Closure Plan, Rev. 2

Tanners Creek Fly Ash Pond

Facility Name: Tanners Creek Plant
Fly Ash Pond Complex

Facility Location: 800 AEP Drive, Lawrenceburg, IN

Facility County: Dearborn

Facility Solid Waste Permit No: N/A

Owner:
Tanners Creek Development, LLC.
1515 Des Peres Rd., Suite 300
St. Louis, MO 63131
p. 314-835-2878

Prepared by:
S&ME, Inc.
6190 Enterprise Court
Dublin, OH 43016

October 18, 2017
Revised June 26, 2018

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EnviroAnalytics
Group

Environmental Engineers

June 26, 2018

IDEM Solid Waste Permitting
ATTN: John Hale
IGCN 1101
100 North Senate Ave
Indianapolis, IN 46204-2251

RE: **Tanners Creek Fly Ash Pond Capping/Closure Plan**
Response to Comments

Dear Mr. Hale,

On behalf of Tanners Creek Development, LLC, current owners of the subject site, EnviroAnalytics Group, LLC (EAG) is providing the attached response to comments made on the capping and closure plan for the fly ash pond (FAP) located on the site, west of Tanners Creek, and north of the Ohio River.

Should you have any questions or require any additional information, please do not hesitate to contact me via phone (314-835-2814) or email (ddunn@enviroanalyticsgroup.com). Thank you for your time and effort regarding this site.

Sincerely,

Daniel M. Dunn, PE
EnviroAnalytics Group LLC

Solid Waste Land Disposal Facilities
Signatures and Certification Statements for Requested Additional Information

329 IAC 10-11-3(d) requires that the signatory of a solid waste land disposal facility permit application and of other information requested by or on behalf of the Commissioner (including the supplemental information requested by our office for your solid waste land disposal facility permit application) sign to the following certification statement:

> "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations. I further certify that I am authorized to submit this information."

Tom Roberts

APPLICANT'S SIGNATURE

6-26-18

DATE

Thomas E. Roberts

APPLICANT'S NAME TYPED

Note: It is not necessary to submit this form if an equivalent signed certification statement is incorporated into your submittal.

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June 26, 2018

EnviroAnalytics
1515 Des Peres Rd, Suite 300
St. Louis, MO 63131

Attention: Mr. Daniel Dunn

Reference: Responses to IDEM 5/10/18 RAI
Fly Ash Pond Closure, Tanners Creek

Mr. Dunn:

In accordance with your request, S&ME has revised the Tanners Creek Fly Ash Pond Closure Plan based on the IDEM Insufficient Response to Request for Additional Information letter dated May 10, 2018, and your preferences as discussed with you on May 22, 2018. This letter summarizes the changes made to the Closure Plan.

In the paragraphs which follow, the IDEM comments are in normal font and responses to each comment follow in *Italic Blue* font.

Engineering Comments, Michelle Lu

Section 5.7 Cover System

1. In response to IDEM's comment regarding the cover system design, you modified the soil cover to include a six-inch vegetative layer over 30 inches of protective soil. The typical sections (Sheet 13), final cover details (Detail 1 on Sheet 14), and closure cost estimate have been modified for 36-inch final cover, but neither the Ash Grading Plan nor the Final Cover System Plan was changed. Please modify these drawings to reflect the 36-inch soil cover, and update the soil and/or ash cut-fill volume on the drawings and in the report (Table 5-1 and Table 5-2). Please verify the surface water control design will accommodate the 36-inch final cover.

Revised as recommended, see discussion below.

Grading Plans – Proposed grades on Drawings 7 and 9 have been modified to reflect the 36-inch cover system thickness. Additionally, the background topographic maps on Drawings 8, 9, and 10 have been modified to reflect the 36-inch cover system.

Closure Design Components – The quantities presented in Tables 5-1 and 5-2 have been updated along with the quantity tables on Drawings 7 and 9. No changes were made to the quantities in Report Section 9 (cost estimate) as these already reflected the 36-inch cover system.

Surface Water Controls – Thickening the cover system from 30-inch to 36-inches changes neither the cross sectional area nor slope of the surface water controls. Therefore, the capacity and erosion protection are adequate as prior designed. No changes made in response to this comment.

2. Your response to our comment regarding the type and source of cover soil states the majority of cover soil will be obtained from the open field area adjacent to the Fly Ash Pond, designated as Borrow Area 4. Please depict Borrow Area 4 on the plans, and provide the test pits results for the borrow area.

Revised as recommended. Drawing 3 has been modified to show the location of Borrow Area 4 including the location of explorations. Exploration logs and laboratory test results for Borrow Area 4 have been added to Closure Plan Appendix VI (Geotechnical Data).

3. For cover system designs with a flatter grade (2%), preventing infiltration is of particular concern. Please provide an analysis of the transmissivity for the geotextile cushion drainage layer, and demonstrate how the use of 16-oz. non-woven geotextile in the flatter area can provide enough transmissivity to remove the moisture from the final cover system. We recommend a minimum transmissivity of 3×10^{-5} m^2 per second for geosynthetic drainage material.

The standard cover system has been modified to include a geocomposite drainage layer in all areas except the small area directly beneath the perimeter drainage channels at the outboard toe of the bottom ash dike. Drawings 6, 11, 14, 15, and 17 have been modified to reflect this change.

<u>Section 6.4 Cover System Stability</u>

4. This section states that the minimum cover system interface friction angle is 24.5°. However, the supporting calculation in Appendix D of Attachment V shows the minimum interface friction angle is 23.8°. Please clarify the discrepancy.

The calculation (and QA/QC Plan) correctly depicted the interface friction angle of 23.8°; Section 6.4 has been modified to match.

<u>Section 7.0 Closure Plan</u>

5. For IDEM Closure Form Parts III through VIII, please address the following:

   a. Part V Item A, please revise the narrative in sub-items (2), (3), and (4) as follows:

      Sub-item (2) Soil obtained from on-site borrow area
      Sub-item (3) 100%
      Sub-item (4) Soil obtained from off-site

      Revised as recommended.

   b. Part V Item B, please change the title for "Two Feet of Final Cover" to "30 Inches of Final Cover".

      Revised as recommended.

c. Part VI Item B (Other Costs), please remove the activity and cost for items 4 (Phase 1 Soil Excavation) and 5 (Phase 2 Soil Excavation and Fill). These two costs have been included in the cost estimates for the 30 inches of final cover and the 6 inches of topsoil.

Revised as recommended.

d. We have noted that some costs submitted and shown below are lower than the commonly accepted amounts generally used by other facilities. Please revisit these costs and make necessary adjustments, or provide supporting documentation to justify that the submitted cost is still valid.

- Excavation unit cost: $1.50 per yd^3
- Placement/Spreading unit cost: $0.50 per yd^3

We generally see a unit cost of $ 2.5 to $ 3.5 per yd^3 for excavation of soil or placement of topsoil.

Owner will be completing these activities using their own equipment and personnel rather than retaining an earthwork contractor. The lower than normal unit rates reflect self-performing the activities. No change has been made to the cost estimate based on this comment.

e. Please include 10% contingency cost in the closure cost estimate.

Revised as recommended.

Attachment IV. Post Closure Care Plan

6. For IDEM Post Closure Form Parts III through V, please address the following:

a. Part V Item B(1)(a), please note the final cover will include geosynthetic material (geomembrane, geocomposite or geotextile) and 36 inches of soil cover and vegetation. Revise this item to add 10% ($/acre) of cost for replacement of geosynthetic material.

Revised as recommended.

b. Part V Item H (cost for groundwater monitoring), please verify the number of required monitoring wells is adequate. Table 4-1 for Summary of Monitoring Wells in Attachment II appears to show more than 17 monitoring wells.

The vast majority of costs associated with monitoring are related to sample collection and chemical analysis. Seventeen of the wells in the Fly Ash Pond monitoring system were to be sampled with the remainder to be monitored for water levels only. So even though the system included more than 17 wells, the cost estimate was based on 17 wells to be sampled. The GWMP has been revised based on Geology comment Nos. 1 & 2 (see separate responses). The cost estimate has been revised based on these changes and both

Table 4-1 and Figure 2 have been updated accordingly. The revised cost estimate is based on the sampling of 19 wells.

Additionally, the prior submitted Groundwater Monitoring Plan Table 4-1 identified 21 wells as part of the groundwater monitoring system for the Fly Ash Pond whereas Figure 2 of the Plan listed 23 wells associated with the Fly Ash Pond. Wells MW-3 and MW-5 have been added to Table 4-1 to correct the discrepancy. Wells MW-3 and MW-5 are to be monitored for water levels only.

The other wells listed on Figure 2 are present at Tanners Creek; but as noted in the facility designation columns, are not part of the Fly Ash Pond Monitoring System as they are not in close proximity to the Fly Ash Pond. These other wells are listed only for informational purposes. Table 4-1 denotes the wells to be monitored for the Fly Ash Pond.

7. Please submit a dust control plan detailing the control measures used, and any corrective actions taken during the entire closure period, particularly for soil excavation from borrow area, the fly ash cut-fill and soil placement.

Revise as recommended; a Dust Control Plan has been included as Appendix VII of the Closure Plan.

Geology Comments, Andrew Najafiarab

1. The *Phase I Ground Water Monitoring Plan, Rev 3* (GWMP) dated March 9, 2018 (VFC #80633887, pg. 59), does not include ground water monitoring wells along the northeast boundary of the Fly Ash Pond (FAP). The northeast boundary of the FAP is hydrogeologically upgradient, as shown in the potentiometric maps included in Appendix A of the GWMP. However the hydrogeologic study for the adjacent Tanners Creek Plant Type I Restricted Waste Landfill (landfill) dated January 31, 2007 (VFC #27877050, pg. 10), indicates ground water flow direction may reverse depending on the water elevation of the Ohio River.

   Due to the potential flux of the ground water flow direction and the lack of ground water quality monitoring points in this area, you need to revise the GWMP to include nested monitoring wells along the northeastern boundary of the FAP. The nested wells need to meet the same spacing and specifications as proposed wells MW-22S through MW-25D.

Additional nested wells have been added along the northeast side of the Fly Ash Pond, see Groundwater Monitoring Plan Table 4-1, Figure 1, and Figure 2. The additional up-gradient wells will be installed, developed, and sampled to establish baseline groundwater quality. The additional wells will then be monitored for water levels only, unless a flow reversal is identified. If a flow reversal is identified, the additional wells would be sampled as down-gradient wells.

2. The original ground water monitoring plan dated February 12, 2014 (VFC #80020801, pg. 142), included ground water sampling at the adjacent municipal ground water supply wells owned by the City of Aurora and the Lawrenceburg, Manchester, Sparta Water Conservancy District (Aurora/LMS).

   We have identified site-wide ground water flow directions that appear radially influenced towards the Aurora/LMS wells. Additionally, the Aurora/LMS wells terminate in the same aquifer lithologies that underlie the Tanners Creek landfill that contains unlined coal combustion residual storage areas. Due to the influence of the municipal supply wells on ground water flow from the Tanners Creek landfill, you need to revise the current GWMP to include ground water monitoring at the Aurora/LMS wells adjacent to the FAP.

   Indiana Michigan Power Co ("AEP") has retained responsibility for ground water monitoring at the Aurora/LMS wells. We currently do not have access to these wells and will promptly inform AEP of your request for such monitoring and have AEP get in touch with you as soon as possible. However, in response to your request, the GWMP has been modified to include sampling of Wells GM-1D & GM-1S which are located between the FAP and the Aurora/LMS production wells. Please refer to Figure 1 of Appendix A of the GWMP and specifically the monitoring well nest identified as GM-1D/1S.

We appreciate being of continued service at Tanners Creek. If you have any questions regarding this submittal, please do not hesitate to contact our office.

Sincerely,

S&ME, Inc.

Michael T. Romanello, PE
Project Geologist

Michael G. Rowland, PE
Senior Engineer

Closure Plan, Rev. 2
Tanners Creek Fly Ash Pond

Facility Name: Tanners Creek Plant
Fly Ash Pond Complex

Facility Location: 800 AEP Drive, Lawrenceburg, IN

Facility County: Dearborn

Facility Solid Waste Permit No: N/A

Owner:
Tanners Creek Development, LLC.
1515 Des Peres Rd., Suite 300
St. Louis, MO 63131
p. 314-835-2878

Prepared by:
S&ME, Inc.
6190 Enterprise Court
Dublin, OH 43016

October 18, 2017
Revised June 26, 2018

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June 26, 2018

Tanners Creek Development, LLC.
1515 Des Peres Rd., Suite 300
St. Louis, MO 63131

Attention: Mr. Daniel Dunn

Reference: **Closure Plan, Rev. 2**
Tanners Creek Plant Fly Ash Pond
Lawrenceburg, Indiana
S&ME Project No. 7217-17-007A

Dear Mr. Dunn:

In accordance with our change order request dated May 25, 2018, which was authorized on June 4, 2018, S&ME has revised the Closure Plan for the Tanners Creek Plant Fly Ash Pond located near Lawrenceburg, Indiana. The Closure Plan includes several documents in addition to this narrative, specifically the following are included as appendices to the Closure Plan: Drawings, a Ground Water Monitoring Plan, a QA/QC Plan, a Post Closure Care Plan, Engineering Calculations, Geotechnical Data, and a Dust Control Plan. The Closure Plan has been revised to respond to the Request for Additional Information (RAI) received from the Indiana Department of Environmental Management dated May 10, 2018 and fully supersedes the previous versions of this document dated October 18, 2017 and March 17, 2018.

We appreciate having been given the opportunity to be of service on this project. If during your review of this submittal you have any questions, please do not hesitate to contact our office.

Sincerely,

S&ME, Inc.

Michael T. Romanello, P.E.
Project Engineer
Indiana PE Registration No. 11600160

Michael G. Rowland, P.E.
Senior Engineer

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Engineer Certification

I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Indiana.

MICHAEL T ROMANELLO
REGISTERED
PE11600160
STATE OF INDIANA
PROFESSIONAL ENGINEER

Signature: [signature] Date: 7-26-18

Name: Michael T. Romanello

Address: 6190 Enterprise Court

Dublin, OH 43016

Telephone Number: 614-793-2226

Professional Engineer Registration No. PE-11600160

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Table of Contents

List of Tables

Attachments

1.0 Introduction

The Tanners Creek Power Plant is located adjacent to the Ohio River on State Route 50 approximately one mile southwest of Lawrenceburg, Indiana. The first of four coal fired steam electric generating units at the facility came on-line in 1951 and power generation ceased in May of 2015. The plant, while active, was operated by the Indiana Michigan Power Company (a subsidiary of American Electric Power). Tanners Creek Development, LLC purchased Tanners Creek Plant in October of 2016 and intends to redevelop portions of the property.

The general facilities currently present at the Tanners Creek Power Plant include the following:

- Power plant and support structures (conveyors, buildings, transmission, etc.);
- remnants of the former coal pile;
- the "Old" ash disposal area;
- the Main Ash Pond;
- the Fly Ash Pond complex; and,
- an IDEM permitted Ash Landfill constructed over a former ash pond (aka overfill).

Figure 1 shows the location of the ash ponds in relation to the plant. This document presents a Closure Plan for the fly ash pond complex only. American Electric Power previously prepared and submitted to the Indiana Department of Environmental Management (IDEM) a Closure Plan for the Tanners Creek ash ponds on March 23, 2015. The AEP Closure Plan addressed the closure of the Fly Ash Pond, the Main Ash Pond, and the "Old" Ash Area. Tanners Creek Development, LLC intends to submit a closure plan for the Main Ash Pond and "Old' Ash Area under separate cover in the future.

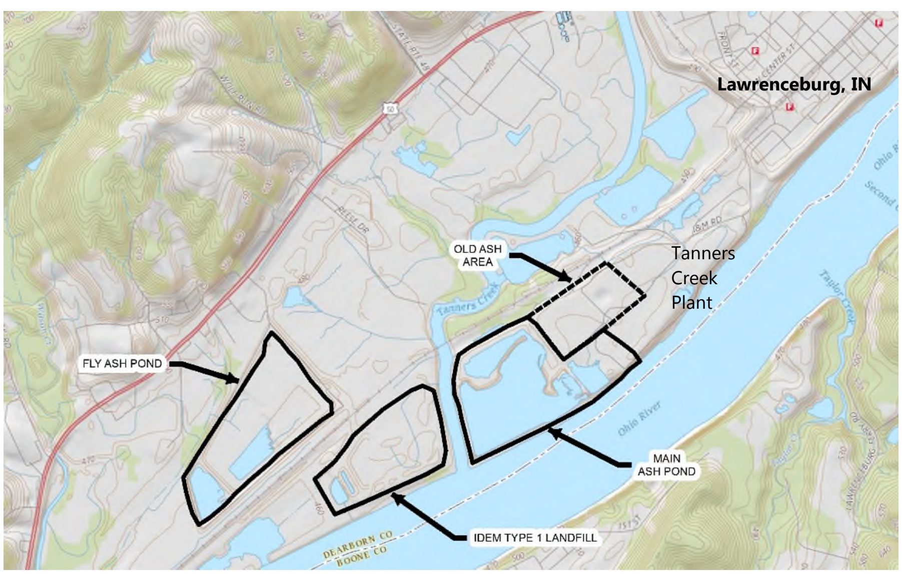

Figure 1-1: Vicinity Map

2.0 Facility Description

2.1 General Configuration

The fly ash pond complex, when originally constructed in 1977 and 1978, consisted of a single impoundment contained by a fully encompassing perimeter earthen dike. The bottom of the pond was extended below the surrounding ground surface and the interior of the pond was lined with a 20 mil PVC geomembrane. Fly ash was sluiced into the pond from the northern end and a clear water area was maintained on the southern end.

The impoundment was physically split into the southern clear water pond and the upper (northern) basin between 2003 and 2007. The reconfiguration was accomplished by constructing an interior dike consisting of bottom ash over the in-place sluiced fly ash. At this time, spillways were installed in the upper basin on the east and west sides near the south end to convey the flow to the clear water pond. In 2010, the upper basin was split into an eastern basin and a western basin with the installation of a splitter dike also constructed of bottom ash over the in-place sluiced fly ash. The upper basin and clear water pond areas are collectively referred to as the fly ash pond (FAP) in this Plan.

Key elevations (nominal) for the FAP are as follows:

- El 465 - 470 – outboard toe of earthen dike.
- EL 458 – bottom of pond.
- El 495 – top of original earthen dike (clear water pond dike on west, south, and east sides).
- El 518 – top of bottom ash dike on west, north, and east sides of the upper basin.
- El 511 – top of bottom ash dike between upper basin and clear water pond.
- El 508 – general surface of the fly ash within upper basin.
- El 488 – 100 year, 24 hour flood level of Ohio River adjacent to the FAP
- El 491 – emergency spillway invert.

2.2 General Operation

When the FAP complex was operational, fly ash sluiced from the Station discharged into the FAP complex at the northern end of the upper basin(s). The water level within the upper basin(s) was controlled by adding/removing stop logs in the spillways located at the southeast and southwest corners. Discharge from the spillway via 30" HDPE pipes was to open channels located at the toe of the bottom ash dikes (inboard side of the original earthen dike crest). The channels discharged into the clear water pond at the northeast and northwest corners.

The water level within the clear water pond was controlled by pumping; the former pump structure is located near the middle of the southern dike. Water was pumped from the clear water pond to the Main Ash Pond through an above ground pipeline. An emergency spillway is located at the southeast corner of clear water pond. The emergency spillway penetrates the top of the original earthen dike via a box culvert and then through a concrete chute down the outboard slope of the earthen dike to a toe ditch. The toe ditch drains westward along the toe of the southern dike before turning south at the southwest corner of the FAP where the ditch discharges into Wilson Creek prior to its confluence with the Ohio River.

2.3 Existing Conditions

Sluicing of fly ash to the FAP ceased in 2014 and AEP initiated preliminary closure activities at that time. The sluice pipes from the plant were removed. The splitter dike between the east and west upper basins was removed along with the upper 6 to 8 feet of the interior dike between the upper basin and clear water ponds. The bottom ash from the dike removal was placed in the clear water pond, leaving a smaller open water area. The outlets of both spillway pipes remain as do the ditches between the spillway pipe outlets and the clear water pond. The pumps in the clear water pond have been removed; water in the clear water pond is conveyed to the Main Ash Pond using a portable pump connected to the original pipeline. The emergency spillway remains intact.

A Conceptual Design Report was prepared and submitted to IDEM in April 2017, and a meeting followed to discuss the report. This Closure Plan generally follows the closure approach presented in the April 2017 Conceptual Design Report.

Preliminary ash excavation and grading are on-going and include the following activities:

- The splitter dike between the clear water pond and upper basin has been excavated to approximate Elevation 500 with the bottom ash pushed into the clear water pond area. This area was then re-constructed to Elevation 505 with fly ash.
- The upper basin has been graded to construct two drainage channels providing positive drainage toward the existing spillways.
- Excess ash cut has been placed into the clear water pond area.
- Both spillways in the upper basin have been exposed and are being used to convey surface (contact) water drainage.

The Closure Drawings prepared as part of this Plan are based on the conditions at the site from April 2017 when the base topographic survey was performed.

3.0 Supporting Information

3.1 Historic Investigations and Permits

The following documents provide a summary of the major investigations, design documents, and inspections related to the Fly Ash pond that are known to have been conducted:

- Investigations for Proposed Fly Ash Pond, Casagrande Consultants, 1976.
- Final Report of Geotechnical Consultation and Inspection Services, Woodward-Clyde Consultants 1979.
- Fly Ash Storage Pond Elevation 518’ Raising Engineering Report, AEP, ProServ, and Bar Engineering, 2002.
- Design Drawings and Construction Specifications, Barr Engineering and AEP, 2002
- Fly Ash Pond 518’ Raising Construction Drawings, AEP, March 3, 2003.

- Fly Ash Pond Bathometric Survey, AEP, December 11, 2008.
- Deformation Review, AEP 2007 and 2009
- Fly Ash Pond Piezometric Static Water Levels, Indiana Michigan Power Company, 2009.
- Site Inspection and Observation Report, Geo/Environmental Associates, 2009.
- Fly Ash Pond Assessment Report, Lockheed Martin/Obrien & Gere, 2009 (for USEPA).
- Geotechnical Exploration Report, TRC, 2014.
- Closure Plan, TRC, February 2015.
- Phase 1 Environmental Site Assessment, Burns McDonnell, March 2016.
- Title V Operating Permit, IDEM, February 6, 2015.
- Title V Permit Retirement, IDEM, January 29, 2016.

The IDEM Solid Waste Permits division prepared a Request for Additional Information dated July 24, 2015 following receipt of the 2015 Closure Plan. A formal response was not prepared by AEP prior to the purchase the Plant. S&ME has provided responses to the IDEM review comments dated July 24, 2015, February 6, 2018 and May 10, 2018 as they pertain to this closure plan. A separate comment log has been prepared and has been included with this Plan as Attachment VII.

3.2 Other Permits

Closure of the FAP will require improving the existing drainage ditches at the toe of the embankment around the eastern and southern portion of the FAP to sufficiently carry runoff from the 100-year storm. The improved ditches will discharge into an unnamed tributary of Wilson Creek near the southeast corner of the FAP. The removal of a culvert in the channel downstream of the FAP is also planned to improve drainage capacity. The FAP drainage ditch improvements will result in minor impacts to the tributary stream and an adjacent wetland.

S&ME coordinated with the regulatory agencies to obtain Indiana Regional General Permit (RGP) No. 1 authorization for the proposed jurisdictional waters impacts. On March 9, 2018, the United States Army Corps of Engineers (USACE) issued RGP No. 1 authorization for the project. The USACE permit reference number is LRL-2017-1143-mdh. On March 29, 2018, Indiana Department of Environmental Management, Office of Water Quality approved the RGP Section 401 Water Quality Certification for the project. The IDEM permit reference number is 2018-188-15-ADF-X.

4.0 New Field Work

4.1 Topographic Survey

S&ME retained GeoPro Consultants to prepare topographic mapping of the fly ash pond complex. Field work for the survey was performed in March 2017. GeoPro utilized a combination of ground survey, existing LiDAR data, and drone imagery to develop topographic contours of the fly ash pond facility. The topographic mapping has been incorporated into the design drawings. The survey was limited to development of topographic contours; services did not included a boundary survey, an ALTA survey, or a utility survey.

Bathymetric topographic contours were generated for the portion of the clear water pond which was below water at the time of the GeoPro survey. The topographic contours were digitized from a bathymetric survey performed by AEP in 2008, with elevations converted from the NAVD29 datum to the NAVD88 datum. The bathymetric topographic contours were utilized for cut/fill volume calculations and are considered approximate.

4.2 Subsurface Investigation

S&ME performed 23 Cone Penetration Test (CPT) soundings to supplement the available geotechnical data provided by the 2002 Dam Raising Design Report and the 2015 Closure Plan. The CPT soundings were performed within the pond to better define the consistency of the in-place sluiced fly ash materials and evaluate the current groundwater conditions. At select locations, pore pressure dissipation and shear wave velocity testing were performed. Additionally, 5 open standpipe piezometers were installed in the upper basin to permit extended groundwater level readings within the ash. The Geotechnical Data Report for the CPT investigation has been included with this Plan as Attachment VI. The Report summarizes the data collection procedures, identifies the CPT locations, provides interpretation plots of the data, and summarizes the extended groundwater level readings.

5.0 Closure Design

5.1 Overview

The closure of the FAP will be constructed using a phased approach. Following demolition of select structures, and installation of initial surface water controls, the first phase will focus on constructing the closure of the upper basin by re-grading the ash and constructing the cover system. Grading will be such that no water is impounded at completion. Surface water will be routed through breaches in the bottom ash dike. During the closure of the upper basin, the clear water pond will be used to manage both contact water and construction runoff directed from the breach channels. Once the cover system on the upper basin is in place and vegetation established, surface water drainage will be diverted away from the clear water pond. This will be accomplished by breaching the original earthen dike and constructing surface water downdrain channels upstream of the clear water pond. Closure of the clear water pond will then take place. During closure of the clear water pond, contact water and construction runoff will be managed within progressively smaller portions of the clear water pond via pumping. Once the final cover system grading is complete, surface water runoff from the clear water pond will be conveyed through the existing emergency spillway. The emergency spillway will be used to permanently carry the runoff from the former clear water pond area to the toe of the slope where it will enter the improved perimeter drainage channel and outlet into the Wilsons Creek tributary stream.

Grading plans have been developed for the limited grading work for the 'Initial' and 'Final' surface water control phases, as well as the mass grading for the closure work in the upper basin and clear water pond. Earthwork associated with the closure of the upper basin is designated as Phase 1, and work associated with the closure of the clear water pond is designated as Phase 2. Separate plan sheets for the 'Top of Ash' and 'Final Grade' have been prepared for both the Phase 1 and Phase 2 grading activities. Quantities for the major tasks associated with each drawing have been included in the Drawings. A complete schedule of values is included with the Engineer's Estimate of Probable Construction Costs presented in Section 7.1 of this Plan.

5.2 Closure Considerations

The following key considerations were used by S&ME based on the conceptual closure design and preliminary discussions with IDEM:

- Achieve positive drainage without the need for dramatic ash cut and fills and to the extent possible, balance the ash cut/fill volumes;
- Relatively flat slopes and channels are acceptable (to minimize ash cut/fill), however design should consider settlement so that channels continue to drain post-settlement;
- Overall closure, and specifically closure of clear water pond, needs to consider management of contact and storm water;
- Grading should be simple and easily constructible;
- Bottom ash dike toe drain pipes to be removed;
- IDEM engineering comments from the 2015 Closure Plan should be addressed.

5.3 Initial Surface Water Controls

The work to implement the initial surface water controls consists of improving the existing ditches between the earthen dike and bottom ash dike to promote positive drainage toward the clear water pond and manage the 100-year 24-hour storm event. With the exception of the final steps of the clear water pond closure where the open water area will be progressively decreased, interim construction storm storage within the clear water pond will be maintained to contain the 25-year 24-hour storm event. Implementation of the initial surface water controls is detailed on Sheet 5 of the Drawings.

5.4 Phase 1 Closure

The proposed grading within the upper basin will create two surface water collection channels that drain southward toward the east and west spillway locations. The bottom ash dike will be breached to allow the surface water collection channels to outlet to the improved ditches. The existing spillway structures and 24-inch drainage conduits will be removed as part of the bottom ash dike breach excavation.

At the time of the topographic survey, the ash surface in the upper basin generally ranged from Elevation 506 to Elevation 510. The invert of the surface water collection channels start near Elevation 508, but the upper basin requires fill ranging up to 8 feet on the north end to create positive drainage into the channels. The collection channels slope at a nominal gradient of 0.5% to Elevation 498 before entering the breach channels. The slope of the ash grades and final grades depicted for the upper basin closure are typically 50H:1V (2%). The intent is to create positive drainage from all areas with minimal cut depths into the fly ash.

Overall, a net cut volume is required in the upper basin area to create enough ash fill for the closure of the clear water pond. During Phase 1 activities, all of the 'cut' material for the clear water pond closure will be placed in northern two-thirds of the clear water pond. The leading edge of the fill has been designed as a 6H to 1V slope. This slope is temporary and will be primarily constructed of dry ash materials placed above the pool elevation of the clear water pond. A slope stability analysis was performed to assess the temporary fill slope configuration. The analysis is discussed in Section 6.3. Additional key design components for the Phase 1 closure task are summarized in Table 5-1.

Table 5-1: Phase 1 Closure Key Design Components

Typical Top Gradient	2%
Perimeter Side Slopes	3H:1V
Collection Channel Gradient	0.5%
Bottom Ash Breach Gradient	East: 16.7 % West: 21.4 %
Breach Side Slopes	4H:1V
Area of Cover System	59.2 AC
Ash Excavation & Fill Volume	206,385 CY
Cover System Protective Soil Layer Fill Volume	238,680 CY
Cover System Vegetative Layer Fill Volume	47,735 CY

5.5 Final Surface Water Controls

In preparation for the Phase 2 grading work, final surface water controls will be implemented by diverting flow from the upper basin to the lower perimeter channels along the toe of the original earthen dike. This will be accomplished by extending both ash breach channels down through the earthen dike. The portion of the improved drainage channel between the bottom ash dike and clear water pond will be filled and redirected to the breach channels. The breach channel are designed at slopes of 4H to 1V. The ash breaches will be armored with a fabric-formed concrete lining and the earth dike breach will be armored with riprap. Discussion of the anticipated flow velocities and selected armoring are included with H&H analysis in Section 6.1. Contact water and construction runoff from within the clear water pond will continue to be controlled via pumping from the small open water area in the southeast corner of the clear water pond.

5.6 Phase 2 Closure

The ash fill placed in the clear water pond during the Phase I closure work will reach a maximum Elevation of 505 feet. The approximate top 10 feet of this ash fill will be used to fill the remaining area of the clear water pond during the Phase 2 closure. A surface water collection channel will extend from the emergency spillway outlet then branch to the north and west. The collection channels slope at a nominal gradient of 0.5%. The typical slopes of the ash surface and final cover system are 125H to 1V. The low gradient results from the need to maintain the ash below the elevation of the earthen dike crest for contact water control, the overall cut/fill balance, and the desire to outlet the surface water collection channels to the existing emergency spillway. The analysis is further discussed in Section 6.3. Additional key design components for the Phase 1 closure task are summarized in Table 5-2.

Table 5-2: Phase 1 Closure Key Design Components

Typical Closure Slope	125H:1V
Collection Channel Gradient	0.5%
Emergency Spillway Inlet Invert Elevation	491.2
Breach Side Slopes	4H:1V
Area of Cover System	11.5
Ash Excavation & Fill Volume	66,255 CY
Cover System Protective Soil Layer Fill Volume	46,450 CY
Cover System Vegetative Layer Fill Volume	9,290 CY

5.7 Cover System

5.7.1 Description

A cover system will be installed above all areas where ash is exposed, as well as down the outboard slopes of the upper basin bottom ash dikes. The cover system will include, from top to bottom:

- 6-inch vegetative layer;
- 30-inches of protective soil layer;
- Geocomposite drainage layer; and
- 40-mil LLDPE or 60 mil HDPE geomembrane.

The primary purpose of the cover soil is to protect the long-term integrity of the geomembrane. As the final cover system will be located above the 100-year flood level, the principal issues that could impact the geomembrane are: 1) erosion and subsequent exposure, 2) vehicle loading, 3) support of vegetation, 4) freeze thaw damage, and 4) burrowing animals.

The majority of soil material for the cover system will be obtained from the adjacent open field area to the southwest of the FAP, designated as Borrow Area 4. The viability of several local borrow areas was documented in a 2008 Borrow Study Report by FMSM Engineers. The report characterized the soils in Borrow Area 4, which has an area of approximately 19 acres, as low plasticity clays and silts (USCS Class CL-ML) based on observation of test pits and a limited number of index tests. Additional index tests in accordance with the QA/QC Plan (Attachment III) will be required during construction. S&ME understands approximately 400,000 CY of borrow material is available from this source, exceeding the requirements for the FAP closure. A small portion of the cover soil will consist of on-site material generated as part of the earthen dike excavation required to establish the surface water controls.

Where the upper basin cover system is installed on the outboard slopes of the bottom ash dike, the geomembrane will extend beneath the drainage channel and terminate in a runout trench on the opposite side. The geomembrane on the south end of the upper basin will be anchored into the east-west bottom ash splitter dike located south of the upper basin. The geomembrane installed for the clear water pond closure will terminate in a runout trench on the crest of the earthen dike on west, south, and east sides. The geomembrane will be welded to geomembrane installed for upper basin closure along the anchor trench across the splitter dike on the north side of the clear water pond.

In addition to providing subsurface drainage capacity, the geocomposite drainage layer also serves as a cushion layer over the geomembrane. The geonet drainage core will outlet in 3 ways: 1) via drainage tubing running beneath the final grade of the collection channels; 2) via drainage tubing at the toe of the inboard slope on the north and south ends of the upper basin; and 3) daylight on the outboard slopes of the bottom ash dike 6" above the perimeter drainage channels. A non-woven geotextile will be used as the cushion layer for the approximate 2 acres where the geomembrane extends beyond the outlet of the geocomposite drainage layer below the perimeter channels. Specifications for all geosynthetics are provided in the QA/QC plan included as Attachment III.

5.8 PVC Liner Penetration

The interior of the original pond is lined with a 20 mil PVC geomembrane. The geomembrane extends up the inboard slopes of the earthen embankment, then presumably terminates in a runout or anchor trench within the crest. Over the upper basin, the proposed cover system liner and geocomposite drainage layer will be extended down the outboard side of the raised embankment and into an anchor trench on the inboard side of the earthen embankment. This termination detail will require the upper portion of the PVC geomembrane to be removed. In bottom lining applications, anchor trenches are initially a critical component of installation needed to prevent liners from creeping down slopes under its own weight, or due to forces such as wind lifting or cyclic expansion/contraction(1). However, once a pond or landfill has been filled, the liner is fully buttressed which prevents such movement, but should be evaluated for global sliding stability. With the construction of the interior dike, the PVC liner is completely buttressed and high factors of safety for global sliding stability would be expected for an inward failure.

An analysis was performed to determine whether the existing bench on the inboard slope of the earthen embankment is wide enough to act as a horizontal runout trench for the existing PVC liner following removal of the liner anchor trench to accommodate the installation of the proposed final cover. Results show the existing 10 foot bench is wider than the minimum necessary to fully engage the tensile strength of the PVC. Therefore, the removal of the upper portion of the PVC geomembrane and anchor trench should not impact the integrity of the liner system. Around the clear water pond, a runout trench on top of the crest or within 18 inches of the top will be used for the proposed liner in the cover system, limiting the impact to the PVC geomembrane. The minimum required runout length calculation is included in the Slope Stability Analysis presented in Attachment V.

6.0 Engineering Analyses

The following sections document the engineering analyses, which were completed in support of the FAP Closure Plan. Analysis results are summarized below with a full narrative and supporting calculations presented in Attachment V of this Plan. The calculations and analyses were performed in general accordance with the requirements of 329 IAC 10-15-8 associated with Municipal Solid Waste Landfills as similar calculation and analysis requirements are not well defined for Restricted Waste Sites.

6.1 Hydrologic & Hydraulic Analysis

A hydrologic and hydraulic (H&H) analysis was performed to demonstrate that proposed surface water controls for the Tanners Creek Fly Ash Pond (FAP) Closure are properly sized in accordance with Indiana Annotated Code Title 329, Article 10, Solid Waste Land Disposal Facilities. Specifically, all permanent drainage controls are to be sized for the 25-year 24-hour design storm event; S&ME used the 100-year 24-hour event for the design of all surface water controls. For computational purposes, we have assumed that the Ohio River is at a normal pool because the 100 year flood elevation reaches partway up the lower perimeter embankment. Results of the H&H study, including an extended narrative, have been detailed in Appendix A of Attachment V.

6.1.1 Hydrologic Study

The permanent drainage controls generally consist of open channels that convey storm water from the northern portion of the basin to two soil breaches. The existing emergency spillway, consisting of a concrete box culvert and concrete chute will convey storm water runoff from the clear water pond area. These drainage controls are discussed in more detail in Appendix A of Attachment V. S&ME used the SCS method to estimate the peak discharge during the design storm event. Hydrologic and hydraulic analyses were conducted using HydroCAD v.10 to model each drainage area using TR-20 methodology.

6.1.2 Hydraulic Study

Permanent drainage controls in this study include culverts and open channels that convey storm water flow to the clear water pond during Phase I or offsite during the final grade configuration. S&ME routed each drainage area through the permanent drainage features using HydroCAD to demonstrate that these features meet the calculation objectives. Characteristics of each drainage control feature are included in Tables 6-1 and 6-2 below and the H&H Appendix.

Table 6-1: Culvert Pipe Characteristics

Description	Material	Rise (in)	Width (in)	Length (ft)	Slope (ft/ft)	Roughness
Box Culvert	Concrete	36	48	89	0.0003	0.011

Table 6-2: Open Channel Characteristics

Channel	Bottom Width (ft)	Side Slopes (XH:1V)	Design Depth (ft)	Bed Slope (ft/ft)	Proposed Lining	Manning's Roughness n
West Drainage Channel	10	50	1.0	0.005	Temp ECB	0.052
West Ash Breach	10	4.2	2.0	0.082	Fabriform	0.025
West Perimeter Channel	10	3.0	2.0	0.002	Temp ECB	0.050
West Soil Breach	10	4.0	2.0	0.21	Riprap	0.054
East Drainage Channel	10	50	1.0	0.005	Temp ECB	0.052
East Ash Breach	10	4.2	2.0	0.069	Fabriform	0.025

Channel	Bottom Width (ft)	Side Slopes (XH:1V)	Design Depth (ft)	Bed Slope (ft/ft)	Proposed Lining	Manning's Roughness n
East Perimeter Channel	10	3.0	2.0	0.002	Temp ECB	0.050
East Soil Breach	10	3.5	2.0	0.17	Riprap	0.051

6.1.3 *Results*

The proposed permanent drainage features were found to be adequately sized for the 100-year design storm event. The results of the open channel flow analysis are summarized in Tables 6-3 and 6-4 below.

Table 6-3: Culvert Pipe Results

Calculation Method	Estimated Peak Flow (cfs)	HW Elevation	Roadway/ Embankment Elevation	Overtopping?
HydroCAD	38.8	492.15	494.0	NO
HY-8	38.8	493.02	494.0	NO

Table 6-4: Open Channel Results

Channel	Calculation Method(1)	Design Depth (ft)	Calculated 100-Year Flow Depth (ft)
West Drainage Channel	HydroCAD/MathCAD	1.0	0.95
West Ash Breach	HydroCAD/MathCAD	2.0	0.63
West Perimeter Channel	HydroCAD/MathCAD	2.0	1.10
West Soil Breach	HydroCAD	2.0	0.73
East Drainage Channel	HydroCAD/MathCAD	1.0	0.95
East Ash Breach	HydroCAD/MathCAD	2.0	0.66
East Perimeter Channel	HydroCAD/MathCAD	2.0	1.04
East Soil Breach	HydroCAD	2.0	0.77

6.2 Slope Stability

A two-dimensional slope stability analysis was performed to evaluate the global stability of the FAP embankments in an interim condition and final closure configuration. Stability calculations were performed in general accordance with the US Army Corps of Engineers (USACE) *Slope Stability* Manual (EM-1110-2-1902) and 329 IAC 10. S&ME selected three cross-sections for the slope stability analysis: 1) the splitter dike between the clear water pond and the upper basin at the completion of Phase I; 2) a section through the upper basin's raised embankment and original earthen embankments; and, 3) the exterior embankment of the clear water pond. Targeted minimum safety factors corresponding to small uncertainty of strength parameters but with potential imminent danger to human life or the environment were used in accordance with 329 IAC 10-5-8 Table 6-1. Results of the slope stability analysis are summarized in Table 6-5. Full results of the assessment, including an extended narrative, have been detailed in Appendix B of Attachment V.

Table 6-5: Stability Analysis Results Summary

Design Cross-Section	Load Case	Failure Mode	Minimum FS	Computed Factor of Safety
A Splitter Dike	Static	Rotational	1.5	1.99
		Translational	1.5	1.82
B Upper Basin	Static	Rotational	1.5	1.94
	Seismic	Rotational	1.3	1.56
C Clear Water Pond	Static	Rotational	1.5	1.77
	Seismic	Rotational	1.3	1.44

6.3 Liquefaction Evaluation

The liquefaction triggering evaluation of the site was performed in general accordance with the requirements of 329 IAC 10-16-7 – Unstable Area Siting Restrictions. The evaluation was conducted in accordance with the Simplified Procedure method (Youd et al, 2001) using CPT liquefaction assessment software. The software program was used to evaluate the liquefaction potential for 9 CPT locations and a continuous plot of the factor of safety was generated. The seismic hazard used in the liquefaction analysis was a 2 percent probability of exceedance in a 50-year period event, resulting in an earthquake magnitude of 5.0 with a design PGA of 0.07g. Results of the analysis indicate that liquefaction of the sluiced fly ash is not predicted to occur. The minimum factor of safety for the CPT locations evaluated was above 2.0. Results of the assessment, including the development of the seismic design parameters, have been detailed in Appendix C of Attachment V.

6.4 Cover System Stability

A veneer stability analysis was performed for the final cover system configuration. The purpose of the performing veneer stability analysis is twofold: 1) to determine the overall minimum interface friction angle needed for the various cover system interfaces; and, 2) determine the allowable transmissivity value of the geocomposite drainage layer. Targeted minimum safety factors corresponding to large uncertainty of strength parameters and no imminent danger to human life or the environment were used in accordance with 329 IAC 10-5-8 Table 1. Results of the veneer stability analysis are summarized below and a full narrative with supporting calculations is presented in Appendix D of Attachment V.

- Minimum cover system interface friction angle: 23.8°
- Minimum Allowable Transmissivity: 8.0 x 10^{-4} m^2/sec

Both results reflect values that appear achievable based on similarly completed projects. In accordance with 329 IAC 10-22-6, the minimum allowable tested hydraulic transmissivity value of the geocomposite drainage layer provides an equivalent hydraulic transmissivity to the required value.

6.5 Settlement Analysis

A settlement analysis was performed to estimate the settlement of the in-place sluiced fly ash and underlying foundation layers due to the loads created during regrading of the ash and construction of the cover system. Two prediction methods were used and compared to estimate the total settlement. One method used a constrained-modulus approach utilizing the site-specific CPT data. The second method was a traditional one-dimensional consolidation theory considering site-specific and typical consolidation parameters of fly ash. Results from a recent test fill placement on in-place sluiced coal combustion products (CCP) suggest the sluiced material exhibits an immediate settlement response compared to the consolidation behavior for clays(2). Therefore, the majority of the expected settlement in the sluiced fly ash is expected to occur prior to reaching the final grade, and the potential impacts of differential settlement impeding positive drainage in the cover system is very low.

Results from the two calculation methods predicted settlement of the in-place sluiced ash in the range of 4 to 12 inches for the upper basin, where the max fill height is 8 feet. In the clear water pond, the max fill height for Phase 2 is approximately 22 feet, but the thickness of the in-place ash is much less and the net stress increase from replacing the impounded water in the lined basin with ash fill is equivalent to approximately 8 feet of ash fill. This combination results in a predicted settlement range of 1 to 2 inches. In both cases, the primary consolidation settlement of the clay foundation layer ranges between 1 to 2 inches. Consolidation settlement in the foundation of this magnitude is not expected to appreciably affect the performance of the cover system. The settlement analysis calculation package is presented in Appendix E of Attachment V.

6.6 Universal Soil Loss

The annual erosion yield from the cover system was estimated using the Universal Soil Loss Equation (USLE). The USLE equation was developed for predicting average annual soil loss to determine the erodibility of a site based on several factors, such as rainfall intensity, slope length and steepness, and maintenance and vegetation. Results of the calculation predict an average annual yield of 2.5 tons per acre per year. This result is below the limiting value of 5 tons per acre per year, as required under 329 IAC 10-30-2. The Universal Soil Loss calculation package is presented in Appendix F of Attachment V.

7.0 Closure Plan Required Information

Rule 30, Section 8 of 329 IAC-10 lists the information required for Closure Plans for Restricted Waste Sites. This narrative meets the requirements of Section 4(a) for a written closure plan, with Section 5.0 presenting the steps necessary to close the facility. The additional required information is presented in the following sections.

7.1 Engineer's Opinion of Probable Construction Costs

An Engineer's Opinion of Probable Construction Cost, as well as the estimated cost per acre, has been incorporated into the IDEM Closure Form for RSWs I, II, III, C/D Site, and Non-MSWLF Facilities. This form is presented in Section 9.0 of this Plan.

7.2 Construction Schedule

Grading of ash within the upper basin (Phase 1 grading) began in the summer of 2017. The work in advance of approval of this plan is limited to ash grading, ash dewatering, and select demolition. No breaches of the dike will occur in advance of approval of this Closure Plan. It is anticipated that this Plan will be approved in 2018. Some construction may begin late in 2018 with full construction initiated in the spring of 2019. It is anticipated that the Phase 1 area will be closed by mid to late summer of 2019 and that Phase II will begin in late summer of 2019. It is desired to complete all closure construction by the end of 2019; however, the schedule includes a contingency for weather delays which provides for full closure construction completion early in 2020.

7.3 Closure Certification

The following will be submitted upon completion of the final closure of the fly ash pond facility in accordance with 329 IAC 10-30.

- A certification statement, signed by both the owner or operator and a registered professional engineer, that the facility has been closed in accordance with the approved closure plan.
- A Certification Report summarizing all aspects of the closure construction, including construction procedures, observations, and test results performed as required by the QA/QC Plan.
- A legal description of the solid waste boundary.
- Verification that the owner of the property on which the facility is located has recorded a notation on the deed to the facility property, or on some other instrument, normally examined during title search, which will, in perpetuity, notify any potential purchaser of the property that the land has been used as a solid waste land disposal facility. At a minimum, the recording must contain the following:

  A. The general types and location of waste.

  B. The depth of fill.

  C. A plot plan, with surface contours at intervals of two (2) feet, which must indicate:

     1. final land surface water run-off direction;

2. surface water diversion structures after completion of the operation; and
3. final grading.

D. A statement that no construction, installation of wells, pipes, conduits, or septic systems, or any other excavation must be done on the property without approval by the commissioner.

7.4 Post Closure Requirements

Tanners Creek Development, LLC is attentive to the maintenance and post-closure requirements for post closure care as required by 329 IAC 10-31. Post-closure requirements must be followed for a period of 30 years following the date of final closure certification. A Post Closure Care Plan has been developed for the Fly Ash Pond Closure and is included with this Plan as Attachment IV.

8.0 Closure Plan Supporting Documents

The following documents have been prepared as part of the overall Closure Plan.

- Section 9.0, IDEM Closure Form Parts III through VIII
- Attachment I: Design Drawings
- Attachment II: Ground Water Monitoring Plan
- Attachment III: Construction Quality Assurance Plan
- Attachment IV: Post Closure Care Plan
- Attachment V: Calculations
- Attachment VI: New Geotechnical Data
- Attachment VII: Comment and Response Log
- Attachment VII: Dust Control Plan

9.0 IDEM Closure Form Parts III to VIII

III. LABOR, MATERIALS, & TESTING (Provide a listing of items necessary to close the facility. For items that will vary depending upon the number of acres to be closed, the quantities should be indicated on a per acre basis.)

A. Item	B. Quantity	C. Units
1. Mobilization & Demobilization	1	LS
2. Erosion and Sediment Control	1	LS
3. Demolition	1	LS
4. Phase 1 Soil Excavation	19,705	CY
5. Phase 2 Soil Excavation and Fill	5,075	CY
6. Phase 1 Ash Excavation and Fill	0	CY
7. Phase 2 Ash Excavation and Fill	66,255	CY
8. Protective Soil Cover	285,130	CY
9. Vegetative Layer	57,025	CY
10. Seeding and Mulching	70.69	AC
11. Liner Subgrade Preparation	7.85	AC
12. Smooth Geomembrane	49.66	AC
13. Textured Geomembrane	23.95	AC
14. Geocomposite Drainage Net	70.04	AC
15. Nonwoven Geotextile Cushion	5.05	AC
16. 6" Drainage Tubing, Perforated, IDOT Item 907.17(a)	6,229	LF
17. 6" Pipe, IDOT Item 907.17(b)	260	LF
18. Drainage Aggregate, IDOT Item 904.03, As Per Plan	650	CY
19. Pipe Bedding and Initial Backfill, As Per Plan	12	CY
20. Channel Lining Cover Material	9,679	CY
21. Fabric-formed Concrete Channel	17,100	SF
22. Rock Type 1	1,575	CY
23. Rock Type 2	820	CY
24. Rock Type 3	47	CY
25. Erosion Control Blanket	60,300	SY
26. INDOT Type 3 Filter Fabric	3,000	SY
27. CQA Testing and Reporting	1	LS

IV EXPECTED YEAR OF CLOSURE

A. Expected Year of Closure — 2019

B. Total Time Required to Close Facility (See instructions) — 9 months

C. Time Required for Intermediate Steps in Closure (Provide a description of intermediate closure activities and the time required. See instructions.)

n/a

V. COST PER ACRE FOR FINAL COVER & VEGETATION

A. What Percent of Final Cover and Topsoil is Available from Areas That are Controlled, and Will be Controlled through Post-Closure, by the Permittee?

1. % of final cover: 100%

2. Describe location of sources: Soil from on-site borrow

3. % of topsoil: 100%

4. Describe location of sources: Soil obtained from off-site borrow

B. Cost Per Acre for Acquisition, Placement, & Compaction of 30-inches of Final Cover

1. Acquisition

   a. Quantity of clay needed per acre (cy/acre): 4,033 cy/ac

   b. Excavation unit cost ($/cy) (if obtained on-site): $1.50 $/cy

   c. Purchase unit cost ($/cy) (if obtained off-site): $0.00 $/cy

   d. Delivery unit cost ($/cy) (if obtained off-site): $0.00 $/cy

e. Acquisition cost ($/acre)
Line 1a * Line 1b (or)
Line 1a * (Line 1c + Line 1d) — $6,050 $/ac

2. Placement and Compaction

a. Placement/spreading unit cost — $0.50 $/cy

b. Compaction unit cost ($/cy) — $1.50 $/cy

c. Placement and compaction cost ($/acre)
Line 1a * (Line 2a + Line 2b) — $8,066 $/ac

3. Testing

a. Soil classification (if soil source) is of variable quality)($/acre) — $400 $/ac

b. Survey control for cover thickness and proper slopes ($/acres) — $500 $/ac

c. Density testing (if planned) ($/acre) — $5,500 $/ac (all field CQA Testing)

d. Testing cost ($/acre)
Line 3a + Line 3b + Line 3c — $6,400 $/ac

4. Clay Cover Cost ($/acre)
Line 1e + Line 2c + Line 3d — $20,516 $/ac

C. <u>Cost Per Acre for Acquisition & Placement of Topsoil</u>

1. Acquisition

a. Quantity of topsoil needed per acre (cy/acre) — 807

b. Excavation unit cost ($/cy) (if obtained off-site) — $0.00 $/cy

c. Purchase unit cost ($/cy) (if obtained off-site) — $3.50 $/cy

	d. Delivery unit cost ($/cy) (if obtained off-site)	$0.50 $/cy
	e. Acquisition cost ($/cy) Line 1a * Line 1b (or) Line 1a * (Line 1c + Line 1d)	$3,228 $/ac
2.	Placement	
	a. Spreading unit cost ($/cy)	$0.50 $/cy
	b. Placement cost ($/acre) Line 1a * Line 2a	$404 $/cy
3.	Topsoil Cost ($/acre) Line 1e + Line 2b	$3,632 $/ac

D. <u>Cost Per Acre to Establish Vegetation</u>

1.	Vegetation	
	a. Seeding unit cost ($/acre)	$1,500 $/ac
	b. Fertilization unit cost ($/acre)	$1,000 $/ac
	c. Mulching unit cost ($/acre)	$500 $/ac
	d. Vegetation Establishment Cost ($/acre) Line 1a + Line 1b + Line 1c	$3,000 $/ac

E. <u>Cost Per Acre to Certify Closure</u>

1.	Registered Professional Engineer	
	a. Initial review of closure plan (hrs)	16 hrs
	b. Total number of inspections	10 visits
	c. Inspection time required (hrs/visit)	12 hrs/visit
	d. Total inspection time (hrs) Line 1b * Line 1c	120 hrs

e. Prepare final documentation (hrs) 120 hrs

f. Total engineer time (hrs)
Line 1a + Line 1d + Line 1e 256 hrs

g. Engineer unit labor cost ($/hr) $135 $/hr

h. Professional engineer cost ($)
Line 1f * Line 1g $34,560 $

i. Area of site permitted for filling (acres) 71.23 acres

j. Closure Certification Cost ($/acre)
Line 1h + Line 1i $485 $/ac

F. Other Costs Per Acre for Final Cover and Vegetation

1. Other Costs ($/acre) (Specify) $0 $/ac

G. Total of Items B through F (Must not be less than $5,000) $27,633 $/ac

VI OTHER CLOSURE COSTS (Give these on a total facility basis rather than per acre.)

A. Notation of Property Deed $500

B. Other Costs

Cost for items such as drainage features, installation of gas vents, etc., should be delineated in this section.

1. **Activity** / **Cost**

Activity	Cost
1. Mobilization & Demobilization	$150,000
2. Erosion and Sediment Control	$100,000
3. Demolition	$15,000
7. Phase 1 Ash Excavation and Fill	$298,147
11. Liner Subgrade Preparation	$68,424
12. Smooth Geomembrane	$930,135
13. Textured Geomembrane	$511,102
14. Geocomposite Drainage Net	$1,952,582
15. Nonwoven Geotextile Cushion	$52,764
16. 6" Drainage Tubing, Perforated, IDOT Item 907.17(a)	$24,916

Continued from Previous Page

VI OTHER CLOSURE COSTS (Give these on a total facility basis rather than per acre.)

B. Other Costs Continued

Cost for items such as drainage features, installation of gas vents, etc., should be delineated in this section.

1. **Activity** / **Cost**

Activity	Cost
17. 6" Pipe, IDOT Item 907.17(b)	$1,040
18. Drainage Aggregate, IDOT Item 904.03, As Per Plan	$12,995
19. Pipe Bedding and Initial Backfill, As Per Plan	$240
20. Channel Lining Cover Material	$62,915
21. Fabric-formed Concrete Channel	$111,150
22. Rock Type 1	$47,250
23. Rock Type 2	$24,600
24. Rock Type 3	$1,410
25. Erosion Control Blanket	$126,600
26. INDOT Type 3 Filter Fabric	$9,000
27. 10% Contingency	$646,257

C. Total (Add costs from Sections A. and B.) $5,141,027

VII CLOSURE COST ESTIMATE (Multiply item I.E. by Item V.G. and then add Item (VI.C.): $7,109,325

VIII ADDITIONAL INFORMATION REQUIRED FOR FACILITIES PROVIDING FINANCIAL ASSURANCE ON AN INCREMENTAL BASIS

A. **Will Closure Financial Assurance be Provided on an Incremental Basis? (If the answer to this question is no, skip to Item IX.)** no

B. **Map of Areas of Waste Deposition (Attach a copy of the facility's final contour map which shows the maximum areas of waste deposition on a yearly basis for the remaining life of the facility.)**

See Attachment 1

C. Maximum Areas of Waste Deposition & Closure Costs (Fill in the following table for each remaining year of the facility's life.)

Year	Max. Area of Waste Deposition (cumulative acres) (end of year)	Closure Cost w/o Partial Closure ($)	Area Partially Closed (cumulative acres) (start of year)	Increm. Closure ($)
2019	71.23 acres	$7,109,325	n/a	$0

Attachments

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Attachment I – Closure Drawings

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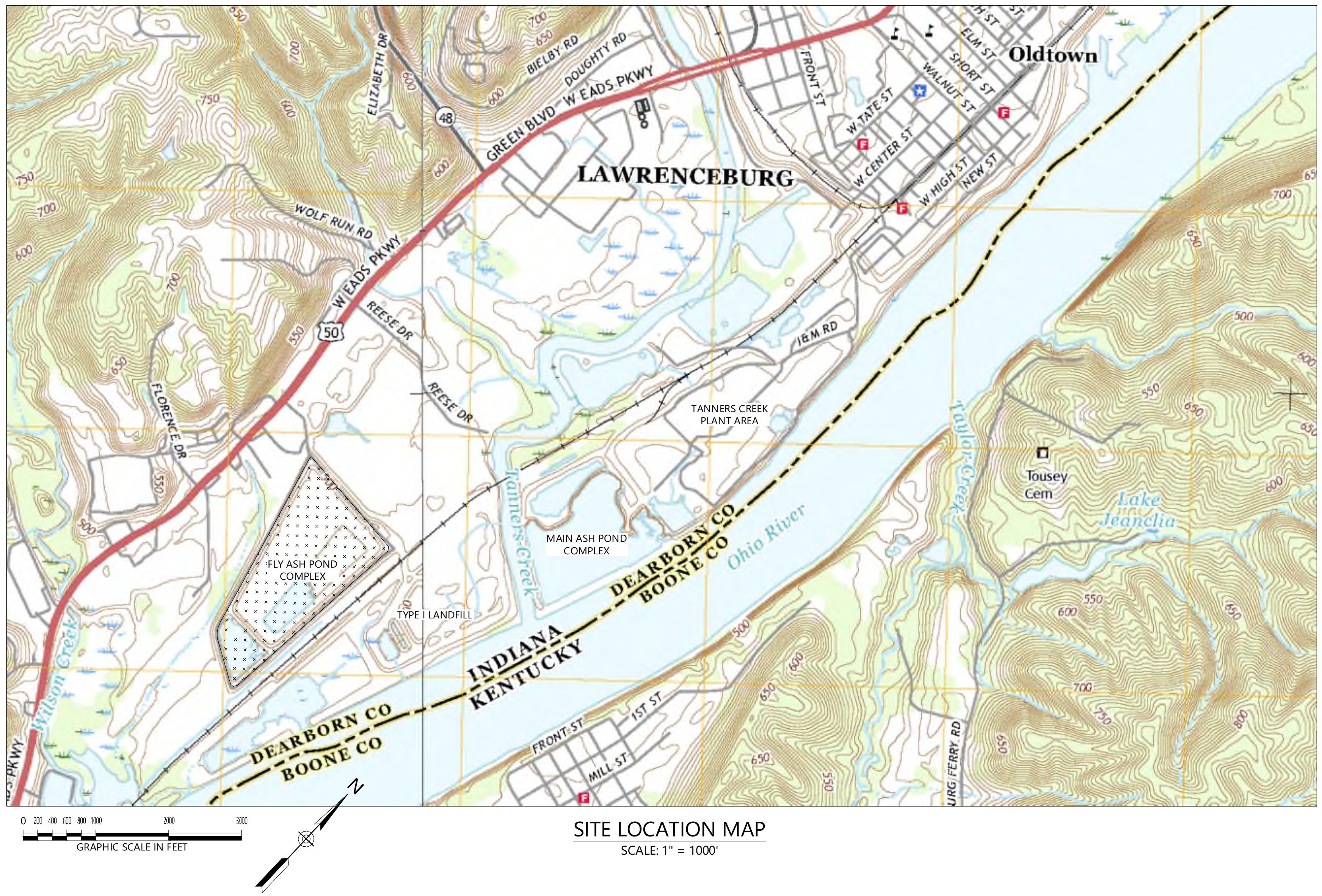
FLY ASH POND CLOSURE
TANNERS CREEK PLANT

LAWRENCEBURG, DEARBORN COUNTY, INDIANA
S&ME PROJECT NO. 7217-17-007
JUNE 22, 2018

VICINITY MAP
SCALE: NTS



SITE LOCATION MAP
SCALE: 1" = 1000'

PROJECT DESCRIPTION:

PROJECT CONSISTS OF THE FINAL CLOSURE OF THE FLY ASH POND BY GRADING THE ASH AND INSTALLING A GEOSYNTHETIC-LINED COVER SYSTEM. WORK TO BE CARRIED OUT IN TWO PHASES:

PHASE I:

- EXCAVATION OF A STORMWATER CHANNEL ALONG THE INBOARD SLOPE OF THE EXISTING SOIL DIKE AT THE TOE OF THE ASH DIKE.
- EXCAVATION OF EAST AND WEST BREACH CHANNELS THROUGH THE EXISTING ASH DIKE.
- REGRADING ASH WITHIN THE FLY ASH POND (FAP) UPPER BASIN TO MATCH FINAL CONFIGURATION.
- INSTALLATION OF FINAL COVER SYSTEM OVER THE FLY ASH POND UPPER BASIN.
- INSTALLATION OF TEMPORARY AND PERMANENT EROSION AND SEDIMENT CONTROL MEASURES.

PHASE II

- EXCAVATION OF SOIL DIKE BREACHES IN CONJUNCTION WITH FILL PLACEMENT WITHIN THE PERIMETER STORM WATER CHANNEL TO CUT OFF FAP STORMWATER FROM REACHING THE CLEAR WATER POND.
- REGRADING ASH WITHIN THE CLEAR WATER POND TO MATCH FINAL CONFIGURATION.
- INSTALLATION OF FINAL COVER SYSTEM OVER THE CLEAR WATER POND AREA.
- INSTALLATION OF TEMPORARY AND PERMANENT EROSION AND SEDIMENT CONTROL MEASURES.

SHEET LIST

OWNER

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1650 DES PERES RD., SUITE 303
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ISSUED FOR APPROVAL

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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
△2	06/22/18	UPDATED FOR IDEM 5/10/18 RAI	PSS	MGR	MTR
△1	03/09/18	IDEM RAI NO. 1	DCV	MGR	MTR
△0	10/31/17	ISSUED FOR APPROVAL	IDT	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
1

DRAWING NAME
COVER SHEET

T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\01_COVER SHEET.dwg-Cover Sheet Jun 21, 2018 - 12:18pm psimko

1 GENERAL

1.1 ANY DISCREPANCY FOUND BETWEEN THE DRAWINGS AND SITE CONDITIONS OR ANY INCONSISTENCIES OR AMBIGUITIES IN DRAWINGS SHALL BE IMMEDIATELY REPORTED TO THE OWNER'S REPRESENTATIVE, IN WRITING, WHO SHALL PROMPTLY ADDRESS SUCH PROBLEMS. WORK DONE BY THE CONTRACTOR AFTER THE DISCOVERY OF SUCH DISCREPANCIES, INCONSISTENCIES OR AMBIGUITIES BEFORE THE OWNER'S REPRESENTATIVE ADDRESSES THE PROBLEMS SHALL BE DONE AT THE CONTRACTOR'S RISK.

1.2 THIS PROJECT INVOLVES GRADING OF COAL COMBUSTION RESIDUALS (CCR) GENERATED AT THE TANNERS CREEK POWER PLANT. CCR GENERATED AT COAL BURNING POWER PLANTS IS KNOWN TO CONTAIN HAZARDOUS MATERIALS AND HAS THE POTENTIAL TO IMPACT HEALTH IF IMPROPERLY HANDLED. THE CONTRACTOR IS RESPONSIBLE FOR DEVELOPMENT OF A HEALTH AND SAFETY PLAN SPECIFIC TO THIS PROJECT THAT ADDRESSES THE SPECIFIC MEANS AND METHODS SELECTED BY THE CONTRACTOR TO ACCOMPLISH THE PROJECT AND CONSIDERS POTENTIAL EXPOSURES OF THEIR EMPLOYEES TO THE FLY ASH MATERIALS. NEITHER S&ME, INC. NOR OUR CLIENT IS RESPONSIBLE FOR THE CONTRACTOR'S HEALTH AND SAFETY PROGRAM FOR THIS WORK.

1.3 THE CONTRACTOR ACKNOWLEDGES ACCEPTANCE CONCERNING THE NATURE AND LOCATION OF THE WORK, THE GENERAL AND LOCAL CONDITIONS, PARTICULARLY THOSE BEARING UPON TRANSPORTATION, DISPOSAL, HANDLING AND STORAGE OF MATERIALS, AVAILABILITY OF LABOR, WATER, ELECTRIC, POWER, ROADS, AND UNCERTAINTY OF WEATHER, GROUNDWATER TABLE OR SIMILAR PHYSICAL CONDITIONS AT THE SITE, THE SUBSURFACE MATERIALS TO BE ENCOUNTERED, THE PRESENCE AND LOCATION OF SUBSURFACE UTILITIES, THE CHARACTER OF EQUIPMENT AND FACILITIES NEEDED PRIOR TO AND DURING THE PROSECUTION OF THE WORK OR THE COST THEREOF UNDER THIS CONTRACT.

1.4 TOPOGRAPHIC INFORMATION SHOWN WITHIN THE PROJECT AREA IS BASED ON AN AERIAL TOPOGRAPHIC SURVEY PERFORMED BY GEOPRO CONSULTANTS IN MARCH, 2017. SUBSEQUENT TO THE TOPOGRAPHIC SURVEY, GRADING ACTIVITIES HAVE BEEN PERFORMED BY THE OWNER WHICH ARE NOT REFLECTED ON THESE DRAWINGS. DATUM: INDIANA STATE PLANE - SOUTH NAD 83 / NAVD 88. GEOPRO SUPPLEMENTED THE AERIAL FLYOVER SURVEY WITH GROUND SURVEY SHOTS.

1.5 WHERE 'OWNER' IS REFERRED TO IN THE PLANS IT SHALL MEAN TANNERS CREEK DEVELOPMENT, LLC. WHERE OWNER'S REPRESENTATIVE IS REFERRED TO IT SHALL MEAN THE FIELD REPRESENTATIVE DESIGNATED BY THE OWNER. INDOT REFERS TO THE 'STATE OF INDIANA DEPARTMENT OF TRANSPORTATION'.

1.6 'INDOT ITEMS' REFER TO THE INDOT STANDARD SPECIFICATIONS, 2016 EDITION. THIS DOCUMENT SHALL GOVERN MATERIALS AND WORKMANSHIP INVOLVED IN THE IMPROVEMENTS SHOWN ON THESE PLANS, EXCEPT WHERE MODIFIED BY THE GENERAL NOTES, CONSTRUCTION DETAILS, OR QA/QC PLAN.

1.7 ALL TRENCHING AND RELATED CONSTRUCTION ACTIVITIES SHALL BE PERFORMED IN ACCORDANCE WITH OSHA 29 CFR 1926 SUBPART P, EXCAVATIONS.

1.8 THE CONTRACTOR SHALL CHECK ALL EXISTING CONDITIONS, (i.e. INVERTS, UTILITY ROUTINGS, UTILITY CROSSINGS, AND DIMENSIONS) IN THE FIELD PRIOR TO COMMENCEMENT OF WORK. REPORT ANY DISCREPANCIES TO THE ENGINEER.

1.9 THE CONTRACTOR SHALL VERIFY THE EXACT LOCATION OF ALL EXISTING UTILITIES. TAKE CARE TO PROTECT UTILITIES OR STRUCTURES THAT ARE TO REMAIN. REPAIR ANY DAMAGE ACCORDING TO LOCAL STANDARDS AND AT THE CONTRACTOR'S EXPENSE. COORDINATE ALL CONSTRUCTION WITH THE APPROPRIATE UTILITY COMPANY. THE CONTRACTOR SHALL CALL NATIONAL ONE CALL (811) 72 HOURS PRIOR TO PROCEEDING WITH ANY EXCAVATION.

1.10 THE CONTRACTOR SHALL CONFORM TO ALL LOCAL CODES AND RECEIVE APPROVAL WHERE NECESSARY BEFORE CONSTRUCTION.

1.11 ANY WORK UNACCEPTABLE TO THE OWNER'S REPRESENTATIVE OR TO THE LOCAL GOVERNING AUTHORITY SHALL BE REPAIRED OR REPLACED BY THE CONTRACTOR AT NO ADDITIONAL EXPENSE TO THE OWNER.

2 TEMPORARY FACILITIES AND CONTROLS

2.1 THE CONTRACTOR SHALL KEEP THE SITE FREE OF TRASH, LITTER AND WASTE MATERIAL, AND SHALL MAINTAIN THE SITE IN A NEAT AND ORDERLY CONDITION THROUGHOUT THE ENTIRE PROJECT. THE CONTRACTOR SHALL REMOVE ALL ASH, MUD, SOIL AND DEBRIS THAT MAY BE TRACKED ONTO EXISTING STREETS, DRIVES OR WALKS BY THEIR EQUIPMENT OR THAT OF SUBCONTRACTORS OR SUPPLIERS ON A DAILY BASIS.

2.2 ALL WORK IS TO BE COMPLETED IN ACCORDANCE WITH THE PLANS AS DEEMED ACCEPTABLE TO THE OWNER. NO WORK SHALL COMMENCE UNTIL ARRANGEMENTS HAVE BEEN MADE WITH THE OWNER FOR CONSTRUCTION OBSERVATION AND DOCUMENTATION.

2.3 THE CONTRACTOR AND ALL THE SUBCONTRACTORS SHALL BE RESPONSIBLE FOR COMPLYING WITH ALL FEDERAL, STATE AND LOCAL SAFETY REQUIREMENTS TOGETHER WITH EXERCISING PRECAUTIONS AT ALL TIMES FOR THE PROTECTION OF PERSONS (INCLUDING EMPLOYEES) AND PROPERTY. IT IS ALSO THE RESPONSIBILITY OF THE CONTRACTOR AND SUBCONTRACTORS TO INITIATE, MAINTAIN AND SUPERVISE ALL SAFETY REQUIREMENTS, PRECAUTIONS AND PROGRAMS IN CONNECTION WITH THE WORK. THE CONTRACTOR AND SUBCONTRACTORS SHALL ALSO ABIDE BY ALL ORDINANCES OF DEARBORN COUNTY.

2.4 CONTRACTOR SHALL PROVIDE AND MAINTAIN TEMPORARY SANITARY FACILITIES AND ENCLOSURES. USE OF EXISTING FACILITIES IS NOT PERMITTED. THE FACILITY SHALL BE MAINTAINED IN CLEAN AND SANITARY CONDITION DAILY. AT END OF CONSTRUCTION, CONTRACTOR SHALL REMOVE ALL TEMPORARY FACILITIES AND RETURN SITE TO SAME OR BETTER CONDITION.

2.5 CONTRACTOR SHALL PROVIDE WASTE REMOVAL FACILITIES AND SERVICES AS REQUIRED TO MAINTAIN THE SITE IN A CLEAN AND ORDERLY CONDITION. CONTAINERS SHALL HAVE LIDS. AT END OF CONSTRUCTION, REMOVE ALL TEMPORARY WASTE CONTAINERS AND RETURN SITE TO SAME OR BETTER CONDITION.

2.6 CONTRACTOR SHALL PROVIDE BARRIERS TO PREVENT UNAUTHORIZED ENTRY TO CONSTRUCTION AREAS. CONTRACTOR SHALL KEEP AUTOMOBILES AWAY FROM CONSTRUCTION AREAS, AND SHALL NOT BLOCK ACCESS TO EXISTING FACILITIES. CONTRACTOR SHALL PROTECT STORED MATERIALS, AND PROTECT EXISTING FACILITIES AND ADJACENT PROPERTIES FROM DAMAGE FROM CONSTRUCTION OPERATIONS.

2.7 CONTRACTOR SHALL OBTAIN OWNER'S APPROVAL FOR USE AND OWNER'S PERMISSION FOR LOCATION PRIOR TO USE OF SITE TRAILERS OR SHEDS, IF NECESSARY.

