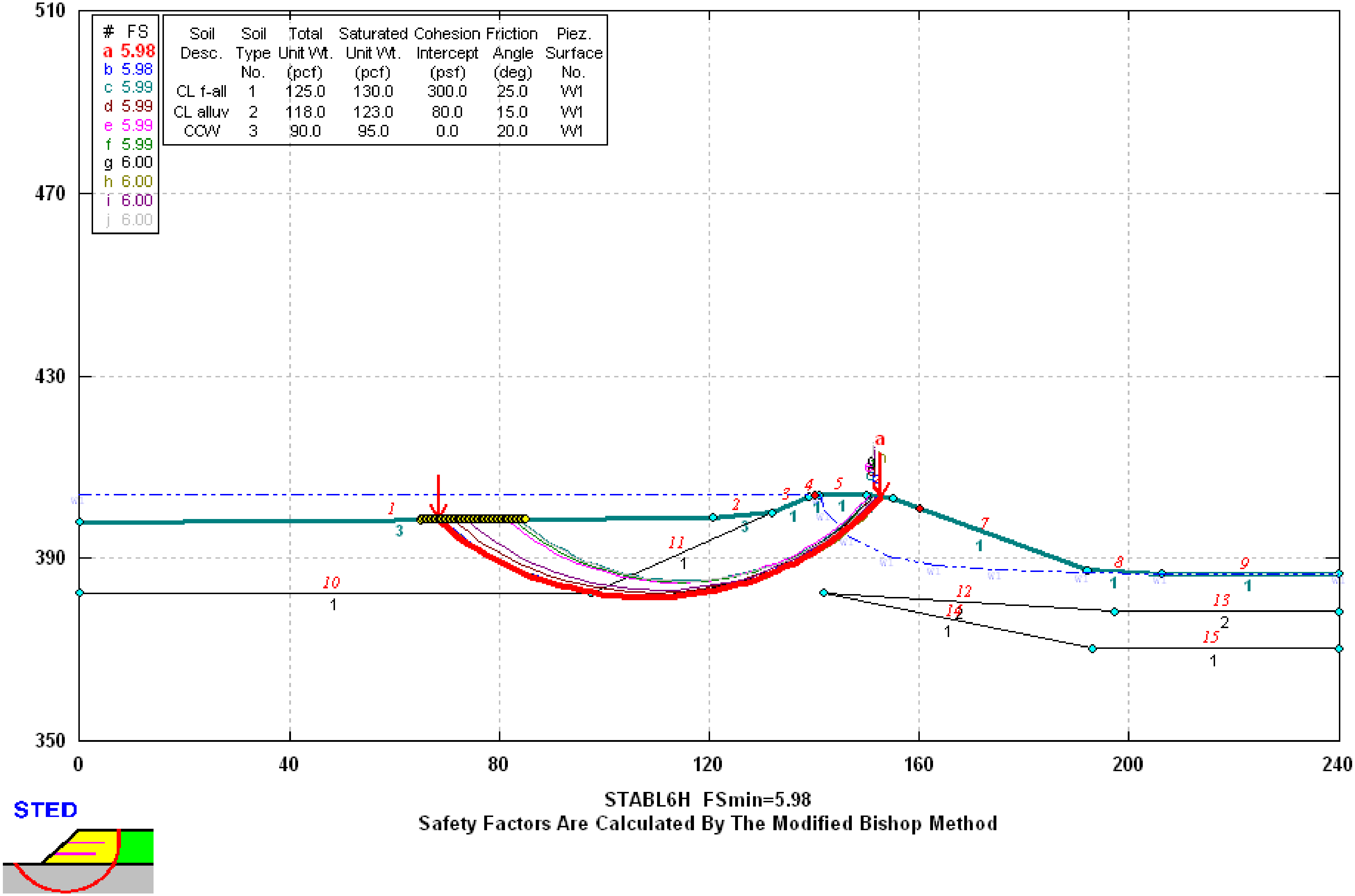
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CL f-all	1	125.0	130.0	300.0	25.0	W1
CL all-1	2	122.0	127.0	100.0	16.0	W1
CL all-2	3	118.0	123.0	80.0	15.0	W1
CCW	4	90.0	95.0	0.0	20.0	W1

STABL6H FSmin=1.20

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 8: Upstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-8\UPSTREAM\SSMAXFLD.PL2 Run By: MACTEC 10/26/2010 12:58PM

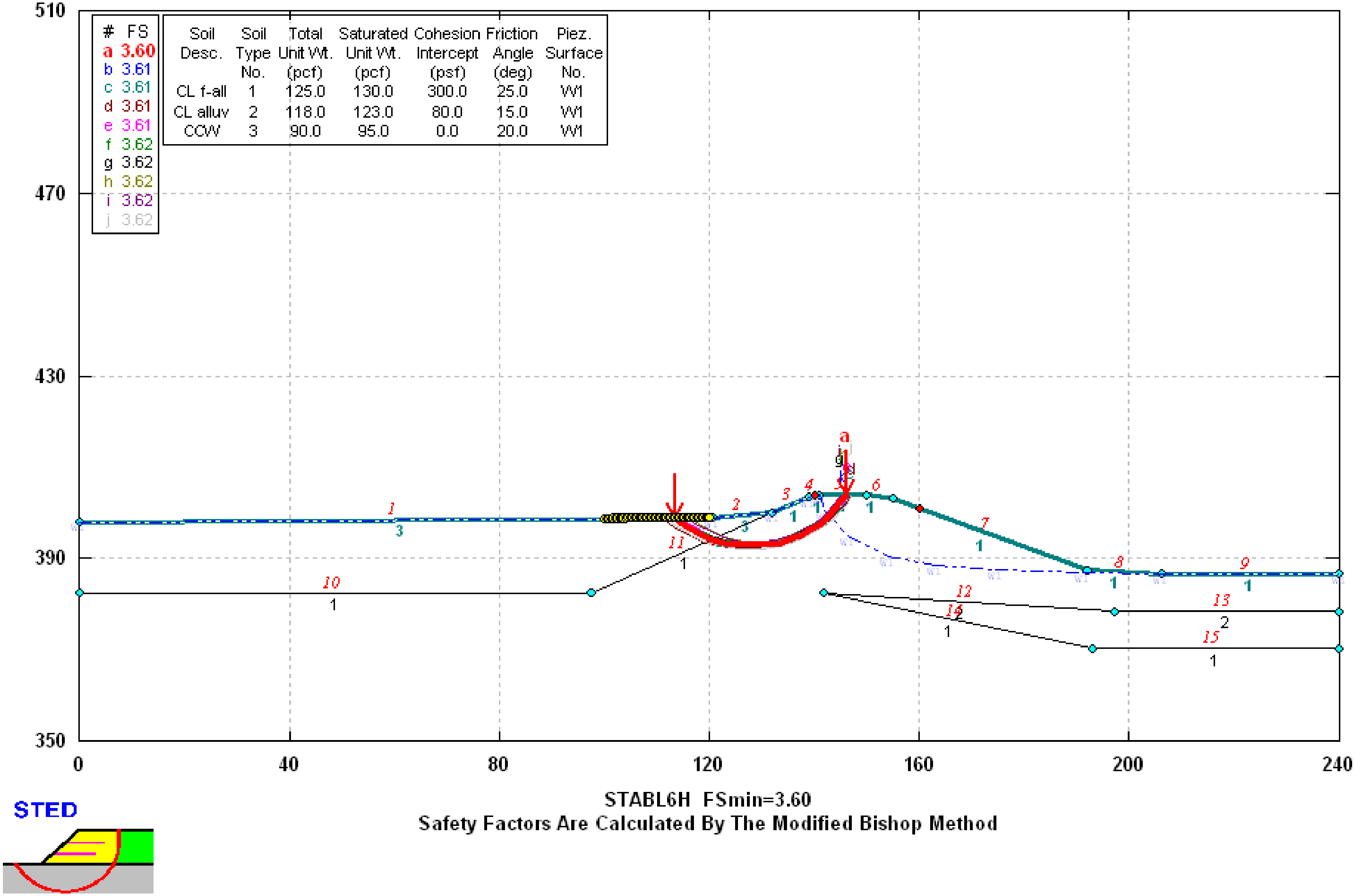


STABL6H FSmin=5.98

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 8: Upstream - Rapid Drawdown

C:\STEDWIN\STEDWIN\GREENR~1\S-8\UPSTREAM\RDD.PL2 Run By: MACTEC 10/15/2010 2:01PM

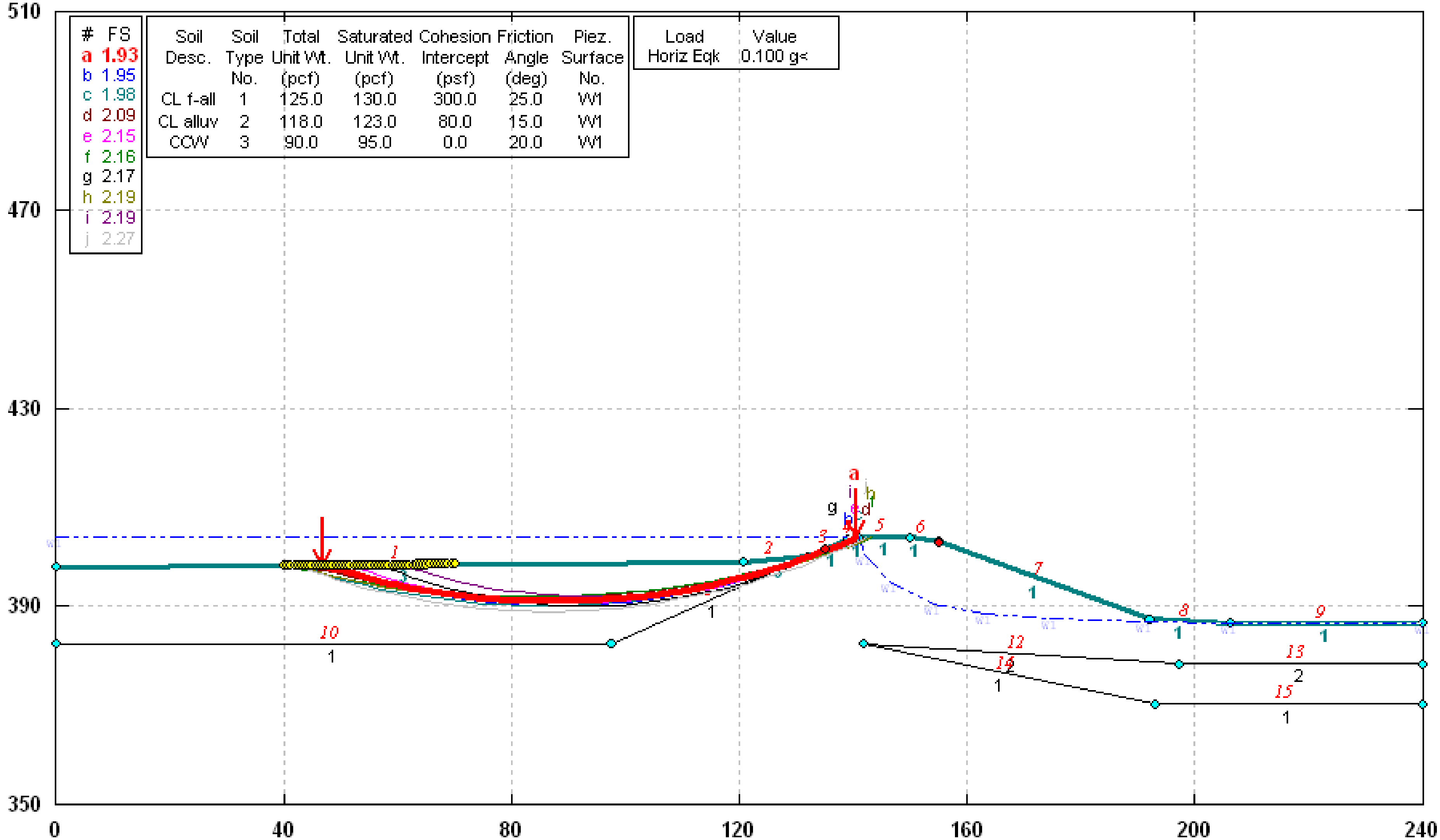


STABL6H FSmin=3.60

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 8: Upstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-8\UPSTREAM\QUAKE.PL2 Run By: MACTEC 12/2/2010 12:35PM



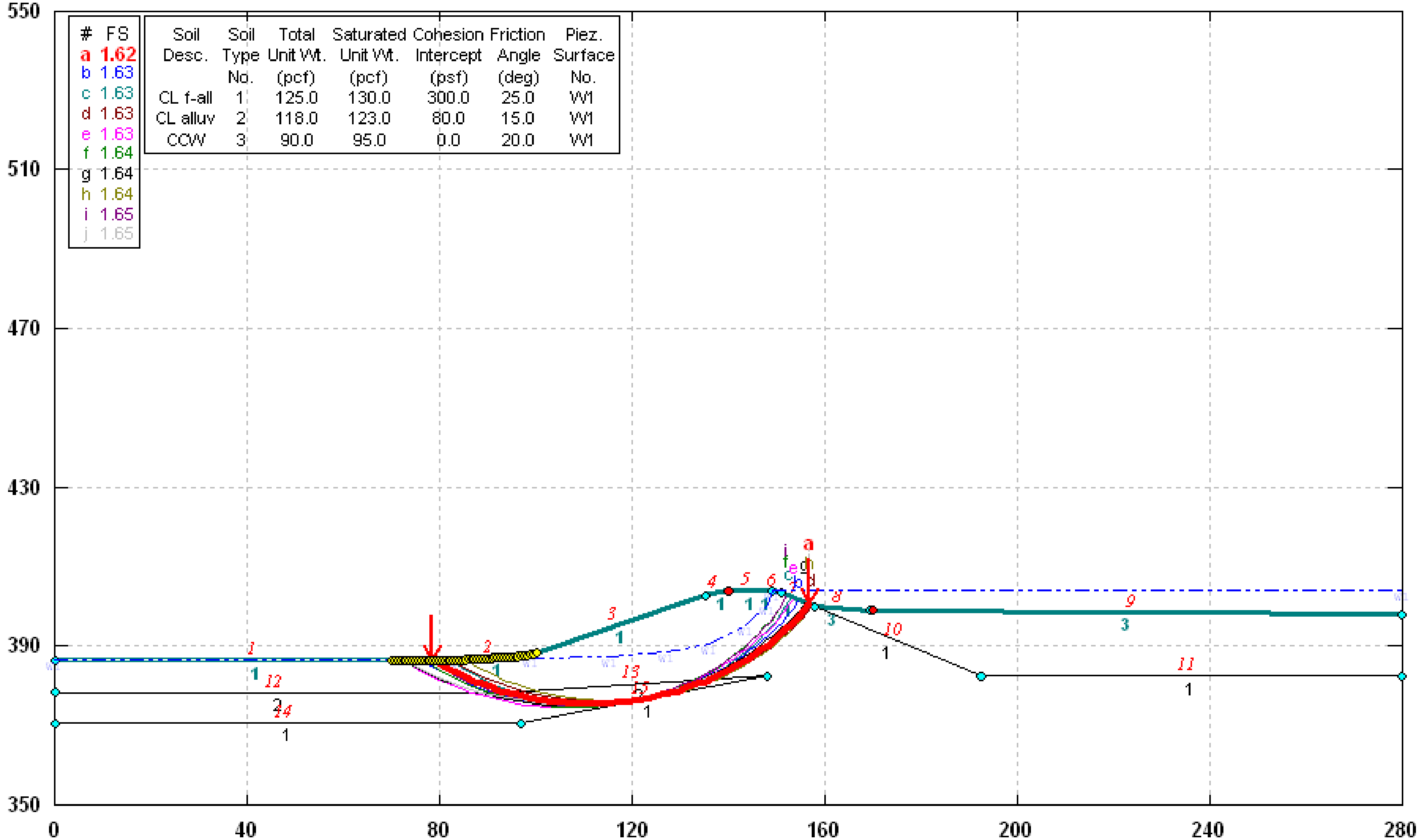
STABL6H FSmin=1.93

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 8: Downstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-8\DOWNST~1\SSMAXFLD.PL2 Run By: MACTEC 10/15/2010 1:52PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CL f-all	1	125.0	130.0	300.0	25.0	W1
CL alluv	2	118.0	123.0	80.0	15.0	W1
CCW	3	90.0	95.0	0.0	20.0	W1

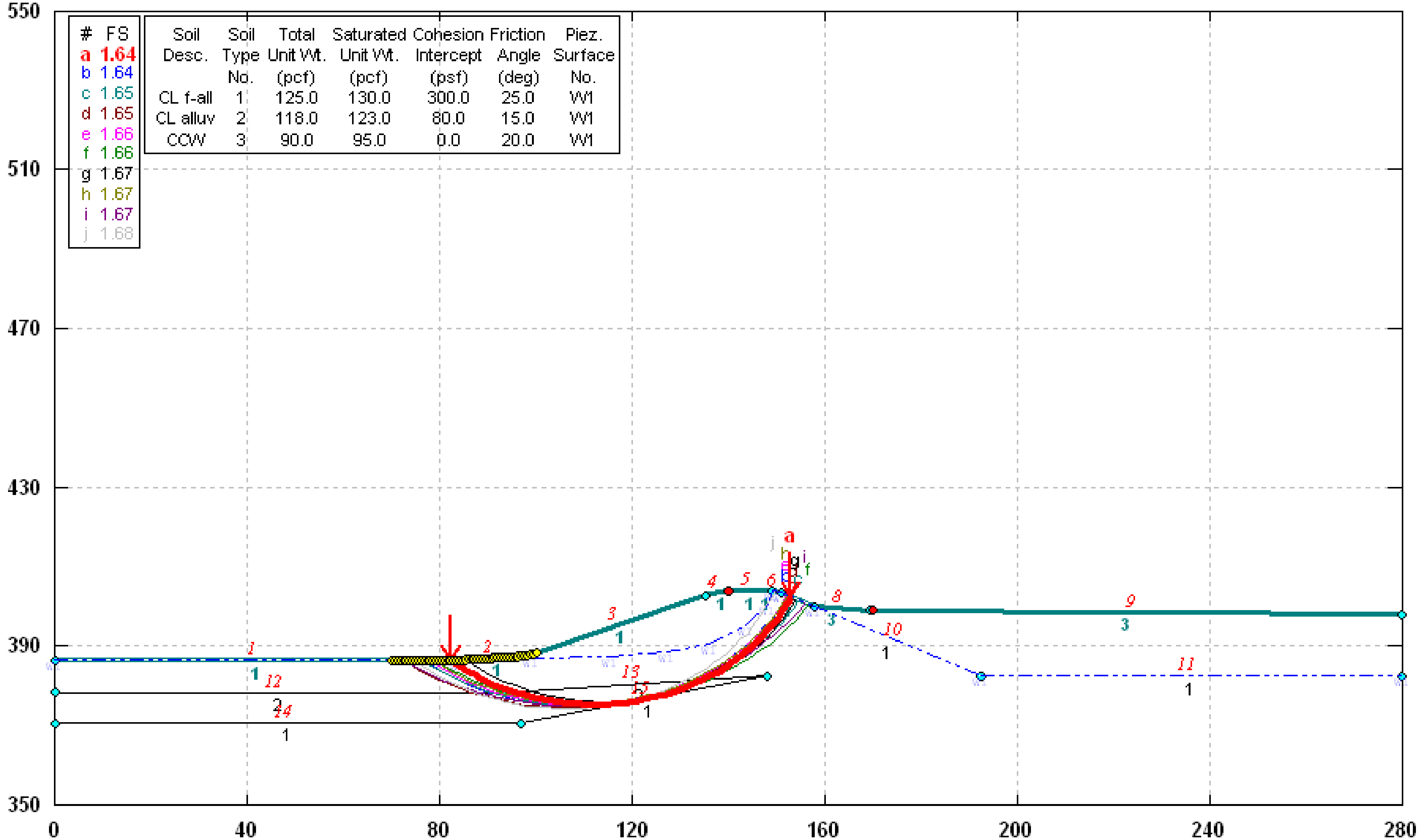
STED

STABL6H FSmin=1.62

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 8: Downstream - RDD - Case 2

C:\STEDWIN\STEDWIN\GREENR~1\S-8\DOWNST~1\RDD~2.PL2 Run By: MACTEC 10/15/2010 1:58PM

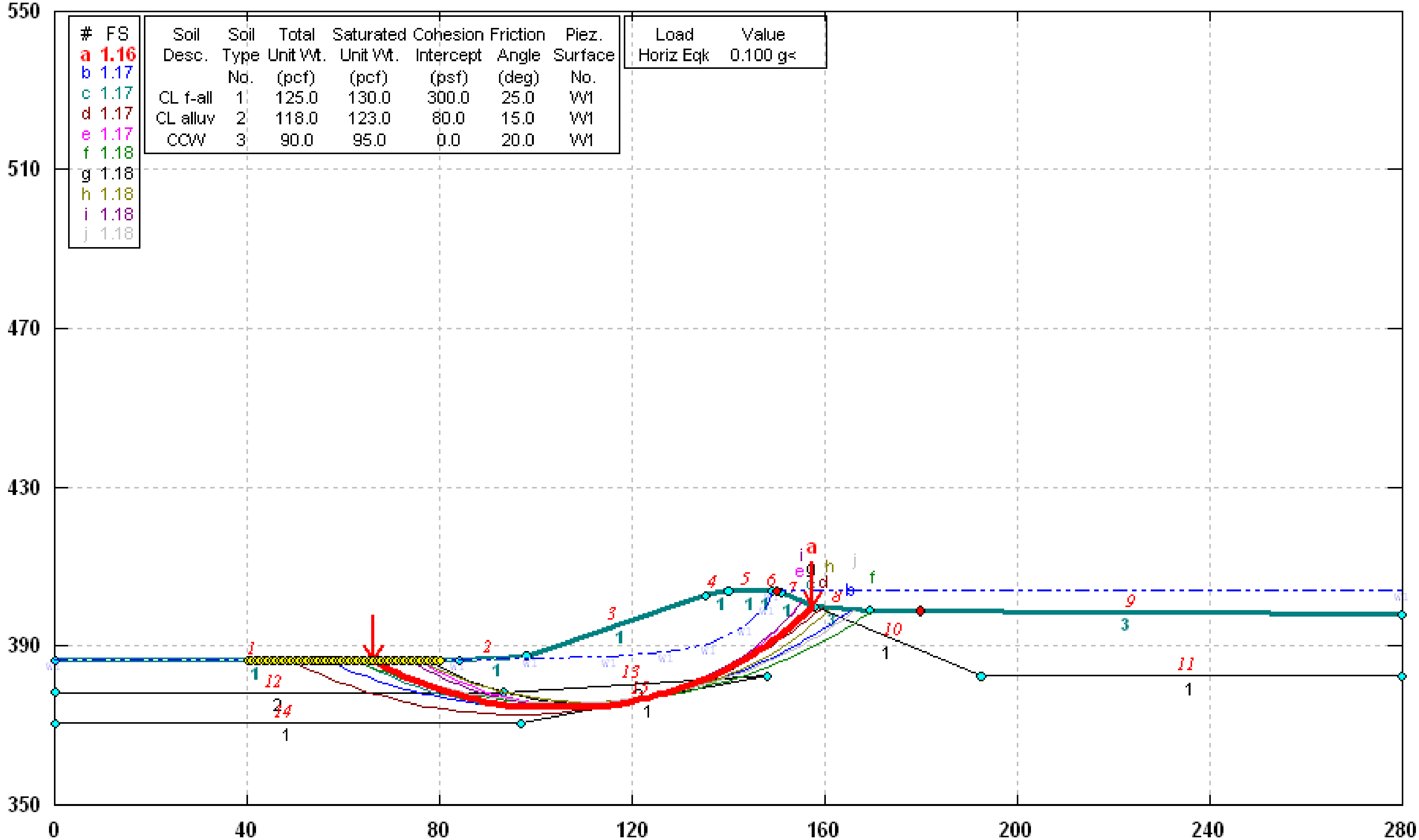


STABL6H FSmin=1.64

Safety Factors Are Calculated By The Modified Bishop Method

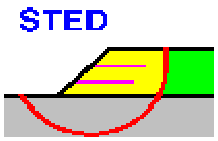
3143-10-1317 Green River Power Station Section 8: Downstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-8\DOWNST~1\QUAKE.PL2 Run By: MACTEC 12/2/2010 12:32PM



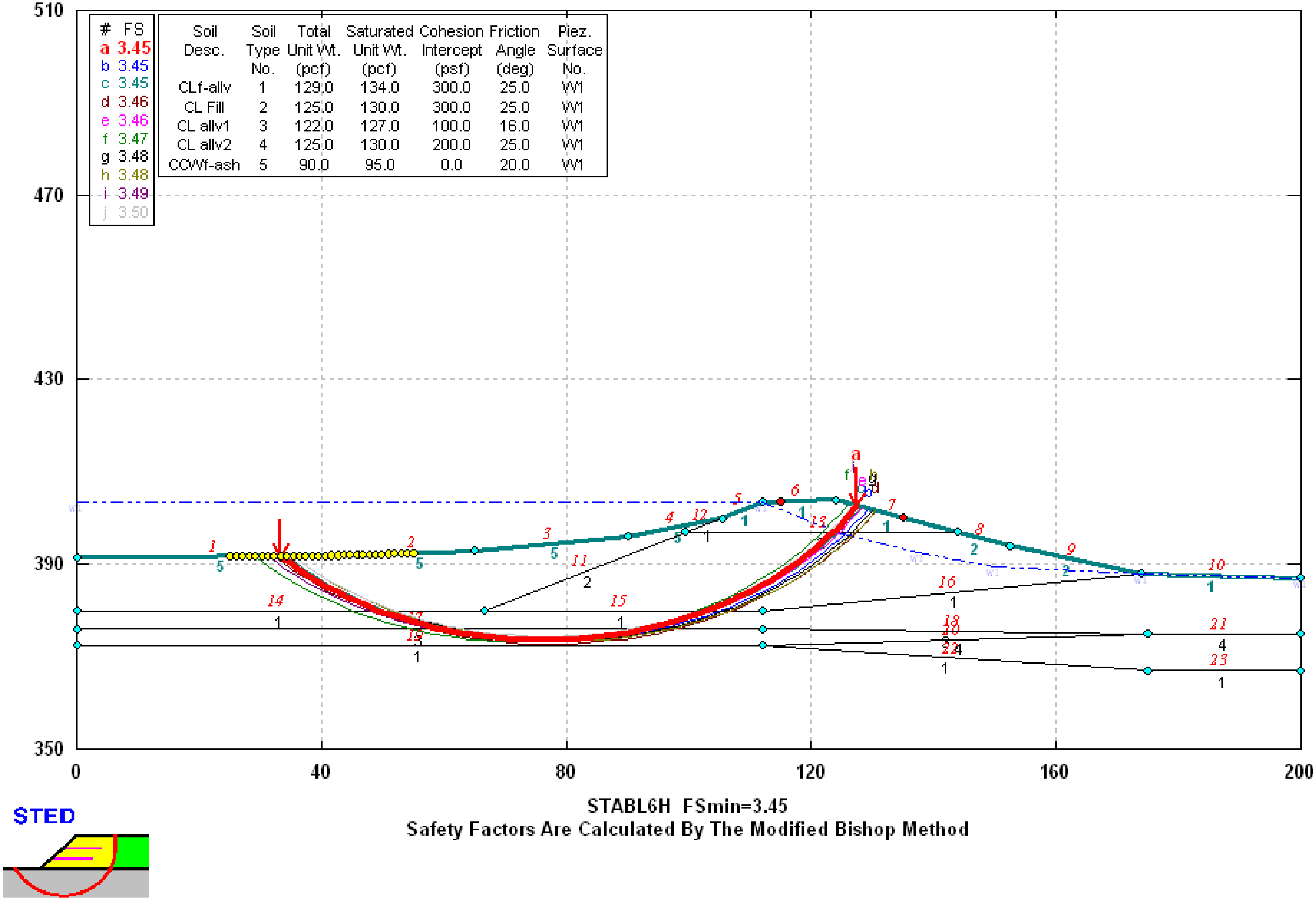
STABL6H FSmin=1.16

Safety Factors Are Calculated By The Modified Bishop Method



3143-10-1317 Green River Power Station Section 9: Upstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-9\UPSTREAM\SSMXFLD2.PL2 Run By: MACTEC 10/15/2010 9:52AM

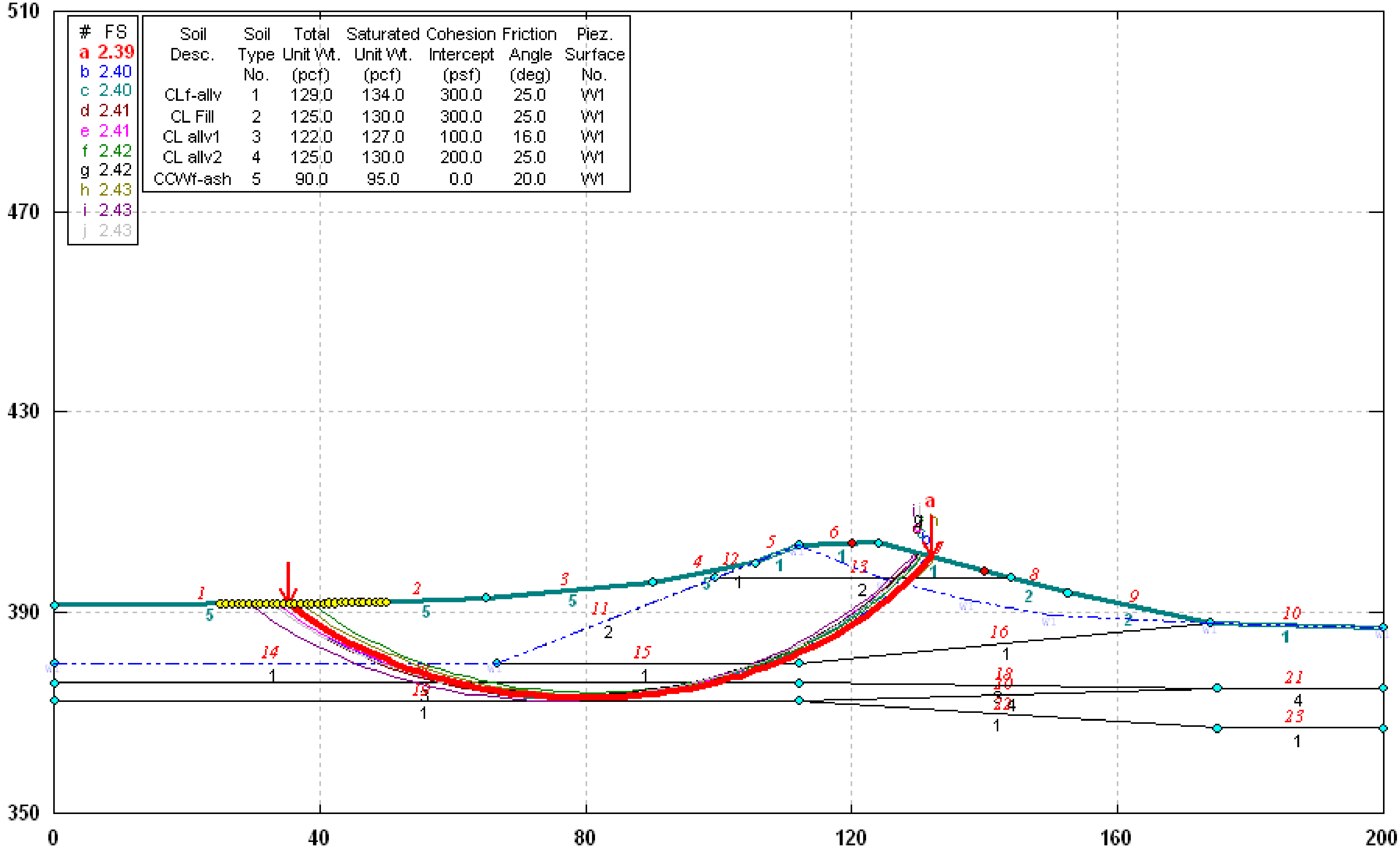


STABL6H FSmin=3.45

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 9: Upstream - Rapid Drawdown

C:\STEDWIN\STEDWIN\GREENR~1\S-9\UPSTREAM\RDD.PL2 Run By: MACTEC 10/15/2010 9:53AM



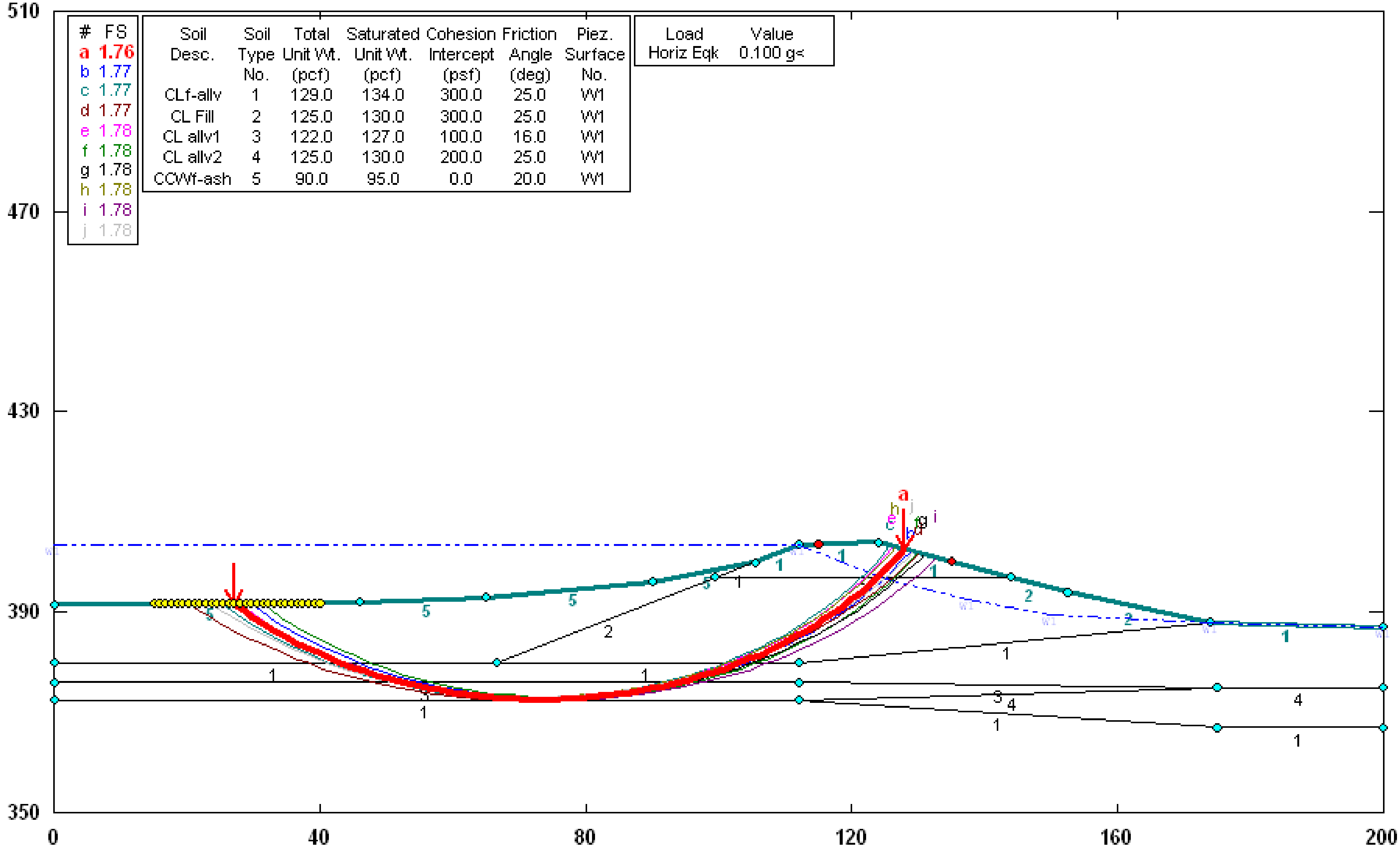
STABL6H FSmin=2.39

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 9: Upstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-9\UPSTREAM\SEISMIC.PL2 Run By: MACTEC 12/2/2010 10:55AM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CLf-allv	1	129.0	134.0	300.0	25.0	W1
CL Fill	2	125.0	130.0	300.0	25.0	W1
CL allv1	3	122.0	127.0	100.0	16.0	W1
CL allv2	4	125.0	130.0	200.0	25.0	W1
CCWf-ash	5	90.0	95.0	0.0	20.0	W1

Load	Value
Horiz Eqk	0.100 g<

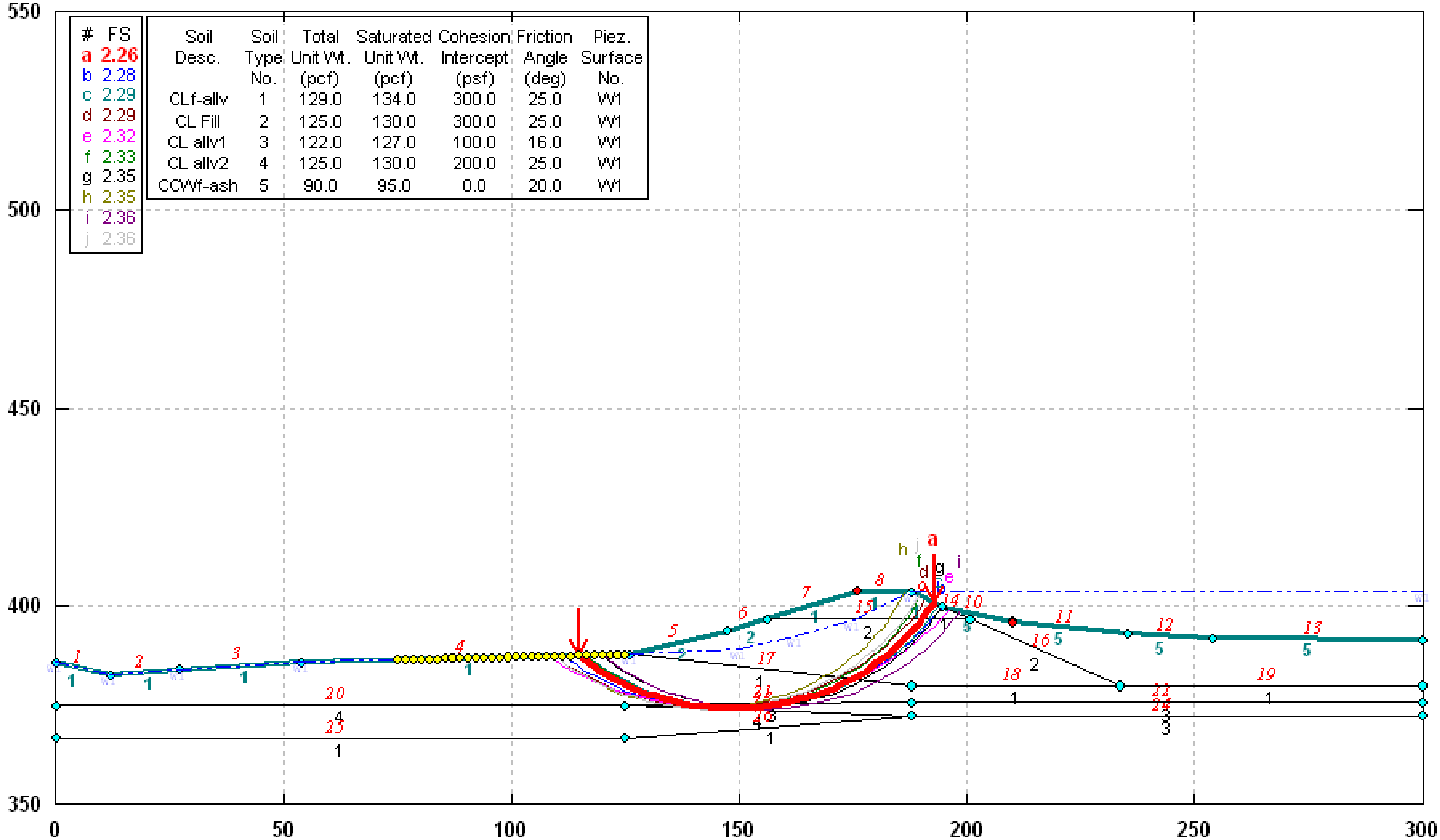
STABL6H FSmin=1.76

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 9: Downstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-9\DOWNST~1\SSMAXFLD.PL2 Run By: MACTEC 10/15/2010 9:55AM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CLf-allv	1	129.0	134.0	300.0	25.0	W1
CL Fill	2	125.0	130.0	300.0	25.0	W1
CL allv1	3	122.0	127.0	100.0	16.0	W1
CL allv2	4	125.0	130.0	200.0	25.0	W1
CCWf-ash	5	90.0	95.0	0.0	20.0	W1

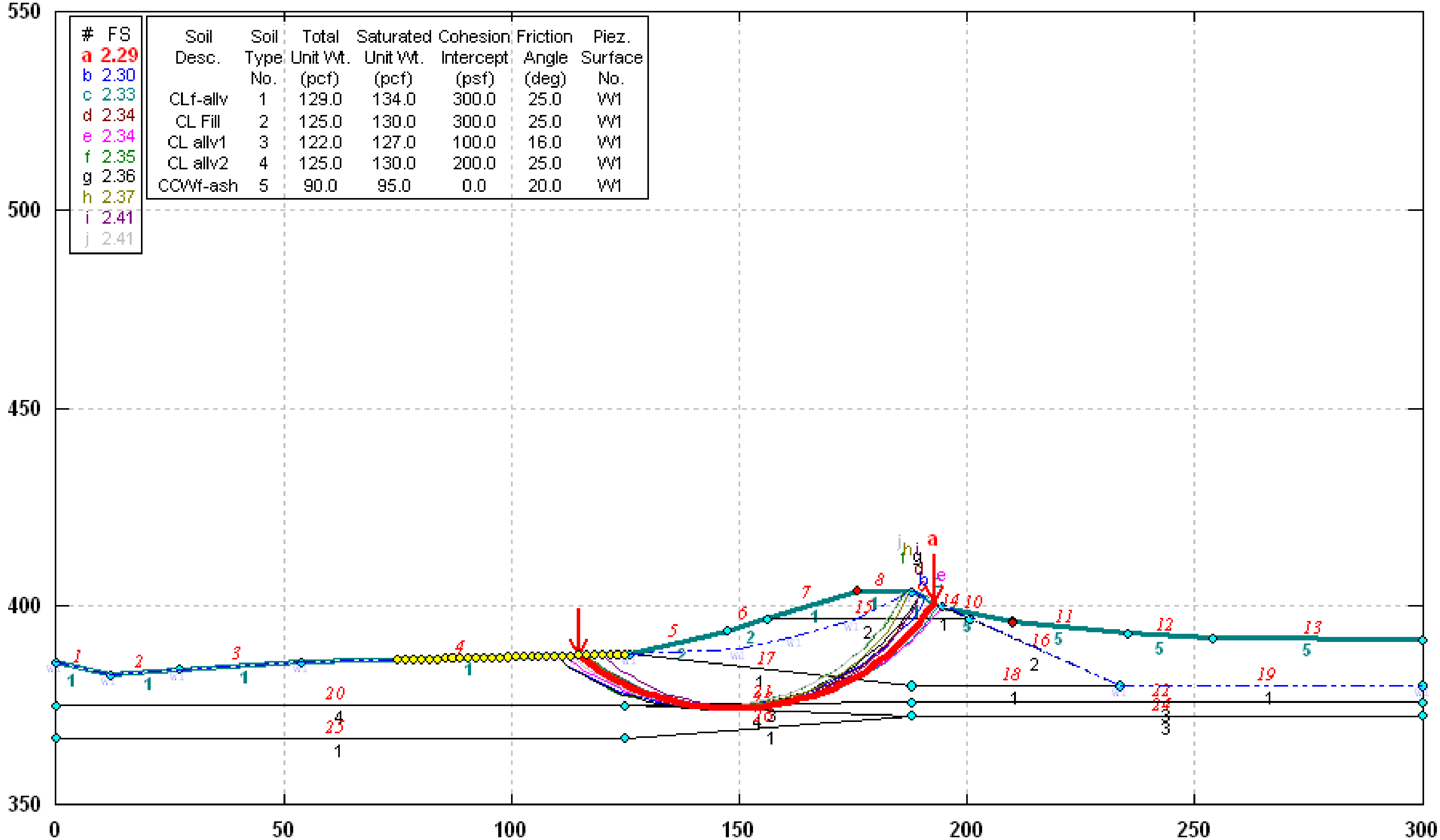
STABL6H FSmin=2.26

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 9: Downstream - Rapid Drawdown

C:\STEDWIN\STEDWIN\GREENR~1\S-9\DOWNST~1\RDD.PL2 Run By: MACTEC 10/15/2010 9:56AM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CLf-allv	1	129.0	134.0	300.0	25.0	W1
CL Fill	2	125.0	130.0	300.0	25.0	W1
CL allv1	3	122.0	127.0	100.0	16.0	W1
CL allv2	4	125.0	130.0	200.0	25.0	W1
CCWf-ash	5	90.0	95.0	0.0	20.0	W1

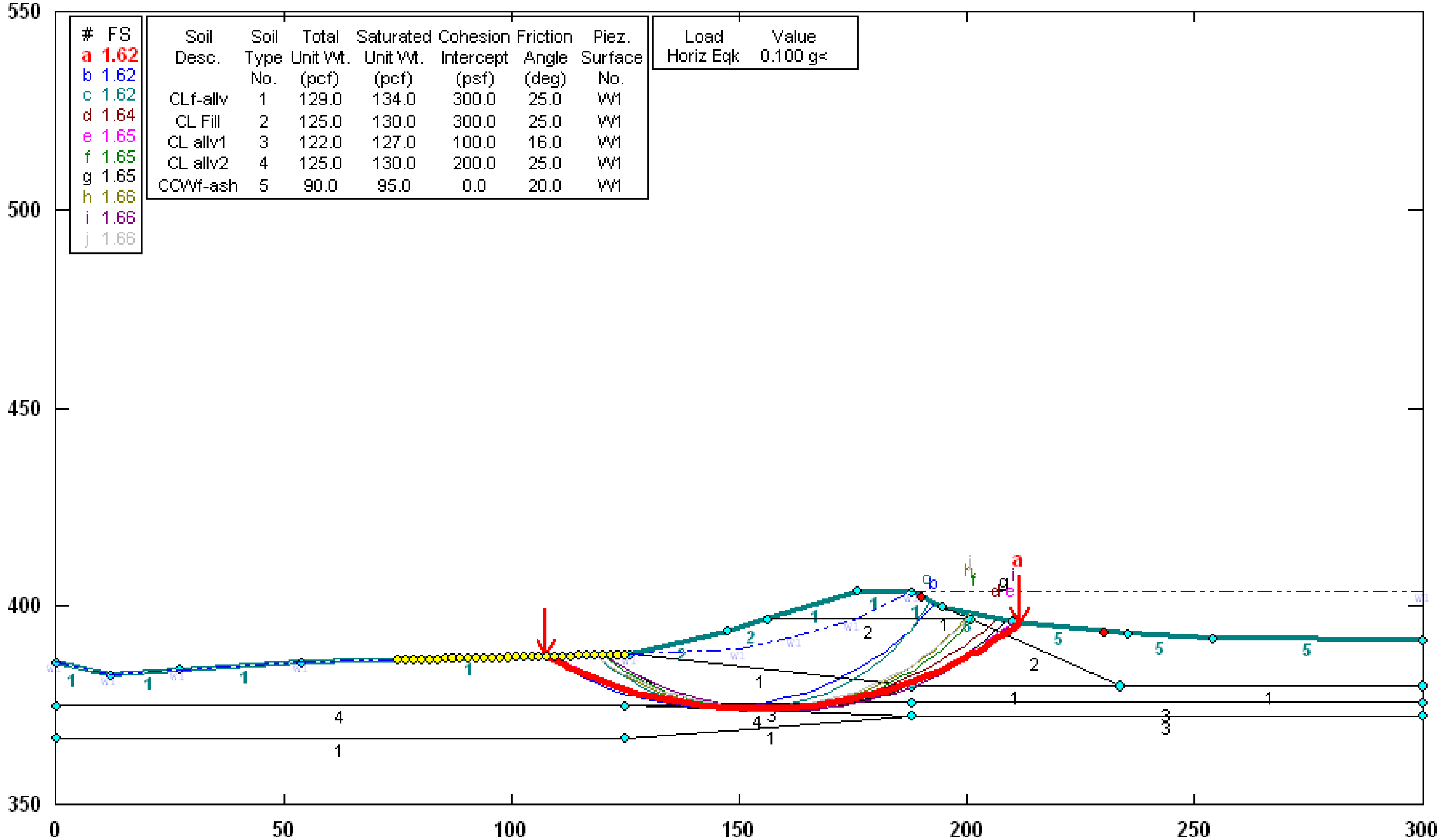
STED

STABL6H FSmin=2.29

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 9: Downstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-9\DOWNST~1\SEISMIC.PL2 Run By: MACTEC 12/2/2010 10:54AM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CLf-allv	1	129.0	134.0	300.0	25.0	W1
CL Fill	2	125.0	130.0	300.0	25.0	W1
CL allv1	3	122.0	127.0	100.0	16.0	W1
CL allv2	4	125.0	130.0	200.0	25.0	W1
CCWf-ash	5	90.0	95.0	0.0	20.0	W1

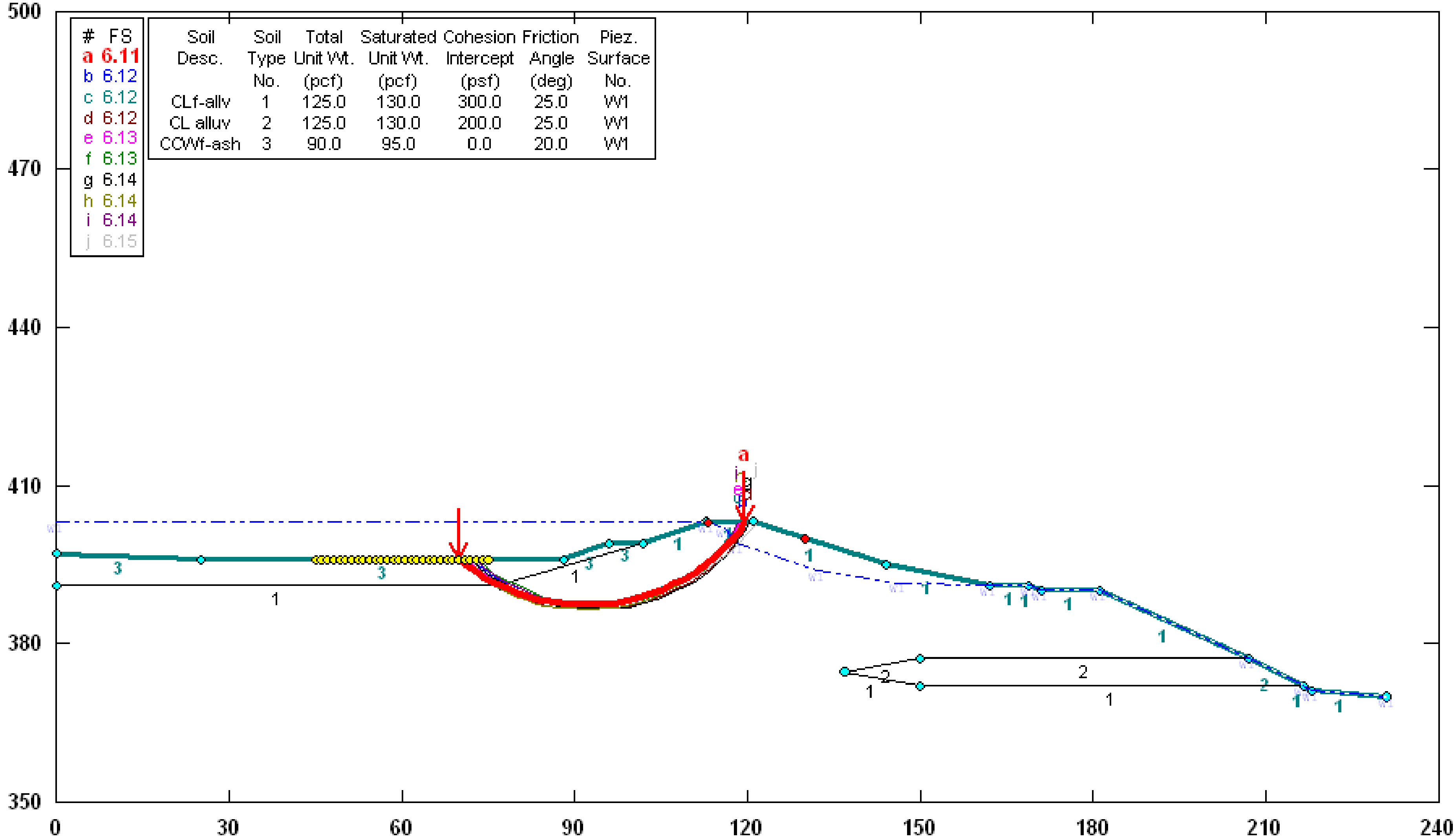
STABL6H FSmin=1.62

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 10: Upstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-10\UPSTREAM\SSMAXFLD.PL2 Run By: MACTEC 10/15/2010 9:31 AM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CLf-allv	1	125.0	130.0	300.0	25.0	W1
CL alluv	2	125.0	130.0	200.0	25.0	W1
CCWf-ash	3	90.0	95.0	0.0	20.0	W1

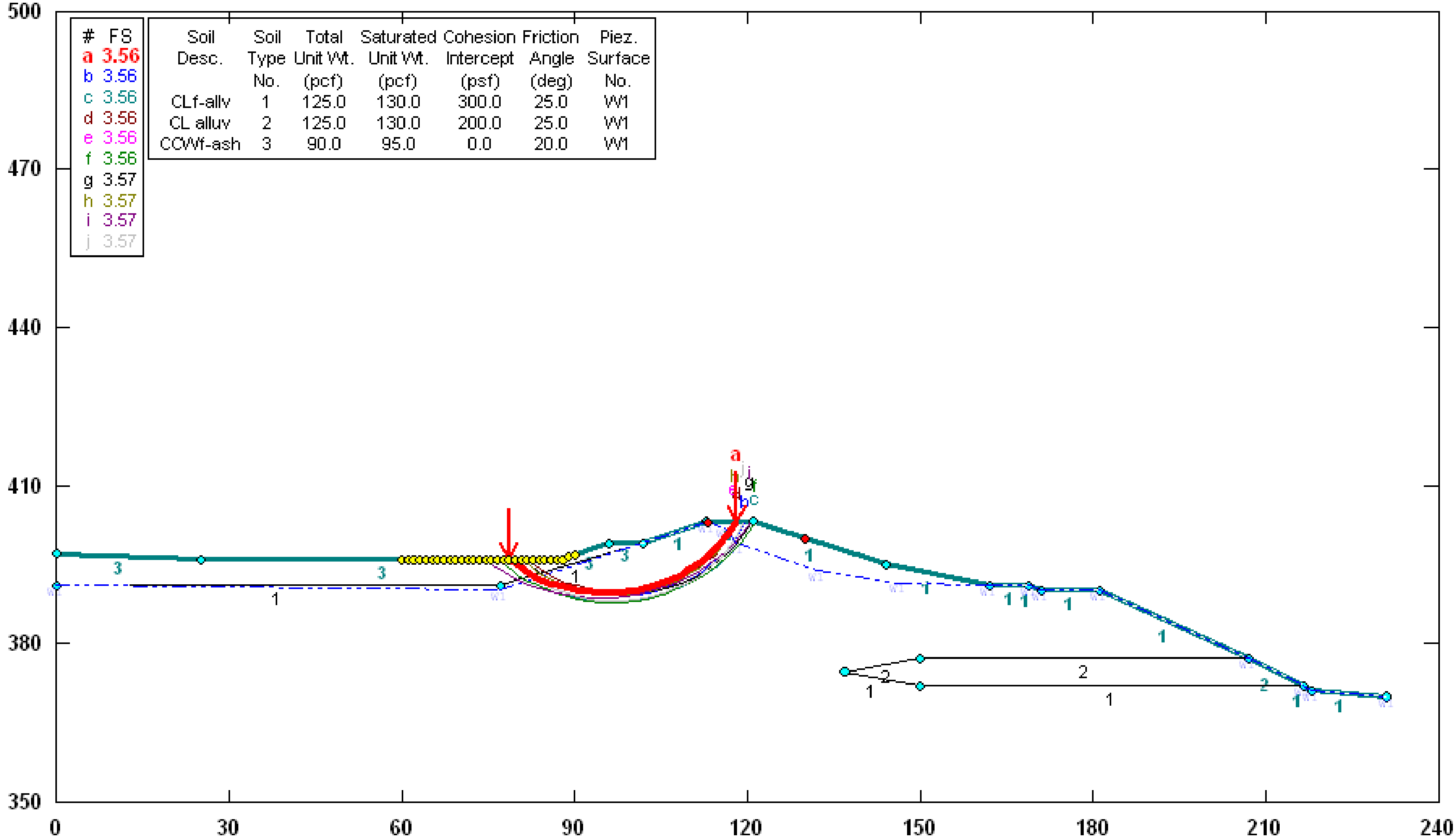
STABL6H FSmin=6.11

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 10: Upstream - Rapid Drawdown

C:\STEDWIN\STEDWIN\GREENR~1\S-10\UPSTREAM\RDD.PL2 Run By: MACTEC 10/15/2010 9:36AM

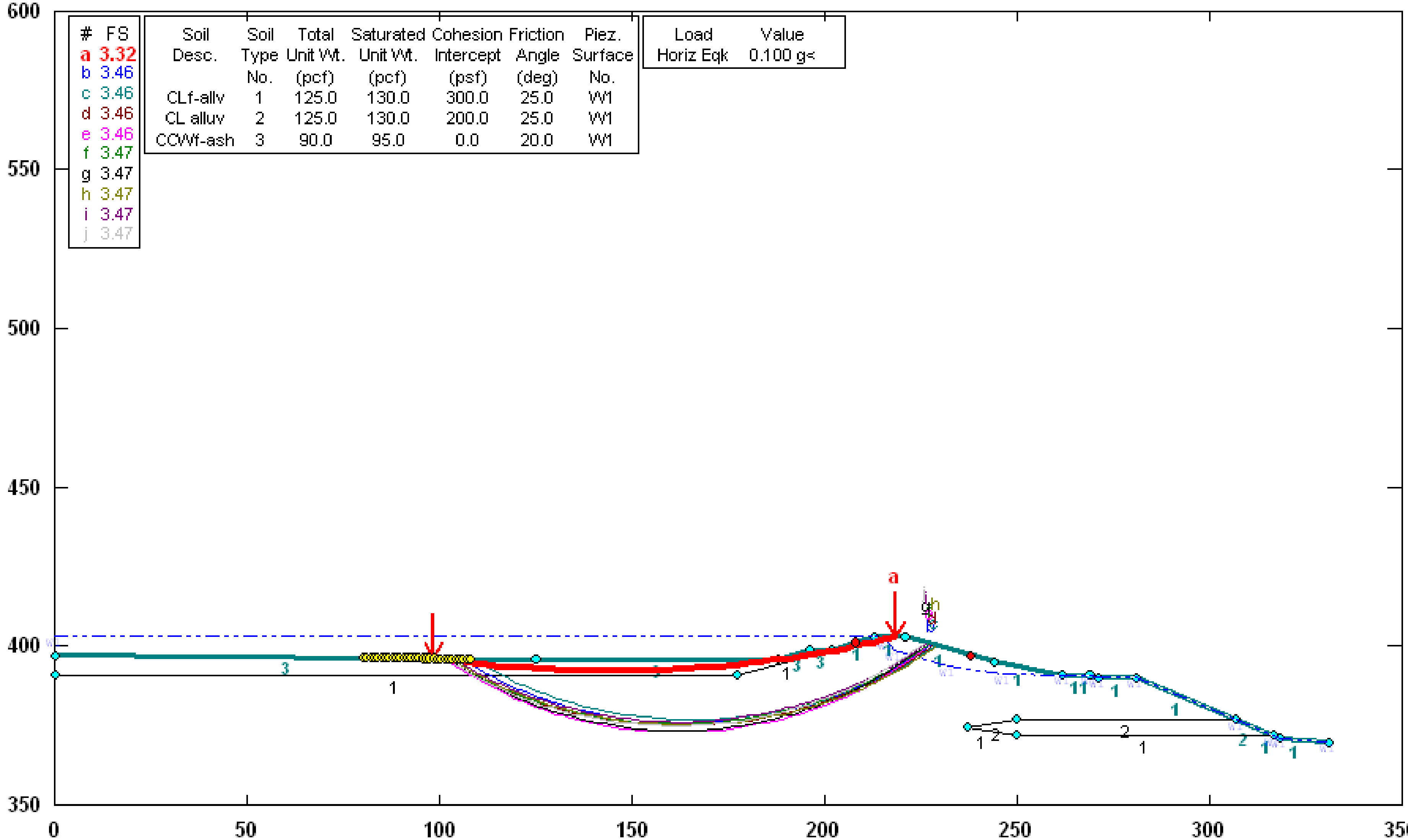


STABL6H FSmin=3.56

Safety Factors Are Calculated By The Modified Bishop Method

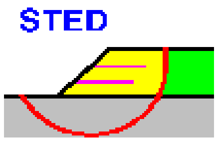
3143-10-1317 Green River Power Station Section 10: Upstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-10\UPSTREAM\SEISMIC.PL2 Run By: MACTEC 12/2/2010 10:52AM



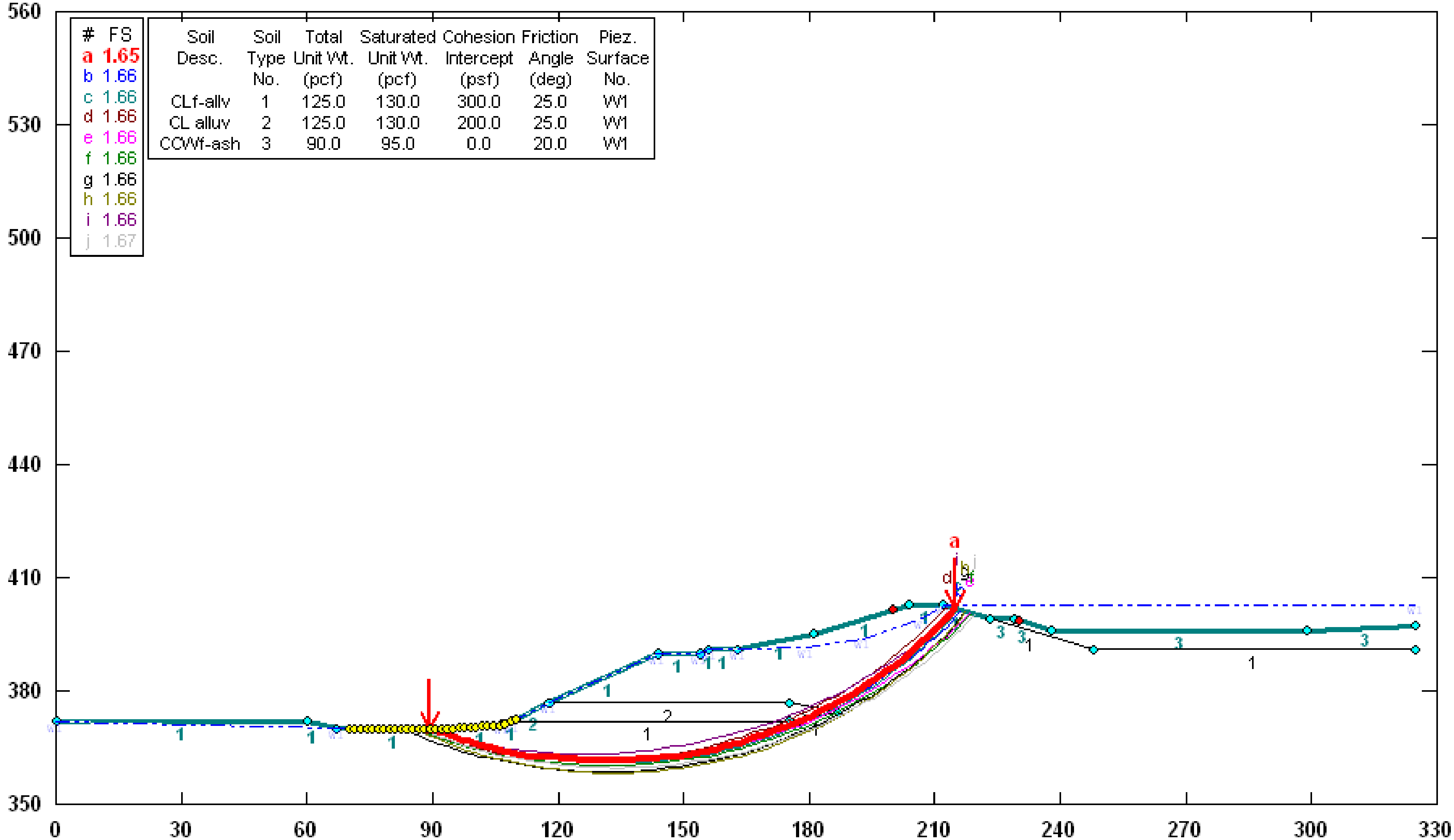
STABL6H FSmin=3.32

Safety Factors Are Calculated By The Modified Bishop Method



3143-10-1317 Green River Power Station Section 10: Downstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-10\DOWNST~1\SSMAXFLD.PL2 Run By: MACTEC 10/15/2010 9:41AM