2.8 CONTRACTOR SHALL NOT DISTURB ADJACENT PROPERTY OWNERS' PROPERTY, EXCEPT WHERE INDICATED ON THE PLANS.

3 EROSION CONTROL NOTES

3.1 SURFACE WATER CONTROLS HAVE BEEN DESIGNED TO MANAGE ALL CONTACT WATER RUNOFF THROUGH THE EXISTING CLEAR WATER POND. THE CONTRACTOR IS RESPONSIBLE FOR DISCHARGING WATER FROM THE CLEAR WATER POND TO THE MAIN ASH POND VIA PUMPING. THE CONTRACTOR MAY COORDINATE WITH THE OWNER REGARDING THE USE OF EXISTING EQUIPMENT TO PERFORM PUMPING OPERATIONS.

3.2 SURFACE WATER RUNOFF FROM FINAL GRADES WILL BE INITIALLY MANAGED THROUGH THE EXISTING CLEAR WATER POND. AS PART OF THE FINAL SURFACE WATER CONTROL IMPLEMENTATION, EROSION AND SEDIMENT CONTROL MEASURES SHALL BE USED FOR SURFACE WATER RUNOFF NOT ENTERING THE CLEAR WATER POND, AS DETAILED ON THE PLANS.

3.3 EROSION PREVENTION AND SEDIMENT CONTROL MEASURES MUST BE IN PLACE AND FUNCTIONAL BEFORE THE SOIL BREACH EXCAVATION IS CONDUCTED AND MUST BE MAINTAINED THROUGHOUT THE CONSTRUCTION PERIOD. TEMPORARY MEASURES MAY BE REMOVED AT THE BEGINNING OF THE WORKDAY BUT MUST BE REPLACED AT THE END OF THE WORKDAY.

3.4 THE FOLLOWING RECORDS SHALL BE MAINTAINED ON OR NEAR SITE: THE DATES WHEN MAJOR GRADING ACTIVITIES OCCUR; THE DATES WHEN CONSTRUCTION ACTIVITIES TEMPORARILY OR PERMANENTLY CEASE ON A PORTION OF THE SITE; THE DATES WHEN STABILIZATION MEASURES ARE INITIATED; INSPECTION RECORDS AND RAINFALL RECORDS.

3.5 THE CONTRACTOR SHALL MAINTAIN A RAIN GAUGE AND DAILY RAINFALL RECORDS AT THE SITE OR USE A REFERENCE SITE FOR A RECORD OF DAILY AMOUNT OF PRECIPITATION.

3.6 PRE-CONSTRUCTION VEGETATIVE GROUND COVER SHALL NOT BE DESTROYED, REMOVED OR DISTURBED MORE THAN 10 DAYS PRIOR TO GRADING OR EARTH MOVING UNLESS THE AREA IS SEEDED AND/OR MULCHED OR OTHER TEMPORARY COVER IS INSTALLED.

3.7 CONSTRUCTION MUST BE SEQUENCED TO MINIMIZE THE EXPOSURE TIME OF GRADED OR DENUDED AREAS.

3.8 SEDIMENT SHOULD BE REMOVED FROM SEDIMENT TRAPS, SILT FENCES, SEDIMENTATION PONDS AND OTHER SEDIMENT CONTROLS AS NECESSARY AND MUST BE REMOVED WHEN DESIGN CAPACITY HAS BEEN REDUCED BY 50% OR AS DIRECTED BY OWNERS REPRESENTATIVE.

3.9 THE CONTRACTOR SHALL REMOVE SEDIMENT FROM ALL DRAINAGE STRUCTURES BEFORE ACCEPTANCE BY LOCAL GOVERNING AGENCY OR AS DIRECTED BY THE OWNER'S REPRESENTATIVE.

3.10 THE CONTRACTOR SHALL REMOVE THE TEMPORARY EROSION AND WATER POLLUTION CONTROL DEVICES ONLY AFTER A SOLID STAND OF GRASS HAS BEEN ESTABLISHED ON GRADED AREAS AND WHEN IN THE OPINION OF THE CONTRACTOR'S REPRESENTATIVE, THEY ARE NO LONGER NEEDED.

3.11 THE CONTRACTOR IS RESPONSIBLE FOR THE CONTROL OF DUST AT THE SITE BY USE OF WATER SPRINKLERS. OTHER DUST CONTROL MEASURES SHALL BE APPROVED BY THE OWNER. ALL WORK SHALL BE PERFORMED TO MINIMIZE DUST TO THE GREATEST EXTENT PRACTICAL.

4 DEMOLITION NOTES

4.1 ALL MATERIALS BEING REMOVED AND NOT RELOCATED UNDER THE NEW CONSTRUCTION, INCLUDING TREES AND SHRUBS, SIGNS, UTILITY STRUCTURES, ETC., SHALL BE FIRST OFFERED TO THE OWNER'S REPRESENTATIVE AND IF NOT ACCEPTED SHALL THEN BE PROPERLY DISPOSED OF BY THE CONTRACTOR.

4.2 THE CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL CHARTED AND UNCHARTED UTILITIES. TAKE CARE TO PROTECT UTILITIES THAT ARE TO REMAIN. REPAIR ANY DAMAGE ACCORDING TO LOCAL STANDARDS AND AT THE CONTRACTOR'S EXPENSE. COORDINATE ALL CONSTRUCTION WITH THE APPROPRIATE UTILITY COMPANY.

4.3 THE CONTRACTOR SHALL VERIFY THE LIMITS OF DEMOLITION WITH THE OWNER'S REPRESENTATIVE PRIOR TO COMMENCEMENT OF WORK.

4.4 CAVITIES LEFT BY STRUCTURE REMOVAL SHALL BE SUITABLY BACKFILLED AND COMPACTED IN ACCORDANCE WITH THESE PLANS.

4.5 THE CONTRACTOR SHALL USE WATER SPRINKLING AND OTHER SUITABLE METHODS AS NECESSARY TO CONTROL DUST AND DIRT CAUSED BY THE DEMOLITION WORK.

4.6 THE CONTRACTOR IS RESPONSIBLE FOR ALL DEMOLITION AND REMOVAL NECESSARY TO ACCOMPLISH THE PROPOSED CLOSURE ACTIVITIES SHOWN ON THESE PLANS.

4.7 THE CONTRACTOR SHALL PRESERVE AND PROTECT SURVEY CONTROL POINTS AND SHALL BE RESPONSIBLE FOR REPLACEMENT OF ANY DISTURBED CONTROL POINTS.

5 CONSTRUCTION SEQUENCE

5.1 PLAN SHEETS 4 THROUGH 10 HAVE BEEN SEQUENTIALLY NUMBERED TO FOLLOW THE GENERAL SEQUENCE OF CONSTRUCTION. THE FOLLOWING IS A GENERAL DESCRIPTION OF THE INTENDED CONSTRUCTION SEQUENCE FOR THE POND CLOSURE:

PHASE 1

- DEMOLITION OF STRUCTURES AND MATERIALS (SHEET 4);
- EXCAVATION OF A STORMWATER CHANNEL ALONG THE INBOARD SLOPE OF THE EXISTING SOIL DIKE AT THE TOE OF THE BOTTOM ASH DIKE (SHEET 5);
- EXCAVATION OF TWO BREACH CHANNELS THROUGH THE EXISTING BOTTOM ASH DIKE (SHEET 6);
- REGRADING ASH WITHIN THE FLY ASH POND UPPER BASIN IN ACCORDANCE WITH THE PHASE 1 TOP OF ASH GRADING PLAN (SHEET 6).
- INSTALLATION OF PHASE 1 FINAL COVER SYSTEM OVER THE FLY ASH POND UPPER BASIN (SHEETS 6 & 7).

PHASE 2

- EXTENSION OF THE BREACH CHANNELS THROUGH THE SOIL DIKE IN CONJUNCTION WITH FILL PLACEMENT WITHIN THE PERIMETER STORM WATER CHANNEL TO CUT OFF FAP STORMWATER FROM REACHING THE CLEAR WATER POND (SHEET 8).
- REGRADING ASH WITHIN THE CLEAR WATER POND IN ACCORDANCE WITH PHASE 2 TOP OF ASH GRADING PLAN (SHEET 9).
- INSTALLATION OF PHASE 2 FINAL COVER SYSTEM OVER THE CLEAR WATER POND AREA (SHEETS 9 & 10).
- IMPROVEMENTS TO EXISTING PERIMETER DITCHES AT THE TOE OF THE SOIL DIKES IN CONJUNCTION WITH THE INSTALLATION OF TEMPORARY AND PERMANENT EROSION AND SEDIMENT CONTROL MEASURES.

6 SITE GRADING NOTES

6.1 THE DISTURBED AREA FOR THIS PROJECT IS APPROXIMATELY 75 ACRES.

6.2 THE SUBJECT PROPERTY DOES LIE WITHIN A SPECIAL FLOOD HAZARD ZONE ACCORDING TO COMMUNITY PANEL NO. FEMA PANEL 0184C OF THE F.E.M.A. FLOOD INSURANCE RATE MAPS FOR DEARBORN COUNTY, INDIANA, WITH AN EFFECTIVE DATE OF APRIL 16, 2014.

6.3 MULCH AND SEED ALL DISTURBED AREAS AS SOON AS POSSIBLE AFTER FINAL GRADING IS COMPLETED, UNLESS OTHERWISE INDICATED. CONTRACTOR SHALL TAKE WHATEVER MEANS NECESSARY TO ESTABLISH PERMANENT SOIL STABILIZATION.

6.4 MAINTAIN PUBLIC ROADWAYS FREE OF TRACKED MUD, DIRT AND ASH.

6.5 PROPOSED CONTOUR LINES ARE THE RESULT OF AN ENGINEERED GRADING DESIGN AND REFLECT A PLANNED INTENT WITH REGARD TO DRAINAGE AND MOVEMENT OF MATERIALS. SHOULD THE CONTRACTOR HAVE ANY QUESTION OF THE INTENT OR ANY PROBLEM WITH THE CONTINUITY OF GRADES, THE ENGINEER SHALL BE CONTACTED IMMEDIATELY.

6.6 CUT AND FILL SLOPES VARY AND SHALL BE AS INDICATED ON THE PLANS.

6.7 IN NO CASE SHALL SLOPE, HEIGHT, SLOPE INCLINATION, OR EXCAVATION DEPTH, INCLUDING TRENCH CONSTRUCTION, EXCEED THOSE SPECIFIED IN LOCAL, STATE AND FEDERAL REGULATIONS, SPECIFICALLY THE CURRENT OSHA HEALTH AND SAFETY STANDARDS FOR EXCAVATIONS (29 CRF PART 1926) SHALL BE FOLLOWED.

6.8 POSITIVE DRAINAGE SHALL BE ESTABLISHED AS THE FIRST ORDER OF WORK AND SHALL BE MAINTAINED AT ALL TIMES DURING AND AFTER CONSTRUCTION. GROUNDWATER INFILTRATION INTO EXCAVATIONS SHOULD BE EXPECTED, AND THE WATER SHALL BE REMOVED USING GRAVITY DRAINAGE OR PUMPING.

6.9 ALL CONSTRUCTION PROCEDURES, INCLUDING SUBGRADE PREPARATION, ASH AND EARTH FILL PLACEMENT, AND INSTALLATION OF GEOSYNTHETIC MATERIALS SHALL FOLLOW THE QA/QC MANUAL DATED SEPTEMBER 1, 2017 PREPARED AS PART OF THE FLY ASH POND CLOSURE PLAN.

6.10 SEDIMENT REMOVED FROM SEDIMENT CONTROL STRUCTURES IS TO BE PLACED AT A SITE APPROVED BY THE OWNER. IT SHALL BE TREATED IN A MANNER SO THAT THE AREA AROUND THE DISPOSAL SITE WILL NOT BE CONTAMINATED OR DAMAGED BY THE SEDIMENT IN THE RUN-OFF. COST FOR THIS TREATMENT IS TO BE INCLUDED IN PRICE BID FOR EROSION AND SEDIMENT CONTROL.

6.11 STOCKPILED TOPSOIL OR FILL MATERIAL IS TO BE TREATED SO THE SEDIMENT RUN-OFF WILL NOT CONTAMINATE SURROUNDING AREAS OR ENTER NEARBY STREAMS.

6.12 IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO WASTE, IF NECESSARY, EXCESS ASH MATERIAL OFF SITE TO THE TANNERS CREEK LANDFILL WITH ADVANCED NOTIFICATION TO THE OWNER AND OWNER'S REPRESENTATIVE.

7 FABRIC FORMED CONCRETE CHANNEL

7.1 PLACE GEOTEXTILE LAYER AND FABRIC LAYER OVER THE GRADED AND COMPACTED AREAS IMMEDIATELY FOLLOWING SLOPE PREPARATION. THE GEOTEXTILE LAYER SHOULD BE PLACED LOOSELY BUT WITHOUT WRINKLES, AND WITH A MINIMUM OVERLAP OF 2 FEET.

7.2 PLACING, JOINING, AND ANCHORING OF CONCRETE FABRIC SHALL BE PERFORMED IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS AND THE APPROVED SUBMITTALS, AND TO THE LINES AND GRADES SHOWN ON THE DRAWINGS.

7.3 CONCRETE PLACEMENT WITHIN THE CONCRETE FABRIC SHALL BE PERFORMED IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS.

7.4 ALLOW CONCRETE TO CURE 48 HOURS. FINE GRADE ALONG EDGES OF FABRIC FORMED CONCRETE CHANNEL.

7.5 REPAIR, SEED, AND MULCH ALL DISTURBED AREAS IN ACCORDANCE WITH THE QA/QC PLAN.

7.6 FABRIC FOR CONCRETE CHANNEL (CONCRETE FABRIC): CHANNEL LINING SHALL CONSIST OF NOMINAL 6-INCH THICK FILTER POINT STYLE FABRIC-FORMED CONCRETE LINING (10" FILTER POINT SPACING). MATERIAL SHALL BE FABRIFORM FPNN BY CONSTRUCTION TECHNIQUES, HYDROTEX FP600 BY SYNTHETEX, OR APPROVED EQUAL.

7.7 CONCRETE: FINE AGGREGATE CONCRETE SHALL BE PROPORTIONED AND MIXED AS TO PROVIDE A PUMPABLE CONCRETE WITH A MINIMUM 28-DAY COMPRESSIVE STRENGTH OF 2,500 PSI; OR, AS RECOMMENDED BY FABRIC MANUFACTURER WITH ENGINEER'S APPROVAL. PROVIDE FINE AGGREGATE CONCRETE WITHIN THE FOLLOWING MIX PROPORTIONS, OR IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS:

7.8 TYPICAL RANGE OF MIX PROPERTIES:

MATERIAL	MIX PROPORTIONS AS DELIVERED (LB/CY)	STANDARD / SPECIFICIATION
CEMENT	750 - 900	ASTM C150, TYPE I OR II
SAND	2030 - 2120	ODOT CMS 703.03
WATER	540 - 555	ASTM C 1602
ENTRAINED AIR CONTENT	RANGE PER MANUFACTUR'S RECOMMENTADATION (MIN. 4%)	ASTM C 260

7.9 FIELD QUALITY CONTROL: CONTRACTOR SHALL MEASURE THE CONSISTENCY OF THE FINE AGGREGATE CONCRETE VIA THE FLOW CONE METHOD (ASTM C939). CONCRETE SAMPLES SHALL BE OBTAINED FROM THE END OF THE GROUT HOSE. RESULTS OF THE FLOW CONE METHOD SHALL BE USED TO ADJUST THE CONSISTENCY OF THE CONCRETE MIX, IF NECESSARY. THE TARGET TIME OF EFFLUX SHALL BE 9 TO 11 SECONDS, OR IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS.

7.10 FIELD QUALITY ASSURANCE: AS PART OF THE OWNER'S QUALITY ASSURANCE PROGRAM, THE OWNER'S REPRESENTATIVE WILL SAMPLE AND TEST GROUT IN ACCORDANCE WITH ASTM C1019 FOR ACCEPTANCE.

8 MATERIALS

8.1 ALL OFF-SITE FILL MATERIAL SHALL BE PREQUALIFIED, PLACED, AND COMPACTED IN ACCORDANCE WITH THE QA/QC MANUAL.

8.2 ALL ASPECTS OF THE GEOSYNTHETIC MATERIALS, INCLUDING PREQUALIFICATION, TESTING, AND INSTALLION, SHALL BE IN ACCORDANCE WITH THE QA/QC MANUAL.

8.3 DRAINAGE TUBING PIPE SHALL BE IN ACCORDANCE WITH IDOT ITEM 907.17(a). HDPE SHALL BE 6" DIAMETER SINGLE WALL CORRUGATED PIPE WITH PERFORATIONS. PERFORATIONS TO BE SLOTS WITH MAXIMUM SLIDE WIDTH OF 0.125 INCHES, AND SHALL PROVIDE AT LEAST 1.9 INCHES OF OPEN AREA PER LINEAR FOOT OF PIPE. TEE CONNECTION SHALL CONSIST OF HDPE FITTINGS.

8.4 OUTLET PIPE SHALL BE IN ACCORDANCE WITH IDOT ITEM 907.25(a) - SOLID WALL HDPE LINER PIPE. HDPE SHALL BE NOMIMAL 6" DIAMETER SDR-17 WITH BUTT FUSION JOINTS . ALL BENDS SHALL CONSIST OF SOLID WALL MOLDED HDPE FITTINGS. HDPE TO CORRUGATED PE CONNECTION SHALL CONSIST OF A FABRICATED COUPLING.

8.5 DRAINAGE AGGREGATE SHALL BE IN ACCORDANCE WITH IDOT ITEM 904.03. COARSE AGGREGATE STONE SIZE SHALL BE EITHER SIZE NO. 57, 67, OR 8.

8.6 CHANNEL LINING COVER MATERIAL SHALL MEET THE SAME MATRIAL AND INSTALLATION REQUIREMENT AS THE PROTECTIVE SOIL LAYER.

9 SUBMITTALS & RECORD DOCUMENTS

9.1 CONTRACTOR SHALL SUBMIT TO THE PROJECT TEAM ELECTRONIC COPIES OF SUBMITTALS, INCLUDING CONSTRUCTION SCHEDULE, MATERIAL CUT SHEETS AND AGGREGATE CERTIFICATES A MINIMUM OF 7 DAYS PRIOR THE SCHEDULED CONSTRUCTION ACTIVITY. GENERAL SUBMITTALS INCLUDE THE FOLLOWING:

- CONTRACTOR'S HEALTH AND SAFETY PLAN
- DUST CONTROL PLAN
- STORM WATER POLLUTION PREVENTION PLAN (SWPPP)
- WORK PLAN

9.2 CONTRACTOR SHALL PREPARE SUBMITTALS FOR ALL WORK ASSOCIATED WITH THE FABRIC-FORMED CONCRETE CHANNEL, WHICH INCLUDES, BUT MAY NOT BE LIMITED TO THE FOLLOWING:

- PRODUCT DATA
- MANUFACTURER SHOP FABRICATION DRAWINGS
- WORK INSTALLATION PLAN
- CONCRETE/GROUT MIX DESIGN
- CONCRETE PLACEMENT AND CURING PROCEDURES, INCLUDING PROPOSED PUMPING AND QUALITY CONTROL EQUIPMENT

9.3 THE CONTRACTOR SHALL BE RESPONSIBLE FOR RECORDING ALL THE APPROVED CHANGES TO THESE PLANS ON A SET OF RECORD DRAWINGS DURING CONSTRUCTION. THE PLANS ARE TO BE SUBMITTED TO THE OWNER'S REPRESENTATIVE AT COMPLETION OF THE PROJECT. ANY MODIFICATION TO THE WORK AS SHOWN ON THESE DRAWING MUST HAVE PRIOR WRITTEN APPROVAL OF OWNER OR OWNER'S REPRESENTATIVE.

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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

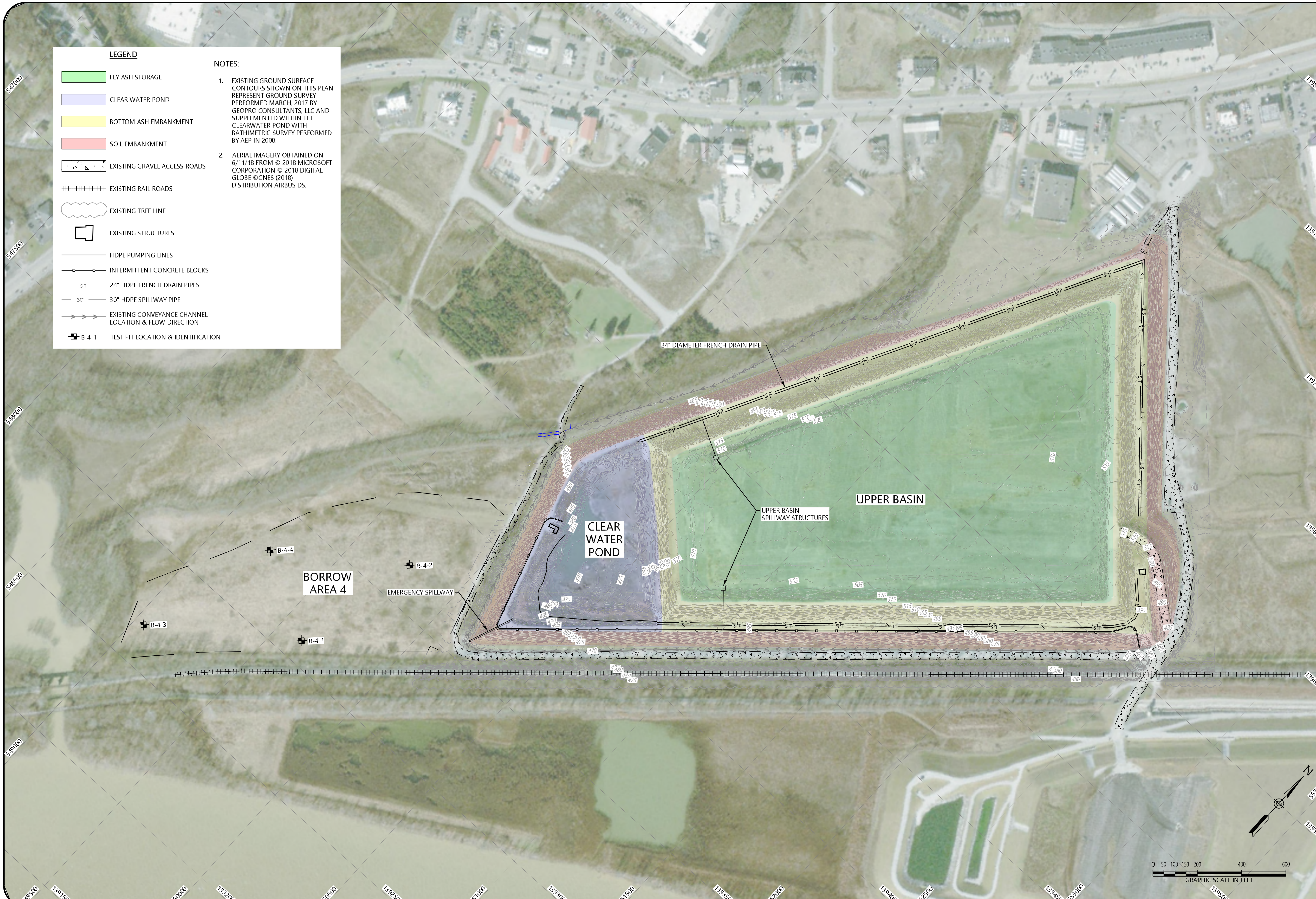
MICHAEL T. ROMANELLO REGISTERED PE11500160 STATE OF INDIANA PROFESSIONAL ENGINEER 10-13-17

NO.	DATE	DESCRIPTION	BY	CHK	APV
0	10/31/17	ISSUED FOR APPROVAL	MTR	MGR	MTR

PROJECT NUMBER 7217-17-007A

DRAWING NUMBER 2

DRAWING NAME GENERAL NOTES



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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

MICHAEL T. ROMANELLO REGISTERED PE11600190 STATE OF INDIANA PROFESSIONAL ENGINEER 10-13-17

NO.	DATE	DESCRIPTION	BY	CHK	APV
1	06/22/18	BORROW AREA 4 & TEST PITS ADDED	PSS	MGR	MTR
0	10/31/17	ISSUED FOR APPROVAL	IDT	MGR	MTR

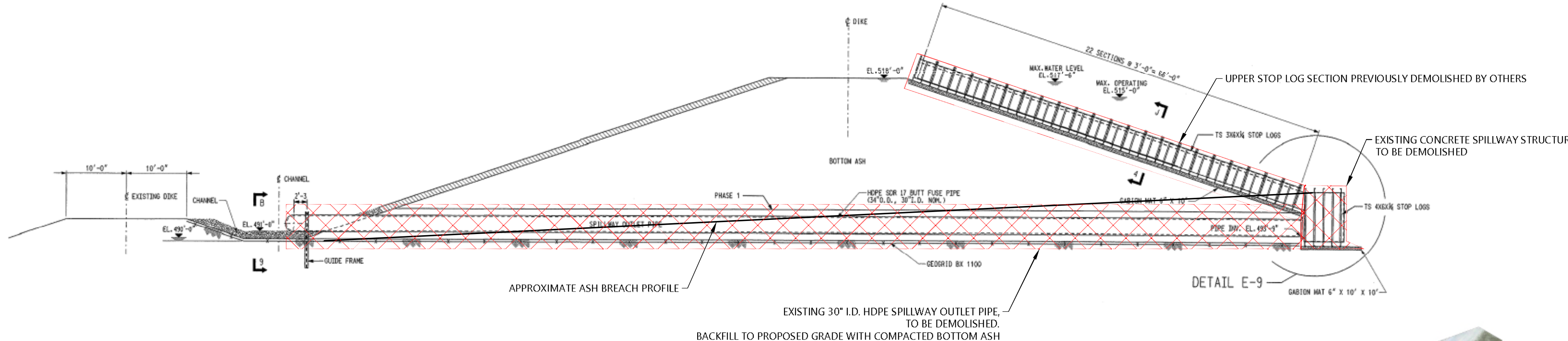
PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
3

DRAWING NAME
EXISTING CONDITIONS

NOTE: BACKFILL VOIDS FROM DEMOLITION WITH COMPACTED SOIL FILL. MATCH ADJACENT GRADES.

(D1) EXISTING PUMP STATION STRUCTURE



(D7) EXISTING UPPER BASIN SPILLWAYS (EAST & WEST)

NOTE: REMOVE PIPES TO A MINIMUM 3 FEET INTO EMBANKMENT. BACKFILL VOIDS FROM DEMOLITION WITH COMPACTED SOIL FILL. MATCH ADJACENT GRADES.

(D5) EXISTING CONCRETE STRUCTURE

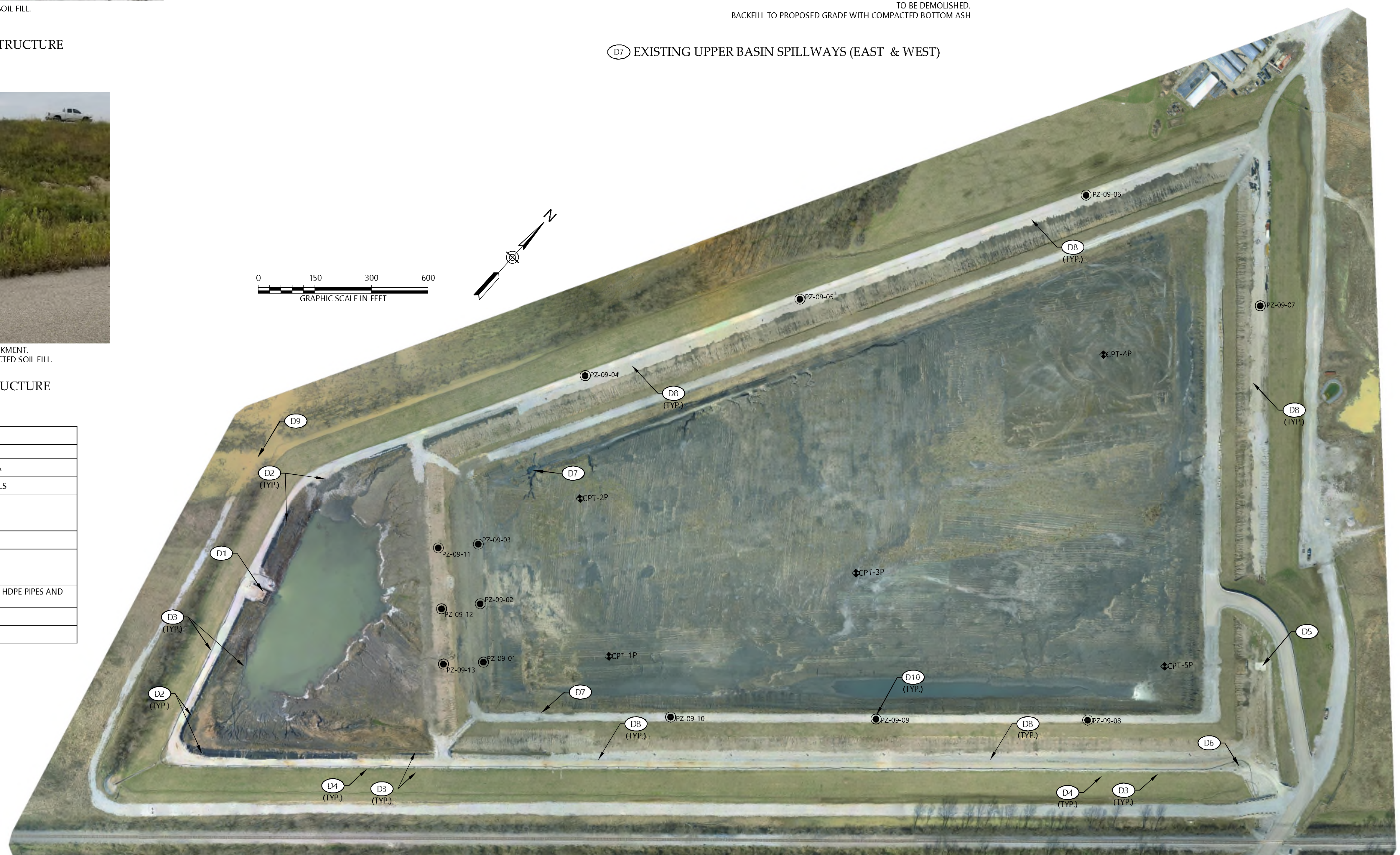
DEMOLITION KEYNOTES	
CODE	DESCRIPTION
D1	REMOVE PUMP STATION STRUCTURE & STAGING AREA
D2	REMOVE CWP INBOARD SLOPE PROTECTION MATERIALS
D3	REMOVE ALL HDPE PUMPING LINES
D4	REMOVE CONCRETE BLOCKS ON CREST
D5	REMOVE CONCRETE STRUCTURES & HDPE PIPE
D6	REMOVE BOLLARDS
D7	REMOVE UPPER BASIN SPILLWAY STRUCTURES
D8	REMOVE PERIMETER FRENCH DRAIN SYSTEM: TWO 24" HDPE PIPES AND STONE
D9	REMOVE 12" DIAM. CULVERT
D10	REMOVE PIEZOMETERS. SEE NOTE D10

LEGEND

CPT-2P OPEN STANDPIPE PIEZOMETER (1" PVC)

PZ-09-11 PIEZOMETER NUMBER AND APPROXIMATE LOCATION

NOTE D10: DEMOLISH ALL PIEZOMETERS. REMOVE PIPES TO A MINIMUM 3 FEET INTO EMBANKMENT. BACKFILL VOIDS FROM DEMOLITION WITH COMPACTED SOIL FILL.



NOTE: AERIAL IMAGERY OBTAINED IN MARCH 2017 BY GEOPRO CONSULTANTS.

T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\04_DEMOLITION PLAN.dwg-Demolition Plan Jun 21, 2018 - 10:20am psimko

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TANNERS CREEK DEVELOPMENT, LLC
1650 DES PERES RD., SUITE 303
ST. LOUIS, MO 63131

FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

MICHAEL T. ROMANELLO REGISTERED PE11600160 STATE OF INDIANA PROFESSIONAL ENGINEER 10-13-17

NO.	DATE	DESCRIPTION	BY	CHK	APV
A	10/31/17	ISSUED FOR APPROVAL	MIR	MGR	MIR

PROJECT NUMBER 7217-17-007A

DRAWING NUMBER 4

DRAWING NAME DEMOLITION PLAN

NOTES:

1. EXISTING GROUND SURFACE CONTOURS SHOWN ON THIS PLAN REPRESENT GROUND SURVEY PERFORMED MARCH, 2017 BY GEOPRO CONSULTANTS, LLC AND SUPPLEMENTED WITHIN THE CLEAR WATER POND WITH BATHYMETRIC SURVEY PERFORMED BY AEP IN 2008.
2. PROPOSED GRADING ON THIS PLAN REPRESENTS EXCAVATION OF PERIMETER CHANNELS TO DIRECT STORMWATER RUN-OFF DURING CONSTRUCTION TO THE CLEAR WATER POND AREA.

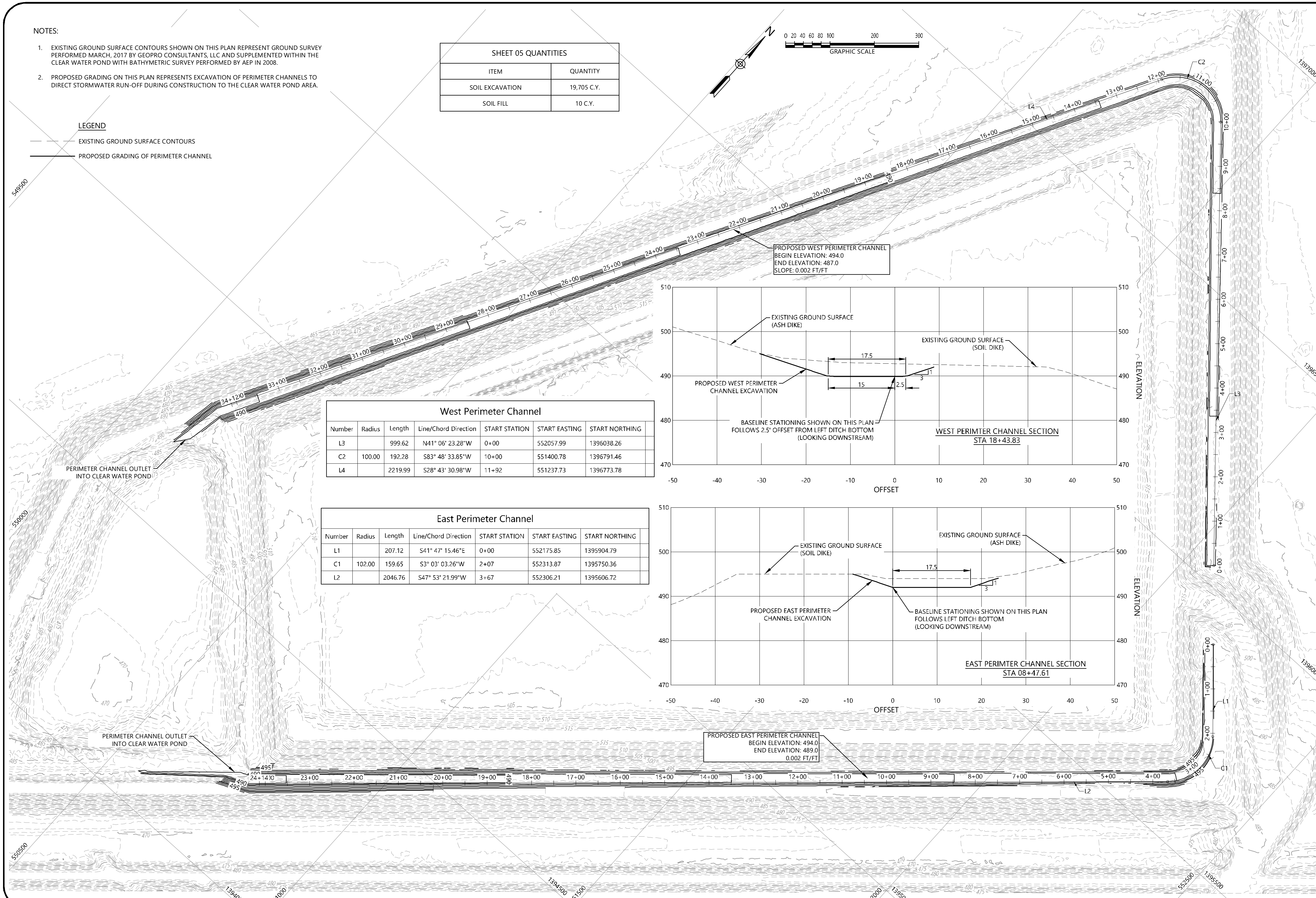
SHEET 05 QUANTITIES

ITEM	QUANTITY
SOIL EXCAVATION	19,705 C.Y.
SOIL FILL	10 C.Y.

LEGEND

EXISTING GROUND SURFACE CONTOURS

PROPOSED GRADING OF PERIMETER CHANNEL



West Perimeter Channel

Number	Radius	Length	Line/Chord Direction	START STATION	START EASTING	START NORTHING
L3		999.62	N41° 06' 23.28"W	0+00	552057.99	1396038.26
C2	100.00	192.28	S83° 48' 33.85"W	10+00	551400.78	1396791.46
L4		2219.99	S28° 43' 30.98"W	11+92	551237.73	1396773.78

East Perimeter Channel

Number	Radius	Length	Line/Chord Direction	START STATION	START EASTING	START NORTHING
L1		207.12	S41° 47' 15.46"E	0+00	552175.85	1395904.79
C1	102.00	159.65	S3° 03' 03.26"W	2+07	552313.87	1395750.36
L2		2046.76	S47° 53' 21.99"W	3+67	552306.21	1395606.72

T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\05_INITIAL SURFACE WATER CONTROLS.dwg-Initial Surface Water Controls Jun 21, 2018 - 10:23am psimko

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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
	10/31/17	ISSUED FOR APPROVAL	MRM	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
5

DRAWING NAME
INITIAL SURFACE WATER CONTROLS

NOTES:

1. EXISTING GROUND SURFACE CONTOURS SHOWN ON THIS PLAN REPRESENT THE GROUND SURFACE UPON COMPLETION OF INITIAL SITE GRADING FROM SHEET 04.
2. PROPOSED GRADING ON THIS PLAN REPRESENTS TOP OF ASH GRADES ACROSS THE FLY ASH STORAGE AREA AND STOCKPILING (FILLING) WITHIN THE CLEAR WATER POND AREA.

KEYNOTES:

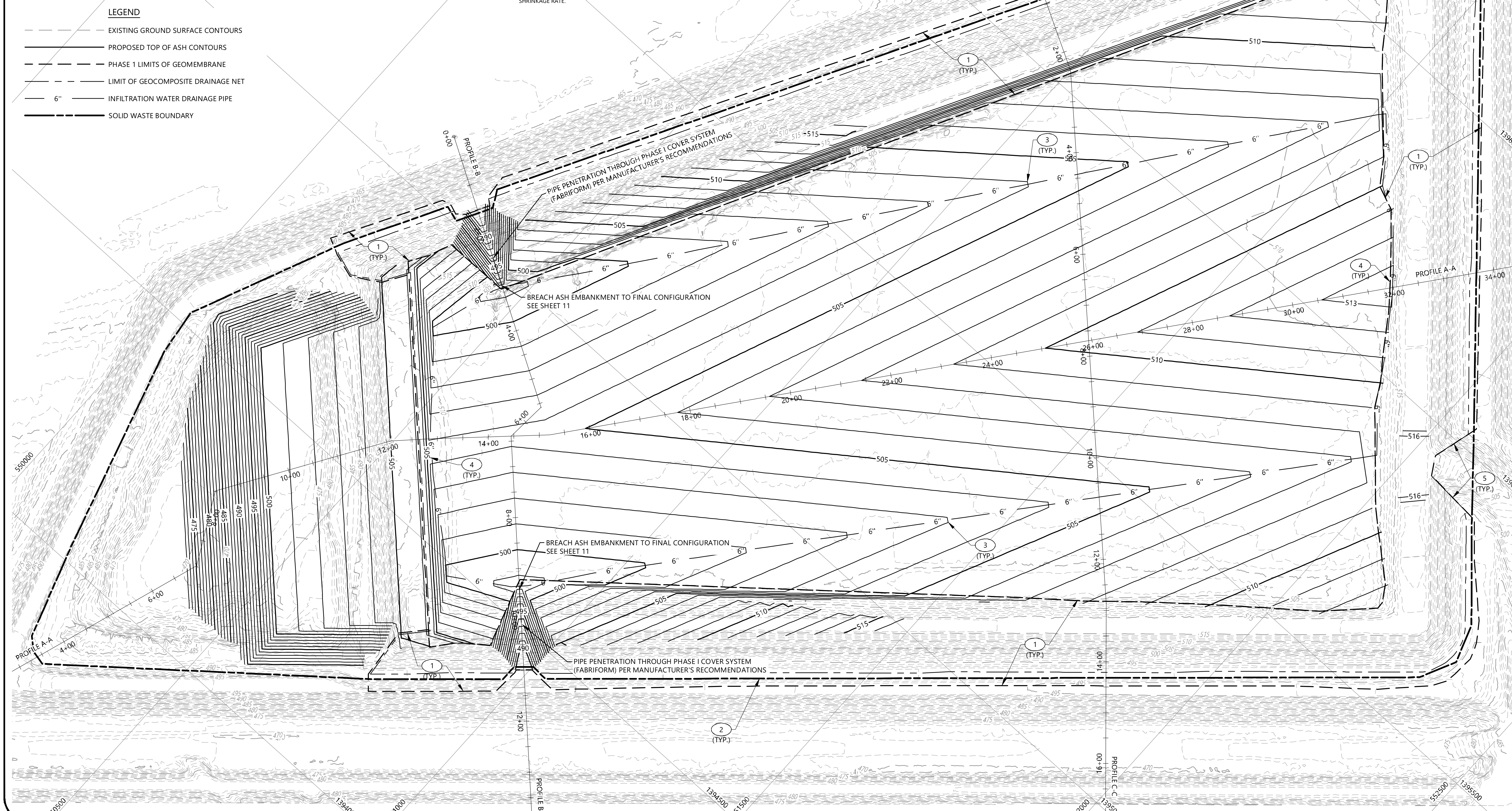
(1) MINIMUM LIMIT OF TEXTURED GEOMEMBRANE - SEE DETAIL 8 ON SHEET 15 FOR TRANSITION TO SMOOTH GEOMEMBRANE
(2) LIMIT OF SOLID WASTE
(3) COLLECTION CHANNEL - SEE DETAIL 6 ON SHEET 15
(4) GEOCOMPOSITE DRAINAGE NET TERMINATION AT TOE OF SLOPE - SEE DETAIL 7 ON SHEET 15
(5) TYPE I ANCHOR TRENCH

LEGEND

- EXISTING GROUND SURFACE CONTOURS
- PROPOSED TOP OF ASH CONTOURS
- PHASE 1 LIMITS OF GEOMEMBRANE
- LIMIT OF GEOCOMPOSITE DRAINAGE NET
- 6" INFILTRATION WATER DRAINAGE PIPE
- SOLID WASTE BOUNDARY

SHEET 06 QUANTITIES	
ITEM	QUANTITY
ASH CUT	206,385 C.Y.
ASH FILL	191,555 C.Y.*
SMOOTH GEOMEMBRANE	1,727,545 S.F.
TEXTURED GEOMEMBRANE	985,255 S.F
GEOCOMPOSITE DRAINAGE LAYER	2,564,719 S.F.
GEOTEXTILE CUSHION LAYER	219,850 S.F.

* ASH CUT VOLUME REPRESENTS AN APPROXIMATE 5% TO 10% SHRINKAGE RATE.



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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
△	06/22/18	PROPOSED ASH GRADE REVISED	PSS	MGR	MTR
△	10/31/17	ISSUED FOR APPROVAL	IDT	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
6

DRAWING NAME
PHASE I ASH GRADING

T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\06_PHASE I ASH GRADING.dwg-Phase I Ash Grading Jun 21, 2018 - 10:58am psimko

KEYNOTES:

1. EXISTING GROUND SURFACE CONTOURS SHOWN ON THIS PLAN REPRESENT THE GROUND SURFACE UPON COMPLETION OF PHASE I ASH GRADING.
2. PROPOSED GRADING ON THIS PLAN REPRESENTS PHASE I FINAL COVER ACROSS THE FLY ASH POND AND PERIMETER DITCH AREAS.
3. SEE SHEET 17 FOR PROFILE VIEWS.

KEYNOTES:

(1) SURFACE WATER COLLECTION CHANNEL - SEE DETAIL 6 ON SHEET 15

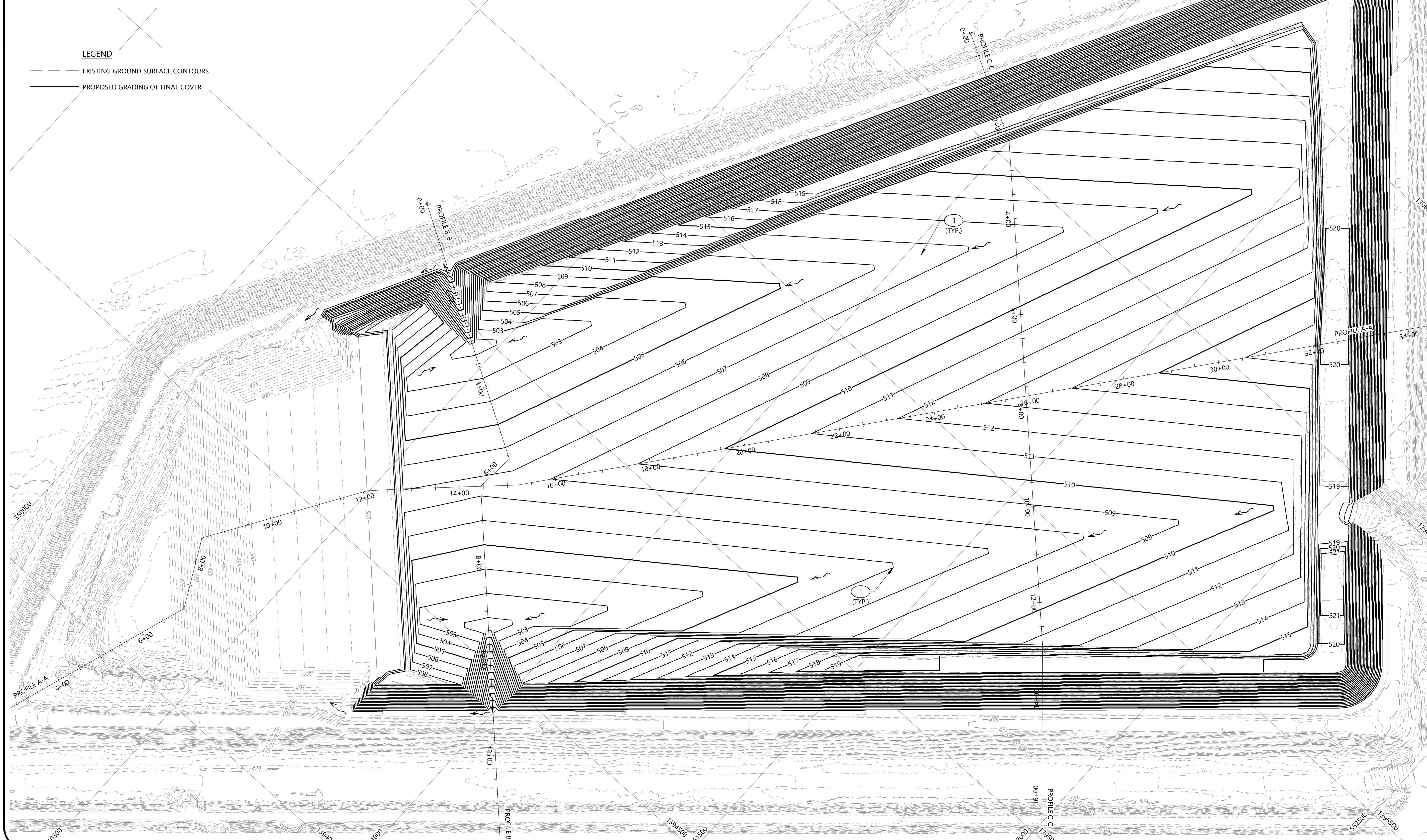
SHEET 7 QUANTITIES	
ITEM	QUANTITY
PROTECTIVE SOIL LAYER FILL	238,680 C.Y.
VEGETATIVE LAYER FILL	47,735 C.Y.
COVER SYSTEM SURFACE AREA	59.2 AC.

0 20 40 60 80 100 200 300
GRAPHIC SCALE IN FEET

LEGEND

EXISTING GROUND SURFACE CONTOURS

PROPOSED GRADING OF FINAL COVER



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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

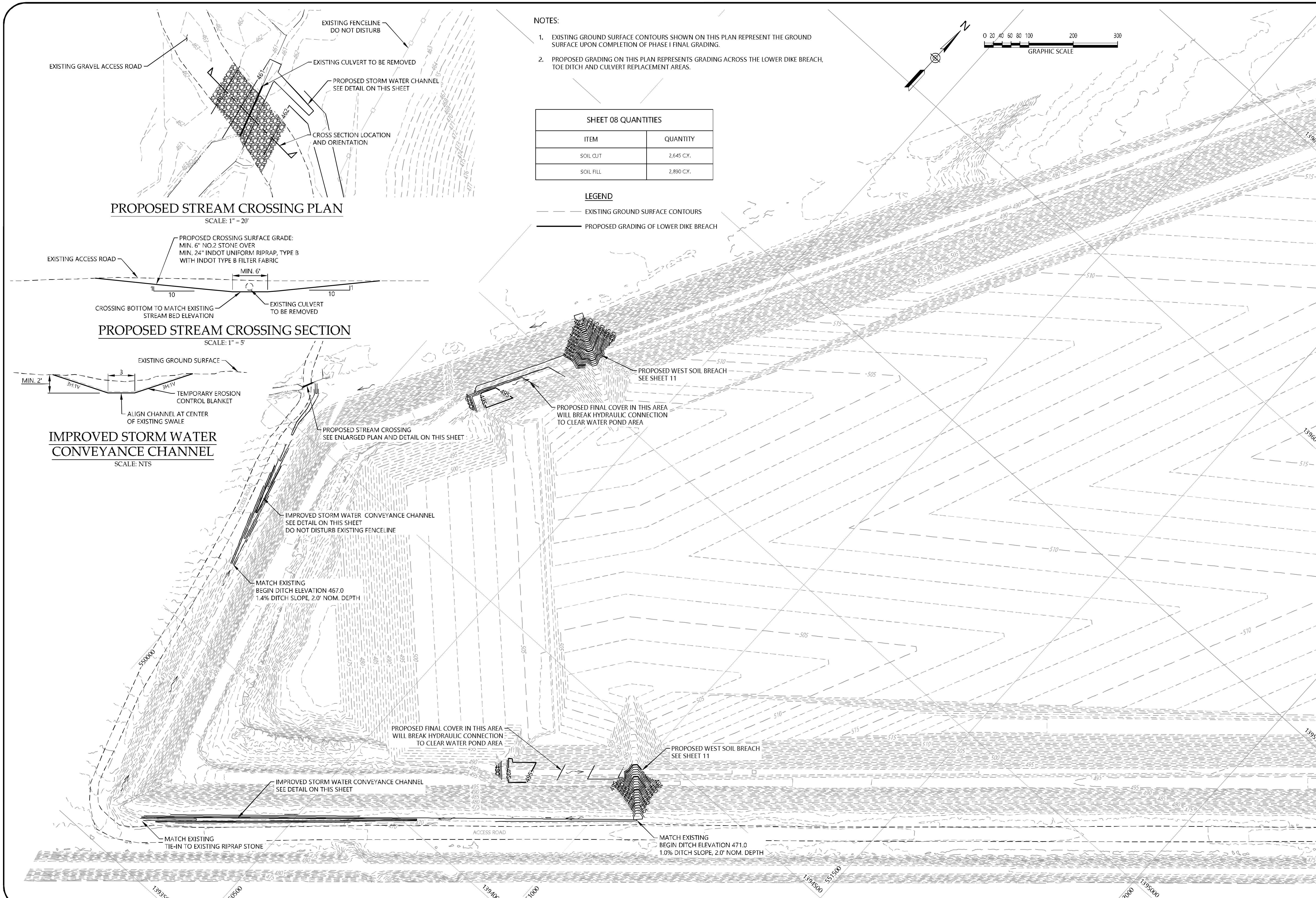
NO.	DATE	DESCRIPTION	BY	CHK	APV
1	06/22/18	FINAL GRADE RAISED 6 INCHES; BACKGROUND GRADES UPDATED; ROAD GRADE REVISED	PSS	MGR	MTR
0	10/31/17	ISSUED FOR APPROVAL	IDT	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
7

DRAWING NAME
PHASE I COVER SYSTEM

T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\07_PHASE I COVER SYSTEM.dwg-Phase I Cover System Jun 21, 2018 - 11:05am psimko



NOTES:

1. EXISTING GROUND SURFACE CONTOURS SHOWN ON THIS PLAN REPRESENT THE GROUND SURFACE UPON COMPLETION OF PHASE I FINAL GRADING.
2. PROPOSED GRADING ON THIS PLAN REPRESENTS GRADING ACROSS THE LOWER DIKE BREACH, TOE DITCH AND CULVERT REPLACEMENT AREAS.

SHEET 08 QUANTITIES	
ITEM	QUANTITY
SOIL CUT	2,645 C.Y.
SOIL FILL	2,890 C.Y.

LEGEND

EXISTING GROUND SURFACE CONTOURS

PROPOSED GRADING OF LOWER DIKE BREACH

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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
	10/31/17	ISSUED FOR APPROVAL	MRM	MGR	MTR
	06/22/18	BACKGROUND GRADES UPDATED	PSS	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
8

DRAWING NAME
FINAL SURFACE WATER CONTROLS

T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\09_PHASE II ASH GRADING.dwg-Phase II Ash Grading Jun 21, 2018 - 11:15am psimko

NOTES:

1. EXISTING GROUND SURFACE CONTOURS SHOWN ON THIS PLAN REPRESENT THE GROUND SURFACE UPON COMPLETION OF PHASE 1 FINAL GRADES AND THE FINAL SURFACE WATER CONTROLS.
2. PROPOSED GRADING ON THIS PLAN REPRESENTS TOP OF ASH GRADING ACROSS THE CLEAR WATER POND.

KEYNOTES:

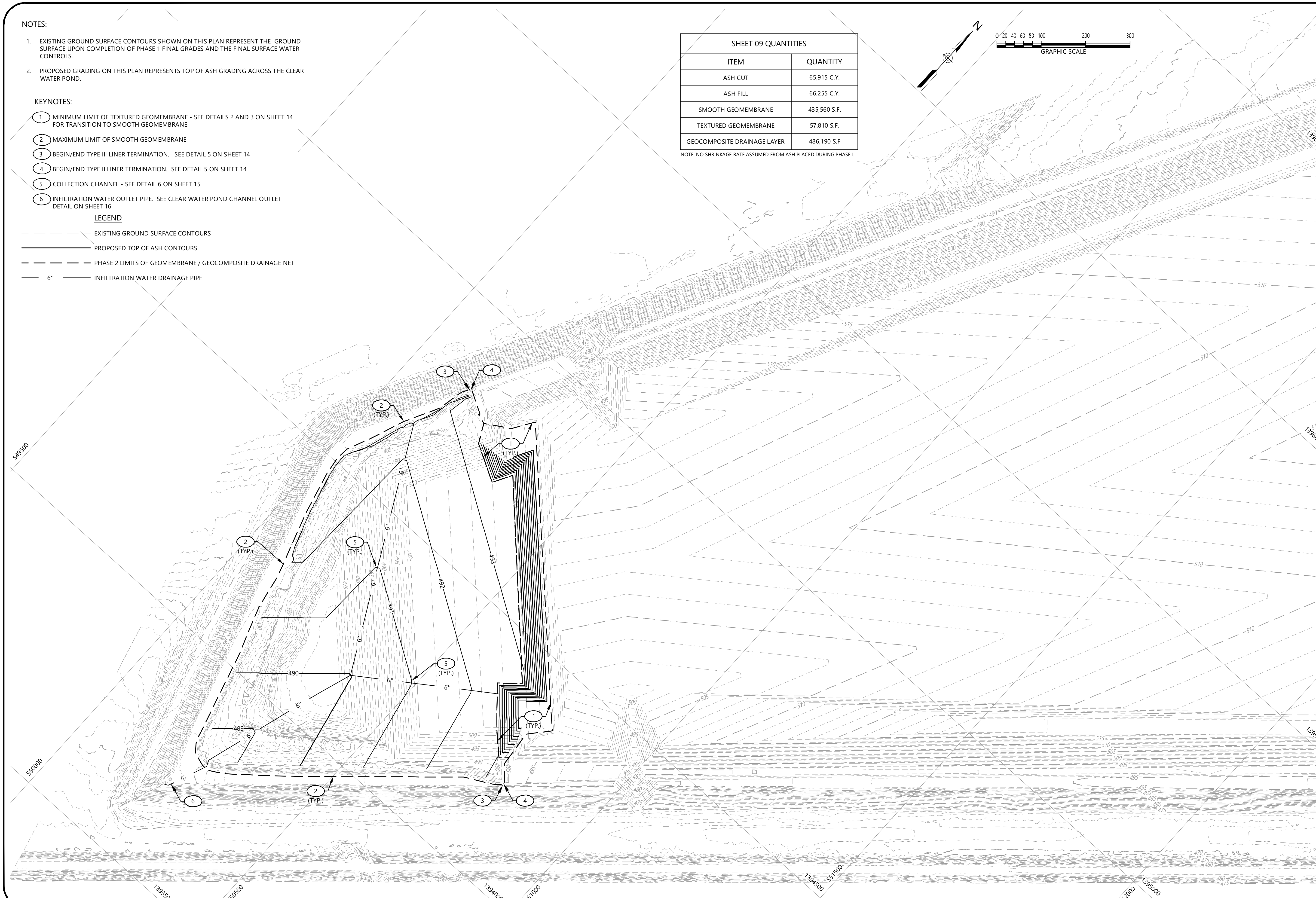
1. MINIMUM LIMIT OF TEXTURED GEOMEMBRANE - SEE DETAILS 2 AND 3 ON SHEET 14 FOR TRANSITION TO SMOOTH GEOMEMBRANE
2. MAXIMUM LIMIT OF SMOOTH GEOMEMBRANE
3. BEGIN/END TYPE III LINER TERMINATION. SEE DETAIL 5 ON SHEET 14
4. BEGIN/END TYPE II LINER TERMINATION. SEE DETAIL 5 ON SHEET 14
5. COLLECTION CHANNEL - SEE DETAIL 6 ON SHEET 15
6. INFILTRATION WATER OUTLET PIPE. SEE CLEAR WATER POND CHANNEL OUTLET DETAIL ON SHEET 16

LEGEND

- EXISTING GROUND SURFACE CONTOURS
- PROPOSED TOP OF ASH CONTOURS
- PHASE 2 LIMITS OF GEOMEMBRANE / GEOCOMPOSITE DRAINAGE NET
- 6" INFILTRATION WATER DRAINAGE PIPE

SHEET 09 QUANTITIES	
ITEM	QUANTITY
ASH CUT	65,915 C.Y.
ASH FILL	66,255 C.Y.
SMOOTH GEOMEMBRANE	435,560 S.F.
TEXTURED GEOMEMBRANE	57,810 S.F.
GEOCOMPOSITE DRAINAGE LAYER	486,190 S.F

NOTE: NO SHRINKAGE RATE ASSUMED FROM ASH PLACED DURING PHASE I.



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FLY ASH POND CLOSURE TANNERS CREEK PLANT

LAWRENCEBURG, DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
1	06/22/18	BACKGROUND GRADES UPDATED	PSS	MGR	MTR
	10/31/17	ISSUED FOR APPROVAL	IDT	MGR	MTR

PROJECT NUMBER 7217-17-007A

DRAWING NUMBER 9

DRAWING NAME PHASE II ASH GRADING

NOTES:

1. EXISTING GROUND SURFACE CONTOURS SHOWN ON THIS PLAN REPRESENT THE GROUND SURFACE UPON COMPLETION OF PHASE II ASH GRADING.
2. PROPOSED GRADING ON THIS PLAN REPRESENTS FINAL GRADING ACROSS CLEAR WATER POND.

KEYNOTES:

(1) SURFACE WATER COLLECTION CHANNEL - SEE DETAIL 6 ON SHEET 15

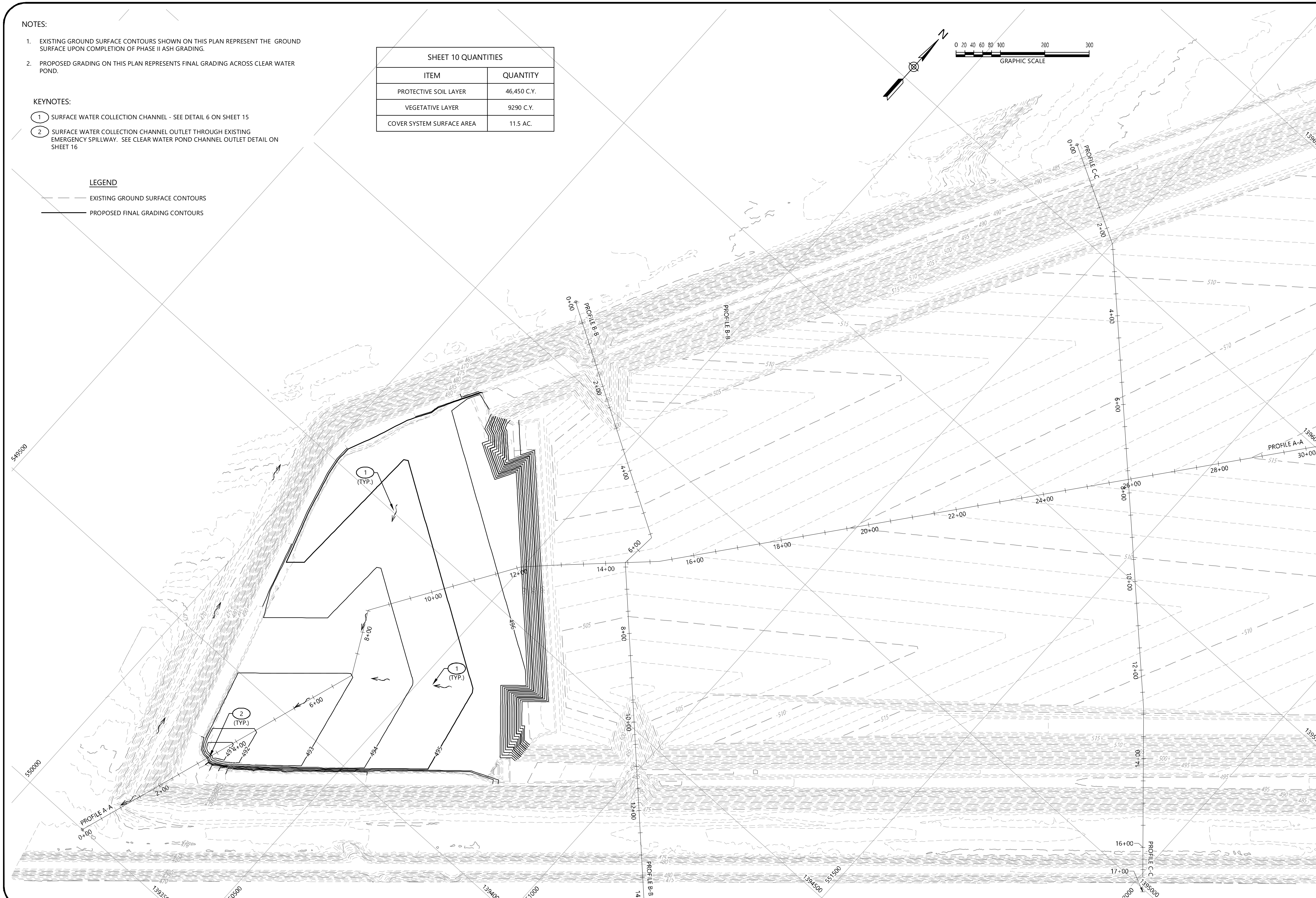
(2) SURFACE WATER COLLECTION CHANNEL OUTLET THROUGH EXISTING EMERGENCY SPILLWAY. SEE CLEAR WATER POND CHANNEL OUTLET DETAIL ON SHEET 16

LEGEND

EXISTING GROUND SURFACE CONTOURS

PROPOSED FINAL GRADING CONTOURS

SHEET 10 QUANTITIES	
ITEM	QUANTITY
PROTECTIVE SOIL LAYER	46,450 C.Y.
VEGETATIVE LAYER	9290 C.Y.
COVER SYSTEM SURFACE AREA	11.5 AC.



T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\10_PHASE II COVER SYSTEM.dwg-10 Phase II Cover System Jun 21, 2018 - 11:21am psimko

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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

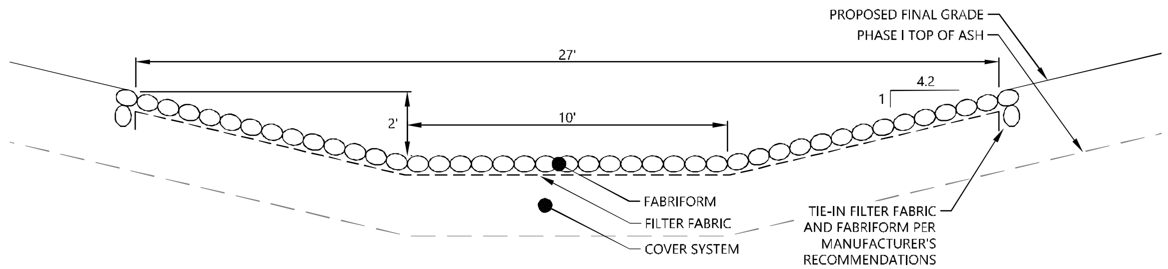
MICHAEL T. ROMANELLO REGISTERED PROFESSIONAL ENGINEER STATE OF INDIANA

NO.	DATE	DESCRIPTION	BY	CHK	APV
△	06/22/18	FINAL GRADE RAISED 6 INCHES; BACKGROUND GRADES UPDATED	PSS	MGR	MTR
△	10/31/17	ISSUED FOR APPROVAL	IDT	MGR	MTR

PROJECT NUMBER
7217-17-007A

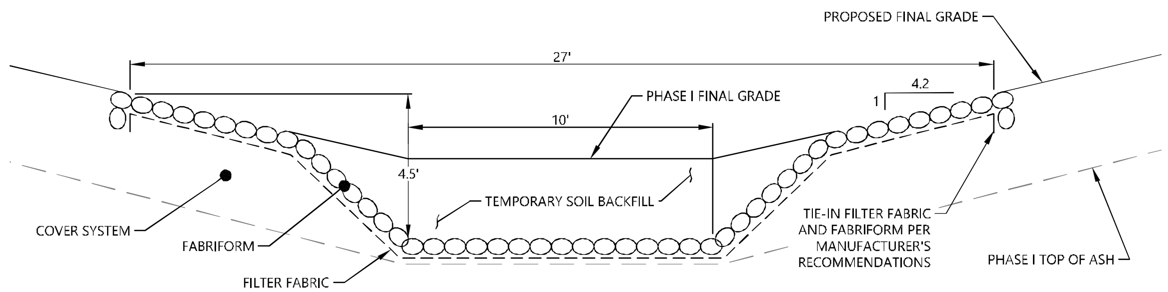
DRAWING NUMBER
10

DRAWING NAME
PHASE II COVER SYSTEM



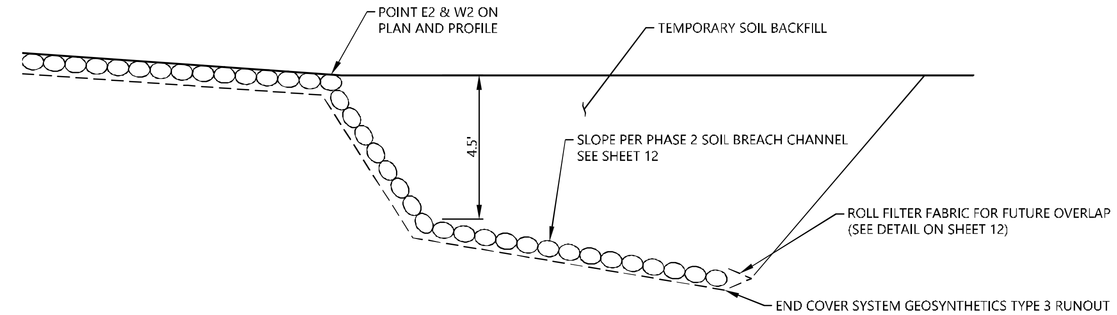
SECTION A-A
ASH BREACH TYPICAL SECTION

SCALE: 1" = 3'



SECTION B-B
ASH BREACH OULET TRANSITION

SCALE: 1" = 3'

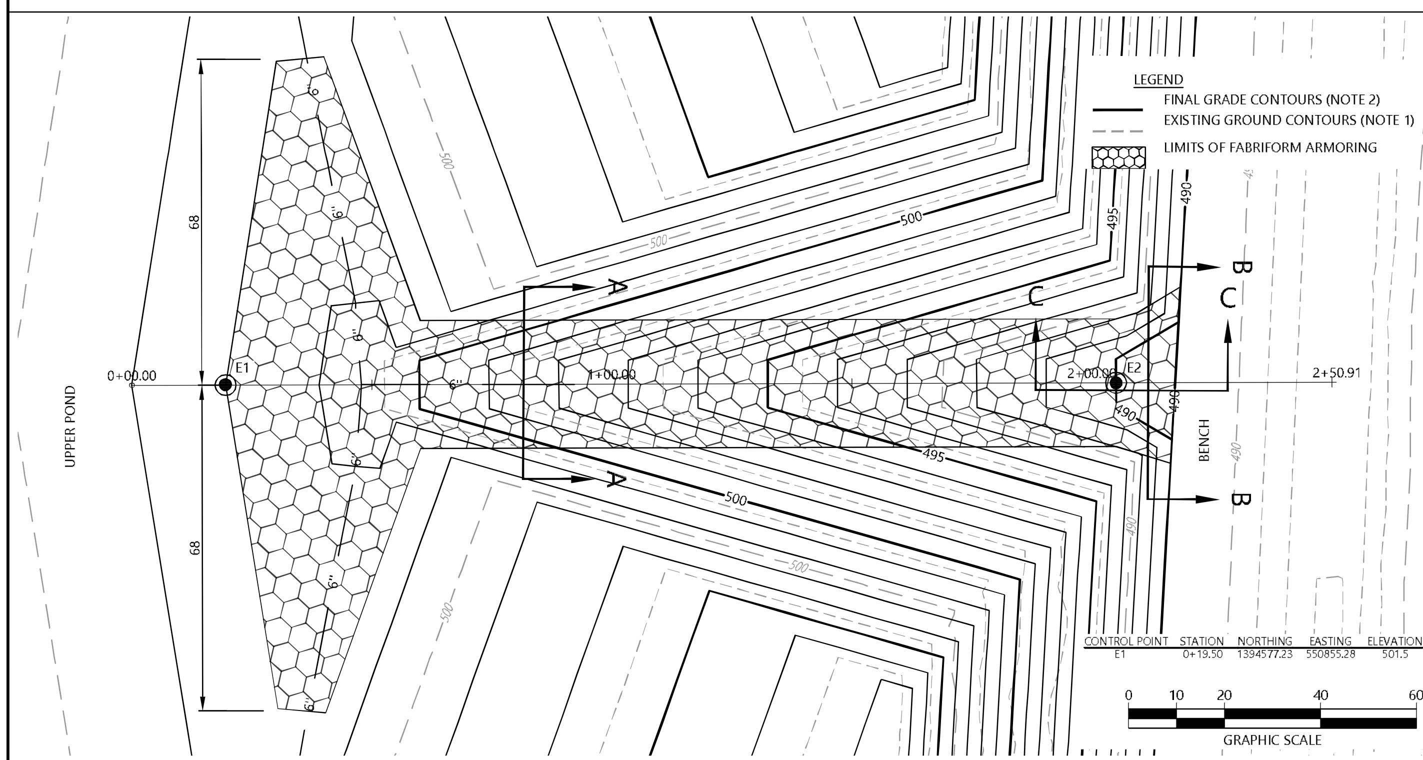


SECTION C-C
ASH BREACH DOWNSTREAM TERMINATION DETAIL

SCALE: 1" = 3'

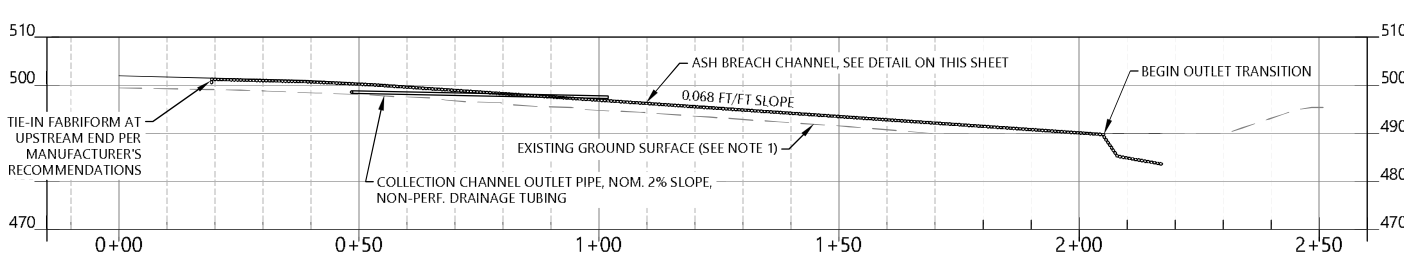
NOTES:

1. EXISTING GROUND SURFACE CONTOURS AND PROFILE ELEMENTS SHOWN ON THIS SHEET REPRESENT A COMPOSITE SURFACE INCLUDING PHASE I ASH GRADES AND EXISTING GROUND SURVEY.
2. PROPOSED GRADES AND PROFILE ELEMENTS SHOWN ON THIS SHEET REPRESENT FINAL COVER ELEVATIONS FOR ASH BREACHES ON BOTH SIDES OF THE ASH POND.
3. FABRIFORM SHALL BE 10-INCH FILTERPOINT AS MANUFACTURED BY FABRIFORM INC. OR APPROVED EQUAL.
4. FILTER FABRIC TYPE 3 FOR FABRIFORM CHANNELS SHALL BE INSTALLED IN ACCORDANCE WITH INDOT SECTION 616.11.