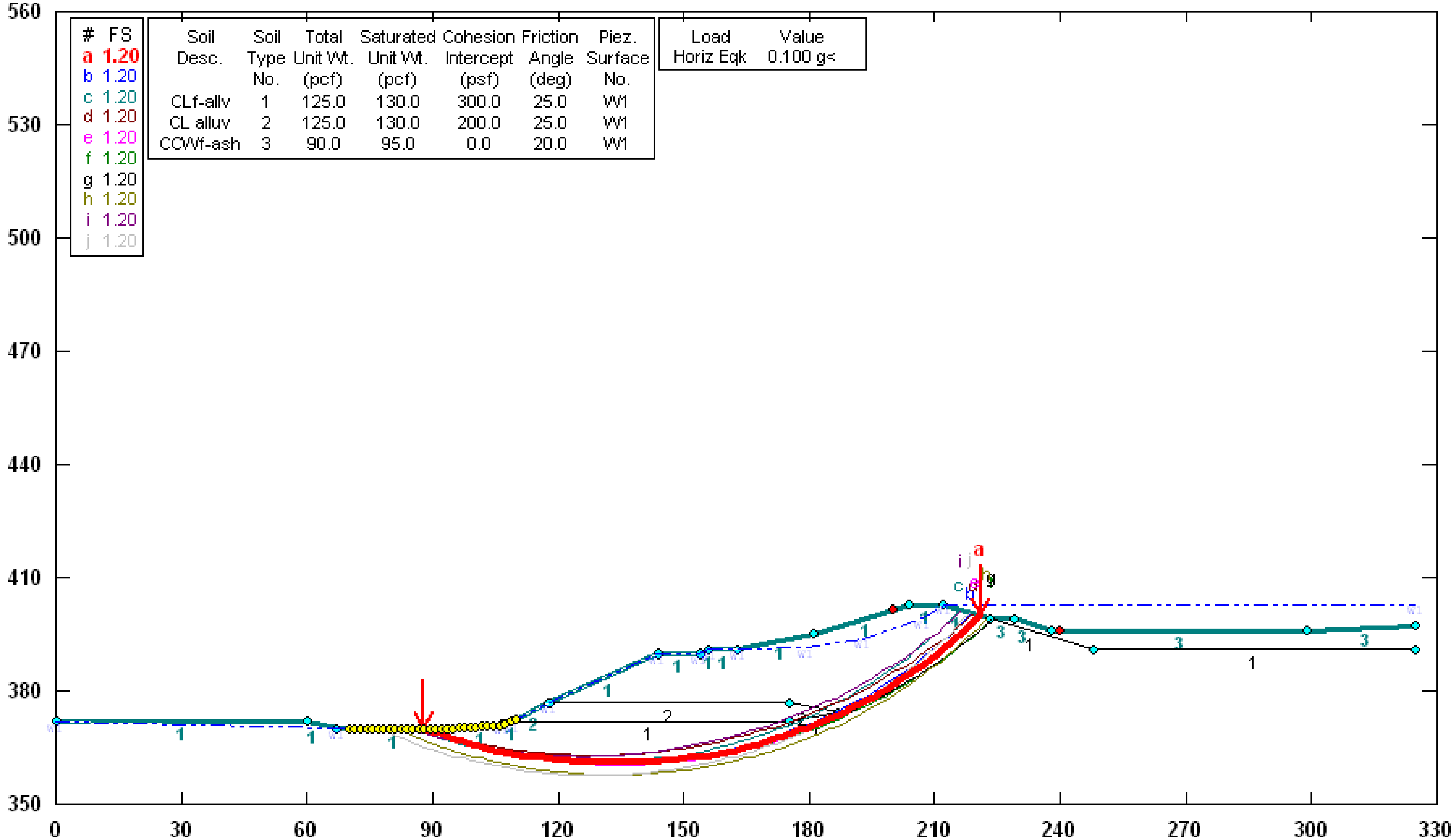


STABL6H FSmin=1.65

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station Section 10: Downstream - Seismic

C:\STEDWIN\STEDWIN\GREENR~1\S-10\DOWNST~1\SEISMIC.PL2 Run By: MACTEC 12/2/2010 10:50AM



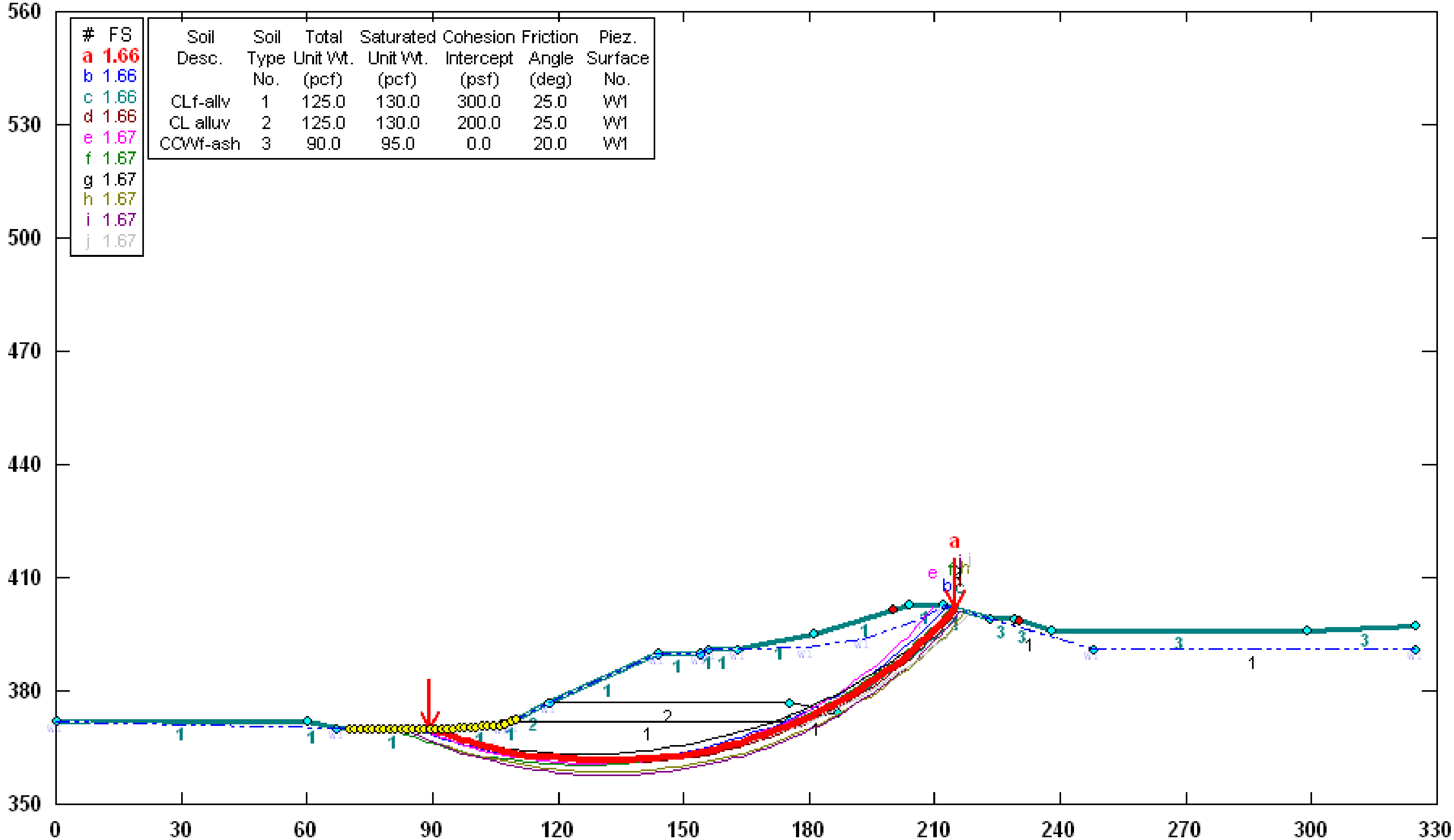
STABL6H FSmin=1.20

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 10: Downstream - Rapid Drawdown

C:\STEDWIN\STEDWIN\GREENR~1\S-10\DOWNST~1\RDD.PL2 Run By: MACTEC 10/15/2010 9:44AM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CLf-allv	1	125.0	130.0	300.0	25.0	W1
CL alluv	2	125.0	130.0	200.0	25.0	W1
CCWf-ash	3	90.0	95.0	0.0	20.0	W1

STABL6H FSmin=1.66

Safety Factors Are Calculated By The Modified Bishop Method

MACTEC

engineering and constructing a better tomorrow

January 24, 2011

Mr. David J. Millay, P.E.
LG&E-KU Services Company, Inc.
220 West Main Street
Louisville, Kentucky 40202
Phone: 502-627-2468
Facsimile: 502-217-2850
Electronic mail: David.Millay@LG&E-KU.com

SUBJECT: Addendum A
Report of Geotechnical Exploration and Slope Stability Analyses
KU Green River Power Station
No. 2 Pond/Coal Pile Runoff Pond and Scrubber Pond
South Carrollton, Muhlenberg County, Kentucky
MACTEC Project No. 3143-10-1317.02

Dear Mr. Millay:

MACTEC Engineering and Consulting, Inc. (MACTEC) is pleased to submit this Addendum to our *Report of Geotechnical Exploration and Slope Stability Analyses*, dated December 3, 2010. The purpose of this addendum is threefold:

1. Transmit updated piezometer data for the project
2. Transmit updated stability analysis data for the project
3. Provide responses and clarifications to selected sections of the *USEPA Dam Safety Assessment* draft report issued by AMEC in September 2010

A discussion of each of the above items follows. Our services were provided in general accordance with our Master Agreement No. 31528, Contract No. 495429 dated August 23, 2010, and our Proposal No. PROP10LVLE Task 162.

Piezometer Data

Piezometer readings have been taken on two occasions since our *Report of Geotechnical Exploration and Slope Stability Analyses* (i.e., our final report) was issued. The attached Table 2 has been revised to include the additional data.

Stability Analyses

Information provided by LG&E-KU suggests it may be possible during normal operation of the ash ponds that solids in the ponds reach a maximum level near the upstream embankment crest elevation. Therefore, we have performed additional stability analyses for the downstream embankment slopes for Section 1 and Sections 4 through 10 that reflect this condition (i.e., "pond full"). The "pond full" condition for Sections 2 and 3 was represented by the steady state/maximum flood analyses reported previously, based on the actual solids level in the No. 2 pond at the time of the bathymetric survey (Associated Engineers, Inc., July 2010) provided to us.

The additional analyses were based on the steady-state/maximum flood cross sections, with the modification of CCW solids extending to the upstream crest elevation. The results of the analyses are provided on the attached *Results of Slope Stability Analyses – Green River Power Station, No. 2 Pond/Coal Pile Runoff Pond & Scrubber Pond* table. In addition, the section geometry, input parameters, and stability analysis results are provided on the attached STABL6H output plots. Our analyses indicate the computed minimum factor of safety (FS) against failure, which ranges from 1.4 to 2.4, exceeds the target FS for each of the downstream embankment sections analyzed except Section 1 Downstream. Although the Section 1 Downstream slope does not meet the target FS under the conditions analyzed, the minimum FS computed does exceed 1.0. This suggests the slope should be stable under steady-state, "pond full" conditions and should not be expected to fail under steady-state, "pond full" conditions. However, some treatment may be required at Section 1 Downstream to increase the minimum FS under steady-state/maximum flood "pond full" conditions, to meet the target FS.

Response to AMEC Draft Report

This Addendum addresses comments provided in the following sections of AMEC's *Dam Safety Assessment* draft report:

Section 3.4, Foundation Conditions
Section 4.3.2, Geotechnical and Stability Recommendations – No. 2 Pond
Section 4.4.2, Geotechnical and Stability Recommendations – Scrubber Pond
Section 4.5.2, Geotechnical and Stability Recommendations – Coal Runoff Pond

AMEC's comments were based, in part, on visual observation of site conditions and review of MACTEC's *Geotechnical Exploration and Slope Stability Analyses Data Package* for the No. 2 Pond/Coal Pile Runoff Pond and Scrubber Pond at the KU Green River Power Station in South Carrollton, Muhlenberg County, Kentucky, dated September 3, 2010. We note that our final report for the listed Green River ponds, which includes additional analyses as well as additional and revised information pertaining to MACTEC's activities on the project, was issued on December 3, 2010, subsequent to AMEC's *Dam Safety Assessment* draft report.

For the purposes of the following discussion, we have identified the three ponds as follows:

A No. 2 Pond
B Coal Pile Runoff Pond
C Scrubber Pond

Seven comments were common to all three ponds, and each pond had one or more additional comments applicable to that specific pond. Below is a listing of AMEC's comments and recommendations along with the applicable pond(s), each followed by our response or clarification.

<u>Pond(s)</u>	<u>Comment/Recommendation/Response/Clarification</u>
A, B, C	"MACTEC's … Data Package … briefly describes foundation conditions. The report states "In general, the dikes were constructed of sandy clay fill reportedly excavated from the incised portion of the ponds. The fill was placed overlying existing alluvial soils comprised of silty to sandy, lean clay."

MACTEC Response: Section 4.4 of our final report provides detailed descriptions of our exploration program and the conditions encountered in our borings, including descriptions of the alluvium and bedrock underlying the embankments. Our referenced report also includes a discussion of the fly ash that was encountered beneath the embankment fill at Section 2, as well as in three supplemental borings drilled east and west of Section 2.

A, B, C "In the opinion of the assessing professional engineer, the criteria for minimum safety factors should be in accordance with USACE…with a minimum seismic safety factor of 1.2 as recommended by …MSHA.."

MACTEC Response: The Green River No. 2 Pond/Coal Pile Runoff Pond and Scrubber Pond are under the jurisdiction of the Kentucky Environment and Energy Cabinet. Therefore, the minimum factors of safety computed during our slope stability analyses were compared to the target factors of safety obtained from Commonwealth of Kentucky documents referenced on Page 2 of our final report.

A, B, C "The analysis should consider all critical stages over the life of the pond including pond full conditions."

MACTEC Response: The stability of the selected cross sections at the noted Green River ponds was originally evaluated under three conditions: steady-state/maximum flood, rapid drawdown, and dynamic (seismic) loading. The results of these analyses were provided in our final report. The ash profile at each cross section was modeled based on our review of the bathymetric surveys provided to us at the time of our analyses (Associated Engineers, Inc., July 2010). At the locations of Sections 2 and 3, the No. 2 Pond survey indicated the presence of ash to near the level of the upstream embankment elevation. At the remaining stability sections, the mapped solids level reflected a partial load in the pond. Information provided recently by LG&E-KU suggests it may be possible during normal operation of the ponds that solids in the ponds reach a maximum level near the upstream embankment crest elevation. Therefore, we have performed additional stability analyses for the downstream embankment slopes for Section 1 and Sections 4 through 10 that reflect the "pond full" condition. The results of these additional analyses have been included on the attached *Results of Slope Stability Analyses – Green River Power Station, No. 2 Pond/ Coal Pile Runoff Pond & Scrubber Pond* table. In addition, the cross section geometry, input parameters, and stability analysis results are provided on the attached STABL6H output plots.

A, B, C "A rapid drawdown (analysis) should be performed for upstream embankment in case the pond would need to be lowered in response to a problem."

MACTEC Response: The results of our rapid drawdown analyses were provided in our final report.

A, B, C "The friction angle value of 30 degrees used for the CCW (ash) in the analysis appears high for loose, saturated ash."

MACTEC Response: Our rationale for selection of unit weight and shear strength values was provided in Section 5.3 of our final report. MACTEC has extensive experience with CCW at LG&E-KU facilities in Kentucky and with other similar facilities in the southeastern United States. Laboratory testing (both triaxial and direct shear tests) of CCW from other facilities indicated friction angles ranging from 28 degrees to over 42 degrees. In addition, we performed sensitivity analyses at a selected Green River Power Station cross section under current conditions. The purpose of the sensitivity analysis was to evaluate stability of the selected section with variations in shear strength for both fly ash and bottom ash. Based on the results of the sensitivity analysis, our experience, and published data, we selected friction angles of 20 degrees for fly ash and 28 degrees for bottom ash to provide, in our opinion, the appropriate level of conservatism.

A, B, C — "Consideration should also be given to allowing some time for water levels in the piezometers to develop and stabilize."

MACTEC Response: Piezometers were installed in a total of six crest borings, including three at No. 2 Pond/Coal Pile Runoff Pond (B-2C, B-3C, and B-4C) and three at Scrubber Pond (B-6C, B-8C, and B-10C), on August 13 and 14, 2010. Groundwater levels in the piezometers were initially measured on August 24, 2010, 1-1/2 weeks following installation, allowing measurement of stabilized groundwater levels. The second set of readings was taken on October 14, 2010. These readings were originally provided in our final report. Additional readings were taken in December 2010 and January 2011, subsequent to our final report. The piezometer readings to-date for this project are presented on the attached *Table 2. Summary of Piezometer Readings.*

A, B, C — "The analyses presented appear limited to a circular surface; different types of failure surfaces should be analyzed and optimized."

MACTEC Response: A circular failure surface is the accepted industry standard and appropriate for these analyses.

A, B, C — "The completed analyses should include data sheets to show all input parameters, (and a) discussion on how each parameter was derived"

MACTEC Response: The material input parameters (e.g., total and saturated unit weights, cohesion, and angle of internal friction) used for each loading condition for each cross section analyzed, as well as the horizontal acceleration for seismic loading, where applicable, are presented on the respective STABL6H plots included in our reports. The embankment geometry, including material layering and piezometric surface, is presented graphically on the respective STABL6H plots. Section 5.3 of our final report clearly describes the soil parameter selections.

A — "AMEC is concerned about the configuration and soil strength parameters used in the analyses (for Section 4). … AMEC recommends this section be reviewed for existing conditions and parameters adjusted to reflect softer conditions at the toe"

MACTEC Response: The geometry of the Section 4 cross section was developed from the survey provided to us (*KU Green River Mapping*, dated February 3, 2010, prepared by L. Robert Kimball & Associates, LLC), and modified based on an as-built survey performed following modifications and regrading at the east embankment of

No. 2 Pond (*As-Built, Number 2 Pond Slope Armoring and Ditch Relocation*, dated September 15, 2010, prepared by Associated Engineers, Inc.). The subsurface stratigraphy was based on the boring data obtained at Section 2 (Borings B-2C and B-2T), with consideration also given to offset borings drilled east and west of Section 2 (B-1.5T, B-1.75T, and B-2.5T). The soil shear strength parameters used in the Section 2 stability analyses provided in our final report varied from those provided in our *Data Report*. Selection of material shear strength parameters was discussed in Section 5.3 of our final report.

A “…embankments constructed over ash would be susceptible to piping and slope failures.”

MACTEC Response: Our borings encountered both bottom ash and fly ash beneath the embankment fill at Section 2. These materials were included in the cross section and assigned appropriate strength parameters for the slope stability evaluations. Our slope stability analyses, which were provided in our final report, indicate the minimum factors of safety computed for the loading conditions evaluated exceed the target factors of safety at Section 2.

Although our borings encountered ash beneath the embankment fill, we did not observe ash to be exposed at the ground surface south of the downstream slope in the vicinity of Section 2. Our observations and boring data suggest the ash beneath the embankment at Section 2 is encapsulated or capped by cohesive soils. Further, free water does not presently exist behind this embankment. Therefore, in our opinion, the ash in its present configuration does not represent a significant potential piping condition. This situation should be reevaluated should unfavorable conditions not previously observed come to the attention of plant personnel or others, or if ash becomes exposed downstream of the embankment through erosion, excavation, or penetration (such as with borings) of the overlying cohesive soils (note: borings performed in conjunction with this exploration were backfilled with a cement-bentonite grout).

B “The 2009 ATC inspection report mentions needed repairs for a surface failure on the downstream slope in this area (i.e., Section 1). During our site visit, the toe and the area below the downstream slope had been recently repaired. Details for the repair were not provided. The analysis for this section (Section 1) was not provided in the preliminary report. The results of the analyses should be reviewed when the final report is completed.”

MACTEC Response: The configuration of the Section 1 embankment was developed from the survey by L. Robert Kimball & Associates, LLC. The stability of both the upstream and downstream embankment faces was evaluated for steady-state/maximum flood, rapid drawdown, and dynamic (seismic) loading conditions. The results of these analyses were provided in our final report. The results of additional stability analysis of the downstream embankment under the steady-state/maximum flood “pond full” condition are attached to this Addendum.

C (compared to Section 7, for which stability analyses were provided in the *Data Package*,) “…it appears … that Section 8 would have a steeper downstream slope and would be more critical. During the site visit, wet conditions were noted below the toe of the south embankment" (where Sections 7 and 8 are located)

MACTEC Response: The downstream slope at Section 8 (approximately 2.4H:1V) is steeper than that at Section 7 (approximately 2.9H:1V). Stability analyses for Sections 4 and 7 were included in our *Data Package*, but our final report included stability analyses for all 10 proposed study sections, including Section 8. The piezometric surface at both Sections 7 and 8 was modeled as daylighting at the toe of the embankments, to account for the wet surface conditions present in the area.

C "Recommendations mentioned in the previous sections such as the configuration of the slope and adjustment of soil strength parameters and a detailed discussion of the methods and parameters should be included in the final report."

MACTEC Response: The geometry (i.e., configuration) of Sections 6 through 10 at Scrubber Pond were developed from the survey by L. Robert Kimball & Associates, LLC). The soil shear strength parameters used in the stability analyses provided in our final report varied from those provided in our *Data Report*. Selection of material shear strength parameters was discussed in Section 5.3 of our final report. The methods used for our evaluation, including slope stability analysis, cross section geometry development, soil parameter selection, piezometric surface development, and seismic conditions, were described in Sections 5.1 through 5.5 of our final report.

We trust the information provided above along with the attachments to this letter sufficiently clarify AMEC's comments related to our *Report of Geotechnical Exploration and Slope Stability Analyses* for the Green River No. 2 Pond/Coal Pile Runoff Pond and Scrubber Pond. Please let us know if additional assistance is required.

This Addendum should be attached to and made part of our *Report of Geotechnical Exploration and Slope Stability Analyses,* dated December 3, 2010. We appreciate the continued opportunity to work with you on this project. Please contact us if you have any questions regarding the information presented in this letter.

Sincerely,

MACTEC ENGINEERING AND CONSULTING, INC.

Melany L. Brite
Senior Professional

Nicholas G. Schmitt, P.E.
Senior Principal Engineer
Licensed Kentucky 10311

Attachments: Table 2. Summary of Piezometer Readings, Revised 1/19/2011
Results of Slope Stability Analyses – Green River Power Station, No. 2 Pond/ Coal Pile Runoff Pond & Scrubber Pond, Revised 1/20/2011
STABL6H Output Plots

Table 2
Summary of Piezometer Readings

Piezometer ID	Date of Installation	Screened Interval Depth (feet)	Top of Ground Elevation (Feet NGVD)	Bottom of Piezometer Elevation (Feet NGVD)	Date of Readings							
					8/24/10		10/14/10		12/08/10		1/14/11	
					Depth*	Elevation	Depth*	Elevation	Depth*	Elevation	Depth*	Elevation
					Feet (depth) / Feet NGVD (elevation)							
B-2C	8/14/10	15 - 25	399.7	374.7	10.2	389.5	10.5	389.2	8.7	391.0	9.1	390.6
B-3C	8/13/10	25.5 - 35.5	399.4	363.9	12.6	386.8	12.6	386.8	12.1	387.3	12.6	386.8
B-4C	8/14/10	20 - 30	399.1	369.1	6.9	392.2	8.0	391.1	7.8	391.3	7.9	391.2
B-6C	8/14/10	15 - 25	404.7	379.7	11.5	393.2	12.6	392.1	12.9	391.8	13.0	391.7
B-8C	8/14/10	29 - 39	404.5	365.5	15.1	389.4	13.7	390.8	12.8	391.7	12.9	391.6
B-10C	8/13/10	15 - 25	403.9	378.9	25.3	378.6	26.4	377.5	24.6	379.3	24.1	379.8
Readings were taken from top of ground (TOG) level.												

Prepared By: *VM*
Checked By: *MLB*
Revised By: MLB 1/19/2011
Checked By: NGS 1/20/2011

MACTEC

Green River Power Station		
3143-10-1317.02		
Prepared by: MLB	Date:	12/2/2010
Checked by: NGS	Date:	12/2/2010
Revised by: MLB	Date:	1/20/2011
Checked by: NGS	Date:	1/21/2011

Minimum Factor of Safety Summary
Green River Power Station
No. 2 Pond/Coal Pile Runoff Pond & Scrubber Pond

Target Section	Slope	Long-Term Steady State/Max Surcharge Pool		Rapid Drawdown		Seismic		Long-Term Steady State/Max Surcharge Pool/Max Solids(2)	
		Target FS(1)	Min FS	Target FS(1)	Min FS	Target FS(1)	Min FS	Target FS(1)	Min FS
1	Upstream	1.5	4.1	1.2	4.1	1.0	2.0	1.5	n/a
	Downstream		1.4		1.6		1.0		1.4
2	Upstream		6.7		8.2		1.3 (3)		n/a
	Downstream		2.3		2.3		1.3		n/a (4)
3	Upstream		6.2		7.8		1.3 (3)		n/a
	Downstream		2.0		2.0		1.3		n/a (4)
4	Upstream		3.6		1.9		1.0		n/a
	Downstream		2.4		2.4		1.5		2.4
5	Upstream		2.5		1.5		0.8		n/a
	Downstream		2.0		2.0		1.2		2.0
6	Upstream		5.1		3.2		2.2		n/a
	Downstream		2.5		2.5		1.8		2.4
7	Upstream		3.6		2.7		1.5		n/a
	Downstream		1.9		1.9		1.2		1.9
8	Upstream		6.0		3.6		1.9		n/a
	Downstream		1.6		1.6		1.2		1.6
9	Upstream		3.5		2.4		1.8		n/a
	Downstream		2.3		1.4		1.6		2.3
10	Upstream		6.1		3.6		3.3		n/a
	Downstream		1.7		1.7		1.2		1.7

x.x Highlighted value does not meet the target minimum FS criteria

(1) Target Factor of Safety Reference: Design Criteria for Dams & Associated Structures (401 KAR 4:030, KAR 4:040)
(2) Includes CCW solids to upstream crest elevation; factor of safety against failure checked for downstream embankment face only
(3) Shallow surface sloughing failure - top of ash at dam crest elevation at this cross-section
(4) Due to pond conditions at the time of the bathymetric survey (Associated Engineers, Inc., July 2010) upon which the models for Sections 2 and 3 were based, the long-term steady state/maximum surcharge pool analysis was performed at "pond full" conditions; therefore, a separate "pond full" or "maximum solids" analysis was not performed.

3143-10-1317 Green River Power Station S-1, Downstream: SS/MxFld/MxSolids

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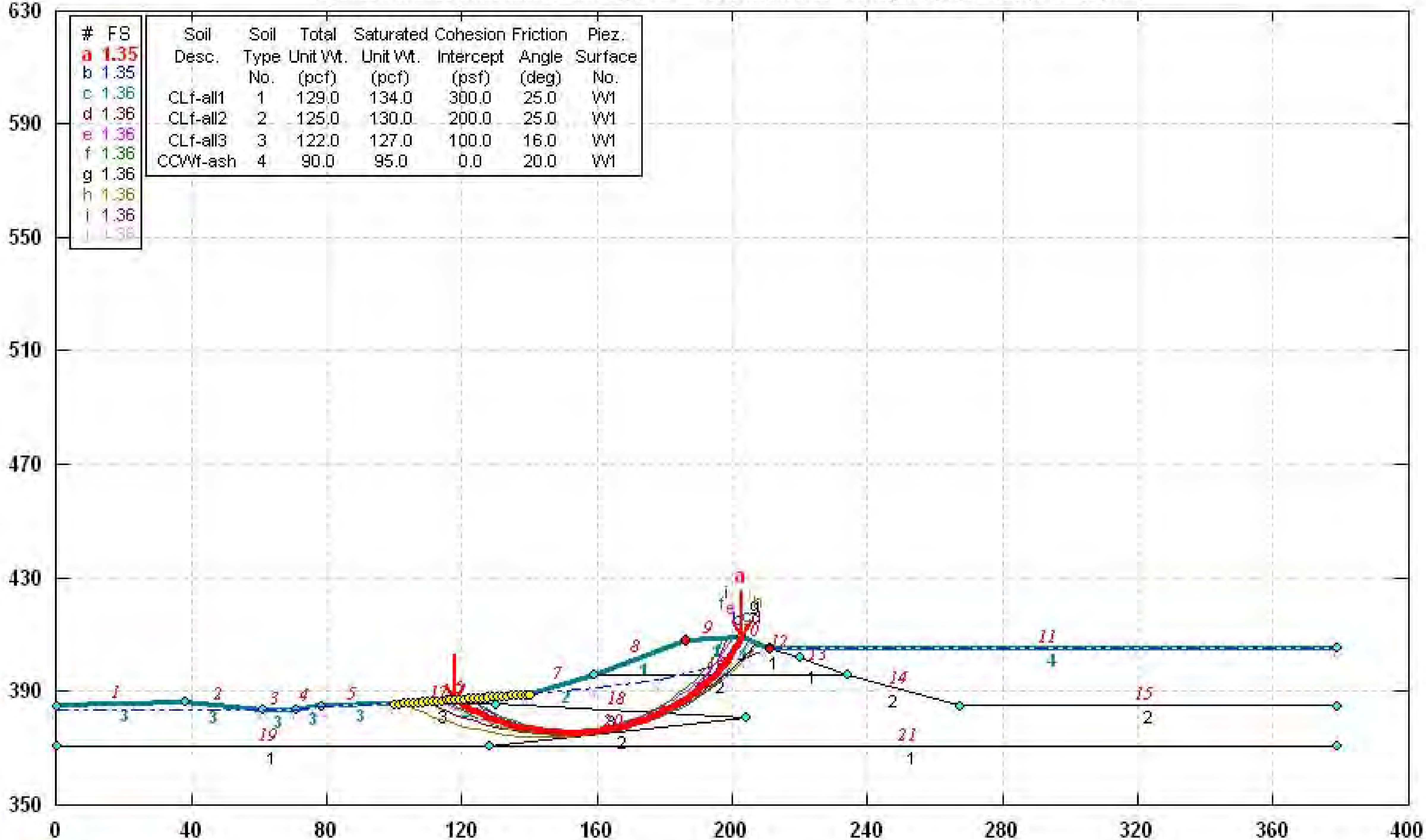

STABL6H FSmin=1.35

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Sta S-4, Downstream: SS/MxFld/MxSolids

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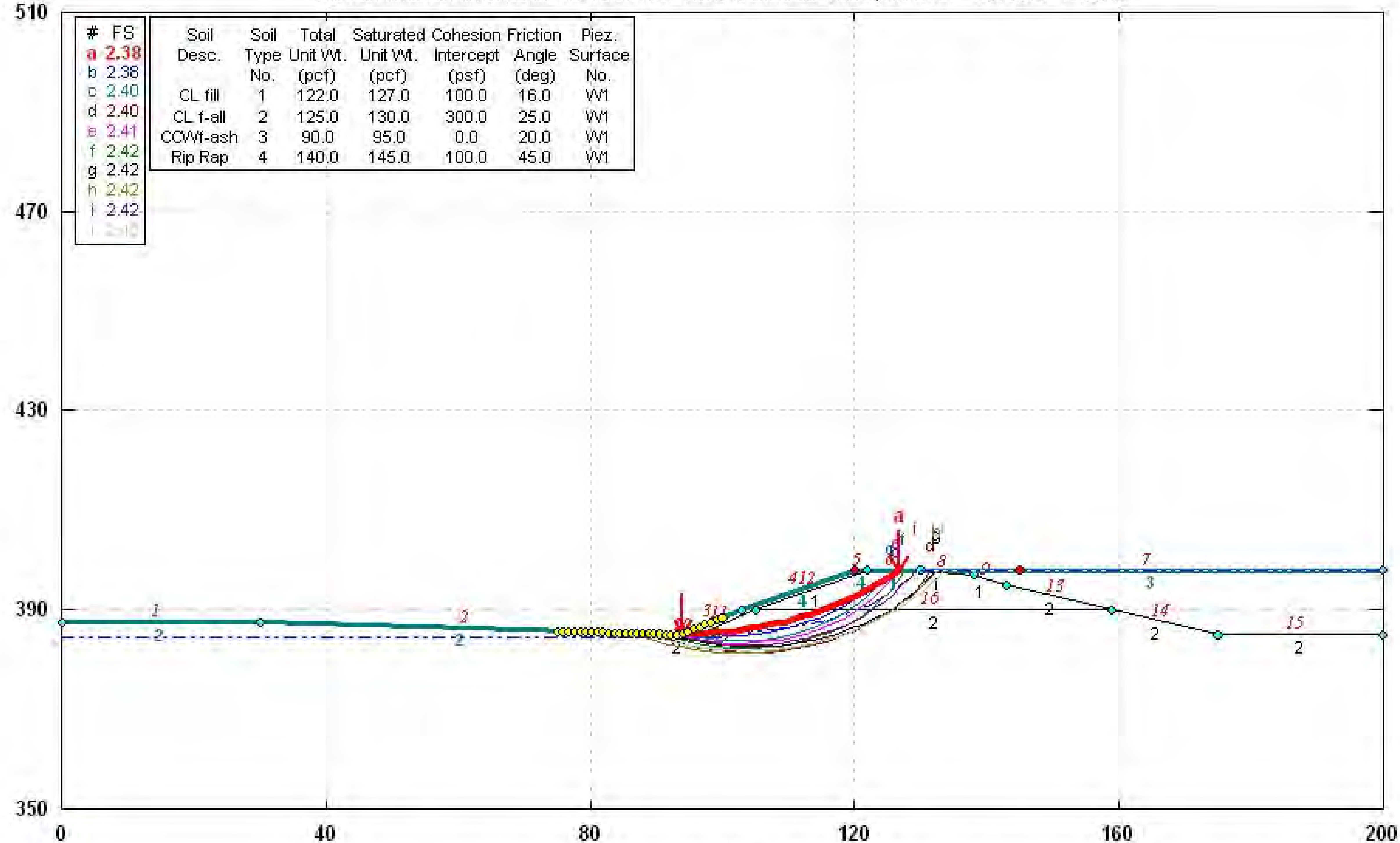

STABL6H FSmin=2.38

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station S-5, Downstream: SS/MxFld/MxSolids

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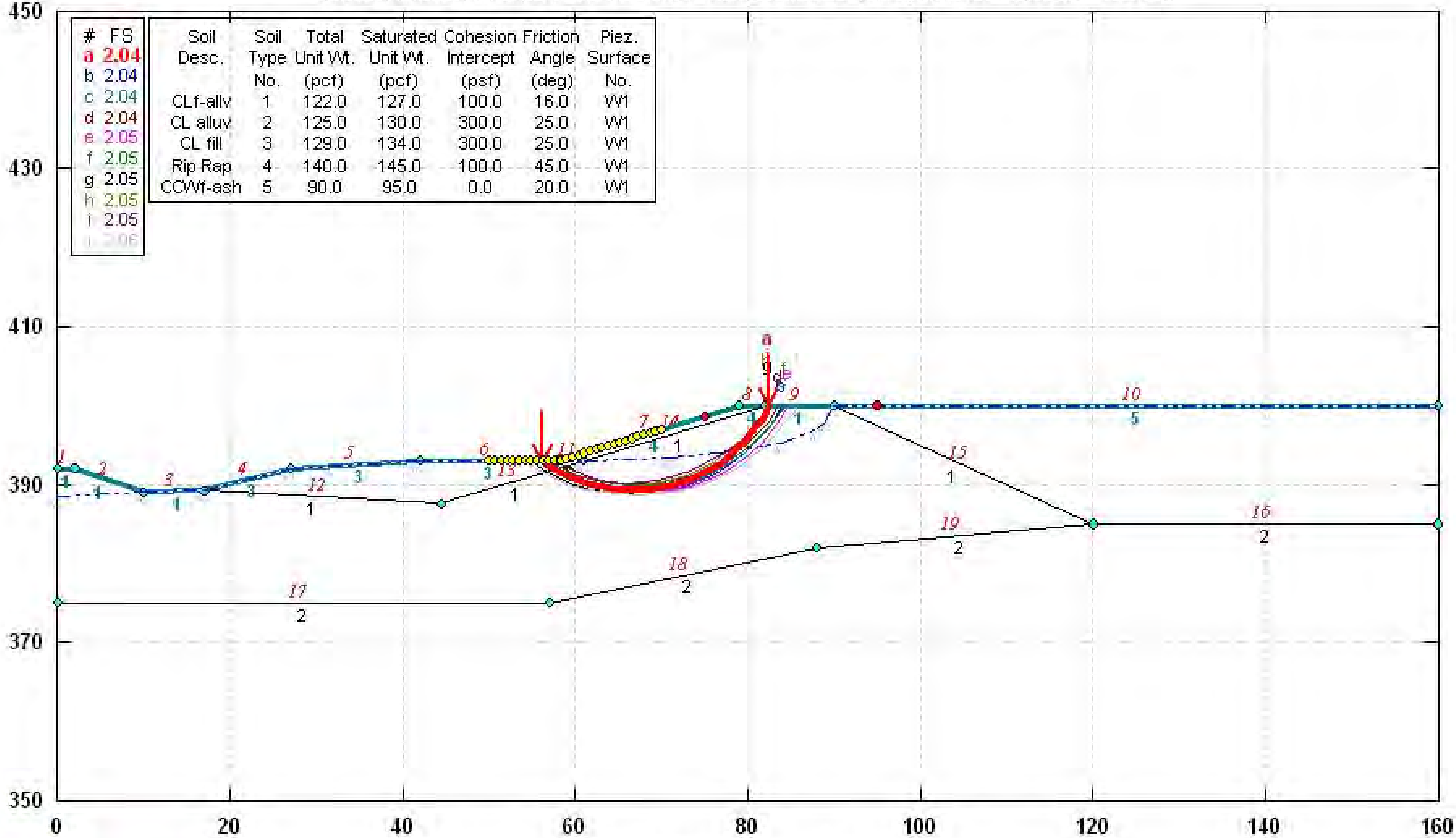

STABL6H FSmin=2.04

Safety Factors Are Calculated By The Modified Bishop Method

3143-10-1317 Green River Power Station S-6, Downstream: SS/MxFld/MxSolids

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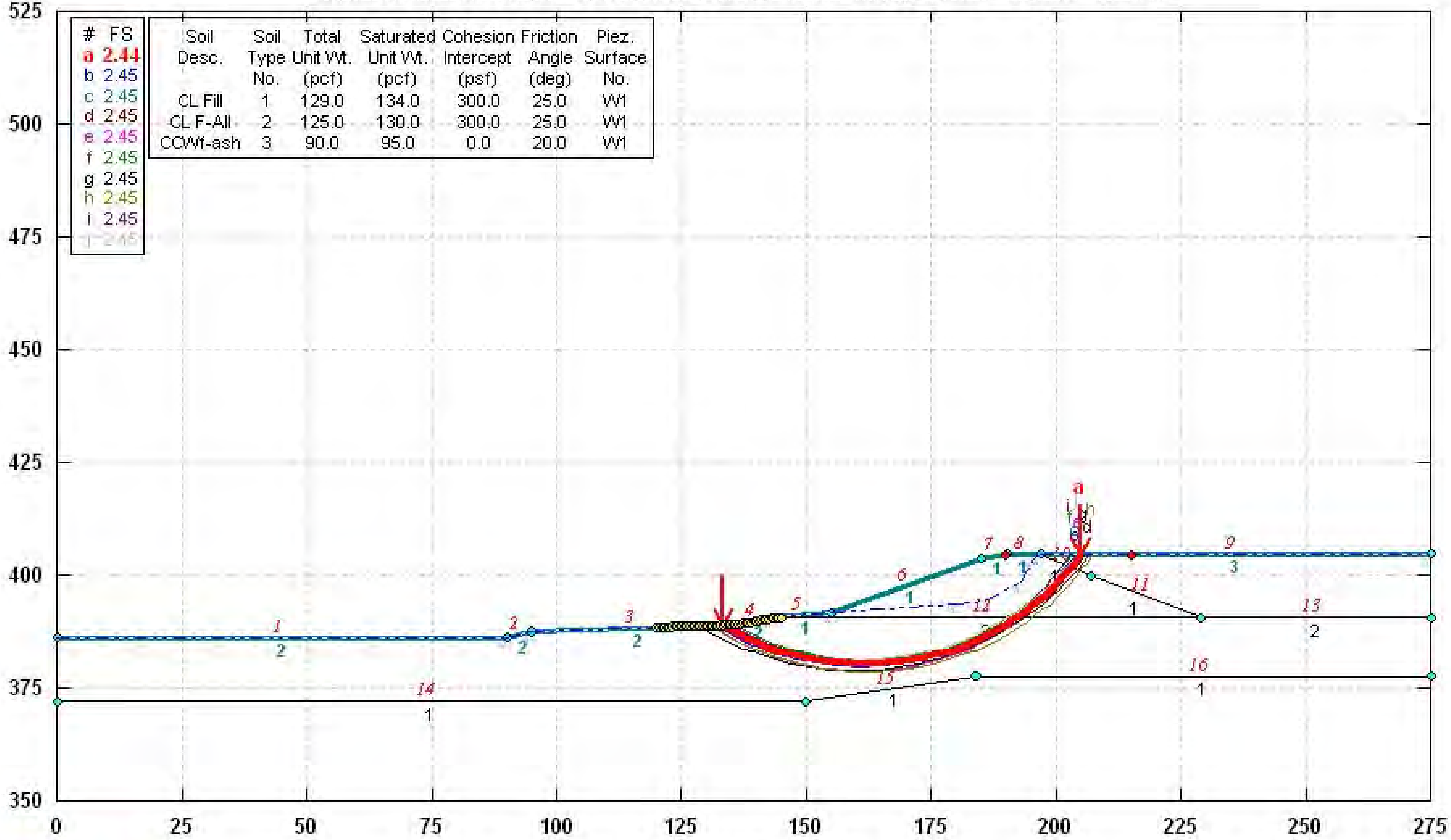

STABL6H FSmin=2.44

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Sta S-7, Downstream: SS/MxFld/MxSolids

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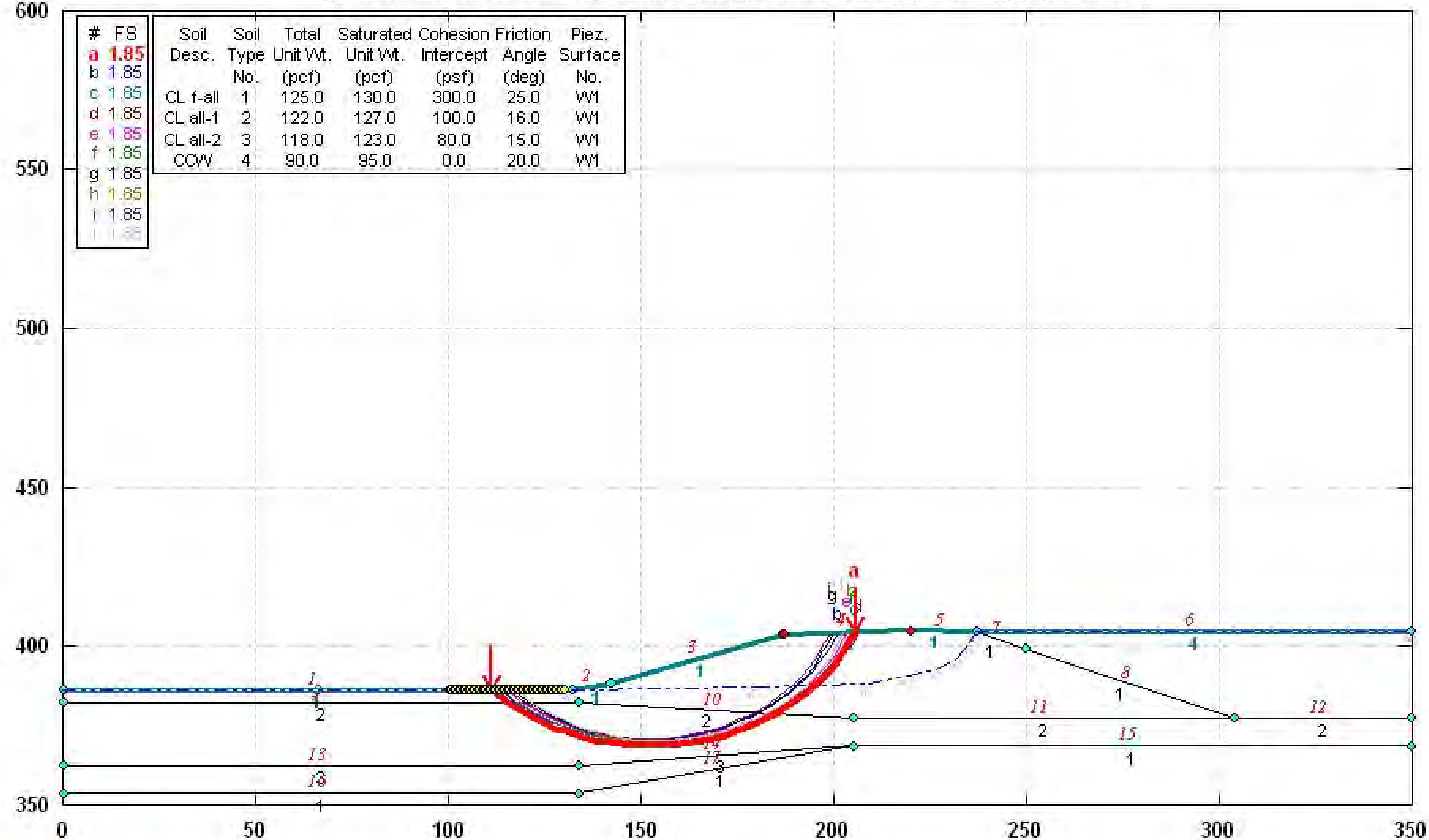


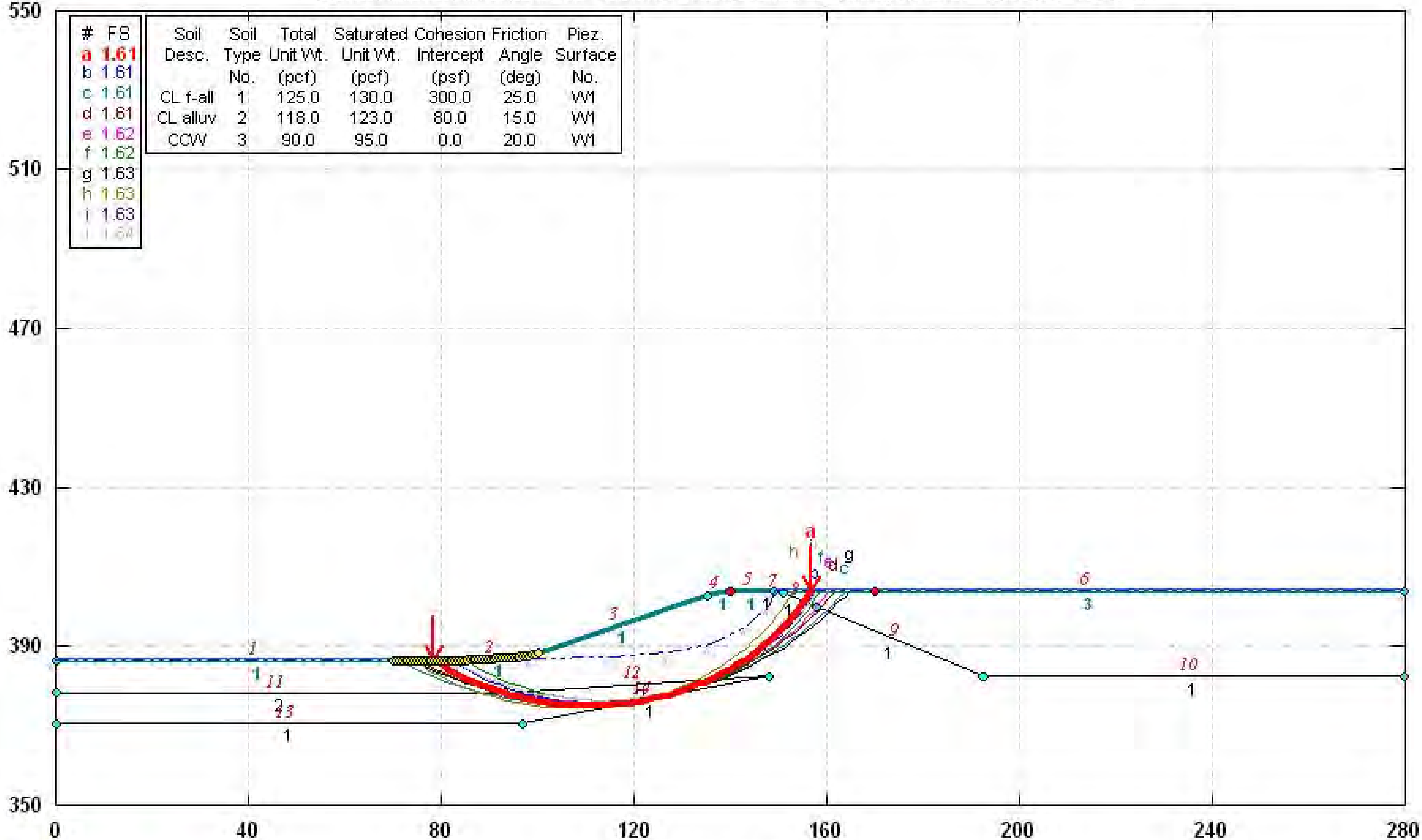
STABL6H FSmin=1.85

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station Section 8: Downstream - SS/Max Flood

C:\STEDWIN\STEDWIN\GREENR~1\S-8\DOWNST~1\GRS8DSMS.PL2 Run By: MACTEC 1/20/2011 10:48AM



STABL6H FSmin=1.61

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station S-9, Downstream: SS/MxFld/MxSolids

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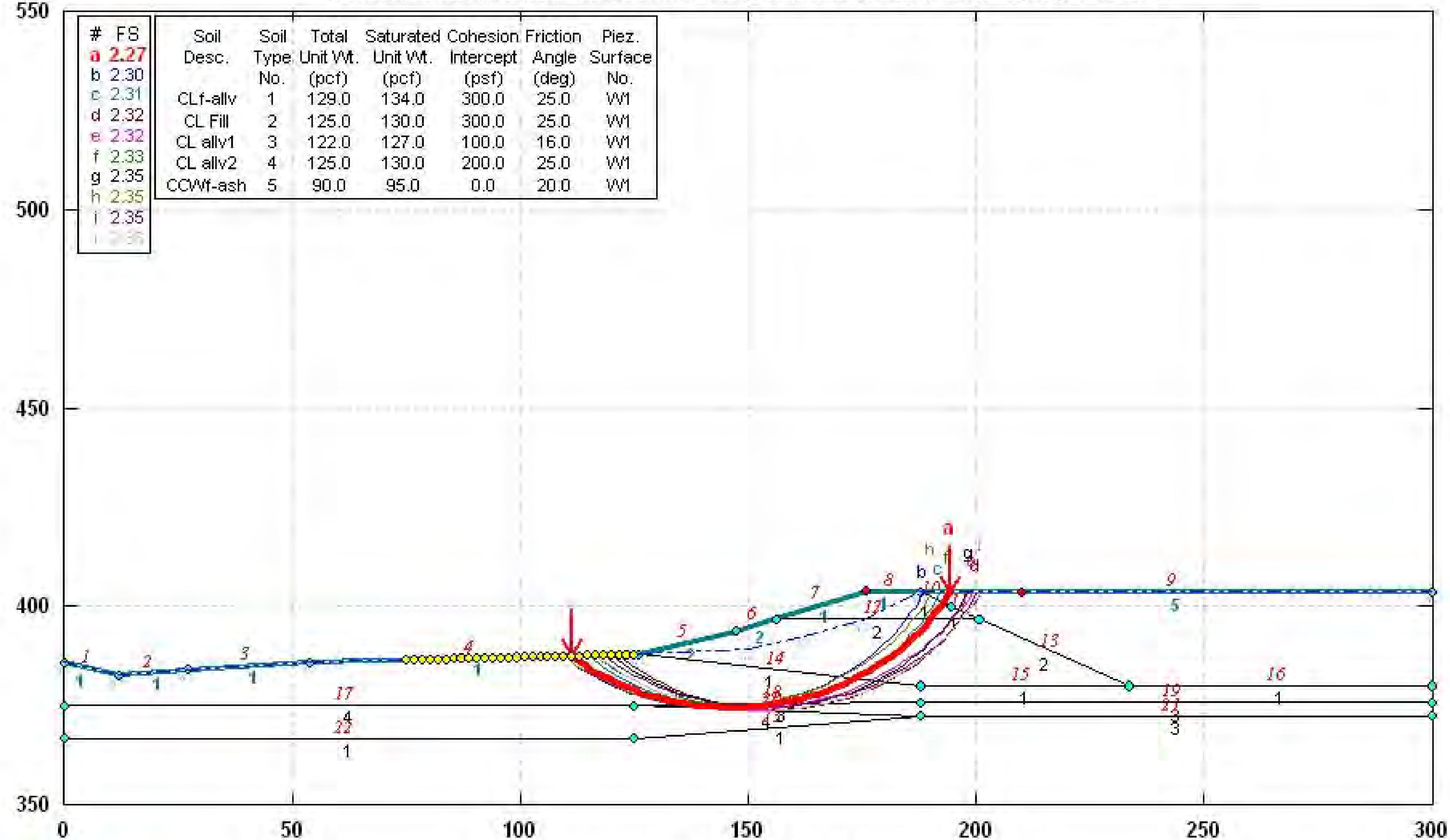

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CLf-allv	1	129.0	134.0	300.0	25.0	W1
CL Fill	2	125.0	130.0	300.0	25.0	W1
CL allv1	3	122.0	127.0	100.0	16.0	W1
CL allv2	4	125.0	130.0	200.0	25.0	W1
CCWf-ash	5	90.0	95.0	0.0	20.0	W1

STABL6H FSmin=2.27

Safety Factors Are Calculated By The Modified Bishop Method

STED

3143-10-1317 Green River Power Station S-10, Downstream: SS/MxFld/MxSolids

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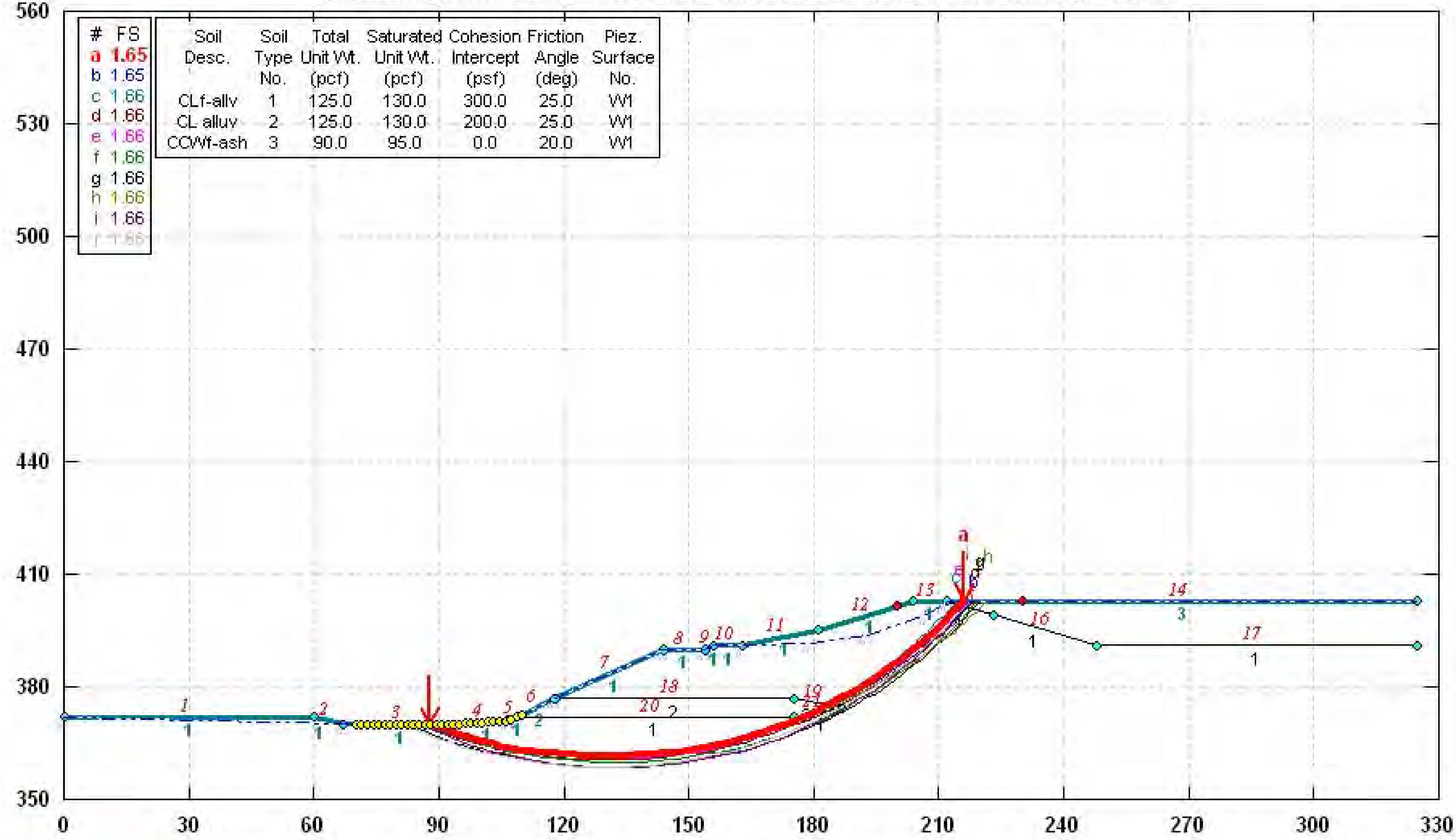
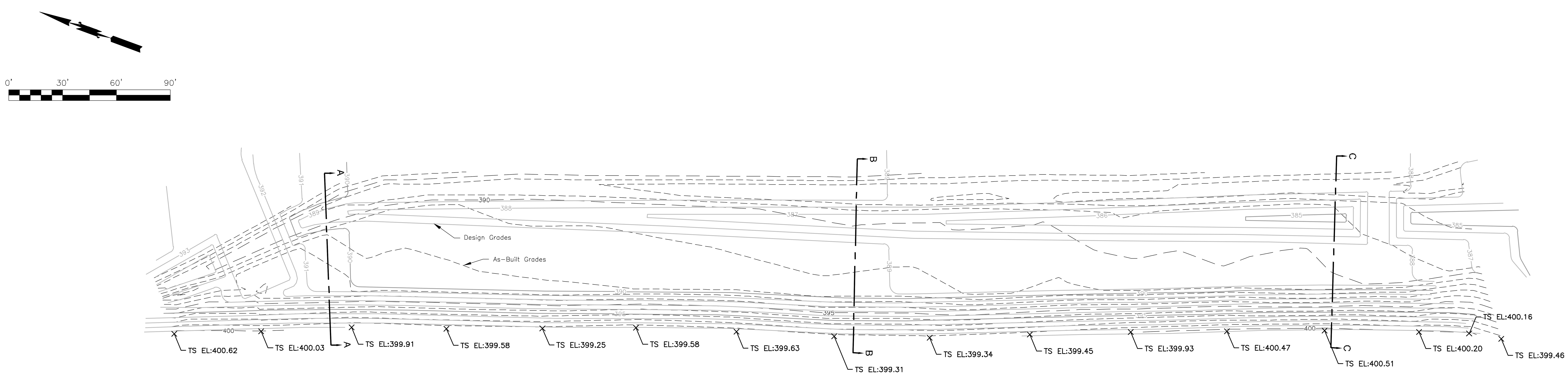
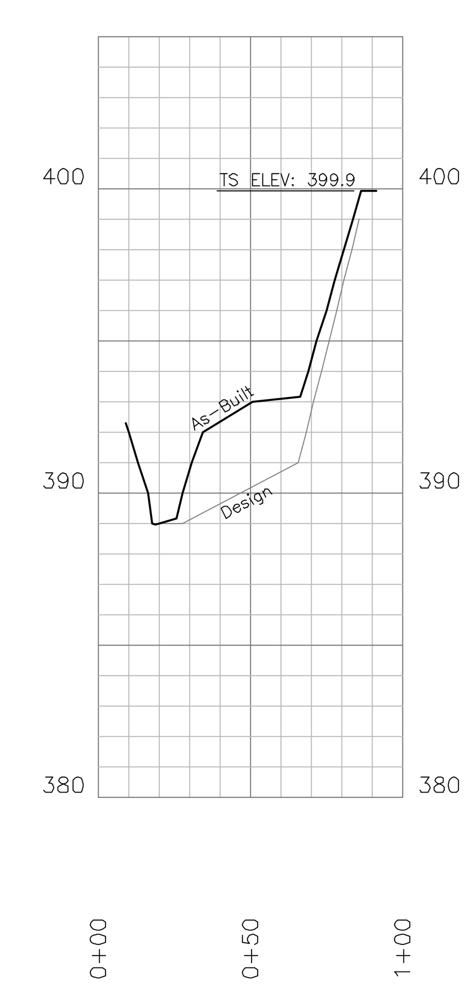


STABL6H FSmin=1.65

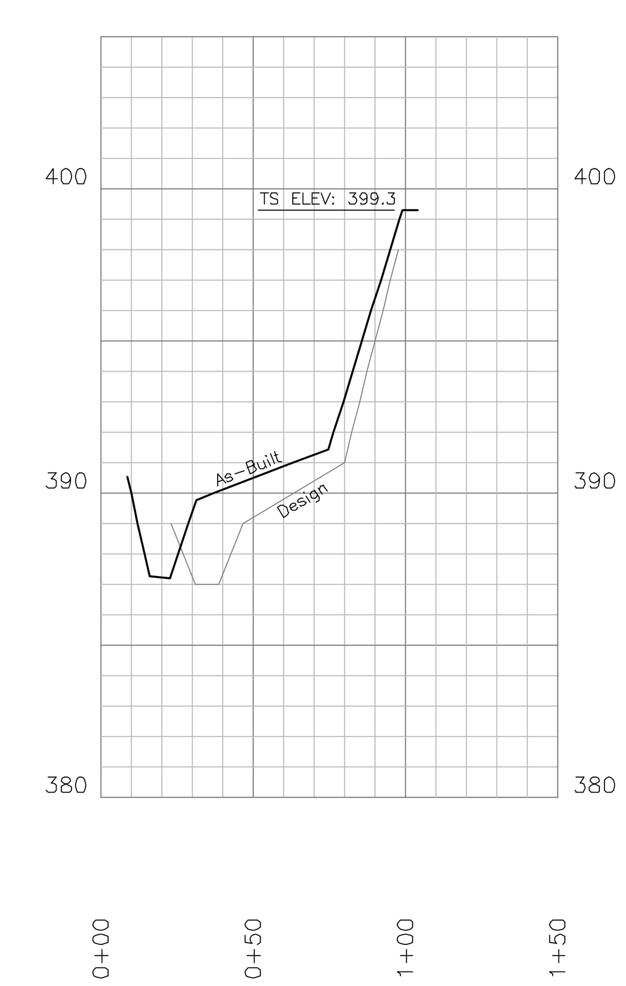
Safety Factors Are Calculated By The Modified Bishop Method

STED

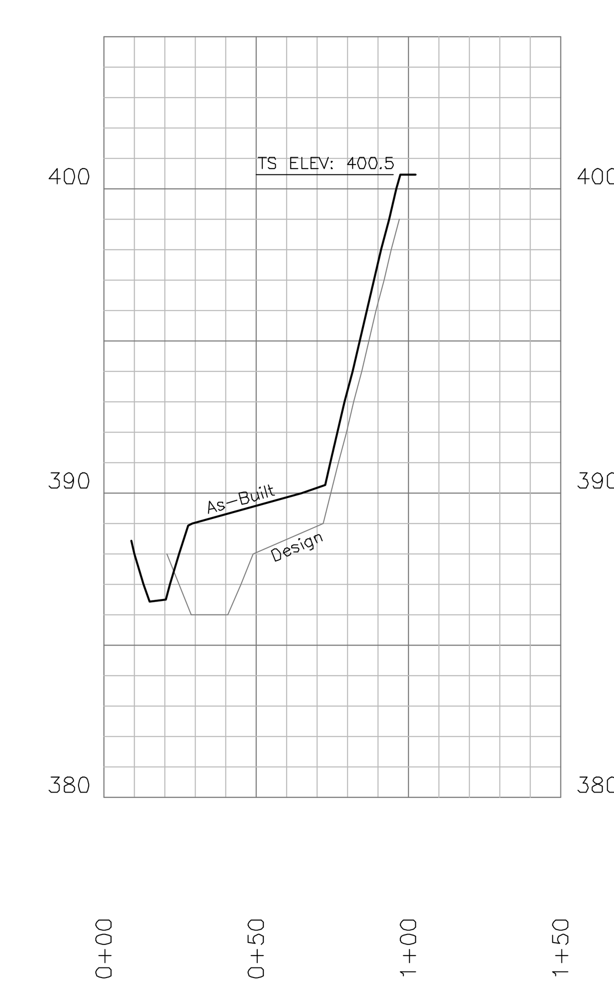




CROSS SECTION A-A
Horz: 1" = 50'
Vert: 1" = 5'



CROSS SECTION B-B
Horz: 1" = 50'
Vert: 1" = 5'



CROSS SECTION C-C
Horz: 1" = 50'
Vert: 1" = 5'

ASSOCIATED ENGINEERS, INC.
ENGINEERS • GEOLOGISTS • SURVEYORS

JOB NO.	09-0364G
DRAWN BY	P.B.
CHECKED BY	G.W.E.
DATE	09/15/2010

EON U.S. GREEN RIVER STATION
SOUTH CARROLTON, KY
NUMBER 2 POND SLOPE ARMORING AND DITCH RELOCATION
AS-BUILT

SHEET NUMBER
1

Attachment 3

Addendum A - Assessment of Spillway Hydrologic Adequacy for the Coal Pile Pond, Ash Treatment Basin No. 2, and Scrubber Pond at Green River Generating Station,

January 25, 2011,
Mactec Engineering and Consulting, Inc.