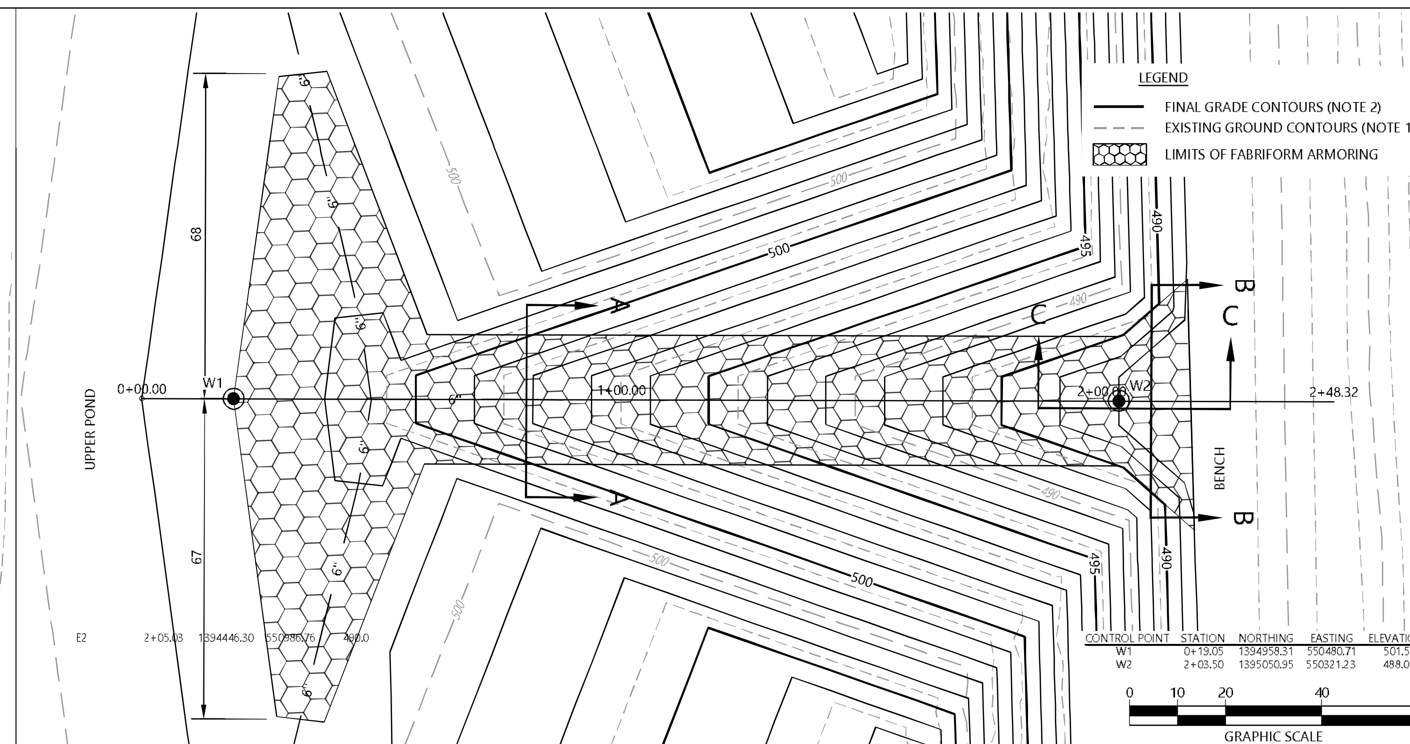
CONTROL POINT	STATION	NORTHING	EASTING	ELEVATION
E1	0+19.50	1394577.23	550855.28	501.5
E2	2+05.03	1394446.30	550986.76	490.0

GRAPHIC SCALE: 0 10 20 40 60



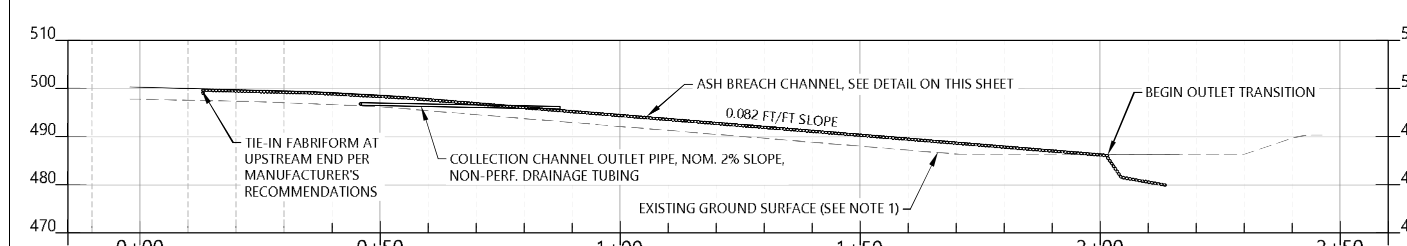
EAST ASH BREACH PLAN AND PROFILE

SCALE H:1"=20'; V:1"=20'



CONTROL POINT	STATION	NORTHING	EASTING	ELEVATION
W1	0+19.05	1394958.31	550480.71	501.5
W2	2+03.50	1395050.95	550321.23	488.0

GRAPHIC SCALE: 0 10 20 40 60



WEST ASH BREACH PLAN AND PROFILE

SCALE H:1"=20'; V:1"=20'

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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

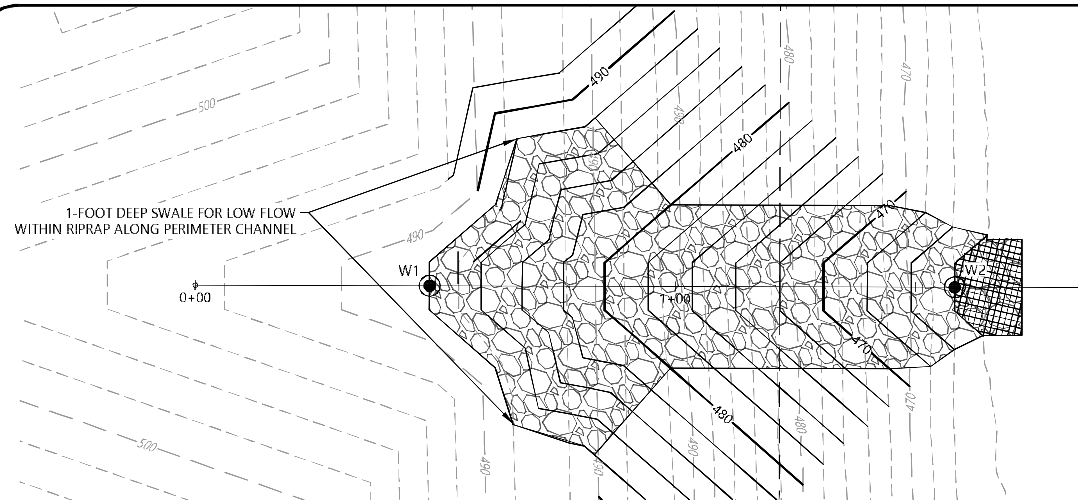
MICHAEL T. ROMANELLO REGISTERED PE11600186 STATE OF INDIANA PROFESSIONAL ENGINEER 10-13-17

NO.	DATE	DESCRIPTION	BY	CHK	APV
2	06/22/18	MODIFIED SECTION C-C	PSS	MGR	MTR
1	10/31/17	ISSUED FOR APPROVAL	MRM	MGR	MTR

PROJECT NUMBER 7217-17-007A

DRAWING NUMBER 11

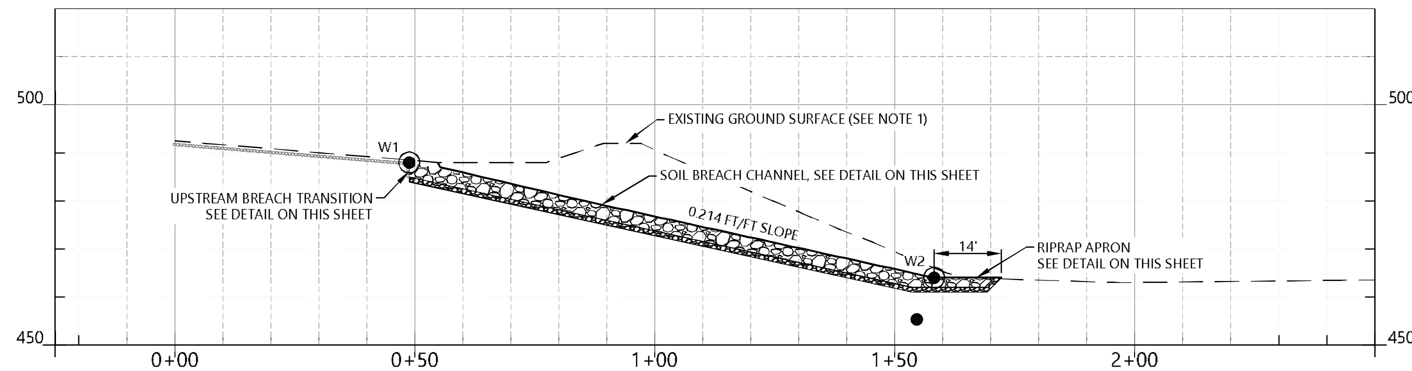
DRAWING NAME ASH BREACH PLAN PROFILE AND DETAILS



LEGEND
- FINAL GRADE CONTOURS (NOTE 2)
- EXISTING GROUND CONTOURS (NOTE 1)
- LIMITS OF RIPRAP CHANNEL ARMORING
- LIMITS OF GROUTED RIPRAP APRON

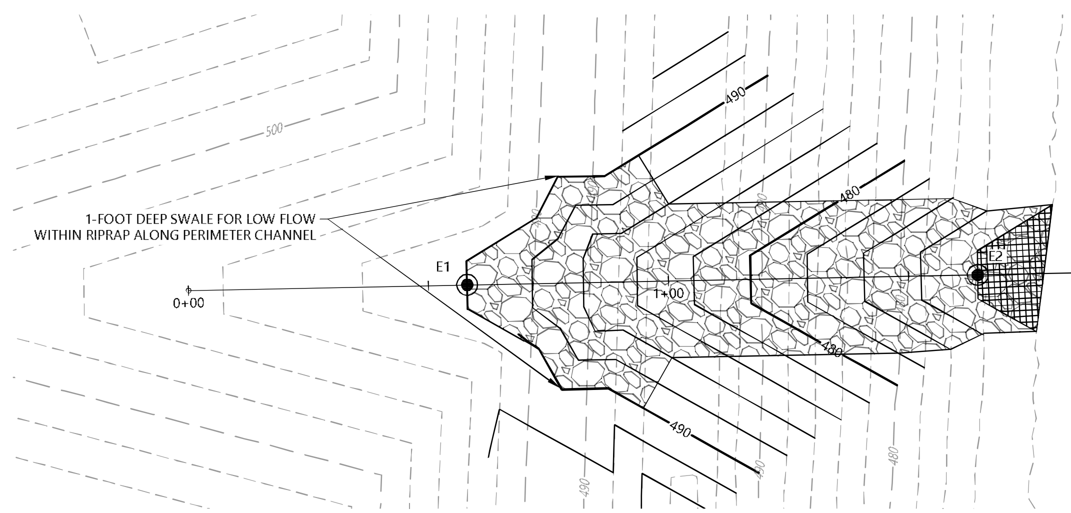
CONTROL POINT	STATION	NORTHING	EASTING	ELEVATION
W1	0+48.80	1395050.95	550321.23	488.0
W2	1+58.23	1395105.92	550226.60	464.0

GRAPHIC SCALE 0 10 20 40 60



WEST SOIL BREACH PLAN AND PROFILE
SCALE H:1"=20'; V:1"=20'

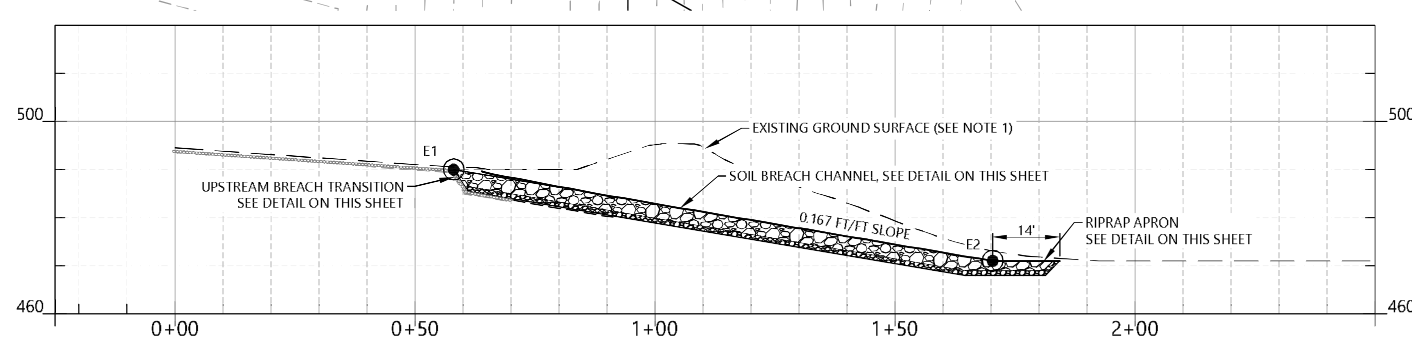
GRAPHIC SCALE 0 10 20 40 60



LEGEND
- FINAL GRADE CONTOURS (NOTE 2)
- EXISTING GROUND CONTOURS (NOTE 1)
- LIMITS OF RIPRAP CHANNEL ARMORING
- LIMITS OF GROUTED RIPRAP APRON

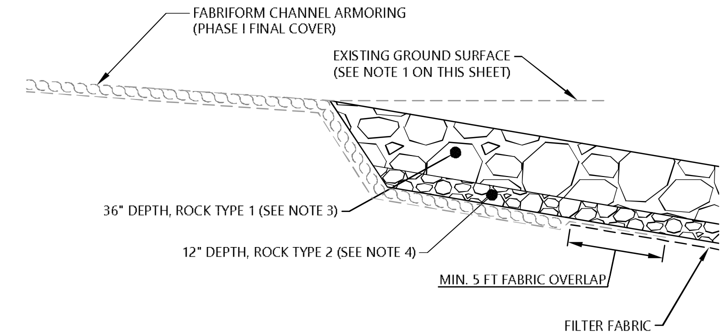
CONTROL POINT	STATION	NORTHING	EASTING	ELEVATION
E1	0+58.07	1394446.31	550986.75	490.0
E2	1+70.34	1394371.27	551062.17	471.0

GRAPHIC SCALE 0 10 20 40 60

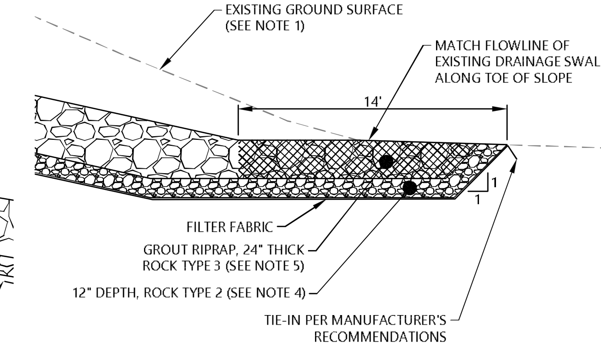


EAST SOIL BREACH PLAN AND PROFILE
SCALE H:1"=20'; V:1"=20'

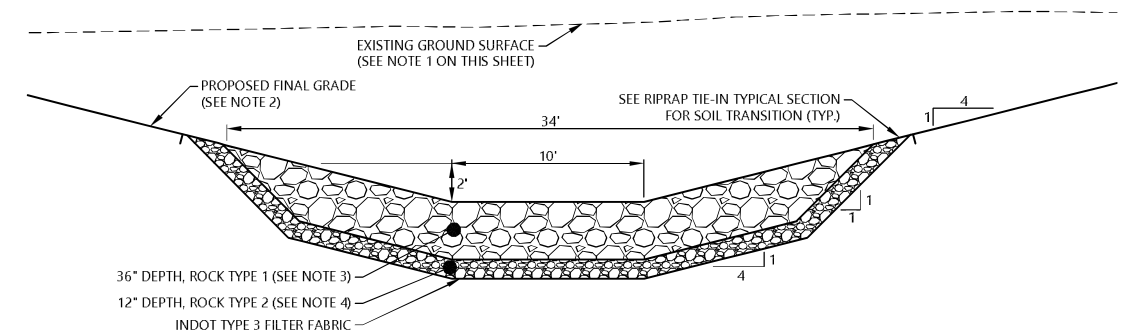
GRAPHIC SCALE 0 10 20 40 60



UPSTREAM BREACH TRANSITION DETAIL
SCALE: 1"=5'

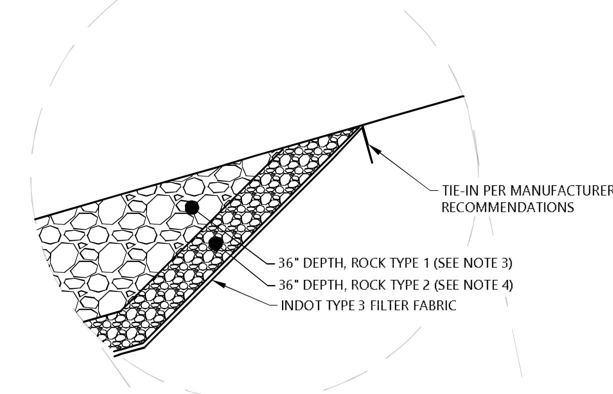


RIPRAP APRON DETAIL (APPLIES ON EAST AND WEST SIDES)
SCALE: 1"=5'

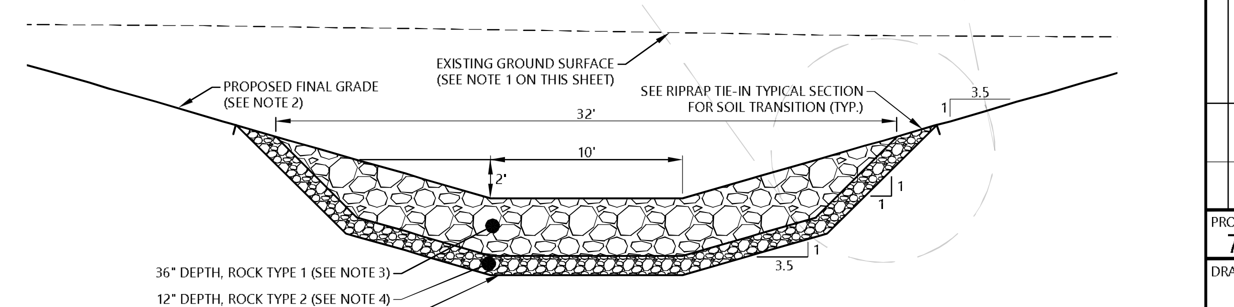


WEST SOIL BREACH TYPICAL SECTION
SCALE: 1"=5'

NOTES:
1. EXISTING GROUND SURFACE CONTOURS AND PROFILE ELEMENTS SHOWN ON THIS SHEET REPRESENT A COMPOSITE SURFACE INCLUDING PHASE I COVER GRADES AND EXISTING GROUND SURVEY.
2. PROPOSED GRADES AND PROFILE ELEMENTS SHOWN ON THIS SHEET REPRESENT FINAL COVER ELEVATIONS FOR SOIL BREACHES ON BOTH SIDES OF THE ASH POND.
3. ROCK TYPE 1 SHALL BE IN ACCORDANCE WITH INDIANA DOT SECTION 616 WITH THE FOLLOWING EXCEPTION: MATERIAL SHALL HAVE AT LEAST 85 PERCENT OF THE TOTAL MATERIAL BY WEIGHT LARGER THAN 12-INCH (0.3m) BUT LESS THAN 24-INCH (0.6m) SQUARE OPENING AND AT LEAST 50% OF THE TOTAL MATERIAL BY WEIGHT LARGER THAN 18-INCH (0.5m) SQUARE OPENING. FURNISH MATERIAL SMALLER THAN A 12-INCH (0.3m) SQUARE OPENING THAT CONSISTS PREDOMINANTLY OF ROCK SPALLS AND ROCK FINES, AND THAT IS FREE OF SOIL.
4. ROCK TYPE 2 SHALL BE UNIFORM RIPRAP TYPE B INSTALLED IN ACCORDANCE WITH INDIANA DOT SECTION 616 AND SECTION 904.04(f).
5. ROCK TYPE 3 (GROUTED RIPRAP) SHALL BE IN ACCORDANCE WITH INDIANA DOT SECTION 616 WITH THE FOLLOWING EXCEPTION: MATERIAL SHALL HAVE AT LEAST 85 PERCENT OF THE TOTAL MATERIAL BY WEIGHT LARGER THAN 6-INCH (150mm) BUT LESS THAN 18-INCH (0.5m) SQUARE OPENING AND AT LEAST 50% OF THE TOTAL MATERIAL BY WEIGHT LARGER THAN 12-INCH (0.3m) SQUARE OPENING. FURNISH MATERIAL SMALLER THAN A 6-INCH (150mm) SQUARE OPENING THAT CONSISTS PREDOMINANTLY OF ROCK SPALLS AND ROCK FINES, AND THAT IS FREE OF SOIL. GROUT MIX AND INSTALLATION SHALL BE IN ACCORDANCE WITH INDOT SECTION 616.04.
6. FILTER FABRIC TYPE 3 FOR RIPRAP CHANNELS SHALL BE INSTALLED IN ACCORDANCE WITH INDIANA DOT SECTION 616.11.



RIPRAP TIE-IN TYPICAL SECTION
SCALE: NTS



EAST SOIL BREACH TYPICAL SECTION
SCALE: 1"=5'

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ST. LOUIS, MO 63131

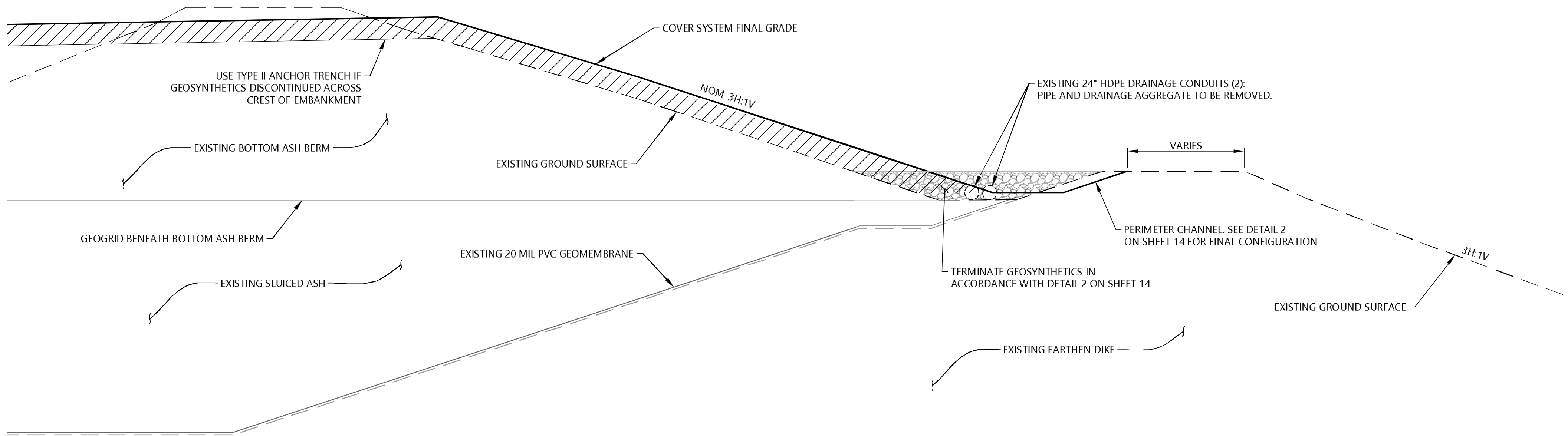
FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
	10/31/17	ISSUED FOR APPROVAL	MRM	MGR	MJR

PROJECT NUMBER 7217-17-007A
DRAWING NUMBER 12
DRAWING NAME SOIL BREACH PLAN PROFILE AND DETAILS

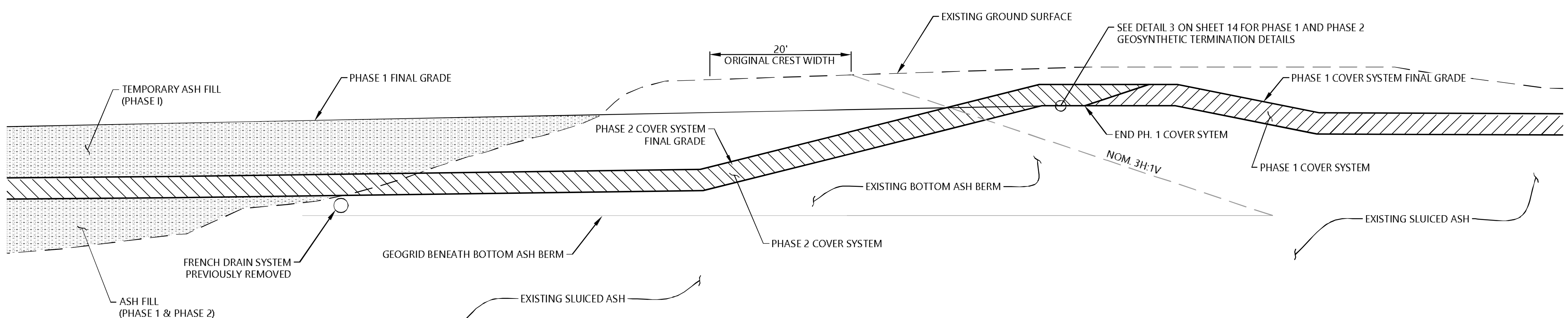
T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\12_DETAILS.dwg Soil Breach Plan Profile and Details Jun 21, 2018 - 11:38am psimko

MODIFIED FOR 36" COVER SYSTEM



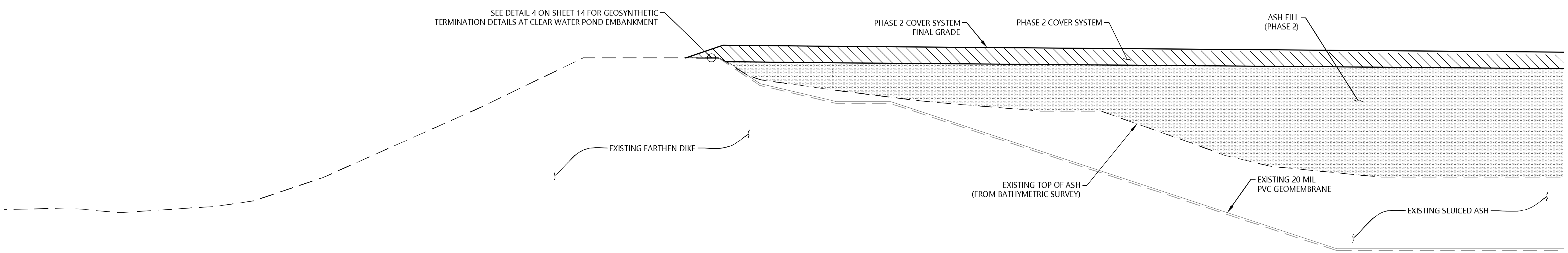
TYPICAL SECTION THROUGH UPPER BASIN EXTERIOR DIKES

SCALE: 1" = 10'



TYPICAL SECTION THROUGH BOTTOM ASH SPLITTER DIKE

SCALE: 1" = 10'



TYPICAL SECTION THROUGH CLEAR WATER POND EXTERIOR EMBANKMENT

SCALE: 1" = 10'

0 2 4 6 8 10 20 30
GRAPHIC SCALE IN FEET

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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

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2	03/09/18	IDEM RAI NO. 1	DCV	MGR	MTR
1	10/31/17	ISSUED FOR APPROVAL	MTR	MGR	MTR

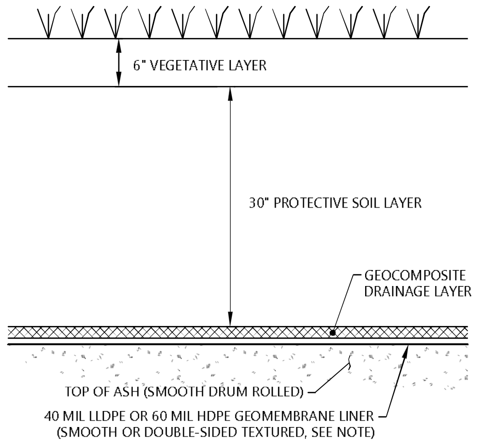
PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
13

DRAWING NAME
TYPICAL SECTIONS

T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\13-16_DETAILS.dwg 13 Details Jun 21, 2018 - 11:50am psimko

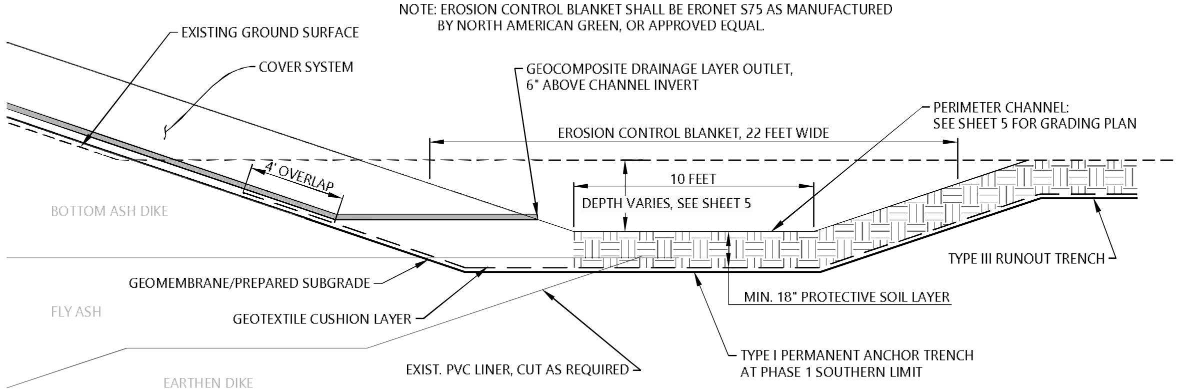
△ MODIFIED FOR 36" COVER SYSTEM



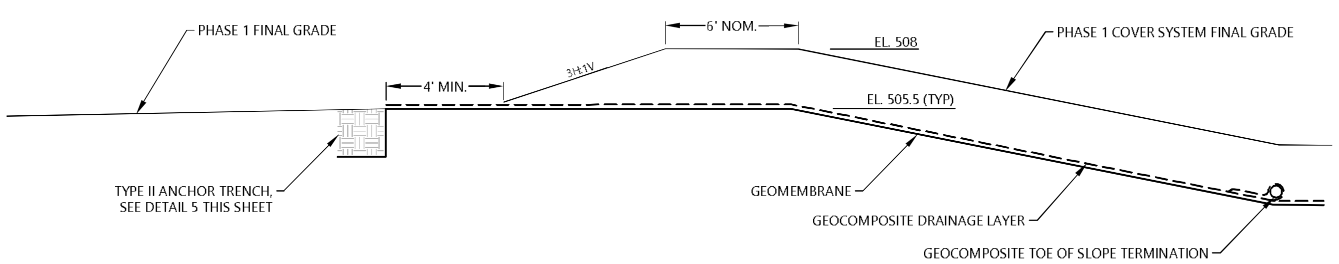
NOTE:
SEE DETAIL 8 ON SHEET 15 FOR TYPICAL TRANSITION BETWEEN SMOOTH AND TEXTURED LINER

1 COVER SYSTEM TYPICAL SECTION
NOT TO SCALE

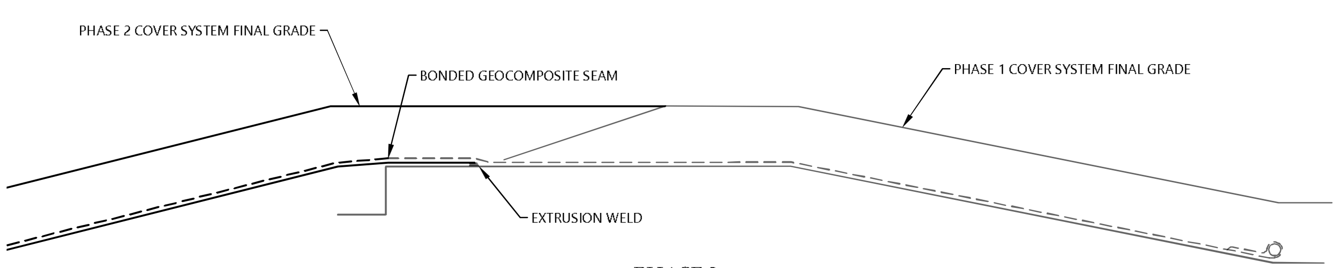
NOTE: EROSION CONTROL BLANKET SHALL BE ERONET S75 AS MANUFACTURED BY NORTH AMERICAN GREEN, OR APPROVED EQUAL.



2 LINER TERMINATION AT PERIMETER CHANNEL
SCALE: 1" = 4'

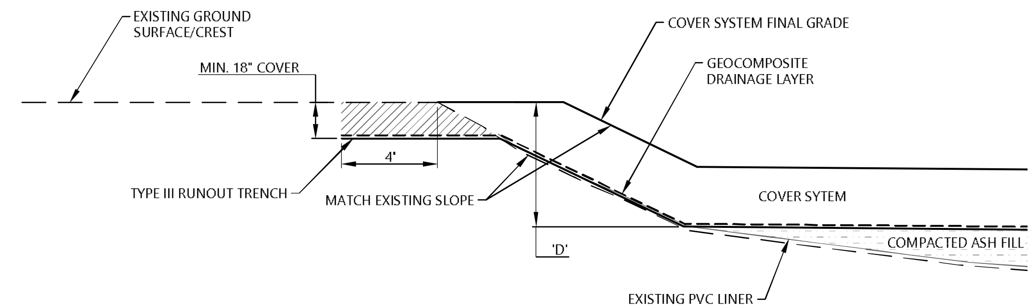


PHASE 1

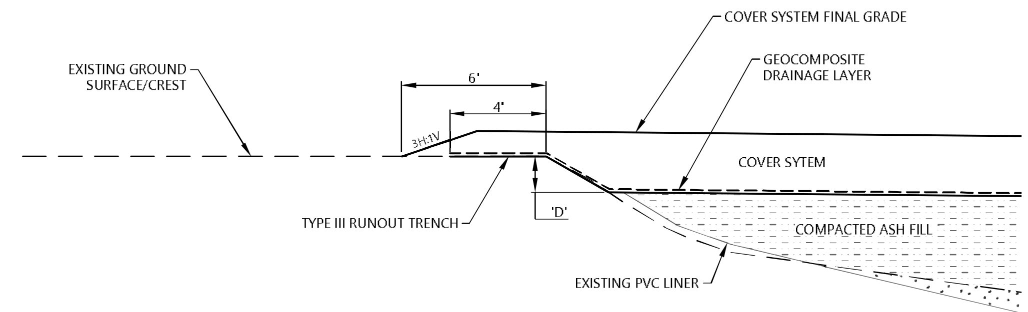


PHASE 2

3 SPLITTER DIKE LINER TERMINATION
SCALE: 1" = 4'

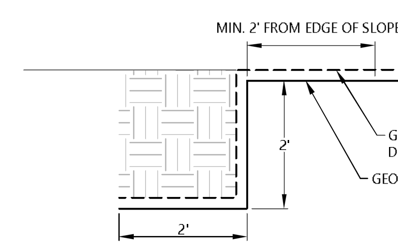


DEPTH TO LINER 'D' GREATER THAN 2 FEET

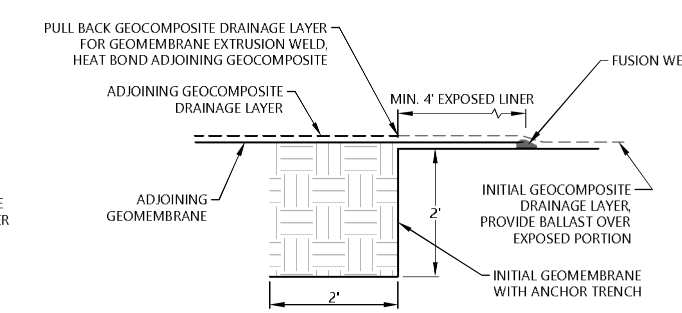


DEPTH TO LINER 'D' LESS THAN 2 FEET

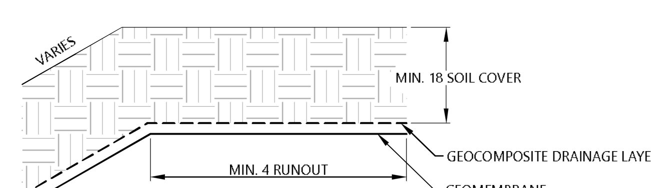
4 CLEAR WATER POND LINER TERMINATION
SCALE: 1" = 4'



TYPE I: PERMANENT ANCHOR TRENCH



TYPE II: TEMPORARY ANCHOR TRENCH



TYPE III: RUNOUT TRENCH

5 LINER TERMINATION DETAILS
NOT TO SCALE

0 1" 2" 3"

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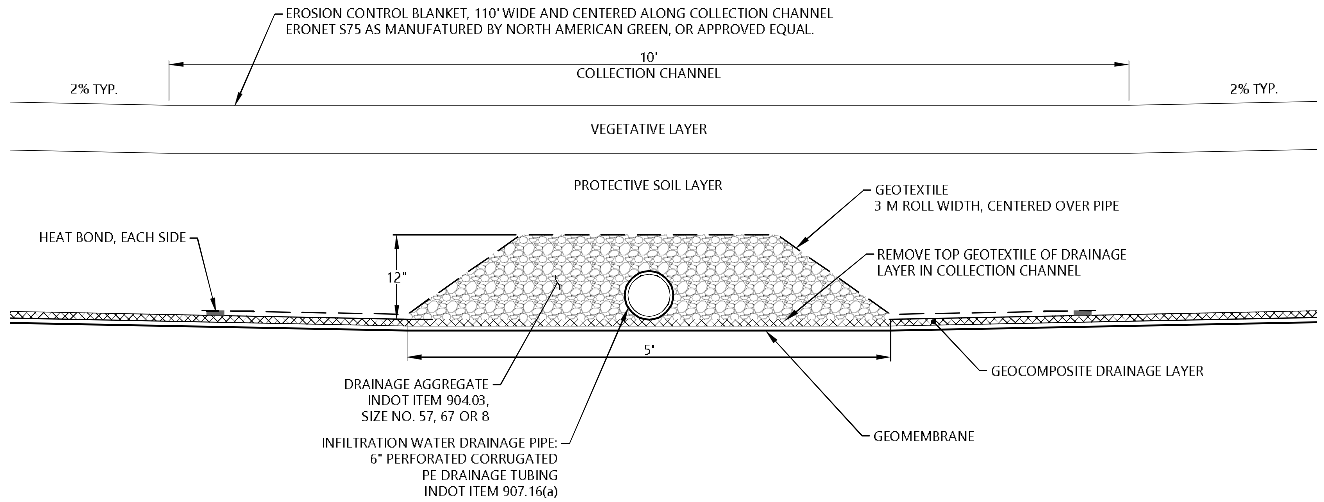
FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG,DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
△	06/22/18	MODIFIED DETAILS 1 & 5	PSS	MGR	MTR
△	03/09/18	IDEM RAI NO. 1	DCV	MGR	MTR
△	10/31/17	ISSUED FOR APPROVAL	MTR	MGR	MTR

PROJECT NUMBER
7217-17-007A

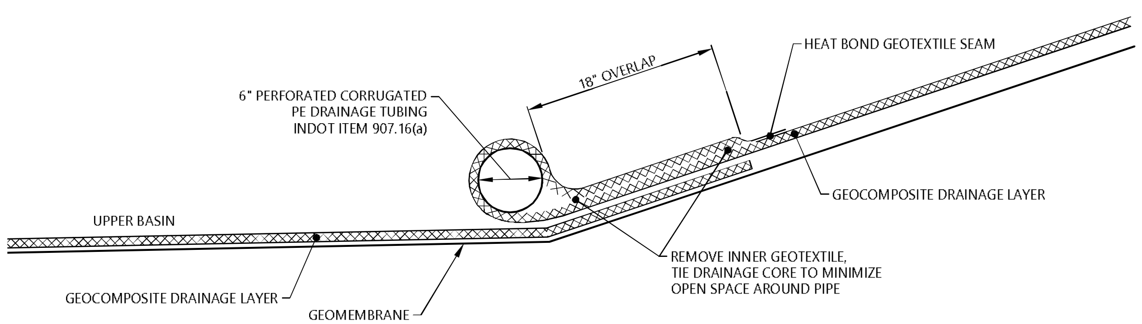
DRAWING NUMBER
14

DRAWING NAME
DETAILS



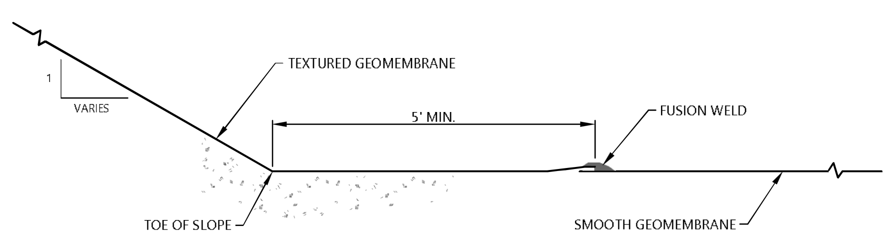
6 COLLECTION CHANNEL

NOT TO SCALE



7 GEOCOMPOSITE OUTLET AT TOE OF SLOPE

NOT TO SCALE



8 SMOOTH TO TEXTURED LINER TRANSITION

NOT TO SCALE

0 1" 2" 3"

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FLY ASH POND CLOSURE
TANNERS CREEK PLANT

LAWRENCEBURG,DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
1	06/22/18	MODIFIED DETAIL 7	PSS	MGR	MTR
0	10/31/17	ISSUED FOR APPROVAL	MTR	MGR	MTR

PROJECT NUMBER
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DRAWING NUMBER
15

DRAWING NAME
DETAILS

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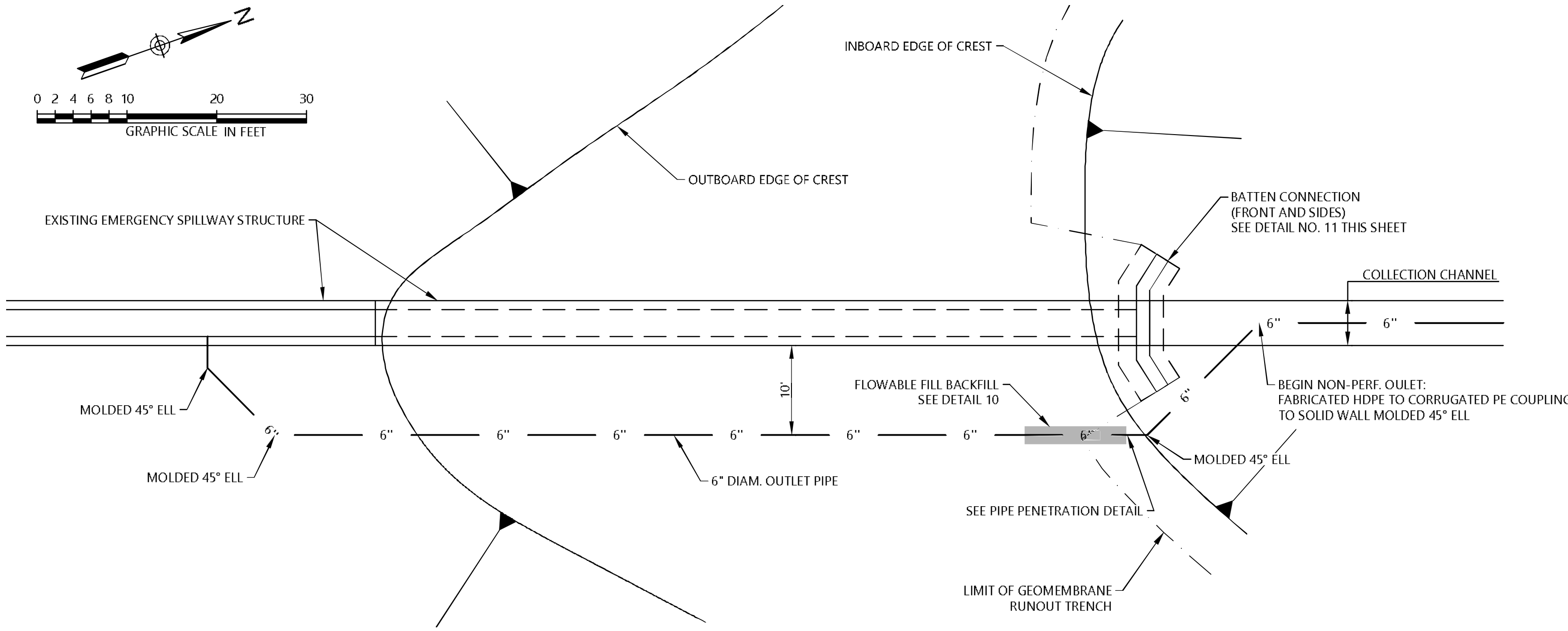
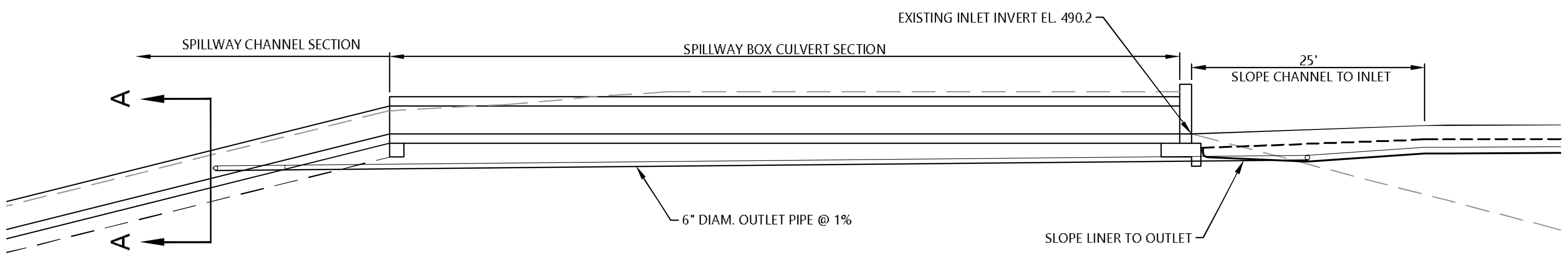
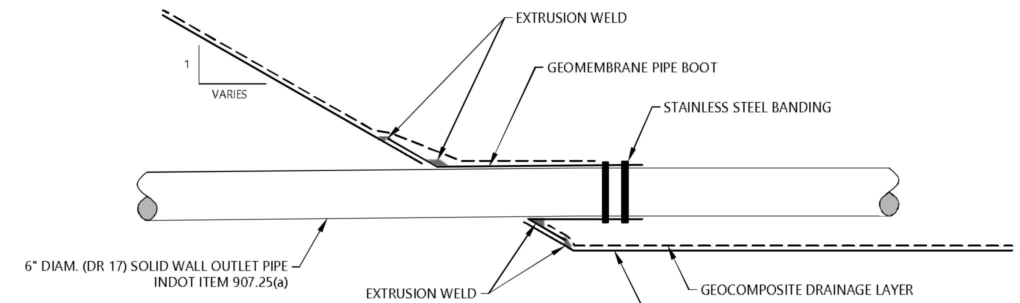


PLAN

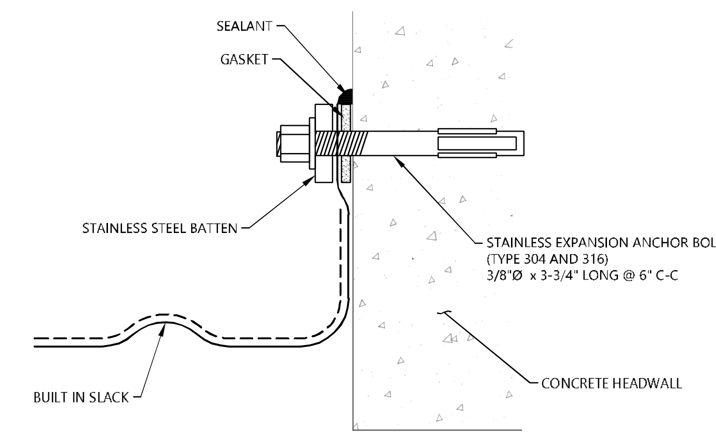


PROFILE

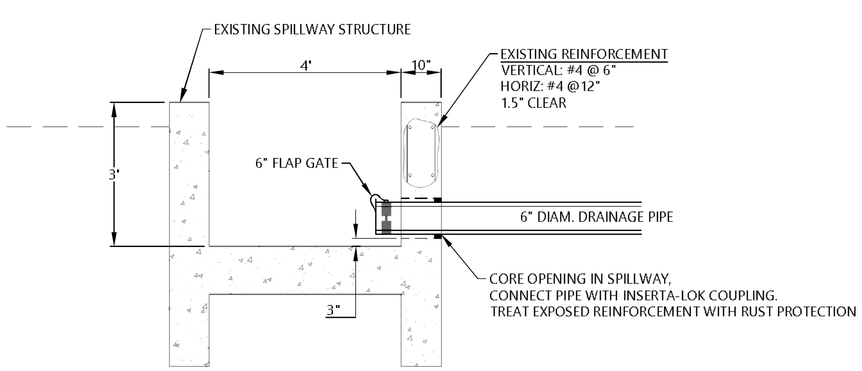
CLEAR WATER POND COLLECTION CHANNEL OUTLET
SCALE: 1" = 10'



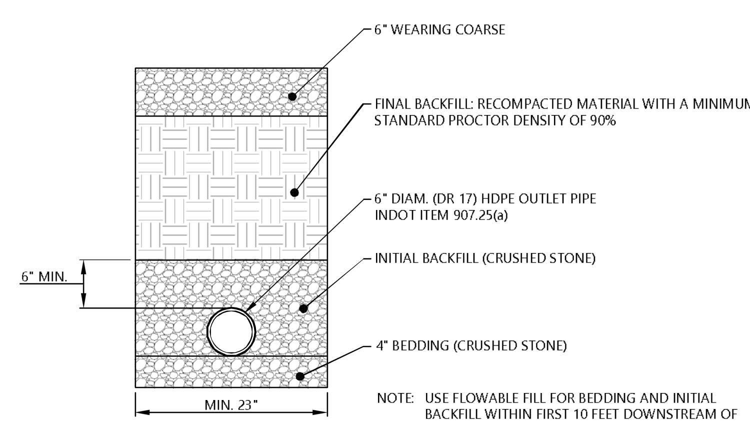
11 PIPE PENETRATION
NOT TO SCALE



12 STEEL BATTEN WITH CONCRETE ANCHOR
NOT TO SCALE



SECTION A-A
SCALE: 1" = 2'



NOTE: USE FLOWABLE FILL FOR BEDDING AND INITIAL BACKFILL WITHIN FIRST 10 FEET DOWNSTREAM OF PIPE PENETRATION.

10 TRENCH INSTALLATION DOWNSTREAM OF LINER PENETRATION
NOT TO SCALE

0 1" 2" 3"

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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
△	10/31/17	ISSUED FOR APPROVAL	MTR	MGR	MTR

PROJECT NUMBER 7217-17-007A
DRAWING NUMBER 16
DRAWING NAME DETAILS

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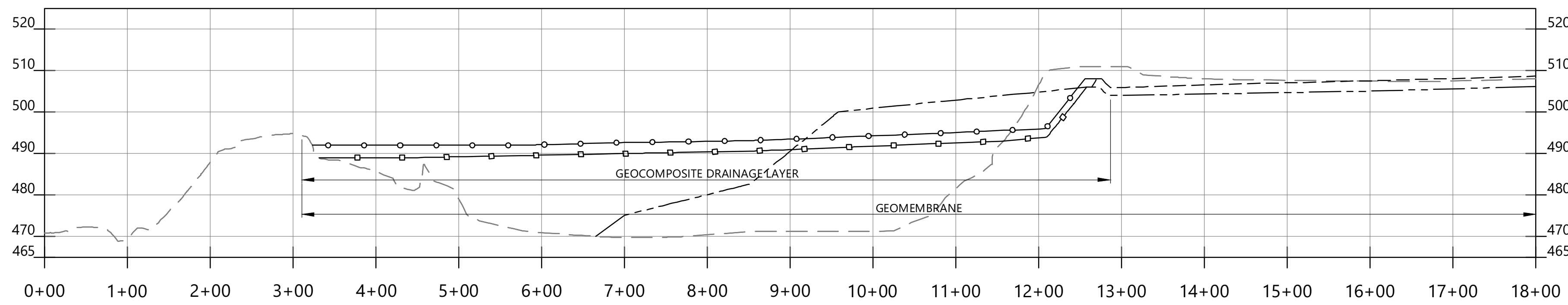
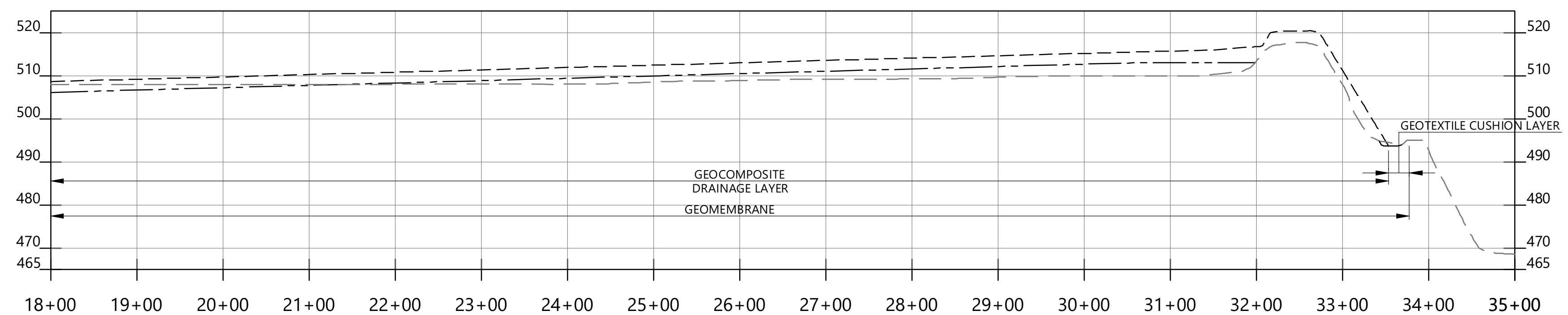
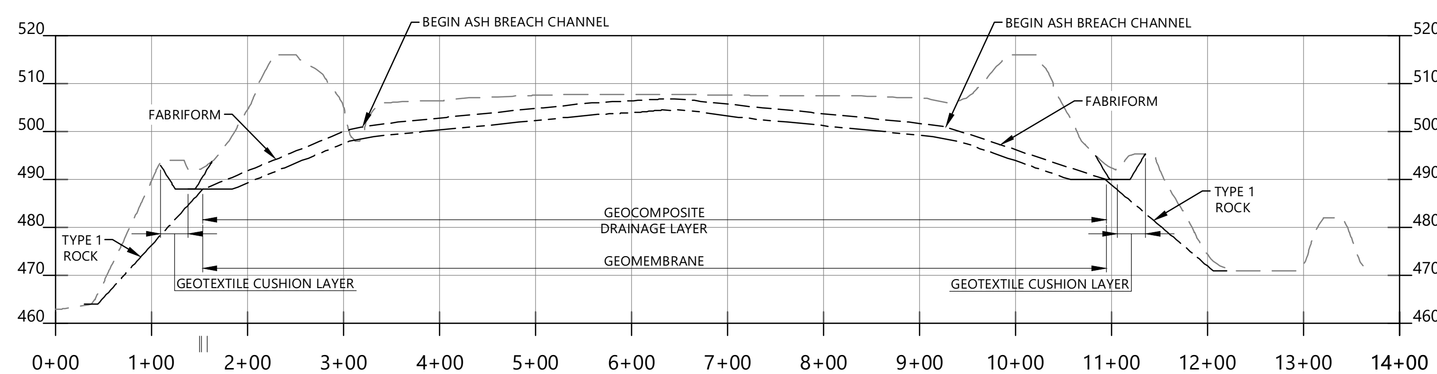
△ ADDED LIMITS OF GEOSYNTHETIC LAYERS



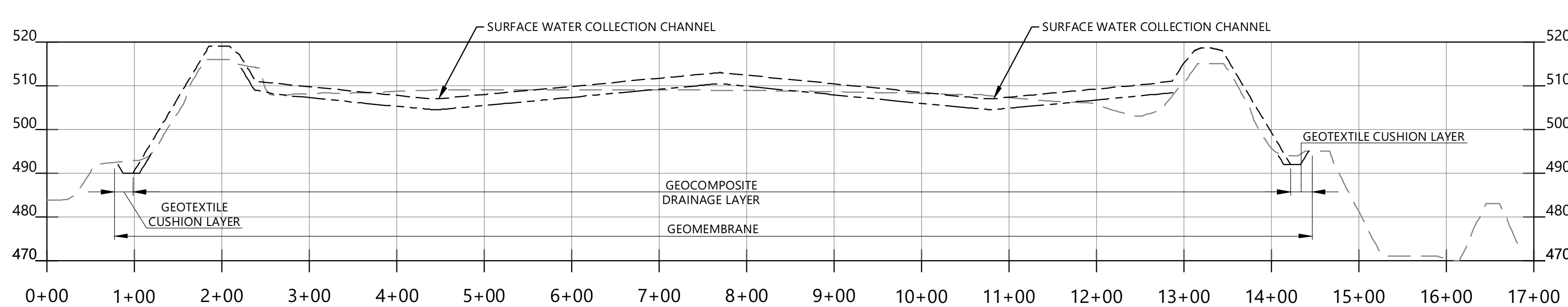
A-A PROFILE
SCALE H:1"=100'; V:1"=20'



A-A PROFILE (CONT'D)
SCALE H:1"=100'; V:1"=20'



B-B PROFILE
SCALE H:1"=100'; V:1"=20'



C-C PROFILE
SCALE H:1"=100'; V:1"=20'

LEGEND

- EXISTING GROUND SURFACE
- INITIAL STORMWATER CONTROLS
- LOWER DIKE BREACH
- PHASE 1 TOP OF ASH
- PHASE 1 FINAL COVER
- PHASE 2 TOP OF ASH
- PHASE 2 FINAL COVER

0 20 40 60 80 100 200 300
GRAPHIC SCALE

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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
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△	03/09/18	IDEM RAI NO. 1	DCV	MGR	MTR
△	10/31/17	ISSUED FOR APPROVAL	MRM	MGR	MTR

PROJECT NUMBER
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DRAWING NUMBER
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DRAWING NAME
CROSS SECTIONS

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Attachment II – Ground Water Monitoring Plan

Phase I Ground Water Monitoring Plan, Rev 4

Fly Ash Pond Complex

Tanners Creek Power Plant

S&ME Project No. 7217-17-007A

Prepared for:

Tanners Creek Development, LLC
1515 Des Peres Rd, Suite 300
St. Louis, MO 63131

Prepared by:

S&ME, Inc.
6190 Enterprise Court
Dublin, OH 43016

February 12, 2014

Revised: June 26, 2018

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Table of Contents

List of Tables

Appendices

Appendix A – Maps and Summaries

Appendix B – Boring and Well Installation Data

Appendix C – Miscellaneous Information

1.0 Introduction

This Phase I Ground Water Monitoring Plan (Plan) has been prepared for the monitoring of ground water flow beneath the Fly Ash Pond at the Tanners Creek Power Plant. Separate ground water monitoring plans have been, or will be, prepared for the Type I Restricted Waste Landfill and the Main Ash Pond at Tanner Creek. This Plan is based on:

- The requirements of 329 IAC 10-29;
- Stage 1 Fly Ash Pond, Sampling and Analysis Plan, AEP February 2014

American Electric Power prepared and submitted to the Indiana Department of Environmental Management (IDEM) a Closure Plan for the Tanners Creek ash ponds on March 23, 2015. The Closure Plan contained Rev 1 of the Ground Water Monitoring Plan. Subsequent revisions to the Plan have been made to address IDEM issued Requests For Additional Information. A history of the revisions to this Plan are as follows:

- Rev 0 February 12, 2014, American Electric Power
- Rev 1 March 23, 2015, TRC Environmental Corp.
- Rev 2 October 13, 2017, S&ME, Inc. revised to address IDEM RAI dated 7/24/2015
- Rev 3 March 9, 2018, S&ME, Inc., revised to address IDEM RAI dated 2/6/2018
- Rev 4 June 22, 2018, S&ME, Inc., revised to address IDEM RAI dated 5/10/2018

2.0 Fly Ash Pond Background

The Tanners Creek Power Plant is located adjacent to the Ohio River on State Route 50 approximately one mile southwest of Lawrenceburg, Indiana. The first of four coal fired steam electric generating units at the facility came on-line in 1951 and power generation ceased in May of 2015. The plant, while active, was operated by the Indiana Michigan Power Company (a subsidiary of American Electric Power). Tanners Creek Development, LLC purchased Tanners Creek in October of 2016.

The fly ash pond complex, when originally constructed in 1977 and 1978, consisted of a single impoundment contained by a fully encompassing perimeter earthen dike. The bottom of the pond was extended below the surrounding natural ground surface and the interior was lined with a 20 mil PVC geomembrane.

The interior of the pond was reconfigured several times. However, the reconfigurations did not include expansion of the pond footprint, changing the bottom grades of the pond, or removal of the PVC liner. Sluicing fly ash to the pond ceased in 2014 and AEP initiated closure activities (ash re-grading and installation of dust control measures). Additional closure activities were completed by Tanners Creek Development, LLC in 2017 (additional ash regrading and ash dewatering). It is anticipated that full closure of the Fly Ash Pond will be completed in late 2018 or 2019.

Key elevations (nominal) for the Fly Ash Pond are as follows:

- El 455 – Ohio River, normal pool

- El 462 – Ohio River, ordinary high water level
- El 488 – Ohio River, 100 year, 24 hour flood level
- El 458 – bottom of pond.
- El 470 – outboard toe of earthen dike.
- El 495 - top of original earthen dike.
- El 518 – top of dike after bottom ash raising.

3.0 Hydrogeologic Conditions

The Tanners Creek Power Plant and peripherals are located in the Ohio River alluvial valley with the ground elevation varying between 470 and 518 feet North American Vertical Datum 1988 (NAVD88). A line of bluffs form the boundary of the alluvial valley to the northwest. An eroded highland province occurs outside of the alluvial valley. The topography of the site is generally flat except in locations modified by site development, e.g. dike construction for the FAP (see discussion Section 2.0). Subsurface conditions are similar across the site; soils consist of alluvial deposits of the adjacent Ohio River and glacial outwash deposits.

Logs of borings drilled adjacent to the Main Ash Pond, Fly Ash Pond, and landfill document native soils of lean clay and silty clay soils overlying sands and gravels. The sands and gravels reportedly terminate on shale bedrock with interbedded limestone layers identified as a member of the Cincinnatian series of Ordovician age. The sands and gravels appear to be continuous across the site and represent the aquifer below the ash ponds. The alluvial aquifer varies from 34 to 53 feet in thickness. The underlying shale bedrock represents the lower confining boundary of the aquifer.

The ground water in the aquifer generally flows to the northwest in response to the slight cone of depression generated by the well field west of the Fly Ash Pond. The well field is composed of municipal water supply wells owned and operated by the City of Aurora and the Lawrenceburg, Manchester, Sparta Water Conservancy District. Potentiometric maps documenting previous ground water monitoring by AEP indicate the sand and gravel aquifer is hydraulically connected to the west-northwest flowing Ohio River.

Additional background on the geology and hydrogeology of the site can be found in previous ground water studies including:

- A 1976 study for the Fly Ash Pond (Woodward-Clyde),
- A 1988 ground water monitoring program for the plant (AEP), and
- The ground water monitoring program for the Type I Restricted Waste Landfill at Tanners Creek Power Plant.

4.0 Ground Water Monitoring System

4.1 Objective

The objective of the ground water monitoring system is to allow for the collection of ground water samples from the aquifer which represent the quality of, both, water unaffected by the Fly Ash Pond and water at the monitoring boundary downgradient of the Fly Ash Pond.

4.2 Well Network

The monitoring network for the Fly Ash Pond is summarized in the following table.

Table 4-1 Summary of Monitoring Wells

ID	Status	Well Type	Designation	Sampled
MW-1	Existing	Monitoring Well	Up-Gradient	Yes
MW-2	Existing	Monitoring Well	Up-Gradient	Yes
MW-3	Existing	Monitoring Well	Up-Gradient	Water Level Only
MW-5	Existing	Monitoring Well	Up-Gradient	Water Level Only
PZ-1	Existing	Piezometer	Up-Gradient	Water Level Only
PZ-4	Existing	Piezometer	Up-Gradient	Water Level Only
GM-1S (shallow)	Existing	Geomon™	Down-Gradient	Yes
GM-1D (deep)	Existing	Geomon™	Down-Gradient	Yes
GM-2S (shallow)	Existing	Geomon™	Down-Gradient	Yes
GM-2D (deep)	Existing	Geomon™	Down-Gradient	Yes
GM-3	Existing	Geomon™	Down-Gradient	Yes
MW-22S (shallow)	Proposed	Monitoring Well	Down-Gradient	Yes
MW-22M (intermediate)	Proposed	Monitoring Well	Down-Gradient	Yes (3)
MW-22D (deep)	Proposed	Monitoring Well	Down-Gradient	Yes
MW-23S (shallow)	Proposed	Monitoring Well	Down-Gradient	Yes
MW-23M (intermediate)	Proposed	Monitoring Well	Down-Gradient	Yes (3)
MW-23D (deep)	Proposed	Monitoring Well	Down-Gradient	Yes
MW-24S (shallow)	Proposed	Monitoring Well	Down-Gradient	Yes
MW-24M (intermediate)	Proposed	Monitoring Well	Down-Gradient	Yes (3)
MW-24D (deep)	Proposed	Monitoring Well	Down-Gradient	Yes
MW-25S (shallow)	Proposed	Monitoring Well	Down-Gradient	Yes
MW-25M (intermediate)	Proposed	Monitoring Well	Down-Gradient	Yes (3)
MW-25D (deep)	Proposed	Monitoring Well	Down-Gradient	Yes
MW-26S (shallow)	Proposed	Monitoring Well	Up-Gradient (1)	Baseline (2)
MW-26M (intermediate)	Proposed	Monitoring Well	Up-Gradient (1)	Baseline (2 & 3)
MW-26D (deep)	Proposed	Monitoring Well	Up-Gradient (1)	Baseline (2)
MW-27S (shallow)	Proposed	Monitoring Well	Up-Gradient (1)	Baseline (2)
MW-27M (intermediate)	Proposed	Monitoring Well	Up-Gradient (1)	Baseline (2 & 3)
MW-27D (deep)	Proposed	Monitoring Well	Up-Gradient (1)	Baseline (2)

Table 4-1 Notes:

1. Under normal groundwater flow conditions the well is up-gradient; however, well could be down-gradient if a groundwater flow reversal occurs.

2. Baseline groundwater quality in accordance with paragraph 6.2.3 will be established. Following establishment of baseline, the well will be monitored for water levels only, If a flow reversal is identified, the well will be sampled as down-gradient in accordance with paragraph 6.2.1 beginning with the first sampling event after the flow reversal was identified and continuing until two consecutive events have occurred with the well in an hydrogeologic up-gradient position.

3. The proposed intermediate "M" wells would only be installed if the saturated thickness of the aquifer at the well location exceeds about 35 feet. Additional information regarding the proposed well screen placement is included on Figure 2 of Appendix A. If the Intermediate wells are installed they well be sampled, subject to Note 2 where applicable.

The locations of the wells are depicted on the Well Location Map Plan included as Figure 1 of Appendix A at the rear of this Plan. Well installation details are summarized on Figure 2 of Appendix A and boring logs/well completion diagrams are presented in Appendix B.

More groundwater monitoring wells than are listed in Table 4-1 or shown on Figure 1 of Appendix A are present at Tanners Creek. The other wells are utilized to monitoring the Type 1 Restricted Waste Landfill and/or the Main Ash Pond. Future revisions of this Plan could include the monitoring of some of the other wells if needed and if appropriate.

Geomon™ samplers ("GM" wells listed in Table 4-1) were installed to allow for remote sampling because of periodic inundation of the well locations by floodwaters. The samplers are dedicated, direct-burial nitrogen gas sampling pumps. The wells are protected by 48-inch diameter concrete manholes with bolted cover. The sampling ports are located on the western dike and are shielded with protective covers. The shallow and deep samplers ("S" and "D") are nested in a single boring along with 1-inch diameter piezometers which are used for measuring the water level.

4.3 New Wells and Well Abandonment

A Work Plan will be prepared prior to installation or abandonment of any wells. The Work Plan will be submitted to IDEM for review and comment prior to the start of work. The Work Plan will describe the materials and methods to be used for well installation or abandonment.

Ground water monitoring wells will be installed following the applicable requirements of Indiana Department of Environmental Management (IDEM), Indiana Department of Natural Resources (IDNR), and 329 IAC 10-21-4. Ground water monitoring wells will be abandoned, if necessary, following the applicable requirements of IDNR, and 312 IAC 13-10-2.

4.4 System Adequacy Evaluation

Each ground water monitoring report (see Paragraph 5.7) will include a ground water flow map depicting the potentiometric surface of the aquifer using contour lines. The basis of the map will be the water level measurements obtained as part of the ground water sample collection (sampling event) being reported.

The reports will include a general discussion of ground water flow and will specifically address any deviation from the well designations presented in this Plan (see Table 4-1).

4.5 Maintenance

Visual inspection of the wells will occur during each sampling event and routine maintenance, (lock replacement, removal of wasp nests, etc.) will be performed as needed. Inspections will be documented using the form included as Figure 2 of Appendix C. Additionally, sample collection field notes (see Figure 3 of Appendix C) will include description of the performance of the dedicated sampling pumps. Any maintenance performed or additional maintenance needed will be noted on the field sampling documentation forms.

4.6 Damage Notification

In the event a monitoring well is damaged, destroyed, or fails to function properly, IDEM will be notified of the defect within 10 days of discovery. An attempt will be made to correct any such defect. If the defect cannot be repaired, the well will be abandoned and replaced within 60 days of the notification, unless IDEM determines that the well is no longer needed as part of the monitoring system.

5.0 Sampling Procedures

5.1 Objective

The objective of the sampling procedures described in this Plan is to provide consistent sampling and analysis methods so that the ground water samples collected provide a reliable indication of ground water quality.