January 25, 2011

Addendum A to

ASSESSMENT OF SPILLWAY HYDROLOGIC ADEQUACY FOR THE COAL PILE POND, ASH TREATMENT BASIN NO. 2, AND SCRUBBER POND AT GREEN RIVER GENERATING STATION

August 12, 2010

By MACTEC Engineering and Consulting, Inc.

An analysis of the spillway capacities and freeboard conditions at the Kentucky Utilities Green River Generating Station was completed. A prior analysis (MACTEC, August 2010) evaluated the existing conditions and potential measures to provide suitable spillway and freeboard conditions with information available at that time. Since that evaluation, additional information has become available (updated topographic mapping, December 2010 and field survey of selected impoundment storage areas) and some facility modifications have been made. The relevant modifications made are as follows:

- The Scrubber Pond discharge pumps were replaced with two 200-gpm capacity pumps that are automatically activated with water level sensors. The pumps controls are set to maintain a water level of approximately 401.0 ft NAVD 1988, or approximately 3.0 ft below the dam crest elevation.
- The low portions of the ATB-2 dam crest were raised to elevation 400.0 ft NAVD 1988.
- The low portions of the Coal Pile Pond dam crest were raised to 405.5 ft NAVD 1988.

This analysis updated the existing conditions scenario for several storm events relevant to evaluation of the suitability of the currently existing spillways and freeboard conditions. The analysis was completed with HEC-HMS version 3.5.

The elevation –area relationships for all four impoundments were updated based on the new information topographic information. Elevation – area curves used in the hydrologic model are provided in Figures A-1 through A-4. The elevation area data measured from the topographic map were not significantly different from the data taken from the previous topographic maps. The elevation – area data provided to MACTEC in a storage capacity report, understood to be from ground survey, indicated generally smaller areas at given elevations than the topographic maps. The topographic mapping agreed reasonably closely with prior topographic mapping, and this consistency suggests that areas may have been underestimated by the field survey work. A relationship for modeling purposes was based on an estimate considering both information sources. Elevation –discharge curves for ATB-1 and ATB-2 are provided in Figures A-5 and A-6. The HEC-HMS optional "control structures" method was used to allow HEC-HMS to calculate the discharge rates for the Scrubber Pond and Coal Pile Pond based on structure data (size, elevations, etc.). The normal water level (initial water level in model) in ATB-2 was lowered slightly based on updated information.

For the Scrubber Pond pumps, it was assumed that the on-elevation for the lead pump is 401.2 ft and the second pump is activated at 401.5 ft. The initial water level was assumed to be 401.00 ft.

None of the four structures analyzed have emergency spillways and the existing conditions model reflects that, It is MACTEC's understanding that Kentucky DNR has historically approved structures without emergency spillways if the principal spillway is able to pass the emergency spillway design flood event without dam overtopping. For the case of a Class A structure, the emergency spillway design flood is the 100-year return period event.

Selected results from the HEC-HMS existing conditions model are summarized in Table A-1. It is observed that the freeboard amounts varied from the earlier analysis, with some increasing and some decreasing. For the 24-hour duration freeboard design flood as defined by Kentucky DNR Engineering Memorandum No. 5, the only structure not meeting the freeboard criteria is ATB-2. The minimum freeboard for the Kentucky Class A structure principal spillway minimum principal spillway design flood (100-year return period) occurs for the 24-hour storm event. The ATB-2 spillway design flood results in a maximum of 0.26 foot overtopping of the ATB-2 dam crest. The other structures have principal spillway design flood freeboard amounts of 1.42 ft, 1.77 ft, and 1.86 ft.

Potential measures to bring ATB-2 into compliance with Kentucky DNR standards were identified. Two approaches were evaluated. Alternative 1 included raising the dam crest elevation to prevent overtopping by the Freeboard Design Flood. Alternative 2 included installation of an emergency spillway while leaving the minimum embankment crest elevation at the existing 400.0 ft NAVD 88. The emergency spillway was assumed to be a 40-ft wide spillway that 1) does not flow for events more frequent than a 10-year event and 2) prevents the Freeboard Design Flood from overtopping the embankment. Variations of combinations of smaller emergency spillways and raising the dam are, of course, also potential alternatives as is some amount of lowering of the normal water level in ATB-2.

It was determined that, for Alternative 1, a minimum dam crest elevation of approximately 402.6 ft NAVD 1988 would be required to avoid dam overtopping for the Freeboard Design Flood.

For Alternative 2, it was determined using an iterative approach that the assumed 40-ft wide emergency spillway with crest elevation at 399.2 ft NAVD 1988 would meet these above criteria, with emergency spillway flow occurring at approximately a 10-year event and no overtopping of the dam for the Freeboard Design Flood. The maximum discharge for the Freeboard Design Flood is nearly 300 cfs.

Results from HEC-HMS analysis of Alternatives 1 and 2 are provided in Tables A-2 and A-3. Since only ATB-2 is affected by these alternatives and ATB-2 is the most downstream structure, no changes occur at the other structures.

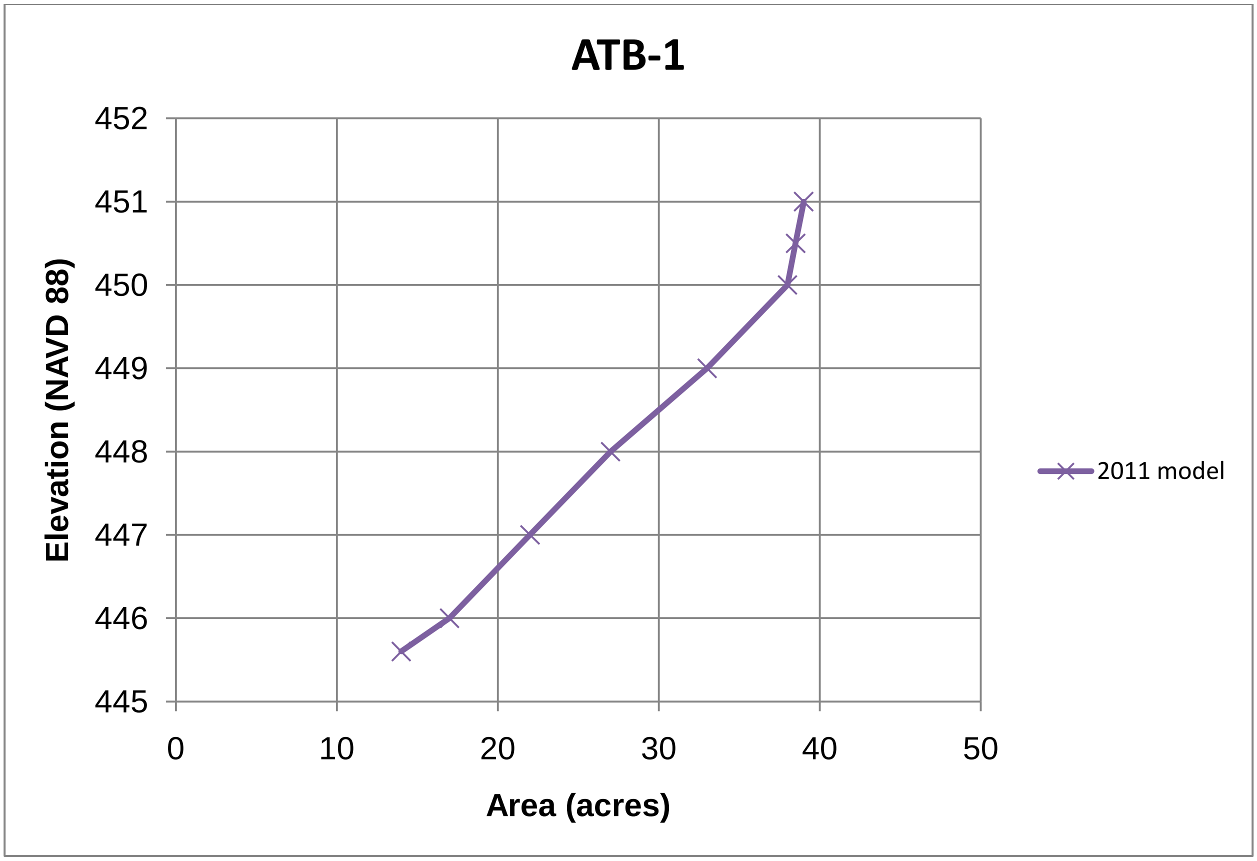


Figure A-1. HEC-HMS Elevation - Area Curve for ATB-1 (2011 Existing Condition).

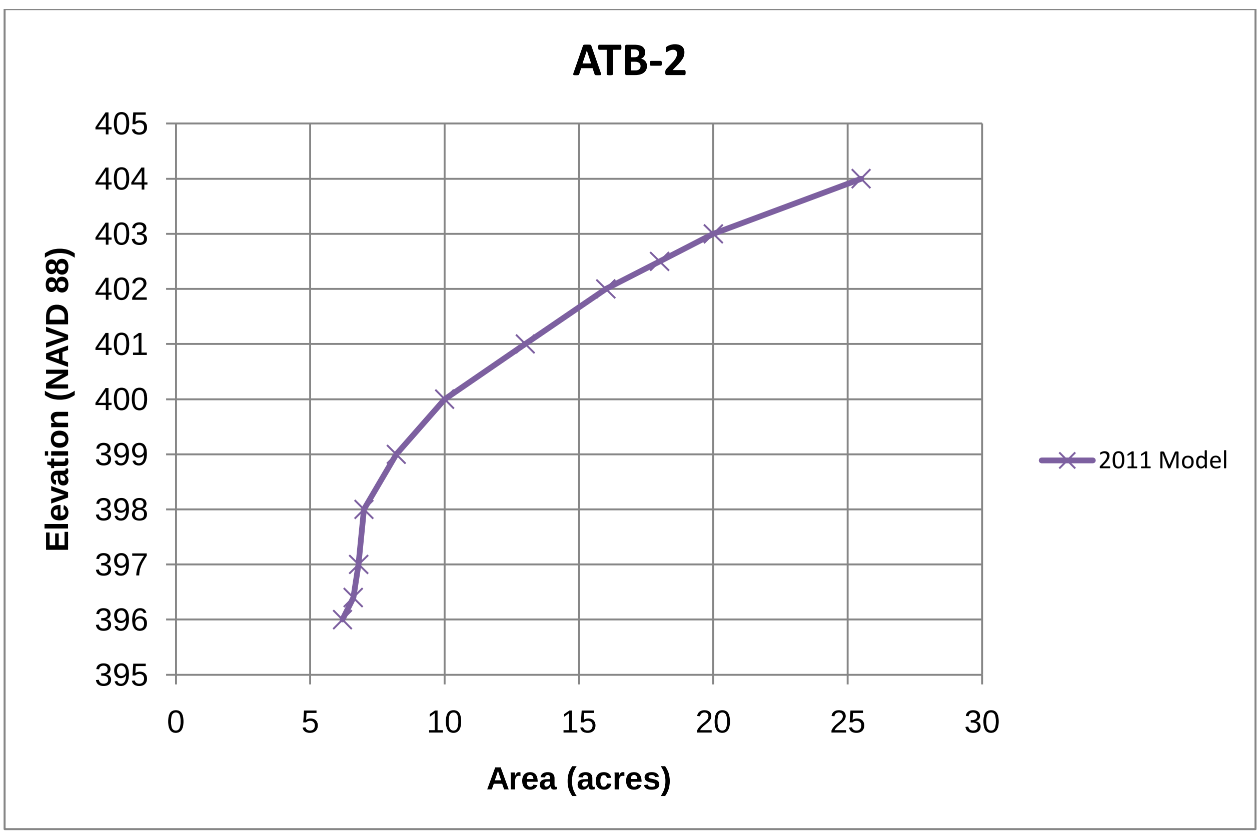


Figure A-2. HEC-HMS Elevation - Area Curve for ATB-2 (2011 Existing Condition).

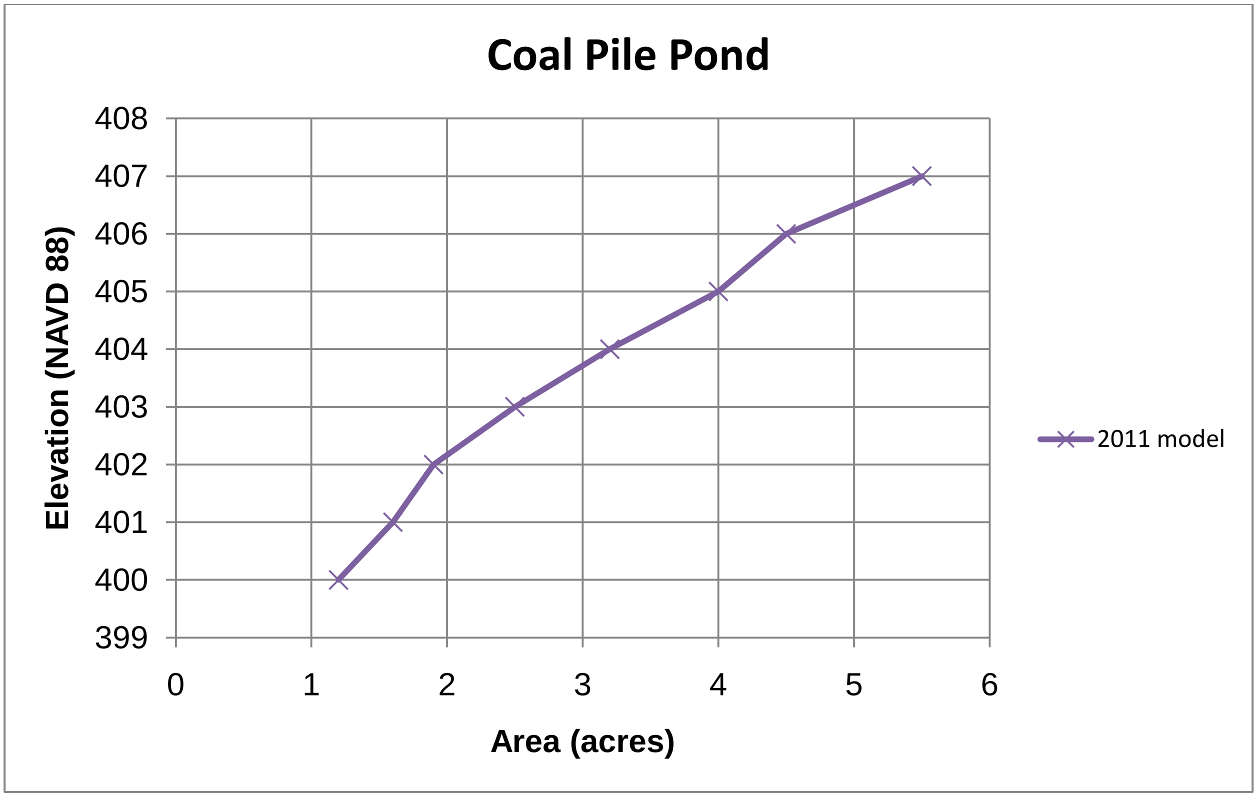


Figure A-3. HEC-HMS Elevation - Area Curve for Coal Pile Pond (2011 Existing Condition).

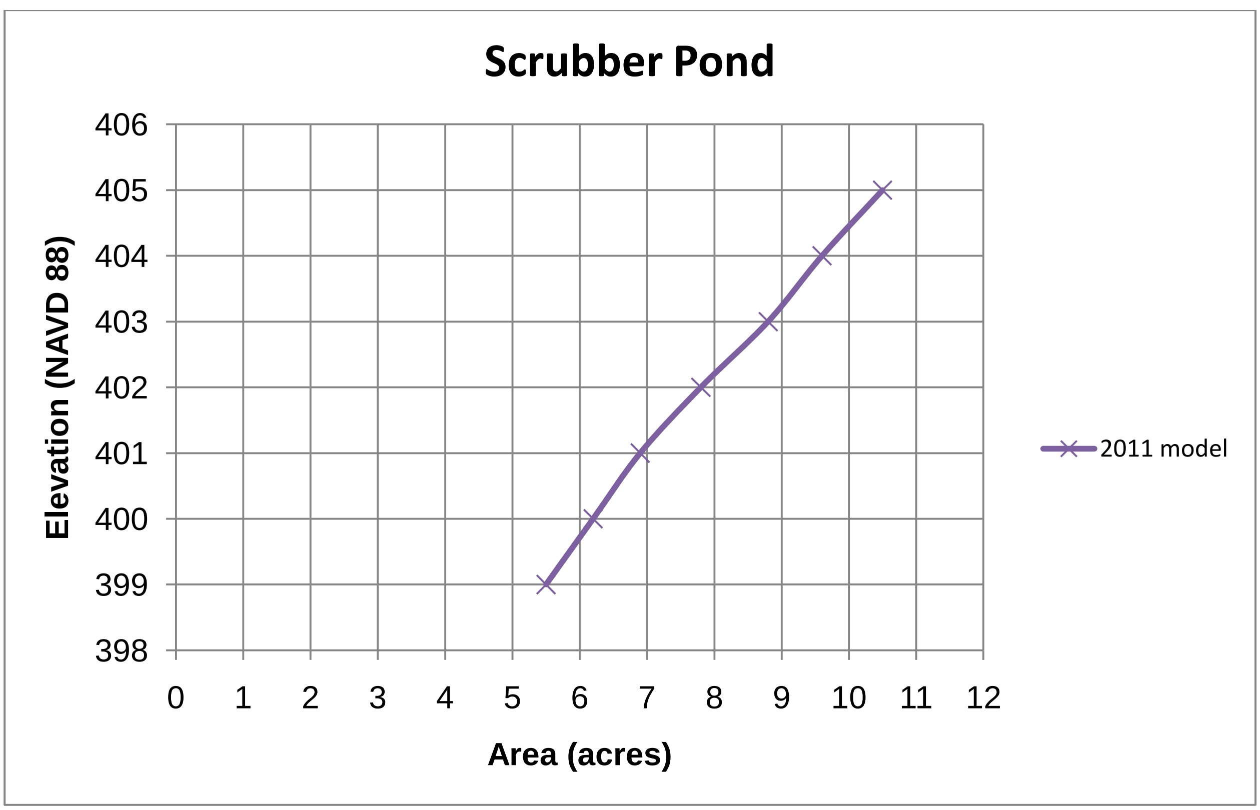


Figure A-4. HEC-HMS Elevation - Area Curve for Scrubber Pond (2011 Existing Condition).

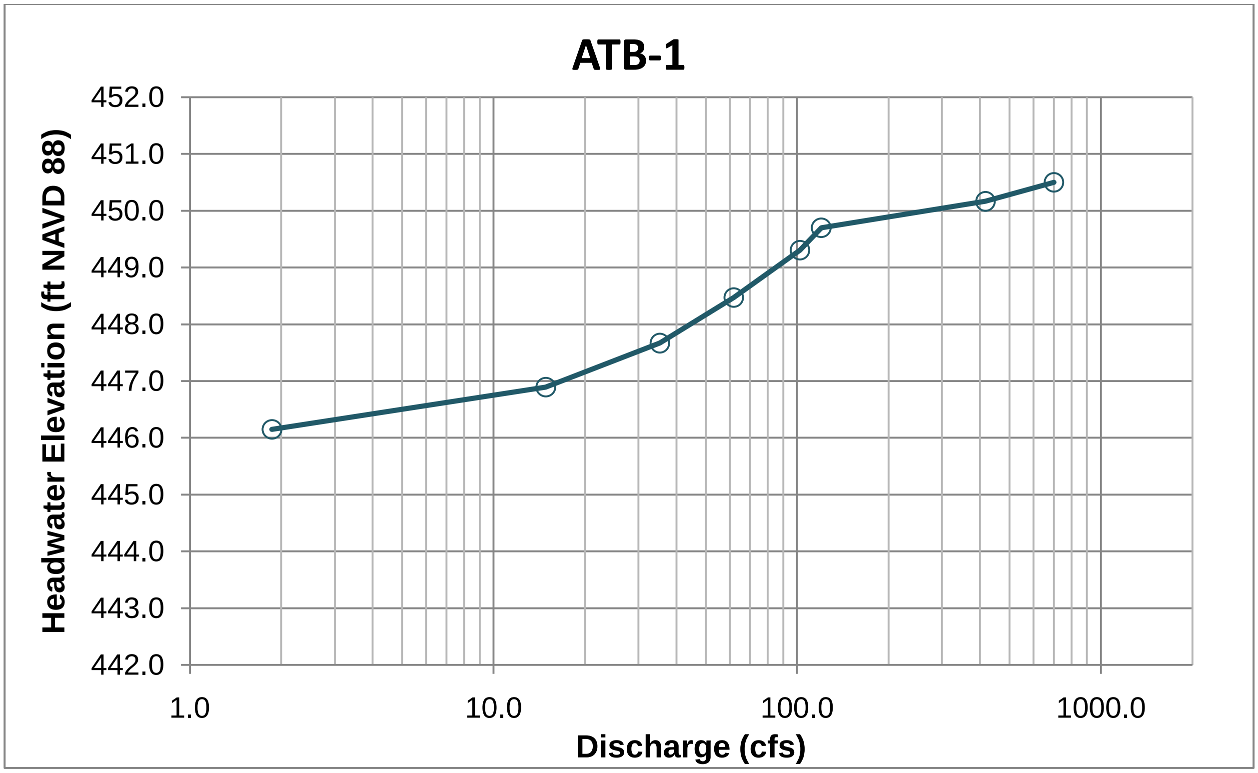


Figure A-5. HEC-HMS Discharge Rating Curve for ATB-1 (2011 Existing Condition).

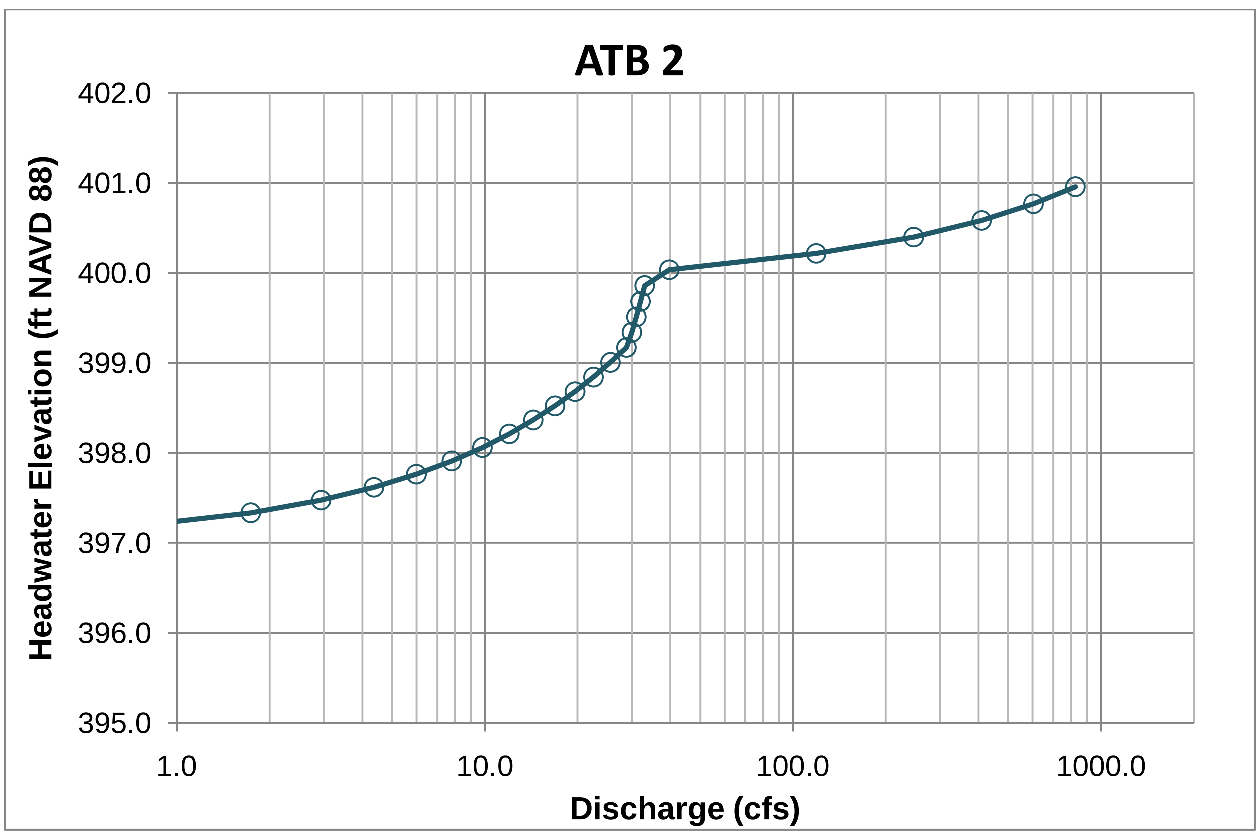


Figure A-6. HEC-HMS Discharge Rating Curve for ATB-2 (2011 Existing Condition).

Table A-1. Summary of Selected HEC-HMS Results for 2011 Existing Conditions

		100-yr, 6-hr		100-yr, 24-hr		100-yr, 48-hr		50-yr, 24-hr		KY Class A FDH, 24-hr		
Existing Conditions:												
Impound-ment	Dam Crest (ft)	Max WSEL (ft)	Free-board (ft)	Max WSEL (ft)	Free-board (ft)	Max WSEL (ft)	Free-board (ft)	Max WSEL (ft)	Free-board (ft)	Max WSEL (ft)	Free-board (ft)	Impound-ment
ATB 2	400.0	399.28	0.72	400.05	-0.05	400.14	-0.14	399.91	0.09	400.26	-0.26	ATB 2
ATB 1	449.4	447.00	2.40	447.52	1.88	447.54	1.86	447.36	2.04	448.04	1.36	ATB 1
SP	403.77	401.52	2.25	401.76	2.01	402.00	1.77	401.65	2.12	402.19	1.58	SP
CPP	405.0	402.80	2.20	403.26	1.74	403.58	1.42	403.04	1.96	404.08	0.92	CPP

Impound-ment	Initial WSEL (ft)	Max WSEL (ft)	Rise (ft)	Max WSEL (ft)	Rise (ft)	Max WSEL (ft)	Rise (ft)	Max WSEL (ft)	Rise (ft)	Max WSEL (ft)	Rise (ft)	Impound-ment
ATB 2	397.0	399.28	2.28	400.05	3.05	400.14	3.14	399.91	2.91	400.26	3.26	ATB 2
ATB 1	445.9	447.00	1.10	447.52	1.62	447.54	1.64	447.36	1.46	448.04	2.14	ATB 1
SP	401.0	401.52	0.52	401.76	0.76	402.00	1.00	401.65	0.65	402.19	1.19	SP
CPP	401.8	402.80	1.00	403.26	1.46	403.58	1.78	403.04	1.24	404.08	2.28	CPP

Existing Conditions:												
Impound-ment	Dam Crest (ft)	Max WSEL (ft)	Peak Q (cfs)	Max WSEL (ft)	Peak Q (cfs)	Max WSEL (ft)	Peak Q (cfs)	Max WSEL (ft)	Peak Q (cfs)	Max WSEL (ft)	Peak Q (cfs)	Impound-ment
ATB 2	400.0	399.28	29.6	400.05	46.10	400.14	85.7	399.91	34.9	400.26	150.0	ATB 2
ATB 1	449.4	447.00	17.8	447.52	31..3	447.54	32.0	447.36	27.1	448.04	47.6	ATB 1
SP	403.77	401.52	1.2	401.76	1.20	402.00	1.2	401.65	1.2	402.19	1.2	SP
CPP	405.0	402.80	8.1	403.26	9.20	403.58	9.9	403.04	8.7	404.08	10.9	CPP

Table A-2. Summary of Selected HEC-HMS Results for 2011 Alternative 1 Conditions

			100-yr, 48-hr			25-yr, 48-hr			10-yr, 48-hr			KY Cl. A ESD, 24-hr			KY Cl. A FDH, 24-hr		
Impound-ment	Dam Crest (ft)		Max WSEL (ft)	Free-board (ft)		Max WSEL (ft)	Free-board (ft)		Max WSEL (ft)	Free-board (ft)		Max WSEL (ft)	Free-board (ft)		Max WSEL (ft)	Free-board (ft)	Impound-ment
ATB 2	402.6		400.93	1.67								400.49	2.11		402.56	0.04	ATB 2
Impound-ment	Initial WSEL (ft)		Max WSEL (ft)	Rise (ft)		Max WSEL (ft)	Rise (ft)		Max WSEL (ft)	Rise (ft)		Max WSEL (ft)	Rise (ft)		Max WSEL (ft)	Rise (ft)	Impound-ment
ATB 2	397.0		400.93	3.93								400.49	3.49		402.56	5.56	ATB 2
Impound-ment	Dam Crest (ft)		Max WSEL (ft)	Peak Q (cfs)		Max WSEL (ft)	Peak Q (cfs)		Max WSEL (ft)	Peak Q (cfs)		Max WSEL (ft)	Peak Q (cfs)		Max WSEL (ft)	Peak Q (cfs)	Impound-ment
ATB 2	402.6		400.93	39.0								400.49	36.5		402.56	40.0	ATB 2

Table A-3. Summary of Selected HEC-HMS Results for 2011 Alternative 2 Conditions

		100-yr, 48-hr		25-yr, 48-hr		10-yr, 48-hr		KY Cl. A ESD, 24-hr		KY Cl. A FDH, 24-hr		
Impound-ment	Dam Crest (ft)	Max WSEL (ft)	Free-board (ft)	Max WSEL (ft)	Free-board (ft)	Max WSEL (ft)	Free-board (ft)	Max WSEL (ft)	Free-board (ft)	Max WSEL (ft)	Free-board (ft)	Impound-ment
ATB 2	400.0	399.45	0.55	399.35	0.65	399.22	0.78	399.36	0.64	399.56	0.44	ATB 2
Impound-ment	Initial WSEL (ft)	Max WSEL (ft)	Rise (ft)	Max WSEL (ft)	Rise (ft)	Max WSEL (ft)	Rise (ft)	Max WSEL (ft)	Rise (ft)	Max WSEL (ft)	Rise (ft)	Impound-ment
ATB 2	397.0	399.45	2.45	399.35	2.35	399.22	2.22	399.36	2.36	399.56	2.56	ATB 2
Impound-ment	Dam Crest (ft)	Max WSEL (ft)	Peak Q (cfs)	Max WSEL (ft)	Peak Q (cfs)	Max WSEL (ft)	Peak Q (cfs)	Max WSEL (ft)	Peak Q (cfs)	Max WSEL (ft)	Peak Q (cfs)	Impound-ment
ATB 2	400.0	399.45	185.0	399.35	98	399.22	46	399.36	110	399.56	298.0	ATB 2

Attachment 4

Addendum A – Final Geotechnical Report
Main Ash Pond Slope Stability Analysis and Repair, Kentucky Utilities
Green River Station

January 24, 2011
Associated Engineers, Inc.

ASSOCIATED ENGINEERS, INC.
ENGINEERS • GEOLOGISTS • SURVEYORS

January 24, 2011

Mr. David J. Millay, P.E.
LG& E-KU Services Company, Inc.
220 West Main Street
Louisville, Kentucky 40202

RE: Addendum A
Final Geotechnical Report
Main Ash Pond Slope Stability Analysis and Repair
KU Green River Station

Dear Mr. Millay:

This submittal is an addendum to our geotechnical report dated July 16, 2010, documenting slope stability analysis and repair for the Main Ash Pond at the Green River Station. The purpose of this addendum is to provide responses and clarifications to Section 4.2.2, *Geotechnical and Stability Recommendations* of the USEPA Dam Safety Assessment draft report issued by AMEC in September, 2010.

Below is a listing of AMEC's comments and recommendations, each followed by our response or clarification.

1. "In the opinion of the assessing professional engineer, the criteria for minimum safety factors should be in accordance with USACE EM 1110-2-1902 with a minimum seismic safety factor of 1.2..."

   AEI Response: The Main Ash Pond is under the jurisdiction of the Kentucky Department for Environmental Protection (KYDEP) which specifies a minimum seismic safety factor of 1.0 with the reservoir at the normal pool. However, the attached stability analyses confirm seismic factors exceeding 1.2.

2. "The repair stability adjusts the friction and phi angle for the material above the ground surface from elevation 385 feet to 393 feet. However, the report notes the slide extending down to approximate elevation 400 feet. From elevation 393 feet to 402 feet a fly ash and clay material was encountered. On the boring log for P-1, this material within the embankment is described as wet.... It is assumed that the lowering of the parameters in the layer above the bedrock by "backing in" to a safety factor of less than 1 and then designing a repair with a safety factor over 1.5 will compensate for the failure and that the repair will provide adequate stability.

AEI Response: As discussed in Section 5.0 of the AEI report, the data indicated that the area of failure was restricted to the dam fill material and did not extend significantly into the original ground below the dam. It was stated that the maximum depth of the slip surface was approximately 11 feet. This point was on the dam slope above the toe of the slide. Since only the dam fill material was impacted, this was the only material for which strength parameters were adjusted. As shown on Section A-A' (Attached), the base of the fill (original ground surface) ranged from approximately 403.5 feet to 404.5 in the area of the slope failure.

3. "A review of the slopes used for the downstream embankment indicated about a 2.7H:1V was used in the analyses. The design slope for the downstream embankment is 2.5H:1V. During the site visit, this area was noted for possible uneven and over-steepened slopes. A survey should be performed at the cross-section to determine the actual configuration of the existing slope."

   AEI Response: A field survey conducted on 1/19/11 verified that the slope used in the model was representative of the actual configuration.

4. "In addition, the minimum depth of slice used in the program was 10 feet. The analysis should be performed with a 5 feet minimum depth of slice to identify shallow failure surfaces."

   AEI Response: The minimum depth of slice of 10 feet was used only in the "back-in" analysis to generate a failure surface duplicating the actual failure surface determined from site investigation.

5. "The analysis should consider all critical stages over the life of the pond including pond full conditions. These conditions would need to be determined in conjunction with the hydraulic
   recommendations above. "

   AEI Response: KYDEP does not specify a minimum safety factor for the pond full condition. However, we have provided analyses for a "worst case" condition assuming a water surface elevation of 449.5 feet and an elevated phreatic surface within the dam significantly higher than indicated from piezometer data. The lowest safety factor generated was 1.416 at section A-A'. This exceeds the minimum safety factor of 1.4 recommended in the U.S. Army Corps of Engineers Engineering Manual (EM) 1110-2-1902. It is emphasized that we do not recommend operation at this level.

6. "The hydraulic analysis should provide a phreatic surface through the embankment."

   AEI Response: All of the analyses performed included a phreatic surface through the embankment. The surface was shown in the REAME sections and output files but was not included on the drawings. The new/revised analyses attached are also modeled with a phreatic surface through the embankment and drawings have been revised and/or added as necessary to indicate the phreatic surface.

7. "A rapid-drawdown should be performed for the A-A' section in case the pond would need to be lowered in response to a problem."

   AEI Response: Rapid-drawdown analysis for A-A' is attached. The resulting safety factor of 1.375 exceeds the minimum value of 1.2 required by KYDEP. For the analysis, the inboard part of the section was revised from the original to more completely delineate the ground surface and extend a greater distance away from the dam crest. As a "worst case" condition, the highest elevation of the phreatic surface was assumed to be at 449.5 and the level within the dam modeled significantly higher than indicated from piezometer data.

8. "The friction angle use for the CCW in the analysis appears to be high for ash material."

   AEI Response: Our research has found values for sluiced ash to range from 24 degrees to over 37 degrees with most reported between 30 and 32 degrees. In our opinion, the value of 26 degrees used for analysis is conservative and appropriate based on the conditions disclosed by our investigation.

9. "Consideration should also be given to allow water levels in the piezometers to develop and stabilize."

   Stabilization time for piezometer levels was considered in modeling the phreatic surface. Based on piezometer data available since our report was submitted, we have revised the long term steady seepage analyses to slightly raise the phreatic surface to represent what is, in our opinion, a "worst case" condition. The resulting safety factors exceed the KYDEP long term steady seepage requirement of 1.5 and USACE seismic requirement of 1.2. As discussed above, the pond full condition has also been modeled as a "worst case" assuming a water surface elevation of 449.5 and an elevated phreatic surface within the dam significantly higher than indicated from piezometer data.

10. "The analyses presented appear limited to a circular surface; different types of failure surfaces should be analyzed and optimized."

    AEI Response: In our opinion, circular surface failure is the accepted industry standard and appropriate for the conditions present at this site.

We trust the above information sufficiently addresses AMEC's recommendations as related to our geotechnical report documenting slope stability analysis and repair for the Main Ash Pond at the Green River Station. Please contact us if have any questions or require any additional information.

Sincerely,

ASSOCIATED ENGINEERS, INC.

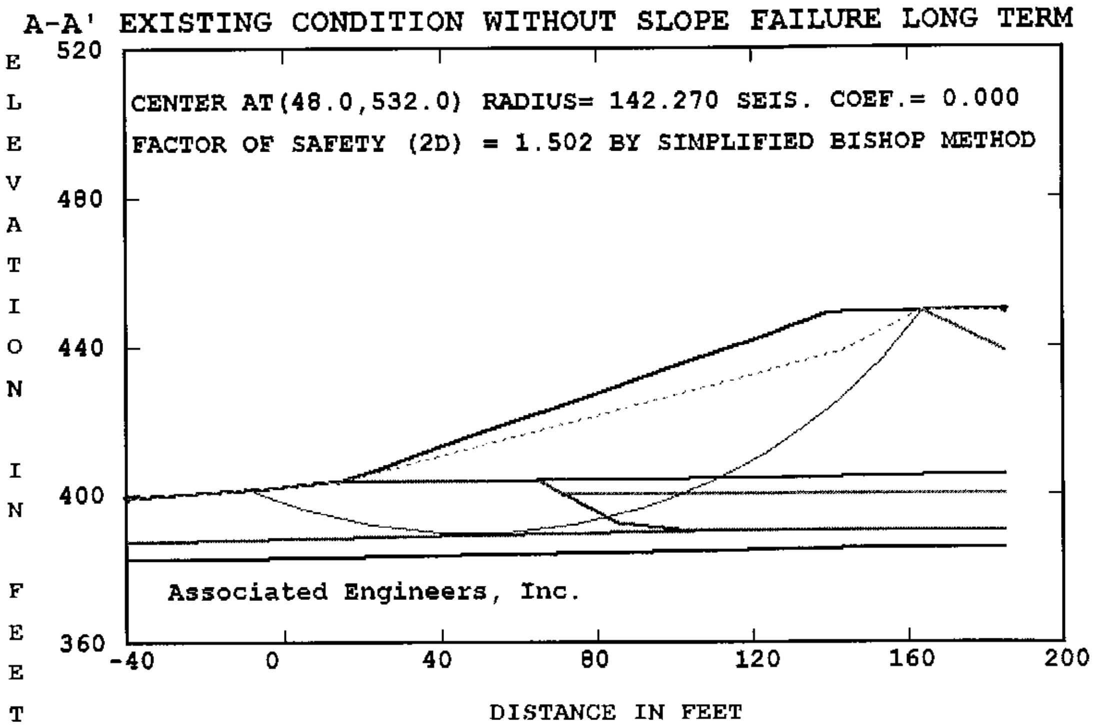
David A. Lamb, P.E.
President

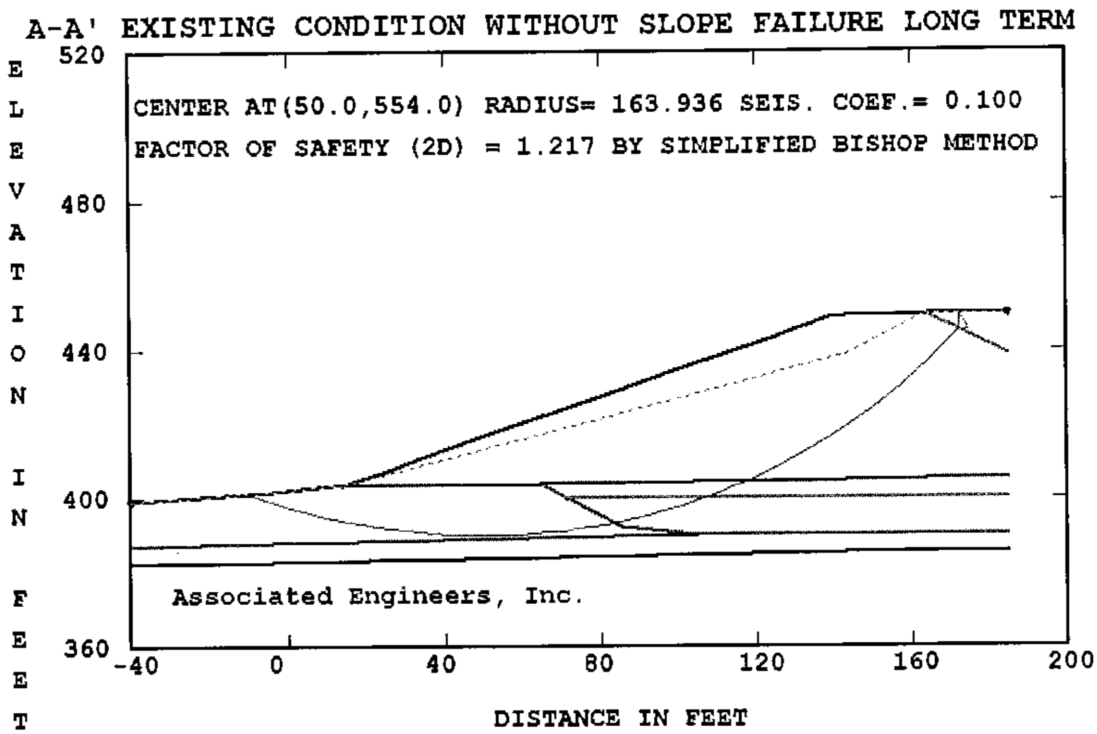
G. Douglas Dunbar, P.G.
Senior Geologist

Stability Analyses

SUMMARY OF SLOPE STABILITY ANALYSES - MAIN ASH POND, GREEN RIVER STATION

Location	Analysis	Sheet	Factor of Safety	Required Factor of Safety	Seismic Factor of Safety	Required Factor of Safety
A - A'	Existing Condition (Without Slope Failure) Long Term Steady Seepage	6	1.502	1.5	1.217	1.2
	Existing Condition (Without Slope Failure) Pond Full	7	1.416	1.4		
	25 FT. Rock Bench Long Term Steady Seepage	2	1.545	1.5	1.228	1.2
	25 FT. Rock Bench Pond Full	5	1.545	1.4		
	Rapid Drawdown	8	1.375	1.2		
	"Back In" Analysis	6	0.926			
B-B'	Long Term Steady Seepage	3	1.576	1.5	1.255	1.2
	Pond Full	4	1.459	1.4		


A-A' EXISTING CONDITION WITHOUT SLOPE FAILURE LONG TERM
CENTER AT(48.0,532.0) RADIUS= 142.270 SEIS. COEF.= 0.000
FACTOR OF SAFETY (2D) = 1.502 BY SIMPLIFIED BISHOP METHOD
ELEVATION IN FEET
520
480
440
400
360
-40
0
40
80
120
160
200
DISTANCE IN FEET
Associated Engineers, Inc.


A-A' EXISTING CONDITION WITHOUT SLOPE FAILURE LONG TERM
CENTER AT(50.0,554.0) RADIUS= 163.936 SEIS. COEF.= 0.100
FACTOR OF SAFETY (2D) = 1.217 BY SIMPLIFIED BISHOP METHOD
Associated Engineers, Inc.
ELEVATION IN FEET
520
480
440
400
360
-40
0
40
80
120
160
200
DISTANCE IN FEET

```
REAME (ROTATIONAL EQUILIBRIUM ANALYSIS OF MULTILAYERED EARTHWORKS)
THIS 2008 VERSION IS LICENSED BY CIVIL ENGINEERING SOFTWARE CENTER TO


INPUT FILE NAME  -C:\REAME2008\EON1ALT.DAT

TITLE -A-A' EXISTING CONDITION WITHOUT SLOPE FAILURE LONG TERM

NO. OF STATIC AND SEISMIC CASES (NCASE) = 2

NO. OF NONCIRCULAR FAILURE SURFACES (NNS) = 0

TWO-DIMENSIONAL ANALYSIS ( THREED = 0 )

ANALYSIS BY DETERMINISTIC METHOD   ( PROB = 0 )


CASE NO.  1   SEISMIC COEFFICIENT (SEIC) =0.000

NO. OF BOUNDARY LINES (NBL) = 7

NO. OF POINTS ON BOUNDARY LINE 1 = 4
 1  X COORD.=-40            Y COORD.= 382.6
 2  X COORD.=-4             Y COORD.= 383.1
 3  X COORD.= 142.9         Y COORD.= 385.4
 4  X COORD.= 185           Y COORD.= 386

NO. OF POINTS ON BOUNDARY LINE 2 = 3
 1  X COORD.=-40            Y COORD.= 387.4
 2  X COORD.=-4             Y COORD.= 388.2
 3  X COORD.= 104.7         Y COORD.= 390.4

NO. OF POINTS ON BOUNDARY LINE 3 = 5
 1  X COORD.= 71.5          Y COORD.= 400.2
 2  X COORD.= 85.2          Y COORD.= 392.3
 3  X COORD.= 104.7         Y COORD.= 390.4
 4  X COORD.= 142.9         Y COORD.= 390.4
 5  X COORD.= 185           Y COORD.= 390.4

NO. OF POINTS ON BOUNDARY LINE 4 = 4
 1  X COORD.= 64.6          Y COORD.= 404.2
 2  X COORD.= 71.5          Y COORD.= 400.2
 3  X COORD.= 142.9         Y COORD.= 400.2
 4  X COORD.= 185           Y COORD.= 400.2

NO. OF POINTS ON BOUNDARY LINE 5 = 4
 1  X COORD.= 13.9          Y COORD.= 403.6
 2  X COORD.= 64.6          Y COORD.= 404.2
 3  X COORD.= 142.9         Y COORD.= 404.9
 4  X COORD.= 185           Y COORD.= 405.6

NO. OF POINTS ON BOUNDARY LINE 6 = 2
 1  X COORD.= 163.9         Y COORD.= 449.5
 2  X COORD.= 185           Y COORD.= 438.5
```

```
NO. OF POINTS ON BOUNDARY LINE 7 = 14
 1  X COORD.=-40            Y COORD.= 399.4
 2  X COORD.=-4             Y COORD.= 402.1
 3  X COORD.= 11            Y COORD.= 403.6
 4  X COORD.= 13.9          Y COORD.= 403.6
 5  X COORD.= 25.2          Y COORD.= 407.7
 6  X COORD.= 33.8          Y COORD.= 411
 7  X COORD.= 49.2          Y COORD.= 416.6
 8  X COORD.= 81.1          Y COORD.= 427.6
 9  X COORD.= 101.3         Y COORD.= 435
 10 X COORD.= 121.3         Y COORD.= 442
 11 X COORD.= 138.9         Y COORD.= 448.5
 12 X COORD.= 142.9         Y COORD.= 448.9
 13 X COORD.= 163.9         Y COORD.= 449.5
 14 X COORD.= 185           Y COORD.= 449.5

LINE NO. AND SLOPE OF EACH SEGMENT ARE:
 1       0.014       0.016       0.014
 2       0.022       0.020
 3      -0.577      -0.097       0.000       0.000
 4      -0.580       0.000       0.000
 5       0.012       0.009       0.017
 6      -0.521
 7       0.075       0.100       0.000       0.363       0.384       0.364
         0.345       0.366       0.350       0.369       0.100       0.029
         0.000

MIN. DEPTH OF TALLEST SLICE (DMIN) = 0
NO. OF RADIUS CONTROL ZONES (NRCZ) = 1

RADIUS DECREMENT (RDEC) FOR ZONE 1 = 0
NO. OF CIRCLES (NCIR) FOR ZONE 1 = 5
NO. OF BOTTOM LINES (NOL) FOR ZONE 1 = 1
LINE NO. (LINO)  BEG. NO. (NBP)  END NO. (NEP)
      1                1              4

ENGLISH UNITS ARE USED WITH DISTANCE IN FEET AND FORCE IN POUND.

SOIL  ENVELOPE COHESION    FRIC. ANGLE     UNIT WEIGHTT
 No.   (TSSE)     (C)         (PHID)           (G)
  1       1     195.000       33.600        130.000
  2       1     250.000       28.000        130.000
  3       1       0.000       26.000        110.000
  4       1     359.000       30.200        133.000
  5       1     289.000       27.900        138.000
  6       1       0.000        0.000         62.400

USE PHREATIC SURFACE
USE GRID
NO. OF SLICES (NSLI) = 10
NO. OF ADD. CIRCLES (NAC) = 3
ANALYSIS BY SIMPLIFIED BISHOP METHOD (MTHD=2)
NUMBER OF FORCES (NFO)= 0
SOFT SOIL NUMBER (SSN)= 0

NO. OF POINTS ON WATER TABLE (NPWT) = 7
 1  X COORD.=-40            Y COORD.= 399.4
```

```
 2  X COORD.=-4              Y COORD.= 402.1
 3  X COORD.= 11             Y COORD.= 403.6
 4  X COORD.= 13.9           Y COORD.= 403.6
 5  X COORD.= 142.9          Y COORD.= 438.42
 6  X COORD.= 163.9          Y COORD.= 449.5
 7  X COORD.= 185            Y COORD.= 449.5
```

NO. OF SOILS WITH DIFFERENT WATER TABLE (NSDW) = 0
NO. OF SOILS WITH DIFFERENT PORE PRESSURE RATIO (NSDP) = 0

INPUT COORD. OF GRID POINTS 1,2,AND 3

```
POINT 1 X COORD. = 0      Y COORD. = 540
POINT 2 X COORD. = 0      Y COORD. = 440
POINT 3 X COORD. = 80     Y COORD. = 440
```

X INCREMENT (XINC) = 8   Y INCREMENT (YINC) = 8
NO. OF DIVISIONS BETWEEN POINTS 1 AND 2 (ND12) = 5
NO. OF DIVISIONS BETWEEN POINTS 2 AND 3 (ND23) = 4
ONLY A SUMMARY TABLE IS PRINTED (NPRT = 0)
SLICES WILL BE SUBDIVIDED

AUTOMATIC SEARCH WILL FOLLOW AFTER GRID

FACTORS OF SAFETY BASED ON GRID

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X COORDINATE	CENTER Y COORDINATE	NO. OF CIRCLE TOTAL	CRITIC.	RADIUS	LOWEST F.S.	WARNING
0.0	540.0	5	1	146.179	2.184	1
0.0	520.0	5	1	127.061	2.283	1
0.0	500.0	5	1	108.261	2.398	1
0.0	480.0	5	1	89.980	2.548	1
0.0	460.0	5	1	72.611	2.844	1
0.0	440.0	5	1	56.830	3.424	0
20.0	540.0	11	7	150.198	1.678	1
20.0	520.0	11	8	130.586	1.742	1
20.0	500.0	11	2	110.881	1.791	0
20.0	480.0	11	2	91.122	1.881	0
20.0	460.0	11	9	70.078	1.985	0
20.0	440.0	11	7	49.168	2.195	0
40.0	540.0	11	8	150.712	1.517	0
40.0	520.0	11	8	130.878	1.534	0
40.0	500.0	11	2	109.326	1.584	0
40.0	480.0	11	2	89.547	1.661	0
40.0	460.0	11	2	69.767	1.765	0
40.0	440.0	11	2	49.990	1.967	0
60.0	540.0	11	7	150.170	1.529	1
60.0	520.0	11	8	129.602	1.517	0
60.0	500.0	11	8	109.787	1.538	0
60.0	480.0	11	8	89.966	1.609	0
60.0	460.0	11	8	70.132	1.776	0
60.0	440.0	11	8	50.298	2.111	0
80.0	540.0	11	7	135.371	1.902	1
80.0	520.0	5	1	126.472	1.684	1

80.0	500.0	11	8	108.493	1.681	0
80.0	480.0	11	8	88.674	1.734	0
80.0	460.0	11	8	68.859	1.925	0
80.0	440.0	11	8	49.045	2.432	0

LOWEST FACTOR OF SAFETY AT EACH GRID POINT IS TABULATED BELOW

COORDINATE	0.000	20.000	40.000	60.000	80.000
540.000	2.184	1.678	1.517	1.529	1.902
520.000	2.283	1.742	1.534	1.517	1.684
500.000	2.398	1.791	1.584	1.538	1.681
480.000	2.548	1.881	1.661	1.609	1.734
460.000	2.844	1.985	1.765	1.776	1.925
440.000	3.424	2.195	1.967	2.111	2.432

MINIMUM FACTORS OF SAFETY OCCUR AT THE FOLLOWING 2 CENTERS

FACTOR OF SAFETY = 1.517 AT (40.000,540.000)
FACTOR OF SAFETY = 1.517 AT (60.000,520.000)

AUTOMATIC SEARCH WILL BE MADE ONLY ON THE CENTER WITH THE SMALLEST F.S.

AT POINT (60.0 , 520.0) RADIUS 129.602
THE MINIMUM FACTOR OF SAFETY IS 1.517

FACTORS OF SAFETY BASED ON SEARCH

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE
MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X	CENTER Y	NO. OF CIRCLE			LOWEST	WARNING
COORDINATE	COORDINATE	TOTAL	CRITIC.	RADIUS	F.S.	
60.0	520.0	11	8	129.602	1.517	0
68.0	520.0	11	8	129.083	1.559	0
52.0	520.0	11	8	130.121	1.508	0
44.0	520.0	11	8	130.629	1.519	0
52.0	528.0	11	8	138.047	1.505	0
52.0	536.0	11	8	145.973	1.506	0
60.0	528.0	11	8	137.528	1.518	0
44.0	528.0	11	8	138.563	1.510	0
54.0	528.0	11	8	137.917	1.507	0
50.0	528.0	11	8	138.177	1.503	0
48.0	528.0	11	8	138.307	1.504	0
50.0	530.0	11	8	140.159	1.503	0
50.0	532.0	11	8	142.140	1.503	0
50.0	534.0	11	8	144.122	1.503	0
52.0	532.0	11	8	142.010	1.505	0
48.0	532.0	11	8	142.270	1.502	0
46.0	532.0	11	8	142.400	1.504	0
48.0	534.0	11	8	144.251	1.502	0
48.0	530.0	11	8	140.288	1.503	0

AT POINT (48.0 , 532.0) RADIUS 142.270

THE MINIMUM FACTOR OF SAFETY IS 1.502

SUMMARY OF SLICE INFORMATION FOR MOST CRITICAL FAILURE SURFACE

SL. NO.	SOIL NO.	SLICE WIDTH	SLICE HEIGHT	WATER HEIGHT	BOTTOM SINE	TOTAL WEIGHT	EFFEC. WEIGHT	RESIS. MOMENT	DRIVING MOMENT
1	2	5.150	1.293	1.293	-.384	.866E+03	.450E+03	.230E+06	-.472E+05
2	2	12.155	5.362	5.362	-.323	.847E+04	.441E+04	.772E+06	-.389E+06
3	2	2.845	8.441	8.441	-.270	.312E+04	.162E+04	.223E+06	-.120E+06
4	2	2.900	9.357	9.357	-.250	.353E+04	.183E+04	.241E+06	-.125E+06
5	2	11.300	13.046	12.521	-.200	.193E+05	.105E+05	.119E+07	-.550E+06
6	2	0.261	16.202	15.137	-.159	.557E+03	.311E+03	.326E+05	-.126E+05
7	2	8.339	18.479	16.925	-.129	.204E+05	.116E+05	.117E+07	-.375E+06
8	2	8.966	22.568	20.119	-.068	.269E+05	.157E+05	.150E+07	-.262E+06
9	2	6.434	25.686	22.515	-.014	.221E+05	.130E+05	.121E+07	-.445E+05
10	2	10.872	28.589	24.710	.047	.417E+05	.249E+05	.227E+07	.276E+06
11	2	17.306	32.085	27.151	.146	.750E+05	.456E+05	.404E+07	.155E+07
12	2	3.723	33.756	28.034	.220	.167E+05	.102E+05	.889E+06	.522E+06
13	2	1.255	34.044	28.122	.237	.566E+04	.346E+04	.300E+06	.191E+06
14	3	12.328	34.696	28.119	.285	.572E+05	.356E+05	.236E+07	.232E+07
15	3	6.617	34.985	27.496	.351	.315E+05	.202E+05	.131E+07	.158E+07
16	3	0.267	34.901	27.082	.376	.128E+04	.829E+03	.533E+05	.685E+05
17	4	9.793	34.510	26.287	.411	.465E+05	.305E+05	.285E+07	.272E+07
18	5	0.628	33.856	25.217	.448	.294E+04	.195E+04	.160E+06	.187E+06
19	5	9.312	32.985	23.947	.482	.424E+05	.285E+05	.232E+07	.291E+07
20	5	7.994	30.916	21.108	.543	.341E+05	.236E+05	.188E+07	.264E+07
21	5	9.606	27.987	17.305	.605	.371E+05	.267E+05	.210E+07	.319E+07
22	5	4.000	24.451	13.631	.653	.135E+05	.101E+05	.793E+06	.125E+07
23	5	3.700	21.261	11.704	.680	.109E+05	.815E+04	.658E+06	.105E+07
24	5	17.306	10.728	6.413	.754	.256E+05	.187E+05	.201E+07	.275E+07
							SUM	.306E+08	.213E+08

AT CENTER (48.000 , 532.000) WITH RADIUS 142.270 AND SEIS. COEFF. 0.00
FACTOR OF SAFETY BY NORMAL METHOD IS 1.436
FACTOR OF SAFETY BY SIMPLIFIED BISHOP METHOD IS 1.502

CASE NO. 2 SEISMIC COEFFICIENT (SEIC) =0.100

AUTOMATIC SEARCH WILL FOLLOW AFTER GRID

FACTORS OF SAFETY BASED ON GRID

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE
MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X COORDINATE	CENTER Y COORDINATE	NO. OF CIRCLE TOTAL	CRITIC.	RADIUS	LOWEST F.S.	WARNING
0.0	540.0	5	1	146.179	1.885	1
0.0	520.0	5	1	127.061	1.965	1
0.0	500.0	5	1	108.261	2.022	1
0.0	480.0	5	1	89.980	2.056	1
0.0	460.0	11	7	71.071	2.211	1
0.0	440.0	5	1	56.830	2.686	0
20.0	540.0	11	7	150.198	1.356	1
20.0	520.0	11	8	130.586	1.411	1
20.0	500.0	11	2	110.881	1.447	0
20.0	480.0	11	9	89.775	1.530	0
20.0	460.0	11	6	70.078	1.654	0
20.0	440.0	11	3	46.718	1.811	0

40.0	540.0	11	8	150.712	1.236	0
40.0	520.0	11	8	130.878	1.258	0
40.0	500.0	11	2	109.326	1.317	0
40.0	480.0	11	2	89.547	1.377	0
40.0	460.0	11	2	69.767	1.455	0
40.0	440.0	11	2	49.990	1.664	0
60.0	540.0	11	7	150.170	1.229	1
60.0	520.0	11	2	127.509	1.239	0
60.0	500.0	11	8	109.787	1.270	0
60.0	480.0	11	8	89.966	1.333	0
60.0	460.0	11	8	70.132	1.493	0
60.0	440.0	11	8	50.298	1.796	0
80.0	540.0	11	2	132.124	1.472	1
80.0	520.0	11	1	126.472	1.420	1
80.0	500.0	11	2	106.134	1.375	0
80.0	480.0	11	2	86.375	1.430	0
80.0	460.0	17	2	66.621	1.610	0
80.0	440.0	17	8	49.045	2.085	0

GRID IS EXPANDED AS FOLLOWS SO MINIMUM FACTOR OF SAFETY FALLS WITHIN THE GRID

0.0	560.0	11	6	164.811	1.719	1
20.0	560.0	11	2	166.171	1.355	1
40.0	560.0	11	8	170.530	1.229	0
60.0	560.0	5	1	166.839	1.309	1
80.0	560.0	5	1	152.431	1.567	1
0.0	580.0	11	6	184.253	1.668	1
20.0	580.0	11	7	187.675	1.353	1
40.0	580.0	11	8	189.402	1.236	1
60.0	580.0	11	2	174.667	1.370	1
80.0	580.0	5	1	167.497	1.654	1

LOWEST FACTOR OF SAFETY AT EACH GRID POINT IS TABULATED BELOW

COORDINATE	0.000	20.000	40.000	60.000	80.000
580.000	1.668	1.353	1.236	1.370	1.654
560.000	1.719	1.355	1.229	1.309	1.567
540.000	1.885	1.356	1.236	1.229	1.472
520.000	1.965	1.411	1.258	1.239	1.420
500.000	2.022	1.447	1.317	1.270	1.375
480.000	2.056	1.530	1.377	1.333	1.430
460.000	2.211	1.654	1.455	1.493	1.610
440.000	2.686	1.811	1.664	1.796	2.085

MINIMUM FACTORS OF SAFETY OCCUR AT THE FOLLOWING 2 CENTERS

FACTOR OF SAFETY = 1.229 AT (40.000,560.000)
FACTOR OF SAFETY = 1.229 AT (60.000,540.000)

AUTOMATIC SEARCH WILL BE MADE ONLY ON THE CENTER WITH THE SMALLEST F.S.

AT POINT (40.0 , 560.0) RADIUS 170.530
THE MINIMUM FACTOR OF SAFETY IS 1.229

FACTORS OF SAFETY BASED ON SEARCH

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE

MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X COORDINATE	CENTER Y COORDINATE	NO. OF CIRCLE TOTAL	CRITIC.	RADIUS	LOWEST F.S.	WARNING
40.0	560.0	11	8	170.530	1.229	0
48.0	560.0	11	8	169.964	1.225	1
56.0	560.0	11	7	166.166	1.281	1
48.0	568.0	11	7	177.347	1.230	1
48.0	552.0	11	8	162.085	1.223	0
48.0	544.0	11	8	154.159	1.223	0
56.0	552.0	11	7	160.832	1.224	1
40.0	552.0	11	8	162.604	1.225	0
50.0	552.0	11	8	161.955	1.221	0
52.0	552.0	11	2	159.695	1.222	1
50.0	554.0	11	8	163.936	1.217	0
50.0	556.0	11	8	165.848	1.222	1
52.0	554.0	11	2	161.054	1.225	1
48.0	554.0	11	8	164.066	1.223	0

AT POINT (50.0 , 554.0) RADIUS 163.936

THE MINIMUM FACTOR OF SAFETY IS 1.217

SUMMARY OF SLICE INFORMATION FOR MOST CRITICAL FAILURE SURFACE

SL. NO.	SOIL NO.	SLICE WIDTH	SLICE HEIGHT	WATER HEIGHT	BOTTOM SINE	TOTAL WEIGHT	EFFEC. WEIGHT	RESIS. MOMENT	DRIVING MOMENT
1	2	6.451	1.482	1.482	-.349	.124E+04	.646E+03	.337E+06	-.126E+06
2	2	11.842	5.420	5.420	-.293	.834E+04	.434E+04	.880E+06	-.457E+06
3	2	3.158	8.277	8.277	-.248	.340E+04	.177E+04	.287E+06	-.147E+06
4	2	2.900	9.178	9.178	-.229	.346E+04	.180E+04	.278E+06	-.141E+06
5	2	11.300	12.734	12.209	-.186	.189E+05	.103E+05	.137E+07	-.572E+06
6	2	0.935	16.000	14.897	-.148	.198E+04	.111E+04	.136E+06	-.434E+05
7	2	7.665	18.237	16.645	-.122	.185E+05	.106E+05	.124E+07	-.312E+06
8	2	10.627	22.507	19.980	-.066	.319E+05	.186E+05	.207E+07	-.204E+06
9	2	4.773	25.638	22.389	-.019	.164E+05	.969E+04	.104E+07	.346E+05
10	2	13.520	28.759	24.781	.036	.522E+05	.312E+05	.327E+07	.624E+06
11	2	18.293	32.887	27.718	.133	.813E+05	.497E+05	.499E+07	.233E+07
12	2	2.178	34.729	28.772	.196	.100E+05	.609E+04	.602E+06	.389E+06
13	3	16.115	35.980	29.140	.252	.775E+05	.482E+05	.363E+07	.375E+07
14	3	1.995	36.663	28.950	.307	.992E+04	.632E+04	.465E+06	.572E+06
15	3	5.451	36.732	28.705	.330	.274E+05	.176E+05	.128E+07	.167E+07
16	4	10.847	36.495	27.815	.379	.545E+05	.357E+05	.371E+07	.378E+07
17	5	3.702	35.851	26.589	.424	.183E+05	.122E+05	.111E+07	.143E+07
18	5	14.591	34.562	24.426	.479	.696E+05	.474E+05	.420E+07	.606E+07
19	5	3.009	32.642	21.632	.533	.136E+05	.949E+04	.822E+06	.130E+07
20	5	4.000	31.127	20.307	.554	.172E+05	.121E+05	.104E+07	.171E+07
21	5	11.284	26.075	18.411	.601	.406E+05	.276E+05	.244E+07	.433E+07
22	5	9.716	17.774	15.350	.665	.238E+05	.145E+05	.147E+07	.277E+07
23	5	8.576	9.108	9.108	.721	.933E+04	.446E+04	.826E+06	.124E+07
							SUM	.375E+08	.300E+08

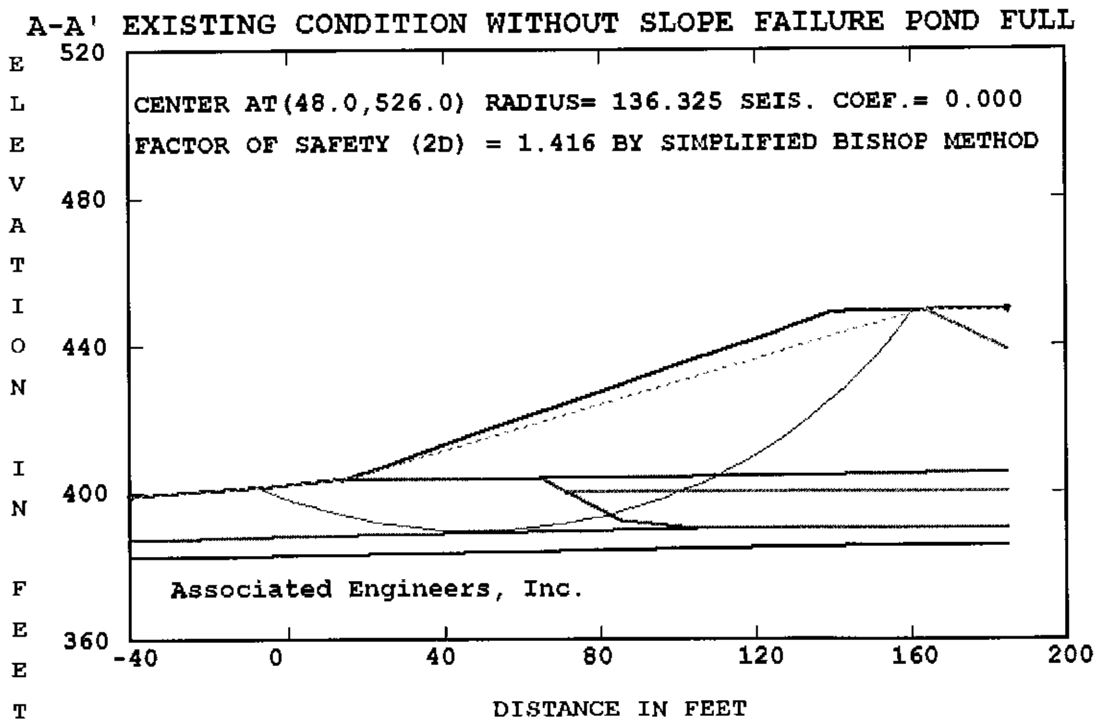
AT CENTER (50.000 , 554.000) WITH RADIUS 163.936 AND SEIS. COEFF. 0.10
FACTOR OF SAFETY BY NORMAL METHOD IS 1.250
FACTOR OF SAFETY BY SIMPLIFIED BISHOP METHOD IS 1.300

SUMMARY OF STABILITY ANALYSIS

FACTOR OF FAFETY IS DETERMINED BY SIMPLIFIED BISHOP METHOD
NUMBER OF CASES = 2

CASE 1 SEISMIC COEFFICIENT = 0
FACTOR OF SAFETY = 1.502

CASE 2 SEISMIC COEFFICIENT = 0.1
FACTOR OF SAFETY = 1.217


A-A' EXISTING CONDITION WITHOUT SLOPE FAILURE POND FULL
CENTER AT(48.0,526.0) RADIUS= 136.325 SEIS. COEF.= 0.000
FACTOR OF SAFETY (2D) = 1.416 BY SIMPLIFIED BISHOP METHOD
Associated Engineers, Inc.
ELEVATION IN FEET
520
480
440
400
360
-40
0
40
80
120
160
200
DISTANCE IN FEET

```
REAME (ROTATIONAL EQUILIBRIUM ANALYSIS OF MULTILAYERED EARTHWORKS)
THIS 2008 VERSION IS LICENSED BY CIVIL ENGINEERING SOFTWARE CENTER TO


INPUT FILE NAME  -C:\REAME2008\EON1AF2.DAT

TITLE -A-A' EXISTING CONDITION WITHOUT SLOPE FAILURE POND FULL

NO. OF STATIC AND SEISMIC CASES (NCASE) = 1

NO. OF NONCIRCULAR FAILURE SURFACES (NNS) = 0

TWO-DIMENSIONAL ANALYSIS ( THREED = 0 )

ANALYSIS BY DETERMINISTIC METHOD   ( PROB = 0 )


CASE NO.  1   SEISMIC COEFFICIENT (SEIC) =0.000

NO. OF BOUNDARY LINES (NBL) = 7

NO. OF POINTS ON BOUNDARY LINE 1 = 4
 1  X COORD.=-40            Y COORD.= 382.6
 2  X COORD.=-4             Y COORD.= 383.1
 3  X COORD.= 142.9         Y COORD.= 385.4
 4  X COORD.= 185           Y COORD.= 386

NO. OF POINTS ON BOUNDARY LINE 2 = 3
 1  X COORD.=-40            Y COORD.= 387.4
 2  X COORD.=-4             Y COORD.= 388.2
 3  X COORD.= 104.7         Y COORD.= 390.4

NO. OF POINTS ON BOUNDARY LINE 3 = 5
 1  X COORD.= 71.5          Y COORD.= 400.2
 2  X COORD.= 85.2          Y COORD.= 392.3
 3  X COORD.= 104.7         Y COORD.= 390.4
 4  X COORD.= 142.9         Y COORD.= 390.4
 5  X COORD.= 185           Y COORD.= 390.4

NO. OF POINTS ON BOUNDARY LINE 4 = 4
 1  X COORD.= 64.6          Y COORD.= 404.2
 2  X COORD.= 71.5          Y COORD.= 400.2
 3  X COORD.= 142.9         Y COORD.= 400.2
 4  X COORD.= 185           Y COORD.= 400.2

NO. OF POINTS ON BOUNDARY LINE 5 = 4
 1  X COORD.= 13.9          Y COORD.= 403.6
 2  X COORD.= 64.6          Y COORD.= 404.2
 3  X COORD.= 142.9         Y COORD.= 404.9
 4  X COORD.= 185           Y COORD.= 405.6

NO. OF POINTS ON BOUNDARY LINE 6 = 3
 1  X COORD.= 163.9         Y COORD.= 449.5
 2  X COORD.= 166.3         Y COORD.= 448
 3  X COORD.= 185           Y COORD.= 438.5
```

NO. OF POINTS ON BOUNDARY LINE 7 = 14

1	X COORD.=-40	Y COORD.= 399.4
2	X COORD.=-4	Y COORD.= 402.1
3	X COORD.= 11	Y COORD.= 403.6
4	X COORD.= 13.9	Y COORD.= 403.6
5	X COORD.= 25.2	Y COORD.= 407.7
6	X COORD.= 33.8	Y COORD.= 411
7	X COORD.= 49.2	Y COORD.= 416.6
8	X COORD.= 81.1	Y COORD.= 427.6
9	X COORD.= 101.3	Y COORD.= 435
10	X COORD.= 121.3	Y COORD.= 442
11	X COORD.= 138.9	Y COORD.= 448.5
12	X COORD.= 142.9	Y COORD.= 448.9
13	X COORD.= 163.9	Y COORD.= 449.5
14	X COORD.= 185	Y COORD.= 449.5

LINE NO. AND SLOPE OF EACH SEGMENT ARE:

1	0.014	0.016	0.014			
2	0.022	0.020				
3	-0.577	-0.097	0.000	0.000		
4	-0.580	0.000	0.000			
5	0.012	0.009	0.017			
6	-0.625	-0.508				
7	0.075	0.100	0.000	0.363	0.384	0.364
	0.345	0.366	0.350	0.369	0.100	0.029
	0.000					

MIN. DEPTH OF TALLEST SLICE (DMIN) = 0
NO. OF RADIUS CONTROL ZONES (NRCZ) = 1

RADIUS DECREMENT (RDEC) FOR ZONE 1 = 0
NO. OF CIRCLES (NCIR) FOR ZONE 1 = 5
NO. OF BOTTOM LINES (NOL) FOR ZONE 1 = 1

LINE NO. (LINO)	BEG. NO. (NBP)	END NO. (NEP)
1	1	4

ENGLISH UNITS ARE USED WITH DISTANCE IN FEET AND FORCE IN POUND.

SOIL No.	ENVELOPE (TSSE)	COHESION (C)	FRIC. ANGLE (PHID)	UNIT WEIGHTT (G)
1	1	195.000	33.600	130.000
2	1	250.000	28.000	130.000
3	1	0.000	26.000	110.000
4	1	359.000	30.200	133.000
5	1	289.000	27.900	138.000
6	1	0.000	0.000	62.400

USE PHREATIC SURFACE
USE GRID
NO. OF SLICES (NSLI) = 10
NO. OF ADD. CIRCLES (NAC) = 3
ANALYSIS BY SIMPLIFIED BISHOP METHOD (MTHD=2)
NUMBER OF FORCES (NFO)= 0
SOFT SOIL NUMBER (SSN)= 0

NO. OF POINTS ON WATER TABLE (NPWT) = 7

```
 1  X COORD.=-40            Y COORD.= 399.4
 2  X COORD.=-4             Y COORD.= 402.1
 3  X COORD.= 11            Y COORD.= 403.6
 4  X COORD.= 13.9          Y COORD.= 403.6
 5  X COORD.= 142.9         Y COORD.= 443.2
 6  X COORD.= 163.9         Y COORD.= 449.5
 7  X COORD.= 185           Y COORD.= 449.5
```

NO. OF SOILS WITH DIFFERENT WATER TABLE (NSDW) = 0
NO. OF SOILS WITH DIFFERENT PORE PRESSURE RATIO (NSDP) = 0

INPUT COORD. OF GRID POINTS 1,2,AND 3

```
POINT 1 X COORD. = 0      Y COORD. = 540
POINT 2 X COORD. = 0      Y COORD. = 440
POINT 3 X COORD. = 80     Y COORD. = 440
```

X INCREMENT (XINC) = 8   Y INCREMENT (YINC) = 8
NO. OF DIVISIONS BETWEEN POINTS 1 AND 2 (ND12) = 5
NO. OF DIVISIONS BETWEEN POINTS 2 AND 3 (ND23) = 4
ONLY A SUMMARY TABLE IS PRINTED (NPRT = 0)
SLICES WILL BE SUBDIVIDED

AUTOMATIC SEARCH WILL FOLLOW AFTER GRID

FACTORS OF SAFETY BASED ON GRID

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE
MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X COORDINATE	CENTER Y COORDINATE	NO. OF CIRCLE TOTAL	CRITIC.	RADIUS	LOWEST F.S.	WARNING
0.0	540.0	5	1	146.179	2.104	1
0.0	520.0	5	1	127.061	2.206	1
0.0	500.0	5	1	108.261	2.328	1
0.0	480.0	5	1	89.980	2.480	1
0.0	460.0	5	1	72.611	2.786	1
0.0	440.0	5	1	56.830	3.383	0
20.0	540.0	5	1	152.867	1.623	1
20.0	520.0	11	8	130.586	1.656	1
20.0	500.0	11	2	110.881	1.718	0
20.0	480.0	11	2	91.122	1.800	0
20.0	460.0	11	9	70.078	1.915	0
20.0	440.0	11	8	47.943	2.126	0
40.0	540.0	11	8	150.712	1.430	0
40.0	520.0	11	8	130.878	1.449	0
40.0	500.0	11	2	109.326	1.495	0
40.0	480.0	11	2	89.547	1.568	0
40.0	460.0	11	2	69.767	1.687	0
40.0	440.0	11	2	49.990	1.881	0
60.0	540.0	11	8	148.094	1.449	1
60.0	520.0	11	8	129.602	1.433	0
60.0	500.0	11	8	109.787	1.443	0
60.0	480.0	11	8	89.966	1.514	0
60.0	460.0	11	8	70.132	1.670	0
60.0	440.0	11	8	50.298	2.001	0
80.0	540.0	11	7	135.371	1.778	1

80.0	520.0	11	1	126.472	1.596	1
80.0	500.0	11	2	106.134	1.589	0
80.0	480.0	11	2	86.375	1.625	0
80.0	460.0	11	8	68.859	1.800	0
80.0	440.0	11	8	49.045	2.289	0

GRID IS EXPANDED AS FOLLOWS SO MINIMUM FACTOR OF SAFETY FALLS WITHIN THE GRID

0.0	560.0	5	1	165.506	2.001	1
20.0	560.0	5	1	171.442	1.562	1
40.0	560.0	11	8	170.530	1.439	0
60.0	560.0	5	1	166.839	1.483	1
80.0	560.0	5	1	152.431	1.844	1

LOWEST FACTOR OF SAFETY AT EACH GRID POINT IS TABULATED BELOW

COORDINATE	0.000	20.000	40.000	60.000	80.000
560.000	2.001	1.562	1.439	1.483	1.844
540.000	2.104	1.623	1.430	1.449	1.778
520.000	2.206	1.656	1.449	1.433	1.596
500.000	2.328	1.718	1.495	1.443	1.589
480.000	2.480	1.800	1.568	1.514	1.625
460.000	2.786	1.915	1.687	1.670	1.800
440.000	3.383	2.126	1.881	2.001	2.289

MINIMUM FACTORS OF SAFETY OCCUR AT THE FOLLOWING 2 CENTERS

FACTOR OF SAFETY = 1.430 AT (40.000,540.000)
FACTOR OF SAFETY = 1.433 AT (60.000,520.000)

AUTOMATIC SEARCH WILL BE MADE ONLY ON THE CENTER WITH THE SMALLEST F.S.

AT POINT (40.0 , 540.0) RADIUS 150.712
THE MINIMUM FACTOR OF SAFETY IS 1.430

FACTORS OF SAFETY BASED ON SEARCH

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE
MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X	CENTER Y	NO. OF	CIRCLE		LOWEST	WARNING
COORDINATE	COORDINATE	TOTAL	CRITIC.	RADIUS	F.S.	
40.0	540.0	11	8	150.712	1.430	0
48.0	540.0	11	8	150.196	1.421	0
56.0	540.0	11	8	149.677	1.436	0
48.0	548.0	11	8	158.122	1.427	0
48.0	532.0	11	8	142.270	1.417	0
48.0	524.0	11	8	134.344	1.417	0
48.0	516.0	11	8	126.413	1.423	0
56.0	524.0	11	8	133.825	1.425	0
40.0	524.0	11	8	134.845	1.442	0
50.0	524.0	11	8	134.214	1.418	0
46.0	524.0	11	8	134.471	1.419	0
48.0	526.0	11	8	136.325	1.416	0
48.0	528.0	11	8	138.307	1.417	0
50.0	526.0	11	8	136.196	1.417	0
46.0	526.0	11	8	136.455	1.418	0

AT POINT (48.0 , 526.0) RADIUS 136.325

THE MINIMUM FACTOR OF SAFETY IS 1.416

SUMMARY OF SLICE INFORMATION FOR MOST CRITICAL FAILURE SURFACE

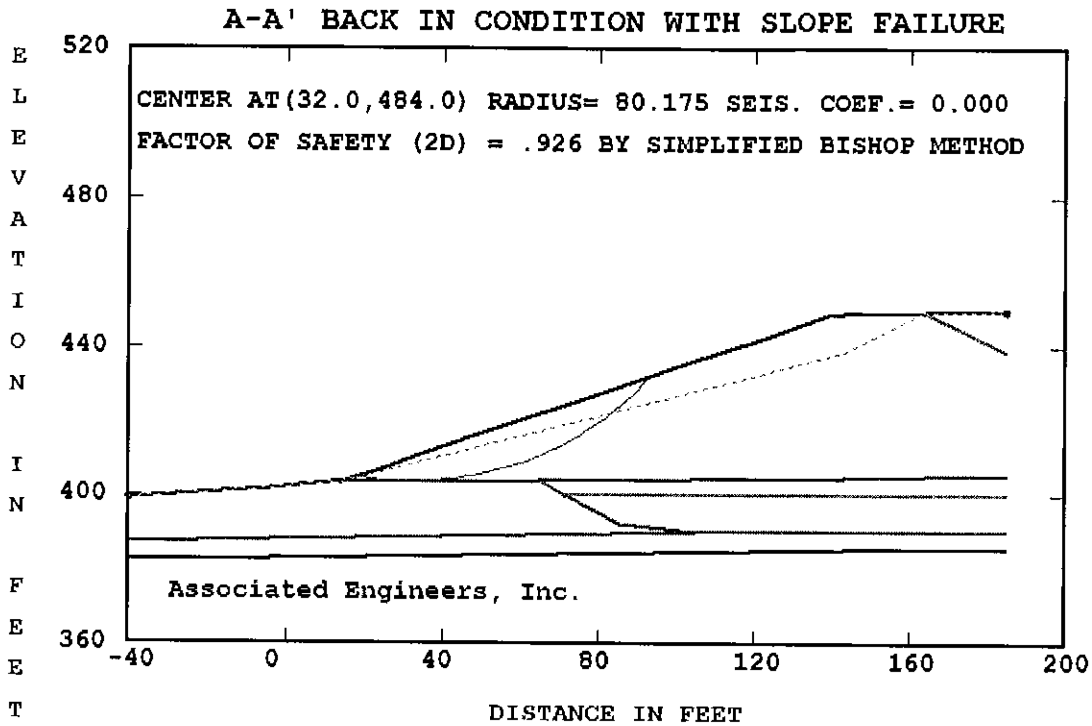
SL. NO.	SOIL NO.	SLICE WIDTH	SLICE HEIGHT	WATER HEIGHT	BOTTOM SINE	TOTAL WEIGHT	EFFEC. WEIGHT	RESIS. MOMENT	DRIVING MOMENT
1	2	4.175	1.080	1.080	-.397	.586E+03	.305E+03	.175E+06	-.317E+05
2	2	12.720	5.194	5.194	-.335	.859E+04	.447E+04	.765E+06	-.392E+06
3	2	2.280	8.367	8.367	-.280	.248E+04	.129E+04	.171E+06	-.946E+05
4	2	2.900	9.208	9.208	-.261	.347E+04	.181E+04	.229E+06	-.123E+06
5	2	11.300	12.974	12.658	-.209	.192E+05	.103E+05	.112E+07	-.547E+06
6	2	0.415	16.220	15.573	-.166	.889E+03	.485E+03	.490E+05	-.201E+05
7	2	8.185	18.522	17.545	-.134	.201E+05	.111E+05	.108E+07	-.367E+06
8	2	8.710	22.553	21.015	-.072	.261E+05	.147E+05	.136E+07	-.257E+06
9	2	6.690	25.692	23.718	-.016	.230E+05	.131E+05	.117E+07	-.492E+05
10	2	10.206	28.539	26.182	.046	.390E+05	.224E+05	.197E+07	.246E+06
11	2	16.895	31.904	29.034	.146	.727E+05	.421E+05	.360E+07	.144E+07
12	2	4.799	33.596	30.316	.225	.215E+05	.124E+05	.104E+07	.660E+06
13	2	1.095	33.908	30.505	.247	.492E+04	.283E+04	.237E+06	.165E+06
14	3	11.001	34.434	30.672	.291	.506E+05	.296E+05	.188E+07	.201E+07
15	3	7.330	34.642	30.335	.358	.346E+05	.207E+05	.129E+07	.169E+07
16	4	0.774	34.496	29.949	.388	.367E+04	.222E+04	.204E+06	.194E+06
17	4	8.733	34.056	29.298	.423	.410E+05	.250E+05	.227E+07	.236E+07
18	5	11.267	32.375	27.186	.496	.503E+05	.312E+05	.247E+07	.341E+07
19	5	5.687	30.129	24.521	.559	.236E+05	.149E+05	.116E+07	.180E+07
20	5	11.913	26.927	20.770	.623	.443E+05	.288E+05	.223E+07	.376E+07
21	5	4.000	22.471	16.357	.681	.124E+05	.832E+04	.655E+06	.115E+07
22	5	0.982	20.306	14.739	.700	.275E+04	.185E+04	.149E+06	.262E+06
23	5	16.895	10.919	7.778	.765	.255E+05	.173E+05	.184E+07	.266E+07
							SUM	.271E+08	.199E+08

AT CENTER (48.000 , 526.000) WITH RADIUS 136.325 AND SEIS. COEFF. 0.00
FACTOR OF SAFETY BY NORMAL METHOD IS 1.361
FACTOR OF SAFETY BY SIMPLIFIED BISHOP METHOD IS 1.416

SUMMARY OF STABILITY ANALYSIS

FACTOR OF FAFETY IS DETERMINED BY SIMPLIFIED BISHOP METHOD
NUMBER OF CASES = 1

CASE 1 SEISMIC COEFFICIENT = 0
FACTOR OF SAFETY = 1.416


A-A' BACK IN CONDITION WITH SLOPE FAILURE
CENTER AT(32.0,484.0) RADIUS= 80.175 SEIS. COEF.= 0.000
FACTOR OF SAFETY (2D) = .926 BY SIMPLIFIED BISHOP METHOD
Associated Engineers, Inc.
ELEVATION IN FEET
520
480
440
400
360
-40
0
40
80
120
160
200
DISTANCE IN FEET

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REAME (ROTATIONAL EQUILIBRIUM ANALYSIS OF MULTILAYERED EARTHWORKS)
THIS 2008 VERSION IS LICENSED BY CIVIL ENGINEERING SOFTWARE CENTER TO


INPUT FILE NAME  -C:\REAME2008\EON2BLT.DAT

TITLE -A-A' BACK IN CONDITION WITH SLOPE FAILURE

NO. OF STATIC AND SEISMIC CASES (NCASE) = 1

NO. OF NONCIRCULAR FAILURE SURFACES (NNS) = 0

TWO-DIMENSIONAL ANALYSIS ( THREED = 0 )

ANALYSIS BY DETERMINISTIC METHOD   ( PROB = 0 )


CASE NO.  1   SEISMIC COEFFICIENT (SEIC) =0.000

NO. OF BOUNDARY LINES (NBL) = 7

NO. OF POINTS ON BOUNDARY LINE 1 = 4
 1  X COORD.=-40            Y COORD.= 382.6
 2  X COORD.=-4             Y COORD.= 383.1
 3  X COORD.= 142.9         Y COORD.= 385.4
 4  X COORD.= 185           Y COORD.= 386

NO. OF POINTS ON BOUNDARY LINE 2 = 3
 1  X COORD.=-40            Y COORD.= 387.4
 2  X COORD.=-4             Y COORD.= 388.2
 3  X COORD.= 104.7         Y COORD.= 390.4

NO. OF POINTS ON BOUNDARY LINE 3 = 5
 1  X COORD.= 71.5          Y COORD.= 400.2
 2  X COORD.= 85.2          Y COORD.= 392.3
 3  X COORD.= 104.7         Y COORD.= 390.4
 4  X COORD.= 142.9         Y COORD.= 390.4
 5  X COORD.= 185           Y COORD.= 390.4

NO. OF POINTS ON BOUNDARY LINE 4 = 4
 1  X COORD.= 64.6          Y COORD.= 404.2
 2  X COORD.= 71.5          Y COORD.= 400.2
 3  X COORD.= 142.9         Y COORD.= 400.2
 4  X COORD.= 185           Y COORD.= 400.2

NO. OF POINTS ON BOUNDARY LINE 5 = 4
 1  X COORD.= 13.9          Y COORD.= 403.6
 2  X COORD.= 64.6          Y COORD.= 404.2
 3  X COORD.= 142.9         Y COORD.= 404.9
 4  X COORD.= 185           Y COORD.= 405.6

NO. OF POINTS ON BOUNDARY LINE 6 = 2
 1  X COORD.= 163.9         Y COORD.= 449.5
 2  X COORD.= 185           Y COORD.= 438.5
```

NO. OF POINTS ON BOUNDARY LINE 7 = 14

1	X COORD.=-40	Y COORD.= 399.4
2	X COORD.=-4	Y COORD.= 402.1
3	X COORD.= 11	Y COORD.= 403.6
4	X COORD.= 13.9	Y COORD.= 403.6
5	X COORD.= 25.2	Y COORD.= 407.7
6	X COORD.= 33.8	Y COORD.= 411
7	X COORD.= 49.2	Y COORD.= 416.6
8	X COORD.= 81.1	Y COORD.= 427.6
9	X COORD.= 101.3	Y COORD.= 435
10	X COORD.= 121.3	Y COORD.= 442
11	X COORD.= 138.9	Y COORD.= 448.5
12	X COORD.= 142.9	Y COORD.= 448.9
13	X COORD.= 163.9	Y COORD.= 449.5
14	X COORD.= 185	Y COORD.= 449.5

LINE NO. AND SLOPE OF EACH SEGMENT ARE:

1	0.014	0.016	0.014			
2	0.022	0.020				
3	-0.577	-0.097	0.000	0.000		
4	-0.580	0.000	0.000			
5	0.012	0.009	0.017			
6	-0.521					
7	0.075	0.100	0.000	0.363	0.384	0.364
	0.345	0.366	0.350	0.369	0.100	0.029
	0.000					

MIN. DEPTH OF TALLEST SLICE (DMIN) = 10
NO. OF RADIUS CONTROL ZONES (NRCZ) = 1

RADIUS DECREMENT (RDEC) FOR ZONE 1 = 0
NO. OF CIRCLES (NCIR) FOR ZONE 1 = 5
NO. OF BOTTOM LINES (NOL) FOR ZONE 1 = 1

LINE NO. (LINO)	BEG. NO. (NBP)	END NO. (NEP)
1	1	4

ENGLISH UNITS ARE USED WITH DISTANCE IN FEET AND FORCE IN POUND.

SOIL No.	ENVELOPE (TSSE)	COHESION (C)	FRIC. ANGLE (PHID)	UNIT WEIGHTT (G)
1	1	195.000	33.600	130.000
2	1	250.000	28.000	130.000
3	1	0.000	26.000	110.000
4	1	359.000	30.200	133.000
5	1	0.000	22.000	138.000
6	1	0.000	0.000	62.400

USE PHREATIC SURFACE
USE GRID
NO. OF SLICES (NSLI) = 10
NO. OF ADD. CIRCLES (NAC) = 3
ANALYSIS BY SIMPLIFIED BISHOP METHOD (MTHD=2)
NUMBER OF FORCES (NFO)= 0
SOFT SOIL NUMBER (SSN)= 0

NO. OF POINTS ON WATER TABLE (NPWT) = 7

1	X COORD.=-40	Y COORD.= 399.4

```
 2  X COORD.=-4              Y COORD.= 402.1
 3  X COORD.= 11             Y COORD.= 403.6
 4  X COORD.= 13.9           Y COORD.= 403.6
 5  X COORD.= 142.9          Y COORD.= 438.42
 6  X COORD.= 163.9          Y COORD.= 449.5
 7  X COORD.= 185            Y COORD.= 449.5
```

NO. OF SOILS WITH DIFFERENT WATER TABLE (NSDW) = 0
NO. OF SOILS WITH DIFFERENT PORE PRESSURE RATIO (NSDP) = 0

INPUT COORD. OF GRID POINTS 1,2,AND 3

```
POINT 1 X COORD. = 0       Y COORD. = 540
POINT 2 X COORD. = 0       Y COORD. = 440
POINT 3 X COORD. = 80      Y COORD. = 440
```

X INCREMENT (XINC) = 8   Y INCREMENT (YINC) = 8
NO. OF DIVISIONS BETWEEN POINTS 1 AND 2 (ND12) = 5
NO. OF DIVISIONS BETWEEN POINTS 2 AND 3 (ND23) = 4
ONLY A SUMMARY TABLE IS PRINTED (NPRT = 0)
SLICES WILL BE SUBDIVIDED

AUTOMATIC SEARCH WILL FOLLOW AFTER GRID

FACTORS OF SAFETY BASED ON GRID

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X COORDINATE	CENTER Y COORDINATE	NO. OF CIRCLE TOTAL	CRITIC.	RADIUS	LOWEST F.S.	WARNING
0.0	540.0	2	1	146.179	1.719	1
0.0	520.0	2	1	127.061	1.856	1
0.0	500.0	2	1	108.261	2.022	1
0.0	480.0	2	1	89.980	2.232	1
0.0	460.0	2	1	72.611	2.596	1
0.0	440.0	3	1	56.830	3.247	0
20.0	540.0	4	4	136.854	1.129	1
20.0	520.0	5	5	116.871	1.176	1
20.0	500.0	5	5	98.215	1.365	0
20.0	480.0	5	5	78.995	1.499	0
20.0	460.0	4	4	61.066	1.681	0
20.0	440.0	4	4	41.818	1.912	0
40.0	540.0	6	4	134.272	0.934	0
40.0	520.0	6	4	114.928	0.936	0
40.0	500.0	6	4	95.585	0.934	0
40.0	480.0	6	5	74.578	0.964	0
40.0	460.0	6	5	55.289	0.986	0
40.0	440.0	5	5	36.009	1.054	0
60.0	540.0	7	4	129.408	1.023	1
60.0	520.0	7	4	110.764	1.000	0
60.0	500.0	7	4	91.497	1.007	0
60.0	480.0	7	4	72.204	1.036	0
60.0	460.0	7	4	52.861	1.101	0
60.0	440.0	6	5	31.653	1.289	0
80.0	540.0	10	8	130.500	1.105	1
80.0	520.0	10	7	112.750	1.082	1

80.0	500.0	7	4	87.261	1.095	0
80.0	480.0	7	4	67.978	1.113	0
80.0	460.0	7	4	48.711	1.222	0
80.0	440.0	7	6	25.089	1.533	0

LOWEST FACTOR OF SAFETY AT EACH GRID POINT IS TABULATED BELOW

COORDINATE	0.000	20.000	40.000	60.000	80.000
540.000	1.719	1.129	0.934	1.023	1.105
520.000	1.856	1.176	0.936	1.000	1.082
500.000	2.022	1.365	0.934	1.007	1.095
480.000	2.232	1.499	0.964	1.036	1.113
460.000	2.596	1.681	0.986	1.101	1.222
440.000	3.247	1.912	1.054	1.289	1.533

MINIMUM FACTORS OF SAFETY OCCUR AT THE FOLLOWING 2 CENTERS

FACTOR OF SAFETY = 0.934 AT (40.000,540.000)
FACTOR OF SAFETY = 0.934 AT (40.000,500.000)

AUTOMATIC SEARCH WILL BE MADE ONLY ON THE CENTER WITH THE SMALLEST F.S.

AT POINT (40.0 , 500.0) RADIUS 95.585
THE MINIMUM FACTOR OF SAFETY IS 0.934

FACTORS OF SAFETY BASED ON SEARCH

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE
MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X COORDINATE	CENTER Y COORDINATE	NO. OF CIRCLE TOTAL	CRITIC.	RADIUS	LOWEST F.S.	WARNING
40.0	500.0	6	4	95.585	0.934	0
48.0	500.0	6	4	93.970	0.965	0
32.0	500.0	6	5	95.606	0.929	0
24.0	500.0	5	5	97.345	1.265	0
32.0	508.0	6	5	103.322	0.931	0
32.0	492.0	5	5	87.890	0.926	0
32.0	484.0	5	5	80.175	0.926	0
32.0	476.0	5	5	72.459	1.129	0
40.0	484.0	6	5	78.436	0.963	0
24.0	484.0	5	5	81.927	1.371	0
34.0	484.0	6	5	79.740	0.935	0
30.0	484.0	5	5	80.610	1.154	0
32.0	486.0	5	5	82.104	0.926	0
32.0	482.0	5	5	78.246	1.022	0

AT POINT (32.0 , 484.0) RADIUS 80.175

THE MINIMUM FACTOR OF SAFETY IS 0.926

SUMMARY OF SLICE INFORMATION FOR MOST CRITICAL FAILURE SURFACE

SL. NO.	SOIL NO.	SLICE WIDTH	SLICE HEIGHT	WATER HEIGHT	BOTTOM SINE	TOTAL WEIGHT	EFFEC. WEIGHT	RESIS. MOMENT	DRIVING MOMENT
1	5	7.257	1.877	1.164	-.130	.188E+04	.135E+04	.434E+05	-.196E+05
2	5	0.248	3.644	2.580	-.083	.124E+03	.846E+02	.273E+04	-.831E+03

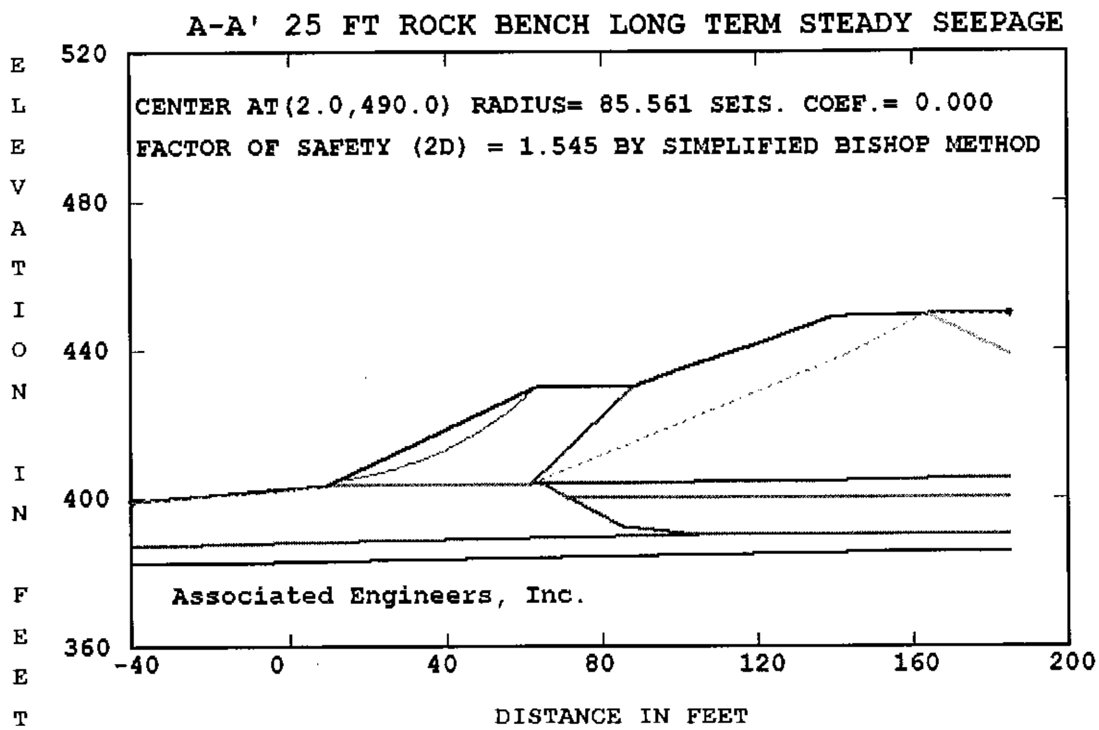
3	5	7.504	5.361	3.856	-.035	.555E+04	.375E+04	.121E+06	-.155E+05
4	5	0.848	7.000	5.020	.017	.819E+03	.554E+03	.179E+05	.113E+04
5	5	6.656	8.221	5.880	.064	.755E+04	.511E+04	.165E+06	.387E+05
6	5	7.504	10.025	7.021	.152	.104E+05	.709E+04	.227E+06	.127E+06
7	5	1.240	10.816	7.403	.207	.185E+04	.128E+04	.405E+05	.307E+05
8	5	6.264	11.234	7.528	.254	.971E+04	.677E+04	.212E+06	.197E+06
9	5	7.504	11.468	7.246	.339	.119E+05	.848E+04	.258E+06	.323E+06
10	5	7.504	10.908	6.124	.433	.113E+05	.843E+04	.246E+06	.392E+06
11	5	7.504	9.384	4.038	.527	.972E+04	.783E+04	.216E+06	.410E+06
12	5	3.123	7.622	1.878	.593	.329E+04	.292E+04	.761E+05	.156E+06
13	5	4.381	6.025	0.000	.640	.364E+04	.364E+04	.907E+05	.187E+06
14	5	7.504	2.725	0.000	.714	.282E+04	.282E+04	.640E+05	.162E+06
							SUM	.178E+07	.199E+07

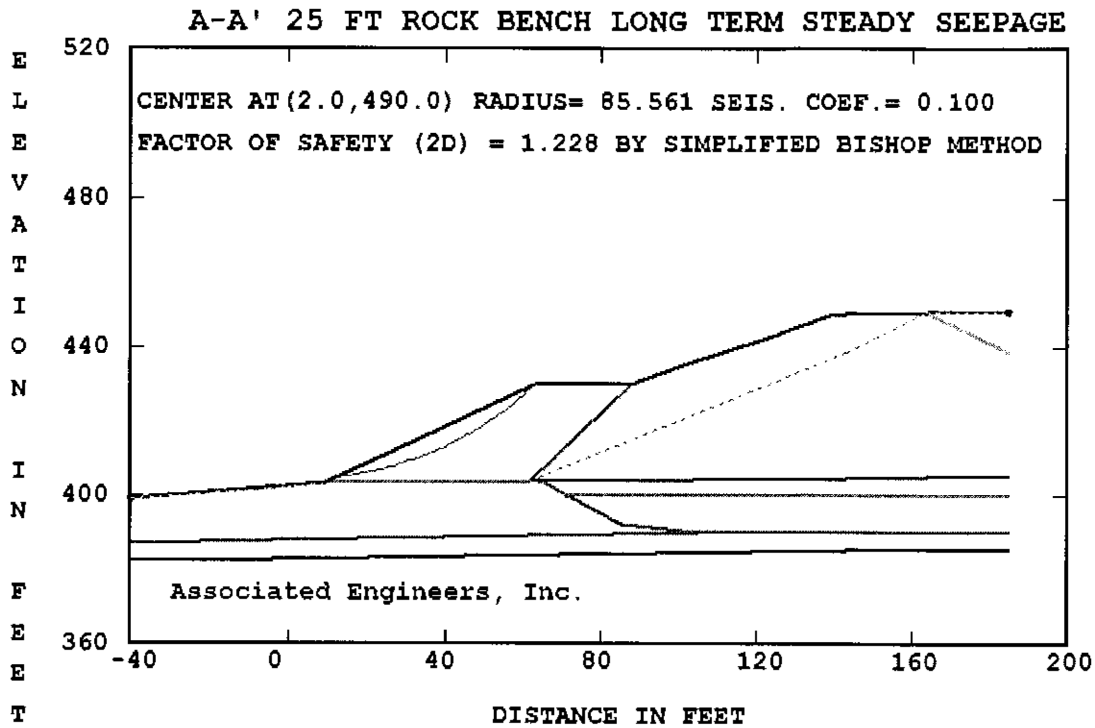
AT CENTER (32.000 , 484.000) WITH RADIUS 80.175 AND SEIS. COEFF. 0.00
FACTOR OF SAFETY BY NORMAL METHOD IS 0.895
FACTOR OF SAFETY BY SIMPLIFIED BISHOP METHOD IS 0.926

SUMMARY OF STABILITY ANALYSIS

FACTOR OF FAFETY IS DETERMINED BY SIMPLIFIED BISHOP METHOD
NUMBER OF CASES = 1

CASE 1 SEISMIC COEFFICIENT = 0
FACTOR OF SAFETY = 0.926


A-A' 25 FT ROCK BENCH LONG TERM STEADY SEEPAGE
CENTER AT(2.0,490.0) RADIUS= 85.561 SEIS. COEF.= 0.000
FACTOR OF SAFETY (2D) = 1.545 BY SIMPLIFIED BISHOP METHOD
Associated Engineers, Inc.
ELEVATION IN FEET
520
480
440
400
360
-40
0
40
80
120
160
200
DISTANCE IN FEET


A-A' 25 FT ROCK BENCH LONG TERM STEADY SEEPAGE
CENTER AT(2.0,490.0) RADIUS= 85.561 SEIS. COEF.= 0.100
FACTOR OF SAFETY (2D) = 1.228 BY SIMPLIFIED BISHOP METHOD
Associated Engineers, Inc.
ELEVATION IN FEET
520
480
440
400
360
-40
0
40
80
120
160
200
DISTANCE IN FEET

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REAME (ROTATIONAL EQUILIBRIUM ANALYSIS OF MULTILAYERED EARTHWORKS)
THIS 2008 VERSION IS LICENSED BY CIVIL ENGINEERING SOFTWARE CENTER TO


INPUT FILE NAME  -C:\REAME2008\EON25LT.DAT

TITLE -A-A' 25 FT ROCK BENCH LONG TERM STEADY SEEPAGE

NO. OF STATIC AND SEISMIC CASES (NCASE) = 2

NO. OF NONCIRCULAR FAILURE SURFACES (NNS) = 0

TWO-DIMENSIONAL ANALYSIS ( THREED = 0 )

ANALYSIS BY DETERMINISTIC METHOD   ( PROB = 0 )


CASE NO.  1   SEISMIC COEFFICIENT (SEIC) =0.000

NO. OF BOUNDARY LINES (NBL) = 8

NO. OF POINTS ON BOUNDARY LINE 1 = 4
 1  X COORD.=-40            Y COORD.= 382.6
 2  X COORD.=-4             Y COORD.= 383.1
 3  X COORD.= 142.9         Y COORD.= 385.4
 4  X COORD.= 185           Y COORD.= 386

NO. OF POINTS ON BOUNDARY LINE 2 = 3
 1  X COORD.=-40            Y COORD.= 387.4
 2  X COORD.=-4             Y COORD.= 388.2
 3  X COORD.= 104.7         Y COORD.= 390.4

NO. OF POINTS ON BOUNDARY LINE 3 = 5
 1  X COORD.= 71.5          Y COORD.= 400.2
 2  X COORD.= 85.2          Y COORD.= 392.3
 3  X COORD.= 104.7         Y COORD.= 390.4
 4  X COORD.= 142.9         Y COORD.= 390.4
 5  X COORD.= 185           Y COORD.= 390.4

NO. OF POINTS ON BOUNDARY LINE 4 = 4
 1  X COORD.= 64.6          Y COORD.= 404.2
 2  X COORD.= 71.5          Y COORD.= 400.2
 3  X COORD.= 142.9         Y COORD.= 400.2
 4  X COORD.= 185           Y COORD.= 400.2

NO. OF POINTS ON BOUNDARY LINE 5 = 4
 1  X COORD.= 61.8          Y COORD.= 404.2
 2  X COORD.= 64.6          Y COORD.= 404.2
 3  X COORD.= 142.9         Y COORD.= 404.9
 4  X COORD.= 185           Y COORD.= 405.6

NO. OF POINTS ON BOUNDARY LINE 6 = 3
 1  X COORD.= 9.3           Y COORD.= 403.5
 2  X COORD.= 61.8          Y COORD.= 404.2
 3  X COORD.= 87.8          Y COORD.= 430
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NO. OF POINTS ON BOUNDARY LINE 7 = 2
 1  X COORD.= 163.9          Y COORD.= 449.5
 2  X COORD.= 185            Y COORD.= 438.5

NO. OF POINTS ON BOUNDARY LINE 8 = 10
 1  X COORD.=-40             Y COORD.= 399.4
 2  X COORD.= 9.3            Y COORD.= 403.4
 3  X COORD.= 62.8           Y COORD.= 430
 4  X COORD.= 87.8           Y COORD.= 430
 5  X COORD.= 101.3          Y COORD.= 435
 6  X COORD.= 121.3          Y COORD.= 442
 7  X COORD.= 138.9          Y COORD.= 448.5
 8  X COORD.= 142.9          Y COORD.= 448.9
 9  X COORD.= 163.9          Y COORD.= 449.5
 10 X COORD.= 185            Y COORD.= 449.5

LINE NO. AND SLOPE OF EACH SEGMENT ARE:
 1        0.014       0.016       0.014
 2        0.022       0.020
 3       -0.577      -0.097       0.000       0.000
 4       -0.580       0.000       0.000
 5        0.000       0.009       0.017
 6        0.013       0.992
 7       -0.521
 8        0.081       0.497       0.000       0.370       0.350       0.369
          0.100       0.029       0.000

MIN. DEPTH OF TALLEST SLICE (DMIN) = 5
NO. OF RADIUS CONTROL ZONES (NRCZ) = 1

RADIUS DECREMENT (RDEC) FOR ZONE 1 = 0
NO. OF CIRCLES (NCIR) FOR ZONE 1 = 5
NO. OF BOTTOM LINES (NOL) FOR ZONE 1 = 1
LINE NO. (LINO)  BEG. NO. (NBP)  END NO. (NEP)
      1                1              4

ENGLISH UNITS ARE USED WITH DISTANCE IN FEET AND FORCE IN POUND.

SOIL  ENVELOPE COHESION    FRIC. ANGLE     UNIT WEIGHTT
 No.   (TSSE)    (C)         (PHID)           (G)
  1       1    195.000       33.600         130.000
  2       1    250.000       28.000         130.000
  3       1      0.000       26.000         110.000
  4       1    359.000       30.200         133.000
  5       1    289.000       27.900         138.000
  6       1      0.000       36.000         115.000
  7       1      0.000        0.000          62.400

USE PHREATIC SURFACE
USE GRID
NO. OF SLICES (NSLI) = 10
NO. OF ADD. CIRCLES (NAC) = 3
ANALYSIS BY SIMPLIFIED BISHOP METHOD (MTHD=2)
NUMBER OF FORCES (NFO)= 0
SOFT SOIL NUMBER (SSN)= 0
```

NO. OF POINTS ON WATER TABLE (NPWT) = 8

1	X COORD.=-40	Y COORD.= 399.4
2	X COORD.=-4	Y COORD.= 402.1
3	X COORD.= 11	Y COORD.= 403.6
4	X COORD.= 13.9	Y COORD.= 403.6
5	X COORD.= 61.8	Y COORD.= 404.2
6	X COORD.= 142.9	Y COORD.= 438.42
7	X COORD.= 163.9	Y COORD.= 449.5
8	X COORD.= 185	Y COORD.= 449.5

NO. OF SOILS WITH DIFFERENT WATER TABLE (NSDW) = 0
NO. OF SOILS WITH DIFFERENT PORE PRESSURE RATIO (NSDP) = 0

INPUT COORD. OF GRID POINTS 1,2,AND 3

POINT 1 X COORD. = 0 Y COORD. = 540
POINT 2 X COORD. = 0 Y COORD. = 440
POINT 3 X COORD. = 80 Y COORD. = 440

X INCREMENT (XINC) = 8 Y INCREMENT (YINC) = 8
NO. OF DIVISIONS BETWEEN POINTS 1 AND 2 (ND12) = 5
NO. OF DIVISIONS BETWEEN POINTS 2 AND 3 (ND23) = 4
ONLY A SUMMARY TABLE IS PRINTED (NPRT = 0)
SLICES WILL BE SUBDIVIDED

AUTOMATIC SEARCH WILL FOLLOW AFTER GRID

FACTORS OF SAFETY BASED ON GRID

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X COORDINATE	CENTER Y COORDINATE	NO. OF CIRCLE TOTAL	CRITIC.	RADIUS	LOWEST F.S.	WARNING
0.0	540.0	7	7	131.387	1.743	1
0.0	520.0	7	7	113.176	1.618	1
0.0	500.0	6	6	95.925	1.565	1
0.0	480.0	10	2	86.530	2.171	1
0.0	460.0	10	6	70.832	2.287	1
0.0	440.0	10	9	50.855	2.730	0
20.0	540.0	6	1	152.867	2.000	1
20.0	520.0	6	6	104.915	1.988	1
20.0	500.0	12	12	86.951	1.802	0
20.0	480.0	12	12	68.729	1.636	0
20.0	460.0	6	6	50.507	1.600	0
20.0	440.0	5	5	33.711	1.731	0
40.0	540.0	11	8	149.614	1.827	0
40.0	520.0	11	8	129.692	1.875	0
40.0	500.0	12	8	109.810	1.949	0
40.0	480.0	12	8	90.012	2.069	0
40.0	460.0	12	12	42.892	1.950	0
40.0	440.0	12	12	24.670	1.834	0
60.0	540.0	11	7	149.893	1.836	1
60.0	520.0	11	8	129.006	1.865	0
60.0	500.0	11	8	109.010	1.939	0
60.0	480.0	11	8	89.015	2.096	0
60.0	460.0	5	1	75.889	2.470	0

60.0	440.0	6	1	55.891	3.103	0
80.0	540.0	5	1	138.619	2.435	1
80.0	520.0	5	1	126.472	2.087	1
80.0	500.0	11	8	108.493	2.105	0
80.0	480.0	11	8	88.677	2.227	0
80.0	460.0	11	8	68.739	2.606	0
80.0	440.0	5	1	55.578	3.634	0

GRID IS EXPANDED AS FOLLOWS SO MINIMUM FACTOR OF SAFETY FALLS WITHIN THE GRID

-20.0	540.0	3	1	142.015	2.637	1
-20.0	520.0	2	1	122.247	3.042	1
-20.0	500.0	1	1	102.569	1000.000	1
-20.0	480.0	1	1	83.044	1000.000	1
-20.0	460.0	1	1	63.815	11.286	1
-20.0	440.0	2	1	45.259	10.146	1

LOWEST FACTOR OF SAFETY AT EACH GRID POINT IS TABULATED BELOW

COORDINATE	-20.000	0.000	20.000	40.000	60.000	80.000
540.000	2.637	1.743	2.000	1.827	1.836	2.435
520.000	3.042	1.618	1.988	1.875	1.865	2.087
500.000	1000.000	1.565	1.802	1.949	1.939	2.105
480.000	1000.000	2.171	1.636	2.069	2.096	2.227
460.000	11.286	2.287	1.600	1.950	2.470	2.606
440.000	10.146	2.730	1.731	1.834	3.103	3.634

MINIMUM FACTORS OF SAFETY OCCUR AT THE FOLLOWING 3 CENTERS

FACTOR OF SAFETY = 1.827 AT (40.000,540.000)
FACTOR OF SAFETY = 1.565 AT (0.000,500.000)
FACTOR OF SAFETY = 1.600 AT (20.000,460.000)

AUTOMATIC SEARCH WILL BE MADE ONLY ON THE CENTER WITH THE SMALLEST F.S.

AT POINT (0.0 , 500.0) RADIUS 95.925
THE MINIMUM FACTOR OF SAFETY IS 1.565

FACTORS OF SAFETY BASED ON SEARCH

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE
MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X	CENTER Y	NO. OF CIRCLE			LOWEST	WARNING
COORDINATE	COORDINATE	TOTAL	CRITIC.	RADIUS	F.S.	
0.0	500.0	6	6	95.925	1.565	1
8.0	500.0	5	5	91.955	1.609	1
-8.0	500.0	4	1	105.567	2.312	1
0.0	508.0	6	6	103.181	1.593	1
0.0	492.0	6	6	88.694	1.551	1
0.0	484.0	10	2	90.126	2.164	1
8.0	492.0	5	5	84.791	1.577	1
-8.0	492.0	3	1	97.973	2.345	1
2.0	492.0	7	7	87.359	1.546	1
4.0	492.0	7	7	86.901	1.565	1
2.0	494.0	7	7	89.158	1.548	1
2.0	490.0	7	7	85.561	1.545	1

2.0	488.0	7	7	83.765	1.546	1
4.0	490.0	7	7	85.108	1.561	1
0.0	490.0	6	6	86.890	1.551	1

AT POINT (2.0 , 490.0) RADIUS 85.561

THE MINIMUM FACTOR OF SAFETY IS 1.545

SUMMARY OF SLICE INFORMATION FOR MOST CRITICAL FAILURE SURFACE

SL. NO.	SOIL NO.	SLICE WIDTH	SLICE HEIGHT	WATER HEIGHT	BOTTOM SINE	TOTAL WEIGHT	EFFEC. WEIGHT	RESIS. MOMENT	DRIVING MOMENT
1	6	5.024	0.893	0.000	.155	.516E+03	.516E+03	.317E+05	.684E+04
2	6	5.024	2.448	0.000	.214	.141E+04	.141E+04	.859E+05	.259E+05
3	6	5.024	3.686	0.000	.272	.213E+04	.213E+04	.127E+06	.497E+05
4	6	5.024	4.592	0.000	.331	.265E+04	.265E+04	.156E+06	.752E+05
5	6	5.024	5.147	0.000	.390	.297E+04	.297E+04	.170E+06	.992E+05
6	6	5.024	5.323	0.000	.449	.308E+04	.308E+04	.171E+06	.118E+06
7	6	5.024	5.085	0.000	.507	.294E+04	.294E+04	.157E+06	.128E+06
8	6	5.024	4.384	0.000	.566	.253E+04	.253E+04	.130E+06	.123E+06
9	6	5.024	3.154	0.000	.625	.182E+04	.182E+04	.884E+05	.974E+05
10	6	4.827	1.344	0.000	.682	.746E+03	.746E+03	.339E+05	.435E+05
11	6	0.197	0.100	0.000	.712	.228E+01	.228E+01	.994E+02	.139E+03
							SUM	.115E+07	.766E+06

AT CENTER (2.000 , 490.000) WITH RADIUS 85.561 AND SEIS. COEFF. 0.00
FACTOR OF SAFETY BY NORMAL METHOD IS 1.503
FACTOR OF SAFETY BY SIMPLIFIED BISHOP METHOD IS 1.545

CASE NO. 2 SEISMIC COEFFICIENT (SEIC) =0.100

AUTOMATIC SEARCH WILL FOLLOW AFTER GRID

FACTORS OF SAFETY BASED ON GRID

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X COORDINATE	CENTER Y COORDINATE	NO. OF CIRCLE TOTAL	CRITIC.	RADIUS	LOWEST F.S.	WARNING
0.0	540.0	7	7	131.387	1.356	1
0.0	520.0	7	7	113.176	1.273	1
0.0	500.0	6	6	95.925	1.241	1
0.0	480.0	10	2	86.530	1.736	1
0.0	460.0	10	6	70.832	1.838	1
0.0	440.0	10	6	50.855	2.177	0
20.0	540.0	6	1	152.867	1.583	1
20.0	520.0	12	12	104.915	1.515	1
20.0	500.0	12	12	86.951	1.400	0
20.0	480.0	12	12	68.729	1.294	0
20.0	460.0	6	6	50.507	1.275	0
20.0	440.0	5	5	33.711	1.387	0
40.0	540.0	11	8	149.614	1.434	0
40.0	520.0	11	8	129.692	1.479	0
40.0	500.0	12	8	109.810	1.545	0
40.0	480.0	12	8	90.012	1.647	0

40.0	460.0	12	12	42.892	1.519	0
40.0	440.0	12	12	24.670	1.474	0
60.0	540.0	11	7	149.893	1.437	1
60.0	520.0	11	8	129.006	1.469	0
60.0	500.0	11	8	109.010	1.529	0
60.0	480.0	11	8	89.015	1.669	0
60.0	460.0	11	8	69.025	1.923	0
60.0	440.0	12	8	49.065	2.475	0
80.0	540.0	5	1	138.619	1.750	1
80.0	520.0	11	1	126.472	1.654	1
80.0	500.0	11	8	108.493	1.656	0
80.0	480.0	11	8	88.677	1.771	0
80.0	460.0	11	8	68.739	2.092	0
80.0	440.0	5	1	55.578	3.044	0

GRID IS EXPANDED AS FOLLOWS SO MINIMUM FACTOR OF SAFETY FALLS WITHIN THE GRID

-20.0	540.0	3	2	140.684	2.112	1
-20.0	520.0	2	2	122.007	2.446	1
-20.0	500.0	1	1	102.569	1000.000	1
-20.0	480.0	1	1	83.044	1000.000	1
-20.0	460.0	1	1	63.815	7.215	1
-20.0	440.0	2	1	45.259	6.181	1

LOWEST FACTOR OF SAFETY AT EACH GRID POINT IS TABULATED BELOW

COORDINATE	-20.000	0.000	20.000	40.000	60.000	80.000
540.000	2.112	1.356	1.583	1.434	1.437	1.750
520.000	2.446	1.273	1.515	1.479	1.469	1.654
500.000	1000.000	1.241	1.400	1.545	1.529	1.656
480.000	1000.000	1.736	1.294	1.647	1.669	1.771
460.000	7.215	1.838	1.275	1.519	1.923	2.092
440.000	6.181	2.177	1.387	1.474	2.475	3.044

MINIMUM FACTORS OF SAFETY OCCUR AT THE FOLLOWING 3 CENTERS

FACTOR OF SAFETY = 1.434 AT (40.000,540.000)
FACTOR OF SAFETY = 1.241 AT (0.000,500.000)
FACTOR OF SAFETY = 1.275 AT (20.000,460.000)

AUTOMATIC SEARCH WILL BE MADE ONLY ON THE CENTER WITH THE SMALLEST F.S.