5.2 Sample Collection

5.2.1 Water Level Measurements

Two ground water measurements will be obtained in each well during each sampling event. A complete set of water level measurements will be obtained within a 24-hour period prior to sampling any well. This set of water levels will be used to prepare the ground water flow map described in Paragraph 4.4 of this Plan. A second ground water level measurement will be obtained immediately prior to purging and sampling the individual wells. Sealed well caps will be installed on wells subject to flooding (top of casing below El 488). The sealed caps will be removed and the water level allowed to stabilize prior to obtaining water level measurements. The general sequence of obtaining water level measurements will be:

1. Remove or loosen all caps from all wells prior to obtaining any ground water level measurements.
2. Measure water level in all wells prior to collection of any ground water samples.
3. Obtain water level measurement in each well immediately prior to well purging.

Water levels will be measured to the nearest 100^{th} of a foot using a weighted electronic tape. Water elevation at each well will be calculated by subtracting the distance between the top of the well casing and the water surface in the well from the surveyed elevation of the top of the well casing.

5.2.2 *Purging and Sample Collection*

All wells will be purged prior to sample collection. The date and time of purging, volume purged, and other relevant water quality stabilization details will be recorded. Purge water will be discarded at the ground surface near the sampled wells.

5.2.2.1 Geomon™ Wells

Based on development data, the Geomon™ pumps are capable of yielding 3 to 6 liters of water. These wells will be purged until dry. Sample collection and measurement of field parameters will be completed the day following purging. Purging will be done slowly to minimize turbidity. Purging procedures to be used are as follows:

1. Connect the head tee quick-connect coupling to the sampler and hand tighten the tubing fitting.
2. Open the nitrogen gas cylinder regulator valve.
3. Allow a few minutes, as needed, for the pressure to buildup and sample delivery to begin.
4. Collect purge water in bucket.
5. Wait for flow from the discharge tube to stop indicating the reservoir has been emptied.
6. Loosen the tube fitting and release the head tee.
7. Measure the purge water volume and properly discard.

Procedures to be use for sample collection are the same as those used for purging. Field parameter will be measured in a clean, unpreserved, sample container. With the exception of the metals fraction of the sample, sample containers will be directly filled from the well pump discharge tubing.

5.2.2.2 Monitoring Wells

Dedicated bladder sampling pumps are (will be) installed in the monitoring wells. Purging will be completed using low-flow purging techniques generally in accordance with the IDEM 2012 Technical Guidance Document "The Micro-Purge Sampling Option." Purging procedures to be used are as follows:

1. Attach discharge elbow and connect air supply tubing from the controller to the pump.
2. Connect air tubing from the compressor to the controller. Take care to avoid the entrapment of air in the pump tubing.
3. Start the compressor and adjust the controller until desired flow rate is achieved.
4. Monitor indicator parameters and water level until stability is achieved.

Purging will be completed at a flow rate in the range of 150 to 500 ml/min; flow rate will be adjusted to attempt to limit drawdown to 4-inches (0.33 feet) or less. Indicator parameters and water level will be measured on nominal 5 minute intervals during purging. Indicator parameters will be measured using a closed flow-through cell. Well will be considered purged when stability of the indicator parameter identified in the table below achieved for three consecutive readings.

Table 5-1 Purging Stability Indicator Parameter Requirements

Parameter	Required Stability
Temperature	+/- 3%
pH	+/- 0.1 pH unit
Conductivity	+/- 3%
Dissolved Oxygen	+/- 10% or 0.2 mg/L, whichever is greater
Eh or ORP	+/- 20 mV

Following achievement of stability, tubing will be removed from flow through cell and sample containers filled using pump tubing.

5.2.2.3 Field Filtering

The fraction of the samples to be analyzed for metals will be field filtered using in-line, capsule, 0.45 micron disposable filters. If necessary, to avoid rapid plugging of the small pore filters, a series of in-line filters may be used concluding with the 0.45 micron filter.

When sampling the monitoring wells, the bladder pumps will be used to move water through the filter. When sampling the other devices, water will be placed in clean, unpreserved, sample container; from there a peristaltic pump will be used to move the water from the container, through the filter, and into the sample container.

5.2.3 Field Data

Data associate with the field sampling will be recorded on a form at the time of sample collection. A sample form is included as Figure 3 of Appendix C. Field analysis will be completed concurrently with purging or sample collection as noted in Paragraph 5.2.2.

The following analysis will be completed in the field using portable equipment:

- Specific conductance,
- pH,
- Temperature
- Turbidity

5.2.4 Sample Containers

5.2.4.1 Preservatives

Sample containers will be provided by the analytical laboratory to perform the chemical analysis. All containers will be new or pre-cleaned by the laboratory. The laboratory personnel will place appropriate preservative in the appropriate containers prior to containers being provided to sampling personnel.

Containers will not be overfilled or filled in a manner which "washes" the preservative from the containers during filling. Preservation will be as identified on Figure 4 of Appendix C.

5.2.4.2 Sample Labeling

All sample containers will be labeled. Labels will include, at a minimum:

- Site ID
- Well ID
- Date/Time of Collection
- Preservative

5.2.5 Cross Contamination

5.2.5.1 Equipment Decontamination

Dedicated sampling pumps are (will be) be installed in each well. In the event of pump failure, new pumps will be installed. Pumps will not be switched between wells.

New, disposable, filters and tubing will be used for the sampling of each well. Filters and tubing will not be re-used.

Field equipment which is used in multiple wells, such as the water level meter, will be decontaminated immediately prior to use in each well. Decontamination will include a phosphate free detergent wash followed by a distilled water rise.

Personnel completing sample collection will wear disposable Nitrile (or similar) gloves. A new pair of gloves will be donned immediately prior to sampling/purging each well.

5.2.5.2 Sampling Sequence

Up-gradient wells will be sampled prior to down-gradient wells. If any of the down-gradient wells are suspected of containing facility impacted waters, those wells will be sampled last. The sampling sequence will be determined in advance of field work based on the results of the previous sampling event.

5.3 Quality Assurance Program

5.3.1 Equipment Calibration and Operation

Specific equipment manufacturers are not identified herein, so that alternate types of equipment can be utilized for sampling and analysis. This flexibility allows for alternate types of equipment to be used in the event of malfunction, or purchase of more efficient and/or advanced equipment. All sampling and analysis equipment will be operated and maintained in accordance with the manufacturer's recommendations. Equipment used for field analysis will be calibrated in accordance with the manufacturer's recommendations prior to each sampling event.

5.3.2 *Field Duplicates*

Field duplicate samples will be collected during each sampling event. Duplicate samples will represent not less than 5% of the samples analyzed by the laboratory. The field duplicate sample(s) will be collected from the wells simultaneously with the primary sample. The duplicate samples will be analyzed for all constituents analyzed in the primary samples.

5.3.3 *Laboratory*

A National Environmental Laboratory Accreditation Program (NELAP) certified laboratory will perform the analysis. General testing and reporting requirements include the following:

- Samples which exceed holding times will not be analyzed.
- All instrumental, sample preparatory, and QA/QC procedures used must be in accordance with the analytical test method.
- Quality Control samples will be analyzed which may include (depending on method):
    - Initial calibration,
    - Initial calibration verification.
    - Continuing calibration verification
    - Method blanks
    - Serial dilution
    - Interference check samples
    - Initial continuing calibration blanks,
    - Matrix Spike/Matrix Spike Duplicates, or
    - Laboratory control samples.
- Analytical Reports are to included, at a minimum:
    - Sample ID
    - Lab ID
    - Sample collection date
    - Sample received date
    - Analysis date
    - Analyst
    - Result
    - Detection limit
    - Practical quantification limit
    - Sample digestion or extraction method
    - Analysis method
    - QA/QC results
    - Discussion of any non-conforming QA/QC result
    - Chain of Custody

5.4 Sample Preservation and Shipment

After collection, the samples will be immediately placed on ice in coolers. Samples will be hand delivered or shipped by third party courier under chain-of-custody record to a NELAP accredited environmental laboratory for analysis. Samples will be transported to the laboratory as soon as practical and any samples held overnight will be stored in a secure location.

5.5 Chain of Custody

Field personnel are responsible for the custody of the samples until custody is transferred. Property chain of custody documentation will be maintained for the ground water samples. The Chain of Custody form will be signed by the person collecting the samples and all subsequent persons who take possession of the samples. At a minimum, the Chain of Custody will contain:

- Date and time of sample collection,
- Sample identification,
- Number of containers per sample,
- Preservatives used,
- Required sample analysis,
- Name of person collecting the samples,
- Date and time of custody transfer, and
- Signatures of sample custodians

5.6 Analysis

The samples will be sent to a third-party testing laboratory for analysis. All analyses will be performed in accordance with the appropriate EPA SW-846 methods or appropriate EPA "Methods for Chemical Analysis of Water and Waste" (EPA 600/4-79-020). Analyses will be completed within the applicable holding times. Analytical testing methods and holding times are listed on Figure 4 of Appendix C

5.7 Reporting

A report will be prepared for each sampling event. The reports will be submitted to IDEM within 60 days of sample collection. The reports will contain, at a minimum:

- Narrative discussion of the sampling event and results,
- Discussion of any problems with the wells including planned or completed maintenance/repairs,
- Discussion of results of Duplicate sample,
- Water level measurements,
- Ground water flow map,
- Summary of analytical results.
- Sampling field data sheets,
- Chain of Custody Record,
- Laboratory Reports of analytical testing,
- Statistical Evaluation Results,
- Data for any wells installed or abandoned since previous sampling event.

6.0 Implementation and Duration of Monitoring

6.1 Initial Implementation

This Plan will be implemented immediately upon IDEM approval of this Plan.

6.2 Sampling Frequency

6.2.1 Schedule

Phase I monitoring will include collection of ground water samples on a semi-annual basis. Sampling events will occur in April and October of each year so that normally high and normally low ground water level conditions will be represented.

6.2.2 Existing Wells

Semi-annual sampling of the existing Phase I wells identified for sampling in Table 4-1 will begin upon approval of this Plan. The first sampling event will occur within 6-months of the approval of this Plan.

6.2.3 New Wells

The proposed wells identified in Table 4-1 of this Plan, and any additional Phase I wells installed in the future, will be sampled on a quarterly basis for two years following well installation (8 quarterly sampling events). Statistical evaluation of the water quality data from the new wells will not be performed as part of the quarterly sampling events. Semi-annual sampling, including statistical evaluation, will begin with the first semi-annual sampling event completed after the 8 quarterly sampling events.

Quarterly sampling will be completed in January, April, July, and October. Results of the events between the normal semi-annual sampling events will be submitted with the results of the subsequent semi-annual sampling events (January events will be reported with April results, and July events will be reported with October results).

6.3 Termination & Suspension

Unless superseded by a Phase II Ground Water Monitoring Plan or Corrective Action Program, sampling and analysis in accordance with this Phase I Plan will continue through the Post-Closure Care period of the Fly Ash Pond. It is possible that portions of the monitoring system will be monitored under this Phase I Plan while other portions of the system are monitored under a Phase II Plan or a Corrective Actions Program.

6.4 Plan Modifications

Any modifications to this Plan will be approved by IDEM prior to implementing the modification.

7.0 Preoperational Conditions

Installation and development of the proposed monitoring wells identified in Table 4-1 will occur within 4 months of IDEM approval of this Plan. IDEM will be notified both in advance of well installation and again after the wells have been installed and developed. The first sampling event report (see Paragraph 5.7) submitted after well installation will include the following information for the newly installed wells:

- Installation dates
- Boring logs,
- Well completion diagrams,
- Development data,
- Decontamination procedures, and
- Surveyed locations (both coordinates and map).

8.0 Determining Increases Over Background

A statistical evaluation will be completed on ground water quality data as part of each semi-annual sampling event, except as noted herein. The evaluation will attempt to determine if there is a statistically significant increase in the down-gradient wells when compared to background water quality data obtained from up-gradient or background wells (inter-well comparisons).

A Statistical Evaluation Plan (StEP) will be submitted to IDEM for review and comment as part of the Sampling Event Report where the 8th quarterly sampling data for the proposed monitoring wells identified in Table 4-1 are submitted. The SteP will be a separate stand-along document which will be implemented upon approval of by IDEM. Statistical evaluation will begin as part of the first semi-annual sampling event completed after IDEM approval of the StEP.

The statistical evaluation will:

- Compare each individual down-gradient well to background, and
- Use a 95% level of confidence.

The specific statistical method used will be based on the nature of the data. However, one of the following will be used:

- Mann-Whitney U-test,
- Student's T-Test,
- Temporal or spatial trend analysis, or
- Other methods identified in USEPA Document 530-R-09-007, March 2009 (Statistical evaluation of Ground-Water Monitoring Data at RCRA Facilities) which are appropriate based on the data distribution and provides a reasonable balance between the probability of falsely identifying significance against the probability of failing to identify significance.

The statistical evaluation will be completed for select parameters as specified in Paragraph 9.1 of this Plan.

9.0 Phase I Monitoring Program

9.1 Monitoring Parameters

Phase 1 monitoring will include chemical analysis for the parameters identified during in Table 9-1. In the event that a parameter is non-detect for eight sampling events and if there is no history of maximum contaminate level exceedance, the Owner may request or IDEM may direct, that individual parameters be deleted from the monitoring program.

Table 9-1 Phase 1 Monitoring Parameters

Parameter	Statistical evaluation	Parameter	Statistical evaluation
Field Measured Parameters		**Other Parameters (continued)**	
Temperature	No	Copper	No
pH	No	Cyanide	No
Specific Conductance	No	Fluoride	No
Turbidity	No	Iron	No
Statistical Evaluation Parameters		Lead	No
Boron	Yes	Lithium	No
Calcium	Yes	Magnesium	No
Molybdenum	Yes	Manganese	No
Potassium	Yes	Mercury	No
Sodium	Yes	Nickel	No
Strontium	Yes	Nitrate as nitrogen	No
Sulfate	Yes	Phosphate	No
Other Parameters		Selenium	No
Aluminum	No	Silica	No
Antimony	No	Silver	No
Arsenic	No	Sulfide	No
Bicarbonate alkalinity	no	Thallium	No
Barium	No	Total Dissolved Solids	No
Beryllium	No	Total Hardness (as $CaCO_3$)	No
Cadmium	No	Radium 226 and 228 combined	No
Chloride	No	Uranium	No
Chromium (all valence states)	No	Vanadium	No
Cobalt	No	Zinc	No

9.2 Statistical Increases

For the purposed of this Plan, a Statistical Exceedance is defined as a statistically significant increase in an individual down-gradient well for 2 or more parameters during the same sampling event. The statistically significant increase will be determined based on the statistical evaluation methods described in Section 8.0 of this Plan. In the event that a Statistical Exceedance occurs, the activities identified on Figure 1 of Appendix C will be implemented.

If a Statistical Exceedance occurs, the affected well(s) will be re-sampled to verify the reliability of the results which caused the exceedance. Sampling procedures for the re-sample will be as per the applicable sampling procedures described in this Plan. The re-sample will be analyzed for:

- Field Measured parameters identified in Table 9.1,
- Statistical Analysis parameters identified in Table 9.1, and
- Ground Water Quality Standard parameters identified in Table 13-1.

The re-sample result for the parameters which caused the exceedance will be compared to the original sample results to verify reliability of the original testing. The procedures to be used to verify the reliability will be as described in the Statistical Evaluation Plan (see Section 8.0).

In the event the activities identified on Figure 1 of Appendix C do not allow a return to Phase I monitoring, the affected well(s) will be placed in a Phase II Detection Monitoring (see Section 10.0)

10.0 Phase II Monitoring Program

Phase II Detection Monitoring will be implemented in the event that the a Statistical Exceedance as defined in Paragraph 9.2 occurs and the subsequent activities described in Paragraph 9.2 do not allow a return to Phase I Monitoring. In the event Phase II Detection Monitoring is required, a separate Phase II Ground Water Detection Monitoring Plan will be developed and submitted to IDEM for approval. The Phase II Plan will address the following alternate procedures, as needed:

- Sampling frequency,
- Sampling protocols
- Analysis parameters,
- Statistical evaluation methods,
- Statistical evaluation parameters, and
- Other appropriate activities.

Phase II monitoring will continue until results over a one year period do not show a Statistically Exceedance in the parameters monitored under the Phase II Plan.

11.0 Increase Not Attributable to Landfill

Statistically significant increases can potentially be caused by issues unrelated to the Fly Ash Pond such as, but not necessarily limited to:

- Sampling error,
- Analysis error, and
- Sources other than the Fly Ash Pond.

If a Statistical Exceedance, as defined in Paragraph 9.2 of this plan occurs, and a potential exists that the cause of the increase may be something other than the Fly Ash Pond, an Alternate Source Demonstration may be prepared and submitted. The timing and conditions related to preparation of an Alternate Source Demonstration are outlined on Figure I of Appendix C. Phase 1 Monitoring will continue uninterrupted while the Alternate Source Demonstration is being prepared. Initiation of Phase II monitoring as described in Section 10 will be deferred until IDEM has reviewed the Alternate Source Demonstration. If the Alternate Source Demonstration is accepted, monitoring will remain in Phase I.

12.0 Corrective Action Program

A corrective Action Program will be developed in the event the concentrations of the parameters identified in Section 13 of this Plan are detected in a down-gradient well(s) at the higher of, either:

- Fly Ash Pond background concentrations in conjunction with a Statistical Exceedance as defined in Paragraph 9.2, or
- Maximum Contaminant Levels.

The Corrective Action Program will comply with Phase II monitoring requirements with the objectives of:

- Determining the areal extent of the contaminant plume for the exceeding parameter(s).
- Demonstrating the effectiveness of the Corrective Action Program.

The intent of the Program will be to:

- Prevent further migration of all constituents that exceed the ground water protection standard
- Minimize any increase in the concentrations of all constituents specified in the ground water protection standard.

Specific actions to be taken under the Corrective Actions Program will be defined when and if a Program is needed.

13.0 Ground Water Quality Standard

Parameters which will be monitored for the potential need for corrective actions are listed in the table below.

Table 13-1 Corrective Actions Triggering Parameters

Parameter	MCL (mg/l)
Arsenic	0.006
Barium	2.0
Cadmium	0.005
Chromium	0.1
Lead	0.015
Mercury	0.002
Nitrate (as nitrogen)	10
Selenium	0.05

Appendices

Appendix A – Maps and Summaries

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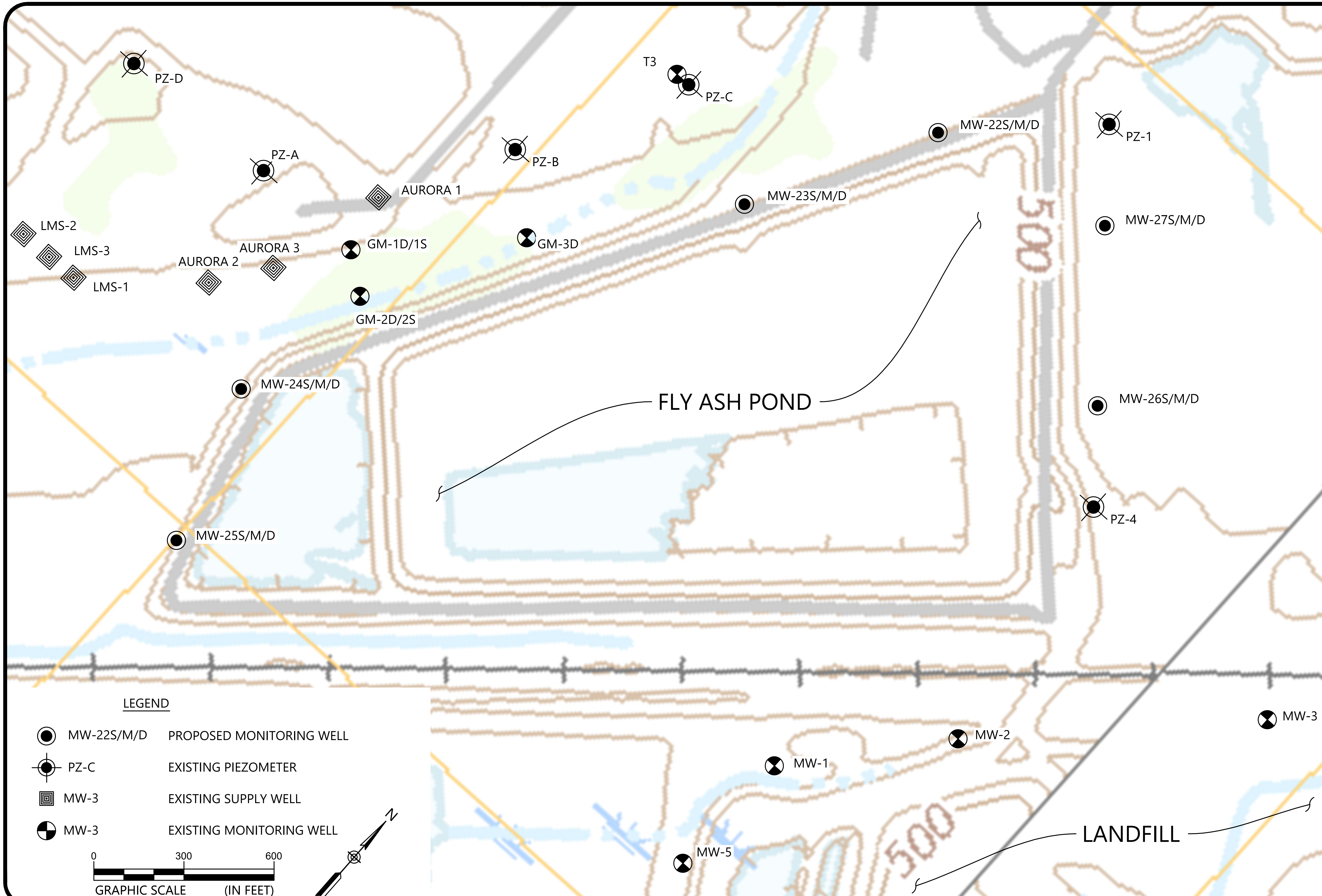

WELL LOCATION MAP

FLY ASH POND GROUND WATER MONITORING
TANNERS CREEK PLANT
LAWRENCEBURG, INDIANA

SCALE:	1" = 300'
DATE:	8/31/2017
PROJECT NUMBER	7217-17-007A
FIGURE NO.	1

Drawing path: Q:\Projects\7217-Civil Columbus\7217-17-007 Tanners Creek\A FA Pond Closure\DWG\CONSTRUCTION\WELL LOCATION MAP.dwg

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Figure 2
Summary of Ground Water Monitoring Wells
Tanners Creek Power Plant

	Location		Designation			Status	Top of Casing	Bot of Screen	Screen	Aquifer Estimates	
ID	Northing	Easting	FAP	Landfill	MAP		(ft msl)	(ft msl)	Length (feet)	Top (ft msl)	Bot (ft msl)
GM-1D			Dwn-Gradnt			Existing	468.19	403.0	5		
GM-1S			Dwn-Gradnt			Existing	467.93	424.0	5		
GM-2D			Dwn-Gradnt			Existing	464.92	403.8	5		
GM-2S			Dwn-Gradnt			Existing	464.59	422.5	5		
GM-3			Dwn-Gradnt			Existing	466.17	403.0	5		
MW-01	1,394,668.2	552,111.9	Up-Gradnt	Dwn-Gradnt		Existing	466.66	421.6	5.2		
MW-02	1,395,144.7	552,508.2	Up-Gradnt	Dwn-Gradnt		Existing	481.98	426.0	5.2		
MW-03	1,395,876.8	553,233.6	Up-Gradnt	Dwn-Gradnt		Existing	477.27	420.2	5.2		
MW-04	1,395,529.1	553,233.6		Up-Gradnt		Existing	468.83	423.5	5.2		
MW-05	1,394,226.0	552,101.3	Up-Gradnt	Dwn-Gradnt		Existing	464.50	419.0	5.2		
MW-06	1,394,023.8	552,585.0		Up-Gradnt		Existing	469.06	418.2	10.2		
MW-07	1,394,293.1	553,130.6		Up-Gradnt		Existing	471.46	426.6	5.2		
MW-08	1,394,754.3	553,895.4		Up-Gradnt		Existing	468.61	417.8	10.2		
MW-13	1,396,477.5	553,895.4			Dwn-Gradnt	Existing	483.14	406.2	9.5		
MW-14					Dwn-Gradnt	Existing	481.02	416.8			
MW-15				Up-Gradnt	Dwn-Gradnt	Existing	480.69	419.1			
MW-16					Up-Gradnt	Existing	482.46	421.4			
MW-17					Up-Gradnt	Existing	492.70	429.4			
MW-18						Existing	486.54	397.1			
MW-19						Existing	488.17	413.8			
MW-20						Existing	488.75	414.4			
MW-21						Existing	486.50	412.1			
MW-22D	*1,396,600*	*551,110*	*Dwn-Gradnt*			*Proposed*	*488*	*400*	*5*	*440*	*395*
MW-22M	*1,396,600*	*551,110*	*Dwn-Gradnt*			*Proposed*	*488*	*415*	*5*	*440*	*395*
MW-22S	*1,396,600*	*551,110*	*Dwn-Gradnt*			*Proposed*	*488*	*430*	*5 or 10*	*440*	*395*
MW-23D	*1,396,000*	*550,790*	*Dwn-Gradnt*			*Proposed*	*482*	*400*	*5*	*450*	*395*
MW-23M	*1,396,000*	*550,790*	*Dwn-Gradnt*			*Proposed*	*482*	*420*	*5*	*450*	*395*
MW-23S	*1,396,000*	*550,790*	*Dwn-Gradnt*			*Proposed*	*482*	*440*	*5 or 10*	*450*	*395*
MW-24D	*1,394,420*	*549,950*	*Dwn-Gradnt*			*Proposed*	*465*	*400*	*5*	*450*	*395*
MW-24M	*1,394,420*	*549,950*	*Dwn-Gradnt*			*Proposed*	*465*	*420*	*5*	*450*	*395*
MW-24S	*1,394,420*	*549,950*	*Dwn-Gradnt*			*Proposed*	*465*	*440*	*5 or 10*	*450*	*395*
MW-25D	*1,393,900*	*550,130*	*Dwn-Gradnt*			*Proposed*	*479*	*400*	*5*	*460*	*395*
MW-25M	*1,393,900*	*550,130*	*Dwn-Gradnt*			*Proposed*	*479*	*425*	*5*	*460*	*395*
MW-25S	*1,393,900*	*550,130*	*Dwn-Gradnt*			*Proposed*	*479*	*450*	*5 or 10*	*460*	*395*
MW-26D	*1,396,280*	*552,120*	Up-Gradnt			*Proposed*	*469*	*400*	*5*	*445*	*395*
MW-26M	*1,396,280*	*552,120*	Up-Gradnt			*Proposed*	*469*	*415*	*5*	*445*	*395*
MW-26S	*1,396,280*	*552,120*	Up-Gradnt			*Proposed*	*469*	*435*	*5 or 10*	*445*	*395*
MW-27D	*1,396,740*	*551,730*	Up-Gradnt			*Proposed*	*467*	*400*	*5*	*450*	*395*
MW-27M	*1,396,740*	*551,730*	Up-Gradnt			*Proposed*	*467*	*420*	*5*	*450*	*395*
MW-27S	*1,396,740*	*551,730*	Up-Gradnt			*Proposed*	*467*	*440*	*5 or 10*	*450*	*395*
PZ-1			Up-Gradnt			Existing	469.19	400.2			
PZ-2						Existing	469.78	424.8			
PZ-3						Existing	474.77	432.8			
PZ-4			Up-Gradnt	Dwn-Gradnt		Existing	473.54	427.2			

Note: Coordinates System: State Plane (Indiana East), NAD 83, NADV 88

Proposed Wells: Information is approximate
"Top of Casing" is approximate Ground Surface
Well screens shown as 5' or 10': 5' if aquifer confined, 10' if aquifer unconfined
"M" well not to be installed if less than 25' of separation will be present between Top of "D" screen and bottom of "S" screen

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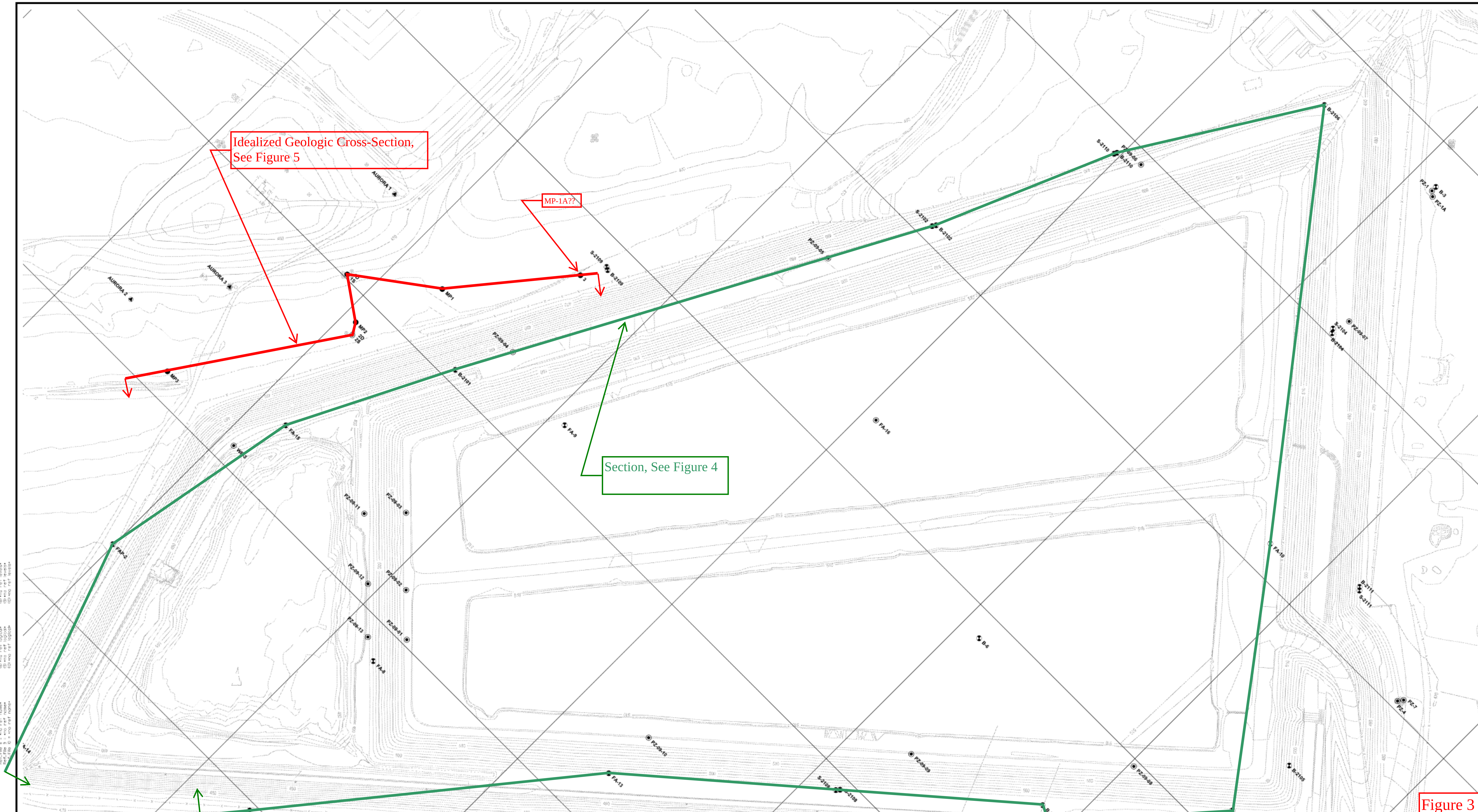


Figure 3

NO.	BY	DATE	REVISION	APP'D.
3.				
2.				
1.				

PROJECT: INDIANA MICHIGAN POWER COMPANY
TANNERS CREEK PLANT
LAWRENCEBURG, INDIANA

SHEET TITLE: FLY ASH POND BORING LOCATIONS

DRAWN BY: lstormer	SCALE:	PROJ. NO. 219466.0000.0000
CHECKED BY: JH		FILE NO. 14-30623.plt
APPROVED BY: MJA	DATE PRINTED:	FIGURE
DATE: FEBRUARY 2015		

TRC
708 Heartland Trail
Suite 3000
Madison, WI 53532
Phone: 608.826.3600

708 Heartland Trail, Suite 3000, Madison, WI 53717 • www.TRCsolutions.com

SHEET ______ OF ______

PROJECT/PROPOSAL/LOCATION NAME: AEP Tanners Creek Ash Pond Closure		PROJECT/PROPOSAL NUMBER: 219466.0000 Phase 3	
SUBJECT: Fly Ash Pond Soil Borings			
PREPARED BY: J. Hetstream / M. Williams	DATE: September 17, 2014 / October 1, 2014	FINAL	☐
CHECKED BY: J. Horstream	DATE: October 17, 2014	REVISION	☐

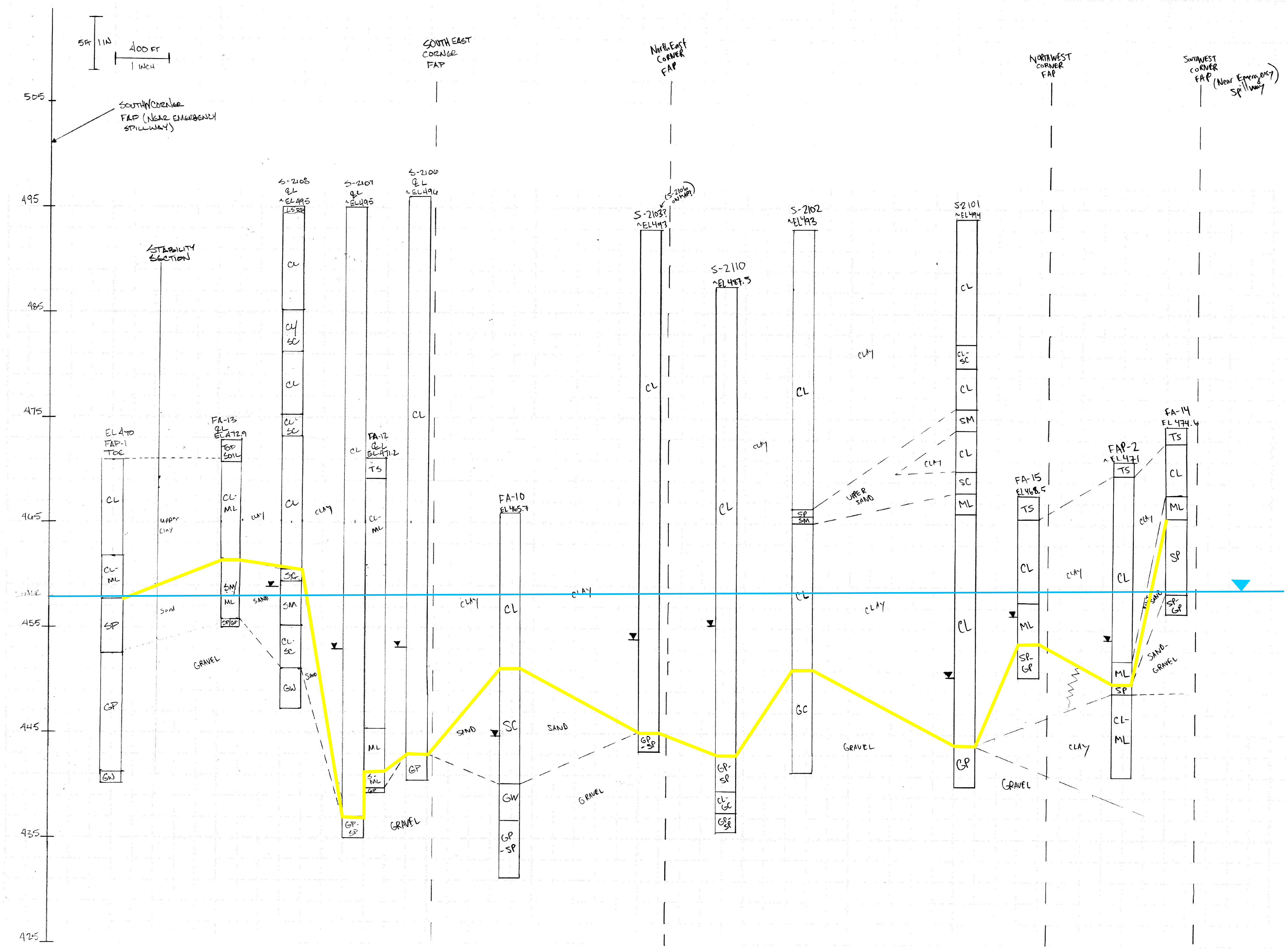
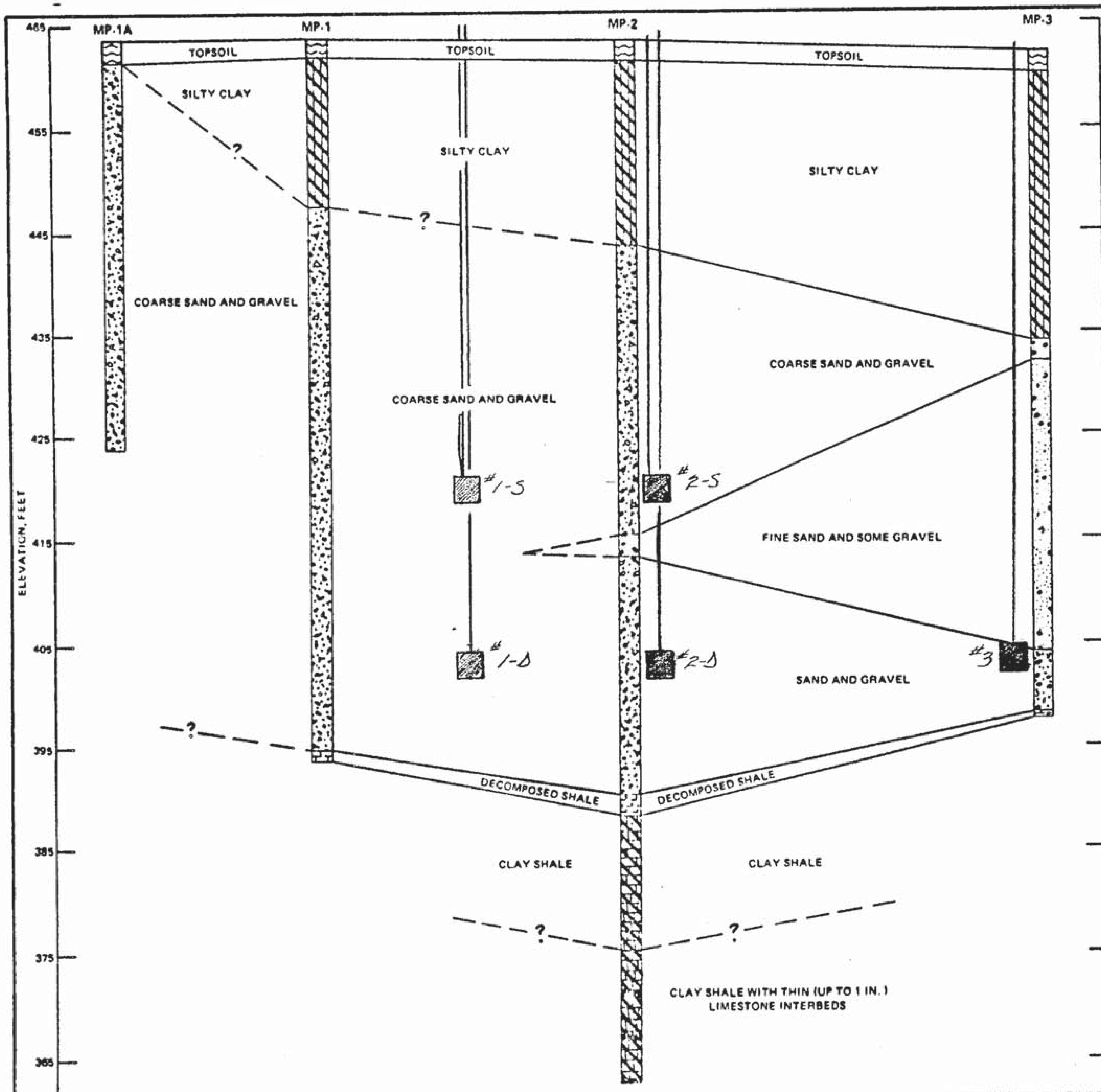


Figure 4

Figure No. 2
Idealized Geologic Cross-Section



SUBSURFACE PROFILE THROUGH MONITORINGS PIEZOMETERS					
WOODWARD-CLYDE CONSULTANTS CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS CLIFTON, NEW JERSEY					
DR. BY: BTD		SCALE: AS SHOWN		PROJ. NO.: 76C011	
CK'D. BY:		DATE: 10 MAY 1976		FIG. NO. 3	

AEPTC001197

Figure 5

AMERICAN ELECTRIC POWER
TANNERS CREEK PLANT FLYASH LANDFILL GROUNDWATER SAMPLING ALLUVIAL AQUIFER
DEARBORN COUNTY
SAMPLED BY: DANIEL ROGERS (FMSM)
DATE/FIELD CONDITIONS: 12-16-08; LIGHT SNOW, 25 DEG F
STATIC WATER LEVELS MEASURED 12-16-08

WELL NO.	NORTHING	EASTING	TOP OF CASING FT. (A)	BOTTOM OF SCREEN FT. (B)	** FEET TO STATIC LEVEL (C)	STATIC WATER LEVEL FT.	*** PURGE WELL AMT (GAL)	ACTUAL AMT. PURGED (GAL)	FIELD pH (S.U.)	FIELD TEMP (DEG C)	FIELD COND (umhos)	FIELD TURBID (NTU)	TIME OF STATIC LEVEL MEAS.	TIME OF SAMPLING	NOTES
MW-1	1394660.22	552111.92	466.66	421.61	12.25	454.41	15.9	21.0	7.48	12.3	680	3.2	1252	1306	clear, no odor
MW-2	1395144.67	552508.15	481.98	424.95	27.36	454.62	14.4	16.0	7.68	12.2	590	0.28	1423	1440	clear, no odor
MW-3	1395876.75	553233.58	477.27	420.23	22.66	454.61	16.8	16.0	7.80	10.8	497	0.85	1610	1621	clear, no odor
MW-4	1395529.14	553913.72	468.83	423.53	12.64	456.19	15.9	16.0	7.39	10.7	630	39.9	1535	1553	clear, no odor
MW-5	1394226.00	552101.25	464.50	418.56	39.00	425.52	3.0	22.0	7.33	10.3	729	92.9	1210	1232	light brown, rotten eggs
MW-6	1394023.84	552584.96	469.06	418.16	13.97	455.09	18.0	21.5	7.07	9.9	775	126	1122	1142	light brown, no odor
MW-7	1394293.05	553130.56	471.46	426.59	15.64	455.82	14.4	20.0	7.29	10.0	700	28.0	923	1024	light brown, rotten, slow recharge
MW-8	1394754.32	553895.38	468.61	417.76	12.93	455.68	18.6	17.0	7.76	10.5	499	3.11	1505	1523	clear, mild rotten egg odor

**STATIC LEVELS ARE TO BE TAKEN ON EACH WELL AT EVERY SAMPLING EVENT ON THE SAME DAY AND AS CLOSE IN TIME AS POSSIBLE PRIOR TO THE PURGING AND SAMPLING EVENT

***[(TOP OF CASING - FEET TO STATIC LEVEL) - BOTTOM OF SCREEN] X 0.163 X3 = PURGE WELL AMT.

RECEIVED

Figure 6

GENERAL NOTES

OHIO RIVER STAGE 459.3 MEASURED 2/21/08 GROUNDWATER FLOW DIRECTIONS WILL LIKELY CHANGE DEPENDANT ON THE ELEVATION OF THE OHIO RIVER AND LMS/AURORA WELLFIELD DRAW DOWN. THEREFORE, WHETHER A WELL IS UPGRADIENT OR DOWN GRADIENT WILL DEPEND ON THE ELEVATION OF THE OHIO RIVER AND WELLFIELD DRAW DOWN ON THE DATE OF SAMPLING

THIS MAPPING CAME FROM INDIANA UNIVERSITY SPATIAL DATA PORTAL FOR 2005 TOPOGRAPHIC ELEVATIONS HTTP://WWW.INDIANA.EDU/~GISDATA/

LEGEND

x509.5 SPOT ELEVATION
INTERMEDIATE CONTOUR
—500— INDEX CONTOUR
DEPRESSION CONTOUR
TREES AND TREELINE
STRUCTURE AND BUILDING
FENCE
POLE
ROADS
EDGE OF WATER
MANHOLES / CATCH BASIN
POWER POLE
PIPES
TOWER
PIEZOMETER
MONITORING WELL
AURORA SUPPLY WELL
BENCHMARK
—458.5— POTENTIOMETRIC CONTOUR
DIRECTION OF GROUND FLOW
FACILITY BOUNDARY
WASTE BOUNDARY

REFERENCE DRAWINGS

14-30205 FLY ASH LANDFILL- BORING LAYOUT

DATE	NO.	DESCRIPTION	APPD.
2/3/2009	G	ADDED WELLS LMW2, LMW1, LSMW1, PZ1, PZ2. STATIC WATER LEVEL MEASURED ON DEC. 16, 2008.	PJA
12/15/08	F	STATIC WATER LEVEL MEASURED ON OCT. 28, 2008	PJA
10/27/08	E	STATIC WATER LEVEL MEASURED ON AUG. 26, 2008	PJA
10/26/08	D	STATIC WATER LEVEL MEASURED ON JUNE 17, 2008	PJA
10/25/08	C	STATIC WATER LEVEL MEASURED ON APRIL 24, 2008	PJA
10/24/08	B	STATIC WATER LEVEL MEASURED ON FEB. 20, 2008	PJA
10/23/08	A	ISSUED FOR PERMIT STATIC WATER LEVEL MEASURED ON DEC. 20, 2007	PJA

REVISIONS

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INDIANA MICHIGAN POWER

TANNERS CREEK PLANT

LAWRENCEBURG INDIANA

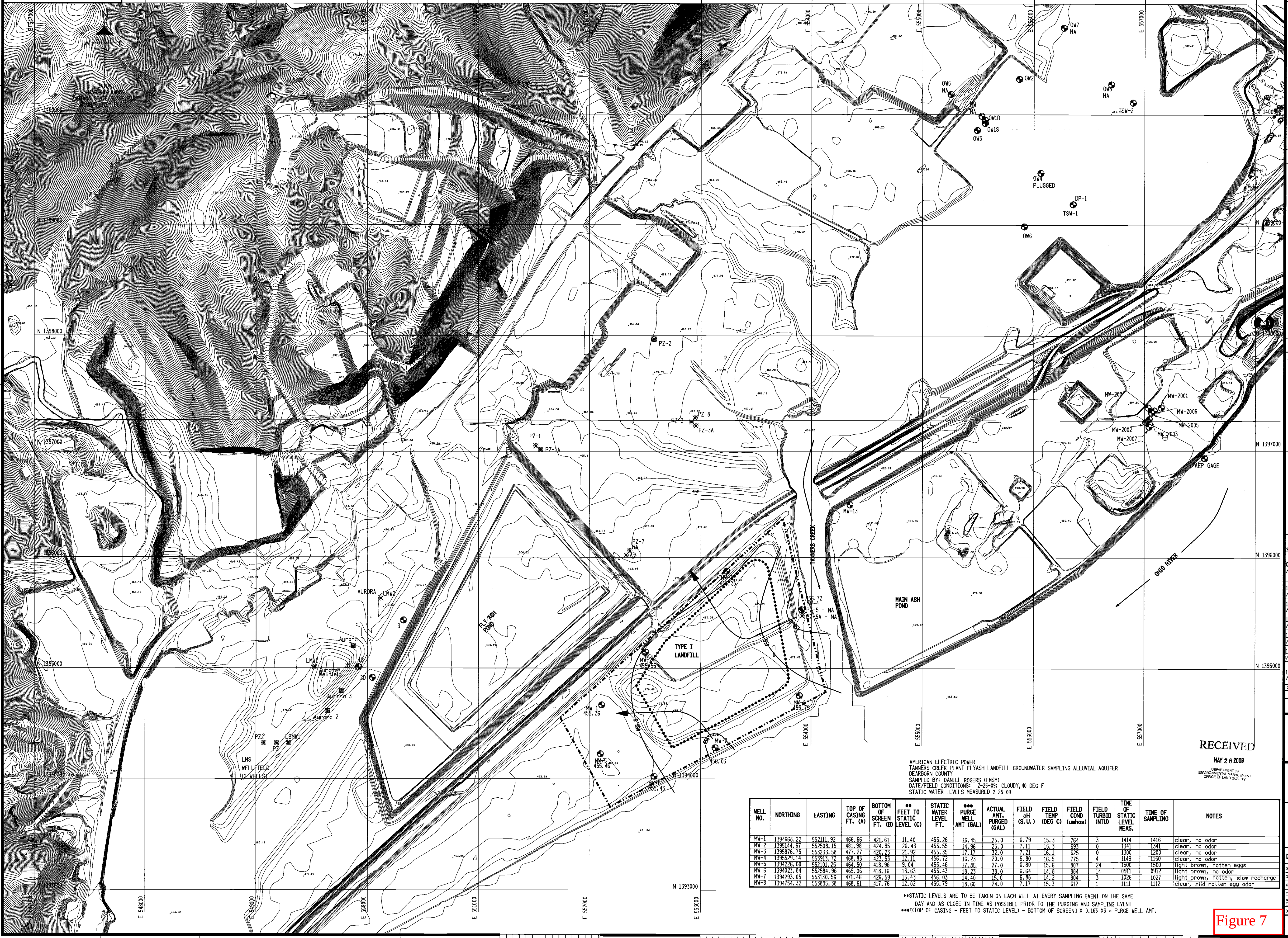
POTENTIOMETRIC MAP

2008 December

DWG. NO. 14-30251-G

SCALE: 1" = 300'
CIVIL ENGINEERING
APPROVED BY Thomas R. Zelina
DATE: 10/23/08

AMERICAN ELECTRIC POWER
AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215



GENERAL NOTES

OHIO RIVER STAGE 459.3 MEASURED 2/21/08
GROUNDWATER FLOW DIRECTIONS WILL LIKELY CHANGE DEPENDANT ON THE ELEVATION OF THE OHIO RIVER AND LMS/AURORA WELLFIELD DRAW DOWN. THEREFORE, WHETHER A WELL IS UPGRADIENT OR DOWN GRADIENT WILL DEPEND ON THE ELEVATION OF THE OHIO RIVER AND WELLFIELD DRAW DOWN ON THE DATE OF SAMPLING

THIS MAPPING CAME FROM INDIANA UNIVERSITY SPATIAL DATA PORTAL FOR 2005 TOPOGRAPHIC ELEVATIONS
HTTP://WWW.INDIANA.EDU/~GISDATA/

LEGEND

- x509.5 SPOT ELEVATION
- INTERMEDIATE CONTOUR
- 500 INDEX CONTOUR
- DEPRESSION CONTOUR
- TREES AND TREELINE
- STRUCTURE AND BUILDING
- FENCE
- POLE
- ROADS
- EDGE OF WATER
- MANHOLES / CATCH BASIN
- POWER POLE
- PIPES
- TOWER
- PIEZOMETER
- MONITORING WELL
- AURORA SUPPLY WELL
- BENCHMARK
- 458.5 POTENTIOMETRIC CONTOUR
- DIRECTION OF GROUND FLOW
- FACILITY BOUNDARY
- WASTE BOUNDARY

REFERENCE DRAWINGS

14-30205 FLY ASH LANDFILL- BORING LAYOUT

AMERICAN ELECTRIC POWER
TANNERS CREEK PLANT FLYASH LANDFILL GROUNDWATER SAMPLING ALLUVIAL AQUIFER
DEARBORN COUNTY
SAMPLED BY: DANIEL ROGERS (FMSM)
DATE/FIELD CONDITIONS: 2-25-09; CLOUDY, 40 DEG F
STATIC WATER LEVELS MEASURED 2-25-09

WELL NO.	NORTHING	EASTING	TOP OF CASING FT. (A)	BOTTOM OF SCREEN FT. (B)	** FEET TO STATIC LEVEL (C)	STATIC WATER LEVEL FT.	*** PURGE WELL AMT (GAL)	ACTUAL AMT. PURGED (GAL)	FIELD pH (S.U.)	FIELD TEMP (DEG C)	FIELD COND (umhos)	FIELD TURBID (NTU)	TIME OF STATIC LEVEL MEAS.	TIME OF SAMPLING	NOTES
MW-1	1394668.22	552111.92	466.66	421.61	11.40	455.26	16.45	25.0	6.79	15.3	764	3	1414	1416	clear, no odor
MW-2	1395144.67	552508.15	481.98	424.95	26.43	455.55	14.96	25.0	7.11	15.3	693	0	1341	1341	clear, no odor
MW-3	1395876.75	553233.58	477.27	420.23	21.92	455.35	17.17	32.0	7.21	16.1	625	0	1300	1200	clear, no odor
MW-4	1395529.14	553913.72	468.83	423.53	12.11	456.72	16.23	20.0	6.80	16.5	775	4	1149	1150	clear, no odor
MW-5	1394226.00	552101.25	464.50	418.96	9.04	455.46	17.85	27.0	6.80	15.6	807	24	1500	1500	light brown, rotten eggs
MW-6	1394023.84	552584.96	469.06	418.16	13.63	455.43	18.23	38.0	6.64	14.8	884	14	0911	0912	light brown, no odor
MW-7	1394293.05	553130.56	471.46	426.59	15.43	456.03	14.40	15.0	6.88	14.2	804	3	1026	1027	light brown, rotten, slow recharge
MW-8	1394754.32	553895.38	468.61	417.76	12.82	455.79	18.60	24.0	7.17	15.3	612	1	1111	1112	clear, mild rotten egg odor

**STATIC LEVELS ARE TO BE TAKEN ON EACH WELL AT EVERY SAMPLING EVENT ON THE SAME DAY AND AS CLOSE IN TIME AS POSSIBLE PRIOR TO THE PURGING AND SAMPLING EVENT
***[(TOP OF CASING - FEET TO STATIC LEVEL) - BOTTOM OF SCREEN] X 0.163 X3 = PURGE WELL AMT.

REVISIONS

DATE	NO.	DESCRIPTION	APPD.
04/14/09	H	STATIC WATER LEVEL MEASURED ON FEB. 25, 2009	PJA
02/03/09	G	ADDED WELLS LMW2, LMW1, LSMW1, PZ1, PZ2. STATIC WATER LEVEL MEASURED ON DEC. 16, 2008.	PJA
12/15/08	F	STATIC WATER LEVEL MEASURED ON OCT. 28, 2008	PJA
10/27/08	E	STATIC WATER LEVEL MEASURED ON AUG. 26, 2008	PJA
10/26/08	D	STATIC WATER LEVEL MEASURED ON JUNE 17, 2008	PJA
10/25/08	C	STATIC WATER LEVEL MEASURED ON APRIL 24, 2008	PJA
10/24/08	B	STATIC WATER LEVEL MEASURED ON FEB. 20, 2008	PJA
10/23/08	A	ISSUED FOR PERMIT STATIC WATER LEVEL MEASURED ON DEC. 20, 2007	PJA

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INDIANA MICHIGAN POWER
TANNERS CREEK PLANT
LAWRENCEBURG INDIANA

POTENTIOMETRIC MAP
2009 February

DWG. NO. 14-30251-H

SCALE: 1" = 300'
DR: Amanda Graphics
CH: DMS
ENGR: JMN
PROJ ENGR: JMN
DATE: 10/23/08

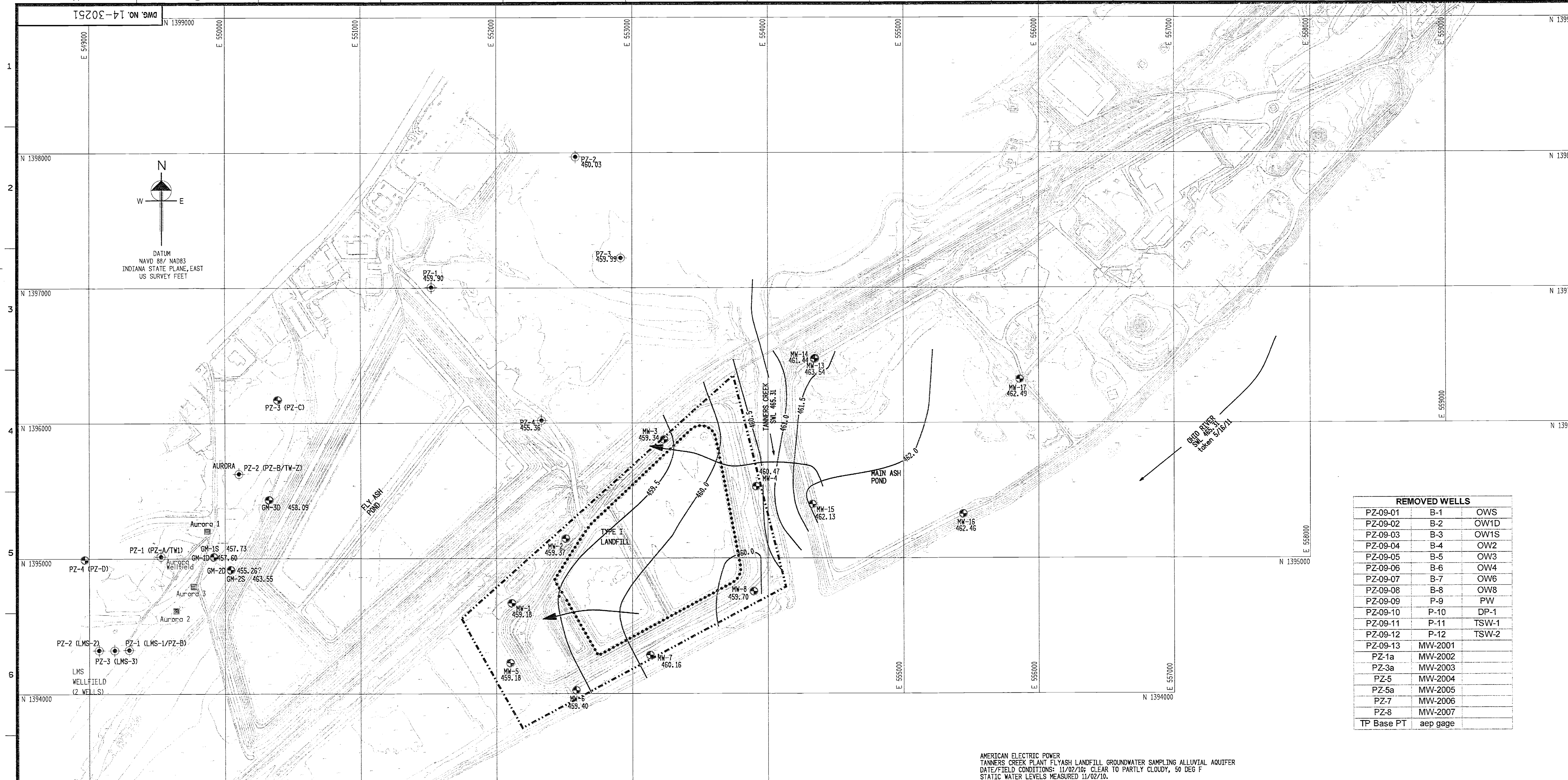
CIVIL ENGINEERING
APPROVED BY Thomas R Zelina

Figure 7

AMERICAN ELECTRIC POWER
AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

SYSTEM DATE-4/14/2009
SYSTEM TIME-9:00:54 AM

DWG. NO. 14-30251



REMOVED WELLS		
PZ-09-01	B-1	OWS
PZ-09-02	B-2	OW1D
PZ-09-03	B-3	OW1S
PZ-09-04	B-4	OW2
PZ-09-05	B-5	OW3
PZ-09-06	B-6	OW4
PZ-09-07	B-7	OW6
PZ-09-08	B-8	OW8
PZ-09-09	P-9	PW
PZ-09-10	P-10	DP-1
PZ-09-11	P-11	TSW-1
PZ-09-12	P-12	TSW-2
PZ-09-13	MW-2001	
PZ-1a	MW-2002	
PZ-3a	MW-2003	
PZ-5	MW-2004	
PZ-5a	MW-2005	
PZ-7	MW-2006	
PZ-8	MW-2007	
TP Base PT	aep gage	

AMERICAN ELECTRIC POWER
TANNERS CREEK PLANT FLYASH LANDFILL GROUNDWATER SAMPLING ALLUVIAL AQUIFER
DATE/FIELD CONDITIONS: 11/02/10; CLEAR TO PARTLY CLOUDY, 50 DEG F
STATIC WATER LEVELS MEASURED 11/02/10.
MW-13 THRU MW-14 STATIC WATER LEVELS TAKEN FROM PLANT DATA 10/28/10.

WELL NO.	TOP OF CASING (FT)	BOTTOM OF SCREEN (FT)	FEET TO STATIC LEVEL (FT)	STATIC WATER LEVEL (FT)	PURGE WELL AMOUNT (GAL)	ACTUAL AMOUNT PURGED (GAL)	FIELD PH (S.U.)	FIELD TEMP (DEG C)	FIELD COND (UHMOS)	FIELD TURBID (NTU)	TIME OF STATIC LEVEL MEAS.	TIME OF SAMPLING	NOTES
DATE: 5-17-11 & 5-18-11													
MW-1	466.66	421.61	7.48	459.18	18.4	15	7.66	14.0	354	101	1045	1100	Brown in color
MW-2	481.98	424.95	22.61	459.37	16.8	15	7.42	14.4	639	0.35	0845	0900	Clear
MW-3	477.27	420.23	17.93	459.34	19.1	10	7.40	14.3	598	0.29	1000	1010	Clear
MW-4	468.83	423.53	8.36	460.47	18.1	10	7.57	14.8	333	15.8	1040	1100	Clear
MW-5	464.50	418.96	5.32	459.18	19.7	30	7.47	14.5	379	205	0945	1010	Brown in color
MW-6	469.06	418.16	9.66	459.4	20.2	15	6.93	14.4	723	57	1520	1545	Clear
MW-7	471.46	426.59	11.30	460.16	16.4	4	7.16	13.8	491	>1000	1145	1455	Silty and brown in color
MW-8	468.61	417.76	8.91	459.70	20.5	15	7.53	14.1	330	41.3	1420	1440	Clear
DATE: 5-23-11													
MW-13	483.14	406.23	19.60	463.54	28.0	15.3	7.97	18.5	517	12	1215	1245	Clear
MW-14	481.02	416.77	19.58	461.44	21.8	13.8	7.90	18.2	522	10	1255	1315	Clear
MW-15	480.69	419.07	18.56	462.13	21.1	16.1	7.79	16.4	533	18	1340	1400	Clear
MW-16	482.46	421.42	20.00	462.46	20.1	15.3	7.90	17.9	468	17	1525	1545	Clear
MW-17	492.70	429.35	30.21	462.49	16.2	16.8	7.37	20.5	555	>1000	1555	1615	Silty and brown in color

**STATIC LEVELS ARE TO BE TAKEN ON EACH WELL AT EVERY SAMPLING EVENT ON THE SAME DAY AND AS CLOSE IN TIME AS POSSIBLE PRIOR TO THE PURGING AND SAMPLING EVENT

***[(TOP OF CASING - FEET TO STATIC LEVEL) - BOTTOM OF SCREEN] X 0.163 X3 = PURGE WELL AMT.

7/22/11
15-12
AI 14850
Dearborn Co.

RECEIVED
JUL 2? 2011

GENERAL NOTES

GROUNDWATER FLOW DIRECTIONS WILL LIKELY CHANGE DEPENDANT ON THE ELEVATION OF THE OHIO RIVER AND LMS/AURORA WELLFIELD DRAW DOWN. THEREFORE, WHETHER A WELL IS UPGRADIENT OR DOWN GRADIENT WILL DEPEND ON THE ELEVATION OF THE OHIO RIVER AND WELLFIELD DRAW DOWN ON THE DATE OF SAMPLING

THIS AERIAL PHOTOGRAPH TAKEN 10/29/10.

LEGEND

- x509.5 SPOT ELEVATION
- INTERMEDIATE CONTOUR
- 500 INDEX CONTOUR
- DEPRESSION CONTOUR
- TREES AND TREELINE
- STRUCTURE AND BUILDING
- FENCE
- POLE
- ROADS
- EDGE OF WATER
- MANHOLES / CATCH BASIN
- POWER POLE
- PIPES
- TOWER
- PIEZOMETER
- MONITORING WELL
- AEP STAFF GAGE
- AURORA SUPPLY WELL
- BENCHMARK
- 458.5 POTENTIOMETRIC CONTOUR
- DIRECTION OF GROUND FLOW
- FACILITY BOUNDARY
- WASTE BOUNDARY

REFERENCE DRAWINGS

- 14-30205 FLY ASH LANDFILL- BORING LAYOUT
- 14-30251B MONITORING WELL CONSTRUCTION DETAILS TABLE
- 14-30251C MONITORING WELL LOCATION PLAN

DATE	NO.	DESCRIPTION	APPD.
7/22/2011	M	DELETED PREVIOUS REVISON A-K. ADDED 2010 AERIAL TOPOGRAPHY. TABLE SHOWS REMOVED WELLS. ADDED STATIC WATER LEVEL FOR MW-13 THRU MW-17 MEASURED ON OCT. 28, 2010. LMW1, LMW2, LSMW1, PZ2, PZ, T3, AND T4 HAVE BEEN RENAMED TO MATCH PLANT NUMBERS PZ-1 (PZ-A/TW1), PZ-2 (PZ-B/TW2), PZ-1 (LMS-1/PZ-B), PZ-2 (LMS-2), PZ-3 (LMS-3), PZ-3 (PZ-C), & PZ-4 (PZ-D). STATIC WATER LEVEL MEASURED ON MAY 16, 2011. Amanda Graphics	NFZ
12/15/10	L	STATIC WATER LEVEL MEASURED ON NOV. 02, 2010. EXCLUDES PIEZOMETER READINGS AROUND THE FLY ASH POND. Amanda Graphics	GFZ

REVISIONS

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INDIANA MICHIGAN POWER

TANNERS CREEK PLANT

LAWRENCEBURG INDIANA

POTENTIOMETRIC MAP

2010 November

DWG. NO. 14-30251-M

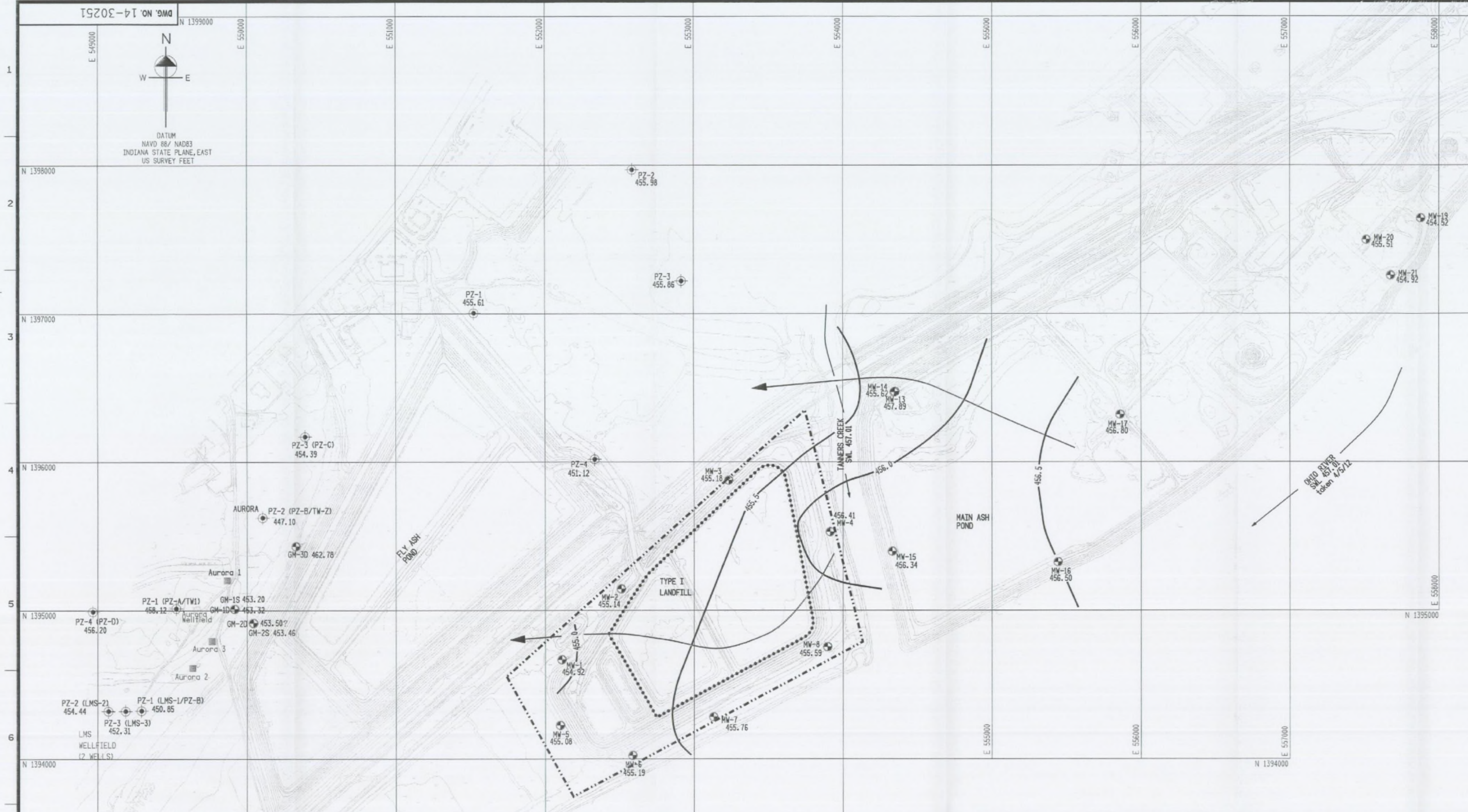
SCALE: 1" = 300'
CIVIL ENGINEERING
DR: Amanda Graphics
CH: DMS
ENGR: JMN
PROJ ENGR: JMN
DATE: 10/23/08
APPROVED BY Thomas R Zelina

Figure 8

AMERICAN ELECTRIC POWER
AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

SYSTEM DATE-7/22/2011
SYSTEM TIME-8:14:13 AM

1512



REMOVED WELLS		
PZ-09-01	B-1	OWS
PZ-09-02	B-2	OW1D
PZ-09-03	B-3	OW1S
PZ-09-04	B-4	OW2
PZ-09-05	B-5	OW3
PZ-09-06	B-6	OW4
PZ-09-07	B-7	OW6
PZ-09-08	B-8	OW8
PZ-09-09	P-9	PW
PZ-09-10	P-10	DP-1
PZ-09-11	P-11	TSW-1
PZ-09-12	P-12	TSW-2
PZ-09-13	MW-2001	
PZ-1a	MW-2002	
PZ-3a	MW-2003	
PZ-5	MW-2004	
PZ-5a	MW-2005	
PZ-7	MW-2006	
PZ-8	MW-2007	
TP Base PT	aep gage	

AMERICAN ELECTRIC POWER
TANNERS CREEK PLANT FLYASH LANDFILL GROUNDWATER SAMPLING ALLUVIAL AQUIFER
DATE/FIELD CONDITIONS: 4/3/12; SUNNY, 78 DEG F
STATIC WATER LEVELS MEASURED 4/3/12.