AT POINT (0.0 , 500.0) RADIUS 95.925
THE MINIMUM FACTOR OF SAFETY IS 1.241

FACTORS OF SAFETY BASED ON SEARCH

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE
MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X	CENTER Y	NO. OF CIRCLE			LOWEST	WARNING
COORDINATE	COORDINATE	TOTAL	CRITIC.	RADIUS	F.S.	
0.0	500.0	6	6	95.925	1.241	1
8.0	500.0	5	5	91.955	1.270	1
-8.0	500.0	10	6	104.430	1.849	1
0.0	508.0	6	6	103.181	1.259	1
0.0	492.0	12	12	88.694	1.233	1

0.0	484.0	10	2	90.126	1.726	1
8.0	492.0	5	5	84.791	1.250	1
-8.0	492.0	3	1	97.973	1.906	1
2.0	492.0	7	7	87.359	1.228	1
4.0	492.0	7	7	86.901	1.242	1
2.0	494.0	7	7	89.158	1.229	1
2.0	490.0	7	7	85.561	1.228	1
2.0	488.0	7	7	83.765	1.229	1
4.0	490.0	7	7	85.108	1.240	1
0.0	490.0	12	12	86.890	1.233	1

AT POINT (2.0 , 490.0) RADIUS 85.561

THE MINIMUM FACTOR OF SAFETY IS 1.228

SUMMARY OF SLICE INFORMATION FOR MOST CRITICAL FAILURE SURFACE

SL. NO.	SOIL NO.	SLICE WIDTH	SLICE HEIGHT	WATER HEIGHT	BOTTOM SINE	TOTAL WEIGHT	EFFEC. WEIGHT	RESIS. MOMENT	DRIVING MOMENT
1	6	5.024	0.893	0.000	.155	.516E+03	.516E+03	.312E+05	.112E+05
2	6	5.024	2.448	0.000	.214	.141E+04	.141E+04	.840E+05	.375E+05
3	6	5.024	3.686	0.000	.272	.213E+04	.213E+04	.124E+06	.668E+05
4	6	5.024	4.592	0.000	.331	.265E+04	.265E+04	.150E+06	.960E+05
5	6	5.024	5.147	0.000	.390	.297E+04	.297E+04	.163E+06	.122E+06
6	6	5.024	5.323	0.000	.449	.308E+04	.308E+04	.162E+06	.141E+06
7	6	5.024	5.085	0.000	.507	.294E+04	.294E+04	.148E+06	.148E+06
8	6	5.024	4.384	0.000	.566	.253E+04	.253E+04	.121E+06	.140E+06
9	6	5.024	3.154	0.000	.625	.182E+04	.182E+04	.814E+05	.109E+06
10	6	4.827	1.344	0.000	.682	.746E+03	.746E+03	.307E+05	.482E+05
11	6	0.197	0.100	0.000	.712	.228E+01	.228E+01	.893E+02	.152E+03
							SUM	.110E+07	.920E+06

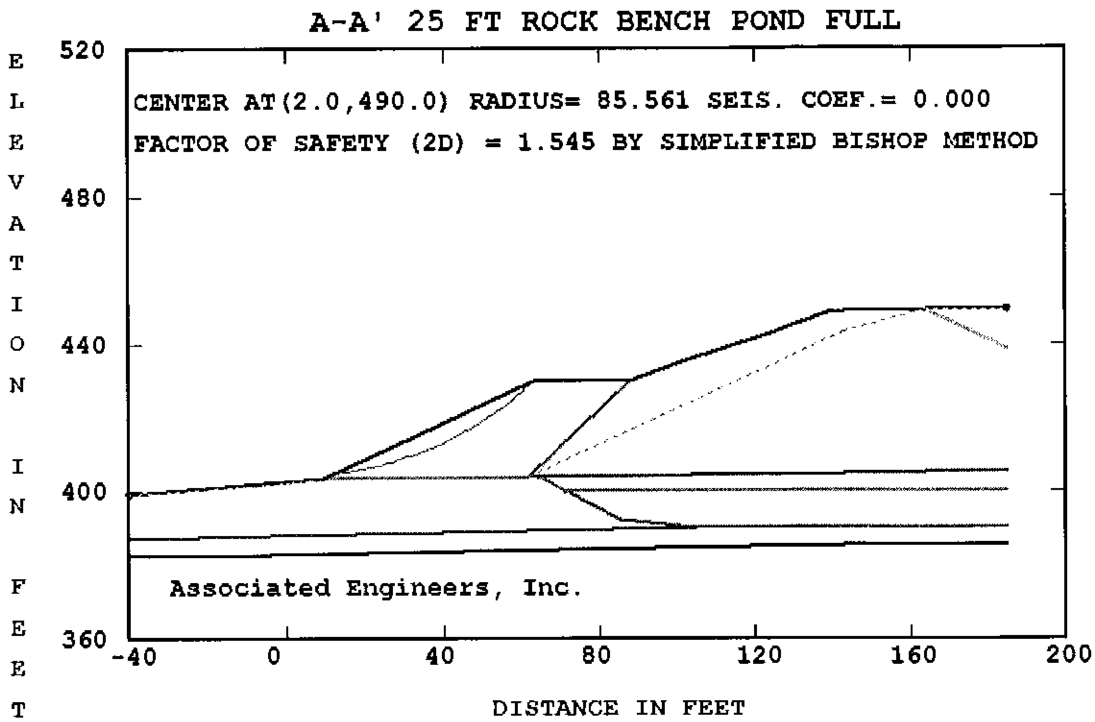
AT CENTER (2.000 , 490.000) WITH RADIUS 85.561 AND SEIS. COEFF. 0.10
FACTOR OF SAFETY BY NORMAL METHOD IS 1.191
FACTOR OF SAFETY BY SIMPLIFIED BISHOP METHOD IS 1.228

SUMMARY OF STABILITY ANALYSIS

FACTOR OF FAFETY IS DETERMINED BY SIMPLIFIED BISHOP METHOD
NUMBER OF CASES = 2

CASE 1 SEISMIC COEFFICIENT = 0
FACTOR OF SAFETY = 1.545

CASE 2 SEISMIC COEFFICIENT = 0.1
FACTOR OF SAFETY = 1.228


A-A' 25 FT ROCK BENCH POND FULL
CENTER AT(2.0,490.0) RADIUS= 85.561 SEIS. COEF.= 0.000
FACTOR OF SAFETY (2D) = 1.545 BY SIMPLIFIED BISHOP METHOD
Associated Engineers, Inc.
ELEVATION IN FEET
520
480
440
400
360
-40
0
40
80
120
160
200
DISTANCE IN FEET

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REAME (ROTATIONAL EQUILIBRIUM ANALYSIS OF MULTILAYERED EARTHWORKS)
THIS 2008 VERSION IS LICENSED BY CIVIL ENGINEERING SOFTWARE CENTER TO


INPUT FILE NAME  -C:\REAME2008\EON25F.DAT

TITLE -A-A' 25 FT ROCK BENCH POND FULL

NO. OF STATIC AND SEISMIC CASES (NCASE) = 1

NO. OF NONCIRCULAR FAILURE SURFACES (NNS) = 0

TWO-DIMENSIONAL ANALYSIS ( THREED = 0 )

ANALYSIS BY DETERMINISTIC METHOD   ( PROB = 0 )


CASE NO.  1   SEISMIC COEFFICIENT (SEIC) =0.000

NO. OF BOUNDARY LINES (NBL) = 8

NO. OF POINTS ON BOUNDARY LINE 1 = 4
 1  X COORD.=-40            Y COORD.= 382.6
 2  X COORD.=-4             Y COORD.= 383.1
 3  X COORD.= 142.9         Y COORD.= 385.4
 4  X COORD.= 185           Y COORD.= 386

NO. OF POINTS ON BOUNDARY LINE 2 = 3
 1  X COORD.=-40            Y COORD.= 387.4
 2  X COORD.=-4             Y COORD.= 388.2
 3  X COORD.= 104.7         Y COORD.= 390.4

NO. OF POINTS ON BOUNDARY LINE 3 = 5
 1  X COORD.= 71.5          Y COORD.= 400.2
 2  X COORD.= 85.2          Y COORD.= 392.3
 3  X COORD.= 104.7         Y COORD.= 390.4
 4  X COORD.= 142.9         Y COORD.= 390.4
 5  X COORD.= 185           Y COORD.= 390.4

NO. OF POINTS ON BOUNDARY LINE 4 = 4
 1  X COORD.= 64.6          Y COORD.= 404.2
 2  X COORD.= 71.5          Y COORD.= 400.2
 3  X COORD.= 142.9         Y COORD.= 400.2
 4  X COORD.= 185           Y COORD.= 400.2

NO. OF POINTS ON BOUNDARY LINE 5 = 4
 1  X COORD.= 61.8          Y COORD.= 404.2
 2  X COORD.= 64.6          Y COORD.= 404.2
 3  X COORD.= 142.9         Y COORD.= 404.9
 4  X COORD.= 185           Y COORD.= 405.6

NO. OF POINTS ON BOUNDARY LINE 6 = 3
 1  X COORD.= 9.3           Y COORD.= 403.5
 2  X COORD.= 61.8          Y COORD.= 404.2
 3  X COORD.= 87.8          Y COORD.= 430
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NO. OF POINTS ON BOUNDARY LINE 7 = 2
 1  X COORD.= 163.9          Y COORD.= 449.5
 2  X COORD.= 185            Y COORD.= 438.5

NO. OF POINTS ON BOUNDARY LINE 8 = 10
 1  X COORD.=-40             Y COORD.= 399.4
 2  X COORD.= 9.3            Y COORD.= 403.4
 3  X COORD.= 62.8           Y COORD.= 430
 4  X COORD.= 87.8           Y COORD.= 430
 5  X COORD.= 101.3          Y COORD.= 435
 6  X COORD.= 121.3          Y COORD.= 442
 7  X COORD.= 138.9          Y COORD.= 448.5
 8  X COORD.= 142.9          Y COORD.= 448.9
 9  X COORD.= 163.9          Y COORD.= 449.5
 10 X COORD.= 185            Y COORD.= 449.5

LINE NO. AND SLOPE OF EACH SEGMENT ARE:
 1       0.014       0.016       0.014
 2       0.022       0.020
 3      -0.577      -0.097       0.000       0.000
 4      -0.580       0.000       0.000
 5       0.000       0.009       0.017
 6       0.013       0.992
 7      -0.521
 8       0.081       0.497       0.000       0.370       0.350       0.369
         0.100       0.029       0.000

MIN. DEPTH OF TALLEST SLICE (DMIN) = 5
NO. OF RADIUS CONTROL ZONES (NRCZ) = 1

RADIUS DECREMENT (RDEC) FOR ZONE 1 = 0
NO. OF CIRCLES (NCIR) FOR ZONE 1 = 5
NO. OF BOTTOM LINES (NOL) FOR ZONE 1 = 1
LINE NO. (LINO)  BEG. NO. (NBP)  END NO. (NEP)
      1                1              4

ENGLISH UNITS ARE USED WITH DISTANCE IN FEET AND FORCE IN POUND.

SOIL  ENVELOPE COHESION    FRIC. ANGLE     UNIT WEIGHTT
 No.   (TSSE)    (C)         (PHID)          (G)
  1       1    195.000       33.600        130.000
  2       1    250.000       28.000        130.000
  3       1      0.000       26.000        110.000
  4       1    359.000       30.200        133.000
  5       1    289.000       27.900        138.000
  6       1      0.000       36.000        115.000
  7       1      0.000        0.000         62.400

USE PHREATIC SURFACE
USE GRID
NO. OF SLICES (NSLI) = 10
NO. OF ADD. CIRCLES (NAC) = 3
ANALYSIS BY SIMPLIFIED BISHOP METHOD (MTHD=2)
NUMBER OF FORCES (NFO)= 0
SOFT SOIL NUMBER (SSN)= 0
```

NO. OF POINTS ON WATER TABLE (NPWT) = 8

1	X COORD.=-40	Y COORD.= 399.4
2	X COORD.=-4	Y COORD.= 402.1
3	X COORD.= 11	Y COORD.= 403.6
4	X COORD.= 13.9	Y COORD.= 403.6
5	X COORD.= 61.8	Y COORD.= 404.2
6	X COORD.= 142.9	Y COORD.= 443.2
7	X COORD.= 163.9	Y COORD.= 449.5
8	X COORD.= 185	Y COORD.= 449.5

NO. OF SOILS WITH DIFFERENT WATER TABLE (NSDW) = 0
NO. OF SOILS WITH DIFFERENT PORE PRESSURE RATIO (NSDP) = 0

INPUT COORD. OF GRID POINTS 1,2,AND 3

POINT 1 X COORD. = 0 Y COORD. = 540
POINT 2 X COORD. = 0 Y COORD. = 440
POINT 3 X COORD. = 80 Y COORD. = 440

X INCREMENT (XINC) = 8 Y INCREMENT (YINC) = 8
NO. OF DIVISIONS BETWEEN POINTS 1 AND 2 (ND12) = 5
NO. OF DIVISIONS BETWEEN POINTS 2 AND 3 (ND23) = 4
ONLY A SUMMARY TABLE IS PRINTED (NPRT = 0)
SLICES WILL BE SUBDIVIDED

AUTOMATIC SEARCH WILL FOLLOW AFTER GRID

FACTORS OF SAFETY BASED ON GRID

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X COORDINATE	CENTER Y COORDINATE	NO. OF CIRCLE TOTAL	CRITIC.	RADIUS	LOWEST F.S.	WARNING
0.0	540.0	7	7	131.387	1.743	1
0.0	520.0	7	7	113.176	1.618	1
0.0	500.0	6	6	95.925	1.565	1
0.0	480.0	10	2	86.530	2.171	1
0.0	460.0	10	6	70.832	2.287	1
0.0	440.0	10	9	50.855	2.730	0
20.0	540.0	6	1	152.867	1.956	1
20.0	520.0	6	6	104.915	1.988	1
20.0	500.0	12	12	86.951	1.802	0
20.0	480.0	12	12	68.729	1.636	0
20.0	460.0	6	6	50.507	1.600	0
20.0	440.0	5	5	33.711	1.731	0
40.0	540.0	11	8	149.614	1.764	0
40.0	520.0	11	8	129.692	1.819	0
40.0	500.0	12	8	109.810	1.909	0
40.0	480.0	12	8	90.012	2.041	0
40.0	460.0	12	12	42.892	1.950	0
40.0	440.0	12	12	24.670	1.834	0
60.0	540.0	11	7	149.893	1.782	1
60.0	520.0	11	8	129.006	1.804	0
60.0	500.0	11	8	109.010	1.870	0
60.0	480.0	11	8	89.015	2.034	0
60.0	460.0	5	1	75.889	2.408	0

60.0	440.0	6	1	55.891	3.050	0
80.0	540.0	5	1	138.619	2.355	1
80.0	520.0	5	1	126.472	2.026	1
80.0	500.0	11	8	108.493	2.042	0
80.0	480.0	11	8	88.677	2.152	0
80.0	460.0	11	8	68.739	2.511	0
80.0	440.0	5	1	55.578	3.541	0

GRID IS EXPANDED AS FOLLOWS SO MINIMUM FACTOR OF SAFETY FALLS WITHIN THE GRID

-20.0	540.0	3	1	142.015	2.637	1
-20.0	520.0	2	1	122.247	3.042	1
-20.0	500.0	1	1	102.569	1000.000	1
-20.0	480.0	1	1	83.044	1000.000	1
-20.0	460.0	1	1	63.815	11.286	1
-20.0	440.0	2	1	45.259	10.146	1

LOWEST FACTOR OF SAFETY AT EACH GRID POINT IS TABULATED BELOW

COORDINATE	-20.000	0.000	20.000	40.000	60.000	80.000
540.000	2.637	1.743	1.956	1.764	1.782	2.355
520.000	3.042	1.618	1.988	1.819	1.804	2.026
500.000	1000.000	1.565	1.802	1.909	1.870	2.042
480.000	1000.000	2.171	1.636	2.041	2.034	2.152
460.000	11.286	2.287	1.600	1.950	2.408	2.511
440.000	10.146	2.730	1.731	1.834	3.050	3.541

MINIMUM FACTORS OF SAFETY OCCUR AT THE FOLLOWING 3 CENTERS

FACTOR OF SAFETY = 1.764 AT (40.000,540.000)
FACTOR OF SAFETY = 1.565 AT (0.000,500.000)
FACTOR OF SAFETY = 1.600 AT (20.000,460.000)

AUTOMATIC SEARCH WILL BE MADE ONLY ON THE CENTER WITH THE SMALLEST F.S.

AT POINT (0.0 , 500.0) RADIUS 95.925
THE MINIMUM FACTOR OF SAFETY IS 1.565

FACTORS OF SAFETY BASED ON SEARCH

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE
MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X	CENTER Y	NO. OF CIRCLE			LOWEST	WARNING
COORDINATE	COORDINATE	TOTAL	CRITIC.	RADIUS	F.S.	
0.0	500.0	6	6	95.925	1.565	1
8.0	500.0	5	5	91.955	1.609	1
-8.0	500.0	4	1	105.567	2.312	1
0.0	508.0	6	6	103.181	1.593	1
0.0	492.0	6	6	88.694	1.551	1
0.0	484.0	10	2	90.126	2.164	1
8.0	492.0	5	5	84.791	1.577	1
-8.0	492.0	3	1	97.973	2.345	1
2.0	492.0	7	7	87.359	1.546	1
4.0	492.0	7	7	86.901	1.565	1
2.0	494.0	7	7	89.158	1.548	1
2.0	490.0	7	7	85.561	1.545	1

2.0	488.0	7	7	83.765	1.546	1
4.0	490.0	7	7	85.108	1.561	1
0.0	490.0	6	6	86.890	1.551	1

AT POINT (2.0 , 490.0) RADIUS 85.561

THE MINIMUM FACTOR OF SAFETY IS 1.545

SUMMARY OF SLICE INFORMATION FOR MOST CRITICAL FAILURE SURFACE

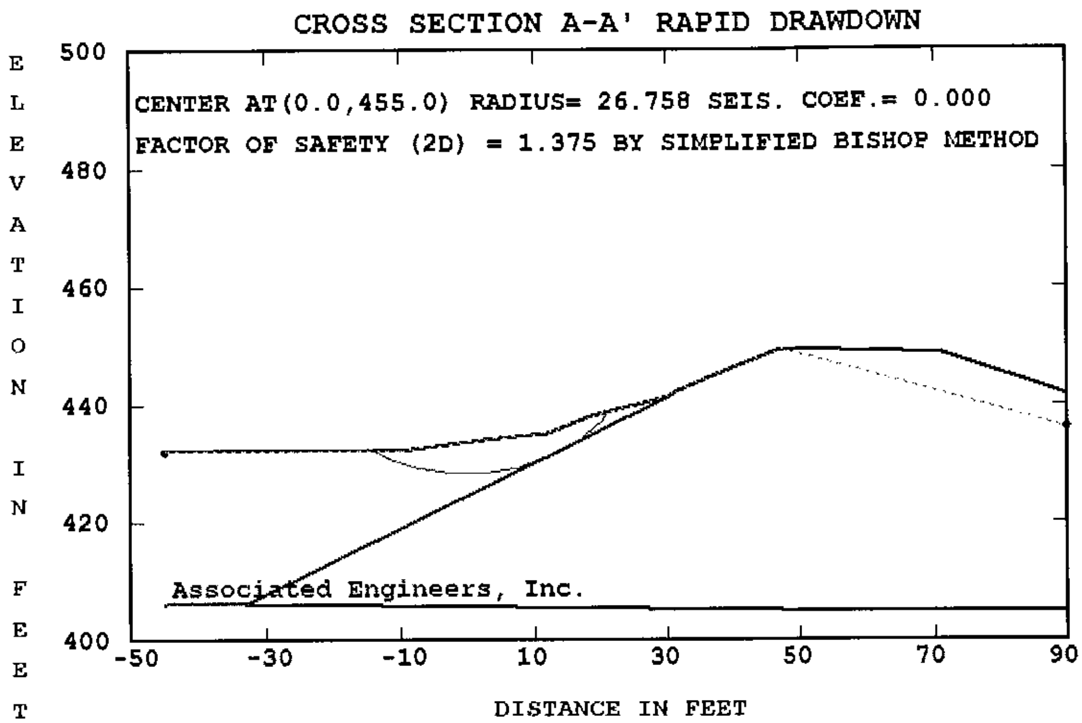
SL. NO.	SOIL NO.	SLICE WIDTH	SLICE HEIGHT	WATER HEIGHT	BOTTOM SINE	TOTAL WEIGHT	EFFEC. WEIGHT	RESIS. MOMENT	DRIVING MOMENT
1	6	5.024	0.893	0.000	.155	.516E+03	.516E+03	.317E+05	.684E+04
2	6	5.024	2.448	0.000	.214	.141E+04	.141E+04	.859E+05	.259E+05
3	6	5.024	3.686	0.000	.272	.213E+04	.213E+04	.127E+06	.497E+05
4	6	5.024	4.592	0.000	.331	.265E+04	.265E+04	.156E+06	.752E+05
5	6	5.024	5.147	0.000	.390	.297E+04	.297E+04	.170E+06	.992E+05
6	6	5.024	5.323	0.000	.449	.308E+04	.308E+04	.171E+06	.118E+06
7	6	5.024	5.085	0.000	.507	.294E+04	.294E+04	.157E+06	.128E+06
8	6	5.024	4.384	0.000	.566	.253E+04	.253E+04	.130E+06	.123E+06
9	6	5.024	3.154	0.000	.625	.182E+04	.182E+04	.884E+05	.974E+05
10	6	4.827	1.344	0.000	.682	.746E+03	.746E+03	.339E+05	.435E+05
11	6	0.197	0.100	0.000	.712	.228E+01	.228E+01	.994E+02	.139E+03
							SUM	.115E+07	.766E+06

AT CENTER (2.000 , 490.000) WITH RADIUS 85.561 AND SEIS. COEFF. 0.00
FACTOR OF SAFETY BY NORMAL METHOD IS 1.503
FACTOR OF SAFETY BY SIMPLIFIED BISHOP METHOD IS 1.545

SUMMARY OF STABILITY ANALYSIS

FACTOR OF FAFETY IS DETERMINED BY SIMPLIFIED BISHOP METHOD
NUMBER OF CASES = 1

CASE 1 SEISMIC COEFFICIENT = 0
FACTOR OF SAFETY = 1.545


CROSS SECTION A-A' RAPID DRAWDOWN
CENTER AT(0.0,455.0) RADIUS= 26.758 SEIS. COEF.= 0.000
FACTOR OF SAFETY (2D) = 1.375 BY SIMPLIFIED BISHOP METHOD
ELEVATION IN FEET
500
480
460
440
420
400
-50
-30
-10
10
30
50
70
90
Associated Engineers, Inc.
DISTANCE IN FEET

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REAME (ROTATIONAL EQUILIBRIUM ANALYSIS OF MULTILAYERED EARTHWORKS)
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TITLE -CROSS SECTION A-A' RAPID DRAWDOWN

NO. OF STATIC AND SEISMIC CASES (NCASE) = 1

NO. OF NONCIRCULAR FAILURE SURFACES (NNS) = 0

TWO-DIMENSIONAL ANALYSIS ( THREED = 0 )

ANALYSIS BY DETERMINISTIC METHOD   ( PROB = 0 )


CASE NO.  1   SEISMIC COEFFICIENT (SEIC) =0.000

NO. OF BOUNDARY LINES (NBL) = 3

NO. OF POINTS ON BOUNDARY LINE 1 = 3
 1  X COORD.=-32.7         Y COORD.= 406.1
 2  X COORD.= 67.1         Y COORD.= 404.9
 3  X COORD.= 90           Y COORD.= 404.8

NO. OF POINTS ON BOUNDARY LINE 2 = 3
 1  X COORD.=-45           Y COORD.= 406.2
 2  X COORD.=-32.7         Y COORD.= 406.1
 3  X COORD.= 30.2         Y COORD.= 441.2

NO. OF POINTS ON BOUNDARY LINE 3 = 12
 1  X COORD.=-45           Y COORD.= 432
 2  X COORD.=-10           Y COORD.= 432
 3  X COORD.= 2.3          Y COORD.= 434
 4  X COORD.= 12           Y COORD.= 435
 5  X COORD.= 18.5         Y COORD.= 438
 6  X COORD.= 30.2         Y COORD.= 441.2
 7  X COORD.= 31.1         Y COORD.= 442
 8  X COORD.= 37.2         Y COORD.= 445
 9  X COORD.= 47           Y COORD.= 449.5
 10 X COORD.= 65.3         Y COORD.= 448.9
 11 X COORD.= 71.2         Y COORD.= 448.5
 12 X COORD.= 90           Y COORD.= 441.6

LINE NO. AND SLOPE OF EACH SEGMENT ARE:
 1      -0.012      -0.004
 2      -0.008       0.558
 3       0.000       0.163       0.103       0.462       0.274       0.889
         0.492       0.459      -0.033      -0.068      -0.367

MIN. DEPTH OF TALLEST SLICE (DMIN) = 5
NO. OF RADIUS CONTROL ZONES (NRCZ) = 1

RADIUS DECREMENT (RDEC) FOR ZONE 1 = 0
```

NO. OF CIRCLES (NCIR) FOR ZONE 1 = 5
NO. OF BOTTOM LINES (NOL) FOR ZONE 1 = 2

LINE NO. (LINO)	BEG. NO. (NBP)	END NO. (NEP)
1	1	3
2	1	2

ENGLISH UNITS ARE USED WITH DISTANCE IN FEET AND FORCE IN POUND.

SOIL No.	ENVELOPE (TSSE)	COHESION (C)	FRIC. ANGLE (PHID)	UNIT WEIGHTT (G)
1	1	289.000	27.900	137.800
2	1	0.000	26.000	110.000

USE PHREATIC SURFACE
USE GRID
NO. OF SLICES (NSLI) = 10
NO. OF ADD. CIRCLES (NAC) = 3
ANALYSIS BY SIMPLIFIED BISHOP METHOD (MTHD=2)
NUMBER OF FORCES (NFO)= 0
SOFT SOIL NUMBER (SSN)= 0

NO. OF POINTS ON WATER TABLE (NPWT) = 11

1	X COORD.=-45	Y COORD.= 432
2	X COORD.=-10	Y COORD.= 432
3	X COORD.= 2.3	Y COORD.= 434
4	X COORD.= 12	Y COORD.= 435
5	X COORD.= 18.5	Y COORD.= 438
6	X COORD.= 30.2	Y COORD.= 441.2
7	X COORD.= 31.1	Y COORD.= 442
8	X COORD.= 37.2	Y COORD.= 445
9	X COORD.= 47	Y COORD.= 449.5
10	X COORD.= 67	Y COORD.= 443.2
11	X COORD.= 90	Y COORD.= 435.9

NO. OF SOILS WITH DIFFERENT WATER TABLE (NSDW) = 0
NO. OF SOILS WITH DIFFERENT PORE PRESSURE RATIO (NSDP) = 0

INPUT COORD. OF GRID POINTS 1,2,AND 3

POINT 1 X COORD. = 0 Y COORD. = 465
POINT 2 X COORD. = 0 Y COORD. = 440
POINT 3 X COORD. = 20 Y COORD. = 440

X INCREMENT (XINC) = 2.4 Y INCREMENT (YINC) = 2.4
NO. OF DIVISIONS BETWEEN POINTS 1 AND 2 (ND12) = 5
NO. OF DIVISIONS BETWEEN POINTS 2 AND 3 (ND23) = 4
ONLY A SUMMARY TABLE IS PRINTED (NPRT = 0)
SLICES WILL BE SUBDIVIDED

AUTOMATIC SEARCH WILL FOLLOW AFTER GRID

FACTORS OF SAFETY BASED ON GRID

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE
MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X CENTER Y NO. OF CIRCLE LOWEST WARNING

COORDINATE	COORDINATE	TOTAL	CRITIC.	RADIUS	F.S.	
0.0	465.0	10	8	49.621	2.259	1
0.0	460.0	11	5	31.479	2.192	1
0.0	455.0	11	5	26.758	1.375	0
0.0	450.0	5	5	21.790	1.586	0
0.0	445.0	11	5	16.839	1.938	0
0.0	440.0	11	5	11.891	2.273	0
5.0	465.0	11	10	44.761	2.024	0
5.0	460.0	11	3	42.844	2.143	0
5.0	455.0	11	7	40.729	2.310	0
5.0	450.0	11	8	40.043	2.556	0
5.0	445.0	11	7	25.008	2.919	0
5.0	440.0	11	5	11.423	3.368	0
10.0	465.0	11	8	42.303	1.853	0
10.0	460.0	11	10	38.997	1.949	0
10.0	455.0	11	3	37.245	2.084	0
10.0	450.0	11	8	33.927	2.290	0
10.0	445.0	11	2	33.512	2.646	0
10.0	440.0	5	1	34.411	3.142	0
15.0	465.0	11	4	39.968	1.773	0
15.0	460.0	11	7	38.307	1.847	0
15.0	455.0	11	11	31.788	1.963	0
15.0	450.0	11	3	31.682	2.133	0
15.0	445.0	11	7	29.976	2.467	0
15.0	440.0	12	2	28.233	2.956	0
20.0	465.0	11	10	35.735	1.758	0
20.0	460.0	11	9	32.622	1.794	0
20.0	455.0	11	9	27.737	1.894	0
20.0	450.0	11	8	26.187	2.049	0
20.0	445.0	11	10	22.944	2.414	0
20.0	440.0	5	1	34.531	2.967	0

GRID IS EXPANDED AS FOLLOWS SO MINIMUM FACTOR OF SAFETY FALLS WITHIN THE GRID

-5.0	465.0	4	1	51.856	2.629	1
-5.0	460.0	4	1	48.826	2.837	1
-5.0	455.0	4	1	46.141	3.069	1
-5.0	450.0	5	5	22.344	2.145	1
-5.0	445.0	5	5	17.469	2.178	0
-5.0	440.0	5	5	12.521	2.263	0

LOWEST FACTOR OF SAFETY AT EACH GRID POINT IS TABULATED BELOW

COORDINATE	-5.000	0.000	5.000	10.000	15.000	20.000
465.000	2.629	2.259	2.024	1.853	1.773	1.758
460.000	2.837	2.192	2.143	1.949	1.847	1.794
455.000	3.069	1.375	2.310	2.084	1.963	1.894
450.000	2.145	1.586	2.556	2.290	2.133	2.049
445.000	2.178	1.938	2.919	2.646	2.467	2.414
440.000	2.263	2.273	3.368	3.142	2.956	2.967

MINIMUM FACTORS OF SAFETY OCCUR AT THE FOLLOWING 2 CENTERS

FACTOR OF SAFETY = 1.758 AT (20.000,465.000)
FACTOR OF SAFETY = 1.375 AT (0.000,455.000)

AUTOMATIC SEARCH WILL BE MADE ONLY ON THE CENTER WITH THE SMALLEST F.S.

AT POINT (0.0 , 455.0) RADIUS 26.758
THE MINIMUM FACTOR OF SAFETY IS 1.375

FACTORS OF SAFETY BASED ON SEARCH

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X	CENTER Y	NO. OF CIRCLE			LOWEST	WARNING
COORDINATE	COORDINATE	TOTAL	CRITIC.	RADIUS	F.S.	
0.0	455.0	11	5	26.758	1.375	0
2.4	455.0	11	2	43.631	2.454	0
-2.4	455.0	5	5	26.868	1.641	1
0.0	457.4	11	5	29.145	2.163	1
0.0	452.6	5	5	24.371	1.470	0
0.6	455.0	11	5	26.710	2.121	0
-0.6	455.0	5	5	26.816	1.431	0
0.0	455.6	11	5	27.356	1.781	0
0.0	454.4	5	5	26.161	1.399	0

AT POINT (0.0 , 455.0) RADIUS 26.758

THE MINIMUM FACTOR OF SAFETY IS 1.375

SUMMARY OF SLICE INFORMATION FOR MOST CRITICAL FAILURE SURFACE

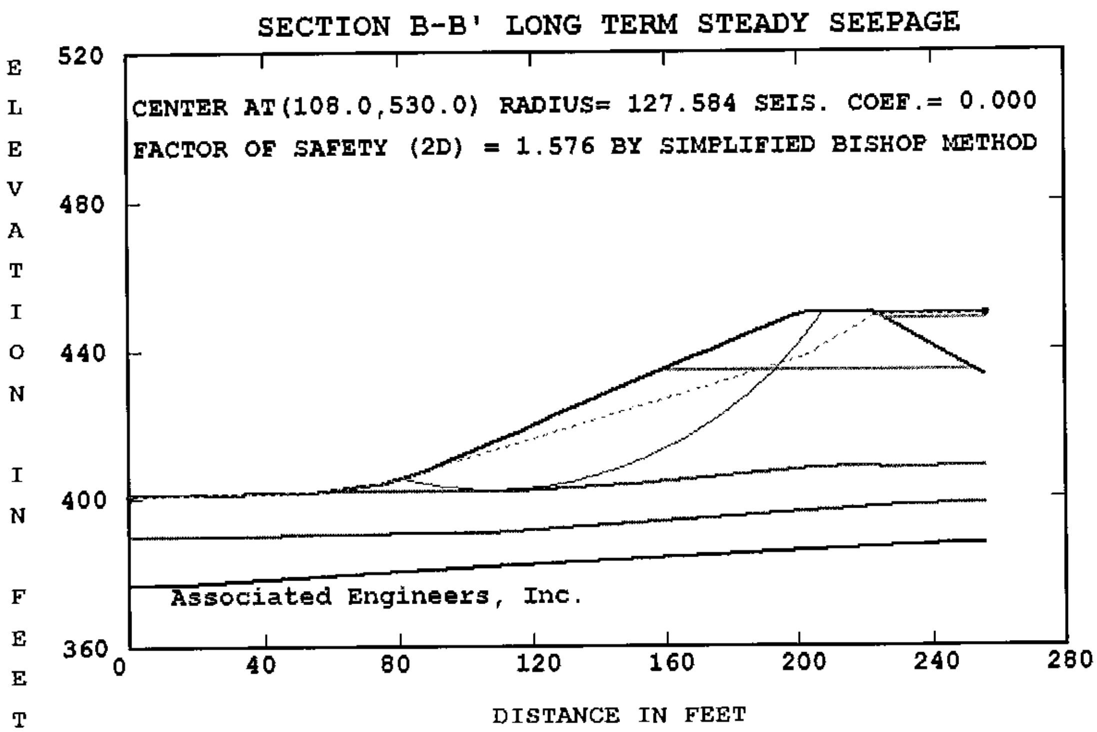
SL. NO.	SOIL NO.	SLICE WIDTH	SLICE HEIGHT	WATER HEIGHT	BOTTOM SINE	TOTAL WEIGHT	EFFEC. WEIGHT	RESIS. MOMENT	DRIVING MOMENT
1	2	3.494	0.953	0.953	-.446	.366E+03	.158E+03	.185E+04	-.437E+04
2	2	0.181	1.783	1.783	-.377	.356E+02	.154E+02	.186E+03	-.359E+03
3	2	3.313	2.694	2.694	-.312	.981E+03	.425E+03	.527E+04	-.819E+04
4	2	3.494	4.121	4.121	-.185	.158E+04	.685E+03	.879E+04	-.782E+04
5	2	3.494	5.110	5.110	-.054	.196E+04	.850E+03	.111E+05	-.284E+04
6	2	2.000	5.564	5.564	.049	.122E+04	.530E+03	.690E+04	.159E+04
7	2	1.494	5.661	5.661	.114	.930E+03	.403E+03	.522E+04	.284E+04
8	2	3.494	5.513	5.513	.207	.212E+04	.917E+03	.117E+05	.117E+05
9	2	3.494	4.881	4.881	.338	.188E+04	.812E+03	.997E+04	.169E+05
10	2	1.218	4.150	4.150	.426	.556E+03	.241E+03	.284E+04	.633E+04
11	2	2.276	3.836	3.836	.491	.960E+03	.416E+03	.472E+04	.126E+05
12	2	3.494	3.288	3.288	.599	.126E+04	.547E+03	.571E+04	.202E+05
13	2	0.730	2.507	2.507	.678	.201E+03	.872E+02	.836E+03	.365E+04
14	2	2.764	1.287	1.287	.743	.391E+03	.169E+03	.148E+04	.778E+04
							SUM	.766E+05	.602E+05

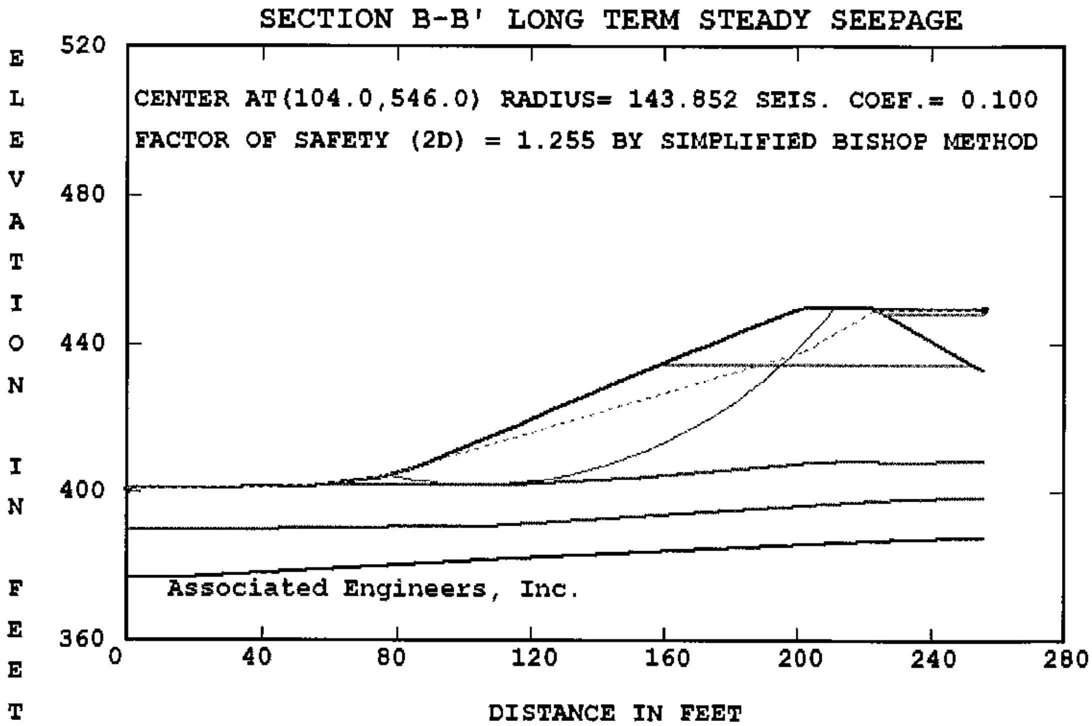
AT CENTER (0.000 , 455.000) WITH RADIUS 26.758 AND SEIS. COEFF. 0.00
FACTOR OF SAFETY BY NORMAL METHOD IS 1.273
FACTOR OF SAFETY BY SIMPLIFIED BISHOP METHOD IS 1.375

SUMMARY OF STABILITY ANALYSIS

FACTOR OF FAFETY IS DETERMINED BY SIMPLIFIED BISHOP METHOD
NUMBER OF CASES = 1

CASE 1 SEISMIC COEFFICIENT = 0
FACTOR OF SAFETY = 1.375


SECTION B-B' LONG TERM STEADY SEEPAGE
CENTER AT(108.0,530.0) RADIUS= 127.584 SEIS. COEF.= 0.000
FACTOR OF SAFETY (2D) = 1.576 BY SIMPLIFIED BISHOP METHOD
ELEVATION IN FEET
520
480
440
400
360
0
40
80
120
160
200
240
280
DISTANCE IN FEET
Associated Engineers, Inc.


SECTION B-B' LONG TERM STEADY SEEPAGE
CENTER AT(104.0,546.0) RADIUS= 143.852 SEIS. COEF.= 0.100
FACTOR OF SAFETY (2D) = 1.255 BY SIMPLIFIED BISHOP METHOD
Associated Engineers, Inc.
ELEVATION IN FEET
520
480
440
400
360
0
40
80
120
160
200
240
280
DISTANCE IN FEET

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REAME (ROTATIONAL EQUILIBRIUM ANALYSIS OF MULTILAYERED EARTHWORKS)
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TITLE -SECTION B-B' LONG TERM STEADY SEEPAGE

NO. OF STATIC AND SEISMIC CASES (NCASE) = 2

NO. OF NONCIRCULAR FAILURE SURFACES (NNS) = 0

TWO-DIMENSIONAL ANALYSIS ( THREED = 0 )

ANALYSIS BY DETERMINISTIC METHOD   ( PROB = 0 )


CASE NO.  1   SEISMIC COEFFICIENT (SEIC) =0.000

NO. OF BOUNDARY LINES (NBL) = 7

NO. OF POINTS ON BOUNDARY LINE 1 = 5
 1  X COORD.= 0            Y COORD.= 377
 2  X COORD.= 12           Y COORD.= 377
 3  X COORD.= 109.8        Y COORD.= 382
 4  X COORD.= 227.8        Y COORD.= 387
 5  X COORD.= 256          Y COORD.= 388

NO. OF POINTS ON BOUNDARY LINE 2 = 5
 1  X COORD.= 0            Y COORD.= 390
 2  X COORD.= 12           Y COORD.= 390
 3  X COORD.= 109.8        Y COORD.= 391
 4  X COORD.= 227.8        Y COORD.= 398
 5  X COORD.= 256          Y COORD.= 399

NO. OF POINTS ON BOUNDARY LINE 3 = 9
 1  X COORD.= 0            Y COORD.= 401
 2  X COORD.= 12           Y COORD.= 401
 3  X COORD.= 55.7         Y COORD.= 402
 4  X COORD.= 109.8        Y COORD.= 402
 5  X COORD.= 152.8        Y COORD.= 404
 6  X COORD.= 201.8        Y COORD.= 408
 7  X COORD.= 221.8        Y COORD.= 409
 8  X COORD.= 227.8        Y COORD.= 408
 9  X COORD.= 256          Y COORD.= 409

NO. OF POINTS ON BOUNDARY LINE 4 = 2
 1  X COORD.= 158          Y COORD.= 434.2
 2  X COORD.= 252.8        Y COORD.= 434.2

NO. OF POINTS ON BOUNDARY LINE 5 = 3
 1  X COORD.= 226.4        Y COORD.= 448
 2  X COORD.= 252.8        Y COORD.= 434.2
 3  X COORD.= 256          Y COORD.= 433
```

NO. OF POINTS ON BOUNDARY LINE 6 = 3

1	X COORD.= 223.6	Y COORD.= 449.5
2	X COORD.= 226.4	Y COORD.= 448
3	X COORD.= 256	Y COORD.= 448

NO. OF POINTS ON BOUNDARY LINE 7 = 22

1	X COORD.= 0	Y COORD.= 401
2	X COORD.= 12	Y COORD.= 401
3	X COORD.= 55.7	Y COORD.= 402
4	X COORD.= 75	Y COORD.= 404
5	X COORD.= 83.3	Y COORD.= 406
6	X COORD.= 89	Y COORD.= 408
7	X COORD.= 94.5	Y COORD.= 410
8	X COORD.= 110.7	Y COORD.= 416
9	X COORD.= 115.8	Y COORD.= 418
10	X COORD.= 125.7	Y COORD.= 422
11	X COORD.= 136.1	Y COORD.= 426
12	X COORD.= 152	Y COORD.= 432
13	X COORD.= 158	Y COORD.= 434.2
14	X COORD.= 168.1	Y COORD.= 438
15	X COORD.= 173.6	Y COORD.= 440
16	X COORD.= 184.4	Y COORD.= 444
17	X COORD.= 189.9	Y COORD.= 446
18	X COORD.= 195.4	Y COORD.= 448
19	X COORD.= 201.8	Y COORD.= 449.8
20	X COORD.= 222.8	Y COORD.= 450
21	X COORD.= 223.6	Y COORD.= 449.5
22	X COORD.= 256	Y COORD.= 449.5

LINE NO. AND SLOPE OF EACH SEGMENT ARE:

1	0.000	0.051	0.042	0.035		
2	0.000	0.010	0.059	0.035		
3	0.000	0.023	0.000	0.047	0.082	0.050
	-0.167	0.035				
4	0.000					
5	-0.523	-0.375				
6	-0.536	0.000				
7	0.000	0.023	0.104	0.241	0.351	0.364
	0.370	0.392	0.404	0.385	0.377	0.367
	0.376	0.364	0.370	0.364	0.364	0.281
	0.010	-0.625	0.000			

MIN. DEPTH OF TALLEST SLICE (DMIN) = 0
NO. OF RADIUS CONTROL ZONES (NRCZ) = 1

RADIUS DECREMENT (RDEC) FOR ZONE 1 = 0
NO. OF CIRCLES (NCIR) FOR ZONE 1 = 5
NO. OF BOTTOM LINES (NOL) FOR ZONE 1 = 1

LINE NO. (LINO)	BEG. NO. (NBP)	END NO. (NEP)
1	1	5

ENGLISH UNITS ARE USED WITH DISTANCE IN FEET AND FORCE IN POUND.

SOIL No.	ENVELOPE (TSSE)	COHESION (C)	FRIC. ANGLE (PHID)	UNIT WEIGHTT (G)
1	1	195.000	33.600	130.200
2	1	565.000	23.800	131.800

3	1	258.000	28.100	138.200
4	1	174.000	26.400	133.800
5	1	0.000	26.000	110.000
6	1	0.000	0.000	62.400

USE PHREATIC SURFACE
USE GRID
NO. OF SLICES (NSLI) = 10
NO. OF ADD. CIRCLES (NAC) = 3
ANALYSIS BY SIMPLIFIED BISHOP METHOD (MTHD=2)
NUMBER OF FORCES (NFO)= 0
SOFT SOIL NUMBER (SSN)= 0

NO. OF POINTS ON WATER TABLE (NPWT) = 9

1	X COORD.= 0	Y COORD.= 401
2	X COORD.= 12	Y COORD.= 401
3	X COORD.= 55.7	Y COORD.= 402
4	X COORD.= 75	Y COORD.= 404
5	X COORD.= 83.3	Y COORD.= 406
6	X COORD.= 89	Y COORD.= 408
7	X COORD.= 202	Y COORD.= 438
8	X COORD.= 223.6	Y COORD.= 449.5
9	X COORD.= 256	Y COORD.= 449.5

NO. OF SOILS WITH DIFFERENT WATER TABLE (NSDW) = 0
NO. OF SOILS WITH DIFFERENT PORE PRESSURE RATIO (NSDP) = 0

INPUT COORD. OF GRID POINTS 1,2,AND 3

POINT 1 X COORD. = 60 Y COORD. = 540
POINT 2 X COORD. = 60 Y COORD. = 440
POINT 3 X COORD. = 140 Y COORD. = 440

X INCREMENT (XINC) = 8 Y INCREMENT (YINC) = 8
NO. OF DIVISIONS BETWEEN POINTS 1 AND 2 (ND12) = 5
NO. OF DIVISIONS BETWEEN POINTS 2 AND 3 (ND23) = 4
ONLY A SUMMARY TABLE IS PRINTED (NPRT = 0)
SLICES WILL BE SUBDIVIDED

AUTOMATIC SEARCH WILL FOLLOW AFTER GRID

FACTORS OF SAFETY BASED ON GRID

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X	CENTER Y	NO. OF	CIRCLE		LOWEST	WARNING
COORDINATE	COORDINATE	TOTAL	CRITIC.	RADIUS	F.S.	
60.0	540.0	5	1	151.397	2.470	1
60.0	520.0	5	1	133.270	2.594	1
60.0	500.0	5	1	115.763	2.765	1
60.0	480.0	5	1	99.202	3.047	1
60.0	460.0	5	1	80.441	3.541	0
60.0	440.0	5	1	60.467	4.512	0
80.0	540.0	11	2	152.761	1.856	0
80.0	520.0	11	8	134.638	1.926	0
80.0	500.0	11	8	114.874	2.026	0

80.0	480.0	11	8	95.086	2.148	0
80.0	460.0	11	2	73.921	2.342	0
80.0	440.0	11	7	56.816	2.696	0
100.0	540.0	17	14	136.905	1.613	0
100.0	520.0	17	14	117.626	1.633	0
100.0	500.0	17	4	96.555	1.724	0
100.0	480.0	17	4	77.391	1.767	0
100.0	460.0	17	15	56.599	1.908	0
100.0	440.0	11	9	50.374	2.165	0
120.0	540.0	11	9	137.167	1.606	0
120.0	520.0	11	9	117.731	1.628	0
120.0	500.0	11	10	96.191	1.643	0
120.0	480.0	11	9	87.162	1.702	0
120.0	460.0	11	9	67.502	1.848	0
120.0	440.0	17	9	47.849	2.154	0
140.0	540.0	11	6	145.043	1.799	1
140.0	520.0	11	3	116.112	1.758	1
140.0	500.0	11	2	106.877	1.754	0
140.0	480.0	11	9	84.775	1.811	0
140.0	460.0	11	6	65.097	1.986	0
140.0	440.0	11	10	43.185	2.485	0

GRID IS EXPANDED AS FOLLOWS SO MINIMUM FACTOR OF SAFETY FALLS WITHIN THE GRID

60.0	560.0	5	1	169.944	2.400	1
80.0	560.0	17	8	173.074	1.820	1
100.0	560.0	17	14	156.185	1.617	0
120.0	560.0	11	3	157.589	1.646	1
140.0	560.0	5	1	160.207	1.850	1

LOWEST FACTOR OF SAFETY AT EACH GRID POINT IS TABULATED BELOW

COORDINATE	60.000	80.000	100.000	120.000	140.000
560.000	2.400	1.820	1.617	1.646	1.850
540.000	2.470	1.856	1.613	1.606	1.799
520.000	2.594	1.926	1.633	1.628	1.758
500.000	2.765	2.026	1.724	1.643	1.754
480.000	3.047	2.148	1.767	1.702	1.811
460.000	3.541	2.342	1.908	1.848	1.986
440.000	4.512	2.696	2.165	2.154	2.485

ONLY ONE MINIMUM F.S. OF 1.606 EXISTS AT (120.000,540.000)

AT POINT (120.0 , 540.0) RADIUS 137.167
THE MINIMUM FACTOR OF SAFETY IS 1.606

FACTORS OF SAFETY BASED ON SEARCH

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE
MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X	CENTER Y	NO. OF CIRCLE			LOWEST	WARNING
COORDINATE	COORDINATE	TOTAL	CRITIC.	RADIUS	F.S.	
120.0	540.0	11	9	137.167	1.606	0
128.0	540.0	11	9	135.533	1.672	1
112.0	540.0	11	10	136.467	1.598	0
104.0	540.0	11	9	148.076	1.651	0

112.0	548.0	11	10	144.219	1.610	0
112.0	532.0	11	10	128.727	1.591	0
112.0	524.0	11	10	120.989	1.589	0
112.0	516.0	11	10	113.250	1.592	0
120.0	524.0	11	9	121.619	1.626	0
104.0	524.0	11	9	132.344	1.658	0
114.0	524.0	11	10	120.593	1.597	0
110.0	524.0	11	10	121.384	1.583	0
108.0	524.0	11	10	121.779	1.578	0
106.0	524.0	11	9	132.104	1.650	0
108.0	526.0	11	10	123.714	1.577	0
108.0	528.0	11	10	125.649	1.577	0
108.0	530.0	11	10	127.584	1.576	0
108.0	532.0	11	10	129.518	1.576	0
110.0	530.0	11	10	127.188	1.582	0
106.0	530.0	11	9	138.004	1.646	0

AT POINT (108.0 , 530.0) RADIUS 127.584

THE MINIMUM FACTOR OF SAFETY IS 1.576

SUMMARY OF SLICE INFORMATION FOR MOST CRITICAL FAILURE SURFACE

SL. NO.	SOIL NO.	SLICE WIDTH	SLICE HEIGHT	WATER HEIGHT	BOTTOM SINE	TOTAL WEIGHT	EFFEC. WEIGHT	RESIS. MOMENT	DRIVING MOMENT
1	3	2.604	0.592	0.592	-.204	.213E+03	.117E+03	.954E+05	-.554E+04
2	3	5.700	2.699	2.699	-.171	.213E+04	.117E+04	.269E+06	-.464E+05
3	3	4.353	5.261	5.047	-.132	.316E+04	.179E+04	.266E+06	-.532E+05
4	3	1.147	6.596	6.113	-.110	.105E+04	.608E+03	.792E+05	-.147E+05
5	3	11.510	9.480	8.336	-.061	.151E+05	.909E+04	.998E+06	-.117E+06
6	3	4.690	12.714	10.721	.003	.824E+04	.510E+04	.502E+06	.293E+04
7	3	5.100	14.475	11.913	.041	.102E+05	.641E+04	.604E+06	.536E+05
8	3	2.867	15.828	12.745	.072	.627E+04	.399E+04	.366E+06	.579E+05
9	3	7.033	17.372	13.602	.111	.169E+05	.109E+05	.972E+06	.239E+06
10	3	5.624	19.005	14.414	.161	.148E+05	.971E+04	.841E+06	.303E+06
11	3	4.776	20.047	14.836	.202	.132E+05	.881E+04	.748E+06	.340E+06
12	3	7.881	20.982	15.045	.251	.229E+05	.155E+05	.129E+07	.732E+06
13	3	8.019	21.641	14.815	.313	.240E+05	.166E+05	.135E+07	.959E+06
14	3	4.638	21.729	14.220	.363	.139E+05	.981E+04	.787E+06	.645E+06
15	3	1.362	21.616	13.803	.387	.407E+04	.290E+04	.230E+06	.201E+06
16	3	10.100	21.196	12.755	.431	.295E+05	.215E+05	.169E+07	.162E+07
17	3	1.195	20.437	11.379	.476	.336E+04	.251E+04	.195E+06	.204E+06
18	3	4.305	19.906	10.577	.497	.117E+05	.891E+04	.690E+06	.745E+06
19	3	8.352	18.359	8.381	.547	.209E+05	.166E+05	.127E+07	.146E+07
20	3	2.448	16.630	6.085	.589	.552E+04	.459E+04	.353E+06	.415E+06
21	3	5.500	15.064	4.122	.620	.112E+05	.977E+04	.753E+06	.886E+06
22	3	2.361	13.255	1.927	.651	.420E+04	.391E+04	.305E+06	.349E+06
23	4	2.349	12.040	0.480	.670	.378E+04	.371E+04	.245E+06	.323E+06
24	4	0.790	11.172	0.000	.682	.118E+04	.118E+04	.787E+05	.103E+06
25	4	6.400	8.729	0.000	.710	.747E+04	.747E+04	.535E+06	.677E+06
26	4	5.467	3.246	0.000	.757	.237E+04	.237E+04	.284E+06	.229E+06
							SUM	.158E+08	.103E+08

AT CENTER (108.000 , 530.000) WITH RADIUS 127.584 AND SEIS. COEFF. 0.00
FACTOR OF SAFETY BY NORMAL METHOD IS 1.531
FACTOR OF SAFETY BY SIMPLIFIED BISHOP METHOD IS 1.576

CASE NO. 2 SEISMIC COEFFICIENT (SEIC) =0.100

AUTOMATIC SEARCH WILL FOLLOW AFTER GRID

FACTORS OF SAFETY BASED ON GRID

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X COORDINATE	CENTER Y COORDINATE	NO. OF CIRCLE TOTAL	CRITIC.	RADIUS	LOWEST F.S.	WARNING
60.0	540.0	11	6	150.522	2.080	1
60.0	520.0	5	1	133.270	2.173	1
60.0	500.0	5	1	115.763	2.223	1
60.0	480.0	5	1	99.202	2.411	1
60.0	460.0	5	1	80.441	2.751	0
60.0	440.0	5	1	60.467	3.370	0
80.0	540.0	11	8	154.399	1.518	0
80.0	520.0	11	7	136.206	1.582	0
80.0	500.0	14	2	113.376	1.673	0
80.0	480.0	11	8	95.086	1.777	0
80.0	460.0	14	8	75.295	1.946	0
80.0	440.0	11	7	56.816	2.241	0
100.0	540.0	11	8	136.905	1.277	0
100.0	520.0	17	14	117.626	1.308	0
100.0	500.0	17	4	96.555	1.377	0
100.0	480.0	17	4	77.391	1.424	0
100.0	460.0	17	15	56.599	1.577	0
100.0	440.0	11	7	48.764	1.849	0
120.0	540.0	11	9	137.167	1.280	0
120.0	520.0	11	10	115.541	1.307	0
120.0	500.0	11	10	96.191	1.337	0
120.0	480.0	11	10	76.844	1.385	0
120.0	460.0	11	8	55.507	1.534	0
120.0	440.0	11	8	36.248	1.824	0
140.0	540.0	11	10	134.622	1.424	1
140.0	520.0	11	3	116.112	1.384	1
140.0	500.0	11	3	97.139	1.422	0
140.0	480.0	11	9	75.287	1.487	0
140.0	460.0	11	9	55.853	1.652	0
140.0	440.0	11	7	43.185	2.137	0

GRID IS EXPANDED AS FOLLOWS SO MINIMUM FACTOR OF SAFETY FALLS WITHIN THE GRID

60.0	560.0	11	6	169.075	2.036	1
80.0	560.0	17	15	156.682	1.469	1
100.0	560.0	11	8	156.185	1.279	0
120.0	560.0	11	9	155.383	1.300	1
140.0	560.0	11	2	153.005	1.431	1

LOWEST FACTOR OF SAFETY AT EACH GRID POINT IS TABULATED BELOW

COORDINATE	60.000	80.000	100.000	120.000	140.000
560.000	2.036	1.469	1.279	1.300	1.431
540.000	2.080	1.518	1.277	1.280	1.424
520.000	2.173	1.582	1.308	1.307	1.384

500.000	2.223	1.673	1.377	1.337	1.422
480.000	2.411	1.777	1.424	1.385	1.487
460.000	2.751	1.946	1.577	1.534	1.652
440.000	3.370	2.241	1.849	1.824	2.137

ONLY ONE MINIMUM F.S. OF 1.277 EXISTS AT (100.000,540.000)

AT POINT (100.0 , 540.0) RADIUS 136.905
THE MINIMUM FACTOR OF SAFETY IS 1.277

FACTORS OF SAFETY BASED ON SEARCH

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X	CENTER Y	NO. OF CIRCLE			LOWEST	WARNING
COORDINATE	COORDINATE	TOTAL	CRITIC.	RADIUS	F.S.	
100.0	540.0	11	8	136.905	1.277	0
108.0	540.0	11	7	137.257	1.275	0
116.0	540.0	11	9	137.884	1.285	0
108.0	548.0	11	7	144.996	1.267	0
108.0	556.0	11	7	152.744	1.276	0
116.0	548.0	11	9	145.659	1.284	0
100.0	548.0	11	8	144.617	1.289	0
110.0	548.0	11	7	144.606	1.284	0
106.0	548.0	11	7	145.391	1.261	0
104.0	548.0	11	7	145.787	1.255	0
102.0	548.0	11	8	144.183	1.294	0
104.0	550.0	11	7	147.721	1.258	0
104.0	546.0	11	7	143.852	1.255	0
104.0	544.0	11	7	141.917	1.255	0
106.0	546.0	11	7	143.457	1.259	0
102.0	546.0	11	7	144.248	1.299	0

AT POINT (104.0 , 546.0) RADIUS 143.852

THE MINIMUM FACTOR OF SAFETY IS 1.255

SUMMARY OF SLICE INFORMATION FOR MOST CRITICAL FAILURE SURFACE

SL. NO.	SOIL NO.	SLICE WIDTH	SLICE HEIGHT	WATER HEIGHT	BOTTOM SINE	TOTAL WEIGHT	EFFEC. WEIGHT	RESIS. MOMENT	DRIVING MOMENT
1	3	5.782	1.208	1.208	-.164	.965E+03	.529E+03	.258E+06	-.483E+05
2	3	5.700	3.740	3.740	-.124	.295E+04	.162E+04	.338E+06	-.611E+05
3	3	1.869	5.503	5.411	-.098	.142E+04	.790E+03	.131E+06	-.186E+05
4	3	3.631	6.746	6.384	-.079	.339E+04	.194E+04	.285E+06	-.306E+05
5	3	9.721	9.577	8.528	-.032	.129E+05	.769E+04	.953E+06	-.866E+03
6	3	6.479	12.610	10.711	.024	.113E+05	.696E+04	.774E+06	.108E+06
7	3	5.100	14.554	11.992	.064	.103E+05	.644E+04	.680E+06	.162E+06
8	3	1.772	15.649	12.642	.088	.383E+04	.243E+04	.251E+06	.740E+05
9	3	8.128	17.125	13.431	.123	.192E+05	.124E+05	.124E+07	.471E+06
10	3	5.223	18.787	14.219	.169	.136E+05	.893E+04	.861E+06	.425E+06
11	3	5.177	19.797	14.609	.205	.142E+05	.944E+04	.891E+06	.519E+06
12	3	8.175	20.768	14.815	.252	.235E+05	.159E+05	.147E+07	.102E+07
13	3	7.725	21.456	14.614	.307	.229E+05	.159E+05	.142E+07	.119E+07
14	3	5.626	21.610	14.051	.353	.168E+05	.119E+05	.104E+07	.986E+06
15	3	0.374	21.539	13.676	.374	.111E+04	.793E+03	.692E+05	.685E+05

16	3	10.100	21.273	12.833	.410	.296E+05	.215E+05	.185E+07	.198E+07
17	3	2.878	20.578	11.437	.456	.813E+04	.608E+04	.514E+06	.600E+06
18	3	2.622	20.133	10.722	.475	.723E+04	.548E+04	.461E+06	.553E+06
19	3	10.729	18.762	8.659	.521	.275E+05	.217E+05	.180E+07	.229E+07
20	3	5.571	16.398	5.459	.578	.124E+05	.105E+05	.863E+06	.114E+07
21	3	4.622	14.472	3.033	.613	.899E+04	.811E+04	.671E+06	.879E+06
22	4	0.878	13.283	1.574	.632	.156E+04	.148E+04	.103E+06	.158E+06
23	4	2.281	12.456	0.685	.643	.380E+04	.370E+04	.260E+06	.390E+06
24	4	4.119	10.585	0.000	.666	.583E+04	.583E+04	.421E+06	.618E+06
25	4	9.232	4.860	0.000	.712	.600E+04	.600E+04	.600E+06	.674E+06
							SUM	.182E+08	.142E+08

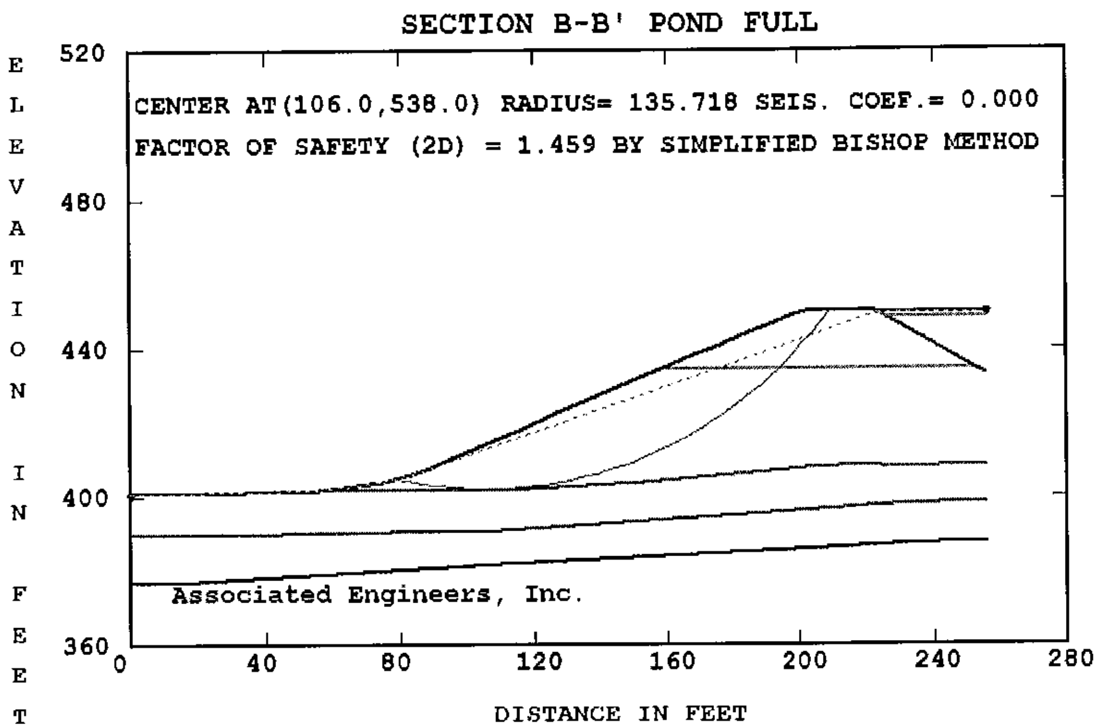
AT CENTER (104.000 , 546.000) WITH RADIUS 143.852 AND SEIS. COEFF. 0.10
FACTOR OF SAFETY BY NORMAL METHOD IS 1.286
FACTOR OF SAFETY BY SIMPLIFIED BISHOP METHOD IS 1.326

SUMMARY OF STABILITY ANALYSIS

FACTOR OF FAFETY IS DETERMINED BY SIMPLIFIED BISHOP METHOD
NUMBER OF CASES = 2

CASE 1 SEISMIC COEFFICIENT = 0
FACTOR OF SAFETY = 1.576

CASE 2 SEISMIC COEFFICIENT = 0.1
FACTOR OF SAFETY = 1.255



SECTION B-B' POND FULL
CENTER AT(106.0,538.0) RADIUS= 135.718 SEIS. COEF.= 0.000
FACTOR OF SAFETY (2D) = 1.459 BY SIMPLIFIED BISHOP METHOD
Associated Engineers, Inc.
ELEVATION IN FEET
520
480
440
400
360
0
40
80
120
160
200
240
280
DISTANCE IN FEET

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REAME (ROTATIONAL EQUILIBRIUM ANALYSIS OF MULTILAYERED EARTHWORKS)
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TITLE -SECTION B-B' POND FULL

NO. OF STATIC AND SEISMIC CASES (NCASE) = 1

NO. OF NONCIRCULAR FAILURE SURFACES (NNS) = 0

TWO-DIMENSIONAL ANALYSIS ( THREED = 0 )

ANALYSIS BY DETERMINISTIC METHOD   ( PROB = 0 )


CASE NO.  1   SEISMIC COEFFICIENT (SEIC) =0.000

NO. OF BOUNDARY LINES (NBL) = 7

NO. OF POINTS ON BOUNDARY LINE 1 = 5
 1  X COORD.= 0             Y COORD.= 377
 2  X COORD.= 12            Y COORD.= 377
 3  X COORD.= 109.8         Y COORD.= 382
 4  X COORD.= 227.8         Y COORD.= 387
 5  X COORD.= 256           Y COORD.= 388

NO. OF POINTS ON BOUNDARY LINE 2 = 5
 1  X COORD.= 0             Y COORD.= 390
 2  X COORD.= 12            Y COORD.= 390
 3  X COORD.= 109.8         Y COORD.= 391
 4  X COORD.= 227.8         Y COORD.= 398
 5  X COORD.= 256           Y COORD.= 399

NO. OF POINTS ON BOUNDARY LINE 3 = 9
 1  X COORD.= 0             Y COORD.= 401
 2  X COORD.= 12            Y COORD.= 401
 3  X COORD.= 55.7          Y COORD.= 402
 4  X COORD.= 109.8         Y COORD.= 402
 5  X COORD.= 152.8         Y COORD.= 404
 6  X COORD.= 201.8         Y COORD.= 408
 7  X COORD.= 221.8         Y COORD.= 409
 8  X COORD.= 227.8         Y COORD.= 408
 9  X COORD.= 256           Y COORD.= 409

NO. OF POINTS ON BOUNDARY LINE 4 = 2
 1  X COORD.= 158           Y COORD.= 434.2
 2  X COORD.= 252.8         Y COORD.= 434.2

NO. OF POINTS ON BOUNDARY LINE 5 = 3
 1  X COORD.= 226.4         Y COORD.= 448
 2  X COORD.= 252.8         Y COORD.= 434.2
 3  X COORD.= 256           Y COORD.= 433
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NO. OF POINTS ON BOUNDARY LINE 6 = 3
 1  X COORD.= 223.6          Y COORD.= 449.5
 2  X COORD.= 226.4          Y COORD.= 448
 3  X COORD.= 256            Y COORD.= 448

NO. OF POINTS ON BOUNDARY LINE 7 = 22
 1  X COORD.= 0              Y COORD.= 401
 2  X COORD.= 12             Y COORD.= 401
 3  X COORD.= 55.7           Y COORD.= 402
 4  X COORD.= 75             Y COORD.= 404
 5  X COORD.= 83.3           Y COORD.= 406
 6  X COORD.= 89             Y COORD.= 408
 7  X COORD.= 94.5           Y COORD.= 410
 8  X COORD.= 110.7          Y COORD.= 416
 9  X COORD.= 115.8          Y COORD.= 418
 10 X COORD.= 125.7          Y COORD.= 422
 11 X COORD.= 136.1          Y COORD.= 426
 12 X COORD.= 152            Y COORD.= 432
 13 X COORD.= 158            Y COORD.= 434.2
 14 X COORD.= 168.1          Y COORD.= 438
 15 X COORD.= 173.6          Y COORD.= 440
 16 X COORD.= 184.4          Y COORD.= 444
 17 X COORD.= 189.9          Y COORD.= 446
 18 X COORD.= 195.4          Y COORD.= 448
 19 X COORD.= 201.8          Y COORD.= 449.8
 20 X COORD.= 222.8          Y COORD.= 450
 21 X COORD.= 223.6          Y COORD.= 449.5
 22 X COORD.= 256            Y COORD.= 449.5

LINE NO. AND SLOPE OF EACH SEGMENT ARE:
 1       0.000       0.051       0.042       0.035
 2       0.000       0.010       0.059       0.035
 3       0.000       0.023       0.000       0.047       0.082       0.050
        -0.167       0.035
 4       0.000
 5      -0.523      -0.375
 6      -0.536       0.000
 7       0.000       0.023       0.104       0.241       0.351       0.364
         0.370       0.392       0.404       0.385       0.377       0.367
         0.376       0.364       0.370       0.364       0.364       0.281
         0.010      -0.625       0.000

MIN. DEPTH OF TALLEST SLICE (DMIN) = 0
NO. OF RADIUS CONTROL ZONES (NRCZ) = 1

RADIUS DECREMENT (RDEC) FOR ZONE 1 = 0
NO. OF CIRCLES (NCIR) FOR ZONE 1 = 5
NO. OF BOTTOM LINES (NOL) FOR ZONE 1 = 1
LINE NO. (LINO)  BEG. NO. (NBP)  END NO. (NEP)
      1                1              5

ENGLISH UNITS ARE USED WITH DISTANCE IN FEET AND FORCE IN POUND.

SOIL  ENVELOPE COHESION    FRIC. ANGLE    UNIT WEIGHTT
 No.   (TSSE)    (C)         (PHID)          (G)
  1       1     195.000      33.600        130.200
  2       1     565.000      23.800        131.800
```

3	1	258.000	28.100	138.200
4	1	174.000	26.400	133.800
5	1	0.000	26.000	110.000
6	1	0.000	0.000	62.400

USE PHREATIC SURFACE
USE GRID
NO. OF SLICES (NSLI) = 10
NO. OF ADD. CIRCLES (NAC) = 3
ANALYSIS BY SIMPLIFIED BISHOP METHOD (MTHD=2)
NUMBER OF FORCES (NFO)= 0
SOFT SOIL NUMBER (SSN)= 0

NO. OF POINTS ON WATER TABLE (NPWT) = 8

1	X COORD.= 0	Y COORD.= 401
2	X COORD.= 12	Y COORD.= 401
3	X COORD.= 55.7	Y COORD.= 402
4	X COORD.= 75	Y COORD.= 404
5	X COORD.= 83.3	Y COORD.= 406
6	X COORD.= 89	Y COORD.= 408
7	X COORD.= 223.6	Y COORD.= 449.5
8	X COORD.= 256	Y COORD.= 449.5

NO. OF SOILS WITH DIFFERENT WATER TABLE (NSDW) = 0
NO. OF SOILS WITH DIFFERENT PORE PRESSURE RATIO (NSDP) = 0

INPUT COORD. OF GRID POINTS 1,2,AND 3

POINT 1 X COORD. = 60 Y COORD. = 540
POINT 2 X COORD. = 60 Y COORD. = 440
POINT 3 X COORD. = 140 Y COORD. = 440

X INCREMENT (XINC) = 8 Y INCREMENT (YINC) = 8
NO. OF DIVISIONS BETWEEN POINTS 1 AND 2 (ND12) = 5
NO. OF DIVISIONS BETWEEN POINTS 2 AND 3 (ND23) = 4
ONLY A SUMMARY TABLE IS PRINTED (NPRT = 0)
SLICES WILL BE SUBDIVIDED

AUTOMATIC SEARCH WILL FOLLOW AFTER GRID

FACTORS OF SAFETY BASED ON GRID

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X	CENTER Y	NO. OF CIRCLE			LOWEST	WARNING
COORDINATE	COORDINATE	TOTAL	CRITIC.	RADIUS	F.S.	
60.0	540.0	5	1	151.397	2.407	1
60.0	520.0	5	1	133.270	2.539	1
60.0	500.0	5	1	115.763	2.710	1
60.0	480.0	5	1	99.202	3.002	1
60.0	460.0	5	1	80.441	3.501	0
60.0	440.0	5	1	60.467	4.485	0
80.0	540.0	11	2	152.761	1.787	0
80.0	520.0	11	8	134.638	1.864	0
80.0	500.0	11	8	114.874	1.966	0
80.0	480.0	11	8	95.086	2.098	0

80.0	460.0	14	2	73.921	2.290	0
80.0	440.0	11	7	56.816	2.653	0
100.0	540.0	11	8	136.905	1.499	0
100.0	520.0	17	14	117.626	1.525	0
100.0	500.0	17	4	96.555	1.615	0
100.0	480.0	17	4	77.391	1.668	0
100.0	460.0	17	15	56.599	1.817	0
100.0	440.0	11	9	50.374	2.103	0
120.0	540.0	11	9	137.167	1.488	0
120.0	520.0	11	10	115.541	1.505	0
120.0	500.0	11	10	96.191	1.524	0
120.0	480.0	11	10	76.844	1.593	0
120.0	460.0	11	10	57.506	1.734	0
120.0	440.0	11	8	36.248	2.048	0
140.0	540.0	11	7	134.622	1.684	1
140.0	520.0	11	3	116.112	1.642	1
140.0	500.0	11	9	94.704	1.628	0
140.0	480.0	11	9	75.287	1.675	0
140.0	460.0	11	9	55.853	1.851	0
140.0	440.0	11	7	43.185	2.359	0

GRID IS EXPANDED AS FOLLOWS SO MINIMUM FACTOR OF SAFETY FALLS WITHIN THE GRID

60.0	560.0	5	1	169.944	2.331	1
80.0	560.0	17	15	156.682	1.741	1
100.0	560.0	11	8	156.185	1.493	0
120.0	560.0	11	9	155.383	1.531	1
140.0	560.0	11	8	154.806	1.735	1

LOWEST FACTOR OF SAFETY AT EACH GRID POINT IS TABULATED BELOW

COORDINATE	60.000	80.000	100.000	120.000	140.000
560.000	2.331	1.741	1.493	1.531	1.735
540.000	2.407	1.787	1.499	1.488	1.684
520.000	2.539	1.864	1.525	1.505	1.642
500.000	2.710	1.966	1.615	1.524	1.628
480.000	3.002	2.098	1.668	1.593	1.675
460.000	3.501	2.290	1.817	1.734	1.851
440.000	4.485	2.653	2.103	2.048	2.359

MINIMUM FACTORS OF SAFETY OCCUR AT THE FOLLOWING 2 CENTERS

FACTOR OF SAFETY = 1.493 AT (100.000,560.000)
FACTOR OF SAFETY = 1.488 AT (120.000,540.000)

AUTOMATIC SEARCH WILL BE MADE ONLY ON THE CENTER WITH THE SMALLEST F.S.