DATE: 4-3-12 WELL NO.	TOP OF CASING (FT)	BOTTOM OF SCREEN (FT)	FEET TO STATIC LEVEL (FT)	STATIC WATER LEVEL (FT)	PURGE WELL AMOUNT (GAL)	ACTUAL AMOUNT PURGED (GAL)	FIELD PH (S.U.)	FIELD TEMP (DEG C)	FIELD COND (UHMOS)	FIELD TURBID (NTU)	TIME OF STATIC LEVEL MEAS.	TIME OF SAMPLING	NOTES
MW-1	466.66	421.61	11.74	454.92	16.3	40.0	7.16	15.2	881	8.73	1024	1030	Clear
MW-2	481.98	424.95	26.84	455.14	14.8	15.0	7.48	14.8	823	0.5	1103	1125	Clear
MW-3	477.27	420.23	22.09	455.18	17.1	20.0	7.41	15.7	754	0.24	1130	1139	Clear
MW-4	468.83	423.53	12.42	456.41	16.1	20.0	7.13	16.6	880	3.12	1350	1415	Clear
MW-5	464.50	418.96	9.42	455.08	17.7	30.0	7.30	16.2	614	9.6	945	1020	Clear
MW-6	469.06	418.16	13.87	455.19	18.1	35.0	6.80	15.9	1025	9.47	1530	1600	Clear
MW-7	471.46	426.59	15.70	455.76	14.3	5.0	7.21	17.6	715	187	1452	1515	Silty, light olive color
MW-8	468.61	417.76	13.02	455.59	18.5	20.0	7.40	16.0	752	7.91	1425	1442	Clear
DATE: 4-4-12 & 4-5-12													
MW-13	483.14	406.23	25.25	457.89	25.3	36.0	7.63	17.9	518	9.4	1230	1250	Clear
MW-14	481.02	416.77	25.40	455.62	19.0	36.0	7.44	18.2	577	8.8	1135	1210	Clear
MW-15	480.69	419.07	24.35	456.34	18.2	20.0	7.34	16.7	652	7.30	1300	1315	Clear
MW-16	482.46	421.42	25.96	456.50	17.2	20.0	7.80	18.4	561	7.3	1325.0	1335	Clear
MW-17	492.70	429.35	35.90	456.80	13.4	70.0	7.44	21.9	628	9.30	1100	1120	Clear
MW-18	486.54	397.14	33.32	453.22	27.4	70.0	7.58	17.3	405	592.0	1420	1500	Silty
MW-19	488.17	413.77	33.65	454.52	19.9	20.0	7.46	18.7	436	8.70	1510	1520	Silty
MW-20	488.75	414.35	33.24	455.51	20.1	30.0	7.40	23.6	403	9.3	1525	1540	Silty
MW-21	486.5	412.1	31.58	454.92	20.9	35.0	7.44	23.0	418	9.40	1545	1600	Silty

**STATIC LEVELS ARE TO BE TAKEN ON EACH WELL AT EVERY SAMPLING EVENT ON THE SAME DAY AND AS CLOSE IN TIME AS POSSIBLE PRIOR TO THE PURGING AND SAMPLING EVENT

***[(TOP OF CASING - FEET TO STATIC LEVEL) - BOTTOM OF SCREEN] X 0.163 X3 = PURGE WELL AMT.

GENERAL NOTES

GROUNDWATER FLOW DIRECTIONS WILL LIKELY CHANGE DEPENDANT ON THE ELEVATION OF THE OHIO RIVER AND LMS/AURORA WELLFIELD DRAW DOWN. THEREFORE, WHETHER A WELL IS UPGRADIENT OR DOWN GRADIENT WILL DEPEND ON THE ELEVATION OF THE OHIO RIVER AND WELLFIELD DRAW DOWN ON THE DATE OF SAMPLING

THIS AERIAL PHOTOGRAPH TAKEN 10/29/10.

LEGEND

- SPOT ELEVATION
- INTERMEDIATE CONTOUR
- INDEX CONTOUR
- DEPRESSION CONTOUR
- TREES AND TREELINE
- STRUCTURE AND BUILDING
- FENCE
- POLE
- ROADS
- EDGE OF WATER
- MANHOLES / CATCH BASIN
- POWER POLE
- PIPES
- TOWER
- PIEZOMETER
- MONITORING WELL
- AURORA SUPPLY WELL
- 458.5 POTENTIOMETRIC CONTOUR
- DIRECTION OF GROUND FLOW
- FACILITY BOUNDARY
- WASTE BOUNDARY

REFERENCE DRAWINGS

14-30205 FLY ASH LANDFILL- BORING LAYOUT
14-30251A MONITORING WELL LOCATION PLAN
14-30251B MONITORING WELL CONSTRUCTION DETAILS TABLE

DATE	NO.	DESCRIPTION	APPD.
5/30/12	O	STATIC WATER LEVEL MEASURED ON APRIL 2, 2012. ADDED WELLS MW-18 THRU 21.	GFZ
12/15/11	N	STATIC WATER LEVEL MEASURED ON OCT. 3, 2011.	GFZ
07/22/11	M	DELETED PREVIOUS REVISON A-K. ADDED 2010 AERIAL TOPOGRAPHY. TABLE SHOWS REMOVED WELLS. ADDED STATIC WATER LEVEL FOR MW-13 THRU MW-17 MEASURED ON OCT. 28, 2010. LMW1, LMW2, LSMW1, PZ2, PZ, T3, AND T4 HAVE BEEN RENAMED TO MATCH PLANT NUMBERS PZ-1 (PZ-A/TW1), PZ-2 (PZ-B/TW2), PZ-1 (LMS-1/PZ-B), PZ-2 (LMS-2), PZ-3 (LMS-3), PZ-3 (PZ-C), & PZ-4 (PZ-D). STATIC WATER LEVEL MEASURED ON MAY 16, 2011.	GFZ
12/15/10	L	STATIC WATER LEVEL MEASURED ON NOV. 02, 2010. EXCLUDES PIEZOMETER READINGS AROUND THE FLY ASH POND.	GFZ

REVISIONS

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INDIANA MICHIGAN POWER

TANNERS CREEK PLANT

LAWRENCEBURG INDIANA

POTENTIOMETRIC MAP

2012 April

DWG. NO. 14-30251-0

SCALE: 1" = 300'
CIVIL ENGINEERING
DR: Amanda Graphics
CH: DMS
ENGR: JMN
PROJ ENGR: JMN
DATE: 10/21/08
APPROVED BY Thomas R Zelina

15-12

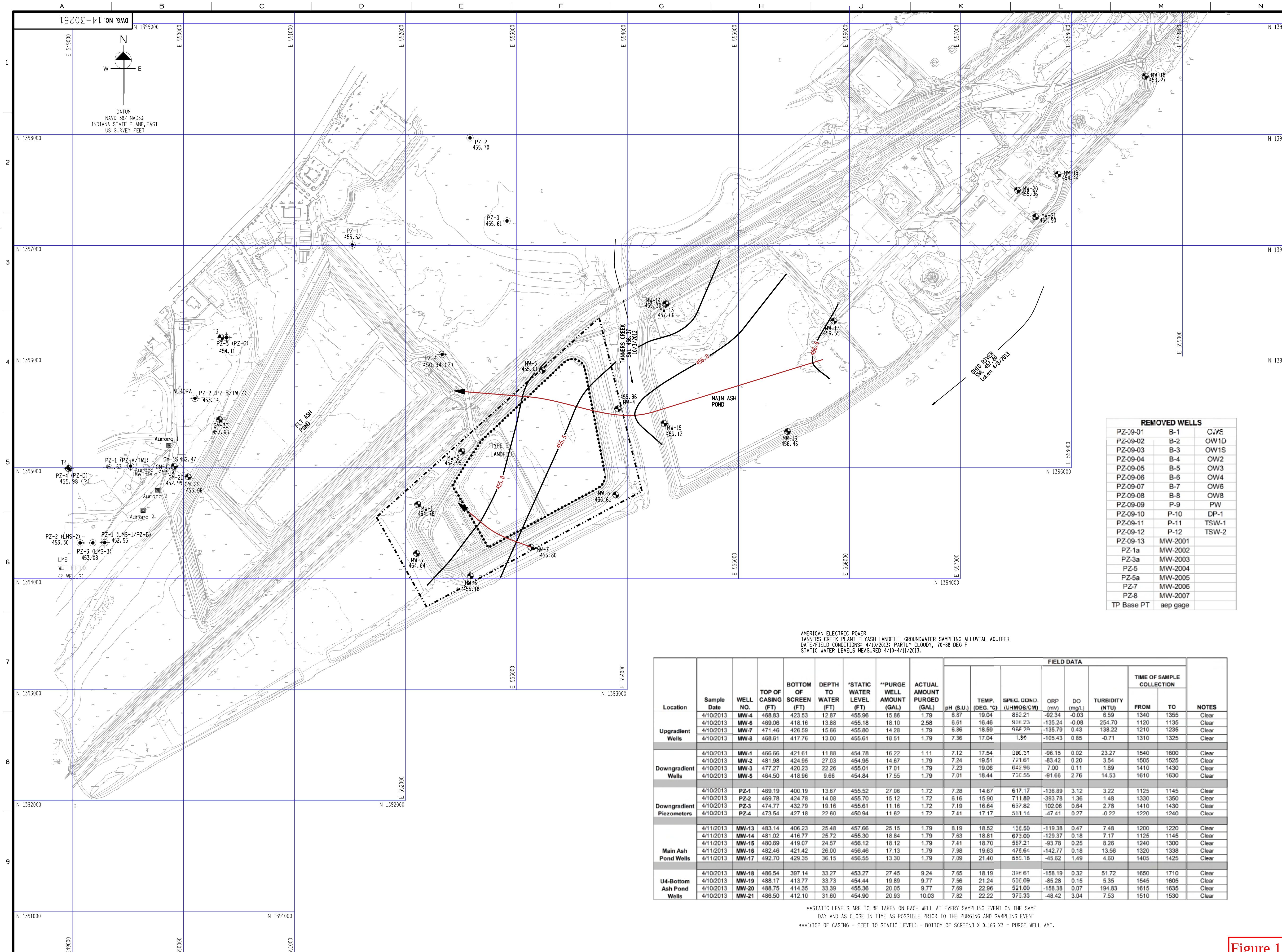
Figure 9

AEP AMERICAN ELECTRIC POWER

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

15-12

SYSTEM DATE-5/30/2012
SYSTEM TIME- 3:20:13 PM



GENERAL NOTES

GROUNDWATER FLOW DIRECTIONS WILL LIKELY CHANGE DEPENDANT ON THE ELEVATION OF THE OHIO RIVER AND LMS/AURORA WELLFIELD DRAW DOWN. THEREFORE, WHETHER A WELL IS UPGRADIENT OR DOWN GRADIENT WILL DEPEND ON THE ELEVATION OF THE OHIO RIVER AND WELLFIELD DRAW DOWN ON THE DATE OF SAMPLING

THIS AERIAL PHOTOGRAPH TAKEN 10/29/10, EXCEPT FOR THE BUBBLED AREA WHICH HAS BEEN UPDATED WITH 11/08/11.

LEGEND

- SPOT ELEVATION
- INTERMEDIATE CONTOUR
- INDEX CONTOUR
- DEPRESSION CONTOUR
- TREES AND TREELINE
- STRUCTURE AND BUILDING
- FENCE
- POLE
- ROADS
- EDGE OF WATER
- MANHOLES / CATCH BASIN
- POWER POLE
- PIPES
- TOWER
- PIEZOMETER
- MONITORING WELL
- AURORA SUPPLY WELL
- 458.5 POTENTIOMETRIC CONTOUR
- DIRECTION OF GROUND FLOW
- FACILITY BOUNDARY
- WASTE BOUNDARY

REFERENCE DRAWINGS

14-30205 FLY ASH LANDFILL- BORING LAYOUT
14-30251A MONITORING WELL LOCATION PLAN
14-30251B MONITORING WELL CONSTRUCTION DETAILS TABLE

REMOVED WELLS		
PZ-09-01	B-1	OWS
PZ-09-02	B-2	OW1D
PZ-09-03	B-3	OW1S
PZ-09-04	B-4	OW2
PZ-09-05	B-5	OW3
PZ-09-06	B-6	OW4
PZ-09-07	B-7	OW6
PZ-09-08	B-8	OW8
PZ-09-09	P-9	PW
PZ-09-10	P-10	DP-1
PZ-09-11	P-11	TSW-1
PZ-09-12	P-12	TSW-2
PZ-09-13	MW-2001	
PZ-1a	MW-2002	
PZ-3a	MW-2003	
PZ-5	MW-2004	
PZ-5a	MW-2005	
PZ-7	MW-2006	
PZ-8	MW-2007	
TP Base PT	aep gage	

AMERICAN ELECTRIC POWER
TANNERS CREEK PLANT FLYASH LANDFILL GROUNDWATER SAMPLING ALLUVIAL AQUIFER
DATE/FIELD CONDITIONS: 4/10/2013; PARTLY CLOUDY, 70-88 DEG F
STATIC WATER LEVELS MEASURED 4/10-4/11/2013.

Location	Sample Date	WELL NO.	TOP OF CASING (FT)	BOTTOM OF SCREEN (FT)	DEPTH TO WATER (FT)	*STATIC WATER LEVEL (FT)	**PURGE WELL AMOUNT (GAL)	ACTUAL AMOUNT PURGED (GAL)	FIELD DATA						TIME OF SAMPLE COLLECTION		NOTES
									pH (S.U.)	TEMP. (DEG. °C)	SPEC. COND. (UHMOS/CM)	ORP (mV)	DO (mg/L)	TURBIDITY (NTU)	FROM	TO	
Upgradient Wells	4/10/2013	MW-4	468.83	423.53	12.87	455.96	15.86	1.79	6.87	19.04	862.21	-92.34	-0.03	6.59	1340	1355	Clear
	4/10/2013	MW-6	469.06	418.16	13.88	455.18	18.10	2.58	6.61	16.46	906.23	-135.24	-0.08	254.70	1120	1135	Clear
	4/10/2013	MW-7	471.46	426.59	15.66	455.80	14.28	1.79	6.86	18.59	966.29	-135.79	0.43	138.22	1210	1235	Clear
	4/10/2013	MW-8	468.61	417.76	13.00	455.61	18.51	1.79	7.36	17.04	[illegible]	-105.43	0.85	-0.71	1310	1325	Clear
Downgradient Wells	4/10/2013	MW-1	466.66	421.61	11.88	454.78	16.22	1.11	7.12	17.54	[illegible]	-96.15	0.02	23.27	1540	1600	Clear
	4/10/2013	MW-2	481.98	424.95	27.03	454.95	14.67	1.79	7.24	19.51	721.61	-83.42	0.20	3.54	1505	1525	Clear
	4/10/2013	MW-3	477.27	420.23	22.26	455.01	17.01	1.79	7.23	19.06	642.96	7.00	0.11	1.89	1410	1430	Clear
	4/10/2013	MW-5	464.50	418.96	9.66	454.84	17.55	1.79	7.01	18.44	730.55	-91.66	2.76	14.53	1610	1630	Clear
Downgradient Piezometers	4/10/2013	PZ-1	469.19	400.19	13.67	455.52	27.06	1.72	7.28	14.67	617.17	-136.89	3.12	3.22	1125	1145	Clear
	4/10/2013	PZ-2	469.78	424.78	14.08	455.70	15.12	1.72	6.16	15.90	711.89	-393.78	1.36	1.48	1330	1350	Clear
	4/10/2013	PZ-3	474.77	432.79	19.16	455.61	11.16	1.72	7.19	16.64	637.82	102.06	0.64	2.78	1410	1430	Clear
	4/10/2013	PZ-4	473.54	427.18	22.60	450.94	11.62	1.72	7.41	17.17	581.14	-47.41	0.27	-0.22	1220	1240	Clear
Main Ash Pond Wells	4/11/2013	MW-13	483.14	406.23	25.48	457.66	25.15	1.79	8.19	18.52	[illegible]	-119.38	0.47	7.48	1200	1220	Clear
	4/11/2013	MW-14	481.02	416.77	25.72	455.30	18.84	1.79	7.63	18.81	673.00	-129.37	0.18	7.17	1125	1145	Clear
	4/11/2013	MW-15	480.69	419.07	24.57	456.12	18.12	1.79	7.41	18.70	587.21	-93.78	0.25	8.26	1240	1300	Clear
	4/11/2013	MW-16	482.46	421.42	26.00	456.46	17.13	1.79	7.98	19.63	476.64	-142.77	0.18	13.56	1320	1338	Clear
	4/11/2013	MW-17	492.70	429.35	36.15	456.55	13.30	1.79	7.09	21.40	559.18	-45.62	1.49	4.60	1405	1425	Clear
U4-Bottom Ash Pond Wells	4/10/2013	MW-18	486.54	397.14	33.27	453.27	27.45	9.24	7.65	18.19	[illegible]	-158.19	0.32	51.72	1650	1710	Clear
	4/10/2013	MW-19	488.17	413.77	33.73	454.44	19.89	9.77	7.56	21.24	506.09	-85.28	0.15	5.35	1545	1605	Clear
	4/10/2013	MW-20	488.75	414.35	33.39	455.36	20.05	9.77	7.69	22.96	521.00	-158.38	0.07	194.83	1615	1635	Clear
	4/10/2013	MW-21	486.50	412.10	31.60	454.90	20.93	10.03	7.82	22.22	[illegible]	-48.42	3.04	7.53	1510	1530	Clear

**STATIC LEVELS ARE TO BE TAKEN ON EACH WELL AT EVERY SAMPLING EVENT ON THE SAME DAY AND AS CLOSE IN TIME AS POSSIBLE PRIOR TO THE PURGING AND SAMPLING EVENT

***[(TOP OF CASING - FEET TO STATIC LEVEL) - BOTTOM OF SCREEN] X 0.163 X3 = PURGE WELL AMT.

DATE	NO.	DESCRIPTION	APPD.
06/04/12	Q	STATIC WATER LEVEL MEASURED ON APRIL 8, 2013.	GFZ
11/28/12	P	ADDED WELL T3 & T4. PARTIAL UPDATED MAPPING. STATIC WATER LEVEL MEASURED ON OCT 1, 2012.	GFZ
05/30/12	O	STATIC WATER LEVEL MEASURED ON APRIL 2, 2012. ADDED WELLS MW-18 THRU 21.	GFZ
12/15/11	N	STATIC WATER LEVEL MEASURED ON OCT. 3, 2011.	GFZ
07/22/11	M	DELETED PREVIOUS REVISON A-K, ADDED 2010 AERIAL TOPOGRAPHY. TABLE SHOWS REMOVED WELLS. ADDED STATIC WATER LEVEL FOR MW-13 THRU MW-17 MEASURED ON OCT. 28, 2010. LMW1, LMW2, LSMW1, PZ2, PZ, T3, AND T4 HAVE BEEN RENAMED TO MATCH PLANT NUMBERS PZ-1 (PZ-A/TW1), PZ-2 (PZ-B/TW2), PZ-1 (LMS-1/PZ-B), PZ-2 (LMS-2), PZ-3 (LMS-3), PZ-3 (PZ-C), & PZ-4 (PZ-D). STATIC WATER LEVEL MEASURED ON MAY 16, 2011.	GFZ
12/15/10	L	STATIC WATER LEVEL MEASURED ON NOV. 02, 2010. EXCLUDES PIEZOMETER READINGS AROUND THE FLY ASH POND.	GFZ

REVISIONS

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INDIANA MICHIGAN POWER

TANNERS CREEK PLANT

LAWRENCEBURG INDIANA

POTENTIOMETRIC MAP

2013 April

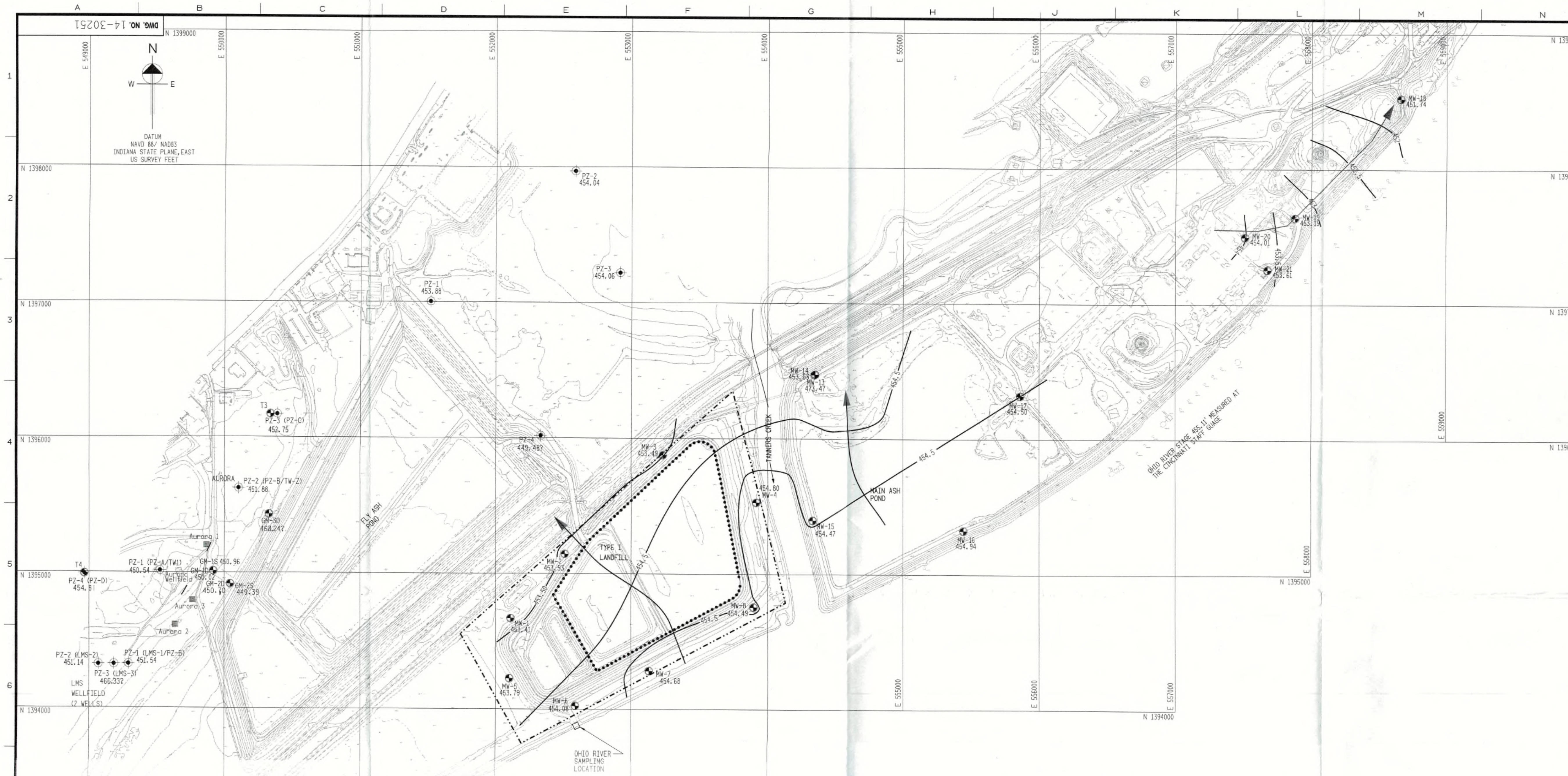
DWG. NO. 14-30251-Q

SCALE: 1" = 300'
CIVIL ENGINEERING
DR: CH: DMS ENGR: JMN PROJ ENGR: JMN DATE: 10/23/08
APPROVED BY: Thomas R. Zelina

Figure 10

AMERICAN ELECTRIC POWER
AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

SYSTEM DATE-9/16/2013
SYSTEM TIME-12:06:06 PM



AMERICAN ELECTRIC POWER
TANNERS CREEK PLANT FLYASH LANDFILL GROUNDWATER SAMPLING ALLUVIAL AQUIFER
DATE/FIELD CONDITIONS: 10/4/2016; SUNNY 60 DEG F.
STATIC WATER LEVELS MEASURED 10/4/16

Location	Sample Date	WELL NO.	TOP OF CASING (FT)	BOTTOM OF SCREEN (FT)	DEPTH TO WATER (FT)	*STATIC WATER LEVEL (FT)	**PURGE WELL AMOUNT (GAL)	FIELD DATA: pH (S.U.)	TEMP. (°C)	SPEC. COND. (uS/cm @ 25 C)	ORP (mV)	DO (mg/L)	TURBIDITY (NTU)	TIME OF SAMPLE COLLECTION: FROM	TO	NOTES
Upgradient Wells	10/4/2016	MW-4	468.83	423.53	14.03	454.80	15.29	6.36	17.76	1044.42	-104.00	-0.02	3.75	13:53:02	14:10:51	
	10/4/2016	MW-6	469.06	418.16	14.98	454.08	17.56	6.36	17.04	1092.93	-127.00	-0.02	5.74	16:44:42	17:05:27	
	10/4/2016	MW-7	471.46	426.59	16.78	454.68	13.74	6.47	18.12	1044.91	-135.92	-0.03	178.12	16:02:45	16:22:45	
	10/4/2016	MW-8	468.61	417.76	14.12	454.49	17.96	6.99	16.75	673.40	-143.53	-0.04	1.26	14:34:58	15:05:18	
Downgradient Wells	10/4/2016	MW-1	466.66	421.61	13.25	453.41	15.55	7.09	15.70	799.17	-135.52	-0.03	5.74	10:27:08	10:43:23	
	10/4/2016	MW-2	481.98	424.95	28.45	453.53	13.98	7.43	15.77	724.16	-91.01	-0.01	0.00	11:02:54	11:22:54	
	10/4/2016	MW-3	477.27	420.23	23.78	453.49	16.26	7.41	16.91	671.32	7.02	0.08	0.00	11:46:52	11:59:43	
	10/4/2016	MW-5	464.50	418.96	10.71	453.79	17.03	7.05	16.77	955.68	-141.65	0.03	1006.03	9:09:00	9:29:00	Sensor errors: turbity not as high as shown
Downgradient Piezometers	10/4/2016	PZ-1	469.19	400.19	15.31	453.88	26.25	--	--	--	--	--	--	--	--	No pump
	10/5/2016	PZ-2	469.78	424.78	15.74	454.04	14.31	6.52	14.90	856.31	7.07	-0.01	9.08	15:22:48	15:37:49	
	10/5/2016	PZ-3	474.77	432.79	20.71	454.06	10.40	6.96	15.35	741.09	-83.06	-0.03	17.40	16:18:13	16:38:13	
	10/6/2016	PZ-4	473.54	427.18	24.06	449.48	10.90	7.51	16.89	663.91	-55.96	0.14	0.00	9:11:42	9:26:42	
Main Ash Pond Wells	10/4/2016	MW-13	483.14	406.23	9.67	473.47	32.88	--	--	--	--	--	--	--	--	No Pump
	10/4/2016	MW-14	481.02	416.77	27.39	453.63	18.02	--	--	--	--	--	--	--	--	Bad pump cable connector
	10/6/2016	MW-15	480.69	419.07	26.22	454.47	17.31	7.49	18.34	600.50	-100.86	0.09	31.54	10:40:11	11:00:11	
	10/6/2016	MW-16	482.46	421.42	27.52	454.94	16.39	8.24	18.35	313.25	-207.00	-0.02	168.57	11:47:22	12:07:22	
	10/6/2016	MW-17	492.70	429.35	38.20	454.50	12.30	7.14	18.89	590.26	-33.97	0.00	6.10	12:36:16	12:56:16	Pump fault
U4-Bottom Ash Pond Wells	10/5/2016	MW-18	486.54	397.14	34.80	451.74	26.70	7.90	18.18	277.05	-155.21	0.04	69.47	11:27:12	11:47:12	
	10/5/2016	MW-19	488.17	413.77	34.98	453.19	19.28	7.69	19.45	499.03	-52.16	0.22	12.59	9:40:11	10:00:11	
	10/5/2016	MW-20	488.75	414.35	34.74	454.01	19.39	7.59	18.53	638.99	-114.44	0.00	150.34	13:40:48	13:57:20	
	10/4/2016	MW-21	486.50	412.10	32.89	453.61	20.30	--	--	--	--	--	--	--	--	Sand collapse around pump

*STATIC LEVELS ARE TO BE TAKEN ON EACH WELL AT EVERY SAMPLING EVENT ON THE SAME DAY AND AS CLOSE IN TIME AS POSSIBLE PRIOR TO THE PURGING AND SAMPLING EVENT

**[(TOP OF CASING - FEET TO STATIC LEVEL) - BOTTOM OF SCREEN] X 0.163 X3 = PURGE WELL AMT.

***NEGATIVE VALUES ARE DUE TO INSTRUMENT CALIBRATION

GENERAL NOTES

GROUNDWATER FLOW DIRECTIONS WILL LIKELY CHANGE DEPENDANT ON THE ELEVATION OF THE OHIO RIVER AND LMS/AURORA WELLFIELD DRAW DOWN. THEREFORE, WHETHER A WELL IS UPGRADIENT OR DOWN GRADIENT WILL DEPEND ON THE ELEVATION OF THE OHIO RIVER AND WELLFIELD DRAW DOWN ON THE DATE OF SAMPLING

RECEIVED
DEC 08 2016
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OFFICE OF LAND QUALITY

LEGEND

- 509.5 SPOT ELEVATION
- INTERMEDIATE CONTOUR
- 500 INDEX CONTOUR
- DEPRESSION CONTOUR
- TREES AND TREELINE
- STRUCTURE AND BUILDING
- FENCE
- POLE
- ROADS
- EDGE OF WATER
- MANHOLES / CATCH BASIN
- POWER POLE
- PIPES
- TOWER
- PIEZOMETER
- MONITORING WELL
- AURORA SUPPLY WELL
- 458.5 POTENTIOMETRIC CONTOUR
- DIRECTION OF GROUND FLOW
- FACILITY BOUNDARY
- WASTE BOUNDARY
- OHIO RIVER SAMPLING LOCATION

REFERENCE DRAWINGS

14-30205 FLY ASH LANDFILL- BORING LAYOUT
14-30251A MONITORING WELL LOCATION PLAN
14-30251B MONITORING WELL CONSTRUCTION DETAILS TABLE

DATE	NO.	DESCRIPTION	APPD.
11/21/16	X	STATIC WATER LEVEL MEASURED ON 10/4/2016.	

REVISIONS

s:tc?\geo_hydro_site\30251.dgn

INDIANA MICHIGAN POWER

TANNERS CREEK PLANT

LAWRENCEBURG INDIANA

POTENTIOMETRIC MAP

2016 October

DWG. NO. 14-30251-X

SCALE: 1" = 300'
CIVIL ENGINEERING
DR: Amanda Graphics
CH: DMS
ENGR: JMN
PROJ ENGR: JMN
DATE: 10/23/08
APPROVED BY Thomas R Zelina

Figure 11

AMERICAN ELECTRIC POWER
AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

SYSTEM DATE-11/21/2016
SYSTEM TIME- 2:02:40 PM

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Appendix B – Boring and Well Installation Data

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PIEZOMETER INSTALLATION REPORT

GM-1S Sampler Installation

Project I&M Tanners Creek Plant - Fly Ash Pond No. 1S

Piez Type Geomon	Depth. 44.3	Riser Desc. 1" PVC SCH 80
Mat'l @ Tip Sand	Sample # 9	Boring Dia. 6.25

Method of Installation HSA

Type of Grnd Protection 48" Concrete Tile

Grnd Elev 468.3	Riser Elev. 467.93	Piez Tip Elev. 424.0

Filter Material Natural Sand from Elev. 453.3 to Elev 424.0

Seal Material Valclay Grout from Elev. 466.3 to Elev 453.3

Installed By Roush - Bumgarner

Date Installed 11-5-87	Date Tested

Method of Testing Piez.

Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water

REMARKS

GM-1D Sampler Installation

PIEZOMETER INSTALLATION REPORT

Project I&M Tanners Creek Plant - Fly Ash Pond No. 1D

Piez Type Geomon	Depth. 69.5	Riser Desc. 1" PVC SCH 80
Mat'l @ Tip Sand	Sample # 13	Boring Dia. 6.25

Method of Installation HSA

Type of Grnd Protection 48" Concrete Tile

Grnd Elev 468.3	Riser Elev. 468.19	Piez Tip Elev. 403.4

Filter Material	Natural Sand	from Elev. 453.3	to Elev 403.4
Seal Material	Valclay Grout	from Elev. 466.3	to Elev 453.3

Installed By Roush - Bumgarner - MacKnight

Date Installed 11-5-87	Date Tested

Method of Testing Piez.

Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water

REMARKS

PIEZOMETER INSTALLATION REPORT

GM-2S Sampler Installation

Project	I&M Tanners Creek Plant - Fly Ash Pond 2S

Piez. Type	Geomon	Depth.	41.4	Riser Desc.	1" PVC SCH 80
Mat'l @ Tip	Sand & Gravel	Sample #	8	Boring Dia.	6.25

Method of Installation HSA

Type of Grnd Protection 48" Concrete Tile

Grnd Elev	463.9	Riser Elev.	464.59	Piez Tip Elev.	422.5

Filter Material	Natural Sand	from Elev.	448.9	to Elev	422.5
Seal Material	Valclay Grout	from Elev.	461.9	to Elev	448.9

Installed By Roush - Bumgarner - MacKnight

Date Installed	11-5-87	Date Tested	

Method of Testing Piez.

Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water

REMARKS

AEPTC001214

PIEZOMETER INSTALLATION REPORT

GM-2D Sampler Installation

Project I&M Tanners Creek Plant - Fly Ash Pond 2D		
Piez Type Geomon	Depth. 60.1	Riser Desc. 1" PVC SCH 80
Mat'l @ Tip Sand & Gravel	Sample # 12	Boring Dia. 6.25
Method of Installation HSA		
Type of Grnd Protection 48" Concrete Tile		
Grnd Elev 463.9	Riser Elev. 464.92	Piez Tip Elev. 403.8
Filter Material Natural Sand	from Elev. 448.9	to Elev 403.8
Seal Material Valclay Grout	from Elev. 461.9	to Elev 448.9
Installed By Roush - Bumgarner - MacKnight		
Date Installed 11-3-87	Date Tested	

Method of Testing Piez.

Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water

REMARKS

PIEZOMETER INSTALLATION REPORT

GM-3 Sampler Installation

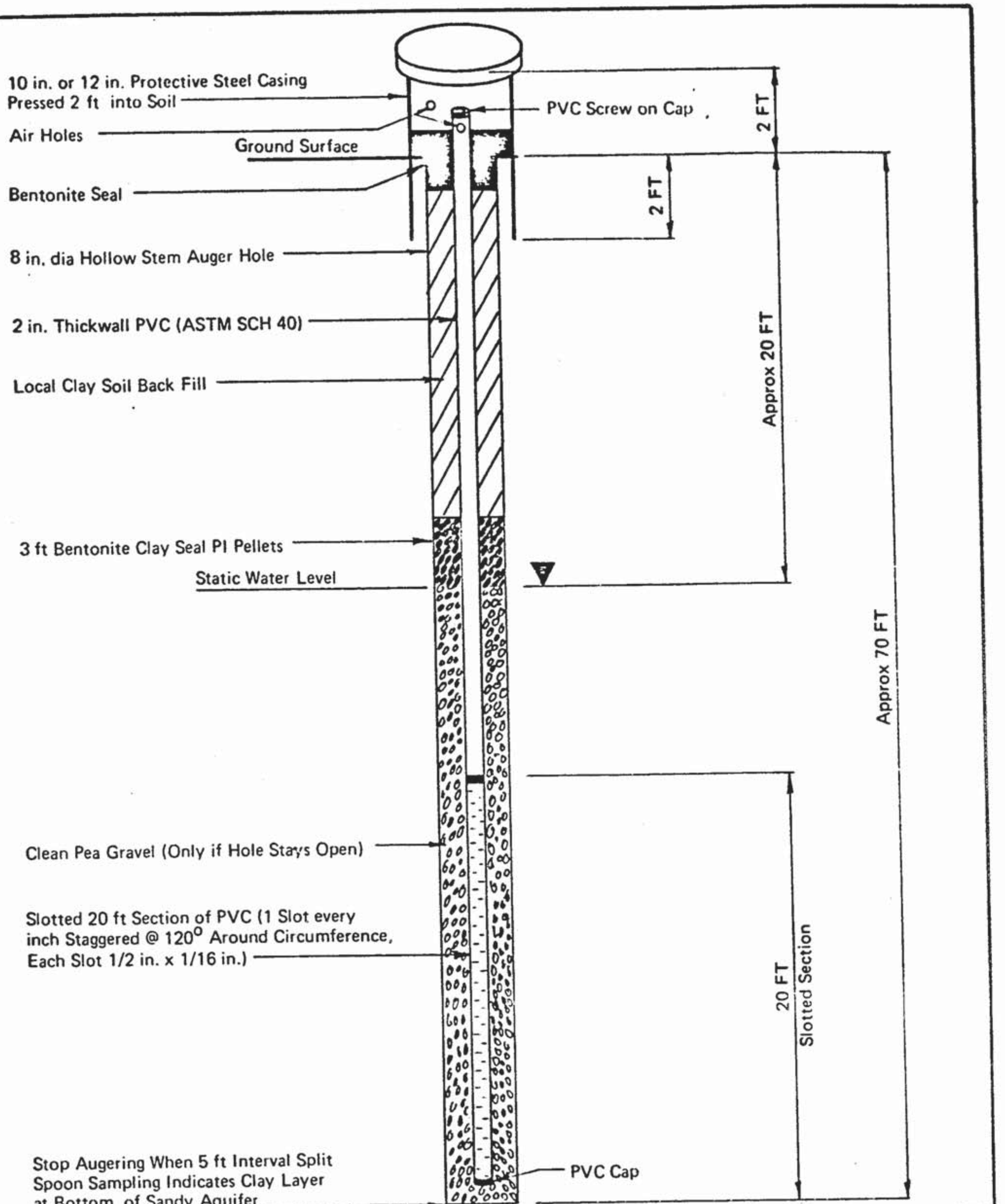
Project	I&M Ganners Creek Plant - Fly Ash Pond				3
Piez Type	Geomon	Depth.	59.8	Riser Desc.	1" PVC SCH 80
Mat'l @ Tip	Sand	Sample #	12	Boring Dia.	6.25
Method of Installation	HSA				
Type of Grnd Protection	48" Concrete Tile				
Grnd Elev	462.8	Riser Elev.	466.17	Piez Tip Elev.	403.0
Filter Material	Natural Sand	from Elev.	447.8	to Elev	403.0
Seal Material	Valclay Grout	from Elev.	460.8	to Elev	447.8
Installed By	Roush - Bumgarner - MacKnight				
Date Installed	11-6-87	Date Tested			

Method of Testing Piez.

Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water

REMARKS

AEPTC001215



GENERALIZED MONITORING PIEZOMETER CONSTRUCTION MP1, MP2, MP3

WOODWARD-CLYDE CONSULTANTS

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
CLIFTON, NEW JERSEY

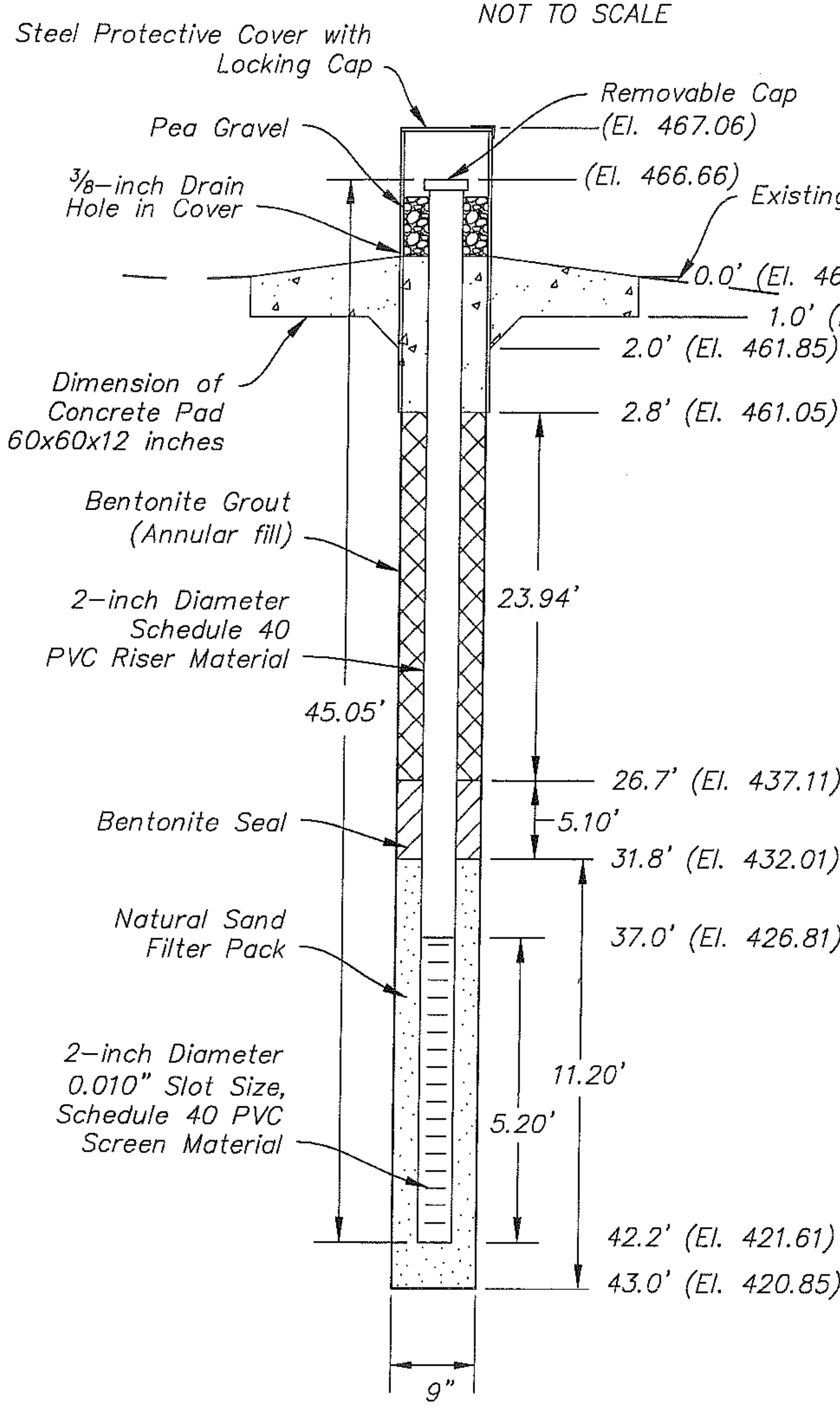
DR. BY:	BTD	SCALE:	NONE	PROJ. NO.:	76C011
CK'D. BY:	[illegible]	DATE:	8 MAY 1976	FIG. NO.:	A-1

Typical Insallation Diagram

Water Level Piezometer
GM-1S, 1D, 2S, 2D, and 3
(aka MP-1, 2, and 3)

WELL CONSTRUCTION DATA SHEET

NOT TO SCALE



Notes:

1) Well Installation started and completed on 4/24/07.

2) Boring advanced with 4 1/4-inch inside diameter hollow stem augers. Standard Penetration Tests (ASTM D1586) were performed continuously from the ground surface to a depth of 42.0' (Elev. 421.85).

3) PVC Riser Material sections joined and made watertight by threading.

4) Annular fill was tremmie placed.

5) Elevation datum used NGVD29.

PROJECT TITLE: Tanners Creek Landfill

PROJECT NO.: CN2006032

OWNER'S WELL NO.: MW-1

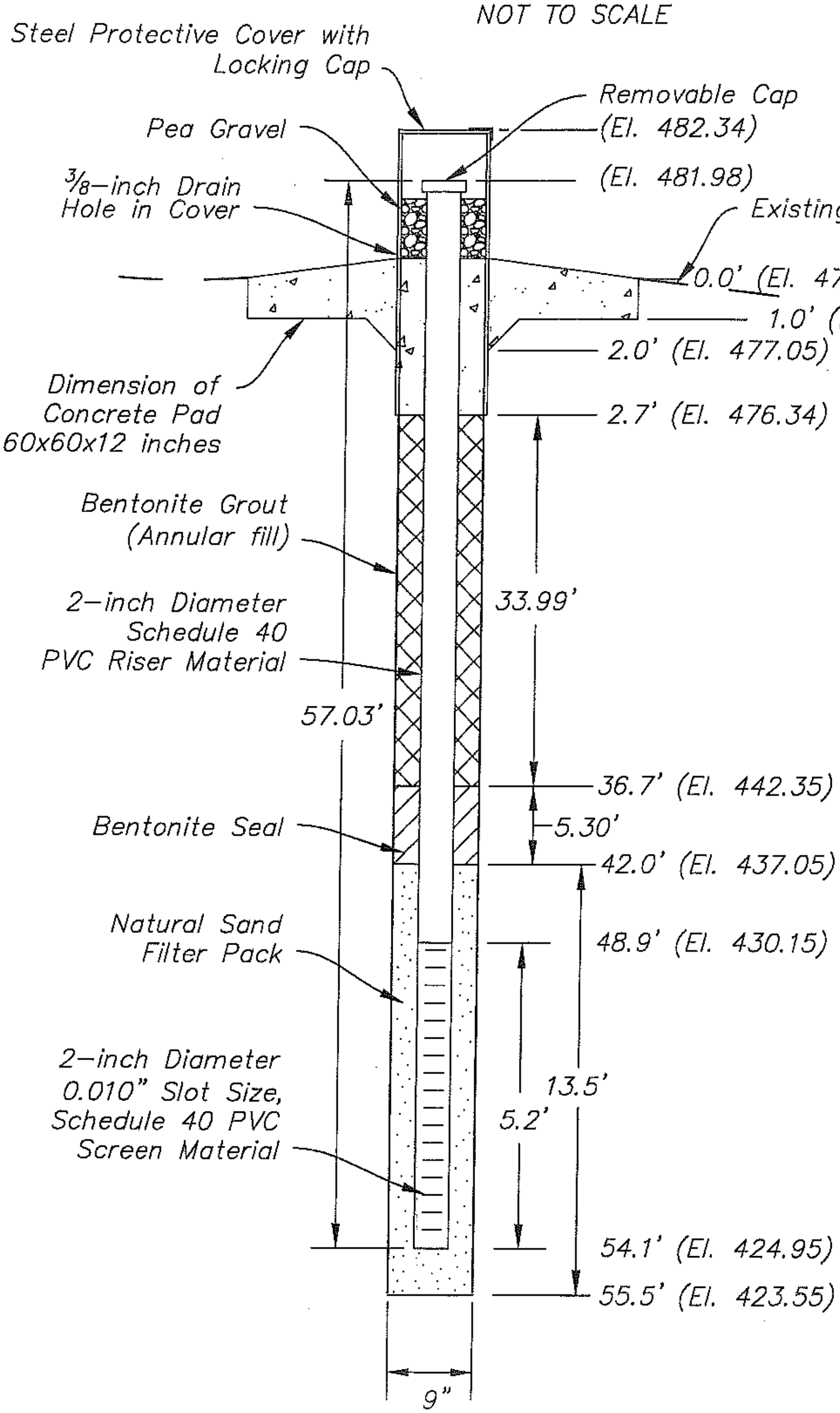
LOCATION (UTM): N. 4327220.641
E. 683601.302

EMSM ENGINEERS

CN2006032\Well Construction\MW-1

WELL CONSTRUCTION DATA SHEET

NOT TO SCALE



Notes:

1) Well Installation started and completed on 4/25/07.

2) Boring advanced with 4 1/4–inch inside diameter hollow stem augers. Standard Penetration Tests (ASTM D1586) were performed continuously from 0.0' to a depth of 55.5' (Elev. 423.55).

3) PVC Riser Material sections joined and made watertight by threading.

4) Annular fill was tremmie placed.

5) Elevation datum used NGVD29.

PROJECT TITLE: Tanners Creek Landfill

PROJECT NO.: CN2006032

OWNER'S WELL NO.: MW–2

LOCATION (UTM): N. 4327367.646
E. 683719.928

FMSM ENGINEERS

CN2006032\Well Construction\MW-2

FORM CE-5
REV. 1/87

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

"GM"

JOB NO. ____
COMPANY T + M
PROJECT Tanner Creek Ash Pond Area
COORDINATES N. 574,771.1 E 721832.2

BORING NO. 15-1D DATE 11-5-87 SHEET 1 OF ____
TYPE OF SAMPLES: SPT ✓ 3" TUBE — CORE —
CASING USED — SIZE — DRILLING MUD USED —
BORING BEGUN 11-5-87 BORING COMPLETED 11-5-87
GROUND ELEVATION 460.3 REFERRED TO ____ DATUM
FIELD PARTY Roush- Bumgarner RIG 61

LOCATION OF BORING:	
WATER LEVEL	19.0
TIME	
DATE	11-5-87

SAMPLE NUMBER	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOW / 6"			TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	DRILLER'S NOTES
1	3.0	4.5	11	12	16	11"				CL	Silty clay- Br moist - low to med plasticity	
2	8.0	9.5	4	4	8	6"		10		GM	Silty Sand + Gravel - Br. moist - ¾" max size poorly Graded - Quartz Rounded	
3	13.0	14.5	14	20	20	12"				GW	Sand + Gravel - Br. moist slight Reaction to HCL - ¾" max size - well Graded Rounded - Quartz	
4	18.0	19.5	7	9	12	7"		20			Same as Sample No. 3 saturated	

8" x 3.25 HSA	✓	
HW CASING ADVANCER 4"		
NQ CORE ROCK		
NW CASING 3"		
SW CASING 6"		RECORDER ____

AEPTC001216

FORM CE-5
REV. 1/87

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

JOB NO. ______
COMPANY ______
PROJECT ______
COORDINATES ______

BORING NO. 1-5 (1D) DATE ______ SHEET 2 OF ____
TYPE OF SAMPLES: SPT ____ 3" TUBE ____ CORE ____
CASING USED ____ SIZE ____ DRILLING MUD USED ____
BORING BEGUN ____ BORING COMPLETED ____
GROUND ELEVATION ____ REFERRED TO ____ DATUM
FIELD PARTY ____ RIG ____

LOCATION OF BORING:	
WATER LEVEL	
TIME	
DATE	

SAMPLE NUMBER	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOW / 6"			TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	DRILLER'S NOTES
								20				
5	23.0	24.5	7	9	12	7"				SP	Sand - Br. Saturated - Poorly Graded - 100% Fine Grain	
6	29.0	29.5	7	11	12	8"				SP	Sand - Br. Saturated poorly Graded - Quartz	
								30				
7	33.0	34.5	14	25	54/3	9"				GP	Sand + Gravel - Br. Saturated 1" max Size - Slight [illegible] to Hel - poorly Graded Rounded - Quartz	
8	38.0	39.5	14	24	35	7"				SP	Gravel + Sand - Br. Saturated Quartz - 1" max Size - Rounded Trace of Fines	
								40				

6" x 3.25 HSA
HW CASING ADVANCER 4"
NQ CORE ROCK
NW CASING 3"
SW CASING 6"

RECORDER ______

FORM CE-5
REV. 1/87

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

JOB No. ______
COMPANY ______
PROJECT ______
COORDINATES ______

BORING No. 15 (written over 17) DATE ______ SHEET 3 OF ____
TYPE OF SAMPLES: SPT ____ 3" TUBE ____ CORE ____
CASING USED ____ SIZE ____ DRILLING MUD USED ____
BORING BEGUN ____ BORING COMPLETED ____
GROUND ELEVATION ____ REFERRED TO ____ DATUM
FIELD PARTY ____ RIG ____

LOCATION OF BORING:	
WATER LEVEL	
TIME	
DATE	

SAMPLE NUMBER	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOW / 6"			TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	DRILLER'S NOTES
								40			✓	
9	43.0	44.5	15	19	25	8"				SP	Sand - Br. Saturated, 100 % Fine Grain - Slight Reaction to HCL	
10	48.0	49.5	21	25	30	8"		50		GW	Sand + Gravel - Br. Saturated Rounded 3/4" max Size - Strong Reaction	
11	53.0	54.5	21	14	15	3"				GM	Silty Sand + Gravel - Br. Saturated - Strong Reaction to HCL - 1/2" max Size Rounded	
12	58.0	59.5	30	50/4		3"		60		SP	Sand - Br. Saturated - [illegible] Rounded - w/ trace of Fines - Strong Reaction to HCL	

6" x 3.25 HSA
HW CASING ADVANCER 4"
NJ CORE ROCK
NW CASING 3"
SW CASING 6"

RECORDER ______

AEPTC001218

FORM CE-5
REV. 1/87

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

JOB NO. ____________

COMPANY ____________

PROJECT ____________

COORDINATES ____________

BORING NO. 1D 15 DATE ____________ SHEET 4 OF 4

TYPE OF SAMPLES: SPT ______ 3" TUBE ______ CORE ______

CASING USED ______ SIZE ______ DRILLING MUD USED ______

BORING BEGUN ______ BORING COMPLETED ______

GROUND ELEVATION ______ REFERRED TO ______ DATUM

FIELD PARTY ______ RIG ______

LOCATION OF BORING:	
WATER LEVEL	
TIME	
DATE	

SAMPLE NUMBER	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOW / 6"			TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	DRILLER'S NOTES
								60				
											Sand - Br. Saturated Slight	
13	63.0	64.5	20	45	40	4"					Reaction to HCL - Well	
											Graded	
										SW		
											SILT - GRAY - SATURATED	
14	68.0	69.5	11	11	15	10"					STRONG Reaction TO HCL	
										ML		
								70				
											Stopped Hole 69.5 FT	
											Two Geomon Tip were	
											Installed - 1D - 64.9 FT	
											1S 44.3 FT	
											WATER Level [illegible] FROM	
											Top of [illegible] PVC - ON 1D - 1S	
											[illegible] was purged 12	
											Times - [illegible]	
											PVC Pipe ASTM	
											F480-81	
											D1784	
											D2665	

6" x 3.25 HSA
HW CASING ADVANCER 4"
NQ CORE ROCK
NW CASING 3"
SW CASING 6"

RECORDER ____________

AEPTC001219

FORM CE-5
REV. 1/87

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING 2-S

"GM"

JOB NO. ______
COMPANY I & M
PROJECT Tanner Creek Ash Storage Area
COORDINATES N. 574676.5 E 721957.6

BORING NO. 2-D DATE 11-2-87 SHEET 1 OF 4
TYPE OF SAMPLES: SPT ✓ 3" TUBE ______ CORE ______
CASING USED ______ SIZE ______ DRILLING MUD USED ______
BORING BEGUN 11-2-87 BORING COMPLETED 11-3-87
GROUND ELEVATION 463.9 REFERRED TO ______ DATUM
FIELD PARTY Roush- Bumgarner RIG 61

LOCATION OF BORING:	
WATER LEVEL	21.0
TIME	11-2-87
DATE	

SAMPLE NUMBER	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOW / 6"			TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	DRILLER'S NOTES
1	3.0	4.5	8	6	9	8"				CL	Silty Clay - Dr. Br. - moist low to med plasticity	
2	8.0	9.5	6	8	10	11"		10		CL	Clay - Br. - moist - med. to low plasticity	
3	13.0	14.5	4	6	6	4"					Same as Sample No. 2	
4	18.0	19.5	16	24	20	1"					Same as Sample No. 2	

6" x 3.25 HSA ✓
HW CASING ADVANCER 4"
NQ CORE ROCK
NW CASING 3"
SW CASING 6"

RECORDER ______

FORM CE-5
REV. 1/87

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

JOB NO. ______
COMPANY ______
PROJECT ______
COORDINATES ______

BORING NO. 25 20 DATE ______ SHEET 2 OF 4
TYPE OF SAMPLES: SPT ______ 3" TUBE ______ CORE ______
CASING USED ______ SIZE ______ DRILLING MUD USED ______
BORING BEGUN ______ BORING COMPLETED ______
GROUND ELEVATION ______ REFERRED TO ______ DATUM
FIELD PARTY ______ RIG ______

LOCATION OF BORING:	
WATER LEVEL	
TIME	
DATE	

SAMPLE NUMBER	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOW / 6"			TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	DRILLER'S NOTES
								20				
3	23.0	24.5	6	5	4	2"				GC	clayey Sand + Gravel - Br. Saturated - Poorly Graded Quartz - ½" max size - Rounded -	
6	28.0	29.5	6	8	7	6"					Same as Sample No 5 1" max size	
								30				
7	33.0	34.5	6	6	7	9"				SP	Sand - Dk. Br. - Poorly Graded Fine to med Grain - moderate Reaction to HCl - Saturated	
8	38.0	39.5	8	11	15	14"				SW	Gravelly Sand - Br. - Saturated Strong Reaction to HCl - well Graded Sand - ½" max size	
								40				

6" x 3.25 HSA
HW CASING ADVANCER 4"
NQ CORE ROCK
NW CASING 3"
SW CASING 6"

RECORDER ______

FORM CE-5
REV. 1/87

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

JOB NO.
COMPANY
PROJECT
COORDINATES

BORING NO. 25 2D DATE SHEET 3 OF 4
TYPE OF SAMPLES: SPT 3" TUBE CORE
CASING USED SIZE DRILLING MUD USED
BORING BEGUN BORING COMPLETED
GROUND ELEVATION REFERRED TO DATUM
FIELD PARTY RIG

LOCATION OF BORING:	
WATER LEVEL	
TIME	
DATE	

SAMPLE NUMBER	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOW / 6"			TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	DRILLER'S NOTES
								40				
9	43.0	44.5	18	20	21	10"				SW	Sand- Br. - Saturated- Quartz well Graded- Slight Reaction to HCL	
10	48.0	49.5	15	23	30	8"					Gravelly Sand- Br. Saturated- Strong Reaction to HCL- Quartz Rounded- 5/8" max Size - Trace of Fines	
								50		SW		
11	53.0	54.5	25	30	30	12"					Same as Sample No. 10 ½" max Size	
12	58.0	59.5	50/.4			4"				GW	Sand + Gravel- Br. Saturated Quartz- 5/8" max Size- Strong Reaction to HCL - Rounded	
								60				

6" x 3.25 HSA
HW CASING ADVANCER 4"
NQ CORE ROCK
NW CASING 3"
SW CASING 6"

RECORDER

AEPTC001222

FORM CE-5
REV. 1/87

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

JOB NO. ____
COMPANY ____
PROJECT ____
COORDINATES ____

BORING NO. 2S 2D DATE ____ SHEET 4 OF 4
TYPE OF SAMPLES: SPT ____ 3" TUBE ____ CORE ____
CASING USED ____ SIZE ____ DRILLING MUD USED ____
BORING BEGUN ____ BORING COMPLETED ____
GROUND ELEVATION ____ REFERRED TO ____ DATUM
FIELD PARTY ____ RIG ____

LOCATION OF BORING:	
WATER LEVEL	
TIME	
DATE	

SAMPLE NUMBER	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOW / 6"			TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	DRILLER'S NOTES
								60				
13	63.0	64.5	30	25	28	4"				GW	Sand + Gravel - LT. Br. Saturated Quartz + Limestone - Trace of Fines - ½" max size well graded -	
											Stopped Hole 64.5 + Installed 2 Geomon Installed. 2D 60.1 2S 41.4 FT	
											Water level 2S 12.8 From Top of 3/4" PVC Casing	
								70			Water level 2D 13.1 From Top of 3/4" PVC Casing	
											Each well was purged 12 Times	
											PVC Pipe ASTM F480-81 D 1784 D 2665	

6" x 3.25 HSA
HW CASING ADVANCER 4"
NQ CORE ROCK
NW CASING 3"
SW CASING 6"

RECORDER ____

AEPTC001223

FORM CE-5
REV. 1/87

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

"GM"

JOB NO. ________
COMPANY I+M
PROJECT Tanner Creek Ash Storage Area
COORDINATES N-575192.5 E ~~462.8~~ 782,240.4

LOCATION OF BORING:	
WATER LEVEL	18'
TIME	
DATE	

BORING NO. 3 DATE 11-6-87 SHEET 1 OF 4
TYPE OF SAMPLES: SPT ✓ 3" TUBE — CORE —
CASING USED — SIZE — DRILLING MUD USED —
BORING BEGUN 11-6-87 BORING COMPLETED 11-6-87
GROUND ELEVATION 462.8 REFERRED TO ________ DATUM
FIELD PARTY Roush - Bumgarner RIG 61

SAMPLE NUMBER	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOW / 6"			TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	DRILLER'S NOTES
1	3.0	4.5	13	12	10	8"				CL	Silty Clay - Dr. Br. - moist Low to med. plasticity	
2	8.0	9.5	6	7	11	6"		10		CL	Clay - Br. - moist - med to low plasticity	
3	13.0	14.5	8	9	10	8"					Same as Sample No. 2 (WET)	
4	19.0	19.5	2	2	2	2"		20		SC	Sandy clay - Br. wet	

6" x 3.25 HSA	✓
HW CASING ADVANCER 4"	
NQ CORE ROCK	
NW CASING 3"	
SW CASING 6"	

RECORDER ________

AEPTC001224

FORM CE-5
REV. 1/87

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

JOB NO. ______
COMPANY ______
PROJECT ______
COORDINATES ______

BORING NO. 3 DATE ______ SHEET 2 OF 4
TYPE OF SAMPLES: SPT ______ 3" TUBE ______ CORE ______
CASING USED ______ SIZE ______ DRILLING MUD USED ______
BORING BEGUN ______ BORING COMPLETED ______
GROUND ELEVATION ______ REFERRED TO ______ DATUM
FIELD PARTY ______ RIG ______

LOCATION OF BORING:	
WATER LEVEL	
TIME	
DATE	

SAMPLE NUMBER	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOW / 6"			TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	DRILLER'S NOTES
								2				
5	23.0	24.5	13	10	11	14"				GC	Clayey Sand + Gravel - Br. Saturated - 1" max size Rounded. Quartz - moderate Reaction to HCL	
6	28.0	29.5	21	50/ [illegible]		8"				SW	Sand - Br. - Saturated. well Graded - Quartz	
								30				
7	33.0	34.5	10	15	20	6"				GW	Sand + Gravel - Br. Saturated well Graded - 3/4" max size Rounded - moderate Reaction to HCL - Quartz	
8	38.0	39.5	6	8	14	8"					Sand - Dr. Br. - Saturated 100% Fine Grain - Quartz Slight Reaction to HCL	
								40				

6" x 3.25 HSA
HW CASING ADVANCER 4"
NQ CORE ROCK
NW CASING 3"
SW CASING 6"

RECORDER ______

FORM CE-5
REV. 1/87

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

JOB NO. ______
COMPANY ______
PROJECT ______
COORDINATES ______

BORING NO. 3 DATE ______ SHEET 3 OF 4
TYPE OF SAMPLES: SPT ______ 3" TUBE ______ CORE ______
CASING USED ______ SIZE ______ DRILLING MUD USED ______
BORING BEGUN ______ BORING COMPLETED ______
GROUND ELEVATION ______ REFERRED TO ______ DATUM
FIELD PARTY ______ RIG ______

LOCATION OF BORING:	
WATER LEVEL	
TIME	
DATE	

SAMPLE NUMBER	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOW / 6"			TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	DRILLER'S NOTES
								40				
9	43.0	44.5	5	12	15	10"				SW	Sand - Dr. Br. - Saturated - strong reaction to HCL well graded - quartz	
10	48.0	49.5	10	11	15	12"				SP	Sand - Dr. Br. - Saturated med. to fine grain - strong reaction to HCL	
								50				
11	53.0	54.5	9	15	20	10"					Same as sample No. 10 with fines	
12	58.0	59.5	15	49	26	9"					Same as sample No. 10 with fines	
								60				

6" x 3.25 HSA
HW Casing Advancer 4"
NQ Core Rock
NW Casing 3"
SW Casing 6"

RECORDER ______

AEPTC001226

FORM CE-5
REV. 1/87

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

JOB NO. ______
COMPANY ______
PROJECT ______
COORDINATES ______

BORING NO. 3 DATE ______ SHEET 4 OF 4
TYPE OF SAMPLES: SPT ______ 3" TUBE ______ CORE ______
CASING USED ______ SIZE ______ DRILLING MUD USED ______
BORING BEGUN ______ BORING COMPLETED ______
GROUND ELEVATION ______ REFERRED TO ______ DATUM
FIELD PARTY ______ RIG ______

LOCATION OF BORING:	
WATER LEVEL	
TIME	
DATE	

SAMPLE NUMBER	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOW / 6"			TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	DRILLER'S NOTES
								60				
13	61.5	61.9	50/.4								Gray clay Shale	
											Stopped Hole 61.9	
											Installed Geomon well	
											Tip 59.8 - .	
											water level 11.3 from Top of 3/4" PVC casing. well was purged 12 times	
											PVC pipe ASTM F 480-81 D 1784 D 2665	

6" x 3.25 HSA
HW CASING ADVANCER 4"
NQ CORE ROCK
NW CASING 3"
SW CASING 6"

RECORDER ______

AEPTC001227

Appendix C – Miscellaneous Information

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Figure 1
Statistical Exceedance Activities
Phase I Monitoring

Note: Phase I Monitoring and Reporting to continue uninterrupted during Exceedance Activities

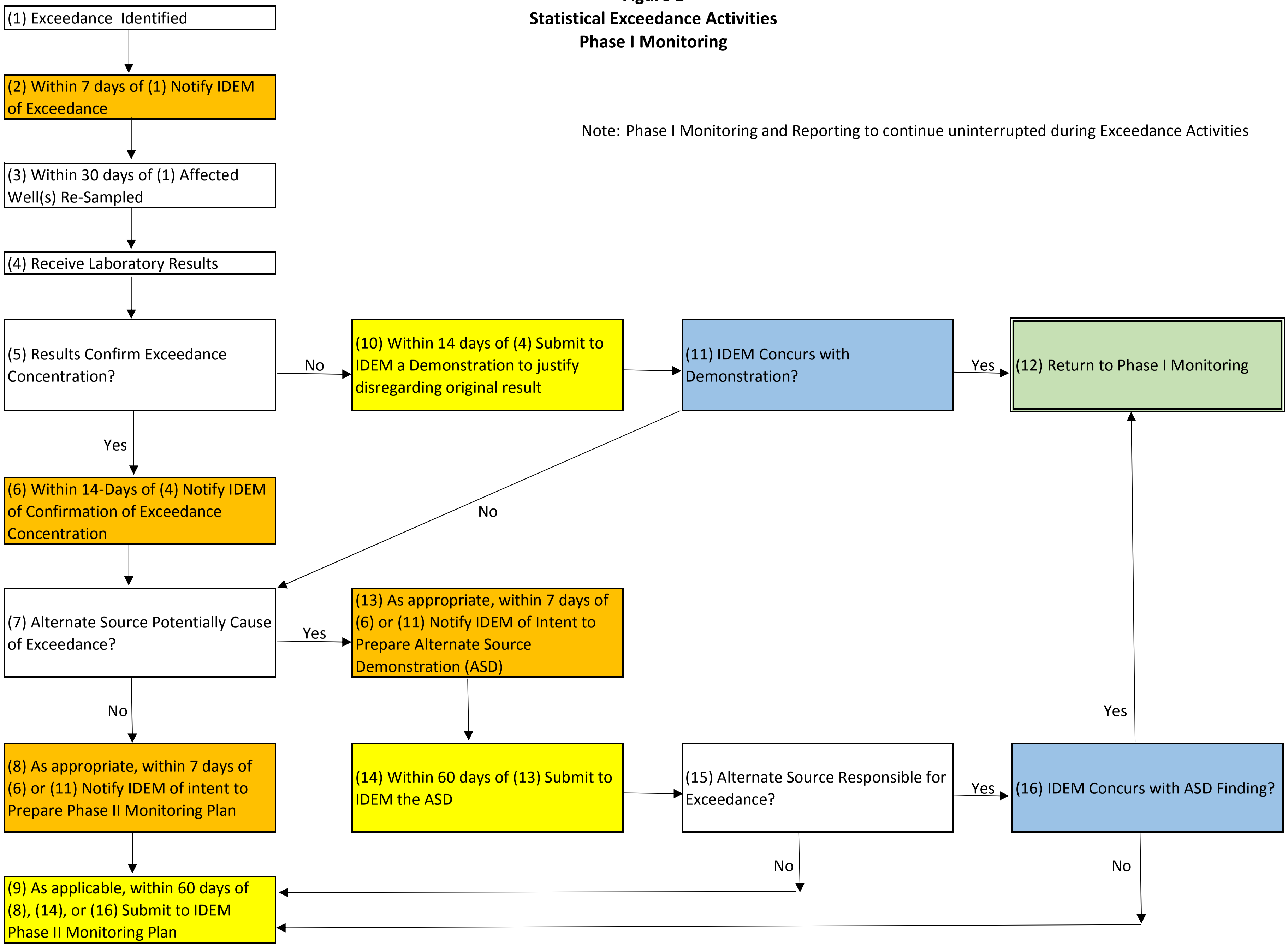

Figure 2: Monitoring Well Evaluation Checklist

Site ____________________

Inspection Date __________

Well Number __________

Major wells repairs* required to maintain well integrity?

Yes	No	NA

Stick-up Monitoring Wells	Yes	No	NA	Comments
1. Outer protective Casing				
Not corroded				
Not dented				
Not cracked				
Not loose				

	Yes	No	NA	
2. Inner casing				
Not corroded				
Not dented				
Not cracked				
Not loose				

	Yes	No	NA	
3. Are there weep holes in outer casing?				
4. Weep holes able to drain?				
5. Is there a lockable cap present?				
6. Is there a lock present?				
7. Bumper posts in good condition?				

Flushmount Monitoring Wells	Yes	No	NA	
8. Can the lid be secured tightly?				
9. Does the lid have a gasket that seals?				
10. No water in the flushmount?				
11. Is the well cap lockable?				
12. Is there a lock present?				

All Monitoring Wells	Yes	No	NA	
Downhole Condition				
12. Water level measuring point clearly marked?				
13. No obstructions in well?				
14. No plant roots or vegetation in well?				
15. No sediment in bottom of well?				
If present, how much sediment?	ft			
16. Installed as total depth.	ft			
17. Measured total depth of well.	ft			

General Condition	Yes	No	NA	
18. Concrete pad installed?				
19 . Concrete pad				
Slope away form casing?				
Not deteriorated?				
Not heaved or below surrounding grade?				
20. No surface seal settling?				
21. Well clearly visible and labeled?				

Comments:

* Major well repair are those that require a subcontractor or separate mobilization to complete

	Project Name: **Location:**	**Well ID:**
	Project No:	**Date:**
	Weather Conditions:	**Ambient Temp:**
	Sampling Personnel:	

EQUIPMENT				**SAMPLE BOTTLES**		**# Bottles**	**SAMPLE METHOD**
Purging:		**Sampling:**			40 mL vial, HCl		
	Grundfos		Grundfos		40 mL vial, no pres.		
	Fultz		Fultz		Liter Amber, HCl		
	Bailer		Bailer		Liter Amber, no pres.		
	Horiba		Horiba		250 mL poly, no pres.		
	YSI		YSI		250 mL poly, HNO3		
	Peristaltic		Peristaltic		125 mL poly, no pres.		
	Proactive		Proactive		250 mL, amber vial		
	Hydrolab						
Notes:							
Work Plan Approved Decontamination Procedures Followed?							