AT POINT (120.0 , 540.0) RADIUS 137.167
THE MINIMUM FACTOR OF SAFETY IS 1.488

FACTORS OF SAFETY BASED ON SEARCH

IN THE FOLLOWING TABLE WARNING INDICATES HOW MANY TIMES THE MAXIMUM RADIUS IS LIMITED BY THE END POINTS OF GROUND LINES

CENTER X COORDINATE	CENTER Y COORDINATE	NO. OF CIRCLE TOTAL	CRITIC.	RADIUS	LOWEST F.S.	WARNING

120.0	540.0	11	9	137.167	1.488	0
128.0	540.0	11	9	135.533	1.553	1
112.0	540.0	11	10	136.467	1.476	0
104.0	540.0	11	7	138.048	1.478	0
112.0	548.0	11	10	144.219	1.481	0
112.0	532.0	11	10	128.727	1.474	0
112.0	524.0	11	10	120.989	1.472	0
112.0	516.0	11	10	113.250	1.480	0
120.0	524.0	11	10	119.417	1.503	0
104.0	524.0	11	8	120.615	1.511	0
114.0	524.0	11	10	120.593	1.479	0
110.0	524.0	11	10	121.384	1.470	0
108.0	524.0	11	10	121.779	1.468	0
106.0	524.0	11	8	120.189	1.510	0
108.0	526.0	11	10	123.714	1.467	0
108.0	528.0	11	10	125.649	1.465	0
108.0	530.0	11	10	127.584	1.463	0
108.0	532.0	11	10	129.518	1.462	0
108.0	534.0	11	10	131.453	1.462	0
108.0	536.0	11	10	133.388	1.463	0
110.0	534.0	11	10	131.058	1.467	0
106.0	534.0	11	7	131.848	1.460	0
104.0	534.0	11	8	130.257	1.500	0
106.0	536.0	11	7	133.783	1.459	0
106.0	538.0	11	7	135.718	1.459	0
106.0	540.0	11	7	137.652	1.459	0
108.0	538.0	11	10	135.322	1.464	0
104.0	538.0	11	7	136.113	1.491	0

AT POINT (106.0 , 538.0) RADIUS 135.718

THE MINIMUM FACTOR OF SAFETY IS 1.459

SUMMARY OF SLICE INFORMATION FOR MOST CRITICAL FAILURE SURFACE

SL. NO.	SOIL NO.	SLICE WIDTH	SLICE HEIGHT	WATER HEIGHT	BOTTOM SINE	TOTAL WEIGHT	EFFEC. WEIGHT	RESIS. MOMENT	DRIVING MOMENT
1	3	4.230	0.920	0.920	-.183	.538E+03	.295E+03	.172E+06	-.133E+05
2	3	5.700	3.258	3.258	-.146	.257E+04	.141E+04	.303E+06	-.509E+05
3	3	3.085	5.395	5.310	-.114	.230E+04	.128E+04	.201E+06	-.356E+05
4	3	2.415	6.682	6.445	-.094	.223E+04	.126E+04	.176E+06	-.283E+05
5	3	10.599	9.539	8.906	-.046	.140E+05	.808E+04	.957E+06	-.866E+05
6	3	5.601	12.667	11.531	.014	.981E+04	.578E+04	.615E+06	.186E+05
7	3	5.100	14.524	13.001	.053	.102E+05	.610E+04	.620E+06	.742E+05
8	3	2.313	15.742	13.894	.081	.503E+04	.303E+04	.300E+06	.551E+05
9	3	7.587	17.250	14.928	.117	.181E+05	.110E+05	.106E+07	.288E+06
10	3	5.427	18.898	16.006	.165	.142E+05	.875E+04	.818E+06	.318E+06
11	3	4.973	19.923	16.634	.203	.137E+05	.853E+04	.783E+06	.378E+06
12	3	8.041	20.876	17.120	.251	.232E+05	.146E+05	.132E+07	.792E+06
13	3	7.859	21.550	17.245	.310	.234E+05	.149E+05	.132E+07	.985E+06
14	3	5.155	21.671	16.945	.358	.154E+05	.999E+04	.869E+06	.750E+06
15	3	0.845	21.580	16.679	.380	.252E+04	.164E+04	.142E+06	.130E+06
16	3	10.100	21.245	15.976	.420	.296E+05	.195E+05	.167E+07	.169E+07
17	3	2.069	20.515	14.846	.465	.583E+04	.391E+04	.333E+06	.368E+06
18	3	3.431	20.029	14.208	.485	.942E+04	.638E+04	.541E+06	.621E+06
19	3	9.583	18.573	12.360	.533	.243E+05	.169E+05	.143E+07	.176E+07
20	3	1.217	16.985	10.437	.573	.281E+04	.201E+04	.172E+06	.218E+06

21	3	5.500	15.784	9.046	.598	.117E+05	.863E+04	.742E+06	.952E+06
22	3	3.535	13.906	6.918	.631	.660E+04	.507E+04	.445E+06	.565E+06
23	4	1.965	12.607	5.467	.651	.331E+04	.264E+04	.196E+06	.293E+06
24	4	0.797	11.874	4.690	.662	.127E+04	.103E+04	.773E+05	.114E+06
25	4	5.603	9.858	2.761	.685	.739E+04	.643E+04	.497E+06	.687E+06
26	4	7.411	4.128	0.000	.733	.409E+04	.409E+04	.445E+06	.407E+06
							SUM	.162E+08	.112E+08

AT CENTER (106.000 , 538.000) WITH RADIUS 135.718 AND SEIS. COEFF. 0.00
FACTOR OF SAFETY BY NORMAL METHOD IS 1.441
FACTOR OF SAFETY BY SIMPLIFIED BISHOP METHOD IS 1.459

SUMMARY OF STABILITY ANALYSIS

FACTOR OF FAFETY IS DETERMINED BY SIMPLIFIED BISHOP METHOD
NUMBER OF CASES = 1

CASE 1 SEISMIC COEFFICIENT = 0
FACTOR OF SAFETY = 1.459

Additional Piezometer Data

KU Green River Station
Main Ash Pond

24-Jan-11
Addendum

Water level readings for Main Ash Pond on January 14, 2011

Piezometer	(ft) Depth to water from ground	(ft) Boring Elevation	(ft) Water Elevation	Pond
P1A	11.45	449.29	437.84	Main
P2A	15.05	449.74	434.69	Main
P3A	16.70	449.62	432.92	Main
P4	2.40	412.69	410.29	Main
P5	-2.08	403.31	405.39	Main

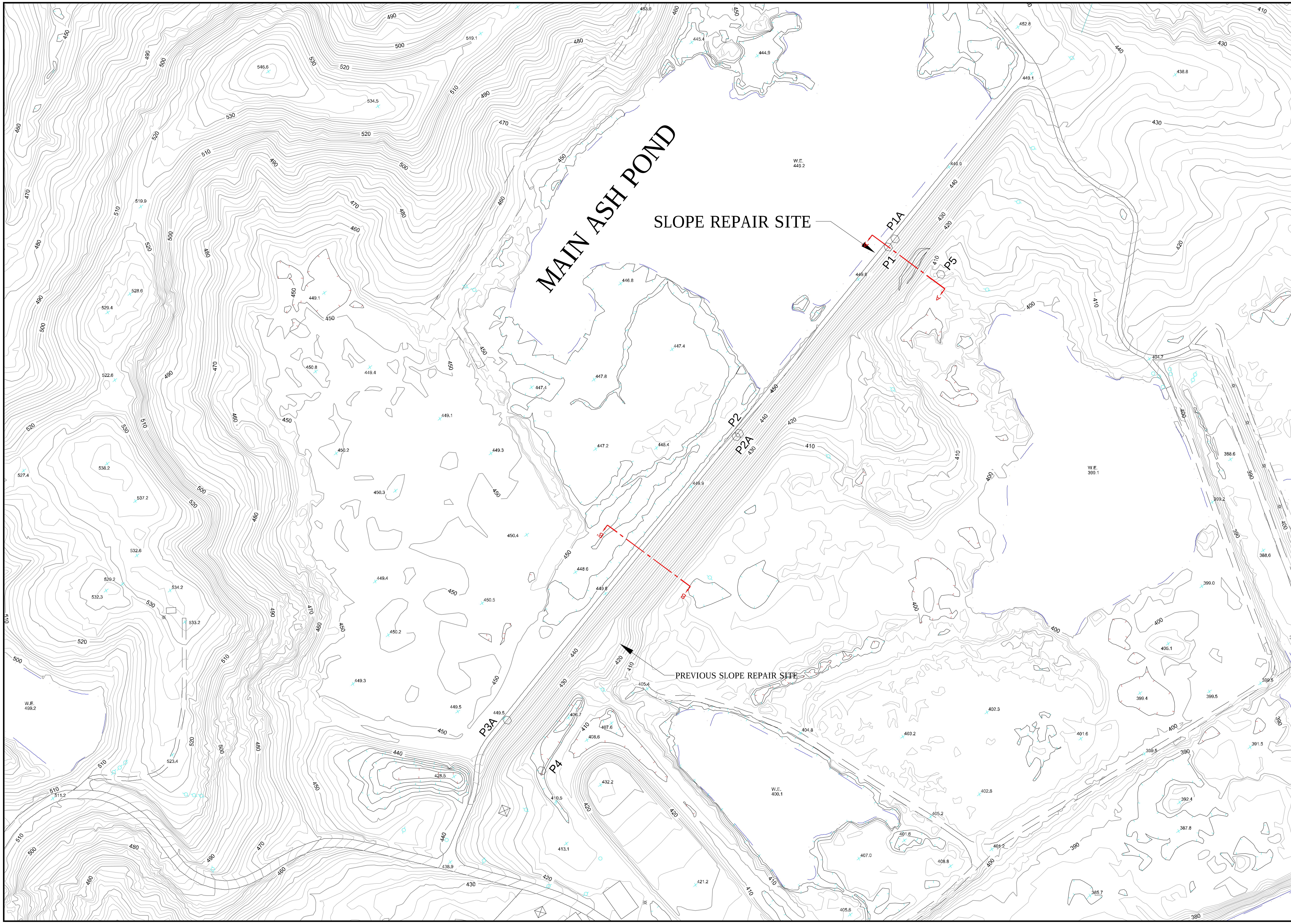
Notes: Depth to top of ice in P5 was observed to be 2.08 feet above ground surface

Water level readings for Main Ash Pond on December 8, 2011

Piezometer	(ft) Depth to water from ground	(ft) Boring Elevation	(ft) Water Elevation	Pond
P1A	12.90	449.29	436.39	Main
P2A	12.60	449.74	437.14	Main
P3A	17.70	449.62	431.92	Main
P4	6.20	412.69	406.49	Main
P5	-1.70	403.31	405.01	Main

Notes: Depth to top of ice in P5 was observed to be 2.08 feet above ground surface

Attachments



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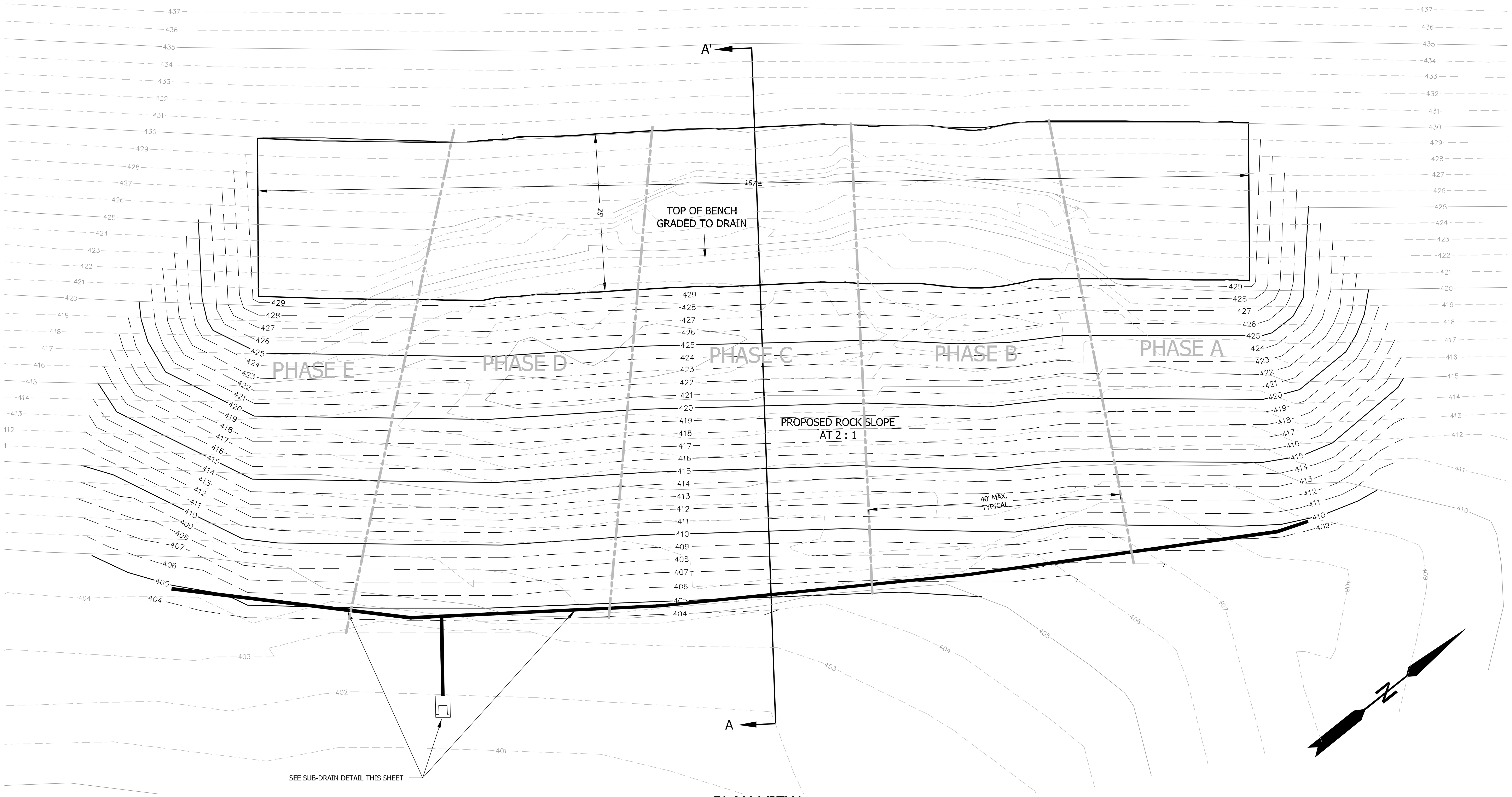
DRAWN BY	P. BRYANT
CHECKED BY	D. DUNBAR
DATE	01/24/2011

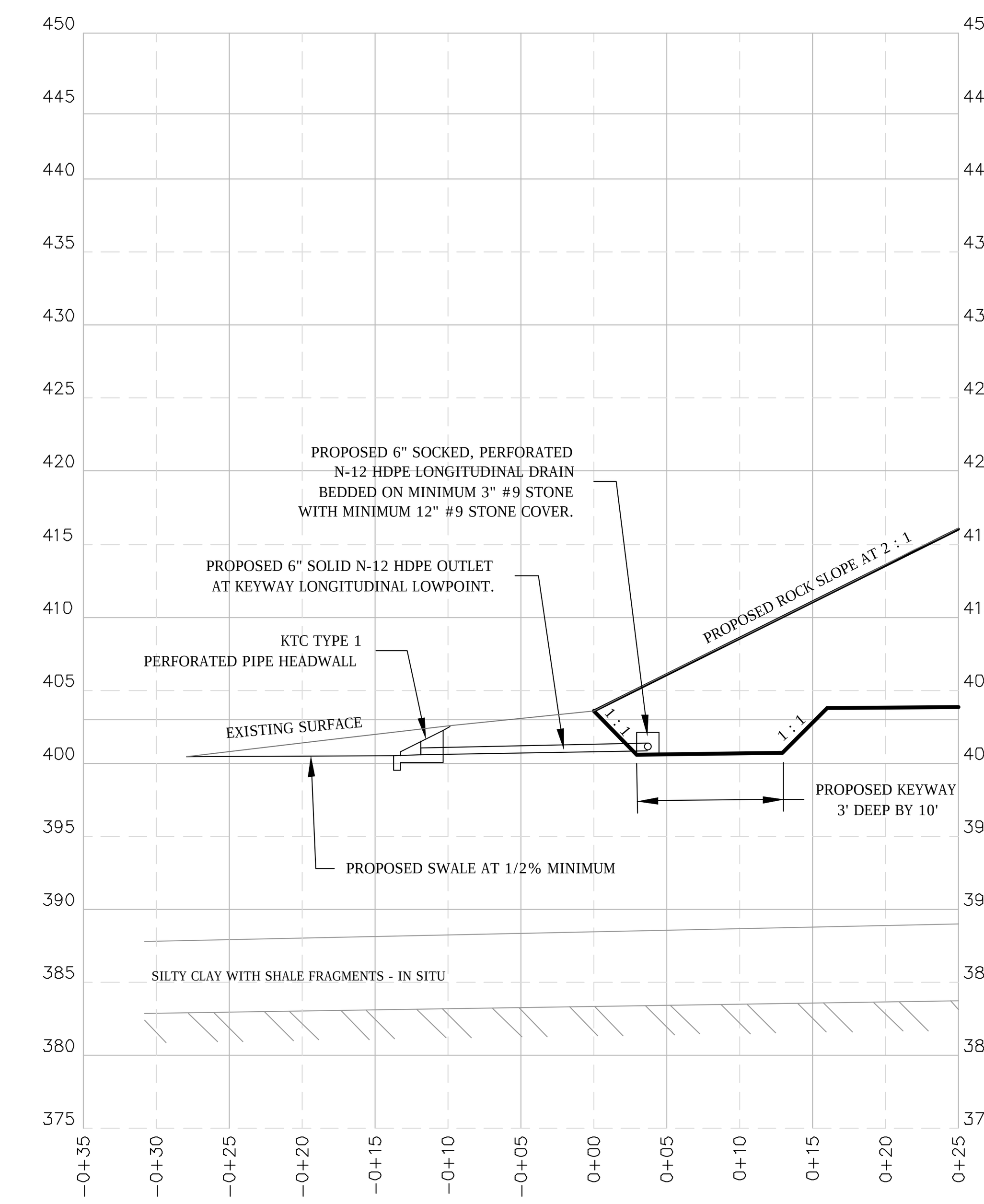
EON U.S. GREEN RIVER STATION
MAIN ASH POND
SLOPE REPAIR LOCATION MAP

SHEET NUMBER
1 of 8



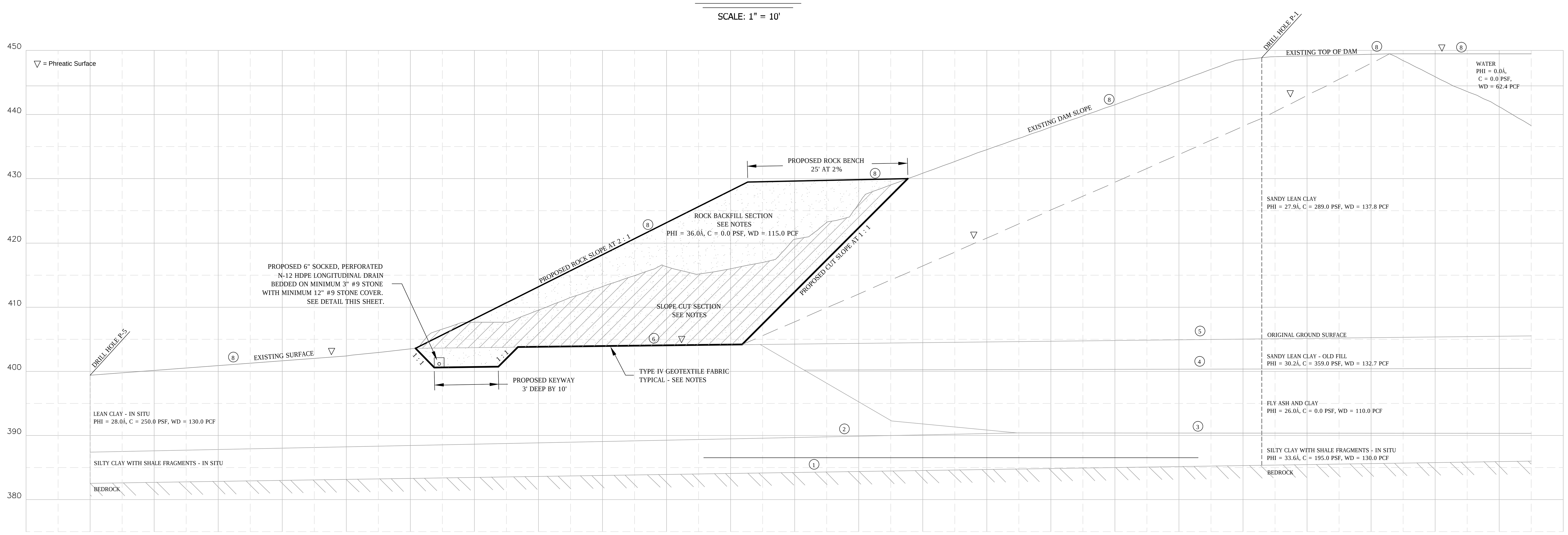
PLAN VIEW

SCALE: 1" = 10'



UNDER DRAIN DETAIL

SCALE: 1" = 10'



SECTION A-A'

25' ROCK BENCH

LONG TERM STEADY SEEPAGE

H: 1" = 10' V: 1" = 10'

Notes:

Place Geotextile Fabric, Type Iv On Excavated Soil Area Meeting The Requirements Of Section 843, Type IV, Of The Current Edition Of Kentucky Dot, Standard Specifications For Road And Bridge Construction. Install Geotextile Fabric According To Section 214 Of The Standard Specifications For Road And Bridge Construction. Prepare The Surface To A Smooth Condition, Free Of Obstructions, Debris, Or Sharp Objects That May Puncture The Fabric. Place The Fabric Smooth And Free Of Tension, Stress, Folds, Wrinkles, Or Creases. Do Not Operate Equipment Directly On The Fabric. Overlap Strips At Least 18 Inches. Place Transverse Laps So The Upslope Strip Laps Over The Downslope Strip. Install Fastener Pins Through Both Strips Of Overlapped Fabric At No Less Than 5-foot Intervals Along A Line Through The Midpoint Of The Overlap, And At Any Other Locations As Necessary To Prevent Any Slippage Of The Fabric. Place Fabric With The Long Dimension Parallel To The Long Dimension Of The Section To Be Covered.

Use Kentucky Coarse Aggregate No. 2's, 3's, Or 23's Meeting The Requirements Of Sections 703 And 805 Of The Standard Specifications For Road And Bridge Construction (Current Edition).

Do Not Stockpile, Even Temporarily, The Excavated Material On Any Slope Of The Dam. Do Not Operate Or Park Equipment On Areas Of The Dam Outside Of The Area To Be Excavated.

Excavation Of The Failed Material Will Involve Some Risk. To Prevent Potential Damage To Upslope Areas, Perform The Excavation In Sections No Longer Than 40 Ft As Measured In The Longitudinal Direction At The Bottom Of The Slope, And Backfill With Rock To The Top Of The Excavation As Soon As Possible. Sequence Construction As Shown. Complete The Back Filling Of Each 40 Ft. Section Within 24 Hours After Beginning Excavation In That Section.

Maintain Positive Drainage Away From All Areas At Toe Of Dam.

Estimated Material Quantities:

The Following Quantities Are Provided As Engineering Budget Estimates Only And Not For Bid Purposes.

Soil Removed From Existing Dam And Proposed Keyway Totals Approximately 3,500 Cubic Yards, Or 22 Cubic Yards Per Foot Of Repair Length (Based From Approximate 157' Of Repair Area Shown).

Stone Backfill Totals Approximately 6,200 Cubic Yards Or 9,600 Tons At 115 Pounds Per Cubic Foot, Or 61 Tons Per Foot Of Repair Length (Based From Approximate 157' Of Repair Area Shown).

Geotextile Fabric Coverage Area Approximately 17,500 Sf - Not Accounting For Lapping Of Fabric.

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DRAWN BY P. BRYANT

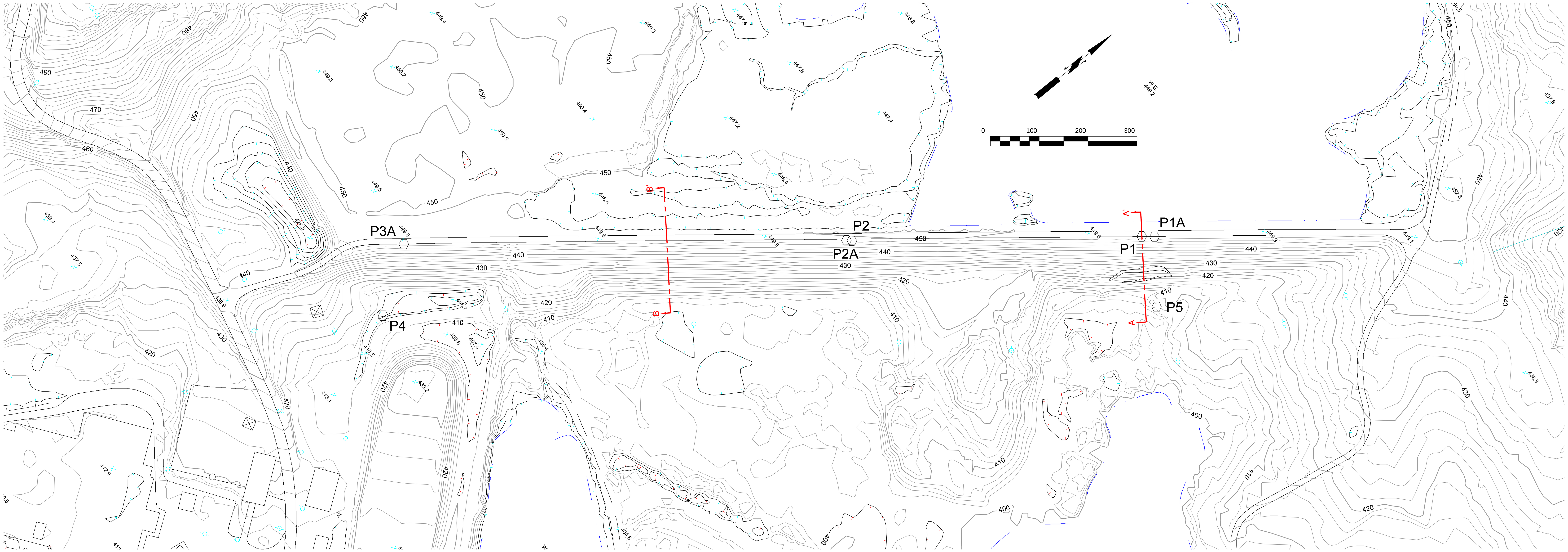
CHECKED BY D. DUNBAR

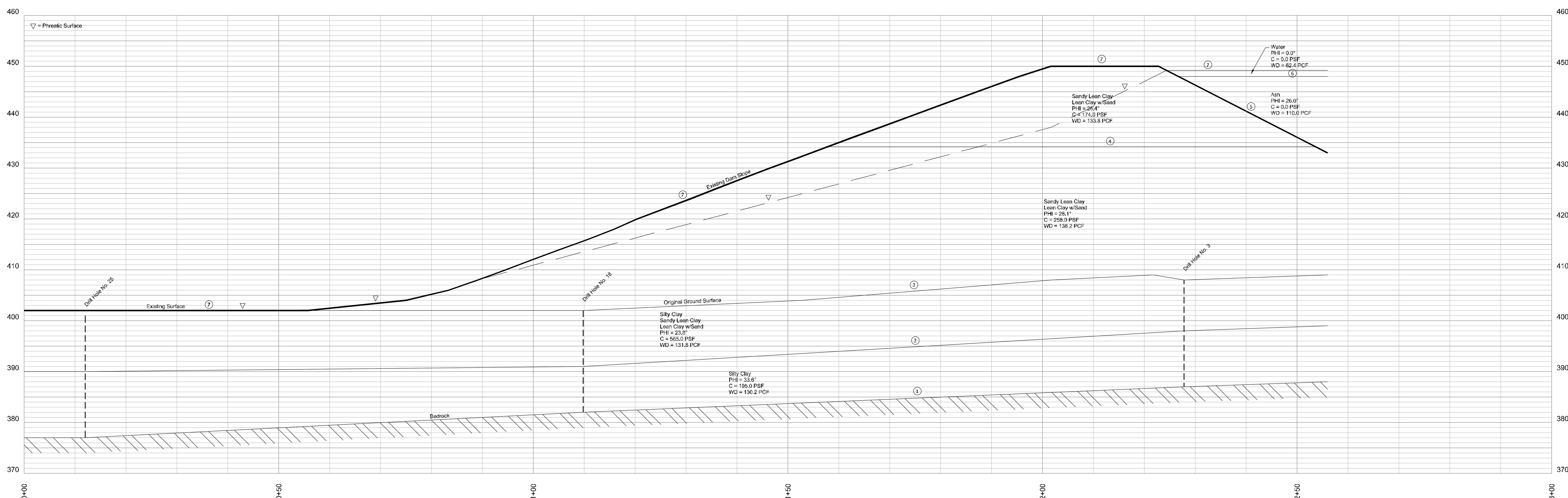
DATE 01/24/2011

EON U.S. GREEN RIVER STATION MAIN ASH POND SLOPE REPAIR PLAN

SHEET NUMBER

2 of 8





CROSS SECTION B-B'
LONG TERM STEADY SEEPAGE
Horiz: 1" = 10'
Vert: 1" = 10'

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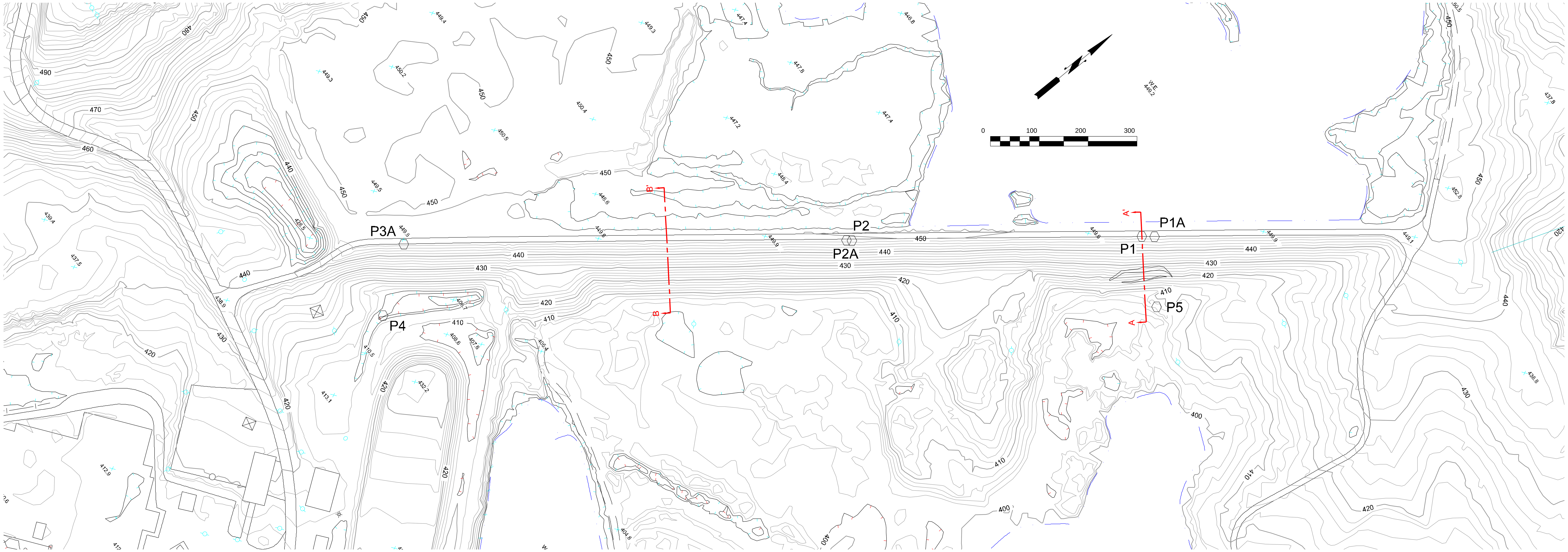
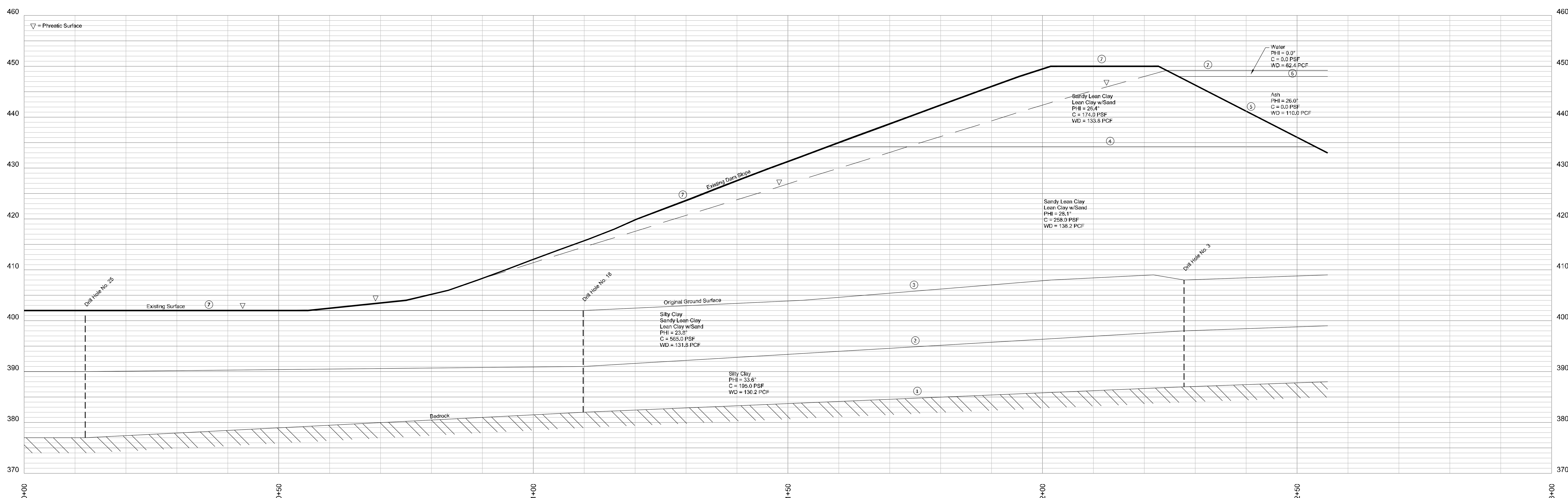
09-0364J	P. BRYANT	D. DUNBAR	01/24/2011

EON U.S. GREEN RIVER STATION
MAIN ASH POND
CROSS SECTION B-B'

SHEET NUMBER
3 of 8





CROSS SECTION B-B'
POND FULL CONDITION
Horz: 1" = 10'
Vert: 1" = 10'

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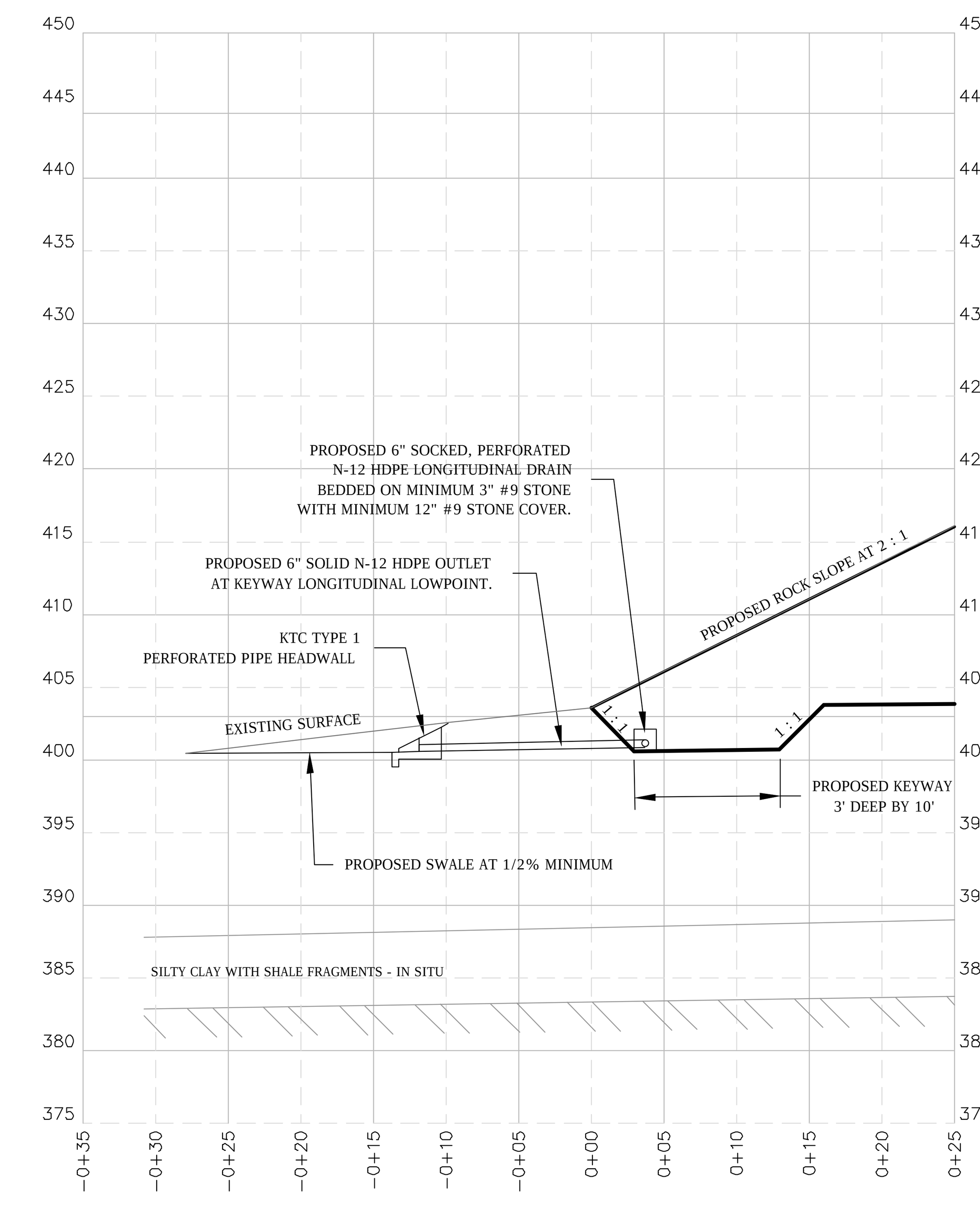
DRAWN BY	P. BRYANT
CHECKED BY	D. DUNBAR
DATE	01/24/2011

EON U.S. GREEN RIVER STATION
MAIN ASH POND
CROSS SECTION B-B'

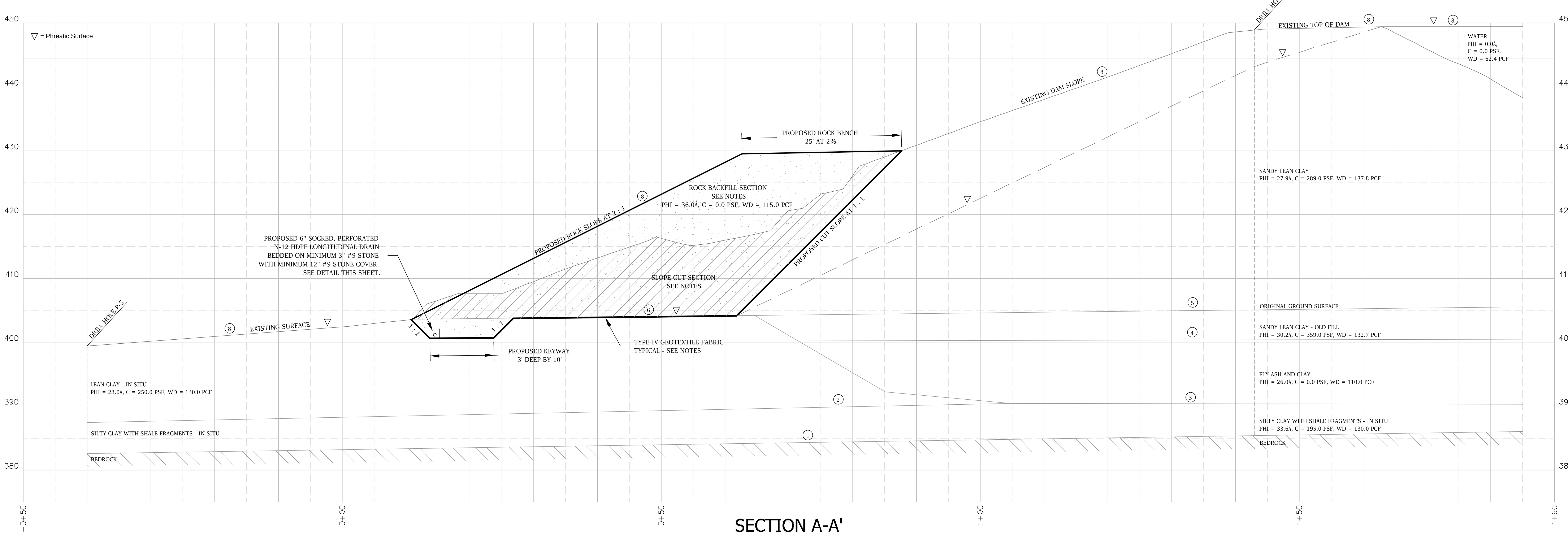
PLAN VIEW

SCALE: 1" = 10'



UNDER DRAIN DETAIL

SCALE: 1" = 10'



SECTION A-A'
25' ROCK BENCH
POND FULL CONDITION

H: 1" = 10' V: 1" = 10'

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CHECKED BY	D. DUNBAR
DATE	01/24/2011

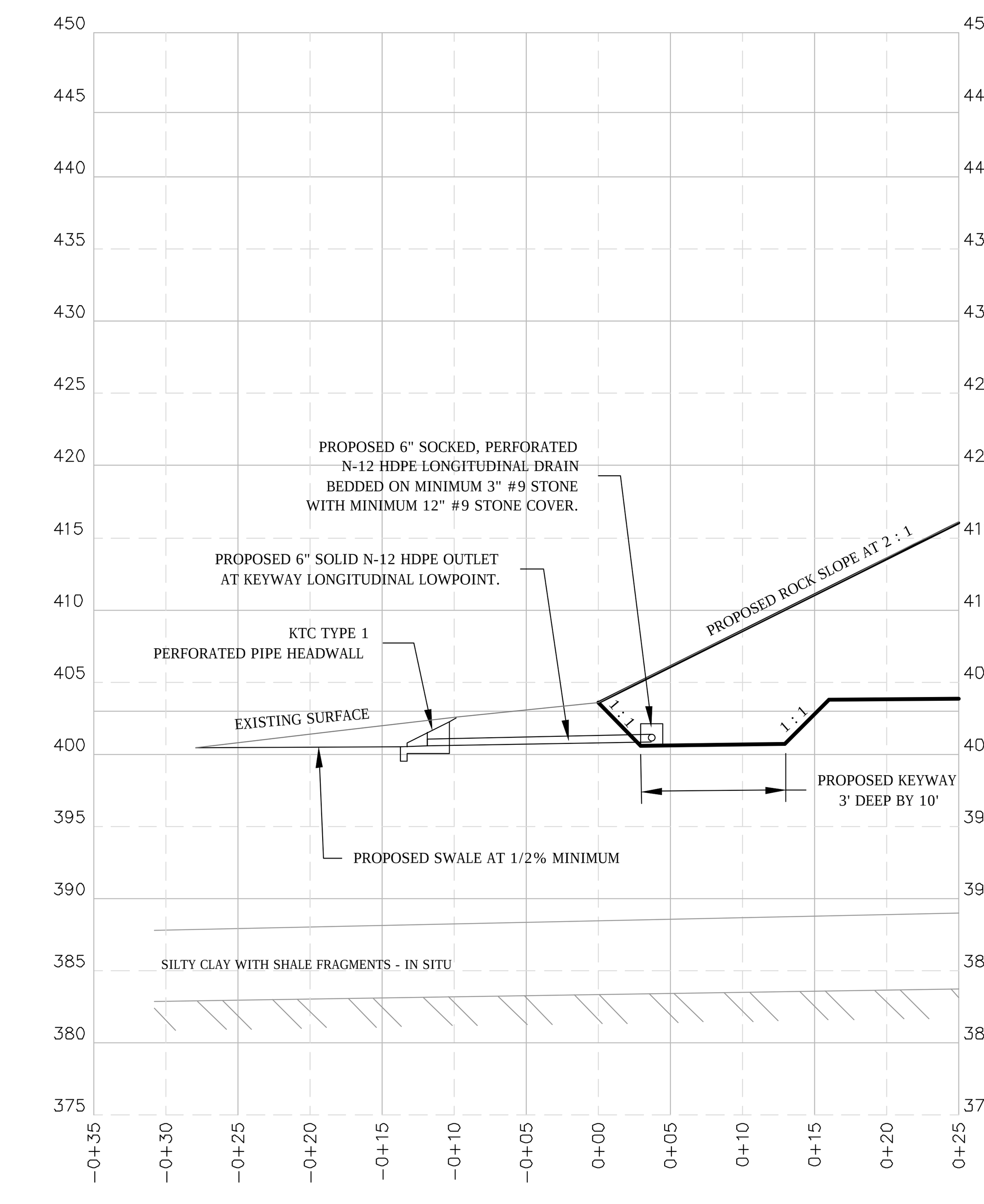
EON U.S. GREEN RIVER STATION
MAIN ASH POND
SLOPE REPAIR PLAN

SHEET NUMBER

5 of 8

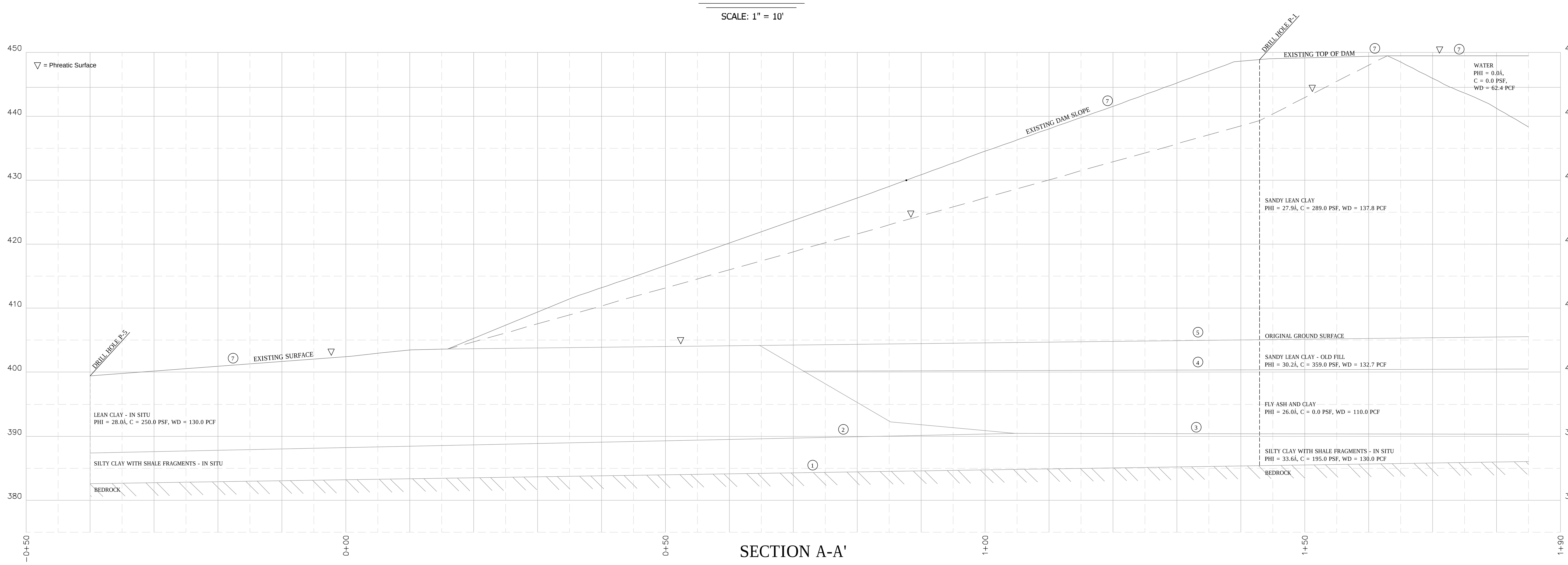
PLAN VIEW

SCALE: 1" = 10'



UNDER DRAIN DETAIL

SCALE: 1" = 10'



SECTION A-A'

EXISTING CONDITION (WITHOUT SLOPE FAILURE)

LONG TERM STEADY SEEPAGE

H: 1" = 10' V: 1" = 10'

Notes:

Place Geotextile Fabric, Type Iv On Excavated Soil Area Meeting The Requirements Of Section 843, Type IV, Of The Current Edition Of Kentucky Dot, Standard Specifications For Road And Bridge Construction. Install Geotextile Fabric According To Section 214 Of The Standard Specifications For Road And Bridge Construction. Prepare The Surface To A Smooth Condition, Free Of Obstructions, Debris, Or Sharp Objects That May Puncture The Fabric. Place The Fabric Smooth And Free Of Tension, Stress, Folds, Wrinkles, Or Creases. Do Not Operate Equipment Directly On The Fabric. Overlap Strips At Least 18 Inches. Place Transverse Laps So The Upslope Strip Laps Over The Downslope Strip. Install Fastener Pins Through Both Strips Of Overlapped Fabric At No Less Than 5-foot Intervals Along A Line Through The Midpoint Of The Overlap, And At Any Other Locations As Necessary To Prevent Any Slippage Of The Fabric. Place Fabric With The Long Dimension Parallel To The Long Dimension Of The Section To Be Covered.

Use Kentucky Coarse Aggregate No. 2's, 3's, Or 23's Meeting The Requirements Of Sections 703 And 805 Of The Standard Specifications For Road And Bridge Construction (Current Edition).

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Maintain Positive Drainage Away From All Areas At Toe Of Dam.

Estimated Material Quantities:

The Following Quantities Are Provided As Engineering Budget Estimates Only And Not For Bid Purposes.

Soil Removed From Existing Dam And Proposed Keyway Totals Approximately 3,500 Cubic Yards, Or 22 Cubic Yards Per Foot Of Repair Length (Based From Approximate 157' Of Repair Area Shown).

Stone Backfill Totals Approximately 6,200 Cubic Yards Or 9,600 Tons At 115 Pounds Per Cubic Foot, Or 61 Tons Per Foot Of Repair Length (Based From Approximate 157' Of Repair Area Shown).

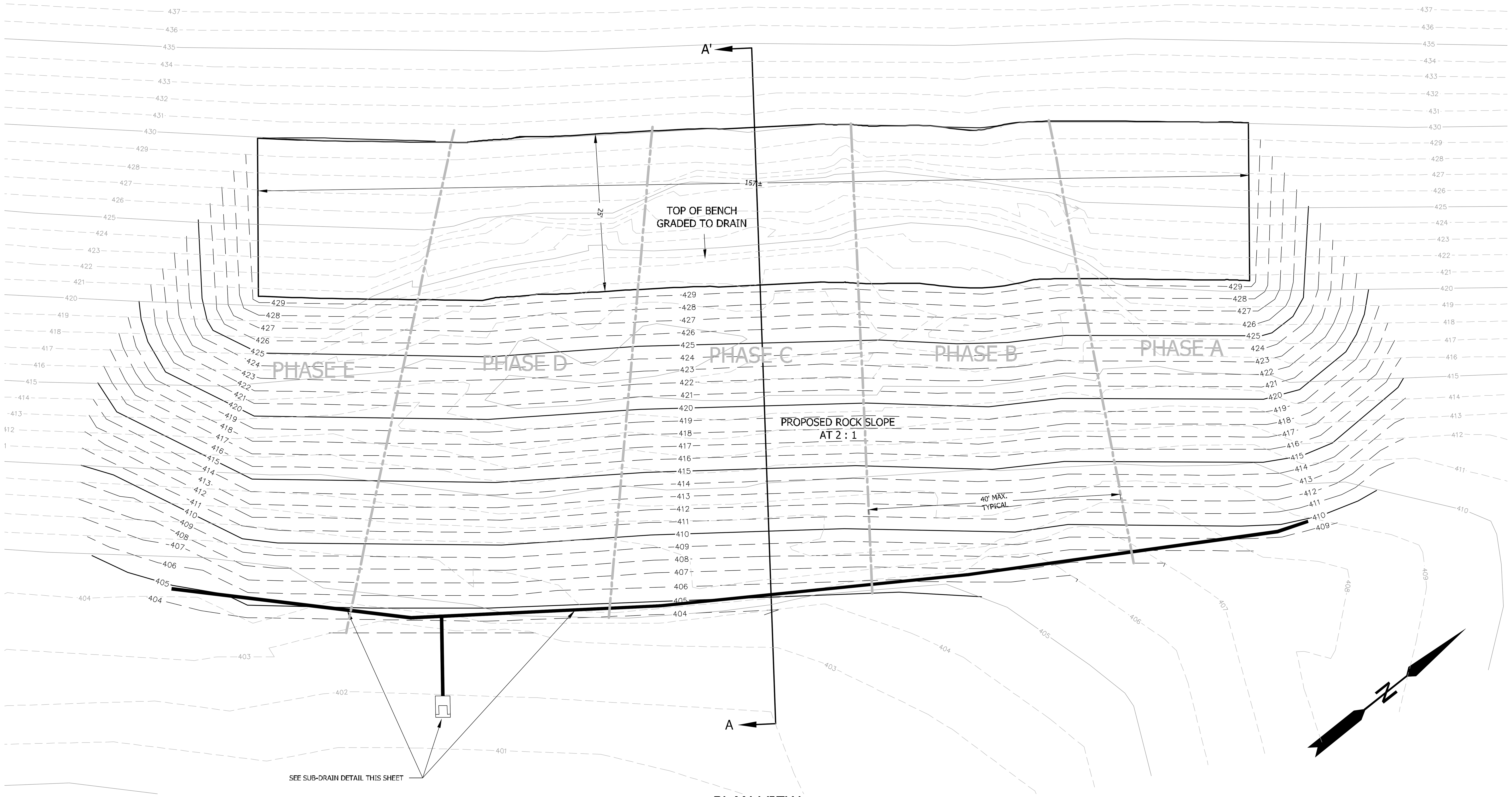
Geotextile Fabric Coverage Area Approximately 17,500 Sf - Not Accounting For Lapping Of Fabric.