Well Diameter (in):	**Depth of well from TOC (ft):**			
Depth to Groundwater (ft):	**Length of Water Column (ft):**	0	**Start:**	**Finish:**
Total Purge Volume (L):		**Purge:**		
Sediment Thickness (ft):		**Sample:**		

Time									
Depth to Water	**ft-bgs**								
Purge Volume	**L**								
Pumping Rate	**L/min**								
Temperature	**C**								
Conductivity	**mS/cm**								
DO	**mg/L**								
pH	**units**								
TDS	**g/L**								
ORP	**mV**								
Turbidity	**NTU**								
Odor									
Color									

Field Parameters (continued)

Time									
Depth to Water	**ft-bgs**								
Purge Volume	**L**								
Pumping Rate	**mL/min**								
Temperature	**C**								
Conductivity	**mS/cm**								
DO	**mg/L**								
pH	**units**								
TDS	**g/L**								
ORP	**mV**								
Turbidity	**NTU**								
Odor									
Color									

Notes:

1 ft. of water in 2" dia. Well = 0.16 gal

1 ft. of water in 4" dia. Well = 0.65 gal

Turbidity Choices: clear, turbid, opaque

Color Choices: clear, brown, gray, milky, orange

Figure 3

Figure 4
Laboratory Analytical Methods, Sample Preservation, and Holding Times

Parameter	Tech	Matrix[1]	EPA Approved Method[2]	SW846 Method[3]	Rec. Volume	Bottle Type	Preservative[4]	Temp	Holding Time	Holding Time Units
Bacteria										
Chlorophyll A/Pheophytin A	Spec	NPW	SM10200H	NA	1L	Amber Glass	None	0 - 6°C	72	Hours
Coliform, Total	MF, MUG	NPW	SM9222B	NA	110ml	Micro	$Na_2S_2O_3$	0 - 6°C	8	Hours
E. Coli	MUG	NPW	SM9223B, Colilert	NA	110ml	Micro	$Na_2S_2O_3$	0 - 6°C	8	Hours
Enterococci		NPW	ASTM D6503-99, Enterolert	NA	110ml	Micro	$Na_2S_2O_3$	0 - 6°C	8	Hours
Fecal Coliform	MF, MUG	NPW	SM9222D	NA	110ml	Micro	$Na_2S_2O_3$	0 - 6°C	6	Hours
Fecal Coliform	MPN	NPW	SM9221C/E	NA	110ml	Micro	$Na_2S_2O_3$	0 - 6°C	6	Hours
Heterotropic Plate Count	Pour Plate	NPW	9215B	NA	110ml	Micro	$Na_2S_2O_3$	0 - 6°C	6	Hours
Salmonella	MPN	NPW	SM9260D	NA	110ml	Micro	$Na_2S_2O_3$	0 - 6°C	8	Hours
Inorganic Classic										
Acidity	Spec	NPW	SM2310B, ASTM D1067	NA	250ml	HDPE	None	0 - 6°C	14	Days
Alkalinity	Titr	NPW	SM2320B	NA	500ml	HDPE	None	0 - 6°C	14	Days
Alkalinity	Spec	NPW	310.2	NA	500ml	HDPE	None	0 - 6°C	14	Days
Ammonia Nitrogen	Spec	NPW	350.1, SM4500NH_3G	NA	500ml	HDPE	H_2SO_4+$Na_2S_2O_3$	0 - 6°C	28	Days
Ammonia, distilled/titration (4500)	Elec	NPW	SM4500NH_3C	NA	500ml	HDPE	H_2SO_4+$Na_2S_2O_4$	0 - 6°C	28	Days
Asbestos	TEM	NPW	100.1	NA	1L	Glass	None	0 - 6°C	48	Hours
BOD/CBOD (Total & Soluble)	Probe	NPW	SM5210B	NA	1L	HDPE	None	0 - 6°C	48	Hours
Bromide	IC	NPW	300.0, SM4110B	9056	125ml	HDPE	None	0 - 6°C	28	Days
Carbon Dioxide	Calc	NPW	SM4500CO2 D	NA	1L	HDPE	None	0 - 6°C	15	Min
Chemical Oxygen Demand (COD)	Spec	NPW	410.4, SM5220D	NA	250ml	HDPE	H_2SO_4	0 - 6°C	28	Days
Chemical Oxygen Demand (COD), Soluble	Spec	NPW	410.4, SM5220D	NA	250ml	HDPE	None	0 - 6°C	28	Days
Chloride	IC	NPW	300.0, SM4110B	9056	125ml	HDPE	None	0 - 6°C	28	Days
Chlorine, residual	Spec	NPW	SM4500Cl-G	NA	250ml	HDPE	None	0 - 6°C	15	Min
Color	PtCo	NPW	SM2120B	NA	250ml	HDPE	None	0 - 6°C	48	Hours
CTAS Surfactants	Spec	NPW	SM5540D	NA	1L	HDPE	None	0 - 6°C	48	Hours
Cyanide - Total	Spec	NPW	335.4, SM4500CNE	9012	250ml	Amber HDPE	NaOH	0 - 6°C	14	Days
Cyanide - Total	Kelada	NPW	Kelada-01	NA	250ml	Amber HDPE	NaOH	0 - 6°C	14	Days
Cyanide, Amenable	Spec	NPW	SM4500CNG	9012	250ml	Amber HDPE	NaOH	0 - 6°C	14	Days
Cyanide, Free	Spec	NPW	SM4500CNE	NA	250ml	Amber HDPE	NaOH	0 - 6°C	14	Days
Cyanide, Weak Acid Dissoc.	Spec	NPW	SM4500CN-I	NA	250ml	Amber HDPE	NaOH	0 - 6°C	14	Days
Dissolved Organic Carbon (DOC)	Comb/ oxi	NPW	SM5310B	9060	250ml	Amber Glass	None	0 - 6°C	28	Days
Ferrous Iron	Spec	NPW	SM3500FeB	NA	250ml	Amber Glass	HCl	0 - 6°C	15	Min
Fluoride	IC	NPW	300.0, SM4110B	9056	125ml	HDPE	None	0 - 6°C	28	Days
Hardness	Calc	NPW	200.7, SM2340B	NA	250ml	HDPE	HNO_3	0 - 6°C	180	Days
Hardness	Spec	NPW	130.1	NA	500ml	HDPE	HNO_3	0 - 6°C	180	Days
Hardness	Titr	NPW	SM2340C	NA	500ml	HDPE	HNO_3	0 - 6°C	180	Days
Iodide	Titr	NPW	345.1	NA	250ml	HDPE	None	0 - 6°C	Immed	
Kjeldahl Nitrogen, TKN	Spec	NPW	351.2, SM4500NorgB/C	NA	250ml	HDPE	H_2SO_4	0 - 6°C	28	Days
Methylene Blue Active Subst. (MBAS)	Spec	NPW	SM5540C	NA	250ml	HDPE	None	0 - 6°C	48	Hours
Nitrate	IC	NPW	300.0, SM4110B	9056	125ml	HDPE	None	0 - 6°C	48	Hours
Nitrate + Nitrite	Spec	NPW	353.2, SM4500NO_3F	NA	250ml	HDPE	H_2SO_4	0 - 6°C	28	Days
Nitrite	IC	NPW	300.0, SM4110B	9056	125ml	HDPE	None	0 - 6°C	48	Hours
Oil & Grease (Hexane Extr)	Grav HEM	NPW	1664A, SM5520B	9070	1L	Glass	HCl	0 - 6°C	28	Days
Oil & Grease, Free	Grav	NPW	1664A	9070	1L	Amber Glass	None	0 - 6°C	28	Days
Organic Nitrogen	Calc	NPW	351.2 - 350.1	NA	500ml	HDPE	H_2SO_4	0 - 6°C	28	Days
Oxygen, dissolved (DO)	Probe	NPW	SM4500O C, SM4500O G	NA	125ml	HDPE	None	0 - 6°C	15	Min
pH	Elec	NPW	SM4500H B	9040	125ml	HDPE	None	0 - 6°C	15	Min
Phenols (Total) by 4AAP	Spec	NPW	420.1, 420.4	9066	250ml	Amber Glass	H_2SO_4	0 - 6°C	28	Days
Phosphate, Ortho	Spec	NPW	365.1, SM4500P-E	NA	250ml	HDPE	None	0 - 6°C	48	Hours
Phosphorus, Total	Spec	NPW	365.1, SM4500P-B.5	NA	250ml	HDPE	H_2SO_4	0 - 6°C	28	Days
Residue, Filterable (TDS)	Grav	NPW	SM2540C	NA	250ml	HDPE	None	0 - 6°C	7	days
Residue, non-Filterable (TSS)	Grav	NPW	SM2540D	NA	1L	HDPE	None	0 - 6°C	7	Days
Residue, Settleable (SS)	Grav	NPW	SM2540F	NA	1L	HDPE	None	0 - 6°C	48	Hours
Residue, Total (TS)	Grav	NPW	SM2540B	NA	250ml	HDPE	None	0 - 6°C	7	Days
Specific Conductance (Conductivity)	Cond.	NPW	120.1, SM2510B	9050	250ml	HDPE	None	0 - 6°C	28	Days
Sulfate	IC	NPW	300.0, SM4110B	9056	125ml	HDPE	None	0 - 6°C	28	Days
Sulfide	Titr	NPW	NA	9030, 9034	500ml	HDPE	NaOH+ZnAc	0 - 6°C	7	Days
Sulfide	Spec	NPW	SM4500S^2D	NA	500ml	HDPE	NaOH+ZnAc	0 - 6°C	7	Days

Figure 4
Laboratory Analytical Methods, Sample Preservation, and Holding Times

Parameter	Tech	Matrix[1]	EPA Approved Method[2]	SW846 Method[3]	Rec. Volume	Bottle Type	Preservative[4]	Temp	Holding Time	Holding Time Units
Sulfide, Dissolved	Spec	NPW	SM4500S^2D	NA	125ml	Amber Glass	NaOH+ZnAc	0 - 6°C	7	Days
Sulfite	Titr	NPW	SM4500SO_3B	NA	250ml	HDPE	None	0 - 6°C	15	Min
Tannins and Lignins	Spec	NPW	SM5550B	NA	250ml	HDPE	None	0 - 6°C	NA	
Temperature	Therm	NPW	SM2550B	NA	onsite		None	0 - 6°C	15	Min
Total Organic Carbon (TOC)	Comb/ oxi	NPW	SM53010B	9060	250ml	Amber Glass	HCl	0 - 6°C	28	Days
Total Organic Halides (TOX)	MC Titr	NPW	450.1, SM5320B	NA	1L	Amber Glass	H_2SO_4	0 - 6°C	28	Days
Turbidity	Neph	NPW	180.1, SM2130B	NA	250ml	HDPE	None	0 - 6°C	48	Hours
Volatile Solids (VS)	Grav	NPW	160.4	NA	250ml	HDPE	None	0 - 6°C	7	Days
Volatile Susp. Solids (VSS)	Grav	NPW	SM2540E	NA	500ml	HDPE	None	0 - 6°C	7	Days
Inorganic Metals										
Chromium, Hexavalent - Cr^{+6}	Spec	NPW	SM3500CrB	7196	250ml	HDPE	None	0 - 6°C	24	Hours
Chromium, Hexavalent - Cr^{+6}	IC	NPW	SM3500CrC	7199	250ml	HDPE	None	0 - 6°C	24	Hours
Chromium, Hexavalent - Cr^{+6}	IC	NPW	218.6, SM3500CrC	NA	125ml	HDPE	$(NH_4)_2SO_4$	0 - 6°C	28[5]	Days
Mercury (Dissolved)	CVFAA	NPW	245.1	7470	500ml	HDPE	None	0 - 6°C	28	Days
Mercury (Total)	CVFAA	NPW	245.1	7470	500ml	HDPE	HNO_3	0 - 6°C	28	Days
Metals (Dissolved) ICP	ICP	NPW	200.7	6010	500ml	HDPE	None	NA	180	Days
Metals (Dissolved) ICPMS	ICPMS	NPW	200.8	6020	500nl	HDPE	None	NA	180	Days
Metals (Total) ICP	ICP	NPW	200.7	6010	500ml	HDPE	HNO_3	NA	180	Days
Metals (Total) ICPMS	ICPMS	NPW	200.8	6020	500ml	HDPE	HNO_3	NA	180	Days
Physical										
Flashpoint/ignitability (Closed Cup)	PM	NPW	ASTM 93-07	1010	1L	Glass	None	0 - 6°C	14	Days
Flashpoint/ignitability (Open Cup)	PM	NPW	ASTM 92-05A	NA	1L	Glass	None	0 - 6°C	14	Days
Organic - Semivolatiles										
Base/Neutral/Acid (BNA)	GCMS	NPW	NA	8270	1L or 100mL	Amber Glass	None	0 - 6°C	7	Days
Base/Neutral/Acid (BNA)	GCMS	NPW	625, SM6410B	NA	1L or 100mL	Amber Glass	$Na_2S_2O_3$	0 - 6°C	7	Days
Diesel Range Organics	GC	NPW	NA	8015	1L, 100mL, or 40mL	Amber Glass	HCl	0 - 6°C	7	Days
Dioxin	HR GCMS	NPW	1613	NA	1L	Amber Glass	$Na_2S_2O_3$	0 - 6°C	1	Year
EDB/DBCP	GC	NPW	NA	8011	2 x 40 ml	Glass	$Na_2S_2O_3$	0 - 6°C	7	Days
Formaldehyde	HPLC	NPW	NA	8315	1L	Amber Glass	None	0 - 6°C	3	Days
Herbicides	GC	NPW	1658, SM6640B	8151	1L	Amber Glass	None	0 - 6°C	7	Days
Polynuclear Aromatic Hydrocarbons (PAH)	GC/MS	NPW	625, SM640B	8270	1L, 100mL, or 40mL	Amber Glass	None	0 - 6°C	7	Days
Polynuclear Aromatic Hydrocarbons (PAH-SIM)	GC/MS	NPW	NA	8270	1L, 100mL, or 40mL	Amber Glass	None	0 - 6°C	7	Days
Polynuclear Aromatic Hydrocarbons (PAH)	HPLC	NPW	610, SM6440B	8310	1L	Amber Glass	None	0 - 6°C	7	Days
Pesticides - Organophos Comp	GC	NPW	614, 622, 1657	8141	1L	Amber Glass	None	0 - 6°C	7	Days
Pesticides & PCB's	GC	NPW	608, SM6630B, SM6630C	8081, 8082	1L or 100mL	Amber Glass	None	0 - 6°C	7	Days
Organic - Volatiles										
Meetac - Methanol and Ethanol	GCMS	NPW	NA	EPA 8015 Mod	40ml	Amber Glass	HCl	0 - 6°C	14	Days
Methane, Ethane, Ethene, Propane	GC	NPW	RSK-175	NA	40ml	Amber Glass	HCl	0 - 6°C	14	Days
BTEX (water)	GC	NPW	602, SM6200C	8021	2 x 40 ml	Amber Glass	HCl	0 - 6°C	14	Days
BTEX (water)	GC	NPW	602, SM6200C	8021	2 x 40 ml	Amber Glass	None	0 - 6°C	7	Days
Gasoline Range Organics (GRO)	GC	NPW	NA	8015	2 x 40 ml	Amber Glass	HCl	0 - 6°C	14	Days
VOC's	GC/MS	NPW	624, SM6200B	8260	2 x 40 ml	Amber Glass	HCl	0 - 6°C	14	Days
VOC's	GC/MS	NPW	624, SM6200B	8260	2 x 40 ml	Amber Glass	none	0 - 6°C	7	Days
Radiochemistry										
Rad - Gross alpha		NPW	900	na	1L	Plastic	HNO_3	0 - 6°C	180	Days
Rad - Gross beta		NPW	900	na	1L	Plastic	HNO_3	0 - 6°C	180	Days
Rad - Radium 226		NPW	903.1	na	1L	Plastic	HNO_3	0 - 6°C	180	Days
Rad - Radium 228		NPW	904	na	1L	Plastic	HNO_3	0 - 6°C	180	Days

Footnotes:

1) Matrix - NPW=Nonpotable Water, PW= Potable Water, SS=Solids

2) EPA Approved Method - Where applicable EPA methods are listed. Compounds/programs not regulated by EPA will have methods appropriate to their regulatory oversight.

3) SW846 Method - Where one exists, the appropriate Solid Waste method will be listed

4) Preservative Key

$(NH_4)_2SO4$ = Ammonium Sulfate

AcAcid = Acetic Acid

Figure 4
Laboratory Analytical Methods, Sample Preservation, and Holding Times

Parameter	Tech	Matrix[1]	EPA Approved Method[2]	SW846 Method[3]	Rec. Volume	Bottle Type	Preservative[4]	Temp	Holding Time	Holding Time Units

CH_3Cl = Methylene Chloride
H_2SO_4 = Sulfuric Acid
HCl= Hydrochloric Acid
HNO_3 = Nitric Acid
MeOH = Methanol
$Na_2S_2O_3$ = Sodium Thiosulfate
$NaHSO_4$ = Sodium Bisulfate
NH_4Cl = Ammonium Chloride
TSP = Trisodium Phosphate
ZnAc = Zinc Acetate

5) Must be field filtered to achieve the extended holding time.
6) Must be received by lab within 7 days of sampling for solvent addition.
7) Must be received by lab within 4 days of sampling for solvent addition.
8) Must be received by lab within 48 hours of sampling for freezing.
9) Must be received by lab within 72 hours of sampling for solvent addition.

Attachment III –Quality Assurance/Quality Control (QA/QC) Plan

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Quality Assurance / Quality Control (QA/QC) Plan, Rev. 1
Fly Ash Pond Complex Closure
Tanners Creek Power Plant
S&ME Project No. 7217-17-007

Prepared for:
Tanners Creek Development, LLC
1515 Des Peres Rd., Suite 300
St. Louis, MO 63131

Prepared by:
S&ME, Inc.
6190 Enterprise Court
Dublin, OH 43016

October 18, 2017
Revised March 9, 2018

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Table of Contents

List of Tables

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1.0 General

This Construction Quality Assurance / Quality Control (QA/QC) Plan has been developed in support of the closure of the Fly Ash Pond at the former Tanners Creek Station in Lawrenceburg, IN.

The purpose of this plan is to outline the procedures to be used to certify the construction of the closure of the Fly Ash Pond. This QA/QC Plan is written using generic terminology (i.e., "Permitting Agency", "Owner," or "Owner's Representative" versus actual names or entities).

1.1 Scope of the QA/QC Plan

For each of the proposed engineered components, this QA/QC Plan describes, as applicable, the following:

- Material Requirements;
- Installation Procedures;
- Sampling and testing procedures to be used in the field and in the lab;
- Required test parameters and frequency; and,
- Procedures to be followed if a test fails;

1.2 Responsibility and Authority

The principal parties involved in the QA/QC include the Permitting Agency, the Owner, the Engineer, the Owner's Representative, and the Contractor. The general responsibilities and authorities of each of these parties are described in the following paragraphs. The responsibility and/or authority of a given party may be modified or expanded as dictated by specific project needs during the Pre-Construction Meeting. It is understood that the Owner may also serve as the Contractor for selected construction elements.

1.2.1 Permitting Agency

Although a formal permit will not be issued for this project by the State of Indiana, the work will be carried out in accordance with the approved closure plan. The Indiana Department of Environmental Management (IDEM) will approve the closure plan and may be considered to act as the permitting agency within the context of this plan. For the purposes of this document, the Permitting Agency will be understood to mean IDEM.

1.2.2 Owner

The Owner is responsible for coordinating the permitting, design, and construction of the ash pond closure. The Owner is responsible for all correspondence with the Permitting Agency, unless the owner designates this responsibility to the Engineer or Owner's Representative. The Owner also manages the activities of the Engineer, and the Owner's Representative. This responsibility includes compliance with the permit, and the submission of QA/QC documentation demonstrating that the facility was constructed in accordance with the design specifications. The Owner is also responsible for procuring a Contractor(s) as required for construction.

The Owner has the authority to select, and dismiss parties charged with permitting, design, construction, and QA/QC. The Owner has the authority to accept or reject permitting documents, design plans, QA/QC Plans, and QA/QC reports. The Owner also has the authority to accept or reject the Contractor's materials and/or workmanship.

1.2.3 Engineer

The Engineer is the firm, retained by the Owner, responsible for preparing permit and design documents for acceptance by the Permitting Agency. These documents include forms, narratives, QA/QC Plan, and any design plans and technical specifications, which support the permitting, and design of the closure. The permit and design documents provide minimum specifications, and are the governing document when a material specification contradiction arises.

During construction, the Engineer may be requested to clarify discrepancies in the documents or the QA/QC Plan, and may approve substantive changes to the design plans or specifications of the facility. Substantive changes include any changes that modify or impact the technical basis for any engineered component of the facility design.

The Engineer for this project is S&ME, Inc.

1.2.4 Owner's Representative

The Owner's Representative is responsible for observing and documenting on-site activities related to the permit documents, design plans, and the QA/QC Plan. In general, the responsibilities and authorities of the Owner's Representative include:

- Complete understanding of the permit documents, design plans, and specifications in relation to all aspects of the QA/QC Plan.
- Scheduling, coordinating, and performing QA/QC activities.
- Performing independent on-site observation of the work in progress to assess compliance with the QA/QC Plan, permit documents, design plans, and technical specifications.
- Recognizing and reporting deviations from the QA/QC Plan, permit documents, design plans, and technical specifications to the Owner.
- Secure documents that approve changes to the QA/QC Plan, permit documents, design plans, and technical specifications.
- Verifying that test equipment meets testing and calibration requirements, and that the tests are conducted according to standardized procedures.
- Recording and maintaining test data.
- Identifying QA/QC tested work that should be accepted, rejected, or further evaluated.
- Verifying that corrective measures are implemented.
- Documenting and reporting QA/QC activities.
- Maintaining open lines of communications with other parties involved in the construction.

The Owner's Representative shall employ the Certifying Engineer who shall have overall Construction Quality Assurance (CQA) responsibility and authority to ensure the Closure is constructed as specified and in accordance with this QA/QC Plan. The CQA Certifying Engineer shall be a registered Professional

Engineer (P.E.) in the State of Indiana. All construction certification documents shall be prepared under the direction of the CQA Certifying Engineer.

1.2.5 QA/QC Personnel

The QA/QC Personnel shall be trained in the proper use of the test methods and equipment for which they are responsible. They shall be able to calibrate their equipment, conduct the required tests, record and interpret data, and record their observations.

Specific responsibilities of the QA/QC Inspectors include:

- Conduct observations and tests to assess compliance with the plans, construction requirements, and quality assurance documents.
- Monitor tests and construction procedures conducted by the construction contractors.
- Report the results of all testing and observations including work that does not meet the construction requirements, fails to meet contract requirements, or deviates from permissible construction procedures.

The QA/QC personnel will report directly to the Owner's Representative who will then report to the Owner.

1.2.6 Contractor

The Contractor, including any subcontractors, is responsible for constructing the components of the closure system. The Contractor may be either the Owner of the site, or a construction firm retained by the Owner.

1.3 Project Meetings

To achieve a high degree of quality during construction, clear, open channels of communication are essential. All meetings will be open to representatives of the Permitting Agency. All meetings will be documented and the files will be retained for the pond closure records. The documentation will be provided in the construction certification report.

1.3.1 Pre-Construction Meeting

A Pre-Construction Meeting will be held at the project site for the purposes of ensuring coordination of all aspects of the QA/QC Plan. The meeting will be attended by all relevant entities involved with implementing the QA/QC Plan, including the Owner, the Engineer, the Owner's Representative, the Contractor, the Permitting Agency, and other involved parties. The meeting will address the following topics:

- Provide each involved entity with all relevant QA/QC documents and supporting information addressing the site-specific QA/QC plan and its role relevant to the construction plans.
- Review the responsibilities, authorities and lines of communication for each of the involved entities.
- Review the established procedures of observation and testing, including sampling strategies identified in the QA/QC Plan.

- Review the established acceptance and rejection criteria as specified in the QA/QC Plan.
- Review the approved specifications, with methods and means for decision making and resolution of problems pertaining to data.
- Review methods for documenting and reporting all inspection data.
- Discuss procedures for the storage and protection of construction material on-site.
- Organize for relevant persons a site walk-around to review the project site layout, construction material and equipment storage locations.
- Discuss the QA/QC plan and other relevant issues and concerns.
- Discuss storm water management practices and sedimentation control appropriate for the construction work or as outlined in the construction specifications and plans

1.3.2 *Daily Meetings*

Whenever necessary, daily meetings will be held between the Owner's Representative, Contractor, and other involved parties. Those attending will discuss, plan, coordinate the work, and QA/QC activities to be completed that day. The Owner's Representative will document the meeting as part of the Owner's Representative's daily record keeping requirements.

1.3.3 *Progress Meetings*

Progress meetings will be held between the Owner's Representative, Contractor, and other parties at a schedule determined by the parties involved based on the work being performed on-site. Those attending will discuss current progress, planned activities for the next week, and new business or revisions to the work as part of the Owner's Representative's daily record keeping requirements.

1.3.4 *Problem or Work Deficiency Meetings*

A special meeting will be held when and if a problem or deficiency, which would impact the construction schedule, is present or likely to occur. The meeting will be attended by the Contractor, affected subcontractors, Owner, and Owner's Representative. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

- Define and discuss the problem or deficiency.
- Review alternative solutions.
- Implement an action plan to resolve the problem or deficiency.

The meeting will be documented by the Owner's Representative, as per the Owner's Representative's daily record keeping requirements. The Owner's Representative will also prepare meeting minutes.

2.0 Documentation and Certification

The Owner's Representative shall document that quality control requirements have been addressed and satisfied. The Engineer shall conduct a final inspection on the completed facilities prior to the issuance of each Certification Report.

The Owner's Representative shall provide the Owner with data sheets and other supporting documents which verify that all monitoring activities have been carried out. The Owner's Representative shall also maintain a complete file of design plans, design specifications, the QA/QC Plan, checklists, test procedures, daily logs, and other pertinent documents. The documents should be readily available upon request from interested parties.

2.1 Daily Recordkeeping

Standard reporting procedures shall include preparation of a daily report by the Owner's Representative or their on-site QA/QC personnel.

Other forms of daily recordkeeping to be used, as appropriate, include construction problem and solution data sheets, design and/or specifications changes reporting forms. This information shall be periodically submitted to and reviewed by the Owner.

2.1.1 Daily Summary Report

The Owner or Owner's Representative shall prepare a Daily Summary Report which shall include the following information when applicable:

- An identifying sheet number for cross referencing and document control;
- Date, project name, location, and other identification;
- Weather conditions;
- Information on meetings held or discussions which took place (when applicable);
- Names of parties in discussions (when applicable);
- Relevant subject matter or issues;
- Decisions reached (when applicable);
- Descriptions and locations of ongoing construction;
- Descriptions and specific locations of areas, or units, of work being tested and/or observed and documented;
- Locations where tests and samples were taken or reference to specific observation logs and/or test data sheets where such information can be found;
- A summary of field/laboratory test results or reference to specific observation logs and/or test data sheets;
- Calibrations or recalibrations of test equipment and actions taken as a result of recalibration, or reference to specific observation logs and/or test data sheets (when applicable);
- Off-site materials received, including quality verification documentation;
- Decisions made regarding acceptance of units of work and/or corrective actions to be taken in instances of substandard quality, and;
- The Owner's Representative's name.

2.1.2 Problem Identification and Corrective Measures Report

Reports describing special construction situations, as required by the Owner, shall be prepared by the Owner's Representative, and cross-referenced to specific observation logs and test data sheets. These reports shall include the following information:

- An identifying sheet number for cross-referencing and document control.
- A detailed description of the situation or deficiency.
- The location and probable cause of the situation or deficiency.

- How and when the situation or deficiency was found or located.
- Documentation of the corrective action taken to address the situation or deficiency.
- Final results of any responses.
- Any measures taken to prevent a similar situation from occurring in the future.
- The signature of the Owner's Representative.

The Owner shall be made aware of any significant recurring non-conformance with the design specification. The Owner's Representative shall then determine the cause of the non-conformance and recommend appropriate changes in procedure or specification to the Owner. These changes will be submitted to the Engineer for approval. When this type of evaluation is made, the results shall be documents, and any revision made to procedures, design specifications, or permit specifications will be approved by the Engineer, Owner, and if necessary, the Permitting Agency.

2.1.3 Design and/or Specification Changes

Design and/or permit specification changes may be required during construction. In such cases, the Owner's Representative shall notify the Owner. The Owner shall then notify the Permitting Agency, if necessary. Design and/or permit specification changes shall be made only with the written agreement of the Owner and the Engineer.

2.2 Construction Reporting

The Owner's Representative shall prepare periodic progress reports, which summarize construction activities and the results of observations and tests. Progress reports shall be prepared at regular time intervals to document the status of the work. Certifications shall be prepared at the completion of major construction activities. At the completion of the work, final documentation shall be prepared and shall include a professional engineers seal and supporting field and laboratory test results.

2.2.1 Progress Reports

The Owner's Representative shall prepare a Progress Report at time intervals established at the pre-construction meeting, and submit the report to the Owner. At a minimum, this report shall include the following information at a frequency as requested by the Owner:

- A unique identifying sheet number for cross-referencing and document control.
- The date, project name, location, and other information.
- A summary of work activities during progress reporting period.
- A summary of construction situation, deficiencies, and/or defects occurring during the progress reporting period.
- A summary of test results, failures, and retests.
- The signature of the Owner's Representative's representative.

The Owner's Representative shall distribute copies of the Progress Reports as decided upon at the pre-construction meeting.

2.2.2 Certification of Construction Activities

At the completion of construction of the final cover system, the Owner's Representative shall prepare a construction certification report (CCR). The CCR shall describe activities associated with the construction of the item including construction procedures, and observations and tests performed by the QA/QC personnel. In the CCR, the registered professional engineer shall certify that the construction of the liner system components, including all permanent storm water control measures, has been completed in accordance with the approved construction plans and this QA/QC plan and in accordance with any other conditions imposed in the approved closure plan.

The CCR shall include a legal description the Fly Ash Pond Complex solid waste boundary.

Certification of closure will not be made for the ash pond until the final cover has been completed and vegetation has been established.

2.3 Sample Archiving

The Owner's Representative shall be responsible for archiving QA/QC samples during the construction of each phase of the ash pond closure. QA/QC samples shall be archived at an on-site location during each construction phase until IDEM approves the construction certification report, after which the samples will be discarded.

3.0 CONSTRUCTION PROCEDURES

The following sections discuss the construction procedures and associated CQA for subgrade earthwork and cap system construction.

3.1 Subgrade Construction

The proposed facility cover system subgrade elevations are shown on the plans and will be established primarily by excavation and regrading (cut/fill) of the in-place materials. If required, ash may be obtained from, or placed in the adjacent landfill to reach the proposed grades. Excavated soil may be stockpiled for future use as cover soil provided if is free of ash or other unacceptable materials. Subgrade construction activities at the site will include stripping existing vegetation, ash regrading/placement, and smooth-drum rolling to provide a smooth subgrade surface for the geomembrane.

3.2 Ash Placement

3.2.1 Ash Fill Placement

Fill material shall be generally free of debris, including significant amounts of vegetation. Fill shall not be placed upon frozen surfaces nor shall snow, ice, or frozen earth be incorporated in the fills.

The six inches of material immediately beneath the cap system (i.e. top of the ash) shall be free of all rocks, stones, sticks, and debris of any kind, with no particle larger than three-eighths inch diameter. Angular, sharp material is not allowed in the upper 6-inches of ash placed, regardless of diameter.

3.2.2 Compaction

All areas to receive ash fill are to be stripped of topsoil and organic materials on the surface of the ash. The stripped materials can be disced or bladed into the in-situ material. Placement of ash will be performed with a dozer and in loose lifts no greater than 12 inches. If within five (5) feet of final subgrade (fill areas only), compaction will be performed using equipment sufficient to achieve an in-place dry density of at least 85% of the Standard Proctor maximum dry density. A test strip will be performed to determine the level of effort and associated equipment required to achieve this. The test strip will be monitored by CQA personnel. Removal and re-compaction of the existing ash within the upper five (5) feet below proposed final subgrade is not required.

Quality assurance criteria for contouring fill and structural fill shall include the requirements as listed in Table 2-1:

Table 3-1: Requirements for Contouring Fill with Existing Ash

Test	Frequency and Timing	Acceptance Parameters	Sample Location	Test Failure Procedures
Free of Unacceptable Material	Continuous visual observation by equipment operators	Free of debris, foreign, or deleterious materials	In-situ fly ash comprising foundation	Remove unacceptable material and replace with structural fill
Material Size	Visual Observation by operator	Not greater than the compacted lift thickness	Borrow Source or Stockpile prior to placement	Remove oversized material
Abrupt grade changes	Visual observation, prior to surveying	Grade changes no greater than 45° or creases no deeper than 1 inch	Final Subgrade graded surface	Regrade surface and/or remove excessive creases by altering roller pattern
Survey to determine bottom of cover system	100 ft grid and swale centerlines and other critical locations	Positive Drainage in General Accordance with Closure Plan Grades	Top of finished subgrade layer	Regrade and resurvey

Quality assurance criteria for contouring fill and structural fill shall also include the following requirements for the final lift.

- The final subgrade surface will be visually observed by the CQA Personnel and smooth-drum rolled;
- The finished subgrade surface will be firm, uniform, and consistent with the design lines and grades.

3.2.3 Moisture Control

The moisture content of the ash material shall be sufficient to reduce dusting during the project. Water will be added during compaction if deemed necessary to achieve the performance required. No minimum water content is specified for the ash material.

When the fill is too dry, sufficient water shall be added to the material by a method approved by the Owner's Engineer to bring the moisture content into the acceptable range. When the fill material is too wet, the material shall be disced, harrowed, or otherwise aerated to reduce the moisture content to within the above specified limits.

3.3 Geomembrane

This section addresses activities associated with the geomembrane to be used in the final cover system. The geomembrane is to be placed directly over the ash placed in accordance with the requirements of Section 3.2. All geomembrane installation activities will be monitored on an as needed basis by QA/QC Personnel.

The following information will be obtained by or provided to the Owner's Representative for all components of the geomembrane as discussed further in this section. The manufacturer or installer are required to submit the information that applies:

- Documentation provided by the manufacturer that describes quality control and quality assurance tests conducted on raw materials and products used in the construction of the liner system component, including a description of methods for sample selection and the frequency with which tests were conducted.
- Certification that the QA/QC tests were conducted in accordance with the approved construction plan.
- A summary of the results of all testing, including documentation of any failed test results.
- A description of corrective measures taken in response to failed tests.
- A description of all retesting conducted and the results of those tests.
- Documentation provided by the Installer that describes the previous relevant work experience and qualifications of the field crew foreman in charge of liner installation.

3.3.1 Material Requirements

The geomembrane for the ash pond cover system will be a 40 mil LLDPE or 60 mil HDPE geomembrane. The geomembrane will be smooth or textured, depending on its location, as detailed in the drawings. The geomembrane will be installed directly in contact with the prepared ash subgrade. Construction of the geomembrane will be performed in accordance with the requirements of this QA/QC Plan.

Quality assurance activities for the geomembrane material consist of obtaining written documentation and quality control test results from the manufacturer that the supplied geomembrane panels comply with the minimum specifications, discussed within this QA/QC Plan. The minimum specifications for a 40-mil LLDPE liner shall be as specified in the most recent version of Geosynthetics Research Institute (GRI) Test Method GM 17 for textured LLDPE geomembranes. The manufacturer's testing frequencies shall meet or exceed the minimum required in Table 1(a) for smooth or Table 2(a) for of the GM 17 specification for the tests specified in Table 3-2. The minimum specifications for a 60-mil HDPE liner shall be as specified in the most recent version of Geosynthetics Research Institute (GRI) Test Method GM 13 for textured HDPE geomembranes. The manufacturer's testing frequencies shall meet or exceed the minimum required in Table 1(a) for smooth or Table 2(a) for of the GM 13 specification for the tests specified in Table 3-2.

No geomembrane shall be installed until the Owner's Representative has reviewed all certifications and supporting test data and determined that the geomembrane furnished for the project is acceptable for use.

Table 3-2: Required Geomembrane Manufacturer Quality Control Testing

Property	Test Method	Frequency
Thickness (textured)	ASTM D5994	**LLDPE** In accordance with GRI-GM 17 requirements; Table 1(a) smooth, Table 2(a) textured **HDPE** In accordance with GRI-GM 13 requirements; Table 1(a) smooth, Table 2(a) textured
Thickness (smooth)	ASTM D5199	
Asperity Height mils (textured only)	ASTM D7466	
Density	ASTM D1505 OR ASTM D792	
Tensile Properties (2) • Yield Strength[1] • Break Strength • Yield Elongation[1] • Break Elongation	ASTM D6693 TYPE IV	
2% Modulus	ASTM D5323	
Tear Resistance	ASTM D1004	
Puncture Resistance	ASTM D4833	
Axi-Symmetric Break Resistance Strain (min.)[2]	ASTM D5617	
Stress Crack Resistance[1]	ASTM D5397	
Carbon Black Content	ASTM 4218 (3)	
Carbon Black Dispersion	ASTM D5596	
Oxidative Induction Time (OIT) (4)		
Standard OIT (min. ave.) **OR**	ASTM D3895	
High Pressure OIT (min. ave.)	ASTM D5885	
Oven Aging at 85°C	ASTM D5721	
Standard OIT (min. ave.) - % retained after 90 days **OR**	ASTM D3895	
High Pressures OIT (min. ave.) - % retained after 90 days	ASTM D5885	
UV Resistance (5)	ASTM D7238	
High Pressure OIT (min. ave.) - % retained after 1600 hrs	ASTM D5885	

(1) HDPE only
(2) LLDPE only

The manufacturer shall also provide the Owner's Representative the results of the testing on raw materials used to produce the geomembrane. The required tests and maximum values are provided in table 3-3.

Table 3-3: Required Geomembrane Resin Properties Testing

Resin Type	Property	Test Method	Required Value	Frequency
LLDPE	Density	ASTM D1505/ D4883	≤ 0.926 g/mL	One per resin batch
	Melt Flow Index	ASTM D1238	< 1.0 g/10 min	
HDPE	Density	ASTM D1505/ D4883	≥ 0.932 g/mL	
	Melt Flow Index	ASTM D1238	< 1.0 g/10 min	

In a review of the testing of raw materials and the geomembrane panels used to manufacture the geomembrane, the Owner' Representative shall do the following:

- Review copies of the origin and identification of the raw materials.
- Review copies of quality control certificates issued by the producers of the raw materials.
- Ensure that the quality control testing meets the specifications of this QA/QC Plan.

In a review of the testing documentation of the geomembrane rolls that are fabricated into geomembrane, the Owner's Representative shall also do the following:

- Check the manufacturer's certified quality control documentation to verify that the geomembrane was continuously inspected during the manufacturing process for the following:
  - Lack of uniformity.
  - Damage.
  - Imperfections.
  - Holes.
  - Cracks.
  - Thin spots.
  - Foreign materials.
- Ensure that any imperfections discovered during inspection were repaired and then re-inspected, either at the manufacturing facility or on-site at the MSWLF.

3.3.2 Conformance Testing

In addition to the manufacturer's quality control testing, the Owner's Representative shall obtain samples for conformance testing. Samples may be obtained prior to shipment at the manufacturing facility by the manufacturer, Engineer or the geosynthetic laboratory. The minimum number of samples shall be one per 100,000 ft^2 or 1 per lot, whichever is more frequent. The samples must be representative of the materials supplied and exclude the outer wrap of geomembrane if evidence of scuffing or other damage is observed. Samples should extend across the full roll width and be at least 3 feet wide.

Representative samples will be sent to a geosynthetics laboratory, paid by the manufacturer, for conformance testing. The laboratory testing program will be directed by the Owner's Representative and include but is not necessarily limited to the tests described in the following table.

Table 3-4: Geomembrane Conformance Testing Summary

Test	Method	Frequency
Thickness	ASTM D5994	One (1) test per 100,000 square feet or one (1) test per lot, whichever is more frequent
Density	ASTM D1505 and/or D 792	
Asperity Height[(1)]	ASTM D 7466 or GRI GM 12	
Carbon Black Dispersion	ASTM D5596	
Carbon Black Content	ASTM D1603	
Tensile Properties:[(2)] • Yield Strength • Break Strength • Yield Elongation • Break Elongation	ASTM D6693	
Tear Resistance	ASTM D1004	
Puncture Resistance	ASTM D4833	

(1) Alternate the Measurement side for double sided textured sheet
(2) Machine direction (MD) and cross machine direction (XMD) average values should on the basis of 5 test specimens each direction.

If a representative sample does not comply with the minimum requirements of GRI-GM 17, Table 2(a), the roll of geomembrane that is in non-conformance shall be replaced at no additional cost to the Owner. The Geosynthetic Installer shall perform additional conformance testing on the closest numerical roll on both sides of the failed roll. Sampling and testing of rolls shall continue until acceptable results are established.

The Owner's Representative shall monitor the rolls upon delivery to the site and report observed deviations from the requirements of this QA/QC Plan to the Contractor. At their discretion, the Owner's Representative may sample rolls from each shipment of geomembrane delivered to the site.

3.3.3 *Delivery, Handling and Storage*

No geomembrane shall be installed until the Owner's Representative has reviewed all certifications and supporting test data and determined that the geomembrane furnished for the project is acceptable for use.

All geomembrane delivery, handling, and unloading shall be performed in the presence of the CQA Personnel. During unloading, the contractor and CQA Personnel shall conduct an inspection of all delivered geomembrane for defects and damage caused by inadequate or improper packaging, shipping, unloading, or handling. The CQA Personnel shall review packing slips or bills of lading to verify delivery of correct materials and that the roll numbers listed on packing slips match the roll numbers on the geomembrane labels. If discrepancies are found, the Owner's Representative shall immediately notify the manufacturer. Any geomembrane that has no label or where the label is damaged or otherwise illegible may either be sampled for laboratory analysis to determine its acceptability, or rejected and removed from the project site, as directed by the Owner's Representative. The Owner's Representative shall also verify that geomembrane production lots, and associated roll numbers, delivered to the project site match the production lots and roll numbers recorded on the approved MQC Certificates. If discrepancies are found, the Owner's Representative shall immediately notify the manufacturer.

All delivery, handling and storage methods should be in conformance with the manufacturer's recommendations. On-site storage shall be as needed to protect the geomembrane rolls from excessive accumulations of soil on the geomembrane surfaces, water, heat, mechanical abrasion, puncture and vehicular traffic.

3.3.4 *Installation*

All aspects of geomembrane installation must be carried out in accordance with the approved construction plans, the approved QA/QC plan and the manufacturer's recommendations.

3.3.4.1 Subgrade Inspection

The QA/QC Personnel shall verify that the geomembrane is installed on supporting soil that is reasonably free of the following:

- Stones.
- Organic Material (except that organic material naturally occurring in the soil).
- Irregularities.
- Protrusions.
- Loose soil or soft spots.
- Standing water.
- Any abrupt change in grade that could damage the geomembrane.

Quality assurance inspection of geomembrane anchors and at penetration attachments includes observations to verify that:

- Anchor trench depths, widths, and locations are as shown on the plans;
- Trench surface and trench backfill are free of sharp edges and jagged rocks;
- The geomembrane is properly installed in the trench or to the penetration; and
- Backfilling and compaction operations do not damage the geomembrane.

3.3.4.2 Geomembrane Inspection

The QA/QC Personnel shall complete a visual inspection of the geomembrane material for the following:

- Lack of Uniformity.
- Damage.
- Imperfections.
- Tears.
- Punctures.
- Blisters
- Excessive Folding.

The QA/QC Personnel shall document that appropriate repairs and re-inspections were made for any deficiencies noted in the material.

3.3.4.3 Field Seaming

Field seaming shall be in accordance with US EPA. Technical Guidance document: "The Fabrication of Polyethylene FML Field Seams" EPA/530/SW-89/069, the manufacturer's recommendations and/or according to this QA/QC Plan, whichever is more stringent. Seaming may be extrusion or fusion welding, with fusion welding being the primary method used by the Geosynthetic Installer. The Engineer reserves the right to reject any proposed seaming method believed to be unacceptable.

Adjoining liner panels shall be overlapped as recommended by the manufacturer, but not less than 4 inches, by adequately lapping the edges of the sheets. The overlap shall not exceed 6 inches for double-wedge fusion welds.

Field seaming should be completed on a compacted smooth surface. Field seaming shall be completed in a manner that leaves the seams free of the following:

- Dust.
- Dirt.
- Moisture.
- Debris.
- Foreign material of any kind.

The following shall be implemented for proper field seaming:

a. All geomembrane shall be seamed the same day that the geomembrane is deployed.
b. All geomembrane shall be ballasted immediately after deployment to prevent uplift by winds.
c. A moveable protective layer of plastic or approved material may be placed directly below each overlap of geomembrane that is to be seamed. This is to prevent any moisture build-up between the sheets to be welded. The protective layer must be removed after welding.
d. All foreign matter (dirt, moisture, oil, etc.) shall be removed from the edges to be bonded. For extrusion welds, the bonding surfaces must be thoroughly cleaned by mechanical abrasion or alternate methods approved by the Engineer to remove surface cure and prepare the surfaces for bonding. No solvents shall be used to clean the geomembrane.
e. Grinding:

    (1) All abrasive buffing shall be performed using No. 80 grit or finer sandpaper.
    (2) The grinding shall be performed so that any and all grind marks are perpendicular to the edge of sheet.
    (3) No grinding greater than 1/4 inch outside the welds is permitted or the Engineer can require patching.

f. As much as practical, field seaming shall start from the top of the slope down. This will minimize large wrinkles from becoming trapped that require cutting and patching.

g. Seaming of the bottom geomembrane to the sidewall geomembrane (toe seam) shall be conducted when conditions minimize thermal expansion effects.
h. Tack welds (if used for temporary conditions) shall use heat only; no double sided tape, glue or other method will be permitted.
i. The geomembrane should be seamed completely to the ends of all panels to minimize the potential of tear propagation along the seam.
j. Seaming will extend to the outside edge of panels to be placed in anchor trenches. If required, a firm substrata should be provided by using a flat board, or similar hard surface directly under the seam overlap to achieve proper support across the anchor trench.
k. The completed geomembrane shall not exhibit any "trampolining" during late morning to early evening hours. All areas exhibiting trampolining must be repaired as directed by the Engineer. Additional slack (i.e.: 1-3%) shall be allowed on the side slopes to reduce the potential for trampolining.
l. All field seams must be uniform in appearance, width and properties, and shall not exhibit warping due to overheating form welding.
m. The peel and shear strengths of the welded seams must comply with the strength criteria stated in Table 3-5 of this Section.
n. Ambient Weather Conditions:

   (1) Ambient temperature is measured 18 inches above the geomembrane surface.
   (2) The Geosynthetics Installer shall supply instrumentation for measurement of ambient temperature.
   (3) Welding of field seams shall not take place except during suitable ambient weather conditions, as confirmed by field trial test welds.
   (4) No seaming should be attempted above 48.8°C (120°F) ambient air temperature.
   (5) No seaming should be attempted below -15°C (5°F) ambient air temperature. GRI Test Method GM 9 must be followed when seaming below 0°C (32°F) ambient air temperature.
   (6) No seaming should be attempted above 70°C (158°F) sheet temperature.
   (7) No seaming should be attempted below -15°C (5°F) sheet temperature. GRI Test Method GM 9 must be followed when seaming below 0°C (32°F) sheet temperature.
   (8) No seaming should be attempted when wind gusts exceed twenty (20) miles per hour.

o. Seams at the panel corners of 3 or 4 sheets shall be completed with a circular patch approximately 12 inches in diameter, extrusion welded to the parent sheets, or with a "T" weld at suitable locations.
p. Temporary Ballast Loading:

   - Adequate temporary ballast loading that will not damage the geomembrane shall be placed by the Geosynthetics Installer over the geomembrane during installation as needed to prevent uplift by wind and by rapid changes in barometric pressure.
   - Temporary ballast loading shall be in addition to the anchor trenches.

- If high winds are expected, boards along the edge of unseamed panels, with weighted sandbags on top, may be used to anchor the geomembrane on the subgrade.
- Staples, U-shaped rods or other penetrating anchors shall not be used to secure the geomembrane on the side slopes, on the floor or anywhere else in the construction area.
- Any damage to the geomembrane including damage due to construction activities or wind, rain, hail, or other weather shall be the sole responsibility of the Geosynthetics Installer.
- All temporary ballast loading shall be removed by the Geosynthetics Installer prior to demobilizing from the site unless otherwise approved by the Owner.

3.3.4.4 Trial Seams

Contactor shall perform a trial seam for peel and shear strength as follows:

- The start of each work day for each seaming crew.
- After every four (4) hours of seaming.
- Every time seaming equipment or welder is changed.
- When significant changes in geomembrane temperature are observed, as determined by the CQA personnel.
- Every time a loss of power for the machine or any prolonged idle period during the day.
- As requested by the Owner's Representative

The trial seam should be approximately 5 feet long. A sample will be collected from the trial seam near the center of the sample. The welder, date, time and equipment, as well as ambient temperature, number of seaming unit, name of seamer, welding temperature, speed of equipment and pass or fail description will be recorded in the Geomembrane Trial Seam Log by the Owner's representative for each trial seam.

A minimum of ten specimens from each sample will be tested on-site (five in peel, five in shear) with a calibrated tensiometer by the Geosynthetics Installer. All tested seams shall be Film Tear Bond (FTB) type failures to qualify as acceptable seams. Testing will be performed in the field by the Contractor under the observation of the Owner's Representative.

All trial seams must pass the seam strength requirements presented Table 3.5. A trial seam failure is defined as failure of any one of the specimens tested in shear or peel. If a trial seam fails, the entire operation will be repeated. If the additional trial seam fails, the seaming apparatus or welding technician will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful full trial seams are achieved.

Table 3-5: Seam Strength Requirements

Seam Strengths	Test Method	Required Value	
		40 mil LLDPE	60 mil HDPE
1. Shear Strength • Hot Wedge Seam • Extrusion Fillet Seam	ASTM D6392	60 lb/in (min.) 60 lb/in (min.)	120 lb/in (min.) 120 lb/in (min.)
2. Peel Strength • Hot Wedge Seam • Extrusion Fillet Seam	ASTM D6392	50 lb/in (min.) 44 lb/in (min.)	91 lb/in (min.) 78 lb/in (min.)
3. Peel Separation • Hot Wedge Seam • Extrusion Fillet Seam	ASTM D6392	25% 25%	25% 25%

Trial seams shall be tested by the Geosynthetics Installer in the field using a tensiometer with a load cell that has been calibrated during the prior calendar year.

3.3.4.5 Seam Monitoring

During seaming, the Owner's Representative will observe the seams for the proper preparation, grinding technique and for evidence of overheating. Where observations indicate that repairs are needed, the method of repair will be determined in the field by the Owner's Representative. The repairs will be logged in the Geomembrane Repair Testing Log by the Owner's Representative.

At the discretion of the Owner's Representative, coupons may be cut from the end of the extrusion seams and the bottom side of the seam will be observed for visible warping or deformation.

The Owner's Representative will observe the geomembrane during the cooler parts of the day to check for slack. Any areas where "trampolining" occurs will be marked and logged in the Geomembrane Defect Log by the Engineer for repair by the Geosynthetic Installer.

All repair locations shall be patched and tested in accordance with Section 02672 of the Technical Specifications prior to acceptance. All patches shall extend a minimum of 6 inches beyond the repair location. All repairs will be logged in the Geomembrane Repair Testing Log by the Owner's Representative.

3.3.4.6 Non-Destructive Testing

The Geosynthetic Installer is responsible for the completion of non-destructive testing of the entire length of field seams. The testing will be vacuum, air pressure and/or spark testing as outlined in this section. Non-destructive testing will be monitored by the Owner's Representative on a full-time basis.

The Geosynthetics Installer shall continuously test every field weld (i.e., 100 percent of the length of all field seams), including field welds around patches, using non-destructive testing techniques. These tests shall be performed in the presence of the Engineer.

1. Single Weld Seams (extrusion welds):

   A. The Geosynthetics Installer shall maintain and use equipment and personnel at the site to perform continuous vacuum box testing in general accordance with ASTM D5641 under the observation of the Engineer on all single weld production seams except those corner seams where vacuum box testing is impossible.
   B. The system shall be capable of applying a vacuum of at least 5 psi.
   C. The vacuum shall be held for a minimum of 15 seconds for each section of seam.
   D. Once the soap solution is uniformly placed over the weld and suction applied to the seam any bubble formation must be noted and the corresponding defective area identified, marked, and subsequently repaired.
   E. Where vacuum box testing is not possible, spark testing or an approved alternative by the Engineer will be used.

2. Double-Wedge Fusion Weld Seams:

   F. The Geosynthetic Installer shall maintain and use equipment and personnel to perform air pressure testing under the observation of the Engineer of all double-wedge fusion weld seams with a continuous air gap between the two welds and which are greater than 20 ft.
   G. Double-wedge fusion weld seams less than 20 ft. may be vacuum box tested.
   H. Pressure Loss Test:

      a. Pressure loss tests shall be conducted in accordance with the procedures outlined in "Pressurized Air Channel Test for Dual Seamed Geomembranes," Geosynthetic Research Institute Test Method GM-6.
      b. The system shall be capable of applying a pressure of between 25 psi and 30 psi for not less than 5 minutes.
      c. Following a 2 minute pressurized stabilization period, pressure losses over a measurement period of 5 minutes shall not exceed 3 psi.
      d. After the 5 minute testing period, the opposite end of the seam shall be cut open and pressure loss monitored to verify the entire length of the seam channel is open. If no pressure loss is realized, the location of the blocked channel must be found and the remainder of the seam tested separately.
      e. If a non-compliant drop of pressure is noted, pressure testing may be repeated in a step fashion each time halving the length of weld being tested until the extent of the defective weld is determined.
      f. Vacuum box testing (ASTM D5641) may also be used to locate a defective area in the top weld or in the top of the air channel.
      g. The air pressure test results shall be documented on all applicable CQA forms.
      h. The length of welded section tested by air pressure shall not exceed 500 feet, without prior approval by the Owner’s Representative.
      i. Once the defect is found, it shall be clearly identified, marked, and repaired. Any defect shall be repaired so that it meets or exceeds the minimum requirements of this Section.
      j. Double weld seams will also be visually inspected on 100% of the seam. If necessary the outside flap can be pulled back to aid in the visual observation.

The results of the non-destructive tests shall be documented by the CQA Personnel. Documentation should include, location of the seam, test unit number, name of person conducting the test and test results.

3.3.4.7 Destructive Testing

Destructive seam samples will be obtained by the Owner's Representative and tested by the Geosynthetics Laboratory. Testing frequency is at least one sample per 500 cumulative linear feet of fusion field seam and one sample per 400 cumulative linear feet of extrusion field seam at locations specified by the Owner's Representative. The Owner's Representative shall also obtain at least one test for each seaming machine. The name of the sample (e.g. LDT-1), date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the Owner's Representative in the Geomembrane Defect Log. Test samples will be at least 39 inches long and 12 inches wide. The destructive test sample shall be cut into three, 12-inch long pieces with one provided to the Geosynthetics Installer, one provided to the Owner's Representative and one archived.

A minimum of five peel specimens will be tested for each sample in accordance with ASTM D6392. At least five specimens from each sample will be tested for bonded shear strength in accordance with ASTM D6392. Peel tests will be performed on both sides of a double-wedge fusion seam.

All destructive tests seams must meet the requirements of Table 3-5, in this section.

The following procedure should be used for failing tests:

- Samples which do not pass the shear and peel tests will be re-sampled from locations at least 10 feet on each side of the original location.
- These two re-test samples must pass both shear and peel testing.
- If these two samples do not pass, then additional samples will continue to be obtained until two consecutive samples on each side of the original sample pass the field seam criteria and the questionable seam area is defined.
- At that point, the extent of the original defect in both directions along the field seam will be considered isolated and the Geosynthetics Installer may then:

    - Either cap, re-weld and re-test the seam up to and including the closest of the two passing samples, and patch and weld the hole of the furthest passing sample; or
    - Cap, re-weld and re-test the entire length of sampling.
    - If approved by the Owner's Representative, double-wedge fusion welds may be repaired by extrusion welding the flap of the top sheet to the bottom sheet if the seam non-compliance is due to a non-FTB failure of the destructive test sample.
    - If the length of the questionable seam area is defined to be excessive by the Engineer, a cap patch may be required over the entire seam with nondestructive testing prior to acceptance of the seam.

3.3.4.8 Repair Procedures and Verification

The Geosynthetic Installer shall visually inspect the geomembrane surface for defects. Portions of the geomembrane exhibiting defects, or failing a destructive or nondestructive test, must be repaired by the Geosynthetic Installer. Repairs shall be made in accordance with this QA/QC Plan.

Each liner repair shall be recorded by the Owner's Representative in the Geomembrane Repair Testing Log including the date of repair, liner panel identification number, repair location, type of defect, cause of defect, and details of repairs made. Each repaired area shall be required to pass non-destructive testing. Large repair areas may require additional destructive test sampling.

The following repair procedures are detailed as part of this Plan:

- All geomembrane defects (scratches, blisters, rips, punctures, tears, holes, pinholes, creases, folds, etc.) and holes created by removal of samples or coupons for destructive testing shall be marked and repaired.
- Damaged and sample coupon areas of geomembrane shall be repaired by the Geosynthetics Installer by completely covering the defect or hole with an oval-shaped piece of the corresponding geomembrane material, and continuously welding the patch to the geomembrane sheet using an extrusion weld construction.
- Patches shall extend a minimum of 6 inches beyond the damaged or cut area.
- No repairs shall be made to seams by application of an extrusion bead to a seam edge previously welded by fusion or extrusion methods.
- All geomembrane repairs shall be documented including date, geomembrane panel identification number, repair location, type of defect, cause of defect and details of repairs made.
- Repaired areas will be tested for seam integrity as specified in this Section.
- Damaged materials are the property of the Geosynthetics Installer and will be removed from the site at Geosynthetics Installer's expense unless authorized by the Owner to dispose of on-site.
- The Geosynthetics Installer will retain all ownership and responsibility for the geomembrane until acceptance by the Engineer.
- The Engineer shall accept the geomembrane after the installation and repair are complete, and after the Engineer has received all necessary documentation for the installation in accordance with these specifications.

3.3.4.9 Panel Identification

The Geosynthetics Installer will mark directly on the geomembrane as described herein for the purpose of readily identifying panels, seams, repairs and destructive test locations.

- Panel Identification
  - Each panel indicated on the pre-construction panel layout drawings will be numbered sequentially using the format P1, P2, etc.
  - Panels in the field must be numbered in the order in which the panels are actually laid regardless of preconstruction numbering.
  - The panels will be permanently marked in white (red for white surfaced geomembrane) with letters approximately 12" high (and 1/3 the way down the slope for geomembranes on slope).

- Each panel will be marked with the Manufacturer's roll number.

- Seam Identification
  - Each seam will be labeled as agreed upon by the Geosynthetics Installer and the CQA Engineer.
  - Typically, a seam will be designated by the panels it joins, i.e., the seam joining Panel 1 (P1) and Panel 2 (P2) will be designated P1/P2.

- Quality Control Marking
  - Following the completion of each seam, patch or repair, the welding technician will write, at the end of the seam or in the middle of the patch or repair, the following: the initials of the technician, date welded, time welded, and welder unit number. The markings will be done clearly with a white or red permanent marking pen or pencil.
  - Similarly, after each quality control test, the Owner's Representative will record the following immediately adjacent to the area tested: initials of QC Technician performing the test, date of the test, type of test (i.e. VB, SP, AP for vacuum box, spark test and air pressure test respectively) and the words "pass (P)" or "fail (F)". For the air pressure test, the QC Technician must also define the limits or zone of the test as well as the amount of pressure loss observed. Again, a permanent white or red marking pen is required. If the test fails and the necessary repair is made, the technician will cross out the previous markings and mark appropriately for the new test results.
  - Destructive test samples will be clearly circled and marked in permanent marker with the words "LDT" as defined in the specifications. The Owner's Representative will mark the words "pass" or "fail" as appropriate. Similarly, any other area needing repair will be clearly marked in permanent marking to identify where the repair is required to be made.
  - The Owner's Representative will mark areas in need of repair using white marking pens (red for white surfaced geomembrane).

3.3.4.10 Acceptance and Closeout Procedures

The Contractor is responsible for providing a record drawing of each layer of geomembrane installation. The record drawings shall include panel corners, transitions in panel geometry, repair locations, the outside bottom corner of the anchor trench, and other significant features. Survey timing should be coordinated with the Geosynthetics Installer and the Owner's Representative so as not to impact the construction schedule of the geosynthetics. The record drawing does not require certification by a Professional Surveyor.

The Geosynthetic Installer's installation supervisor shall observe and check all phases of the geomembrane installation. The Contractor will retain all ownership and responsibility for the geomembrane until acceptance by the Owner. The Owner shall accept the geomembrane after:

- installation and repair are complete,
- record drawings have been submitted, and
- Owner's Representative has received and accepted all necessary documentation for the installation in accordance with requirements of the Quality Assurance Plan.

When the geomembrane is finally accepted by the Owner, the Geosynthetic Installer shall submit a Letter of Acceptance to the Owner that the installation conforms to the requirements of the Manufacturer.

3.4 Geocomposite Drainage Layer

The purpose of the geocomposite drainage layer is to collect, convey, and discharge precipitation that percolates through the cover soil. The geocomposite drainage layer will be placed on top of the geomembrane at the locations shown on the plans and shall be constructed in accordance with project construction requirements; all installation activities will be monitored on a daily basis by CQA Personnel.

The following information will be obtained by or provided to the Owner's Representative for the geocomposite drainage layer as discussed further in this section. The manufacturer or installer are required to submit the information that applies:

- Documentation provided by the manufacturer that describes quality control and quality assurance tests conducted on raw materials and products used in the construction of the liner system component, including a description of methods for sample selection and the frequency with which tests were conducted.
- Certification that the QA/QC tests were conducted in accordance with the approved construction plan.
- A summary of the results of all testing, including documentation of any failed test results.
- A description of corrective measures taken in response to failed tests.
- A description of all retesting conducted and the results of those tests.
- Documentation provided by the Installer that describes the previous relevant work experience and qualifications of the field crew foreman in charge of liner installation.

3.4.1 Material Requirements

The geocomposite drainage layer shall consist of a geocomposite drainage net (GDN) manufactured with an HDPE geonet drainage core with nonwoven geotextiles heat bonded to each side. Construction of the geomembrane will be performed in accordance with the requirements of this QA/QC Plan.

The geocomposite materials submitted for the project shall meet the following requirements:

1. Geocomposite shall be a high-flow capacity geocomposite consisting of an HDPE geonet drainage core with nonwoven geotextiles heat bonded to each side.
2. The synthetic mesh structure shall consist of solid rib extruded high density polyethylene.
3. The geocomposite provided by the Supplier shall be stock products. No more than 2% by weight of factory regrind shall be used to manufacture the geonet core. Factory regrind shall have resin documentation.
4. The geocomposite shall retain its structure during handling, placement, and long-term service.
5. The geocomposite shall be capable of withstanding outdoor exposure for a minimum of 30 days with no measurable deterioration.
6. The geonet core shall be manufactured by extruding:

   - Two crossing strands to form a bi-planar drainage net structure; or

- Three sets of strands to form a tri-planar drainage net structure consisting of a thick vertical rib with diagonally placed top and bottom ribs.

Quality assurance activities for the geomembrane material consist of obtaining written documentation and quality control test results from the manufacturer that the supplied geocomposite complies with the minimum specifications within this plan.

The Geosynthetic Installer will submit the following as obtained from the geosynthetic manufacturer to the Owner's Representative:

- The factory QA/QC plan for operating the system.
- Manufacturer's installation instructions.
- Manufacturer's product information and manufacturer quality control test results. The results of these tests must meet the minimum required physical properties for geocomposite at the frequencies specified in Table 3-6 and values specified in Table 3-7.

The information supplied shall be in the form of a factory quality control certificate for each geocomposite roll and shall include the following:

- Lot, batch, or roll numbers and identification.
- Length and width of each roll.
- Date each roll was manufactured.
- Sampling procedures.

Table 3-6: Required Geocomposite Manufacturer Quality Control Testing

Property	Test Method	Frequency
Geonet		
Thickness	ASTM D5199	50,000 ft^2
Density (geonet)	ASTM D1505	50,000 ft^2
Tensile Strength, lb/in	ASTM D5035	50,000 ft^2
Carbon Black Content	ASTM D4218	50,000 ft^2
Resin		
Polymer Density	ASTM D1505 or ASTM 4883	Once per lot
Melt Flow Index	ASTM D1238	Once per lot
Geotextiles		
Mass per Unit Area	ASTM D5261	100,000 ft^2
Grab Tensile	ASTM D4632	100,000 ft^2
CBR Puncture Strength	ASTM D6241	100,000 ft^2
AOS, US Sieve	ASTM D4751	540,000 ft^2
Water Flow Rate	ASTM D4491	540,000 ft^2
UV Resistance	ASTM D4355	Once per resin formulation
Geocomposite		
Ply Adhesion	ASTM D7005	50,000 ft^2
Transmissivity	ASTM D4716	1,000,000 ft^2

Table 3-7: Required Geocomposite Test Values

Properties and Requirements(1,2)	Test Method	Qualifier3	Minimum Average Values
Geonet			
Polymer Composition, %			95% polyethylene by weight
Thickness, mil	ASTM D5199	MAV	SEE TABLE 3-9
Density, g/cm^3	ASTM D1505 or ASTM D4883	MAV	0.94
Tensile Strength, lb/in	ASTM D7179	MAV	SEE TABLE 3-8
Carbon Black Content, %	ASTM D4218	range	2.0 – 3.0
Resin			
Polymer Density, g/cm^3	ASTM D1505	MAV	> 0.94
Melt Flow Index, g/10 min	ASTM D1238	MAX	≤ 1.0
Geotextile			
Mass per Unit Area, oz/yd^2	ASTM D5261	MAV	8
Grab Tensile, lb	ASTM D4632	MAV	200
Puncture Strength, lb	ASTM D6241	MAV	410
AOS, US Sieve (mm)	ASTM D4751	MAV	80 (0.18 mm)
UV Resistance (% retained after 500 hours)	ASTM D4355	MAV	70
Geocomposite			
Transmissivity, m^3/m/sec (Liner)	ASTM D4716	MAV	SEE TABLE 3-9
Water Flow Rate, gpm/ft^2	ASTM D4491	MAV	95
Ply Adhesion, lb/in	ASTM D7005	MAV	1.0

Notes:

(1) MAV = Minimum Average Value, MAX = Maximum Value

Table 3-8: Required Geocomposite Test Values by Thickness

Properties and Requirements(1,2)	Minimum Average Values (lb/in)		
Geonet	250 mil	275 mil	300 mil
Tensile Strength, lb/in	55	65	75

Table 3-9: Transmissivity Requirements

Thickness, mil	Transmissivity1 m^3/m/sec
Final Cover System	
As required to achieve transmissivity	8.0 x 10^{-4}

Notes:

Transmissivity Test: Gradient of 0.33. Design normal stress value of 500 psf, between soil and steel plate at seat time of 100 hours.

3.4.2 Conformance Testing

In addition to the manufacturer's quality control testing, the Owner's Representative shall obtain samples for conformance testing. Samples may be obtained prior to shipment at the manufacturing facility by the manufacturer, Engineer or the geosynthetic laboratory. The minimum number of samples shall as specified in Table 3-10. The samples must be representative of the materials supplied and exclude the outer wrap of GDN if evidence of scuffing or other damage is observed. Samples should extend across the full roll width and be at least 3 feet wide.

Representative samples will be sent to a geosynthetics laboratory for conformance testing and will be paid by the Manufacturer. The laboratory testing program will be directed by the Owner's Representative and include but is not necessarily limited to the tests described in the following table.

Table 3-10: GDN Conformance Testing Summary

Test	Method	Frequency
Thickness, mil	ASTM D5199	One (1) test per 100,000 square feet or one (1) test per lot, whichever is more frequent
Density, g/cm^3	ASTM D1505 or ASTM D4883	
Ply Adhesion, lb/in	ASTM D7005	
Transmissivity, m^3/m/sec	ASTM D4716	One (1) test per 1,000,000 square feet of GDN Placement

If a representative sample does not comply with the minimum requirements of Table 3-7, 3-8 and 3-9, the roll of GDN that is in non-conformance shall be replaced at no additional cost to the Owner. The Geosynthetic Installer shall perform additional conformance testing on the closest numerical roll on both sides of the failed roll. Sampling and testing of rolls shall continue until acceptable results are established.

The Owner's Representative shall monitor the rolls upon delivery to the site and report observed deviations from the requirements of this QA/QC Plan to the Contractor. At their discretion, the Owner's Representative may sample rolls from each shipment of geomembrane delivered to the site.

3.4.3 Delivery, Handling and Storage

No geocomposite shall be installed until the Owner's Representative has reviewed all certifications and supporting test data and determined that the GDN furnished for the project is acceptable for use.

All geocomposite delivery, handling, and unloading shall be performed in the presence of the CQA Personnel. During unloading, the contractor and CQA Personnel shall conduct an inspection of all delivered GDN for defects and damage caused by inadequate or improper packaging, shipping, unloading, or handling. The CQA Personnel shall review packing slips or bills of lading to verify delivery of correct materials and that the roll numbers listed on packing slips match the roll numbers on the GDN labels. If discrepancies are found, the Owner's Representative shall immediately notify the manufacturer. Any GDN that has no label or where the label is damaged or otherwise illegible may either be sampled for laboratory analysis to determine its acceptability, or rejected and removed from the project site, as directed by the Owner's Representative. The Owner's Representative shall also verify that geocomposite production lots, and associated roll numbers, delivered to the project site match the production lots and roll numbers recorded on the approved MQC Certificates. If discrepancies are found, the Owner's Representative shall immediately notify the manufacturer.

All delivery, handling and storage methods should be in conformance with the manufacturer's recommendations.

3.4.4 *Installation*

The Geosynthetics Installer shall furnish all labor, materials, supervision and equipment to complete the Geocomposite Liner for the project including, but not limited to, geocomposite layout, seaming, patching, and all necessary and incidental items required to complete the work, in accordance with the Drawings and this QA/QC Plan. All geocomposite installation operations shall be performed in the presence of the CQA Personnel.

3.4.4.1 Deployment

1. The Geosynthetics Installer shall handle all geocomposite in such a manner as to ensure the material is not damaged in any way.
2. The geocomposite roll should be installed in the direction of the slope and in the intended direction of flow unless otherwise specified by the Engineer.
3. The geocomposite shall be unrolled and placed in such a manner as to minimize dragging of panels into position ("spotting");
4. Along landfill benches, the geocomposite machine direction shall be installed in the slope direction. The slope direction is the direction perpendicular to the contour lines indicated on the Drawings.
5. On slopes, secure geocomposite and then roll geocomposite down slope in manner to continually keep geocomposite in tension. If necessary, position geocomposite by hand after unrolling to minimize wrinkles.
6. Weight geocomposite with sandbags or equivalent in presence of wind. Do not remove weight until replaced with cover material. Handle sandbags with care to prevent rupture or damage of sandbag.
7. If the project includes an anchor trench at the top of the slopes, the geocomposite shall be properly anchored to resist sliding. Anchor trench compacting equipment shall not come into direct contact with the geocomposite.
8. Do not weld geocomposite to geomembrane unless otherwise specified in construction plans.
9. Cut geocomposite using scissors or other cutting tools as specified by the Manufacturer.
10. Do not damage underlying geosynthetic layers during placement of geocomposite.
11. During geocomposite deployment, do not entrap dirt, excessive dust that could cause clogging of drainage system, or stones that could damage adjacent geomembrane. If dirt or excessive dust is entrapped in geocomposite, hose clean prior to placement of next layer of material.
12. The geocomposite shall be shingled such that the "downstream" panel overlaps the "upstream" panel in order to minimize the possibility of lifting panel edges during placement of covering material; and offsetting all panel seams parallel to the toe of a slope ("longitudinal seams") at the specified distance from the toe of the slope;

3.4.4.2 Seams and Overlap

Each component of the geocomposite (i.e., geotextile(s) and geonet) will be secured or seamed to the like component at overlaps.

1. Geonet Components

    a. Overlap adjacent geonet rolls minimum of 4 in.
    b. Geonet roll ends (butt seams) shall be overlapped one foot in areas with less than 10 percent slope.
    c. In areas of greater than 10 percent slope, butt seams shall be overlapped two feet. Two staggered rows of ties shall be applied at 12 inch intervals.
    d. Tie geonet overlaps with plastic fasteners. Use white or yellow tying devices for easy inspection.
    e. Geonet ties shall be plastic fasteners recommended by the Manufacturer. Do not use metallic devices.
    f. Tie every 5 ft along edges, every 12 in. in anchor trench, and every 12 in. along end-to-end seams.
    g. In corners of side slopes of rectangular landfills, where overlaps between perpendicular geonet strips are required, unroll an extra layer of geonet along slope, on top of previously installed geonet, from top to bottom of slope.
    h. Stagger joints when more than one layer of geonet is installed.
    i. When several layers of geonet are stacked, deploy rolls in same direction to prevent strands of one layer from penetrating channels of adjacent layer.

2. Geotextile Components

    a. The bottom layer of geotextiles shall be overlapped. The top layer of geotextile shall be continuously sewn. Geotextiles shall be overlapped a minimum of 4 inches prior to seaming.
    b. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile component, shall be used for all sewing. The seams shall be sewn to provide a flat (prayer) seam, "J" seam or "butterfly-folded" seam and shall be a two-thread, double-lock stitch or a double row of single-thread, chain stitch.

3.4.4.3 Field Quality Control

The Contractor shall be aware of the activities outlined in the QA/QC Plan and shall account for these QA/QC activities in the installation schedule. The finished geocomposite shall have good appearance qualities. It shall be free from such defects that would affect the specific properties of the geocomposite, or its proper functioning.

A. Defects and Repairs:

    1. Repair damage to geocomposite as follows, if hole or tear width across roll is less than 50% of width of roll.

        c. Place patch extending 2 ft beyond edges of hole or tear.

d. Secure patch to original geocomposite by tying every 6 inches. Use approved tying devices specified by Manufacturer.
e. The top geotextile component of the patch shall be heat sealed to the top geotextile of the geocomposite needing repair.

2. Repair damage to geocomposite as follows, if hole or tear width across roll is greater than 50% of width of roll.

   a. On base of landfill, cut out damaged area and replace with new geocomposite.
   b. On side slopes, remove and replace damaged geocomposite panel.
   c. Join in the new portions as noted in Part 3.4 B1 above in this Section.

Owner's Representative shall observe repairs and report noncompliance in writing to Owner and Engineer. Before initial placement of soil cover or other cover, inspect system seams and repaired areas to ensure tight, continuously bonded installation. Repair damaged system and re-inspect repaired work.

3.4.4.4 Protection of Finished Work

Protect installed geocomposite according to geocomposite manufacturer's instructions. Repair or replace areas of geocomposite damaged by scuffing, punctures, traffic, rough subgrade, or other unacceptable conditions. Tools shall not be left on, in, or under the geocomposite.

The Geosynthetics Installer and Contractor shall use all means necessary to protect all prior Work and all materials and completed work of other Sections included in these Specifications.