ASSOCIATED ENGINEERS, INC.
ENGINEERS • GEOLOGISTS • SURVEYORS
2740 North Main St. • Madisonville, KY 42431 | 1001 Frederica St. • Owensboro, KY 42301
Phone: (270) 821-7732 • Fax: (270) 821-7789 | Phone: (270) 684-8450 • Fax: (270) 684-8449
www.associatedengineers.com

JOB NUMBER	09-0364J
DRAWN BY	P. BRYANT
CHECKED BY	D. DUNBAR
DATE	01/24/2011

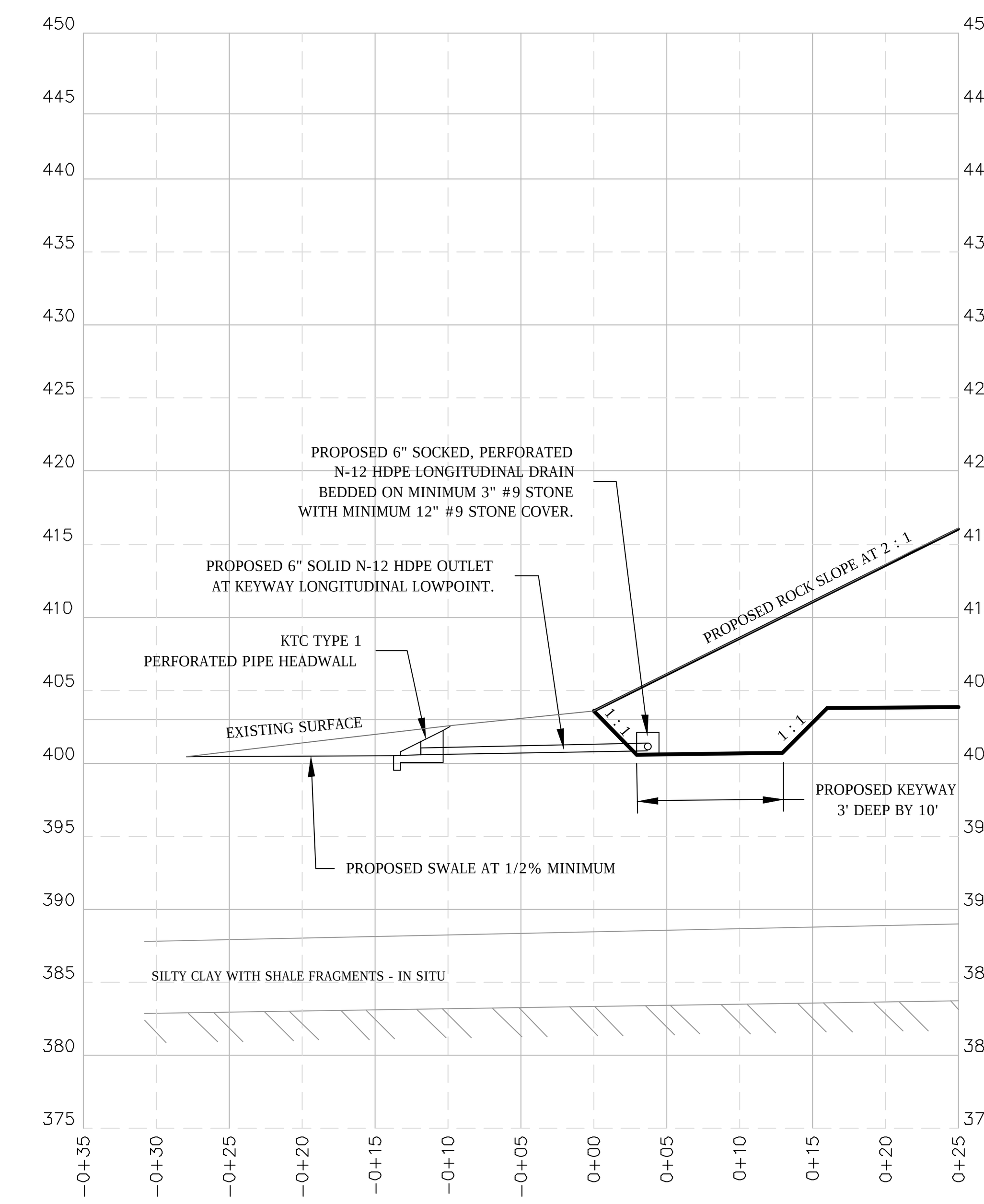
EON U.S. GREEN RIVER STATION
MAIN ASH POND
SLOPE REPAIR PLAN

SHEET NUMBER



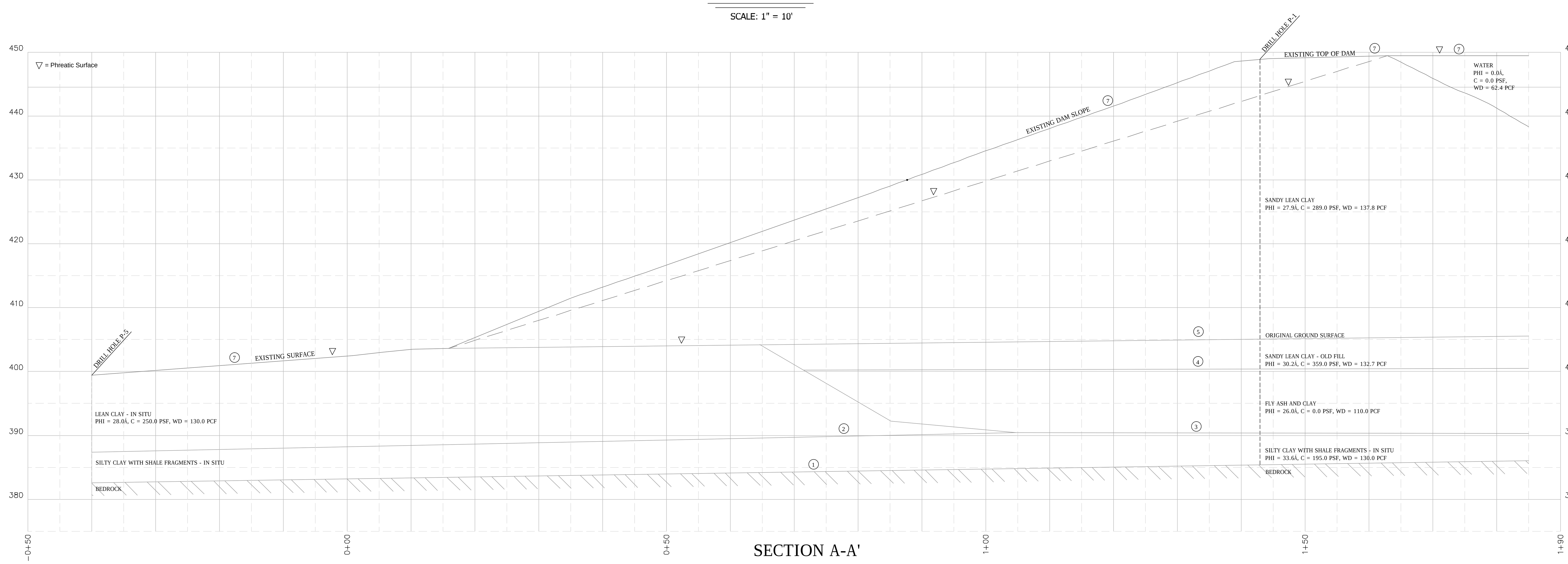
PLAN VIEW

SCALE: 1" = 10'



UNDER DRAIN DETAIL

SCALE: 1" = 10'



SECTION A-A'

EXISTING CONDITION (WITHOUT SLOPE FAILURE)

POND FULL CONDITION

H: 1" = 10' V: 1" = 10'

Notes:

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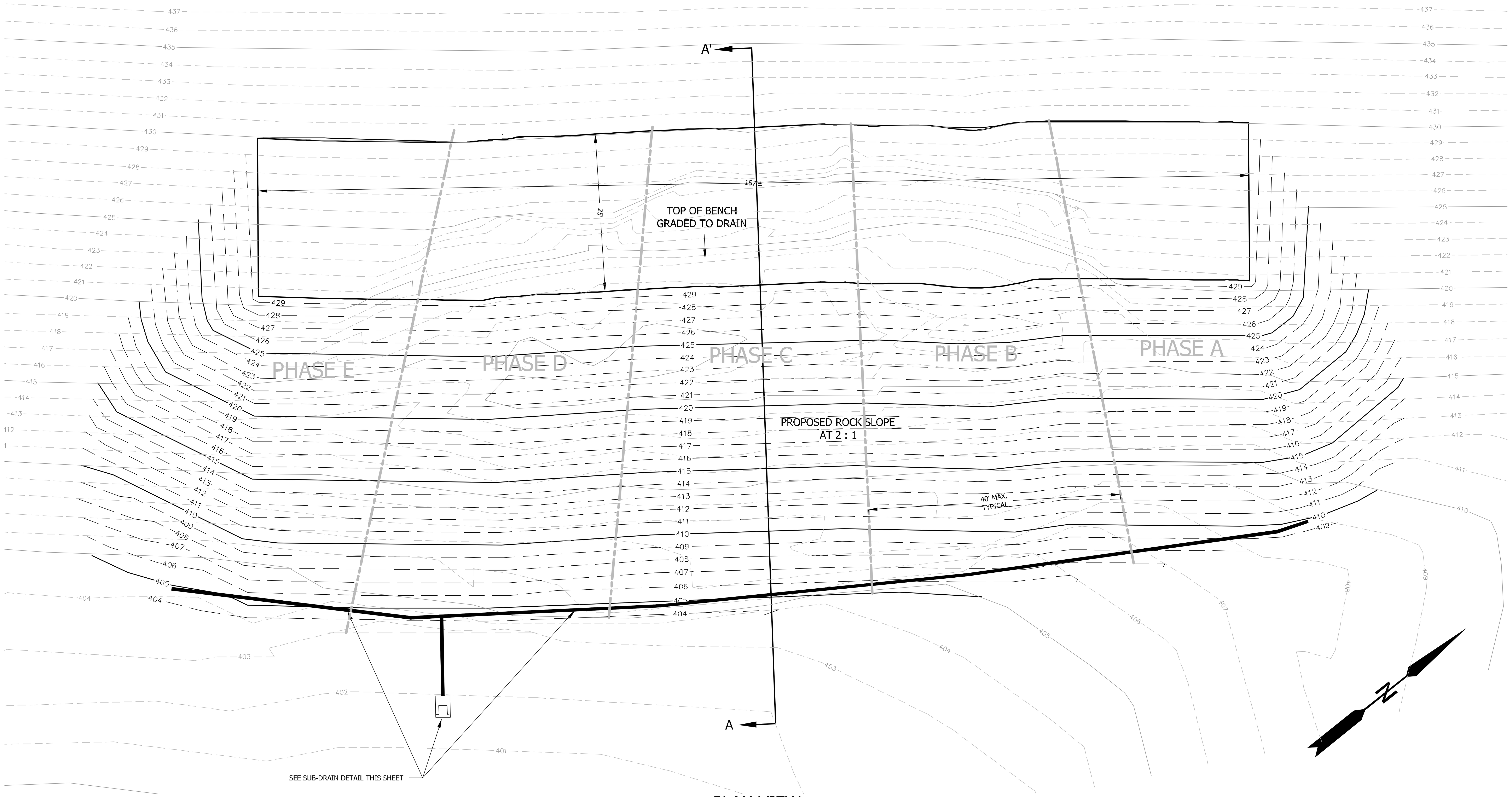
JOB NUMBER	09-0364J
DRAWN BY	P. BRYANT
CHECKED BY	D. DUNBAR
DATE	01/24/2011

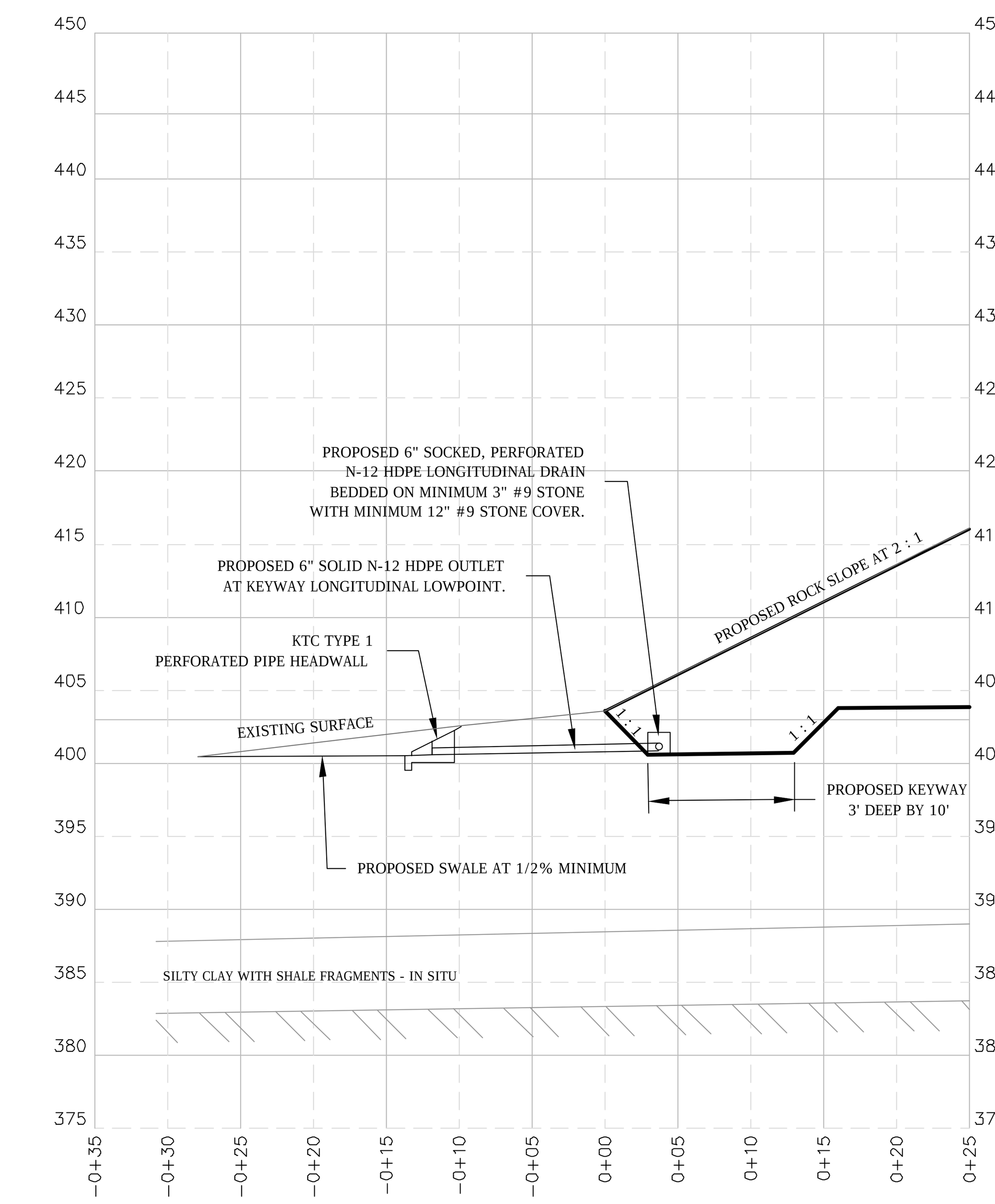
EON U.S. GREEN RIVER STATION MAIN ASH POND SLOPE REPAIR PLAN

SHEET NUMBER



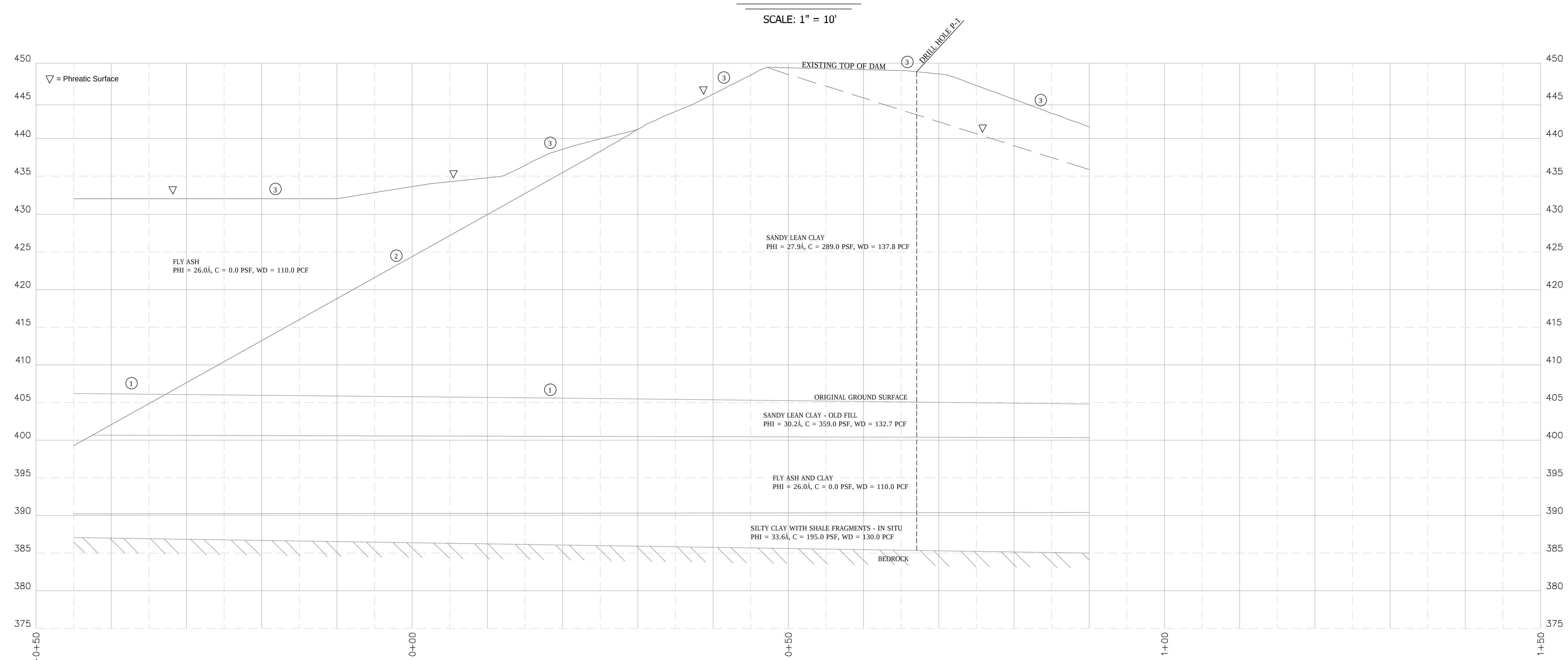
PLAN VIEW

SCALE: 1" = 10'



UNDER DRAIN DETAIL

SCALE: 1" = 10'



SECTION A-A'

RAPID DRAWDOWN

H: 1" = 10' V: 1" = 10'

Notes:

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ENGINEERS • GEOLOGISTS • SURVEYORS

JOB NUMBER	09-0364J
DRAWN BY	P. BRYANT
CHECKED BY	D. DUNBAR
DATE	01/24/2011

EON U.S. GREEN RIVER STATION
MAIN ASH POND
SLOPE REPAIR PLAN

<u>Attachment 5</u>

Cover pages, cover letter, appendices A and B of
2011 Pond Inspections Visual Site Assessment Report Six Impoundment Facilities

January 25, 2011
ATC Associates, Inc.

2011 POND INSPECTIONS
VISUAL SITE ASSESSMENT REPORT
SIX IMPOUNDMENT FACILITIES

KU GREEN RIVER STATION
KU PINEVILLE STATION
KU TYRONE STATION

LG&E AND KU SERVICES COMPANY

ATC PROJECT NO. 27.11000.1G37

JANUARY 25, 2011

PREPARED FOR:

LG&E AND KU SERVICES COMPANY
220 WEST MAIN STREET
LOUISVILLE, KENTUCKY 40202

ATTENTION: MR. DAVID MILLAY P.E.

2011 Pond Inspections
Visual Site Assessment Report
Six Impoundment Facilities

KU Green River Station
KU Pineville Station
KU Tyrone Station

LG&E and KU Services Company

ATC Project No. 27.11000.1G37

January 25, 2011

Prepared For:

LG&E and KU Services Company
220 West Main Street
Louisville, Kentucky 40202

Attention: Mr. David Millay P.E.

ATC ASSOCIATES INC.
Engineering Individual Solutions

11001 Bluegrass Parkway, Suite 250
Louisville, KY 40299
502-722-1401
Fax 502-267-4072
www.atcassociates.com

January 25, 2011

LG&E and KU Services Company
220 West Main Street
Louisville, Kentucky 40202
502-627-2468 office
502-693-0479 cell
David.Millay@lge-ku.com

Attention: Mr. David Millay P.E.
Civil Engineer

Re: **2011 Pond Inspections**
Visual Site Assessment Report
Six CCP Impoundment Facilities
KU Green River, KU Pineville, and KU Tyrone Stations
ATC Project No. 27.11000.1G37

Dear Mr. Millay:

ATC Associates Inc. (ATC) has completed Visual Site Assessments for a total of six Coal Combustion byProducts (CCP) pond facilities at the following power generation stations: four pond facilities at KU Green River Station, one pond facility at KU Tyrone Station, and one pond facility at KU Pineville Station. Previous assessments by ATC included one Finishing Pond at both the Tyrone and Green River Stations. The Finishing Ponds at both Tyrone and Green River were taken out of service in 2010 and no longer impound water. These ponds were not included during this assessment interval. This assessment report includes three pond facilities classified as "dams" by the Kentucky Energy and Environment Cabinet, Division of Water, Dam Safety Section (KDSS), and three ponds which are not classified and do not have a hazard rating or an identification number.

Our field observations were made during the month of January, 2011. These assessments were performed in general accordance with safety inspection protocols published in "Guidelines for Maintenance and Inspection of Dams in Kentucky" prepared by the Kentucky Natural Resources and Environmental Protection Cabinet, Division of Water, dated July 1985.

Report Terminology
The following terminology will be utilized in this report:

Pond: A facility consisting of an excavation, a soil embankment or a combination of both that impounds water or solids. A pond is typically composed of an area impounding water, an excavation slope or an impounding embankment and a spillway to discharge water. Descriptions of various pond configurations used by the US EPA are shown on Figure 1 (Appendix A); these descriptions will be utilized in this Assessment Report.

Embankment: A compacted earthen mound placed under controlled conditions that serve to impound water or solids. An embankment could be classified as either a dam or a berm depending of the height and volume of material retained.

Dam: An embankment that impounds water or solids that meets the KRS 151 definition. In general a dam is 25 or more feet in height or has an impounding capacity of fifty or more acre-feet at the lowest point on the top of the dam. Height is measured from the natural bed of the stream or watercourse at the downstream toe of the embankment to the low point in the top of the dam.

Berm: An embankment that impounds water or solids that does not meet the KY Department for Natural Resources and Environmental Protection definition of a dam.

Assessment Activities

The scope of these assessments was limited to an examination of readily observable surficial features of the ponds and a review of information provided to us. Our field team was accompanied by LG&E/KU. representatives at each site visit. Our assessments did not include any test drilling, material testing, precise physical measurements of pond features, detailed calculations to verify spillway capacities or embankment stability, or other engineering analyses. Although the visual assessments were conducted by experienced personnel in accordance with generally accepted methods, the assessments should not be considered as a warranty or guaranty of the future safety of the facilities.

All the ponds addressed by this assessment were located at existing or former power stations and generally consisted of an excavated pond enclosed on one or more sides with an earthen embankment. The ponds generally receive minimal storm water runoff, with the majority of water inflow resulting from the sluicing of CCP and other power generation process water into the impoundments. **Table 1** summarizes the facilities assessed by ATC during this phase of work.

Table 1- Summary of Assessed Ponds

		Pond Type $_1$	**Secondary Spillway Present**	**No. Findings: 2011 Inspection**	**Condition Rating 2011 Inspection** $_2$
Green River	Main Ash Pond	Side Hill	No	10	F
	Scrubber Pond	Side Hill/Diked	No	5	F
	Number 2 Pond	Side Hill	No	4	F
	Coal Runoff Pond	Side Hill	No	6	F
Pineville	Ash Pond	Side Hill	No	8	F
Tyrone	Ash Pond	Side Hill/Incised	No	14	F

S – Satisfactory
F – Fair
CP- Conditionally Poor
P – Poor
U – Unsatisfactory

Note 1: See Appendix A
Note 2: See Pond Assessment Forms

This summary report includes the following items for each pond assessed:

- Site Vicinity Map
- Findings and Recommendations Table
- Dam Assessment Form
- Photographs
- Site Plan with Photographs
- Site Plan with GPS Locations and Field Observations

Findings and Recommendations

The findings and recommendations summarized in the appendices to this report are grouped by Power Station and by pond facility. The findings and recommendations are categorized with a priority level of High, Moderate, or Normal (described in "Findings and Recommendations" Tables).

The recommendations provided in the Findings and Recommendations Tables are specific to each pond facility; however, we have developed four general recommendations that apply to all the facilities.

1. Prepare or update an Operation and Maintenance Manual for each facility. The manual will allow rapid assessments of any variations in the day to day operation of each facility, will assist in troubleshooting problems, and will provide a source of data for future plant personnel responsible for the management of the facility. **Normal Priority**

2. Continue regular facility inspections. These inspections will allow changes in the facility to be observed in a timely fashion and allow preventative measures to be taken as part of regular maintenance rather than on an emergency basis. The personnel conducting the inspections should receive training on the proper inspection techniques, the specific items that should be inspected, the frequency of inspections and the documentation that is required. The inspection regime should also include a regular (yearly) assessment by either outside consultants or LG&E and KU corporate personnel not routinely assigned to a power station. **High Priority**

3. Determine for each pond the maximum pool level that can be safely maintained to provide adequate freeboard capacity with the existing spillway configurations. The maximum elevation should then be surveyed and marked on each spillway inlet. Documentation of the maximum allowable water elevation should also be placed in the Operation and Maintenance Manual for each pond. **High Priority**

4. Evaluate each pond facility with an embankment to determine whether a redundant method to prevent or safely control impounded water from overtopping the embankment crest is needed. The Findings and Recommendations page for each pond describes whether the ponds have emergency or secondary spillways. Published literature indicates that progressive erosion of the embankment crest during an overtopping event is one of the most common causes of embankment failure. **Normal Priority**

Discussion

The appendices to this report contain a Findings and Recommendation Table for each pond assessed. Discussion and clarification of specific recommendations are provided below.

Three of the ponds addressed by this report are currently not classified by the KY Division of Water, Dam Safety Branch as "Dams", and therefore do not have a State Dam ID number. However 401 KAR 4:030, which is the regulation which dictates the engineering standards for "*dams and all other impounding obstructions which might create a hazard to life and/or property*", may apply to the three unclassified ponds, since most impound CCP or fluids using an obstruction and are not incised ponds.

Our Findings and Recommendations table for each structure include suggestions to "Evaluate" or "Monitor" specific items associated with each structure. In this report "Evaluate" should be interpreted to mean - additional data is required for a qualified individual such as an engineer to determine whether:

- Such an evaluation has been made previously,
- Past evaluations are valid for the current structure in its current configuration and use, and
- Additional engineering analyses are needed.

In this report "Monitor" should be interpreted to mean – observe that specific item during future follow-up assessments and during regular inspections to observe and document any changes noted from the preceding assessment.

We appreciate the opportunity to provide our assessment services to you. If you have any questions concerning information contained in this report, or if the condition of the facilities should change significantly from that described herein, please do not hesitate to call either of the undersigned.

Sincerely,

ATC Associates Inc.

Mark J. Schuhmann P.E.
Principal Engineer
KY License 12,500

Josh English, E.I.T.
Staff Engineer

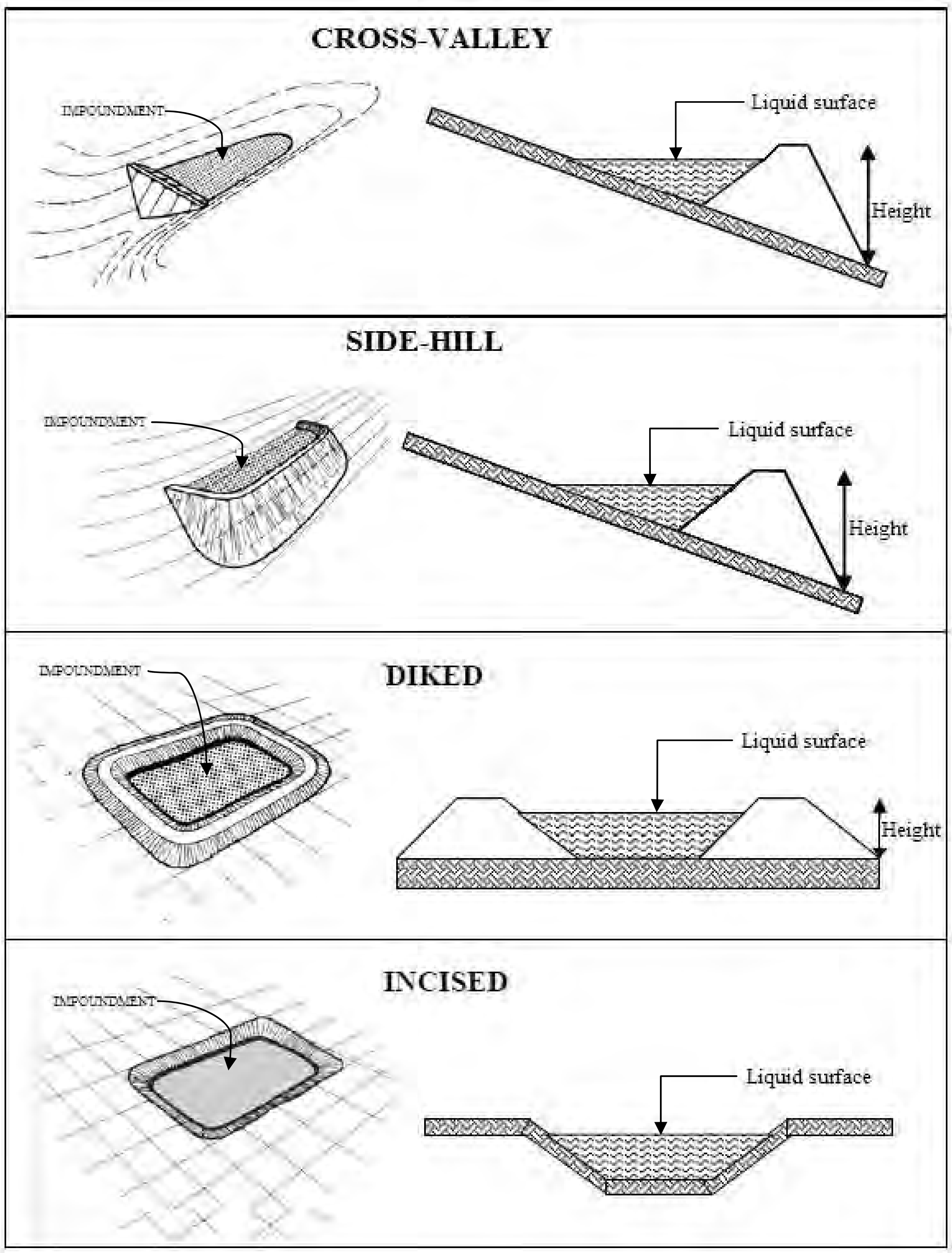
Appendix A
General Information

Appendix A
General Information

List of Contents

Item	Page Number
Pond Type Nomenclature	A-3
Dam Assessment Form	A-4
Memorandum #5 – Structure Classification	A-8

Pond Type Nomenclature



DAM/POND ASSESSMENT FORM

Name of Professional Conducting Inspection:	KY Professional License No.:
Company Name: ATC Associates Inc.	Phone:
Address:	
Inspection Preparation: Reviewed all pertinent technical documentation related to this dam and site in: the State's files Yes ☐ No ☐ ; and Owner's Files: Yes ☐ No ☐	
Comments:	

Dam/Pond Name:		Hazard Class:	Topographic Quad:	Date of Inspection:
State Dam ID:	County:	Latitude	Longitude	Last Inspection:

Power Station Name:					
Address:					
Site Contact:			Phone:		
Drainage Area (mi^2):	Surface Area(AC):	Height (Ft):	Crest Length (Ft):	Crest Width (Ft):	Crest Elevation
Slope (Ft): Interior: Exterior:	Principal Spillway Type:	Principal Spillway Size:	Spillway Control Elevation:	Feet Freeboard:	
CCP placed in Pond:	Emergency Spillway Type:	Emergency Spillway Size:	Spillway Control Elevation:	Feet Freeboard:	

FIELD CONDITIONS OBSERVED

CCP Above Crest:Yes:☐ None:☐	Location:	Max. Height above pool
Water Level (Below Dam Crest, Ft):		
Ground Moisture Condition: Dry ☐ Wet ☐ Snow cover ☐ Other:		
Monitoring: Yes ☐ None: ☐ (☐ Gage Rod ☐ Piezometers ☐Seepage Weirs ☐ Survey Monuments ☐ Other)		
Comments:		

A	**INTERIOR SLOPE**	**Problems Noted**: ☐ None ☐ Riprap – Missing, Sparse ☐ Wave Erosion ☐ Cracks ☐ Sinkholes ☐ Appears Too Steep ☐ Depressions or Bulges ☐ Slides ☐ Animal Burrows ☐ Trees, Bushes, Briars ☐ Other
GOOD	☐	**Comments**:
ACCEPTABLE	☐	
DEFICIENT	☐	
POOR	☐	
B	**CREST**	**Problems Noted**: ☐ None ☐ Ruts or Puddles ☐ Erosion ☐ Cracks ☐ Sinkholes ☐ Not Wide Enough ☐ Low Areas ☐ Misalignment ☐ Inadequate Surface Drainage ☐ Trees, Bushes, Briars ☐ Other
GOOD	☐	**Comments**:
ACCEPTABLE	☐	
DEFICIENT	☐	
POOR	☐	

CCP: Coal Combustion Products;
Spillway Size: Pipe Dia. for drop inlet; open channel width (typically emergency or (auxiliary) spillway) at the control section, Ft;.
Freeboard: vertical distance from the emergency spillway control section to the lowest point of the crest of the dam.

DAM/POND ASSESSMENT FORM

ATC ASSOCIATES INC.

C EXTERIOR SLOPE	**Problems Noted**: ☐ None ☐ Livestock Damage ☐ Erosion, Gullies ☐ Cracks ☐ Sinkholes ☐ Appears Too Steep ☐ Depression or Bulges ☐ Slide ☐ Soft Areas ☐ Trees, Bushes, Briars ☐ Animal Burrows ☐ Other
GOOD ☐ ACCEPTABLE ☐ DEFICIENT ☐ POOR ☐	**Comments**:

D SEEPAGE	**Problems Noted**: ☐ None ☐ Saturated Embankment Area ☐ Seepage Exits on Embankment ☐ Seepage Exits at Point Source ☐ Seepage Area at Toe ☐ Flow Adjacent to Outlet
GOOD ☐	**If Seepage**: ☐ Clear ☐ Muddy
ACCEPTABLE ☐	**Drain Outfalls Seen**: Yes ☐ No ☐ Flow: ☐ Clear ☐ Muddy ☐ Dry ☐ Obstructed
DEFICIENT ☐ POOR ☐	**Comments**:

E PRINCIPAL SPILLWAY	**Description**:
GOOD ☐ ACCEPTABLE ☐	**Problems Noted**: ☐ None ☐ Deterioration ☐ Separation ☐ Cracking ☐ Inlet, Outlet Deficiency ☐ Stilling Basin Inadequacies ☐ Trash Rack ☐ Other
DEFICIENT ☐ POOR ☐	**Comments**:

F AUXILIARY SPILLWAY	**Description**:
GOOD ☐ ACCEPTABLE ☐ DEFICIENT ☐ POOR ☐	**Problems Noted**: ☐ None ☐ No Auxiliary Spillway Found ☐ Erosion with Backcutting ☐ Crack with Displacement ☐ Appears to be Structurally Inadequate ☐ Appears too Small ☐ Inadequate Freeboard ☐ Flow Obstructed ☐ Concreted Deteriorated/Undermined ☐ Other
	Comments:

G MAINTENANCE AND REPAIRS	**Problems Noted**: ☐ None ☐ Access Road Needs Maintenance ☐ Cattle Damage ☐ Spillway Obstruction ☐ Vegetation on Interior Slope, Crest, Exterior Slope, Toe ☐ Trees on Interior Slope, Crest, Exterior Slope, Toe ☐ Rodent Activity on Interior Slope, Crest, Exterior Slope, Toe ☐ Deteriorated Concrete –Facing, Outlet, Spillway ☐ Gate and/or Drawdown Need Repair ☐ Other
GOOD ☐ ACCEPTABLE ☐ DEFICIENT ☐ POOR ☐	
	Comments:

H IMPOUNDMENT AREA	**Problems Noted**: ☐ None ☐ Ponded Water within Ash ☐ Ash blocking spill way ☐ Signs of damage from dredging ☐ Ash deposits in spillway ☐ Other
GOOD ☐	
ACCEPTABLE ☐	**Impoundment receives surface water runoff in addition to sluiced ash**: Yes ☐ No ☐
DEFICIENT ☐	**Release of ponded water could cause overtopping of dam**: Yes ☐ No ☐ N/A ☐
POOR ☐	**Comments**:

DAM/POND ASSESSMENT FORM

I OVERALL CONDITIONS		Comments:
SATISFACTORY	☐	
FAIR	☐	
CONDITIONALLY POOR	☐	
POOR	☐	
UNSATISFACTORY	☐	

Summary of Findings and Recommendations in Attached Table

This visual dam assessment was conducted to assess the general overall condition of the reservoir/ash pond/dam, identify visible deficiencies, and recommend areas for monitoring, additional investigative studies and corrective actions. The assessment is based only on visible features/areas of the dam on the day of inspection; it does not constitute a formal safety inspection nor a review or evaluation from each specialist of an inspection team, such as geologists, civil, geotechnical, structural, or hydraulics engineer. The owner should verify the findings of this report and take corrective actions. This assessment does not relieve the owner/operator from their responsibility to conduct routine inspections, maintenance, repairs, modifications, monitoring, documentation, and/or investigative studies.

Professional Engineer's Signature: ________________________________ Date: __________

Reviewed by: ____ Date: __________

Owner/Owner Representative Signature

DAM/POND ASSESSMENT FORM

POND CONDITION GUIDELINES

Conditions Observed – Applies to Interior Slope, Crest, Exterior Slope, Principal Spillway , Auxiliary Spillway and Impoundment area			
Good In general, this part of the structure has a good appearance, and conditions observed in this area do not appear to threaten the safety of the dam	**Acceptable** Although general cross-section is maintained, surfaces may be irregular, eroded, rutted, spalled, or otherwise not in new conditions. Conditions in this area do not currently appear to threaten the safety of the dam.	**Deficient** Continued deterioration and/or unusual loading may threaten the safety of the dam.	**Poor** Conditions observed in this area appear to threaten the safety of the dam. Conditions observed in this area are unacceptable.
Conditions Observed – Applies to Seepage			
Good No evidence of uncontrolled seepage. No unexplained increase in flows from designed drains. All seepage is clear. Seepage conditions do not appear to threaten the safety of the dam.	**Acceptable** Some seepage exposits at areas other than drain outfalls, or other designed drains. No unexplained increase in flows from designed drains. All seepage is clear. Seepage conditions observed do not currently appear to threaten the safety of the dam.	**Deficient** Excessive seepage exists at areas other than drain outfalls and other designed drains. Seepage needs to be evaluated; increase flow and/or continued deterioration in seepage conditions may threaten the safety of the dam.	**Poor** Excessive seepage conditions observed appear to threaten the safety of the dam and is unacceptable. Examples: 1) Designed drain or seepage flow have increased without increase in reservoir level. 2) Drain or seepage flows contain sediment. 3) Widespread seepage, concentrated seepage or ponding appears to threaten the safety of the dam.
Conditions Observed – Applies to Maintenance and Repair			
Good Dam appears to receive effective on-going maintenance and repair, and only a few minor items may need to be addressed.	**Acceptable** Dam appears to receive maintenance, but some maintenance items need to be addressed. No major repairs are required.	**Deficient** Level of maintenance of the dam needs significant improvement. Major repairs may be required. Continued neglect of maintenance may threaten the safety of the dam.	**Poor** Dam does not receive adequate maintenance. One or more items needing maintenance or repair have begun to threaten the safety of the dam. Level of maintenance is unacceptable.

Overall Conditions				
Satisfactory No existing or potential dam safety deficiencies recognized. Safe performance is expected under all anticipated loading conditions, including such events as infrequent hydrologic and/or seismic events. Project files contain necessary hydrologic and other engineering calculations to verify dam safety and performance.	**Fair** No existing dam safety deficiencies are recognized for normal loading conditions. Infrequent hydrologic and/or seismic events would probably result in a dam safety deficiency.	**Conditionally Poor** A potential safety deficiency is recognized for unusual loading conditions which may realistically occur during the expected life of the structure. This designation may also be used when uncertainties exist as to critical analysis parameters which identify a potential dam safety deficiency; further investigations and studies are necessary.	**Poor** A potential dam safety deficiency is clearly recognized for normal loading conditions. Immediate actions to resolve the deficiency are recommended; reservoir restrictions may be necessary until problem resolution.	**Unsatisfactory** A dam safety deficiency exists for normal conditions. Immediate remedial action is required for problem resolution.

SECTION B - STRUCTURE CLASSIFICATION

In determining structure classification, a number of factors must be considered. Consideration must be given to the damage that might occur to existing and future developments downstream resulting from a sudden breach of the earth embankment and the structures themselves. The effect of failure on public confidence is an important factor. State and local regulations and the responsibility of the involved public agencies must be recognized. The stability of the spillway materials, the physical characteristics of the site and valley downstream, and the relationship of the site to industrial and residential areas all have a bearing on the amount of potential damage in the event of a failure.

Structure classification is determined by the above conditions. It is not determined by the criteria selected for design.

1. CLASS OF STRUCTURES

The following broad classes of structures are established to permit the association of criteria with the damage that might result from a sudden major breach of the structure.

A. Class (A) - Low Hazard

This classification may be applied for structures located such that failure would cause loss of the structure itself but little or no additional damage to other property. Such structures will generally be located in rural or agricultural areas where failure may damage farm buildings other than residences, agricultural lands, or county roads.

B. Class (B) - Moderate Hazard

This classification may be applied for structures located such that failure may cause significant damage to property and project operation, but loss of human life is not envisioned. Such structures will generally be located in predominantly rural agricultural areas where failures may damage isolated homes, main highways or major railroads, or cause interruption of use or service of relatively important public utilities.

C. Class (C) - High Hazard

This classification must be applied for structures located such that failure may cause loss of life, or serious damage to houses, industrial or commercial buildings, important public utilities, main highways or major railroads. This classification must be used if failure would cause probable loss of human life.

The responsible engineer shall determine the classification of the proposed structure after considering the characteristics of the valley below the site and probable future development. Establishment of minimum criteria does not preclude provisions for greater safety when deemed necessary in the judgment of the engineer. Considerations other than those mentioned in the above classifications may make it desirable to exceed the established minimum criteria. A statement of the classification established by the responsible engineer shall be clearly shown on the first sheet of the plans.

II. STRUCTURES IN SERIES

When structures are spaced so that the failure of an upper structure could endanger the safety of a lower structure, the possibility of a multiple failure must be considered assigning the structure classification of the upstream structure.

Additional safety can be provided in either structure by (1) increasing the retarding storage and/or (2) increasing the emergency spillway capacity.

Appendix B
KU Green River Station

Appendix B
KU Green River Station

List of Contents

Item	Page Number
Site Vicinity Map	**B-3**
Main Pond	**B-4**
Scrubber Pond	**B-19**
Number 2 Pond	**B-29**
Coal Runoff Pond	**B-40**

ATC ASSOCIATES INC.
11001 Bluegrass Parkway, Suite 250
Louisville, KY 40299
(502) 722-1401

PROJECT NO: 27.11000.1G37		
DESIGNED BY: RR	SCALE:N/A	REVIEWED BY: JE
DRAWN BY: RR	DATE: 1/17/11	FIGURE: B-1

SITE VICINITY MAP

KU GREEN RIVER STATION
LG&E and KU 2011 Pond Inspections
Moorman, KY

Map provided by mapquest.com

Findings and Recommendations

Plant: **Green River**
Structure: **Main Pond**
State ID# **803**
Field date: **1/14/2011**

Item #	Priority Rating	GPS Point	Photo #	Location Description	Action Item
1	High	G13	7	Principal Spillway	Clearly mark highest allowable stoplog elevation on principal spillway inlet. Elevation to be determined by others. Include instruction in Operation manual for pond.
2	Moderate	G10, G11, G12	2	Exterior Slope	Repair and re-establish vegetation in areas reworked in fall of 2010, numerous locations.
3	Moderate	G1	3	Toe	Enlarge and armor remaining portion of groin ditch on west end of south embankment below culvert outlet.
4	Moderate	G3	3, 13	Toe	Rework culvert inlet at exterior toe, west side of south embankment. Culvert inlet is clogged with vegetation.
5	Moderate	G2, G10	4	Toe	Evaluate presence of wet areas on south embankment including area near piezometer P2A, monitor for changes in seepage. Piezometer showing piezometeric head 2 feet above ground level at toe.
6	Moderate	G8	14	Toe	Repair concrete culvert inlet at coal pile storage area. Inlet is crushed and partially clogged with loose coal.
7	Moderate	-	6	Toe	Rework drainage below new seep collection pipe outlet. Ditch below pipe outlet partially filled with loose coal allowing water to pond in outlet pipe. Mineral buildup in pipe will prevent drainage of collected seepage water.
8	Normal	G14	5	West Interior Slope	Add slope erosion protection along interior of west embankment where exposed to pond water.
9	Normal	G9	1	Interior Slopes	Move discharge for new ash line on east interior slope at least 10 feet from slope to prevent potential erosion to interior slope.
10	Normal	G11	11	Toe	Cut vegetation at toe of south embankment and 10 feet beyond toe.

Priority:
High - Recommend that action item be addressed as soon as possible
Moderate - Recommend that action item be addressed during next construction season
Normal - Recommend that action item be as part of ongoing maintenance of the structure

Location:
Crest, Toe, Abutment
Interior Slope, Exterior Slope
Principal Spillway, Emergency Spillway

DAM ASSESSMENT FORM

Name of Professional Conducting Inspection: Mark J. Schuhmann, P. E.	KY Professional License No.: 12,500
Company Name: ATC Associates, Inc.	Phone: 502-722-1401
Address: 11001 Bluegrass Parkway, Suite 250, Louisville, KY 40299	
Inspection Preparation: Reviewed all pertinent technical documentation related to this dam and site in: the State's files Yes ☐ No ☒ ; and Owner's Files: Yes ☒ No ☐	
Comments: Side Hill Construction. Significant improvements made to dam since last ATC inspection in 2009. Piezometers installed in 2010, stabilization berm added at downstream toe east of plant process water outfall to pond, groin ditches added.	

Dam/Pond Name: **Green River Main Ash Pond**		Hazard Class: Low	Topographic Quad: Central City East	Date of Inspection: 1/14/11
State Dam ID: 803	County: Muhlenberg	Latitude: 37º 22' 7.00"	Longitude: 87º 7' 14.00"	Last ATC Inspection: 10/28/09

Power Station Name: **KU Green River Station**					
Address: 811 Power Plant Road, Central City, KY 42330					
Site Contact: Travis Harper			Phone: 270-757-6105		
Drainage Area (AC): 71	Surface Area(AC): 32	Height (Ft): 50	Crest Length (Ft): 2700	Crest Width (Ft): 20	Crest Elevation(Ft): 450
Slope (H:V): Interior: 1.7:1 Exterior: 2.5:1	Principal Spillway Type: Concrete drop Inlet with stop logs	Principal Spillway Size: 36 inches	Spillway Control Elevation(Ft): varies	Freeboard (Ft): 5.5 feet at spillway	
CCP placed in Pond: Bottom Ash, Fly Ash, Pyrites	Emergency Spillway Type: None	Emergency Spillway Size: N/A	Spillway Control Elevation: N/A	Freeboard(Ft): N/A	

FIELD CONDITIONS OBSERVED

CCP Above Crest:Yes:☒ None:☐	Location: Dry stacking area located at west and northeast end of pond	Max. Height above pool(Ft): 10
Water Level (Below Dam Crest, Ft): 5.5		
Ground Moisture Condition: Dry ☐ Wet ☒ Snow cover ☒ Other:		
Monitoring: Yes ☒ None: ☐ (☐ Gage Rod ☒ Piezometers ☐Seepage Weirs ☐ Survey Monuments ☒ Other)		
Comments: *Piezometers installed in 2010 to monitor piezometric head.*		

A	**INTERIOR SLOPE**	**Problems Noted**: ☐ None ☒ Riprap – Missing, Sparse ☒ Wave Erosion ☐ Cracks ☐ Sinkholes ☐ Appears Too Steep ☐ Depressions or Bulges ☐ Slides ☐ Animal Burrows ☐ Trees, Bushes, Briars ☐ Other
GOOD	☐	***Comments***: *Interior embankments missing erosion and wave protection. Vegetation recently cut on south and east slopes exposes sparse vegetative covering leaving slopes exposed to wave erosion.*
ACCEPTABLE	☒	
DEFICIENT	☐	
POOR	☐	
B	**CREST**	**Problems Noted**: ☒ None ☐ Ruts or Puddles ☐ Erosion ☐ Cracks ☐ Sinkholes ☐ Not Wide Enough ☐ Low Areas ☐ Misalignment ☐ Inadequate Surface Drainage ☐ Trees, Bushes, Briars ☐ Other
GOOD	☒	***Comments***: *None*
ACCEPTABLE	☐	
DEFICIENT	☐	
POOR	☐	

CCP: Coal Combustion Products;
Spillway Size: Pipe Dia. for drop inlet; open channel width (typically emergency or (auxiliary) spillway) at the control section, Ft;.
Freeboard: vertical distance from the emergency spillway control section to the lowest point of the crest of the dam.

DAM ASSESSMENT FORM

C EXTERIOR SLOPE		**Problems Noted:** ☐ None ☐ Erosion, Gullies ☐ Cracks ☐ Sinkholes ☐ Appears Too Steep ☐ Depression or Bulges ☐ Slide ☐ Soft Areas ☒ Trees, Bushes, Briars ☐ Animal Burrows ☒ Other
GOOD	☐	***Comments**: Substantial improvements to exterior slope since last ATC inspection. Channelize and armor groin ditch at toe of slope west side of south embankment. Mow all vegetation 10 ft. below toe, and continue to mow remaining slope areas.. Culvert inlet at west end of south embankment toe was clogged with vegetation.*
ACCEPTABLE	☒	
DEFICIENT	☐	
POOR	☐	
D SEEPAGE		**Problems Noted:** ☐ None ☐ Saturated Embankment Area ☐ Seepage Exits on Embankment ☐ Seepage Exits at Point Source ☒ Seepage Area at Toe ☐ Flow Adjacent to Outlet
GOOD	☐	**If Seepage:** ☒ Clear ☐ Muddy See below
ACCEPTABLE	☒	**Drain Outfalls Seen:** Yes ☒ No ☐ Flow: ☐ Clear ☐ Muddy ☐ Dry ☒ Obstructed
DEFICIENT	☐	***Comments**: Plastic seepage collection pipes at toe of slope near process water outfall pipes were modified since last ATC inspection in 2009. Ditch below new plastic seepage collection pipes is partially clogged and allows standing water to pond in outfall pipe. Wet areas observed at toe of south embankment*
POOR	☐	
E PRINCIPAL SPILLWAY		**Description:** Drop Inlet with stop logs.
GOOD	☐	**Problems Noted:** ☐ None ☐ Deterioration ☐ Separation ☐ Cracking ☒ Inlet, Outlet Deficiency ☐ Stilling Basin Inadequacies ☐ Trash Rack ☐ Other
ACCEPTABLE	☒	
DEFICIENT	☐	***Comments**: Stoplogs can be placed in spillway inlet so water elevation in pond is within a few feet of the dam crest. Spillway inlet should be marked with maximum safe elevation for stoplogs.*
POOR	☐	
F AUXILIARY SPILLWAY		**Description:** No auxiliary spillway observed
GOOD	☐	**Problems Noted:** ☐ None ☒ No Auxiliary Spillway Found ☐ Erosion with Backcutting ☐ Crack with Displacement ☐ Appears to be Structurally Inadequate ☐ Appears too Small ☐ Inadequate Freeboard ☐ Flow Obstructed ☐ Concreted Deteriorated/Undermined ☐ Other
ACCEPTABLE	☐	
DEFICIENT	☐	
POOR	☐	
		***Comments**: None*
G MAINTENANCE AND REPAIRS		**Problems Noted:** ☐ None ☐ Access Road Needs Maintenance ☐ Spillway Obstruction ☒ Vegetation on Interior Slope, and Toe ☐ Trees on Exterior Slope ☐ Rodent Activity on Interior Slope, Crest, Exterior Slope, Toe ☐ Deteriorated Concrete –Facing, Outlet, Spillway ☐ Gate and/or Drawdown Need Repair ☒ Other
GOOD	☐	
ACCEPTABLE	☒	
DEFICIENT	☐	***Comments**: Vegetation at water line on Interior slopes needs continued mowing. Spray vegetation to prevent regrowth, Interior slopes need erosion protection. Armor groin ditches at toe of embankments with rip rap. Pipe inlets and outlet need clearing.*
POOR	☐	
H IMPOUNDMENTAREA		**Problems Noted:** ☐ None ☐ Ponded Water within Ash ☐ Ash blocking spill way ☐ Signs of damage from dredging ☐ Ash deposits in spillway ☒ Other
GOOD	☐	
ACCEPTABLE	☒	**Inflow sources:** ☒ Runoff ☒ Ash Sluicing ☒ Process Water ☐ Other
DEFICIENT	☐	Release of ponded water could cause overtopping of dam: Yes ☐ No ☒ N/A ☐
POOR	☐	***Comments**: New ash sluicing line installed on south and east embankment interior. Discharge point is on interior slope. Line should be extended to discharge 10 from interior slope to prevent potential damage to interior slope.*

DAM ASSESSMENT FORM

I OVERALL CONDITIONS		*Comments: Substantial improvements made since last ATC inspection.*
SATISFACTORY	☐	*To obtain "Satisfactory" rating Address all High and Moderate priority action items listed in Findings and Recommendations Table and schedule to address all "Normal" priority action items.*
FAIR	☒	
CONDITIONALLY POOR	☐	
POOR	☐	
UNSATISFACTORY	☐	

Summary of Findings and Recommendations in Attached Table

This visual dam assessment was conducted to assess the general overall condition of the reservoir/ash pond/dam, identify visible deficiencies, and recommend areas for monitoring, additional investigative studies and corrective actions. The assessment is based only on visible features/areas of the dam on the day of inspection; it does not constitute a formal safety inspection nor a review or evaluation from each specialist of an inspection team, such as geologists, civil, geotechnical, structural, or hydraulics engineer. The owner should verify the findings of this report and take corrective actions. This assessment does not relieve the owner/operator from their responsibility to conduct routine inspections, maintenance, repairs, modifications, monitoring, documentation, and/or investigative studies.

Professional Engineer's Signature: [signature] Date: 1-25-11

Reviewed by: [signature] David J. Millay Date: 1-25-11

Owner/Owner Representative Signature

GREEN RIVER MAIN POND PHOTOS
January 14, 2011

Photo #1: Sparse vegetation, interior slope of east embankment, looking NW
Note: Ash discharge line

Photo #2: Minor areas of sparse vegetation, south embankment,
exterior slope, looking north

GREEN RIVER MAIN POND PHOTOS
January 14, 2011

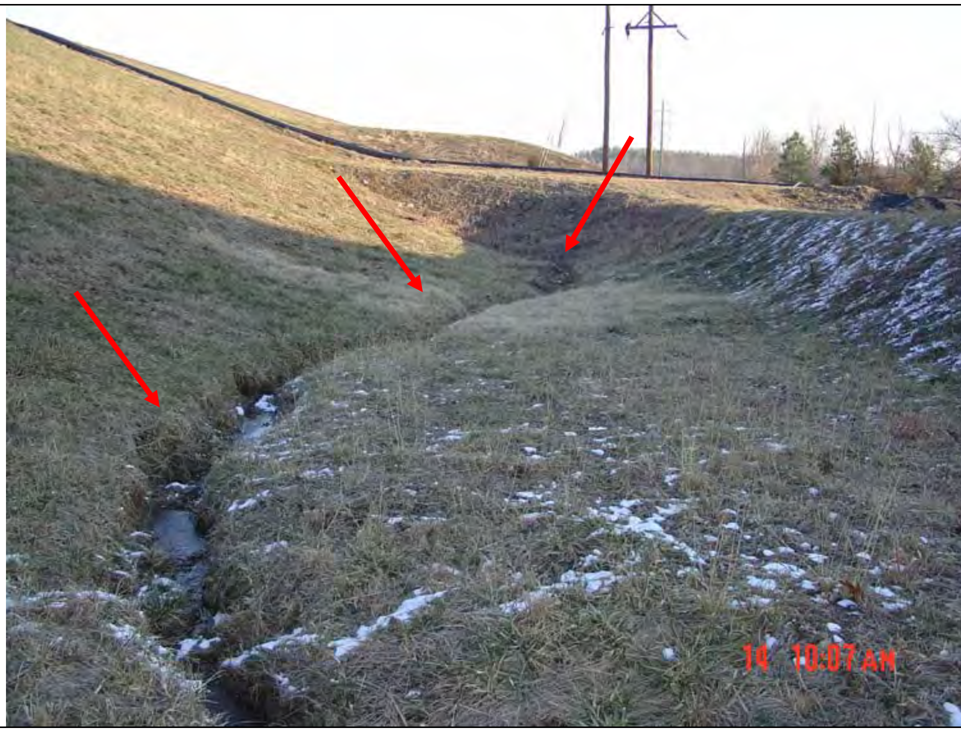


Photo #3: South embankment toe, exterior slope, looking NE
Note: Groin ditch along toe, clogged culvert

Photo #4: South embankment toe, looking SW
Note: Ponded water along exterior slope toe

GREEN RIVER MAIN POND PHOTOS
January 14, 2011

Photo #5: Interior slope of west embankment, looking west

Photo #6: Drainage pipe at west end of south embankment, looking NE
Note: Ponded water in outlet pipe

GREEN RIVER MAIN POND PHOTOS
January 14, 2011

Photo #7: Principal Spillway inlet
Note: Top of stop logs just below water surface

Photo #8: East end of south embankment, exterior slope, looking east
Note: Rock toe berm

GREEN RIVER MAIN POND PHOTOS
January 14, 2011

Photo #9: East end of south embankment, exterior slope, looking NE
Note: Rock groin ditch recently installed along toe

Photo #10: Exterior slope of west embankment, east

<u>GREEN RIVER MAIN POND PHOTOS</u>
<u>January 14, 2011</u>

Photo #11: Toe of south exterior slope, looking NE
Note: Recently installed rock toe berm and observed tall vegetation at toe

Photo #12: East end of south embankment, exterior slope, looking south
Note: Rock groin ditch recently installed along toe

GREEN RIVER MAIN POND PHOTOS
January 14, 2011

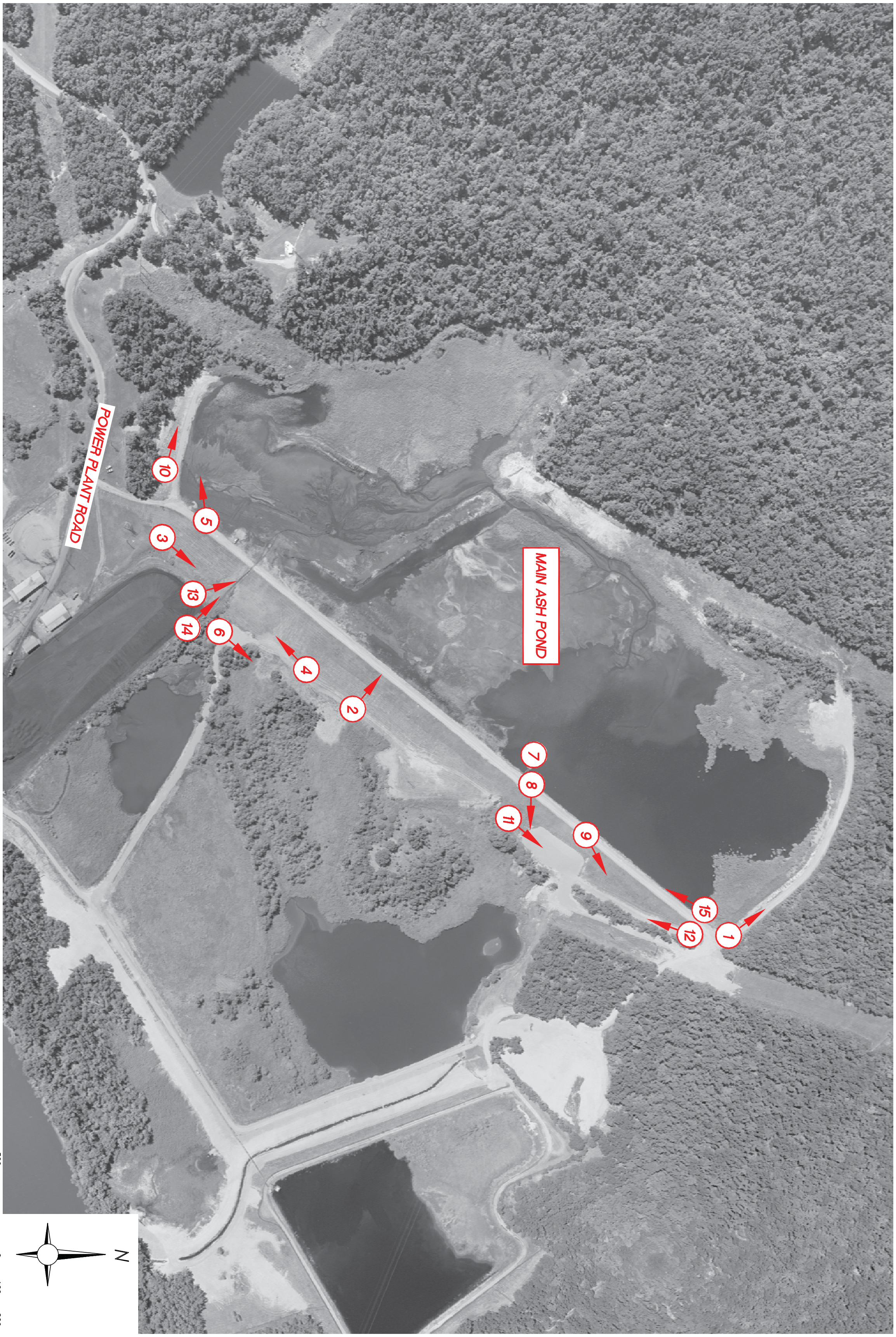
Photo #13: Culvert inlet clogged with vegetation, west side of south embankment, looking NE

Photo #14: Repair concrete culvert inlet at toe near west end of south embankment, looking NW

GREEN RIVER MAIN POND PHOTOS
January 14, 2011

Photo #15: East end of south embankment, interior slope and crest, looking west
Note: Ash discharge line

AUGUST 2010 AERIAL PHOTOGRAPHS PROVIDED BY:
L.R. KIMBALL ASSOCIATES INC.
STATE PLANE COORDINATE SYSTEM: KENTUCKY (FIPS 1600), NAD83



SCALE: 1" = 300'

LG&E - KU 2011 POND INSPECTIONS
KU GREEN RIVER STATION - MAIN ASH POND
PLAN WITH PHOTOS

Date: 1/11
Scale: AS SHOWN
Figure: B-2

LEGEND:

LOCATION OF PHOTOGRAPH

10 — DIRECTION OF PHOTOGRAPH
PHOTO DESIGNATION

Project Number: 27.11000.1G37	Drn. By: SP
Drawing File: SEE LOWER LEFT	Ckd. By: JE
ATC ASSOCIATES INC.	App'd By: MS
	Ckd. Date: 1/11

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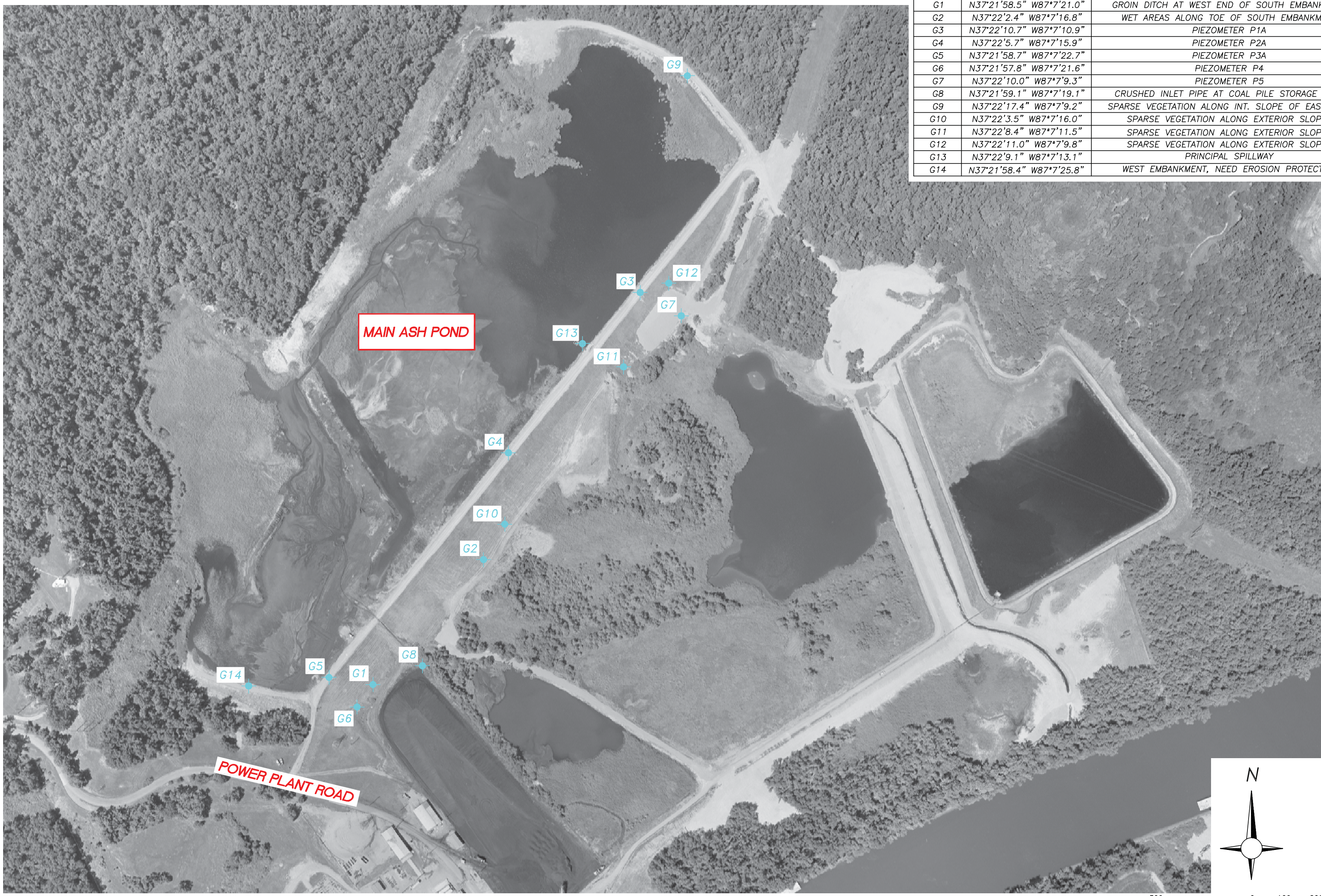
ASH POND – FIELD OBSERVATIONS

GPS PT.	COORDINATES	DESCRIPTION
G1	N37°21'58.5" W87°7'21.0"	GROIN DITCH AT WEST END OF SOUTH EMBANKMENT
G2	N37°22'2.4" W87°7'16.8"	WET AREAS ALONG TOE OF SOUTH EMBANKMENT
G3	N37°22'10.7" W87°7'10.9"	PIEZOMETER P1A
G4	N37°22'5.7" W87°7'15.9"	PIEZOMETER P2A
G5	N37°21'58.7" W87°7'22.7"	PIEZOMETER P3A
G6	N37°21'57.8" W87°7'21.6"	PIEZOMETER P4
G7	N37°22'10.0" W87°7'9.3"	PIEZOMETER P5
G8	N37°21'59.1" W87°7'19.1"	CRUSHED INLET PIPE AT COAL PILE STORAGE AREA
G9	N37°22'17.4" W87°7'9.2"	SPARSE VEGETATION ALONG INT. SLOPE OF EAST EMB.
G10	N37°22'3.5" W87°7'16.0"	SPARSE VEGETATION ALONG EXTERIOR SLOPES
G11	N37°22'8.4" W87°7'11.5"	SPARSE VEGETATION ALONG EXTERIOR SLOPES
G12	N37°22'11.0" W87°7'9.8"	SPARSE VEGETATION ALONG EXTERIOR SLOPES
G13	N37°22'9.1" W87°7'13.1"	PRINCIPAL SPILLWAY
G14	N37°21'58.4" W87°7'25.8"	WEST EMBANKMENT, NEED EROSION PROTECTION



AUGUST 2010 AERIAL PHOTOGRAPHS PROVIDED BY:
L.R. KIMBALL ASSOCIATES INC.
STATE PLANE COORDINATE SYSTEM: KENTUCKY (FIPS 1600), NAD83

LG&E – KU 2011 POND INSPECTIONS
KU GREEN RIVER STATION – MAIN ASH POND
GPS COORDINATES/ SITE OBSERVATIONS

Date: 1/11
Scale: AS SHOWN
Figure: B-3

Project Number: 27.11000.1G37
Drawing File: SEE LOWER LEFT
Drn. By: SP
Ckd. By: JE
App'd By: MS
Ckd. Date: 1/11

ATC ASSOCIATES INC.

Findings and Recommendations

Plant: Green River
Structure: Scrubber Pond
State ID# 804
Field date: 1/14/2011

Item #	Priority Rating	GPS Point	Photo #	Location Description	Action Item
1	Moderate	multiple	1	Exterior Slope	Re-seed areas where sparse vegetation exists on exterior slopes
2	Moderate	G44	2	Interior Slope	Add erosion protection on all interior slopes at water line, restore slope configuration where eroded by wave action.
3	Moderate	-	-	Principal Spillway	Evaluate need for spillway to prevent overtopping.
4	Moderate	-	-	Crest	Fill low areas on dam crest to maintian consistent freeboard depth. Elevation survey by others indicates one foot variation is present.
5	Normal	G43	-	Toe	Regrade area south of pond to prevent ponding water.

Priority:
- High - Recommend that action item be addressed as soon as possible
- Moderate - Recommend that action item be addressed during next construction season
- Normal - Recommend that action item be as part of ongoing maintenance of the structure

Location:

Crest	Interior Slope	Principal Spillway
Toe	Exterior Slope	Emergency Spillway
Abutment		

DAM ASSESSMENT FORM

Name of Professional Conducting Inspection: Mark J. Schuhmann, P. E..				KY Professional License No.: 12500	
Company Name: ATC Associates, Inc.				Phone: 502-722-1401	
Address: 11001 Bluegrass Parkway, Suite 250, Louisville, KY 40299					
Inspection Preparation: Reviewed all pertinent technical documentation related to this dam and site in: the State's files Yes ☐ No ☒ ; and Owner's Files: Yes ☒ No ☐					
Comments: Side Hill/Diked Pond Configuration. Pond no longer receives process water, only inflow is from rainfall on impoundment. An automatic floating pump at the SW corner of the impoundment was added in 2010 to control the water level in the pond. Pond level reduced from last ATC inspection in 2009.					
Dam/Pond Name: **Green River Scrubber Pond**		Hazard Class: Low	Topographic Quad: Central City East	Date of Inspection: 1/14/11	
State Dam ID: 804	County: Muhlenberg	Latitude: 37º 22' 0.00"	Longitude: 87º 6' 54.00"	Last ATC Inspection: 10/28/09	
Power Station Name: **KU Green River Station**					
Address: 811 Power Plant Road, Central City, KY 42330					
Site Contact: Travis Harper			Phone: 270-757-6105		
Drainage Area (AC): 10	Surface Area(AC): 10	Height (Ft): 18	Crest Length (Ft): 2500	Crest Width (Ft): 12	Crest Elevation(Ft): 404 to 405
Slope: Interior: 2.5:1 Exterior: 2.2:1	Principal Spillway Type: None, water is pumped out manually	Principal Spillway Size: N/A	Spillway Control Elevation(Ft): N/A	Freeboard (Ft): 4.5 at crest adjacent to SW pond corner.	
CCP placed in Pond: Previously SO2 sludge	Emergency Spillway Type: None	Emergency Spillway Size: N/A	Spillway Control Elevation: N/A	Freeboard(Ft): N/A	

FIELD CONDITIONS OBSERVED

CCP Above Crest:Yes:☒ None:☐	Location: North end of pond	Max. Height above pool (Ft): less than 2 feet
Water Level (Below Dam Crest, Ft): 4.5 feet at SW pond corner		
Ground Moisture Condition: Dry ☐ Wet ☒ Snow cover ☒ Other:		
Monitoring: Yes ☐ None: ☐ (☐ Gage Rod ☒ Piezometers ☐Seepage Weirs ☐ Survey Monuments ☐ Other)		
Comments: *Three piezometers were installed on dam crest in 2010.*		

A **INTERIOR SLOPE**		**Problems Noted**: ☐ None ☒ Riprap – Missing, Sparse ☒ Wave Erosion ☐ Cracks ☐ Sinkholes ☒ Appears Too Steep ☐ Depressions or Bulges ☐ Slides ☐ Animal Burrows ☒ Trees, Bushes, Briars ☒ Other
GOOD	☐	***Comments***: *Tall vegetation present in previous inspections was cut exposing interior slope for entire perimeter of pond. Numerous areas of old wave erosion were observed with over-steepened slopes that encroach upon nominal crest width in some places. Several areas of over-steepened slopes require placement of additional material to flatten slopes and protect crest.*
ACCEPTABLE	☐	
DEFICIENT	☒	
POOR	☐	
B **CREST**		**Problems Noted**: ☐ None ☒ Ruts or Puddles ☐ Erosion ☐ Cracks ☐ Sinkholes ☒ Not Wide Enough ☒ Low Areas ☐ Misalignment ☐ Inadequate Surface Drainage ☐ Trees, Bushes, Briars ☐ Other
GOOD	☐	***Comments***: *Crushed stone placed on crest roadbed since 2009 ATC inspection. Interior slope erosion starting to narrow crest width in few places.*
ACCEPTABLE	☒	
DEFICIENT	☐	
POOR	☐	

CCP: Coal Combustion Products;
Spillway Size: Pipe Dia. for drop inlet; open channel width (typically emergency or (auxiliary) spillway) at the control section, Ft;.
Freeboard: vertical distance from the emergency spillway control section to the lowest point of the crest of the dam.

DAM ASSESSMENT FORM

ATC ASSOCIATES INC.

C DOWNSTREAM SLOPE	
GOOD ☒	**Problems Noted**: ☐ None ☐ Livestock Damage ☐ Erosion, Gullies ☐ Cracks ☐ Sinkholes ☐ Appears Too Steep ☐ Depression or Bulges ☐ Slide ☐ Soft Areas ☐ Trees, Bushes, Briars ☐ Animal Burrows ☒ Other
ACCEPTABLE ☐	***Comments**: Erosion gullies noted in previous inspections have been filled. Sparse vegetation in few areas needs to be reseeded to establish grass cover.*
DEFICIENT ☐	
POOR ☐	

D SEEPAGE	
	Problems Noted: ☒ None ☐ Saturated Embankment Area ☐ Seepage Exits on Embankment ☐ Seepage Exits at Point Source ☐ Seepage Area at Toe ☐ Flow Adjacent to Outlet
GOOD ☒	**If Seepage**: ☐ Clear ☐ Muddy
ACCEPTABLE ☐	**Drain Outfalls Seen**: Yes ☐ No ☐ Flow: ☐ Clear ☐ Muddy ☐ Dry ☐ Obstructed
DEFICIENT ☐	***Comments**: Continue to monitor wet area south of south embankment toe.*
POOR ☐	

E PRINCIPAL SPILLWAY	
	Description: *Automatic duplex pump system was installed in 2010 to control the water level in the pond.*
GOOD ☐	**Problems Noted**: ☒ None ☐ Deterioration ☐ Separation ☐ Cracking ☐ Inlet, Outlet Deficiency ☐ Stilling Basin Inadequacies ☐ Trash Rack ☐ Other
ACCEPTABLE ☒	
DEFICIENT ☐	***Comments**: Evaluate need for gravity fed emergency spillway for overflow protection.*
POOR ☐	

F AUXILIARY SPILLWAY	
	Description: No auxiliary spillway observed
GOOD ☐	**Problems Noted**: ☐ None ☒ No Auxiliary Spillway Found ☐ Erosion with Backcutting ☐ Crack with Displacement ☐ Appears to be Structurally Inadequate ☐ Appears too Small ☐ Inadequate Freeboard ☐ Flow Obstructed ☐ Concreted Deteriorated/Undermined ☐ Other
ACCEPTABLE ☐	
DEFICIENT ☐	
POOR ☐	
	***Comments**: N/A*

G MAINTENANCE AND REPAIRS	
GOOD ☐	**Problems Noted**: ☐ None ☐ Access Road Needs Maintenance ☐ Cattle Damage ☐ Spillway Obstruction ☐ Vegetation on Upstream Slope ☐ Trees on Downstream Slope ☐ Rodent Activity on Upstream Slope, Crest, Downstream Slope, Toe ☐ Deteriorated Concrete –Facing, Outlet, Spillway ☐ Gate and/or Drawdown Need Repair ☐ Other
ACCEPTABLE ☒	
DEFICIENT ☐	
POOR ☐	
	***Comments**: Vegetation along water line on upstream slope should continue to be mowed, crest width starting to narrow at few locations needs maintenance.*

H IMPOUNDMENT AREA	
	Problems Noted: ☒ None ☐ Ponded Water within Ash ☐ Ash blocking spill way ☐ Signs of damage from dredging ☐ Ash deposits in spillway ☐ Other
GOOD ☒	
ACCEPTABLE ☐	**Inflow sources**: ☒ Runoff ☐ Ash Sluicing ☐ Process Water ☐ Other
DEFICIENT ☐	**Release of ponded water could cause overtopping of dam**: Yes ☐ No ☐ N/A ☒
POOR ☐	***Comments**: None*

DAM ASSESSMENT FORM

I OVERALL CONDITIONS		*Comments*: *Substantial improvements made since last ATC inspection. Interior slope vegetation cut prior to inspection allowing extent of old wave erosion to interior slope to be observed.* *To obtain "Satisfactory" rating Address all Moderate priority action items listed in Findings and Recommendations Table and schedule to address all "Normal" priority action items.*
SATISFACTORY	☐	
FAIR	☒	
CONDITIONALLY POOR	☐	
POOR	☐	
UNSATISFACTORY	☐	

Summary of Findings and Recommendations in Attached Table

This visual dam assessment was conducted to assess the general overall condition of the reservoir/ash pond/dam, identify visible deficiencies, and recommend areas for monitoring, additional investigative studies and corrective actions. The assessment is based only on visible features/areas of the dam on the day of inspection; it does not constitute a formal safety inspection nor a review or evaluation from each specialist of an inspection team, such as geologists, civil, geotechnical, structural, or hydraulics engineer. The owner should verify the findings of this report and take corrective actions. This assessment does not relieve the owner/operator from their responsibility to conduct routine inspections, maintenance, repairs, modifications, monitoring, documentation, and/or investigative studies.

Professional Engineer's Signature: [signature] Date: 1-25-11

Reviewed by: [signature] Date: 1-25-11
Owner/Owner Representative Signature

GREEN RIVER SCRUBBER POND PHOTOS
January 14, 2011

Photo #1: Exterior slope toe, south embankment east side, looking NW

Photo #2: Interior slope of south embankment, looking east
Note: Note wave erosion encroaching on edge of dam crest

Photo #3: East embankment, interior slope, looking south

Photo #4: West embankment, crest and interior slope, looking north

GREEN RIVER SCRUBBER POND PHOTOS
January 14, 2011

Photo #5: West embankment, exterior slope,
looking north

Photo #6: East embankment, exterior slope and toe, looking north

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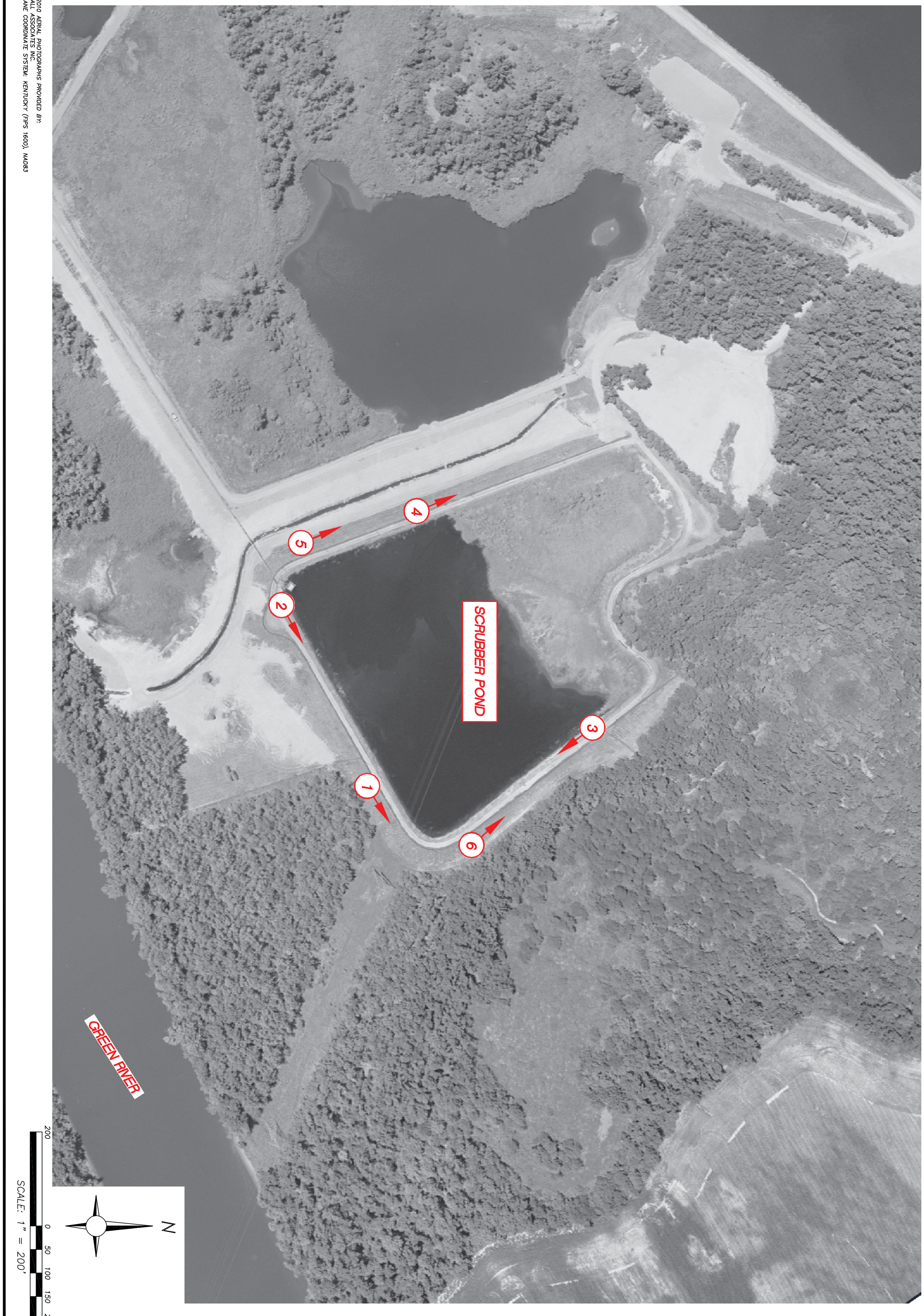
AUGUST 2010 AERIAL PHOTOGRAPHS PROVIDED BY:
L.R. KIMBALL ASSOCIATES INC.
STATE PLANE COORDINATE SYSTEM: KENTUCKY (FIPS 1600), NAD83



LG&E - KU 2011 POND INSPECTIONS
KU GREEN RIVER STATION - SCRUBBER POND
PLAN WITH PHOTOS

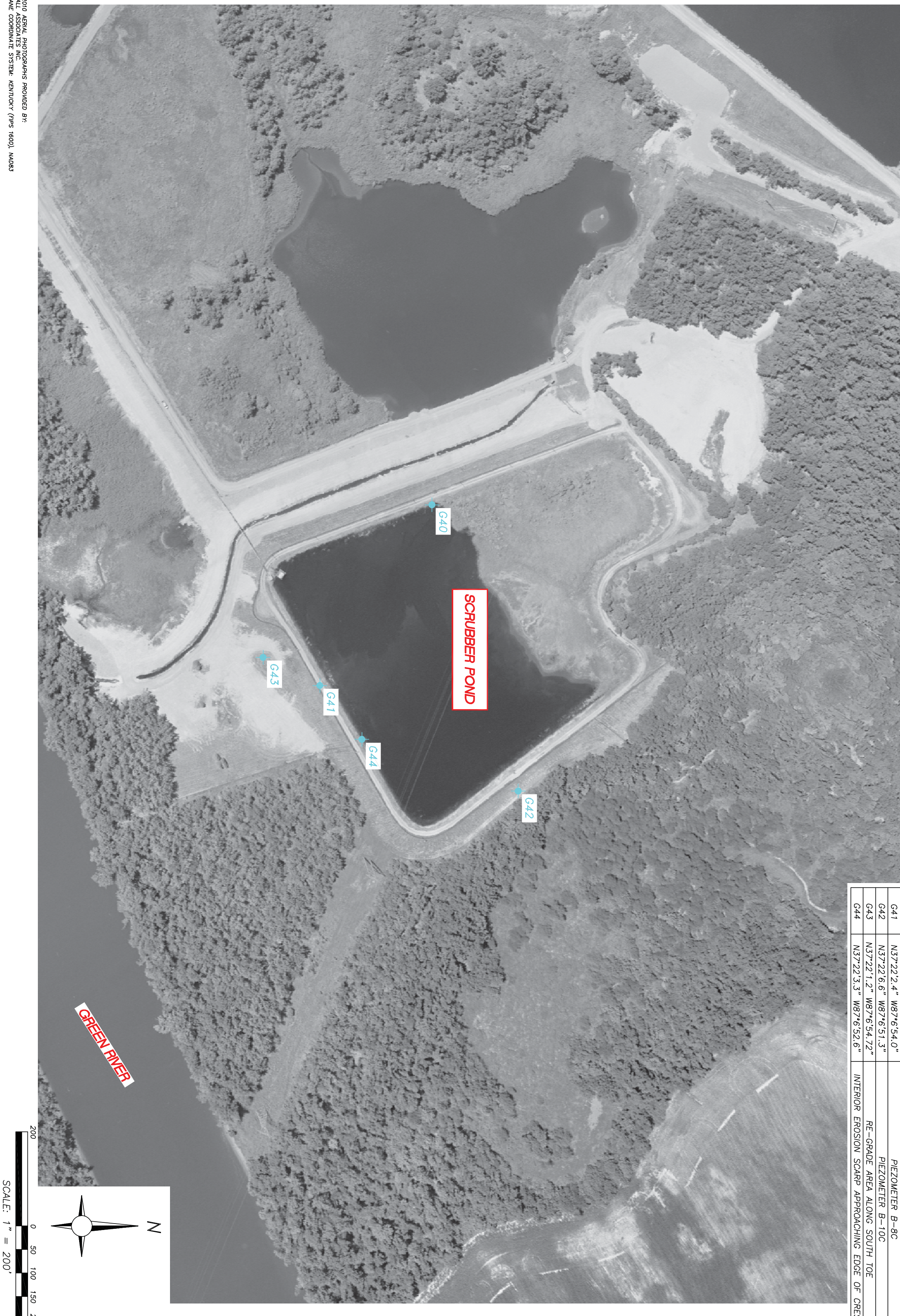
LEGEND:

LOCATION OF PHOTOGRAPH
10 — DIRECTION OF PHOTOGRAPH
PHOTO DESIGNATION

Figure:	B-4
Scale:	AS SHOWN
Date:	1/11
Project Number:	27.11000.1G37
Drawing File:	SEE LOWER LEFT
Drn. By:	SP
Ckd. By:	JE
App'd By:	MS
Ckd. Date:	1/11

ATC ASSOCIATES INC.

AUGUST 2010 AERIAL PHOTOGRAPHS PROVIDED BY:
L.R. KIMBALL ASSOCIATES INC.
STATE PLANE COORDINATE SYSTEM: KENTUCKY (FIPS 1600), NAD83



SCRUBBER POND – FIELD OBSERVATIONS

GPS PT.	COORDINATES	DESCRIPTION
G40	N37°22'4.7" W87°6'58.8"	PIEZOMETER B–6C
G41	N37°22'2.4" W87°6'54.0"	PIEZOMETER B–8C
G42	N37°22'6.6" W87°6'51.3"	PIEZOMETER B–10C
G43	N37°22'1.2" W87°6'54.72"	RE–GRADE AREA ALONG SOUTH TOE
G44	N37°22'3.3" W87°6'52.6"	INTERIOR EROSION SCARP APPROACHING EDGE OF CREST

LG&E – KU 2011 POND INSPECTIONS
KU GREEN RIVER STATION – SCRUBBER POND
GPS COORDINATES/ SITE OBSERVATIONS

Figure: B–5
Scale: AS SHOWN
Date: 1/11

Project Number: 27.11000.1G37
Drawing File: SEE LOWER LEFT
Drn. By: SP
Ckd. By: JE
App'd By: MS
Ckd. Date: 1/11

ATC ASSOCIATES INC.

Findings and Recommendations

Plant: **Green River**
Structure: **Number 2 Pond**
State ID# **Non-classified**
Field date: **1/14/2011**

Item #	Priority Rating	GPS Point	Photo #	Location Description	Action Item
1	High	Multiple	1	Crest	Place fill as needed to return crest to design elevation. Elevation survey by others indicates crest elevations vary up to 1.5 feet.
2	High	G22	2	Exterior Slope	Place filter over observed seep at west end of south embankment at boring drilled in 2010 (B-1.75T) to prevent piping and loss of soil.
3	High	G20	3	Principal Spillway	Mark principal spillway to prevent stop log placement which would result in overtopping of the crest.
4	Moderate	Multiple	1	Interior Slope	Place erosion protection at waterline of interior slopes.

Priority:
- High - Recommend that action item be addressed as soon as possible
- Moderate - Recommend that action item be addressed during next construction season
- Normal - Recommend that action item be as part of ongoing maintenance of the structure

Location:
Crest, Toe, Abutment, Interior Slope, Exterior Slope, Principal Spillway, Emergency Spillway

DAM ASSESSMENT FORM

Name of Professional Conducting Inspection: Mark J. Schuhmann P.E.	KY Professional License No.: 12500
Company Name: ATC Associates Inc.	Phone: 502-722-1401
Address: 11001 Bluegrass Parkway, Suite 250, Louisville, KY 40299	
Inspection Preparation: Reviewed all pertinent technical documentation related to this dam and site in: the State's files Yes ☐ No ☒ ; and Owner's Files: Yes ☒ No ☐	
Comments: Side Hill pond, no longer actively receiving ash, but receives water from Main Ash pond, coal runoff pond and SO2 pond. Substantial improvements made to pond since last ATC inspection.	

Dam/Pond Name: **Green River Number 2 Pond**		KDEP Hazard Class: N/A	Topographic Quad: Central City East	Date of Inspection: 1/14/11
State Dam ID: N/A	County: Muhlenberg	Latitude: W 37º 22' 3.79"	Longitude: N 87º 7' 5.69"	Last ATC Inspection: 10/28/09

Power Station Name: **KU Green River Station**		
Address: 811 Power Plant Road, Central City , KY 42330		
Site Contact: Travis Harper	Phone: 270-757-6105	

Drainage Area (AC): 23	Surface Area (AC): 8 (water Surface)	Height (Ft): 15	Crest Length (Ft): 2500	Crest Width (Ft): 15	Crest Elevation (Ft): 399.69
Slope (H:V) Upstream:not visible Downstream: 2:1	Principal Spillway Type: Drop Inlet	Principal Spillway Size(In): 36	Spillway Control Elevation:	Freeboard(Ft): 4.4	
CCP/Fluids in Pond: Plant outfall, flyash, Bottom Ash	Emergency Spillway Type: None	Emergency Spillway Size: N/A	Spillway Control Elevation: N/A	Freeboard(Ft): N/A	

FIELD CONDITIONS OBSERVED

CCP Above Crest:Yes:☒ None:☐	Location: South and east ends of pond	Max. Height above pool(Ft): 2 to 3 feet

Water Level (Below Dam Crest, Ft): 4.4

Ground Moisture Condition: Dry ☐ Wet ☒ Snow cover ☒ Other:

Monitoring: Yes ☐ None: ☒ (☐ Gage Rod ☒ Piezometers ☐Seepage Weirs ☐ Survey Monuments ☐ Other)

Comments*: Piezometers installed on dam crest in 2010.*

A INTERIOR SLOPE	
	Problems Noted: ☐ None ☒ Riprap – Missing, Sparse ☐ Wave Erosion ☐ Cracks ☐ Sinkholes ☐ Appears Too Steep ☐ Depressions or Bulges ☐ Slides ☐ Animal Burrows ☐ Trees, Bushes, Briars ☐ Other
GOOD ☐	***Comments****: Interior slope of east embankment needs erosion protection.*
ACCEPTABLE ☒	
DEFICIENT ☐	
POOR ☐	

B CREST	
	Problems Noted: ☐ None ☐ Ruts or Puddles ☐ Erosion ☐ Cracks ☐ Sinkholes ☐ Not Wide Enough ☒ Low Areas ☐ Misalignment ☐ Inadequate Surface Drainage ☐ Trees, Bushes, Briars ☐ Other
GOOD ☐	***Comments****: Elevation survey of dam crest (by others) indicates crest elevations vary 1.5 feet. Place fill as needed to return crest to design elevation.*
ACCEPTABLE ☒	
DEFICIENT ☐	
POOR ☐	

CCP*:* Coal Combustion byProducts;
Spillway Size: Pipe Dia. for drop inlet; open channel width (typically emergency or (auxiliary) spillway) at the control section, Ft;.
Freeboard: vertical distance from the emergency spillway control section to the lowest point of the crest of the dam.

DAM ASSESSMENT FORM

C **EXTERIOR SLOPE** GOOD ☒ ACCEPTABLE ☐ DEFICIENT ☐ POOR ☐	**Problems Noted**: ☐ None ☐ Erosion, Gullies ☐ Cracks ☐ Sinkholes ☐ Appears Too Steep ☐ Depression or Bulges ☐ Slide ☐ Soft Areas ☐ Trees, Bushes, Briars ☐ Animal Burrows ☒ Other ***Comments***: *All trees have been cut on exterior slope and rip rap erosion protection placed. .*
D **SEEPAGE** GOOD ☐ ACCEPTABLE ☐ DEFICIENT ☒ POOR ☐	**Problems Noted**: ☐ None ☐ Saturated Embankment Area ☐ Seepage Exits on Embankment ☒ Seepage Exits at Point Source ☒ Seepage Area at Toe ☐ Flow Adjacent to Outlet **If Seepage**: ☒ Clear ☐ Muddy **Drain Outfalls Seen**: Yes ☐ No ☒ Flow: ☐ Clear ☐ Muddy ☐ Dry ☐ Obstructed ***Comments***: *Observed seep and wet area at toe of south embankment at boring drilled by others in 2010 (B-1.75C). Flow of water from seep estimated at less than gallon per minute. Open vertical void present 18" deep. Boring encountered flyash at 4 feet. Recommend filter be placed over seep to prevent soil piping.*
E **PRINCIPAL SPILLWAY** GOOD ☐ ACCEPTABLE ☒ DEFICIENT ☐ POOR ☐	**Description**: Drop inlet with stop logs used to vary water level in pond **Problems Noted**: ☐ None ☐ Deterioration ☐ Separation ☐ Cracking ☒ Inlet, Outlet Deficiency ☐ Stilling Basin Inadequacies ☐ Trash Rack ☐ Other ***Comments***: *Stop logs in spillway can be added so that water level in pond will overtop crest in current condition. Maximum stop log placement (elevation) must be marked on spillway to prevent overtopping.*
F **AUXILIARY SPILLWAY** GOOD ☐ ACCEPTABLE ☐ DEFICIENT ☐ POOR ☐	**Description**: No auxiliary spillway observed **Problems Noted**: ☐ None ☒ No Auxiliary Spillway Found ☐ Erosion with Backcutting ☐ Crack with Displacement ☐ Appears to be Structurally Inadequate ☐ Appears too Small ☐ Inadequate Freeboard ☐ Flow Obstructed ☐ Concreted Deteriorated/Undermined ☐ Other ***Comments***: *N/A*
G **MAINTENANCE AND REPAIRS** GOOD ☐ ACCEPTABLE ☒ DEFICIENT ☐ POOR ☐	**Problems Noted**: ☐ None ☐ Access Road Needs Maintenance ☐ Cattle Damage ☐ Spillway Obstruction ☐ Vegetation on Interior Slope, Crest, Exterior Slope, Toe ☐ Trees on Interior Slope, Crest, Exterior Slope, Toe ☐ Rodent Activity on Interior Slope, Crest, Exterior Slope, Toe ☐ Deteriorated Concrete –Facing, Outlet, Spillway ☐ Gate and/or Drawdown Need Repair ☐ Other ***Comments***: *Interior slope of east embankment needs erosion protection, fill low spots on crest to establish consistent dam crest elevation.*
H **IMPOUNDMENT AREA** GOOD ☐ ACCEPTABLE ☒ DEFICIENT ☐ POOR ☐	**Problems Noted**: ☐ None ☐ Ponded Water within Ash ☐ Ash blocking spill way ☐ Signs of damage from dredging ☐ Ash deposits in spillway ☐ Other **Inflow sources**: ☒ Runoff ☐ Ash Sluicing ☒ Process Water ☒ Other **Release of ponded water could cause overtopping of dam**: Yes ☐ No ☐ N/A ☒ ***Comments***:

DAM ASSESSMENT FORM

I OVERALL CONDITIONS		*Comments: Substantial improvements made since last ATC inspection.*
SATISFACTORY	☐	*To obtain "Satisfactory" rating Address all High and Moderate priority action items listed in Findings and Recommendations Table.*
FAIR	☒	
CONDITIONALLY POOR	☐	
POOR	☐	
UNSATISFACTORY	☐	

Summary of Findings and Recommendations in Attached Table

This visual dam assessment was conducted to assess the general overall condition of the reservoir/ash pond/dam, identify visible deficiencies, and recommend areas for monitoring, additional investigative studies and corrective actions. The assessment is based only on visible features/areas of the dam on the day of inspection; it does not constitute a formal safety inspection nor a review or evaluation from each specialist of an inspection team, such as geologists, civil, geotechnical, structural, or hydraulics engineer. The owner should verify the findings of this report and take corrective actions. This assessment does not relieve the owner/operator from their responsibility to conduct routine inspections, maintenance, repairs, modifications, monitoring, documentation, and/or investigative studies.

Professional Engineer's Signature: [signature] Date: 1-25-11

Reviewed by: David J. Millay Date: 1-25-11

Owner/Owner Representative Signature

GREEN RIVER, NUMBER 2 POND PHOTOS
January 14, 2011

Photo #1: East embankment crest and upstream slope, looking south
Note: steep slopes with sparse rip rap erosion protection.

Photo #2: Seep at toe of south embankment, looking east
Note: Source of flow adjacent to grouted hole

GREEN RIVER, NUMBER 2 POND PHOTOS
January 14, 2011

Photo #3: Principal Spillway Inlet

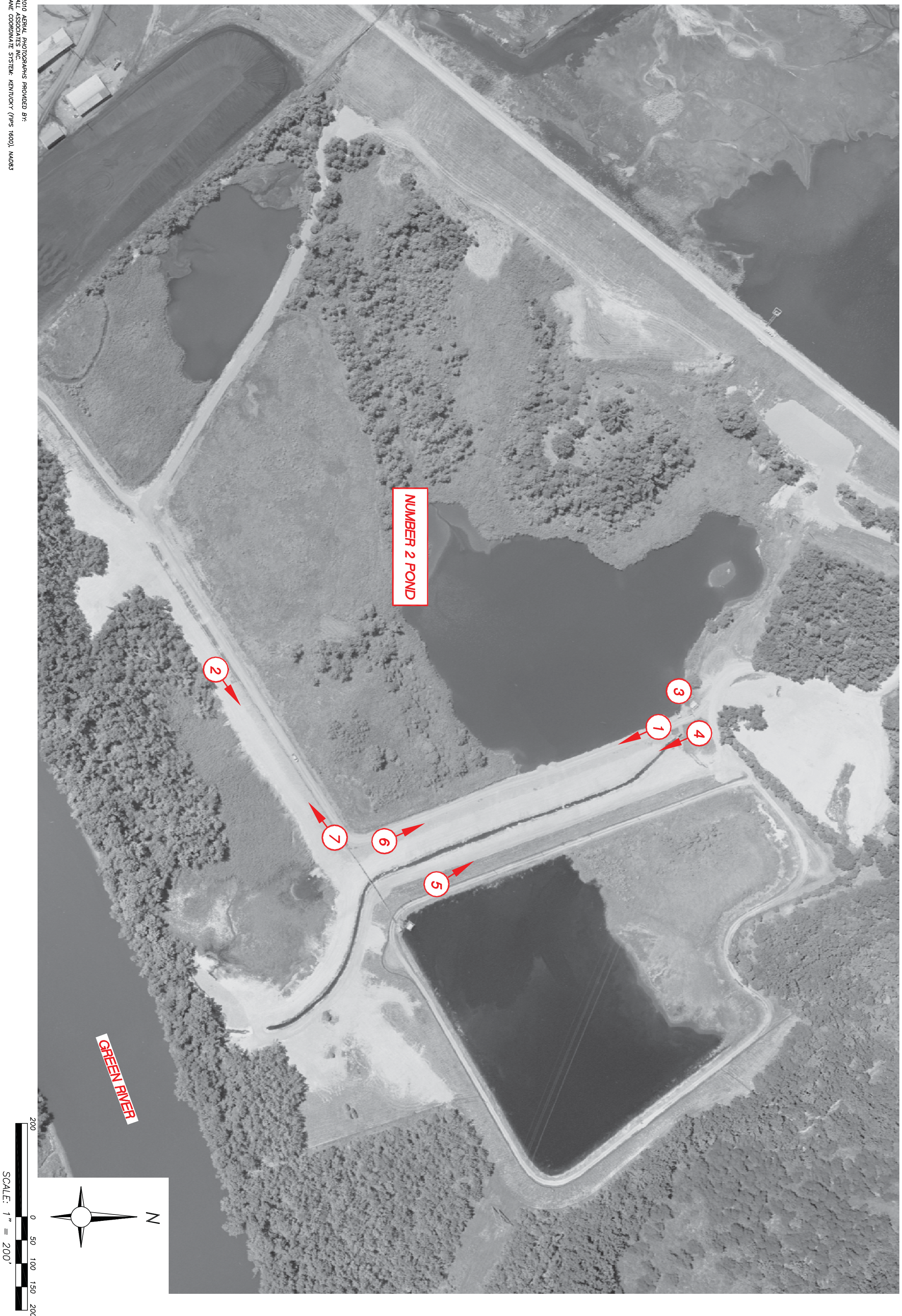
Photo #4: East embankment, downstream slope, toe, and principal spillway outlet, looking south

Photo #5: East embankment, downstream slope and toe, looking northwest

Photo #6: East embankment crest and downstream slope, looking north

Photo #7: South embankment, downstream slope, southwest

AUGUST 2010 AERIAL PHOTOGRAPHS PROVIDED BY:
L.R. KIMBALL ASSOCIATES INC.
STATE PLANE COORDINATE SYSTEM: KENTUCKY (FIPS 1600), NAD83



LG&E - KU 2011 POND INSPECTIONS
KU GREEN RIVER STATION - NUMBER 2 POND
PLAN WITH PHOTOS

Date: 1/11
Scale: AS SHOWN
Figure: B-6

LEGEND:
LOCATION OF PHOTOGRAPH
10 — DIRECTION OF PHOTOGRAPH
PHOTO DESIGNATION

Project Number: 27.11000.1G37	Drn. By: SP
Drawing File: SEE LOWER LEFT	Ckd. By: JE
ATC ASSOCIATES INC.	App'd By: MS
	Ckd. Date: 1/11

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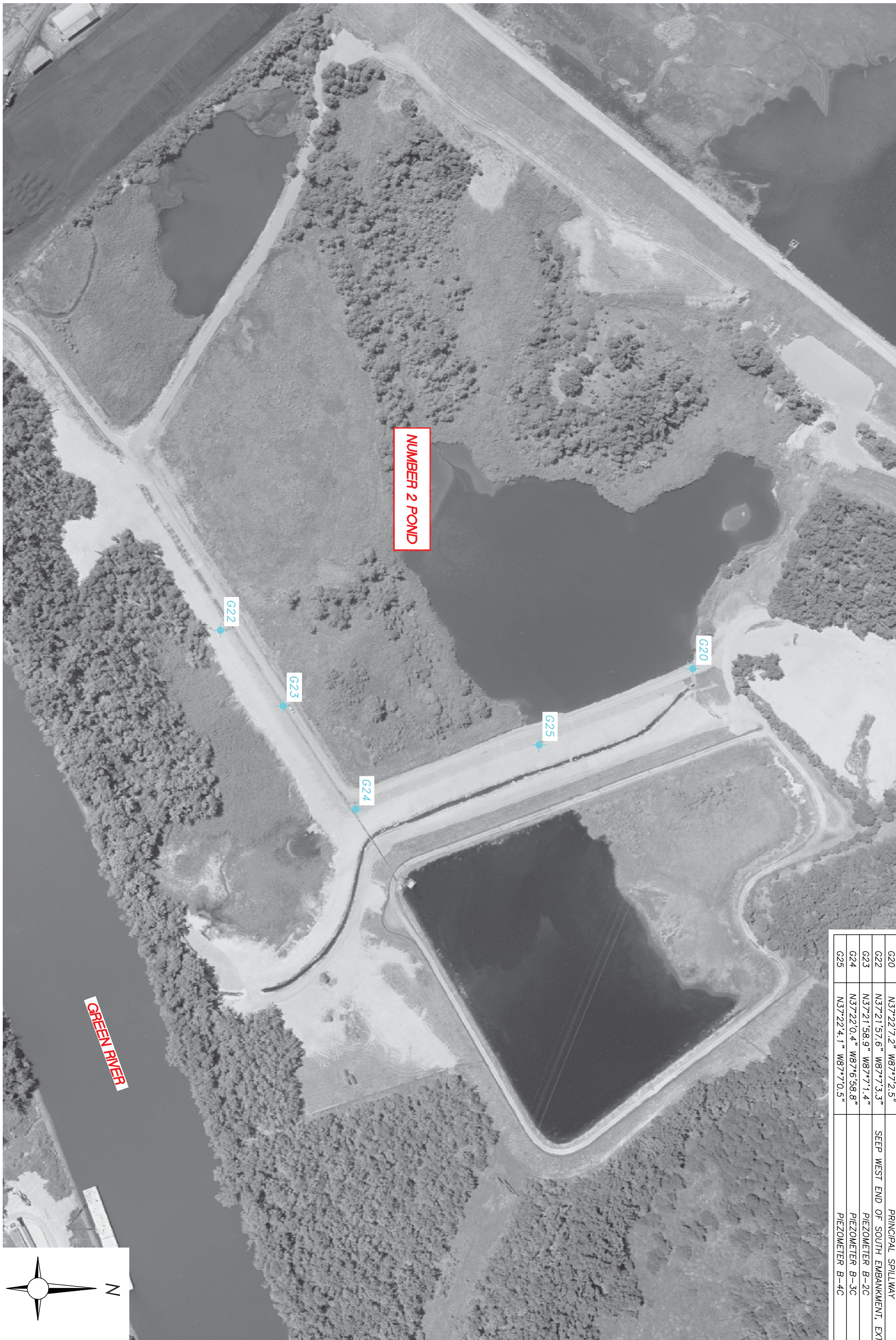
AUGUST 2010 AERIAL PHOTOGRAPHS PROVIDED BY:
L.R. KIMBALL ASSOCIATES INC.
STATE PLANE COORDINATE SYSTEM: KENTUCKY (FIPS 1600), NAD83



NUMBER 2 POND – FIELD OBSERVATIONS

GPS PT.	COORDINATES	DESCRIPTION
G20	N37°22'7.2" W87°7'2.5"	PRINCIPAL SPILLWAY
G22	N37°21'57.6" W87°7'3.3"	SEEP WEST END OF SOUTH EMBANKMENT, EXT. SLOPE
G23	N37°21'58.9" W87°7'1.4"	PIEZOMETER B-2C
G24	N37°22'0.4" W87°6'58.8"	PIEZOMETER B-3C
G25	N37°22'4.1" W87°7'0.5"	PIEZOMETER B-4C

Figure: B-7
Scale: AS SHOWN
Date: 1/11

LG&E - KU 2011 POND INSPECTIONS
KU GREEN RIVER STATION - NUMBER 2 POND
GPS COORDINATES/ SITE OBSERVATIONS

Project Number: 27.11000.1G37
Drawing File: SEE LOWER LEFT
Drn. By: SP
Ckd. By: JE
App'd By: MS
Ckd. Date: 1/11

ATC ASSOCIATES INC.

Findings and Recommendations

Plant: **Green River**
Structure: **Coal Runoff Pond**
State ID# **Non-classified**
Field date: **1/14/2011**

Item #	Priority Rating	GPS Point	Photo #	Location Description	Action Item
1	Moderate	G61	2	Spillway	Excavate sediment accumulated at intake to spillway to prevent clogging and growth of vegetation.
2	Normal	G64, G65	-	Interior Slope	Repair animal burrows along interior slope of east embankment
3	Normal	G60	-	Exterior Slope	Monitor area of old scarp on south embankment exterior for signs of movement.
4	Normal	Multiple	1	Interior Slope	Cut remaining woody vegetation on interior slope of west embankment. Cut trees flush with ground, then establish grass cover.
5	Normal	G62	-	Crest	Evaluate grade support needed for 2 HDPE ash lines to Main Ash Pond, approximately 8 foot long section is undermined near north end of west embankment
6	Normal	G63	3	Int. and Ext. Slopes	Repair concrete inlet pipe from coal storage yard to coal runoff pond. Pipe inlet is crushed and partially filled with coal.

Priority:
High - Recommend that action item be addressed as soon as possible
Moderate - Recommend that action item be addressed during next construction season
Normal - Recommend that action item be as part of ongoing maintenance of the structure

Location:
Crest
Toe
Abutment
Interior Slope
Exterior Slope
Principal Spillway
Emergency Spillway

DAM ASSESSMENT FORM

Name of Professional Conducting Inspection: Mark J. Schuhmann P.E.	KY Professional License No.: 12500
Company Name: ATC Associates Inc.	Phone: 502-722-1401
Address: 11001 Bluegrass Parkway, Suite 250, Louisville, KY 40299	
Inspection Preparation: Reviewed all pertinent technical documentation related to this dam and site in: the State's files Yes ☐ No ☒ ; and Owner's Files: Yes ☐ No ☒	
Comments: Side Hill Pond. Excavated pond with embankments on south and east sides. East embankment shared with Ash pond #2. Woody vegetation cleared from interior and exterior slopes since last ATC inspection.	

Dam/Pond Name: **Green River Coal Runoff Pond**		KDEP Hazard Class: N/A	Topographic Quad: Central City East	Date of Inspection: 1/14/11
State Dam ID: N/A	County: Muhlenberg	Latitude: W 37º 21' 56.58"	Longitude: N 87º 7' 13.15"	Last ATC Inspection: 10/28/09

Power Station Name: **KU Green River Station**	
Address: 811 Power Plant Road, Central City, KY 42330	
Site Contact: Travis Harper	Phone: 270-757-6105

Drainage Area (AC): unknown	Surface Area(AC): 6	Height (Ft): 18	Crest Length (Ft): 1200	Crest Width (Ft): 15	Crest Elevation (Ft): N/A
Slope (H:V): Interior: 2.2:1 Exterior: 2:1	Principal Spillway Type: CMP	Principal Spillway Size(In): 18	Spillway Control Elevation: N/A	Freeboard (Ft): 4.4 at east embankment crest near principal spillway	
CCP/Fluids in Pond: Storm Water, Coal Fines	Emergency Spillway Type: None	Emergency Spillway Size: N/A	Spillway Control Elevation: N/A	Freeboard(Ft): N/A	

FIELD CONDITIONS OBSERVED

Coal fines Above Crest: Yes: ☒ None: ☐	Location: South 1/3 of pond	Max. Height above pool (Ft): minimal
Water Level (Below Dam Crest, Ft): 4.4		
Ground Moisture Condition: Dry ☐ Wet ☒ Snow cover ☐ Other:		
Monitoring: Yes ☐ None: ☒ (☐ Gage Rod ☐ Piezometers ☐Seepage Weirs ☐ Survey Monuments ☐ Other)		
Comments: *None*		

A **INTERIOR SLOPE**	**Problems Noted**: ☐ None ☐ Riprap – Missing, Sparse ☒ Wave Erosion ☐ Cracks ☐ Sinkholes ☐ Appears Too Steep ☐ Depressions or Bulges ☐ Slides ☒ Animal Burrows ☒ Trees, Bushes, Briars ☐ Other
GOOD ☐ ACCEPTABLE ☐ DEFICIENT ☒ POOR ☐	***Comments***: *Woody vegetation on south and east interior slope has been cut leaving sparse vegetative cover and bare earth. Animal burrows observed on interior slope of east embankment.*
B **CREST**	**Problems Noted**: ☒ None ☐ Ruts or Puddles ☐ Erosion ☐ Cracks ☐ Sinkholes ☐ Not Wide Enough ☐ Low Areas ☐ Misalignment ☐ Inadequate Surface Drainage ☐ Trees, Bushes, Briars ☐ Other
GOOD ☒ ACCEPTABLE ☐ DEFICIENT ☐ POOR ☐	***Comments***: *Crushed stone placed on dam crest roads on south and east embankments.*

CCP: Coal Combustion byProducts;
Spillway Size: Pipe Dia. for drop inlet; open channel width (typically emergency or (auxiliary) spillway) at the control section, Ft;.
Freeboard: vertical distance from the emergency spillway control section to the lowest point of the crest of the dam.

DAM ASSESSMENT FORM

C **EXTERIOR SLOPE** GOOD ☐ ACCEPTABLE ☒ DEFICIENT ☐ POOR ☐	**Problems Noted**: ☐ None ☐ Livestock Damage ☐ Erosion, Gullies ☐ Cracks ☐ Sinkholes ☐ Appears Too Steep ☒ Depression or Bulges ☐ Slide ☐ Soft Areas ☐ Trees, Bushes, Briars ☐ Animal Burrows ☐ Other ***Comments****: Old scarp observed near exterior crest of slope on south embankment deflecting process pipe rack along crest. Trees cleared off slope since last ATC inspection, grassing on cleared slopes will need to be established.*
D **SEEPAGE** GOOD ☒ ACCEPTABLE ☐ DEFICIENT ☐ POOR ☐	**Problems Noted**: ☒ None ☐ Saturated Embankment Area ☐ Seepage Exits on Embankment ☐ Seepage Exits at Point Source ☐ Seepage Area at Toe ☐ Flow Adjacent to Outlet **If Seepage**: ☐ Clear ☐ Muddy **Drain Outfalls Seen**: Yes ☐ No ☐ Flow: ☐ Clear ☐ Muddy ☐ Dry ☐ Obstructed ***Comments****: None*
E **PRINCIPAL SPILLWAY** GOOD ☐ ACCEPTABLE ☒ DEFICIENT ☐ POOR ☐	**Description**: 18 Inch CMP with small skimmer and oil absorption bags present. **Problems Noted**: ☐ None ☐ Deterioration ☐ Separation ☐ Cracking ☒ Inlet, Outlet Deficiency ☐ Stilling Basin Inadequacies ☐ Trash Rack ☐ Other ***Comments****: Siltation occurring near inlet allowing vegetation to grow up around inlet to spillway. Clear accumulated sediment from inlet.*
F **AUXILIARY SPILLWAY** GOOD ☐ ACCEPTABLE ☐ DEFICIENT ☐ POOR ☐	**Description**: No auxiliary spillway observed **Problems Noted:** ☐ None ☒ No Auxiliary Spillway Found ☐ Erosion with Backcutting ☐ Crack with Displacement ☐ Appears to be Structurally Inadequate ☐ Appears too Small ☐ Inadequate Freeboard ☐ Flow Obstructed ☐ Concreted Deteriorated/Undermined ☐ Other ***Comments****: N/A*
G **MAINTENANCE AND REPAIRS** GOOD ☐ ACCEPTABLE ☒ DEFICIENT ☐ POOR ☐	**Problems Noted**: ☐ None ☐ Access Road Needs Maintenance ☐ Spillway Obstruction ☒ Vegetation on Interior Slope ☒ Trees on Interior Slope ☒ Rodent Activity on Interior Slope ☐ Deteriorated Concrete –Facing, Outlet, Spillway ☐ Gate and/or Drawdown Need Repair ☐ Other ***Comments****: Continue to monitor interior slopes for rodent activity. Woody vegetation present on interior slope west embankment. Where clearing was recently performed, grass cover on slopes needs to be established.*
H **IMPOUNDMENT AREA** GOOD ☐ ACCEPTABLE ☒ DEFICIENT ☐ POOR ☐	**Problems Noted**: ☐ None ☐ Ponded Water within Ash ☐ Ash blocking spill way ☐ Signs of damage from dredging ☐ Ash deposits in spillway ☐ Other **Inflow sources**: ☒ Runoff ☐ Ash Sluicing ☒ Process Water ☐ Other **Release of ponded water could cause overtopping of dam**: Yes ☐ No ☒ N/A ☐ ***Comments****: Exposed coal fines ash at south end of pond, siltation starting to occur near spillway inlet causing vegetation to grow up around spillway inlet.*

DAM ASSESSMENT FORM

I OVERALL CONDITIONS		*Comments: Substantial improvements made since last ATC inspection. Continue to monitor slopes for rodent activity.* *To obtain "Satisfactory" rating Address all Moderate priority action items listed in Findings and Recommendations Table and schedule to address all "Normal" priority action items.*
SATISFACTORY	☐	
FAIR	☒	
CONDITIONALLY POOR	☐	
POOR	☐	
UNSATISFACTORY	☐	

Summary of Findings and Recommendations in Attached Table

This visual dam assessment was conducted to assess the general overall condition of the reservoir/ash pond/dam, identify visible deficiencies, and recommend areas for monitoring, additional investigative studies and corrective actions. The assessment is based only on visible features/areas of the dam on the day of inspection; it does not constitute a formal safety inspection nor a review or evaluation from each specialist of an inspection team, such as geologists, civil, geotechnical, structural, or hydraulics engineer. The owner should verify the findings of this report and take corrective actions. This assessment does not relieve the owner/operator from their responsibility to conduct routine inspections, maintenance, repairs, modifications, monitoring, documentation, and/or investigative studies.

Professional Engineer's Signature: [signature] Date: 1-25-11

Reviewed by: David J. Hillay Date: 1-25-11
Owner/Owner Representative Signature

GREEN RIVER COAL RUNOFF PHOTOS
January 14, 2011

Photo #1: West embankment at NW corner, looking south
Note: Sparse vegetation and trees along interior of embankment

Photo #2: Principal Spillway inlet

GREEN RIVER COAL RUNOFF PHOTOS
January 14, 2011

Photo #3: Inlet pipe from coal storage yard to coal runoff pond crushed, partially filled with coal, looking north

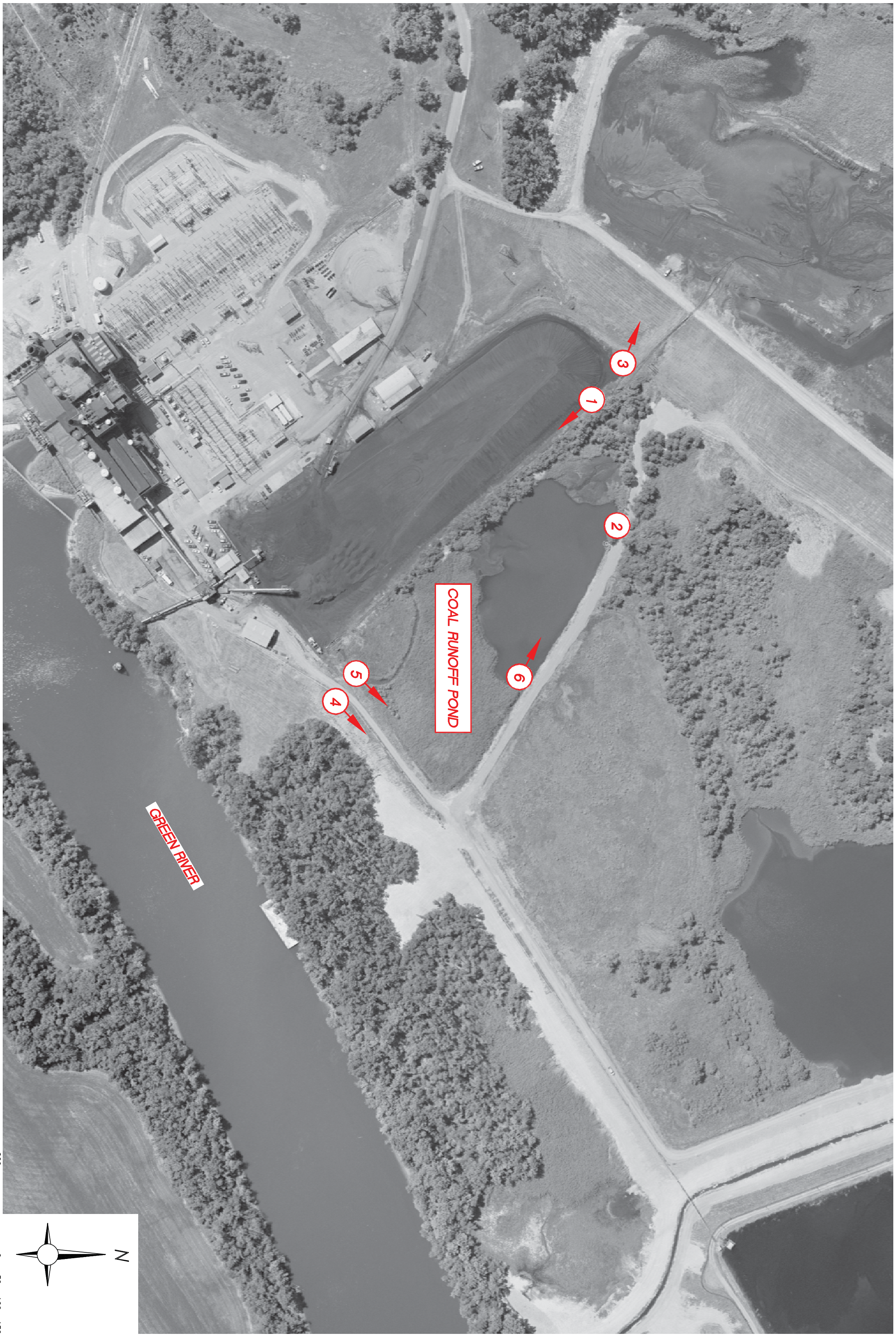
Photo #4: South embankment, exterior slope, looking east
Note: Low spot in crest

GREEN RIVER COAL RUNOFF PHOTOS
January 14, 2011

Photo #5: South embankment, interior slope, looking east
Note: Sparse vegetation

Photo #6: East embankment, interior slope, looking north
Note: Animal burrows

AUGUST 2010 AERIAL PHOTOGRAPHS PROVIDED BY:
L.R. KIMBALL ASSOCIATES INC.
STATE PLANE COORDINATE SYSTEM: KENTUCKY (FIPS 1600), NAD83



SCALE: 1" = 200'
200 0 50 100 150 200

LG&E - KU 2011 POND INSPECTIONS
KU GREEN RIVER STATION - COAL RUNOFF POND
PLAN WITH PHOTOS

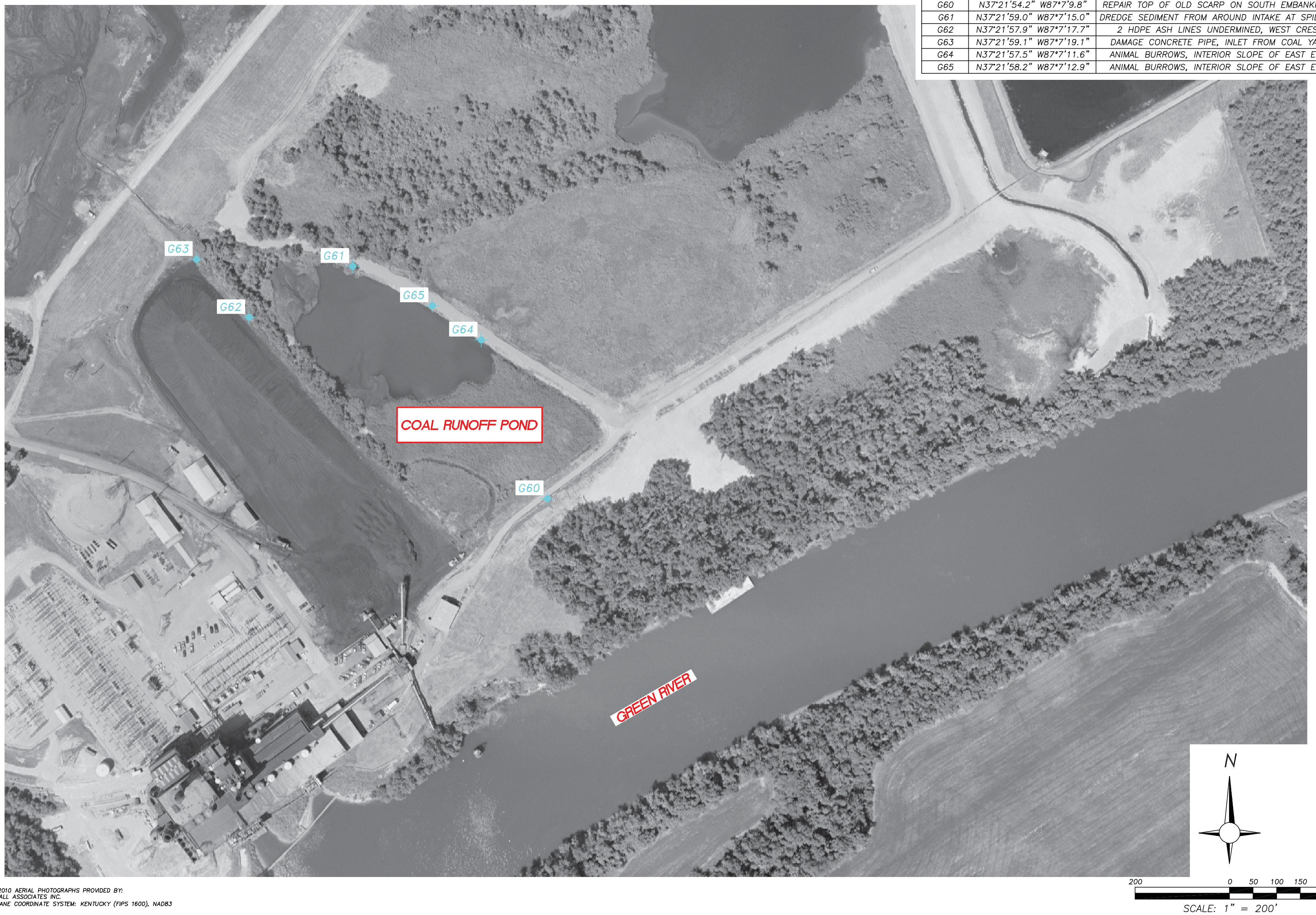
Date: 1/11
Scale: AS SHOWN
Figure: B-8

LEGEND:
LOCATION OF PHOTOGRAPH
10 — DIRECTION OF PHOTOGRAPH
PHOTO DESIGNATION

Project Number: 27.11000.1G37	Drn. By: SP
Drawing File: SEE LOWER LEFT	Ckd. By: JE
ATC ASSOCIATES INC.	App'd By: MS
	Ckd. Date: 1/11

COAL RUNOFF POND – FIELD OBSERVATIONS

GPS PT.	COORDINATES	DESCRIPTION
G60	N37°21'54.2" W87°7'9.8"	REPAIR TOP OF OLD SCARP ON SOUTH EMBANKMENT
G61	N37°21'59.0" W87°7'15.0"	DREDGE SEDIMENT FROM AROUND INTAKE AT SPILLWAY
G62	N37°21'57.9" W87°7'17.7"	2 HDPE ASH LINES UNDERMINED, WEST CREST
G63	N37°21'59.1" W87°7'19.1"	DAMAGE CONCRETE PIPE, INLET FROM COAL YARD
G64	N37°21'57.5" W87°7'11.6"	ANIMAL BURROWS, INTERIOR SLOPE OF EAST EMB.
G65	N37°21'58.2" W87°7'12.9"	ANIMAL BURROWS, INTERIOR SLOPE OF EAST EMB.



AUGUST 2010 AERIAL PHOTOGRAPHS PROVIDED BY:
L.R. KIMBALL ASSOCIATES INC.
STATE PLANE COORDINATE SYSTEM: KENTUCKY (FIPS 1600), NAD83

LG&E – KU 2011 POND INSPECTIONS
KU GREEN RIVER STATION – COAL RUNOFF POND
GPS COORDINATES/ SITE OBSERVATIONS

Date: 1/11
Scale: AS SHOWN
Figure: B-9

Project Number: 27.11000.1G37
Drawing File: SEE LOWER LEFT
Drn. By: SP
Ckd. By: JE
App'd By: MS
Ckd. Date: 1/11

ATC ASSOCIATES INC.