In the event of damage, the Geosynthetics Installer and/or Contractor (depending on who damages the geocomposite) shall immediately make all repairs and replacements necessary, to the approval of the Owner's Representative and at no additional cost to Owner.

3.5 Geotextile Cushion Layer

The geotextile cushion layer will consist of a 16-ounce polypropylene nonwoven, needle-punched geotextile and will be installed at the locations shown on the plans where the Geocomposite Drainage Layer is not present. The geotextile Manufacturer's Quality Control Certificates shall verify the following properties using the test methods, frequencies, and minimum values listed in Table 3-11:

Table 3-11: Geotextile Manufacturer Testing and Frequency

Property	Test Method	Frequency	Required Value (MARV)
Mass per Unit Area (oz/SY)	ASTM D5261	100,000 ft^2	16
Grab Tensile Strength, lb	ASTM D4632	100,000 ft^2	370
Grab Elongation, %	ASTM D4632	100,000 ft^2	50%
CBR Puncture Strength, lb	ASTM D6241	100,000 ft^2	1,100
Trapezoidal Tear Strength, lb	ASTM D4533	100,000 ft^2	150
UV Resistance (% retained after 500 hours)	ASTM D4355	Per Manufacturer Standard Frequency	70

Prior to or coincident with shipment of cushion geotextile to the project site, the Owner's Representative shall review and approve submittals from the Manufacturer which shall include:

- Geotextile Cushion Layer's Manufacturer's specification sheet(s);
- Geotextile Cushion Layer's Manufacturer's Quality Control (MQC) Certificates; and
- Other information required by the project specifications.

No cushion geotextile shall be installed until the Owner's Representative has reviewed all certifications and supporting test data and determined that the cushion geotextile furnished for the project is acceptable for use.

The CQA Personnel shall review packing slips or bills of lading to verify delivery of correct materials and that the roll numbers listed on packing slips match the roll numbers on the cushion geotextile labels. If discrepancies are found, the Owner's Representative shall immediately notify the manufacturer. Any cushion geotextile that has no label or where the label is damaged or otherwise illegible may either be sampled for laboratory analysis to determine its acceptability, or rejected and removed from the project site, as directed by the Owner's Representative. The Owner's Representative shall also verify that cushion geotextile production lots, and associated roll numbers, delivered to the project site match the production lots and roll numbers recorded on the approved MQC Certificates. If discrepancies are found, the Owner's Representative shall immediately notify the manufacturer.

All filtration geotextile installation operations shall be performed per the manufacturer's recommendations and the requirements of Table 3-12. The installation shall be performed in the presence of the CQA Personnel. During installation, the CQA Personnel shall verify and/or document that equipment and tools used to deploy and place cushion geotextile will not puncture, tear, or otherwise damage the geomembrane.

Table 3-12: Geotextile Field Observation Requirements

Field Test	Frequency and Timing	Acceptance Parameters	Sample Location	Test Failure Procedures
Inventory and Visual Inspection	Each Roll during delivery	Log roll and shipping data. Inspect rolls for defects/damage	On-site material stockpile	If shipping data does not match submitted MQC data, do not allow installation
Placement Observations	Continuous	Meeting Criteria stated in this section of QA/QC Plan	Placed material	Replace/repair areas as required
Field Seaming Observations	Each seam	Continuously sewn or wedge welded along overlap, unless otherwise noted on the drawings	Placed material	Adjust panels as needed to provide adequate seams. Replace/repair areas as needed.

3.6 Geosynthetic Liner System

The following sections apply to all the geosynthetics layers discussed within this QA/QC Plan

3.6.1 Manufacturer Requirements

Manufacturer shall provide sufficient qualifications and references to the Owner and Owner's Representative.

3.6.2 Installer Requirements

The geosynthetics installer shall provide an installation foreman who shall be experienced in all phases of installation and quality control testing and procedures as follows:

1. The foreman shall have served in a similar role on at least 1 similar project within the previous year.
2. The foreman will be dedicated to performing or directing the Geosynthetics Installer's quality control activities, (i.e. air pressure, vacuum box and spark non-destructive testing and field destructive testing).
3. The QCF and the Superintendent may be the same person if approved by the Engineer.

3.6.3 Interface Testing

The Geosynthetic Installer will submit representative samples of the proposed geomembrane to the Engineer or a geosynthetic testing laboratory as directed by the Engineer. The Owner's Representative shall perform interface friction testing to evaluate the interface shear strength between the geomembrane and the overlying and underlying materials, as specified in this section.

The effective interface shear strength envelope at the interface between the geosynthetics and the materials in direct in contact with a geosynthetic layer shall be verified by the Owner's Representative by performing interface friction testing on representative materials to be used for construction of the liner system. The results shall be as follows:

- The minimum effective friction angle shall be 23.8 degrees at a confining stress of 500 psf.
- The interface frictional resistance shall be determined by direct shear tests in general accordance with ASTM D5321.
- The interfaces and/or soil during the test shall be saturated with water and compacted within the moisture and density parameters specified within this report.

The following interfaces are identified for testing:

1. Ash / Geomembrane (textured only)
2. Geomembrane (textured only)/Geocomposite
3. Geocomposite/Cover Soil

3.7 Aggregate

Several aggregate types and sizes are proposed for use on the project. All aggregate suppliers shall be listed on the most recent version of the INDOT Approved Aggregate Sources Map. The aggregate supplier shall provide certification that the material furnished for construction meets the gradation and quality requirements of the 2016 version of the Indiana Department of Transportation's Standard Specifications. No aggregate shall be installed until the Owner's Representative has reviewed all certifications and determined that the aggregate furnished for the project is acceptable for use.

All aggregate installation operations shall be performed in the presence of the CQA Personnel. During installation, the CQA Personnel shall verify and/or document the following:

- Aggregate is only deployed on GDN and/or geotextile that has been installed in accordance with the specifications and QA/QC Plan, and has been accepted by the Contractor, GDN Installer, and Owner's Representative; and
- Equipment and tools used to deploy and place filter geotextile and aggregate will not puncture, tear, or otherwise damage the GDN/geotextile, and shall protect the underlying geomembrane from damage.

The following aggregate types and/or sizes are proposed for use on the project:

- Rock Type 1 shall be in accordance with IDNOT 616 with the following exception: material shall have at least 85 percent of the total material by weight larger than 12-inch, but less than 24-inch square opening and at least 50% of the total material by weight larger than 18-inch square opening. Furnish material smaller than a 12-inch square opening that consists predominantly of rock spalls and rock fines, and that is free of soil.
- Rock Type 2 shall be uniform riprap, type B installed in accordance with INDOT 616.
- Drainage Aggregate: Coarse Aggregate Size No. 8, 57, or 67 (AASHTO M43) at the locations shown on the drawings.

All aggregates shall meet the requirements of INDOT 904.03. Where specified in the drawings, geotextile shall be placed beneath the aggregate channels in accordance with INDOT 616.11.

3.8 Fabric-Formed Concrete Channel Lining

A fabric-formed concrete lining product is proposed to protect the ash breach channel from relatively high estimated velocities. The channel lining shall consist of a nominal 6-inch thick filter point style (10" filter point spacing) fabric-formed concrete lining filled with fine aggregate concrete. A geotextile layer is to be placed beneath the lining. Field quality control shall be performed by the Contractor by measuring the consistency of the fine aggregate concrete using the flow cone method (ASTM C939). Field Quality Assurance shall consist of unconfined compression testing in accordance with ASTM C1019 (Standard Test Method for Sampling and Testing Grout) and shall be performed by the CQA Personnel. Project specifications have been included on the General Notes sheet of the Drawings.

3.9 Drainage Pipe

Drainage tubing will be used to collect and convey infiltration water within the cover system. Drainage tubing is utilized for two cases:

1. Along the center of the surface water collection channels in the pond's upper basin and clear water pond; and
2. At the toe of the inboard slope of the bottom ash embankment where the geocomposite drainage net is replaced with a geotextile cushion layer.

For Case 1, the drainage tubing rests on the geocomposite drainage net and is to be encompassed by drainage aggregate. The top geotextile of the geocomposite drainage net is to be removed where in contact with the drainage aggregate. For Case 2, the geocomposite drainage net will wrap around the drainage tubing ends and the interior geotextile is to be removed. The drainage tubing for Case 2 will drain by gravity to the drainage tubing for Case 1. Details for both Case 1 and Case 2 have been provided in the Drawings.

Drainage tubing shall consists of single wall HDPE corrugated pipe (INDOT Item 907.17a) with perforations. Outlet pipes shall consist of dual wall HDPE corrugated pipe (INDOT 907.17b) with soil tight joints.

3.10 Cover Soil Layer

A minimum of 30 inches of protective cover soil will be placed over the geocomposite/geotextile layer. The cover soil for the final cover system shall come from an on-site or off-site site borrow source and shall meet the requirements of the Quality assurance criteria for the General Fill Layer listed in Table 3-13 and also include the following:

The maximum particle size shall be less than or equal to half of the compacted lift thickness.

Table 3-13: Cover Soil Layer Requirements

<table>
<tr><th>Test</th><th>Frequency and Timing</th><th>Acceptance Parameters</th><th>Sample Location</th><th>Test Failure Procedures</th></tr>
<tr><td>Visual Classification</td><td>Continuous during placement</td><td>Correlation (color, texture, compactability) with accepted borrow sources or stockpiled materials</td><td rowspan="3">Borrow sources, stockpiles, and placed material</td><td rowspan="3">Reject unacceptable materials.</td></tr>
<tr><td>Particle Size (ASTM D1140, D422)</td><td rowspan="2">1 Test per 10,000 CY;

Visual observation during placement</td><td rowspan="2">• Unified Soil Classification ML, CL, MH, CH or OH
• Visual observation: Free of residual waste, debris, foreign, or deleterious materials
• Maximum particle size: 3” diameter for 6” zone above geosynthetics, remainder of layer maximum particle size is 6” diameter.</td></tr>
<tr><td>Atterberg Limits (ASTM D4318)</td></tr>
</table>

3.10.1 Construction

Placement of the cover soil layer shall be performed in 3 lifts. The initial lift must be at least 12 inches and no greater than 15 inches thick. The second and third lift should be between 8 and 12 inches thick. Each protective cover soil lift shall be spread using a low ground pressure dozer meeting the requirements of Table 3-14. No additional compactive effort shall be applied to the initial lift. The Owner’s Representative will monitor operational cover placement on a full-time basis.

Wrinkles in the underlying geosynthetics resulting from protective cover placement will be "walked out" prior to additional protective cover placement. Excessive wrinkles will be observed by the Owner’s Representative for possible repair by the Geosynthetic Installer.

When placing protective soil cover, do not drive directly on the geosynthetic materials. Only use equipment to place, spread, and compact infiltration layer that produces ground pressures compliant with the following section.

3.10.2 Placement of Soil on Geosynthetics

The Contractor will be required to place all soil materials located on top of a geotextile in such a manner as to ensure the following:

- The geotextile and underlying material are not damaged;
- Minimal slippage occurs between the geotextile and underlying layers; and,
- Excess stresses are not produced in the geotextile.

Unless otherwise specified by the Engineer, a minimum thickness of 12 inches of soil will be required between low ground-pressure equipment and the geotextile. The CQA Manager will perform close inspection of the placement and spreading of any soils over the geotextile with earthmoving equipment.

Equipment used for placing the overlying material on the geosynthetics shall conform to the maximum ground pressure limitations in the following table.

Table 3-14 – Equipment Ground Pressure Restrictions on Soil Placement above Geosynthetics

Thickness of Material above Geomembrane (in)	Maximum Equipment Ground Pressure (psi)
<12	Equipment not permitted
12 -24	< 10
24 -36	< 20
> 36	> 20

3.10.3 Testing

In-place testing of the cover soil is not required. However, the Owner's Representative will monitor cover soil placement and can request additional passes of the low-ground pressure dozer at their discretion.

Bulk samples of the cover soil layer are not required to be collected. However the Owner's Representative can collect samples at their discretion if suspicious soils are encountered based on look or smell. Testing for loss-on-ignition (LOI) can be performed by the Owner's Representative. If greater than 4% organics, as determined by weight, is found in the soil, the material will be rejected for use in the cover soil layer.

3.11 Vegetative Layer

A vegetative layer, consisting of approximately 6 inches of soil or an approved alternate, will be placed on the cover soil layer in all areas except where protected by rip rap or concrete. The vegetative layer shall be placed immediately after the cover soil layer installation is complete. The vegetative layer shall be constructed using soils obtained from existing on-site or off-site borrow sources. The vegetative layer shall consist of a maximum particle size of 3 inches. Quality assurance criteria for the vegetative layer are listed in Table 3-15.

Table 3-15: Cap Erosion Layer Requirements

Test	Frequency and Timing	Acceptance Parameters	Sample Location	Test Failure Procedures
Visual Classification	Continuous during placement	Correlation (color, texture, compactability) with accepted borrow sources or stockpiled materials	Borrow sources, stockpiles, and placed material	Reject unacceptable materials and use acceptable materials

Free of Unacceptable Material	Visual observation during placement	Maximum particle size is 3 inches. Shall be free of residual waste, debris, foreign, or deleterious materials.	Borrow sources, stockpiles, and placed material	Reject unacceptable materials and use acceptable materials
Survey to confirm top of cap system	Same locations as for base of cover survey	Minimum Cover Thickness Achieved	Top of finished vegetative layer	Regrade/fill with appropriate material and resurvey

Quality assurance criteria also includes the following:

- Materials (e.g., topsoil, fertilizer, seed) provided meet construction requirements;
- During the construction care period (a minimum of one full growing season) erosion protection is to be maintained; and
- If required, periodic irrigation will be utilized to produce satisfactory growth.

3.11.1 Construction

Placement of the vegetative layer can be completed a single lift by spreading with a dozer. The Owner's Representative will monitor the erosion layer placement on a full-time basis.

3.11.2 Testing

In-place testing of the infiltration is not required. However, the Owner's Representative will monitor infiltration layer placement and can request additional passes of the low-ground pressure dozer at their discretion.

Bulk samples of the vegetative layer are not required to be collected. The material placed for the vegetative layer must contain organics as determined based on look and smell. At their discretion, the Owner's Representative can collect samples if the presence of organics is in question. Testing for loss-on-ignition (LOI ASTM D7348) can be performed by the Owner's Representative. If less than 2% organics, as determined by weight, is found in the soil, the material will be amended as necessary for use in the vegetative layer.

3.11.3 Vegetation

A vegetative cover shall be established to minimize erosion of the soil cover and reduce run-off velocities.

3.11.4 Materials Requirements and Application Rates

3.11.4.1 Seed

After the topsoil has been prepared, the seed mix will be applied at the following per acre rates:

- 16 lbs. Red Fescue *(Festuca rubra)*;
- 12 lbs. Indian grass *(Sorghastrum nutans)*;
- 10 lbs. Kentucky Bluegrass *(Poa pratensis)*;
- 8 lbs. Perennial Ryegrass *(Lolium perenne)*;

- 8 lbs. Little Bluestem *(Andropogon gerardii)*;
- 4 lbs. White Clover *(Trifolium repens)*.

For fall applications also include 30 lbs. of Winter Rye *(Secale cereale)*; or, for spring applications include 10 lbs. of Annual Ryegrass *(Lolium multiflorum)*.

The varieties of grass seed to be furnished shall bear a tag on each bag showing species, lot number, grower's name, the percent of purity, the percent of germination, and the weed content. Tags shall be provided to the Owner’s Representative.

All seeds shall be free from noxious weeds and under no condition shall the total weed content of any lot of seed or seed mixture exceed one-half of one percent by weight.

No seed shall be utilized which has a mix date older than one year. The Owner reserves the right to test, reject, or approve any and all seed after delivery.

3.11.4.2 Fertilizer

Commercial grade 10-20-10 fertilizer shall be applied at a minimum rate of 500 pounds per acre, if required.

3.11.4.3 Mulch

All mulch material shall be free from mature seedbearing stalks, roots, and noxious or prohibited weeds. Alfalfa, clover, and salt grass hay are not acceptable. Straw mulch shall include baled wheat, oats, or straw. It shall be dry and reasonably free of weeds, stalks, or other foreign material. Mulch shall be applied at a minimum rate of 2 tons per acre.

3.11.5 Handling and Placement

Establishment of a vegetative cover shall begin as soon as possible after the placement of soil cover materials.

Fertilizer shall be spread uniformly over all areas to be seeded and the areas then loosened by discing, harrowing, or other approved methods immediately prior to seeding. The soil shall be loosened to a depth of approximately three inches.

Seed shall be sown immediately following preparation of the area for seeding. Seed shall be sown by methods which provide for uniform distribution of the seed mix. After broadcasting or otherwise applying the seed, the surface of the seedbed shall be raked, culti-packed, or brush dragged very lightly. All raking shall be done in a direction parallel to contour lines.

Mulch shall be applied to the sown area within 24 hours of seeding and spread to a uniform depth. A mechanical blower may be used to apply mulch material, provided the machine has been specifically designed and approved for this purpose. Machines which cut mulch into short pieces shall not be permitted. Mulch shall be placed in a moist condition or shall be sprinkled immediately after placement.

3.12 Inspection and Repair

The Contractor is responsible for maintaining the erosion protection for a minimum of one full growing season following seeding. The Contractor shall provide periodic irrigation if required for satisfactory growth. All areas lacking at least 50% vegetative cover after one full growing season shall be re-seeded by the contractor.

Attachment IV – Post Closure Care Plan

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Post Closure Care Plan, Rev 2

Fly Ash Pond Complex

Tanners Creek Power Plant

S&ME Project No. 7217-17-007A

Prepared for:

Tanners Creek Development, LLC
1515 Des Peres Rd, Suite 300
St. Louis, MO 63131

Prepared by:

S&ME, Inc.
6190 Enterprise Court
Dublin, OH 43016

October 18, 2017

Revised: June 26, 2018

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Appendicies

1.0 General

This Post-Closure Care Plan has been developed in support of the closure of the Fly Ash Pond Complex at the Tanners Creek Power Plan located near Lawrenceburg, Indiana. This plan was prepared by S&ME, Inc. for Tanners Creek Development, LLC, the owner of the facility.

The post-closure care activities described include inspection, maintenance, and monitoring. The Post-Closure Care period will begin upon IDEM acceptance of the Closure Certification and will last for 30 years.

A summary of revisions to this document are as follows:

- Rev 0 10/18/17 Initial Issue
- Rev 1 3/19/18 Revised for IDEM RAI dated March 6, 2018, extend Post Closure Care Period
- Rev 2 6/22/18 Revised for IDEM RAI dated May 10, 2018, modify Post-Closure Care Cost Estimate

2.0 Post-Closure Contact

During the post-closure period, the primary contact will be:

Mr. Adam Peetz, EnviroAnalytics Group, LLC
1650 Des Peres Rd, Suite 303
St. Louis, MO 63131
Telephone: 314-835-2878
Email: apeetz@elltransfer.com

3.0 Inspection and Maintenance Activities

3.1 Inspections

Inspections will be completed on a semi-annual basis throughout the Post-Closure Care period. A report of each inspection will be prepared and submitted to IDEM within 60 days of the date of the inspection. The inspection reports will be maintained throughout the Post-Closure Care Period.

The reports will discuss the systems observed and any deficiencies identified and corrective actions taken since the previous inspection. The inspection will, at a minimum, include observations of the following:

<u>Final cover</u>

- Evidence of surface erosion,
- Evidence of ponding,
- Condition of vegetation,
- Evidence of settlement or subsidence,
- Evidence of slope instability, and

- Evidence of animal burrows.

Surface water management system
- Evidence of erosion,
- Evidence of breaching, and
- Evidence of excessive sediment buildup.

Monitoring wells
- Condition of well caps,
- Integrity of locks, and
- Condition of ground seal.

Access Roads
- Rutting, and
- Erosion.

3.2 Maintenance

Normal maintenance activities will include, as necessary, the following:

- Mowing of the final cover (a minimum of twice per year),
- Removing excessive sediment from surface controls,
- Repairing surface erosion and/or settlement,
- Restoring vegetation,
- Repairing animal burrows, and
- Repairing monitoring wells.

Maintenance activates and corrective actions taken will be documented in a facility log.

4.0 Groundwater Monitoring

Groundwater monitoring in accordance with the approved plan for Fly Ash Pond monitoring will continue throughout the Post-Closure Care period.

5.0 Security

Access to the Tanners Creek Power Plant is controlled by gates secured with lock and key. Vehicle access adjacent to the gates is controlled by physical barriers such as existing tree lines or ditches. No waste within the ash pond will remain exposed upon completion of closure. Access to the closed site will not pose a health hazard.

6.0 Post-Closure Uses

There are no current plans to redevelop the site, which will remain closed to the general public. The anticipated post-closure use is open space. If the site use changes or requires disturbance of the final cover, liner, or other component of the containment system, including any removal of waste, notification will be provided to IDEM prior to any changes being made.

7.0 Post-Closure Certification

The post-closure care will continue for 30 years. At the end of the post-closure care period, a certification statement signed by the Owner and a registered professional Engineer will be submitted to IDEM indicating that:

- The requirements of this Plan have been met,
- The site is stable, and
- Post-Closure Care is being terminated.

8.0 Post-Closure Cost Estimate

An Engineer's Opinion of Probable Costs associated with Post Closure Care has been incorporated into the IDEM Post-Closure Form for RSWs I, II, III, C/D Site, and Non-MSWLF Facilities. Parts II through V of the form are included in Appendix A of this Plan.

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Appendices

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Appendix A. IDEM Post-Closure Form Parts III through V

III. GROUNDWATER MONITORING ACTIVITIES (Provide a description of planned ground water monitoring activities including the frequency of the activities. See instructions.)

See Closure Plan Attachment II

IV. MAINTENANCE ACTIVITIES (Provide a description of planned maintenance activities and the frequency at which they will be performed. See instructions.)

See Post Closure Care Plan Text

V. POST-CLOSURE COST ESTIMATE (See instructions. Note that these estimates are to be presented for the entire post-closure care period rather than on a year basis.)

A. Cost for Semi-Annual Inspections and Reports

1. Inspection

a. Number of inspections during post-closure period (semiannual inspections for 30 years)	60
b. Inspector time required (hrs/insp)	10
c. Inspector unit labor cost ($/hr)	$135
d. Inspection Cost ($) Line 1a * Line 1b * Line c	$81,000

2. Report Preparation

a. Number of reports during post-closure period	60
b. Cost per report ($)	$750
c. Report cost ($) Line 2a * Line 2b	$45,000

3. Inspection and Report Cost ($) $126,000

B. Cost for Maintenance of Final Cover and Vegetation

The cost for cover maintenance and vegetation shall be 10% of the cost per acre calculated for final cover and vegetation in the closure plan.

1. Final Cover Maintenance

a. 10% of cost for placement of final cover and vegetation (as determined in Item V.G. of the the Closure Plan)($/acre)	* $3,039
b. Total area of site permitted for filling (acres)	71.23
c. Cover Maintenance Cost ($) Line 1a * Line 1b	$216,489

* Value includes a 10% Contingency for Geosynthetics

C. Cost for Vegetation Control

Certain areas are required to be mowed per regulation. See instructions.

1. Mowing

a. Mowing frequency (visits/30 years) 60

b. Area to be mowed (acres/visit) 71.23

c. Mowing unit cost ($/acre) $50.00

d. Vegetation Control Cost ($)
Line 1a * Line 1b * Line 1c $213,690

D. Cost for Maintenance of Access Control & Benchmarks

1. Access Control Maintenance

a. Access control maintenance frequency (visits/30 years) 30

b. Amount of fence needing replacement (linear feet/visit) 50

c. Fencing unit cost ($/linear foot) $10

d. Fence cost ($)
Line 1a * Line 1b * Line 1c $15,000

e. Other ($) $60,000
(Specify) Road Maintenance

f. Access Control Maintenance Cost ($)
Line 1d + Line 1e $75,000

2. Benchmark Maintenance Cost (if any) ($) $0

3. Access Control & Benchmark Repair Cost ($)
Line 1f + Line 2 $75,000

E. Cost for Leachate Collection System Monitoring and Maintenance

1. Leachate Collection System Inspection

a. Inspection frequency (insp/30 years) 0

b. Inspection time required (hrs/insp) 0

c. Inspector unit labor cost ($/hr) 0

d. Inspection cost ($)
Line 1a * Line 1b * Line 1c 0

2. Leachate Collection System Maintenance

a. Number of pumps replaced during post-closure
(pumps/30 years) 0

b. Pump unit cost ($/pump) 0

c. Other ($)
(specify) ____________________ 0

d. Leachate system maintenance
(Line 2a * Line 2b) + Line 2c 0

3. Leachate Collection Monitoring and Maintenance Cost ($)
Line 1d + Line 2d $0

F. Cost for Methane Control System Monitoring and Maintenance

1. Methane Control System Monitoring

a. Gas Monitoring frequency
(visits/30 years) 0

b. Time required to monitor (hrs/visit) 0

c. Contract lab technician unit
labor cost ($/hr) 0

d. Gas monitoring cost ($)
Line 1a * Line 1b * Line 1c — 0

2. Gas Monitoring Well Maintenance

a. Maintenance frequency (visits/30 years) — 0

b. Monitoring wells needing maintenance per visit — 0

c. Maintenance time required (hrs/well) — 0

d. Unit labor cost ($/hr) — 0

e. Monitoring and well maintenance cost ($)
Line 2a * Line 2b * Line 2c * Line 2d — 0

3. Gas Monitoring and Maintenance Cost ($)
Line 1d + Line 2e — $0

G. <u>Cost for Ground Water Monitoring System Maintenance</u>

1. Monitoring Well Maintenance

a. Maintenance frequency (visits/30 yrs) — 60

b. Number of monitoring wells needing maintenance per visit — 1

c. Maintenance time required (hrs/well) — 1

d. Unit labor cost ($/hr) — $100

e. Monitoring well maintenance cost ($)
Line 1a * Line 1b * Line 1c * Line 1d — $6,000

2. Monitoring Well and Parts Replacement

a. Number of wells needing replacement during post-closure period — 5

b. Existing monitoring well sealing unit cost ($/well) — $2,000

c. New monitoring well construction unit cost ($/well) — $5,000

d. Monitoring well replacement cost ($) Line 2a * (Line 2b + Line 2c) — $35,000

e. Number of pumps needing replacement during post-closure period — 34

f. Pump unit cost ($/pump) — $800

g. Pump cost ($) Line 2e * Line 2f — $27,200

3. Ground Water Monitoring System Maintenance Cost ($) Line 1e + Line 2d + Line 2g — $68,200

H. Cost for Ground Water Monitoring

1. Ground Water Monitoring

a. Number of required monitoring wells — 19

b. Monitoring frequency (semiannual sampling for 30 years) — 60

c. Sampling and analysis cost ($/well) — $1,100

d. Ground Water Monitoring Cost ($) Line 1a * Line 1b * Line 1c — $1,254,000

I. Cost for Leachate Hauling

1. Leachate Pumping & Hauling

a. Leachate removal frequency (visits/30 years) — 0

b. Quantity to be managed off-site (gallons/visit) 0

c. Truck capacity (gallons) 0

d. Number of loads/visit
Line 1b/Line 1c
(round up to the nearest integer) 0

e. Pumping and transportation unit cost ($/load) 0

f. Leachate Hauling Cost ($)
Line 1a * Line 1d * Line 1e 0

J. Cost for Leachate Disposal

1. Leachate Treatment

a. Volume of leachate requiring disposal (gallons) 0

b. Disposal unit cost ($/gal) 0

c. Leachate Disposal Cost ($)
Line 1a * Line 1b 0

K. Other Costs

Any costs not included in the above items should be included here. These might include drainage ditch, access road, and sedimentation pond maintenance, lift station power costs, etc.

1. **Activity** / **Cost**

Activity	Cost
1. Surface Water Controls	$45,000
2. Dike Maintenance	$120,000
3. Contingency (25% of Items A thru J plus K1 and K2)	$529,595

2. Total of Other Costs ($) $694,595

L. Total Post Closure Cost Estimate ($) $2,647,974

(Total of preceding categories)

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Attachment V – Calculations

Appendix A – Hydrologic and Hydraulic Analysis

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COVER SHEET

S&ME

Project Name: Tanner's Creek Fly Ash Pond Closure	
Subject: Hydrologic and Hydraulic Study	
Project No. 7217-17-007A	Calc. No.
Discipline Water Resources	Sheet 1 of 11

Tanner's Creek Fly Ash Pond Closure
Hydrologic and Hydraulic Study

Computations By:	Signature:		Date	9/1/2017
	Name:	Matthew R Marquis, P.E.		
	Title:	Project Engineer		
Assumptions and Procedures Checked By:	Signature:		Date	9/1/2017
	Name:	Patrick L. McMahon, P.E.		
	Title:	Project Engineer		
Computations Checked By:	Signature:		Date	9/1/2017
	Name:	Wesley R Harrison, E.I.		
	Title:	Staff Engineer		
Reviewed By:	Signature: William Barry Sep 1 2017 2:37 PM	CoSign	Date	9/1/2017
	Name:	Ken Barry, P.E.		
	Title:	Senior Project Engineer		

No.	Description	By	AS & PR	Comp	Review	Date
0	Original Issue					

WILLIAM K. BARRY REGISTERED STATE OF INDIANA PROFESSIONAL ENGINEER

William Barry
Sep 1 2017 2:37 PM CoSign

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List of Tables

Objective

This objective of this calculation package is to demonstrate that proposed surface water controls for the Tanner's Creek Fly Ash Pond (FAP) Closure are properly sized in accordance with Indiana Annotated Code Title 329, Article 10, Solid Waste Land Disposal Facilities. Specifically, all permanent drainage controls are to be sized for the 25-year 24-hour design storm event; S&ME used the 100-year 24-hour event for the design of all surface water controls at the direction of the Indiana Department of Environmental Management (IDEM). For computational purposes, we have assumed that the Ohio River is at a normal operating pool because tail water from the 100-year storm event floods a significant portion of the site.

Site Description

The fly ash pond complex, when originally constructed in 1977 and 1978, consisted of a single impoundment contained by a fully encompassing perimeter earthen dike. The bottom of the pond was extended below the surrounding ground surface and the interior was lined with a 20 mil PVC geomembrane. Fly ash was sluiced in from the northern end and a clear water pond was maintained on the southern end. The impoundment was physically split into the southern clear water pond and the upper (northern) basin between 2003 and 2007. The reconfiguration was accomplished by constructing an interior dike consisting of bottom ash over the in-place sluiced fly ash. At that time, spillways were installed in the upper basin on the east and west sides near the south end to convey the flow to the clear water pond. In 2010, the upper basin was split into an eastern basin and a western basin with the installation of a splitter dike also constructed of bottom ash over the in-place sluiced fly ash. See Figure A.1 in the Appendix for an overall site plan. A listing of items included in the appendix is included at the end of this report.

Closure Approach

The proposed closure approach includes two phases of ash grading as described below. Site plans depicting drainage areas and proposed site grading for each phase of construction modeled as part of this study can be found in the Appendix. The planned construction is described in the following sections.

Phase I

Phase I begins with an excavation of a perimeter drainage channel through the upstream side of the existing soil embankment near the toe of the ash dike on both sides of the basin. The purpose of the perimeter channel is to direct all storm water to the clear water pond during construction. Existing storm water conveyance structures will be removed within the fly ash pond (FAP) area and replaced with an open channel cut through the existing ash dike (designated the ash breach) on both sides of the basin. The open channels will collect storm water runoff from the FAP area and the perimeter drainage channel and carry that runoff to the pond. Ash grading will primarily focus on the northern fly ash storage area. The ash will be regraded to match the final grading plan configuration. Excess cut material will be placed within the pond at the southern end of the basin in preparation for Phase II. H&H analysis for the Phase I drainage features are included as part of this study. See Figure A.2 in the Appendix.

Phase II

Phase II will consist of regrading the ash within the pond to match the final grade configuration. Specifically, the final grades are configured to allow the existing emergency spillway to be used to convey storm water runoff from the clear water pond post construction. To achieve this the ash within the pond area will be regraded into drainage swales toward the outlet. The intermediate Phase II configuration within the clearwater pond, prior to placement of final cover, was not evaluated as part of this analysis. The Clear Water Pond manages storm water via pumps and that process will continue throughout construction. Accumulations of storm water during construction will be pumped to the main Ash Pond until Phase II ash regrading work commences and the hydraulic connection disconnects from the Phase I areas final cover areas. See Figure A.3 in the Appendix.

Final Grades

The Phase I (FAP) and Phase II (Clear water pond) areas will receive final cover at different times. The FAP area will receive final cover but will continue to convey storm water to the clear water pond until the area is stabilized with vegetation. At that time, Phase II grading will begin and the soil breaches will be constructed. The clear water pond will convey storm water through the existing emergency spillway structure. H&H analysis of the final grade configuration for both Phase I and Phase II is included in the sections below.

Key elevations (nominal) for the FAP are as follows:

- El 465 - 470 – outboard toe of earthen dike.
- EL 458 – bottom of pond.
- El 495 - top of original earthen dike (clear water pond dike on west, south, and east sides).
- El 518 – top of bottom ash dike on west, north, and east sides of the upper basin.
- El 511 – top of bottom ash dike between upper basin and clear water pond.
- El 508 – general surface of the fly ash within upper basin.
- El 488 – 100 year, 24 hour flood level of Ohio River adjacent to the FAP
- El 491 – emergency spillway invert.

Hydrologic Study

The permanent drainage controls generally consist of open channels that convey storm water from the northern portion of the basin to two soil breaches. The existing emergency spillway, consisting of a concrete box culvert and concrete chute will convey storm water runoff from the pond area. These drainage controls are discussed in more detail in the sections below. S&ME used the SCS method to estimate the peak discharge during the design storm event. Hydrologic and hydraulic analyses were conducted using HydroCAD v.10 to model each drainage area using TR-20 methodology. See Figures A.2-A.3 as a reference for the discussion below.

Drainage Area

The study was divided into two hydrologic models. The first model represents the FAP configuration upon completion of Phase I ash grading. The second model represents the final grade configuration for both Phase I and Phase II. Table 1 describes the drainage areas for both models.

Table 1 – Phase I and Phase II Model Drainage Areas

HydroCAD Node	Area (AC)	Runoff CN	Time of Concentration (Min)
I-W1A	24.6	79	25.6
I-W2A	9.0	79	40.4
I-E1A	22.7	79	23.1
I-E2A	5.9	79	28.1
I-PA	13.1	86	7.3
II-W1A	25.1	79	25.6
II-W2A	9.0	79	40.4
II-E1A	23.7	79	23.1
II-E2A	5.9	79	28.1
II-PA	12.0	79	28.7

Drainage Areas were delineated using AutoCAD Civil3D 2017 from proposed design contours and survey data provided by GEOPRO Consultants, LLC March, 2017.

Curve Number

Estimated curve number values for observed land uses were based on recent site visits, 2017 aerial imagery and CN values used in a similar studies. Calculations of the composite runoff curve numbers for each drainage area are included in the HydroCAD output results in the Appendix.

Table 2 – Curve Number Assumptions

Surface Type	Estimated Curve Number	Description
Final Cover / Vegetated	79	>50% Grass Cover, Fair-Good condition, HSG C
Ash Material	89	Fallow, Bare soil, HSG B

Time of Concentration

S&ME used the TR-55 method to estimate time of concentration for each drainage area. Storm water runoff within each drainage area was broken down into overland sheet flow, shallow concentrated flow, and channel flow. Time of concentration calculations are included in the summary report from HydroCAD in the Appendix. Manning's roughness values used for the analysis of channelized flow reaches were obtained from HydroCAD.

Rainfall

S&ME used the National Atmospheric and Oceanic Administration (NOAA) database to determine the 100-year, 24-hour point precipitation depth. This analysis reflects the NRCS Type II distribution, 24-hour duration storm. Point precipitation data represent a point located near the ash pond, and the resulting data are included in the Appendix.

Clear Water Pond Storage

S&ME estimated storage within the Clear Water Pond at both the end of the Phase I ash grading and then near the concrete box culvert at the end of final cover placement as part of Phase II. Stage storage curves are presented in the Appendix. Note that the operating pool within the pond is currently maintained using pumps and that will continue during construction. The clear water pond storage (Phase I) and upstream storage behind the concrete box culvert (Phase II) indicate that sufficient storage is available to store runoff from the design storm event or that the concrete culvert can safely pass the design storm without overtopping the existing embankment.

Hydraulic Study

Permanent drainage controls in this study include culverts and open channels that convey storm water flow to the pond during Phase I or offsite during the final grade configuration. S&ME routed each drainage area through the permanent drainage features using HydroCAD to demonstrate that these features meet the calculation objectives. Characteristics of each drainage control feature are included in the sections below.

Culverts

S&ME used Hydrocad to route storm water runoff through the existing emergency spillway culvert as part of the final grade configuration for the phase II clear water pond. S&ME used HY-8 software developed by the Federal Highway Administration to verify the results from the HydroCAD routing. The culvert geometry and elevation data were based on ground survey data obtained by GEOPRO Consultants, LLC in March 2017, and recent site visits. Table 3 describes the existing culvert included in this study. Results from HydroCAD and HY-8 are included in the Appendix.

Table 3 – Culvert Pipe Characteristics

Description	Material	Rise (in)	Width (in)	Length (ft)	Slope (ft/ft)	Roughness[1]
Box Culvert	Concrete	36	48	89	0.0003	0.011

[1] Manning's roughness value based on closed conduit concrete pipe, straight and clean.

Open Channels

Open channel capacity was estimated using Manning's equation for open channel flow within HydroCAD. Ditch geometry was developed from 2016 survey data and proposed final grading. Table 4 describes the open channels included in this study.

Table 4 – Open Channel Characteristics

Channel (HydroCAD Reference)	Bottom Width (ft)	Side Slopes (XH:1V)	Design Depth (ft)	Bed Slope (ft/ft)	Proposed Lining	Manning's Roughness n[1]
West Drainage Channel (WC1)	10	50	1.0	0.005	Temp ECB	0.052
West Ash Breach (WC2)	10	4.2	2.0	0.082	Fabriform	0.025

Channel (HydroCAD Reference)	Bottom Width (ft)	Side Slopes (XH:1V)	Design Depth (ft)	Bed Slope (ft/ft)	Proposed Lining	Manning's Roughness n[1]
West Perimeter Channel (WC3)	10	3.0	2.0	0.002	Temp ECB	0.050
West Soil Breach (WC4)	10	4.0	2.0	0.21	Riprap	0.054
East Drainage Channel (EC1)	10	50	1.0	0.005	Temp ECB	0.052
East Ash Breach (EC2)	10	4.2	2.0	0.069	Fabriform	0.025
East Perimeter Channel (EC3)	10	3.0	2.0	0.002	Temp ECB	0.050
East Soil Breach (EC4)	10	3.5	2.0	0.17	Riprap	0.051
Upper Spillway Channel	4.0	Vertical	3.0	0.001	Concrete	0.012
Middle Spillway Channel	4.0	Vertical	3.0	0.256	Concrete	0.012
Lower Spillway Channel	4.0	Vertical	3.0	0.003	Concrete	0.012

[1] See discussion in the section below for the methods used to calculate the Manning's roughness coefficient.

Manning's Roughness for Storm Water Channels

The proposed channel lining for each storm water channel was chosen based on the velocity and shear stress anticipated during the design event. Unreinforced vegetation was considered for each channel as a first step, however many of the steeper channels appear to be unstable without additional armoring. All technical sheets and calculations discussed in this section are included in the Appendix.

For WC1, WC3, EC1, and EC3 the unreinforced vegetation appears to be a stable option with very low estimated velocities. These four channels are ten feet wide however and S&ME has designed these channels with a temporary erosion control blanket (ECB) in order to help prevent the concentration of flow during lesser storm events prior to vegetation maturation. Manning's roughness values for these channels were estimated from the North American Green Erosion Control Materials Design Software (ECMDS) Version 5.0 based on a temporary EroNet ECB. A smaller design storm event (2-YR 24-HR) was used to estimate the depth of flow in these channels to determine the required installation width of the ECB materials. A HydroCAD summary report estimating peak runoff for the 2-YR 24-HR event and ECMDS summary sheets for each channel are included in the Appendix. For the perimeter drainage channels (WC3 and EC3) ECBs will extend along the side slopes two feet above the bottom of the channel for an approximate width of 24-feet. For the upper drainage channels where the side slopes are laid back at a 50H:1V ECBs will extend to the equivalent of a 1-foot depth in the channel for an approximate width of 110-feet.

For II-WC2 and II-EC2 a Fabriform 10-inch Filterpoint product was chosen to portect the channel from relatively high estimated velocities within the ash breach channels. The Fabriform product also has a thin profile to maximize the thickness of clay cap over the liner system. Manning's roughness for the fabriform material is based on a technical sheet provided by the manufacturer.

For II-EC4 and II-WC4 a riprap rock chute was designed using the ARS Chute Method. One of the limitations on this project was to keep a relatively small footprint at the toe of the ash pond slope, particularly on the west side of the basin. The rock chute allows for some dissipation of energy within the channel and reduces the size of the downstream riprap apron at the toe of the slope. The Manning's roughness for each channel was estimated within the calculation using the ARS chute method (Robinson, 1998).

Soil Breach Channels

The east and west soil breach channels pass the design storm event with no greater than a 1-foot depth of flow. The proposed channel consists of riprap stone armoring that extends across the full width of the channel and up each side slope to an elevation that corresponds with a 2-foot depth within the channel. The riprap stone size for the breach channel was estimated using the ARS Chute Method. The required riprap size (D50) for each breach channel is approximately 18-inches. These calculations are included in the Appendix.

Runoff velocities will be dissipated with the use of riprap aprons at the base of the ditches. The riprap for these aprons was sized using the Hydraulic Engineering Circular (HEC-14), Chapter 10 design of riprap aprons. An equivalent circular diameter was determined for the calculation using the design storm flow depth in the storm water ditches. Tailwater was estimated as 0.4D for this calculation. These calculations are included in the Appendix, and the resulting riprap apron dimensions are summarized in Table 5 below:

Table 5 – Minimum Required Riprap Apron Dimensions

Ditch	Req'd D50 (in)(1)	Length (ft)	Depth (ft)(2)
West Soil Breach Apron	12	14	2.0
East Soil Breach Apron	12	14	2.0

(1) Required D50 shown in Table 5 represents the required stone size for grouted riprap which was calculated as ½ of the estimated D50 using the HEC-14 method.
(2) Minimum depth of riprap apron does not include proposed bedding stone beneath the stone.

Concrete Channel Outlet

The existing concrete culvert and open channel chute will handle storm water runoff from the clear water pond post construction. The chute is comprised of three segments, an upper chute that is relatively flat, a steep middle portion, and a lower segment that terminates into an existing riprap lined channel. Normal depth in all three channel segments was estimated using Manning's equation for open channel flow. S&ME used USBR Technical Publication No. 25 - The Hydraulic Design of Stilling Basins and Energy Dissipators - to estimate the height and length of the hydraulic jump at the base of middle concrete chute where the bed slope transitions from a steep portion to a flat portion at the bottom. It appears that the lower portion of the concrete chute has sufficient depth and length to handle the hydraulic jump resulting from the design storm event.

Results / Discussion

Culverts

The existing culvert was found to be sufficiently sized for the design storm event. The results of the HY-8 culvert analysis are included in Table 6 below:

Table 6 – Culvert Pipe Results

Calculation Method	Estimated Peak Flow (cfs)	HW Elevation	Roadway/ Embankment Elevation	Overtopping?
HydroCAD (II-P)	38.8	492.15	494.0	NO
HY-8	38.8	493.02	494.0	NO

Open Channels

The proposed permanent drainage features were found to be adequately sized for the 100-year design storm event. The results of the open channel flow analysis are summarized in Table 7 below:

Table 7 – Open Channel Results

Channel	Calculation Method(1)	Design Depth (ft)	Calculated 100-Year Flow Depth (ft)
West Drainage Channel	MathCAD	1.0	0.95
West Ash Breach	MathCAD	2.0	0.63
West Perimeter Channel	MathCAD	2.0	1.10
West Soil Breach	HydroCAD (F-WC4)	2.0	0.73
East Drainage Channel	MathCAD	1.0	0.95
East Ash Breach	MathCAD	2.0	0.66
East Perimeter Channel	MathCAD	2.0	1.04
East Soil Breach	HydroCAD (F-EC4)	2.0	0.77
Upper Spillway Channel	MathCAD	3.0	1.70
Middle Spillway Channel	MathCAD	3.0	0.26
Lower Spillway Channel	MathCAD	3.0	1.69

(1) HydroCAD output reports and MathCAD worksheets for these open channel calculations are included in the Appendix.

References

Chow, Ven Te. "Chapter 5 - Development of Uniform Flow and Its Formulas." *Open-channel Hydraulics*. New York: McGraw-Hill, 1959. Print.

HydroCAD User Manual. Vers. 10.00. n.p.: HydroCAD Software Solutions LLC, Program documentation.

Peterka, A. J. Hydraulic Design of Stilling Basins and Energy Dissipators, *Engineering Monograph No. 25*. US Department of Interior, Bureau of Reclamation, May 1984.

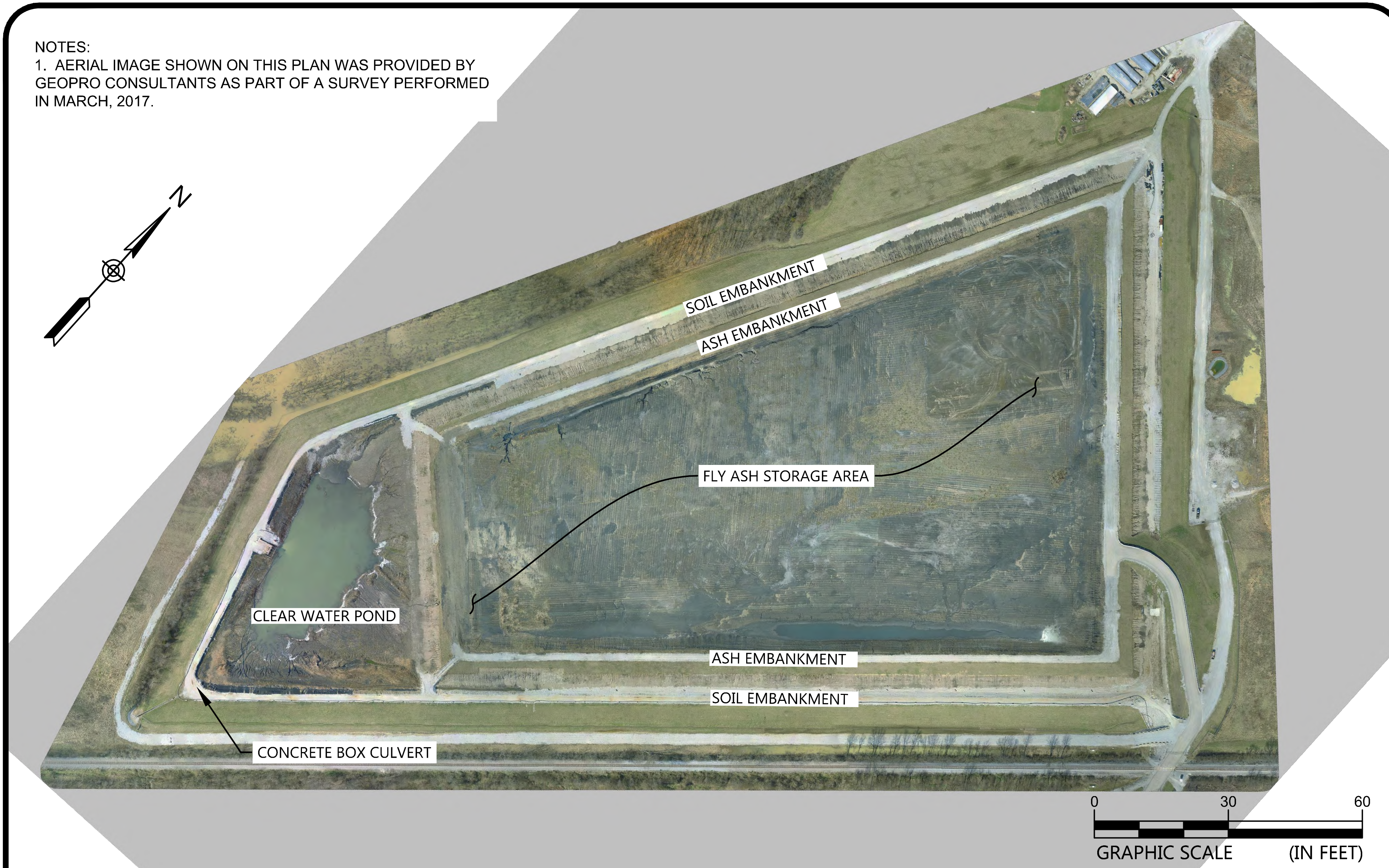
Robinson, K. M., C. E. Rice, and K. C. Kadavy. *Design of Rock Chutes*. Rep. Vol. 41. American Society of Agricultural Engineers, 1998. Print.

Thompson, Philip L, and Roger T Kilgore. "Hydraulic Design of Energy Dissipators for Culverts and Channels." *Hydraulic Design of Energy Dissipators for Culverts and Channels*, 3rd ed., FHWA, 2006. *Hydraulic Engineering Circular No. 14*.

US Department of Agriculture. Urban Hydrology for Small Watersheds, *Technical Release 55 (TR55)*, Washington D.C., June 1986.

Appendices

NOTES:
1. AERIAL IMAGE SHOWN ON THIS PLAN WAS PROVIDED BY GEOPRO CONSULTANTS AS PART OF A SURVEY PERFORMED IN MARCH, 2017.



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SITE PLAN

FLY ASH POND CLOSURE TANNER'S CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

SCALE:	SITE PLAN
DATE:	8/31/2017
PROJECT NUMBER	7217-17-007A
FIGURE NO.	A.1

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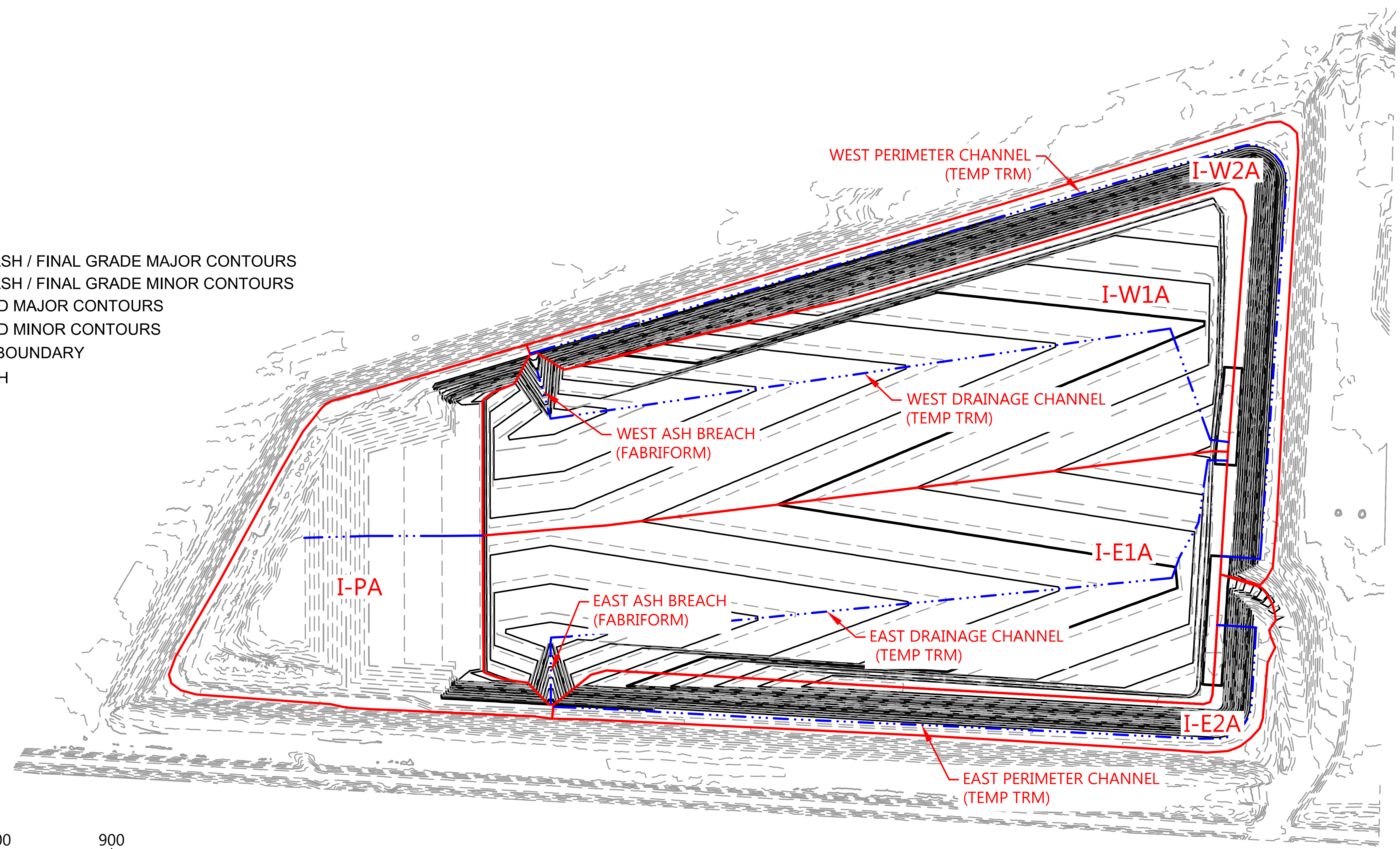
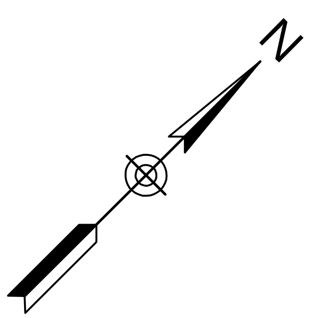
NOTES:

1. EXISTING CONTOURS SHOWN ON THIS PLAN REPRESENT PHASE I TOP OF ASH GRADES SUPPLEMENTED WITH A GROUND SURVEY PROVIDED BY GEOPRO CONSULTANTS LLC FROM A SURVEY PERFORMED MARCH. 2017.
2. PROPOSED CONTOURS SHOWN ON THIS SHEET REPRESENT PROPOSED FINAL GRADES UPON COMPLETION OF PHASE I.
3. ALL CONTOURS SHOWN AT A 2' AND 10' INTERVAL.

LEGEND

- PHASE I TOP OF ASH / FINAL GRADE MAJOR CONTOURS
- PHASE I TOP OF ASH / FINAL GRADE MINOR CONTOURS
- EXISTING GROUND MAJOR CONTOURS
- EXISTING GROUND MINOR CONTOURS
- DRAINAGE AREA BOUNDARY
- TC LONGEST PATH





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GRAPHIC SCALE

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TANNER'S CREEK
FLY ASH POND CLOSURE
H&H STUDY

LAWRENCEBURG, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV

PROJECT NUMBER 7217-17-007A

DRAWING NUMBER A.2

DRAWING NAME PHASE I GRADES

NOTES:

1. EXISTING CONTOURS SHOWN ON THIS PLAN REPRESENT PHASE I FINAL GRADES WITH PHASE II TOP OF ASH GRADES SUPPLEMENTED WITH A GROUND SURVEY PROVIDED BY GEOPRO CONSULTANTS LLC FROM A SURVEY PERFORMED MARCH. 2017.

2. PROPOSED CONTOURS SHOWN ON THIS SHEET REPRESENT PROPOSED FINAL GRADES UPON COMPLETION OF PHASE II.

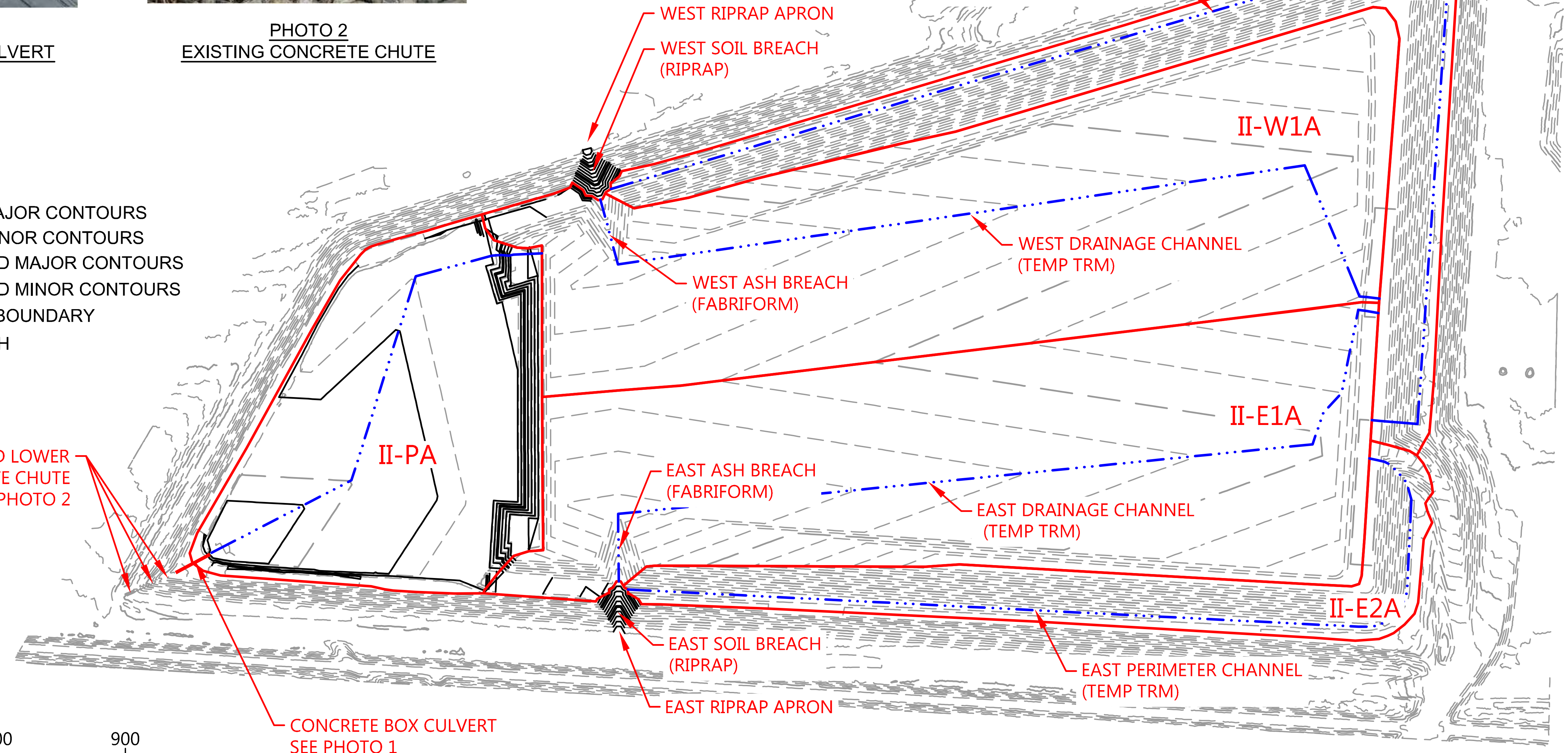
3. ALL CONTOURS SHOWN AT A 2' AND 10' INTERVAL.

PHOTO 1
EXISTING CONCRETE CULVERT
(UPSTREAM END)

PHOTO 2
EXISTING CONCRETE CHUTE

LEGEND

- FINAL GRADES MAJOR CONTOURS
- FINAL GRADES MINOR CONTOURS
- EXISTING GROUND MAJOR CONTOURS
- EXISTING GROUND MINOR CONTOURS
- DRAINAGE AREA BOUNDARY
- TC LONGEST PATH
- CULVERT PIPE



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0 150 300 600 900

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TANNER'S CREEK
FLY ASH POND CLOSURE
H&H STUDY

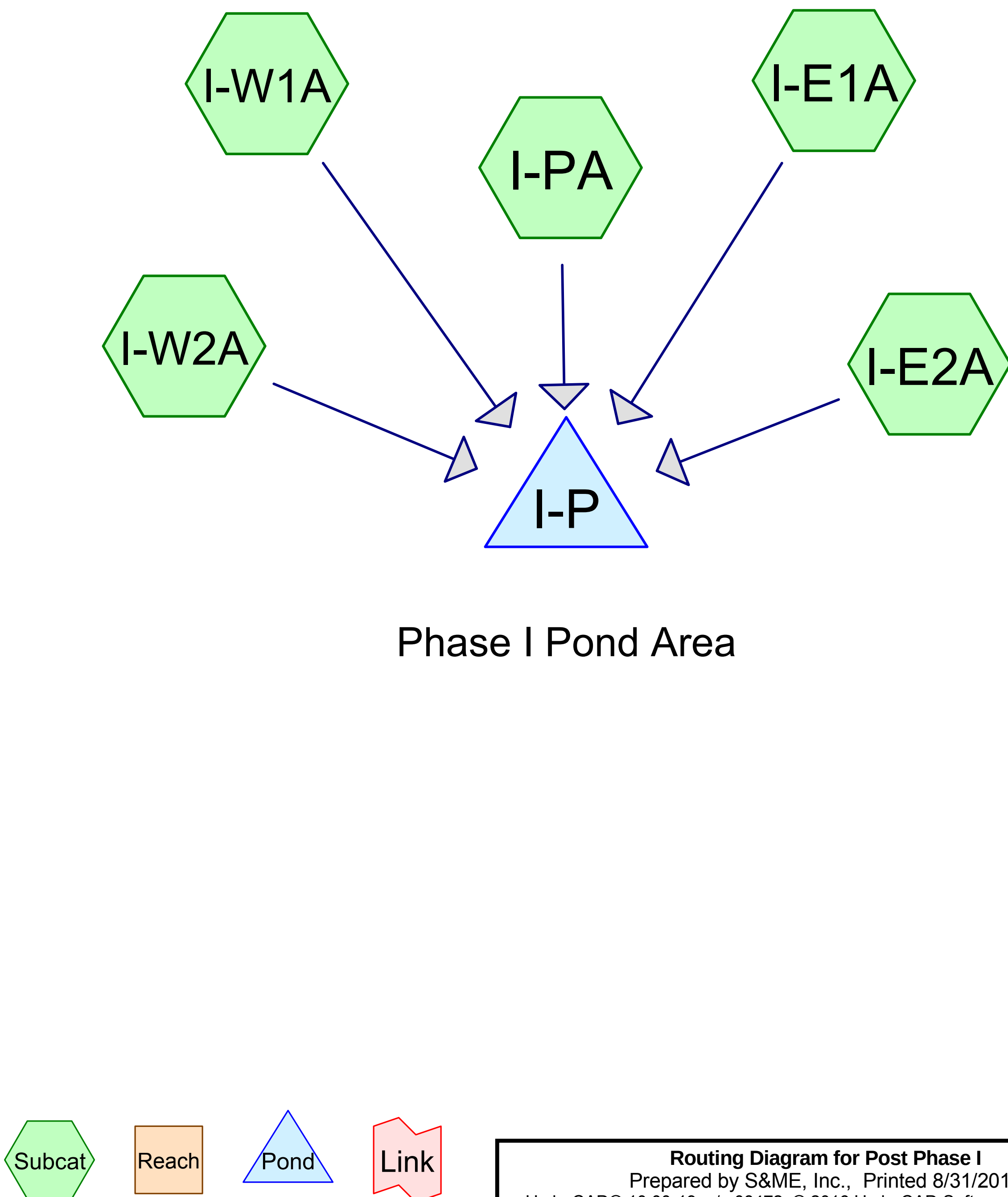
LAWRENCEBURG, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
A.3

DRAWING NAME
PHASE II
FINAL
GRADES



Routing Diagram for Post Phase I
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Summary for Subcatchment I-E1A:

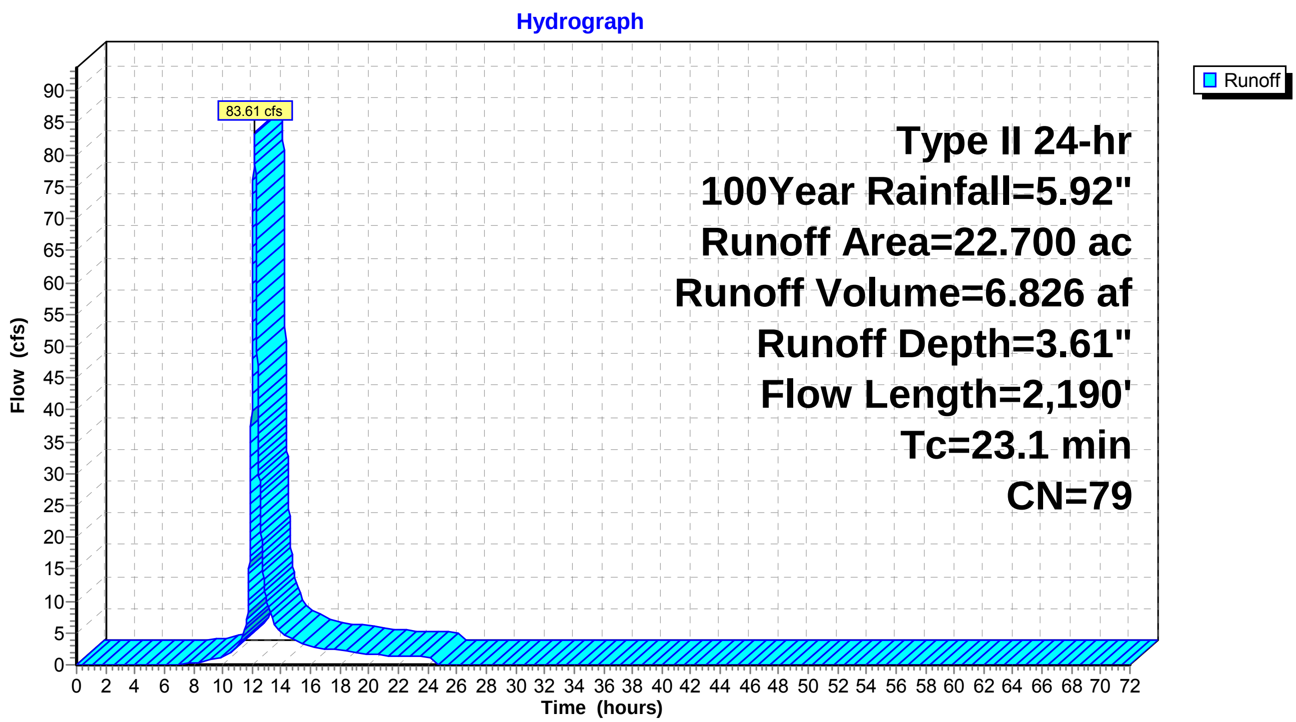
Runoff = 83.61 cfs @ 12.16 hrs, Volume= 6.826 af, Depth= 3.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100Year Rainfall=5.92"

Area (ac)	CN	Description
22.700	79	50-75% Grass cover, Fair, HSG C
22.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	29	0.0200	0.13		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.00"
0.0	19	0.2630	7.69		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
2.7	341	0.0200	2.12		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
16.4	1,642	0.0050	1.67	100.21	**Channel Flow,** Area= 60.0 sf Perim= 110.0' r= 0.55' n= 0.042
0.2	159	0.0689	13.03	185.07	**Channel Flow,** Area= 14.2 sf Perim= 18.6' r= 0.76' n= 0.025
23.1	2,190	Total			

Subcatchment I-E1A:



Summary for Subcatchment I-E2A:

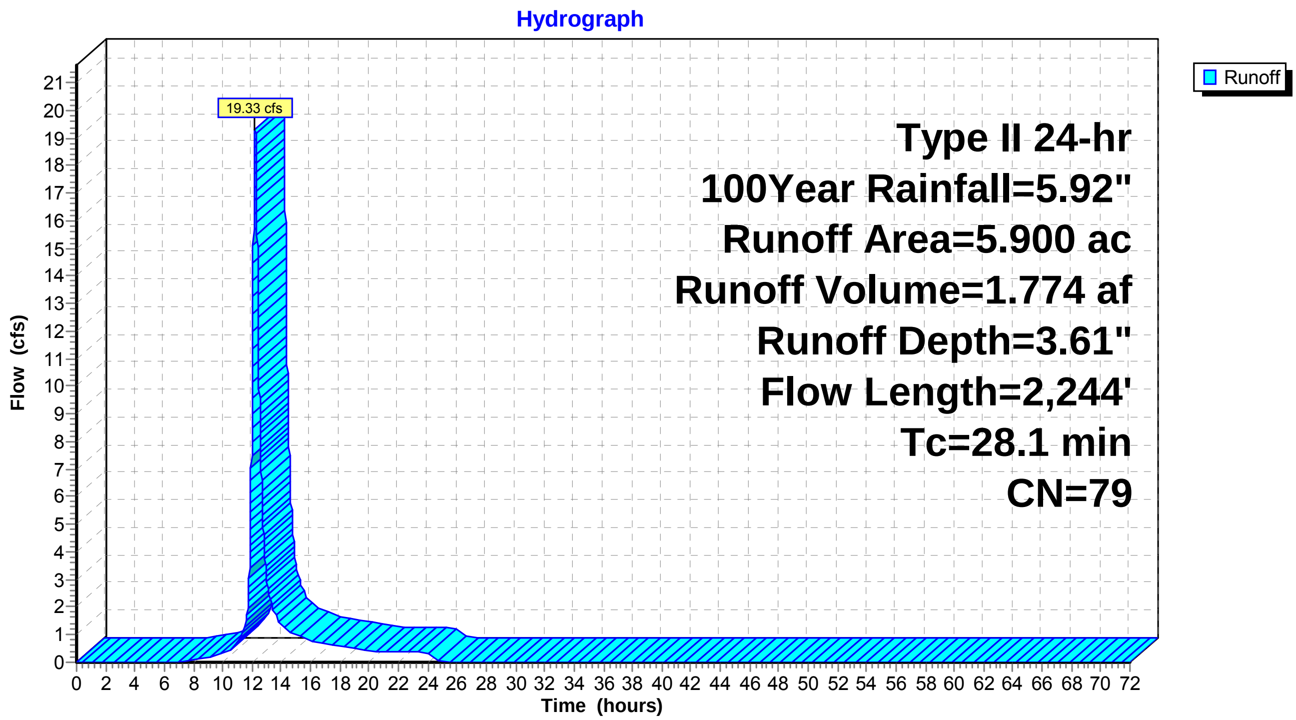
Runoff = 19.33 cfs @ 12.21 hrs, Volume= 1.774 af, Depth= 3.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100Year Rainfall=5.92"

Area (ac)	CN	Description
5.900	79	50-75% Grass cover, Fair, HSG C
5.900		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.7	19	0.0200	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.00"
0.3	131	0.3000	8.22		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
25.1	2,094	0.0019	1.39	18.10	**Channel Flow,** Area= 13.0 sf Perim= 16.3' r= 0.80' n= 0.040
28.1	2,244	Total			

Subcatchment I-E2A:



Summary for Subcatchment I-PA:

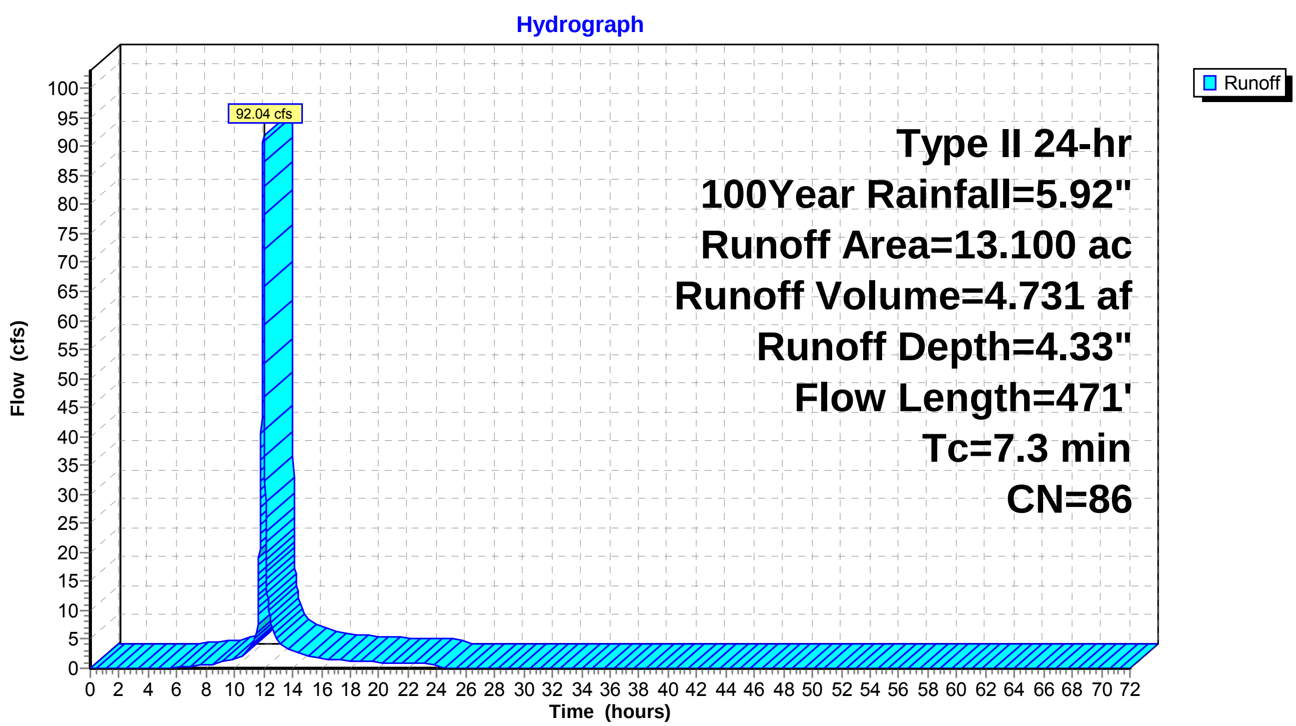
Runoff = 92.04 cfs @ 11.98 hrs, Volume= 4.731 af, Depth= 4.33"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100Year Rainfall=5.92"

Area (ac)	CN	Description
12.600	86	Fallow, bare soil, HSG B
0.500	79	50-75% Grass cover, Fair, HSG C
13.100	86	Weighted Average
13.100		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.2	100	0.0200	0.40		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
2.4	201	0.0200	1.41		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.7	170	0.1667	4.08		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
7.3	471	Total			

Subcatchment I-PA:



Summary for Subcatchment I-W1A:

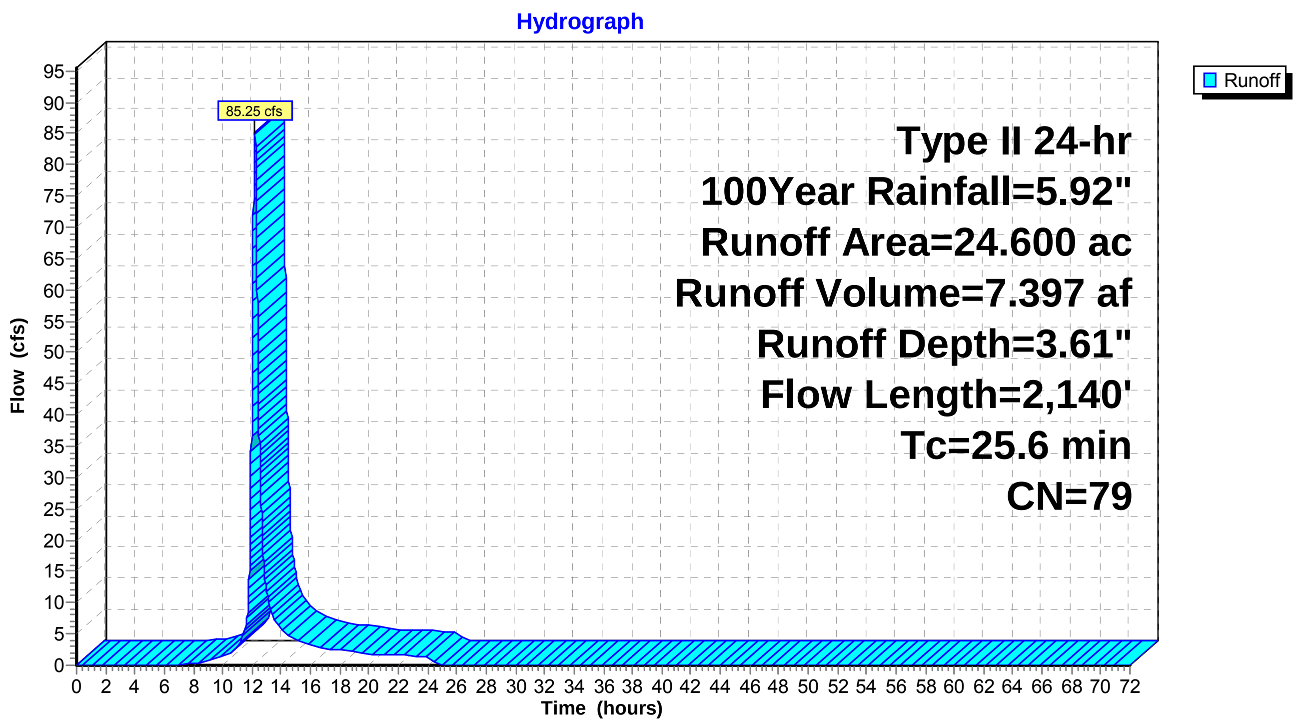
Runoff = 85.25 cfs @ 12.20 hrs, Volume= 7.397 af, Depth= 3.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100Year Rainfall=5.92"

Area (ac)	CN	Description
24.600	79	50-75% Grass cover, Fair, HSG C
24.600		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.5	29	0.0050	0.07		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.00"
0.0	19	0.3334	8.66		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
2.6	334	0.0200	2.12		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
16.3	1,600	0.0050	1.63	97.88	**Channel Flow,** Area= 60.0 sf Perim= 110.0' r= 0.55' n= 0.043
0.2	158	0.0816	14.13	200.68	**Channel Flow,** Area= 14.2 sf Perim= 18.7' r= 0.76' n= 0.025
25.6	2,140	Total			

Subcatchment I-W1A:



Summary for Subcatchment I-W2A:

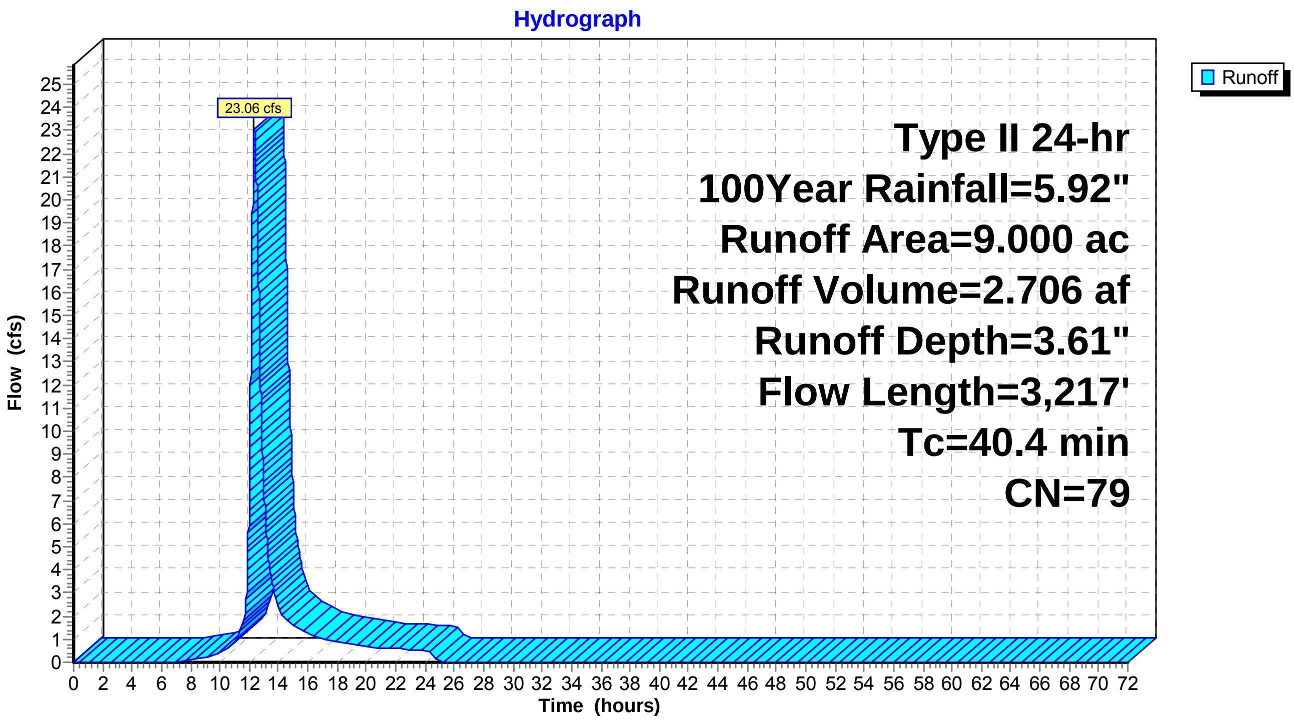
Runoff = 23.06 cfs @ 12.35 hrs, Volume= 2.706 af, Depth= 3.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100Year Rainfall=5.92"

Area (ac)	CN	Description
9.000	79	50-75% Grass cover, Fair, HSG C
9.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.8	25	0.0050	0.07		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.00"
0.2	87	0.2640	7.71		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
34.4	3,105	0.0019	1.51	19.57	**Channel Flow,** Area= 13.0 sf Perim= 16.3' r= 0.80' n= 0.037
40.4	3,217	Total			

Subcatchment I-W2A:



Summary for Pond I-P: Phase I Pond Area

Inflow Area = 75.300 ac, 0.00% Impervious, Inflow Depth = 3.73" for 100Year event
Inflow = 222.19 cfs @ 12.17 hrs, Volume= 23.434 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 486.92' @ 26.31 hrs Surf.Area= 0.000 ac Storage= 23.434 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	471.00'	40.320 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
471.00	0.000
472.00	0.420
473.00	1.050
474.00	1.800
475.00	2.680
476.00	3.680
477.00	4.790
478.00	6.010
479.00	7.360
480.00	8.820
481.00	10.420
482.00	12.170
483.00	14.090
484.00	16.190
485.00	18.470
486.00	20.950
487.00	23.640
488.00	27.000
489.00	31.100
490.00	35.540
491.00	40.320

Post Phase I *Type II 24-hr 100Year Rainfall=5.92"*
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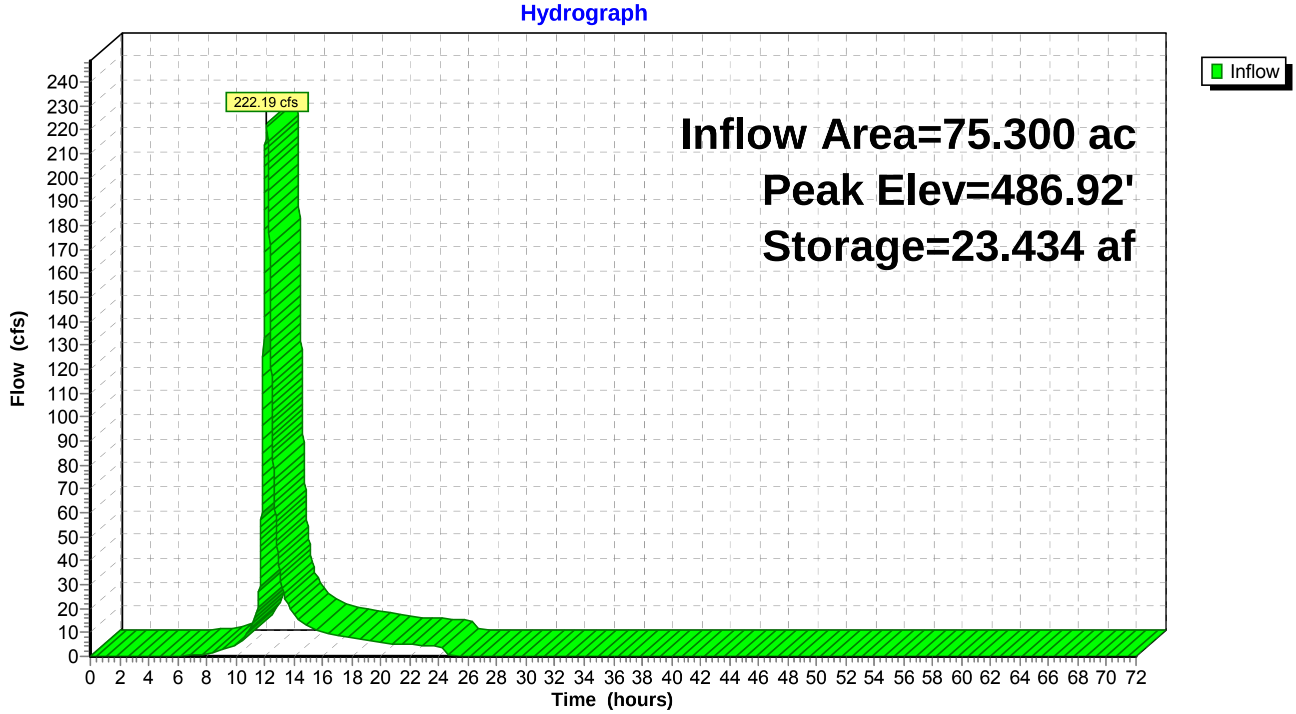
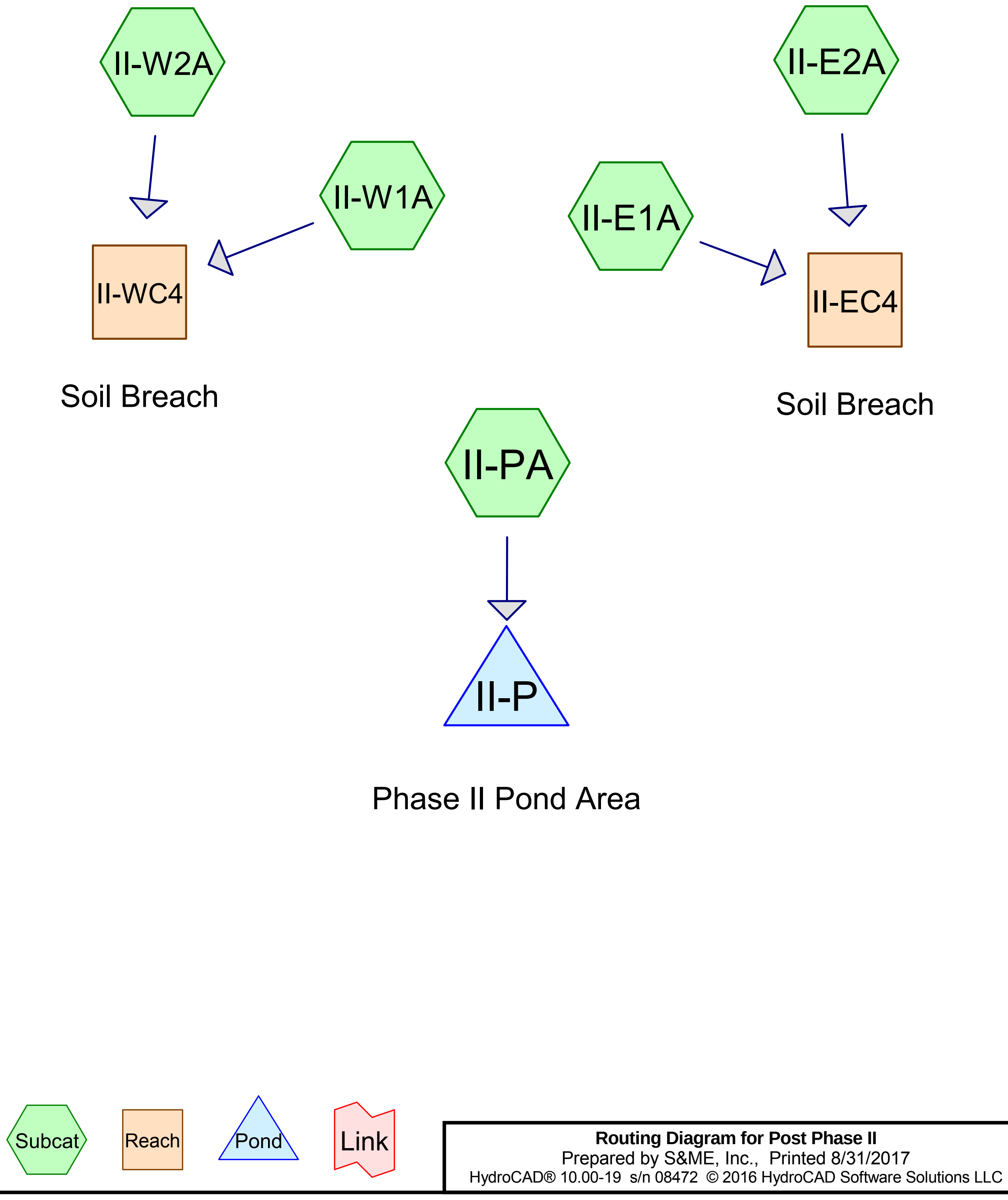
Pond I-P: Phase I Pond Area





Routing Diagram for Post Phase II
Prepared by S&ME, Inc., Printed 8/31/2017
HydroCAD® 10.00-19 s/n 08472 © 2016 HydroCAD Software Solutions LLC

Summary for Subcatchment II-E1A:

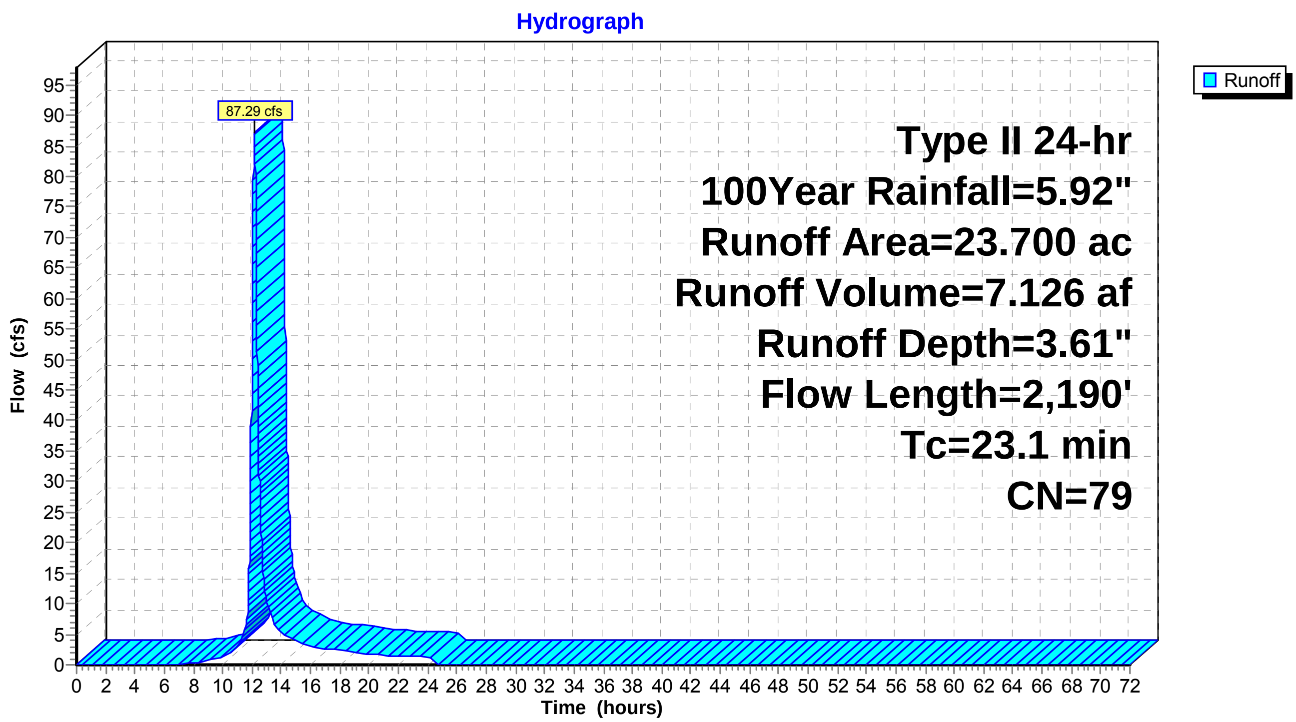
Runoff = 87.29 cfs @ 12.16 hrs, Volume= 7.126 af, Depth= 3.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100Year Rainfall=5.92"

Area (ac)	CN	Description
23.700	79	50-75% Grass cover, Fair, HSG C
23.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	29	0.0200	0.13		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.00"
0.0	19	0.2630	7.69		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
2.7	341	0.0200	2.12		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
16.4	1,642	0.0050	1.67	100.21	**Channel Flow,** Area= 60.0 sf Perim= 110.0' r= 0.55' n= 0.042
0.2	159	0.0689	13.03	185.07	**Channel Flow,** Area= 14.2 sf Perim= 18.6' r= 0.76' n= 0.025
23.1	2,190	Total			

Subcatchment II-E1A:



Summary for Subcatchment II-E2A:

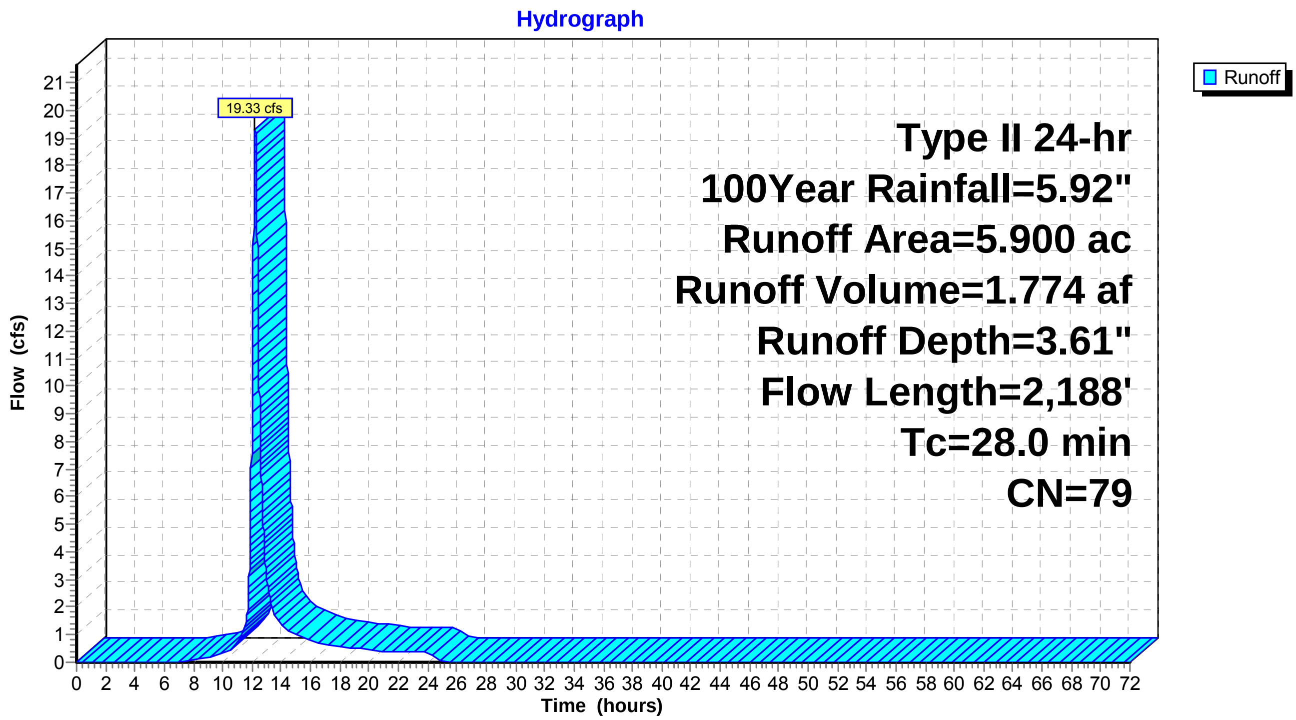
Runoff = 19.33 cfs @ 12.22 hrs, Volume= 1.774 af, Depth= 3.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100Year Rainfall=5.92"

Area (ac)	CN	Description
5.900	79	50-75% Grass cover, Fair, HSG C
5.900		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.7	19	0.0200	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.00"
0.2	75	0.3000	8.22		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
25.1	2,094	0.0019	1.39	18.10	**Channel Flow,** Area= 13.0 sf Perim= 16.3' r= 0.80' n= 0.040
28.0	2,188	Total			

Subcatchment II-E2A:



Summary for Subcatchment II-PA:

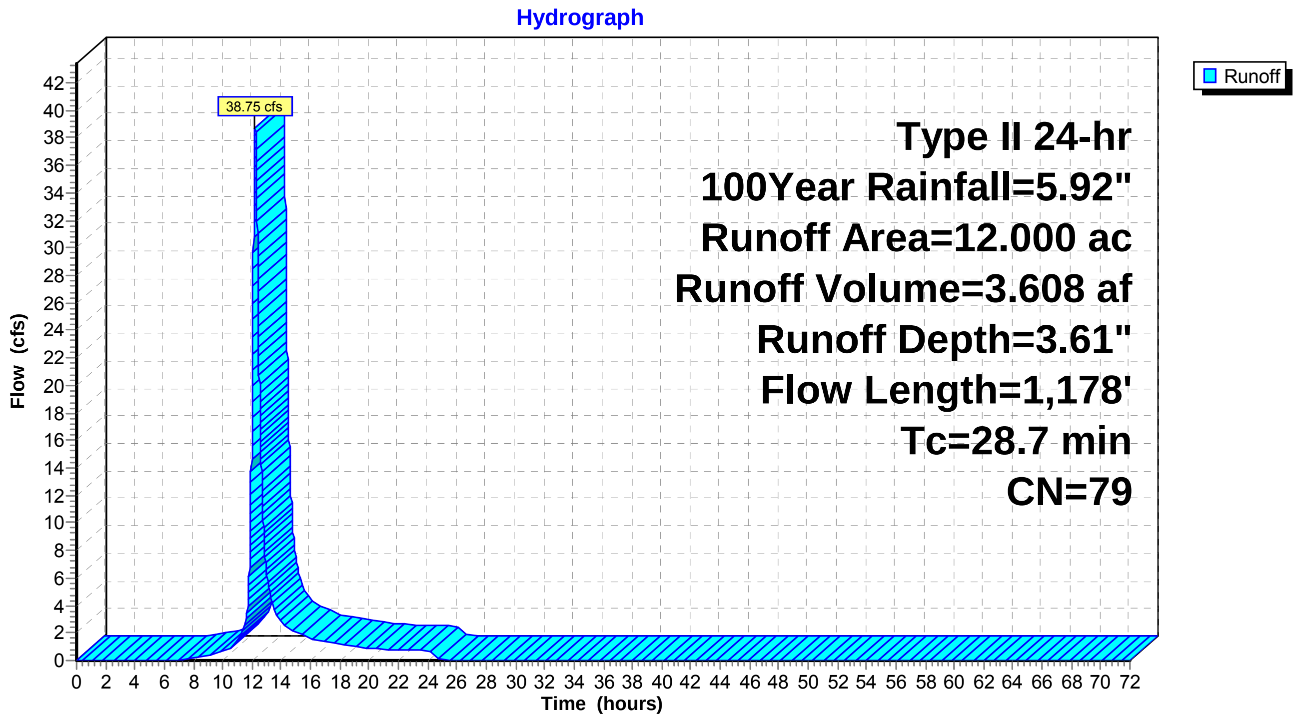
Runoff = 38.75 cfs @ 12.22 hrs, Volume= 3.608 af, Depth= 3.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100Year Rainfall=5.92"

Area (ac)	CN	Description
12.000	79	50-75% Grass cover, Fair, HSG C
12.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	67	0.0200	0.15		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.00"
0.1	40	0.2500	7.50		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
2.4	197	0.0080	1.34		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
18.9	874	0.0080	0.77	2.32	**Channel Flow,** Area= 3.0 sf Perim= 41.2' r= 0.07' n= 0.030 Earth, grassed & winding
28.7	1,178	Total			

Subcatchment II-PA:



Summary for Subcatchment II-W1A:

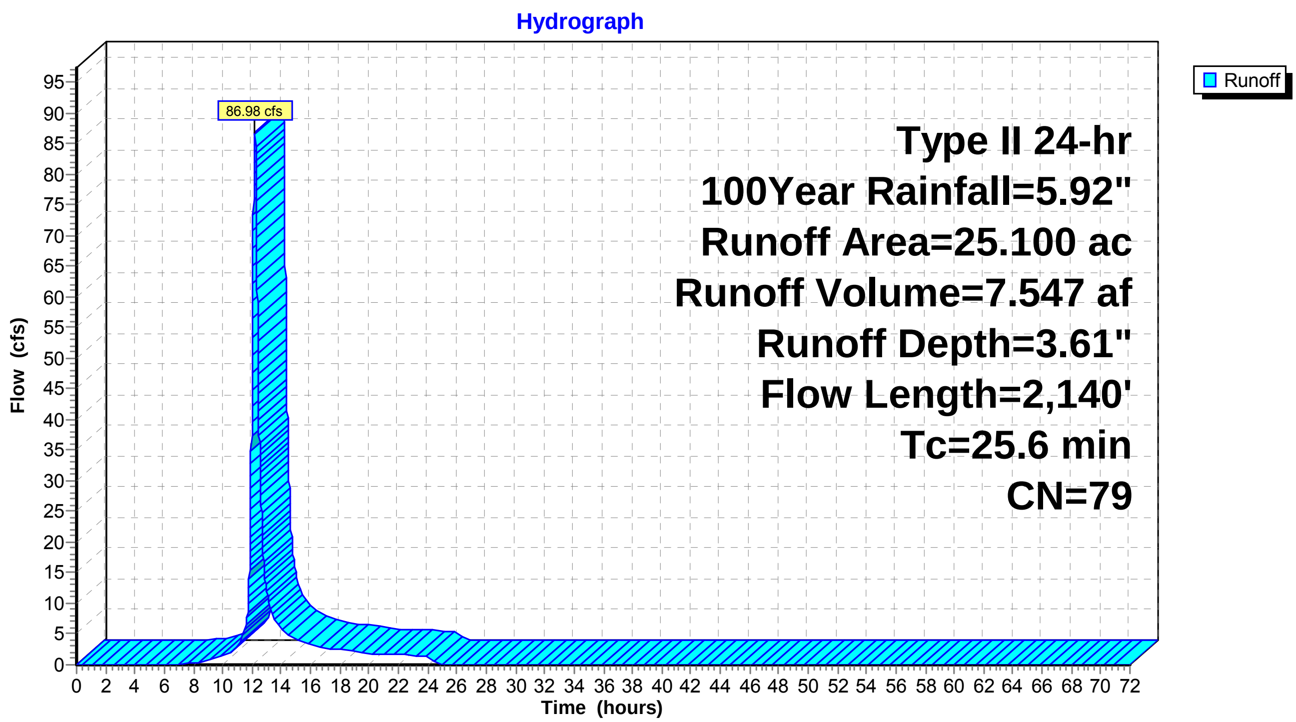
Runoff = 86.98 cfs @ 12.20 hrs, Volume= 7.547 af, Depth= 3.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100Year Rainfall=5.92"

Area (ac)	CN	Description
25.100	79	50-75% Grass cover, Fair, HSG C
25.100		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.5	29	0.0050	0.07		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.00"
0.0	19	0.3334	8.66		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
2.6	334	0.0200	2.12		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
16.3	1,600	0.0050	1.63	97.88	**Channel Flow,** Area= 60.0 sf Perim= 110.0' r= 0.55' n= 0.043
0.2	158	0.0816	14.13	200.68	**Channel Flow,** Area= 14.2 sf Perim= 18.7' r= 0.76' n= 0.025
25.6	2,140	Total			

Subcatchment II-W1A:



Summary for Subcatchment II-W2A:

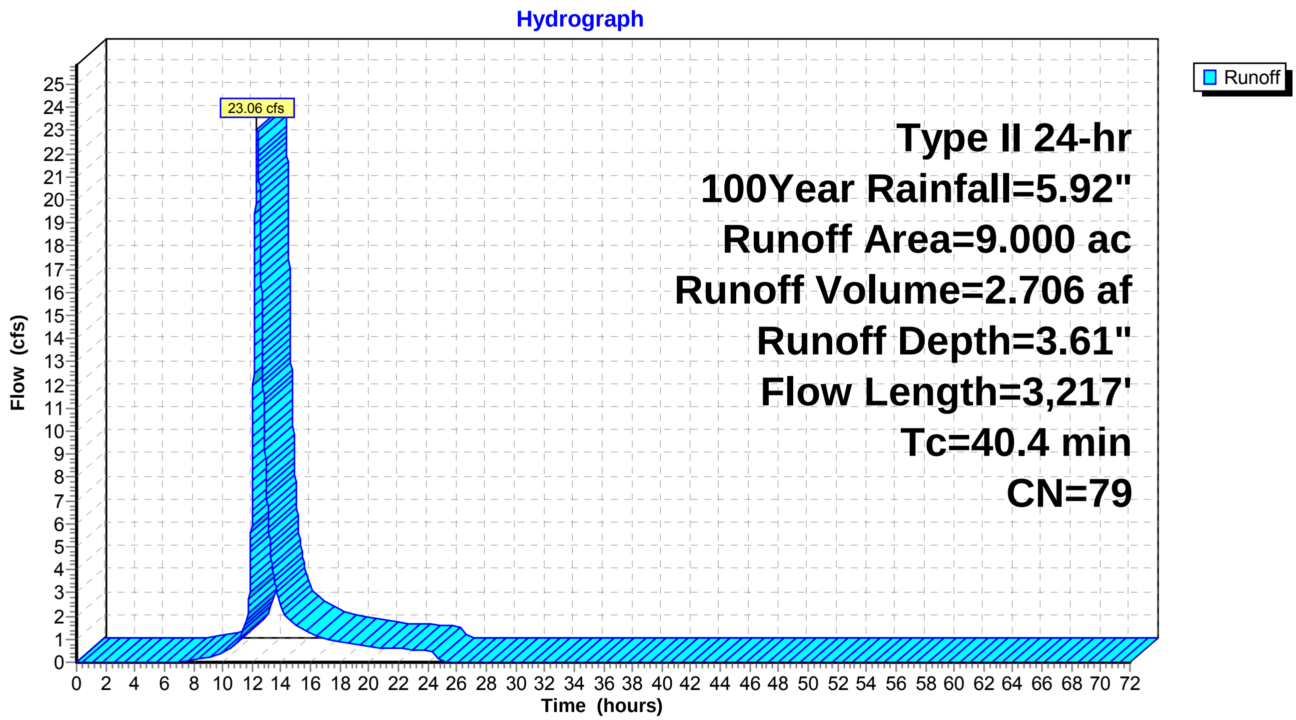
Runoff = 23.06 cfs @ 12.35 hrs, Volume= 2.706 af, Depth= 3.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100Year Rainfall=5.92"

Area (ac)	CN	Description
9.000	79	50-75% Grass cover, Fair, HSG C
9.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.8	25	0.0050	0.07		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.00"
0.2	87	0.2640	7.71		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
34.4	3,105	0.0019	1.51	19.57	**Channel Flow,** Area= 13.0 sf Perim= 16.3' r= 0.80' n= 0.037
40.4	3,217	Total			

Subcatchment II-W2A:



Summary for Reach II-EC4: Soil Breach

Inflow Area = 29.600 ac, 0.00% Impervious, Inflow Depth = 3.61" for 100Year event
Inflow = 105.89 cfs @ 12.17 hrs, Volume= 8.900 af
Outflow = 105.88 cfs @ 12.17 hrs, Volume= 8.900 af, Atten= 0%, Lag= 0.2 min

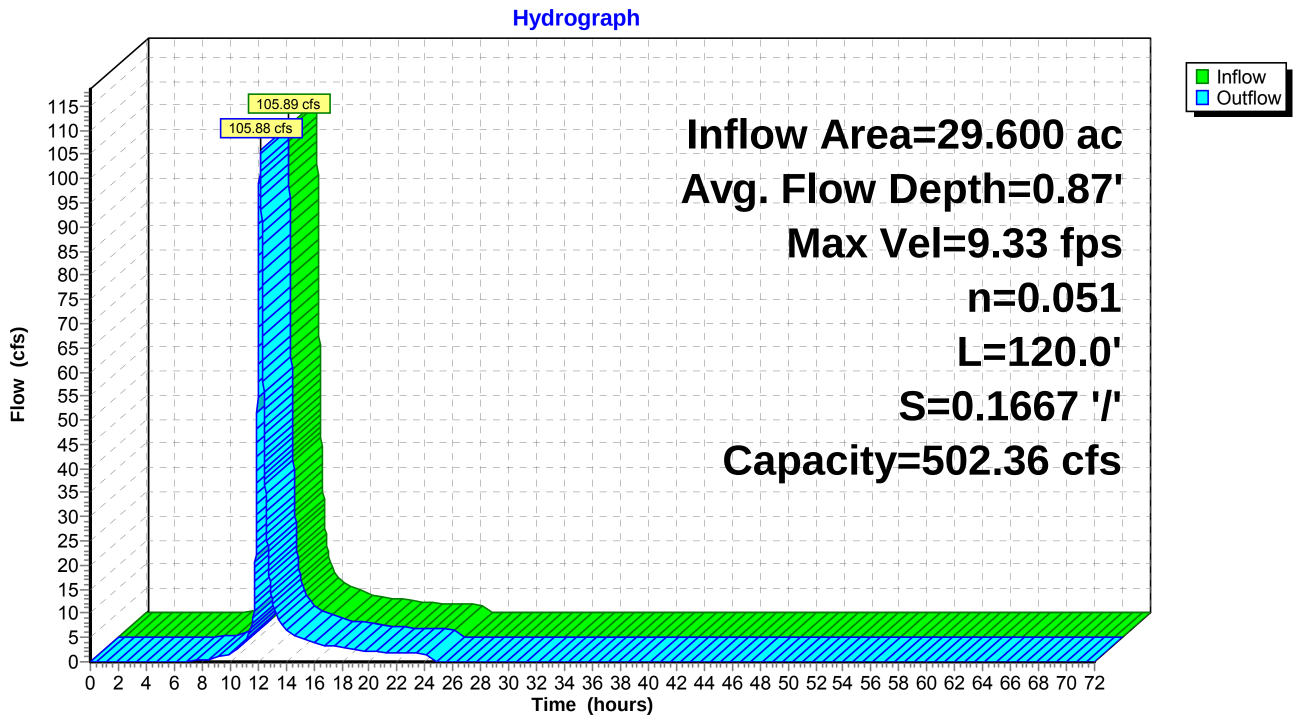
Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 3
Max. Velocity= 9.33 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 2.64 fps, Avg. Travel Time= 0.8 min

Peak Storage= 1,362 cf @ 12.17 hrs
Average Depth at Peak Storage= 0.87'
Bank-Full Depth= 2.00' Flow Area= 34.0 sf, Capacity= 502.36 cfs

10.00' x 2.00' deep channel, n= 0.051
Side Slope Z-value= 3.5 '/' Top Width= 24.00'
Length= 120.0' Slope= 0.1667 '/'
Inlet Invert= 490.00', Outlet Invert= 470.00'

‡

Reach II-EC4: Soil Breach



Summary for Reach II-WC4: Soil Breach

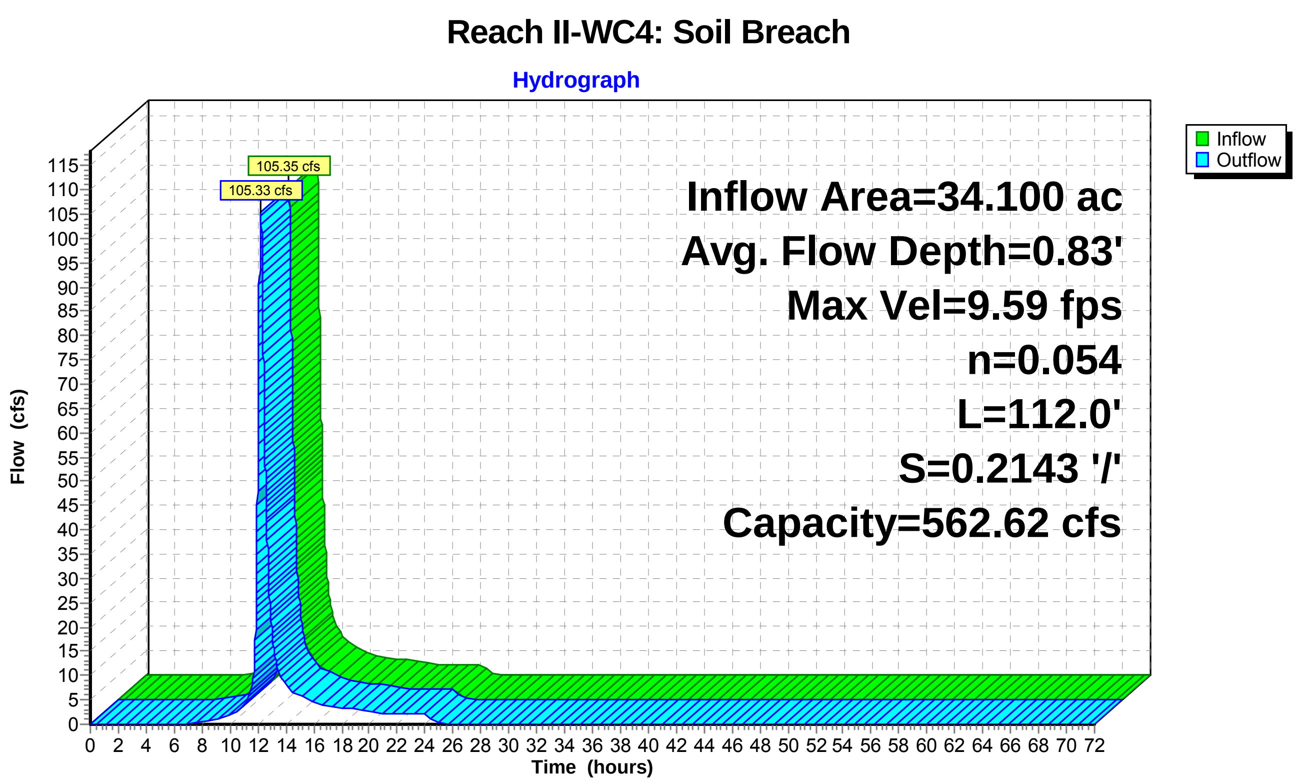
Inflow Area = 34.100 ac, 0.00% Impervious, Inflow Depth = 3.61" for 100Year event
Inflow = 105.35 cfs @ 12.20 hrs, Volume= 10.254 af
Outflow = 105.33 cfs @ 12.21 hrs, Volume= 10.254 af, Atten= 0%, Lag= 0.2 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 3
Max. Velocity= 9.59 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 2.83 fps, Avg. Travel Time= 0.7 min

Peak Storage= 1,230 cf @ 12.21 hrs
Average Depth at Peak Storage= 0.83'
Bank-Full Depth= 2.00' Flow Area= 36.0 sf, Capacity= 562.62 cfs

10.00' x 2.00' deep channel, n= 0.054
Side Slope Z-value= 4.0 '/' Top Width= 26.00'
Length= 112.0' Slope= 0.2143 '/'
Inlet Invert= 488.00', Outlet Invert= 464.00'

‡



Summary for Pond II-P: Phase II Pond Area

Inflow Area = 12.000 ac, 0.00% Impervious, Inflow Depth = 3.61" for 100Year event
Inflow = 38.75 cfs @ 12.22 hrs, Volume= 3.608 af
Outflow = 25.04 cfs @ 12.44 hrs, Volume= 3.608 af, Atten= 35%, Lag= 13.4 min
Primary = 25.04 cfs @ 12.44 hrs, Volume= 3.608 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 492.16' @ 12.44 hrs Surf.Area= 0.000 ac Storage= 0.712 af
Flood Elev= 494.00' Surf.Area= 0.000 ac Storage= 5.060 af

Plug-Flow detention time= 34.2 min calculated for 3.607 af (100% of inflow)
Center-of-Mass det. time= 34.4 min (869.6 - 835.2)

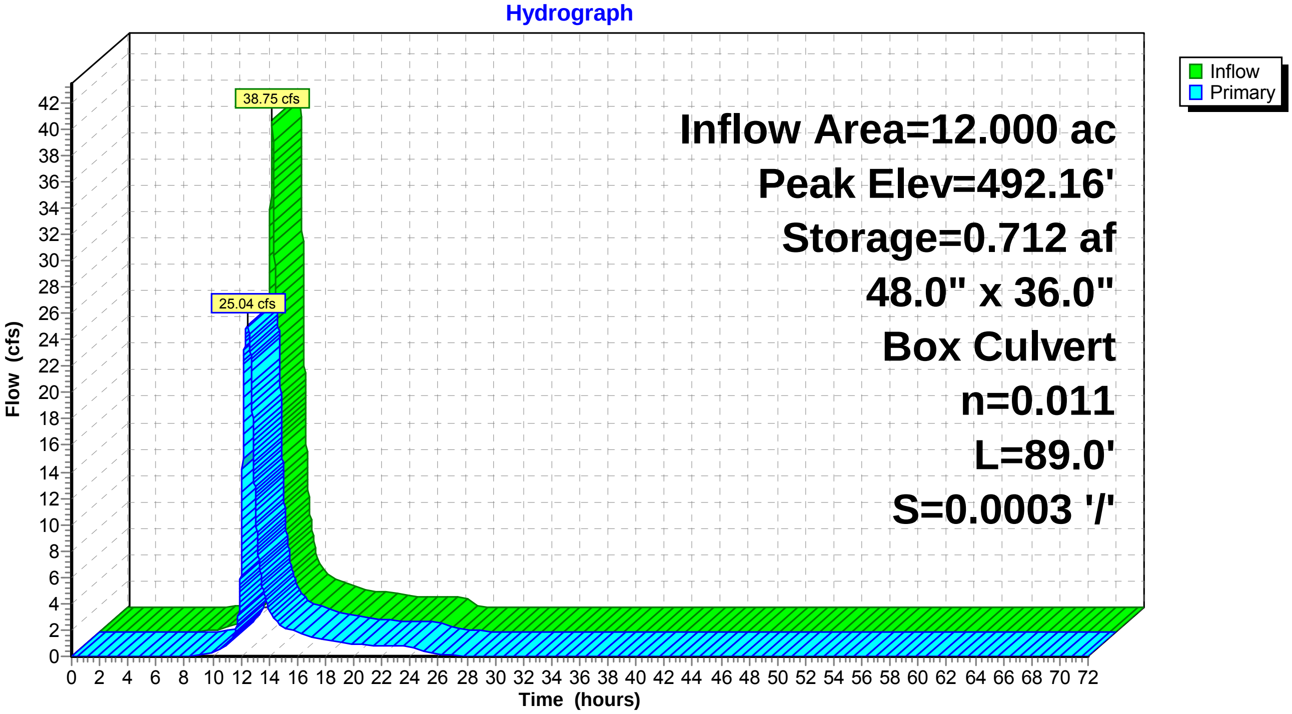
Volume	Invert	Avail.Storage	Storage Description
#1	490.18'	5.060 af	**Custom Stage Data** Listed below

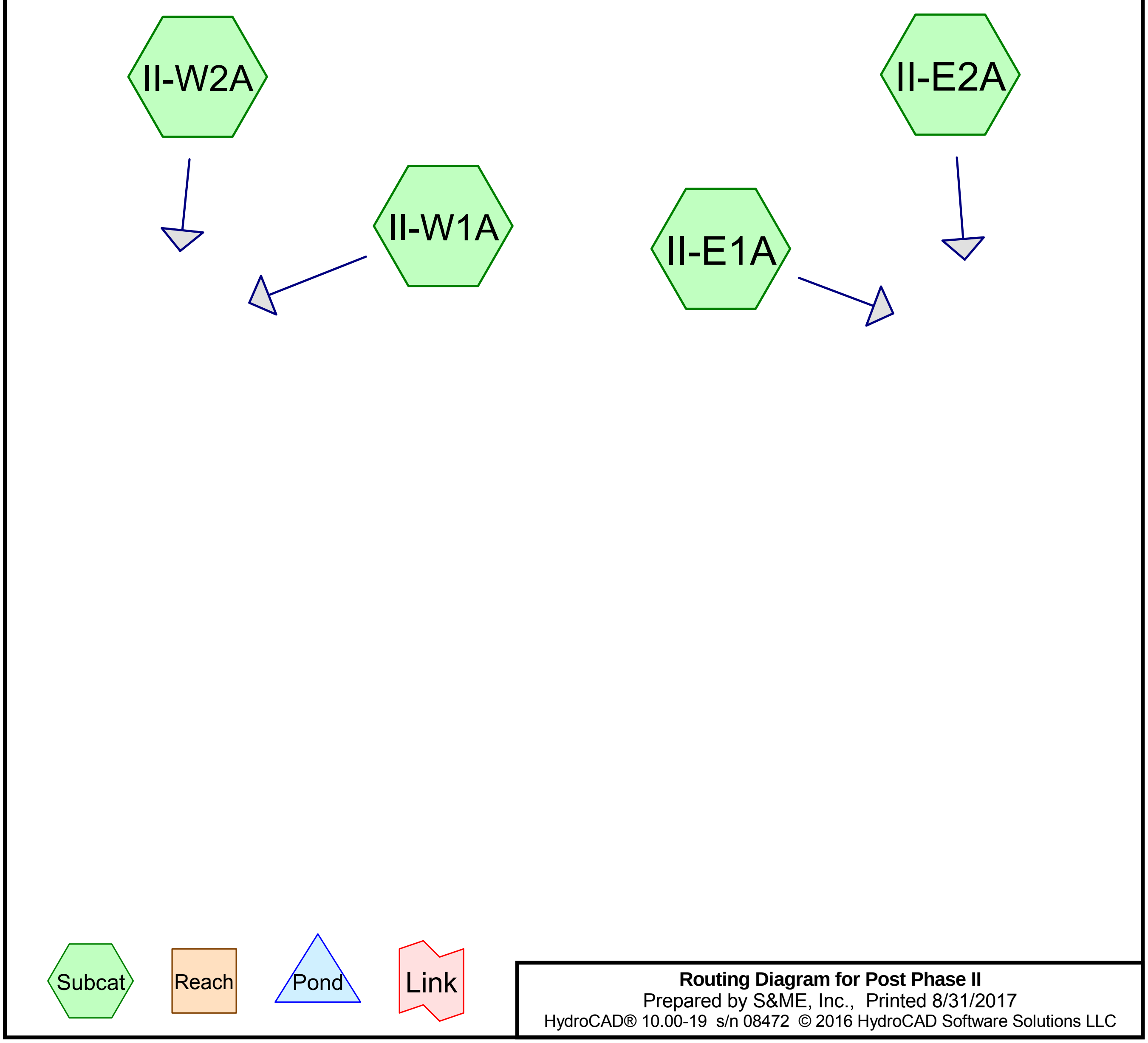
Elevation (feet)	Cum.Store (acre-feet)
490.18	0.000
492.00	0.510
493.00	1.810
494.00	5.060

Device	Routing	Invert	Outlet Devices
#1	Primary	490.18'	**48.0" W x 36.0" H Box Culvert** L= 89.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 490.18' / 490.15' S= 0.0003 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean, Flow Area= 12.00 sf

Primary OutFlow Max=25.03 cfs @ 12.44 hrs HW=492.16' (Free Discharge)
└─**1=Culvert** (Barrel Controls 25.03 cfs @ 4.22 fps)

Pond II-P: Phase II Pond Area





Routing Diagram for Post Phase II
Prepared by S&ME, Inc., Printed 8/31/2017
HydroCAD® 10.00-19 s/n 08472 © 2016 HydroCAD Software Solutions LLC

Summary for Subcatchment II-E1A:

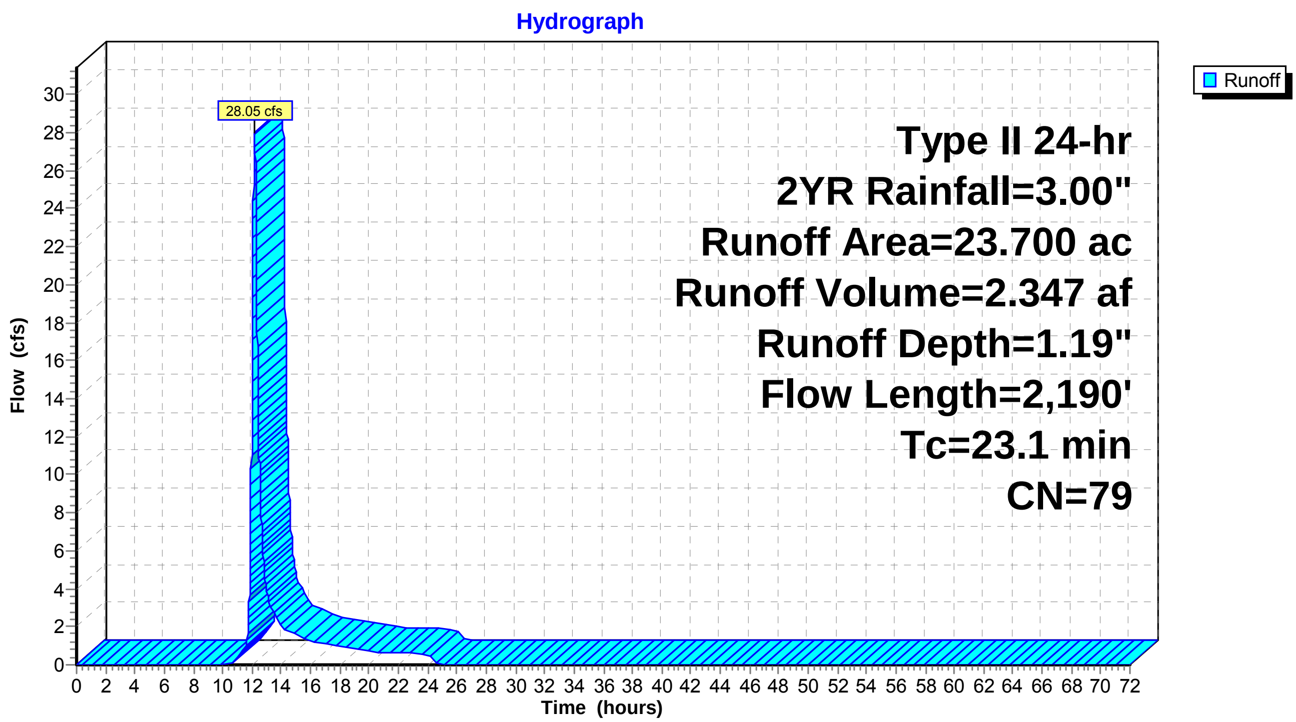
Runoff = 28.05 cfs @ 12.17 hrs, Volume= 2.347 af, Depth= 1.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2YR Rainfall=3.00"

Area (ac)	CN	Description
23.700	79	50-75% Grass cover, Fair, HSG C
23.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	29	0.0200	0.13		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.00"
0.0	19	0.2630	7.69		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
2.7	341	0.0200	2.12		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
16.4	1,642	0.0050	1.67	100.21	**Channel Flow,** Area= 60.0 sf Perim= 110.0' r= 0.55' n= 0.042
0.2	159	0.0689	13.03	185.07	**Channel Flow,** Area= 14.2 sf Perim= 18.6' r= 0.76' n= 0.025
23.1	2,190	Total			

Subcatchment II-E1A:



Summary for Subcatchment II-E2A:

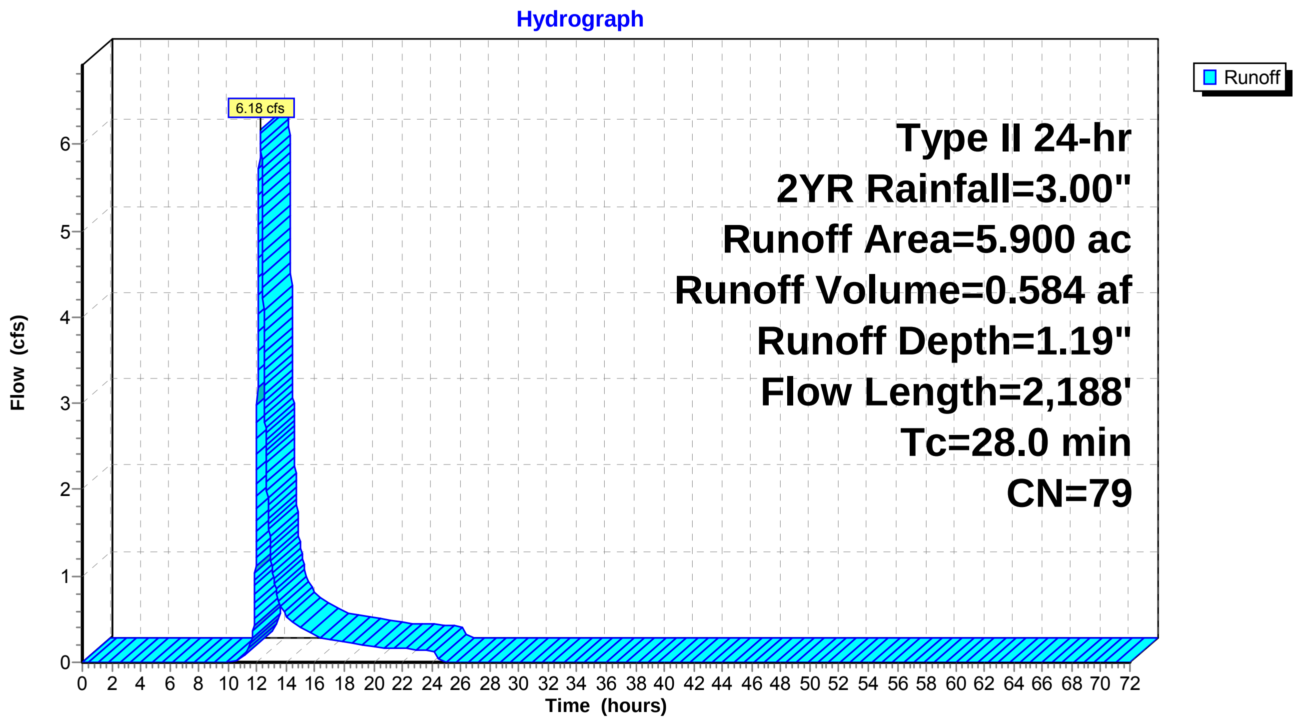
Runoff = 6.18 cfs @ 12.23 hrs, Volume= 0.584 af, Depth= 1.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2YR Rainfall=3.00"

Area (ac)	CN	Description
5.900	79	50-75% Grass cover, Fair, HSG C
5.900		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.7	19	0.0200	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.00"
0.2	75	0.3000	8.22		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
25.1	2,094	0.0019	1.39	18.10	**Channel Flow,** Area= 13.0 sf Perim= 16.3' r= 0.80' n= 0.040
28.0	2,188	Total			

Subcatchment II-E2A:



Summary for Subcatchment II-W1A:

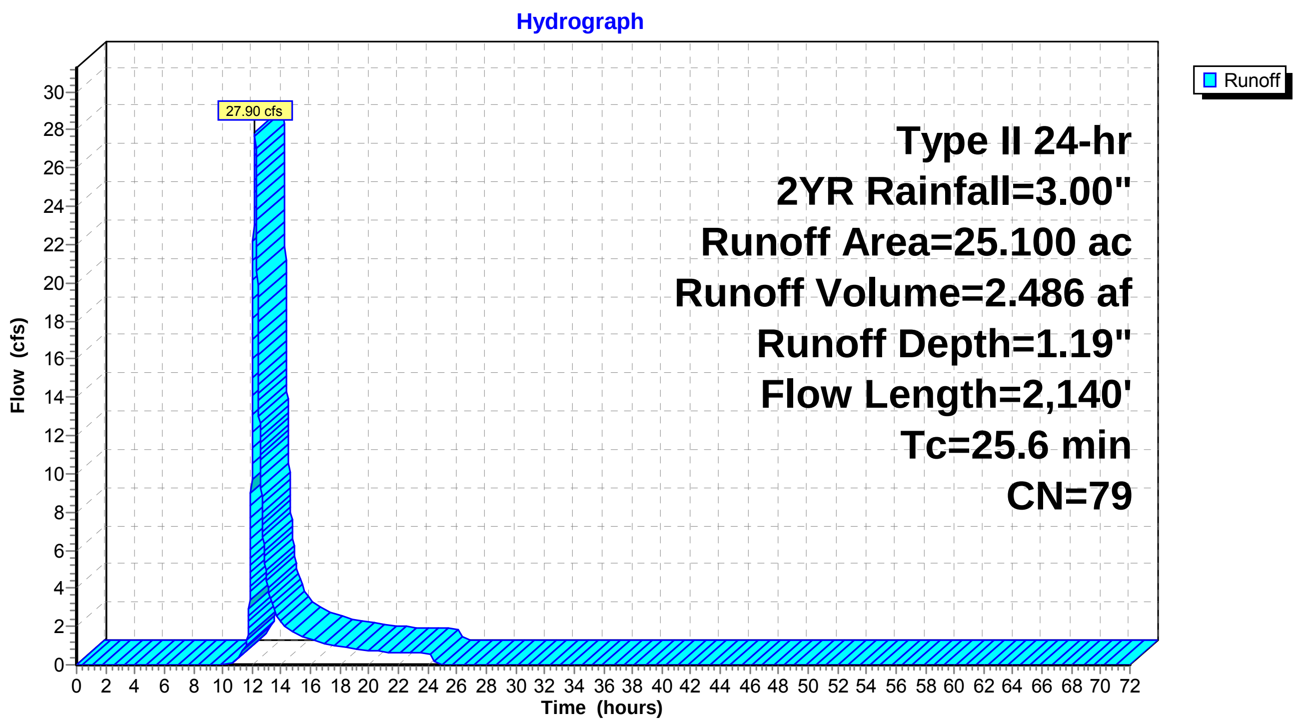
Runoff = 27.90 cfs @ 12.20 hrs, Volume= 2.486 af, Depth= 1.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2YR Rainfall=3.00"

Area (ac)	CN	Description
25.100	79	50-75% Grass cover, Fair, HSG C
25.100		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.5	29	0.0050	0.07		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.00"
0.0	19	0.3334	8.66		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
2.6	334	0.0200	2.12		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
16.3	1,600	0.0050	1.63	97.88	**Channel Flow,** Area= 60.0 sf Perim= 110.0' r= 0.55' n= 0.043
0.2	158	0.0816	14.13	200.68	**Channel Flow,** Area= 14.2 sf Perim= 18.7' r= 0.76' n= 0.025
25.6	2,140	Total			

Subcatchment II-W1A:



Summary for Subcatchment II-W2A:

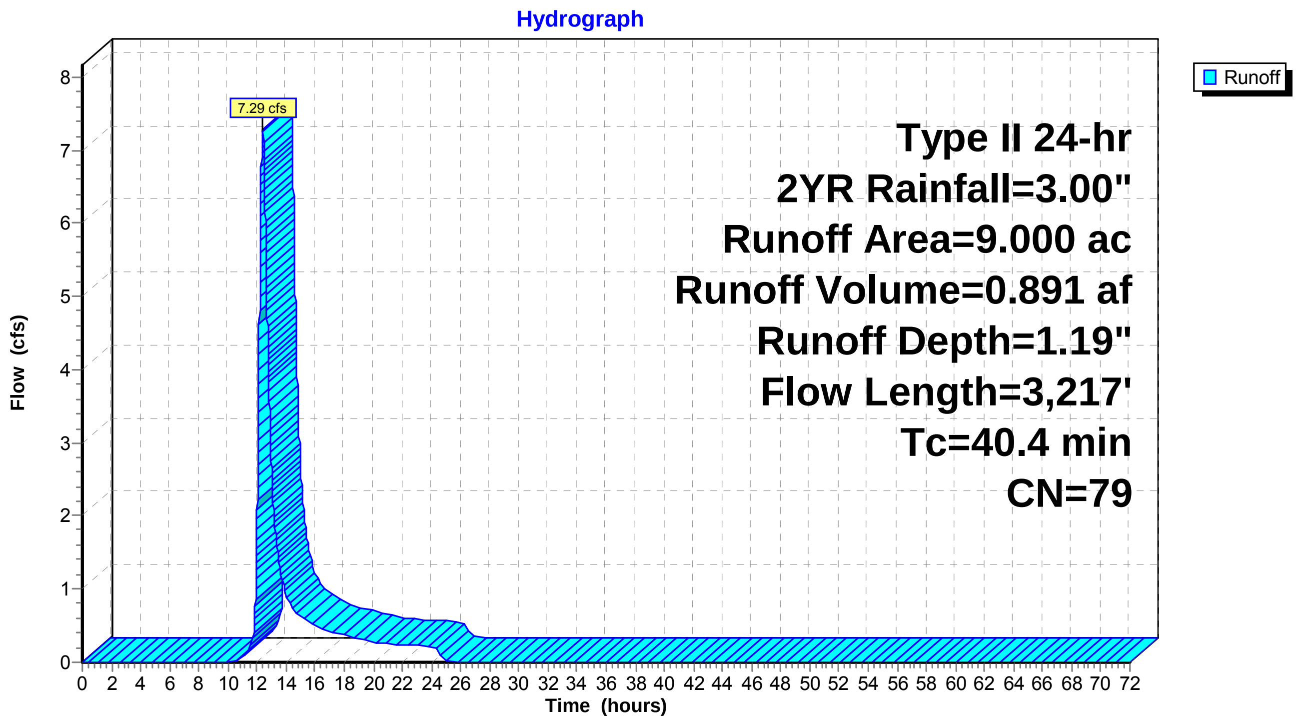
Runoff = 7.29 cfs @ 12.39 hrs, Volume= 0.891 af, Depth= 1.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2YR Rainfall=3.00"

Area (ac)	CN	Description
9.000	79	50-75% Grass cover, Fair, HSG C
9.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.8	25	0.0050	0.07		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.00"
0.2	87	0.2640	7.71		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
34.4	3,105	0.0019	1.51	19.57	**Channel Flow,** Area= 13.0 sf Perim= 16.3' r= 0.80' n= 0.037
40.4	3,217	Total			

Subcatchment II-W2A:



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HY-8 Culvert Analysis Report

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Water Surface Profile Plot for Culvert: Culvert 1

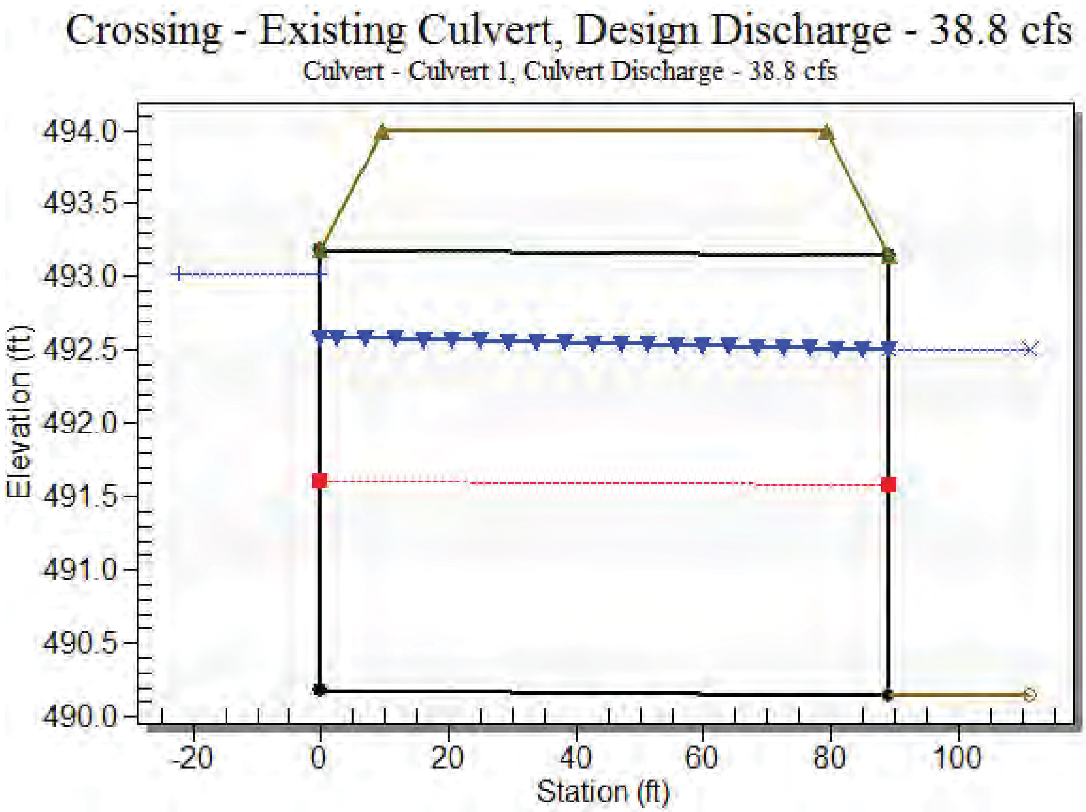

Table 1 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	490.18	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
4.50	4.50	490.85	0.578	0.670	3-M2t	0.683	0.340	0.519	0.519	2.168	2.168
9.00	9.00	491.23	0.917	1.049	3-M2t	1.097	0.540	0.823	0.823	2.733	2.733
13.50	13.50	491.55	1.202	1.372	3-M2t	1.465	0.707	1.088	1.088	3.101	3.101
18.00	18.00	491.85	1.456	1.665	3-M2t	1.809	0.857	1.333	1.333	3.375	3.375
22.50	22.50	492.12	1.677	1.939	3-M2t	2.139	0.994	1.566	1.566	3.591	3.591
27.00	27.00	492.38	1.884	2.199	3-M2t	3.000	1.123	1.790	1.790	3.770	3.770
31.50	31.50	492.63	2.083	2.448	3-M2t	3.000	1.244	2.008	2.008	3.921	3.921
36.00	36.00	492.87	2.276	2.689	3-M2t	3.000	1.360	2.221	2.221	4.052	4.052
38.80	38.80	493.02	2.395	2.836	3-M2t	3.000	1.430	2.352	2.352	4.124	4.124
45.00	45.00	493.33	2.657	3.153	3-M2t	3.000	1.578	2.637	2.637	4.267	4.267

****

Straight Culvert

Inlet Elevation (invert): 490.18 ft, Outlet Elevation (invert): 490.15 ft

Culvert Length: 89.00 ft, Culvert Slope: 0.0003

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 490.18 ft

Outlet Station: 89.00 ft

Outlet Elevation: 490.15 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 4.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0110

Culvert Type: Straight

Inlet Configuration: Square Edge (0º flare) Wingwall

Inlet Depression: None

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 38.8 cfs

Maximum Flow: 45 cfs

Table 2 - Summary of Culvert Flows at Crossing: Existing Culvert

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
490.18	0.00	0.00	0.00	1
490.85	4.50	4.50	0.00	1
491.23	9.00	9.00	0.00	1
491.55	13.50	13.50	0.00	1
491.85	18.00	18.00	0.00	1
492.12	22.50	22.50	0.00	1
492.38	27.00	27.00	0.00	1
492.63	31.50	31.50	0.00	1
492.87	36.00	36.00	0.00	1
493.02	38.80	38.80	0.00	1
493.33	45.00	45.00	0.00	1
494.00	56.20	56.20	0.00	Overtopping

Table 3 - Downstream Channel Rating Curve (Crossing: Existing Culvert)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	490.15	0.00	0.00	0.00	0.00
4.50	490.67	0.52	2.17	0.03	0.53
9.00	490.97	0.82	2.73	0.05	0.53
13.50	491.24	1.09	3.10	0.07	0.52
18.00	491.48	1.33	3.37	0.08	0.52
22.50	491.72	1.57	3.59	0.10	0.51
27.00	491.94	1.79	3.77	0.11	0.50
31.50	492.16	2.01	3.92	0.13	0.49
36.00	492.37	2.22	4.05	0.14	0.48
38.80	492.50	2.35	4.12	0.15	0.47
45.00	492.79	2.64	4.27	0.16	0.46

Tailwater Channel Data - Existing Culvert

Tailwater Channel Option: Rectangular Channel

Bottom Width: 4.00 ft

Channel Slope: 0.0010

Channel Manning's n: 0.0120

Channel Invert Elevation: 490.15 ft

Roadway Data for Crossing: Existing Culvert

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 200.00 ft

Crest Elevation: 494.00 ft

Roadway Surface: Gravel

Roadway Top Width: 70.00 ft

NOAA Atlas 14, Volume 2, Version 3
Location name: Lawrenceburg, Indiana, USA*
Latitude: 39.074°, Longitude: -84.8838°
Elevation: 485.44 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.382** (0.350–0.417)	**0.452** (0.414–0.494)	**0.531** (0.486–0.579)	**0.590** (0.540–0.643)	**0.662** (0.603–0.720)	**0.716** (0.651–0.776)	**0.764** (0.691–0.828)	**0.813** (0.732–0.880)	**0.873** (0.781–0.945)	**0.915** (0.814–0.991)
10-min	**0.593** (0.544–0.647)	**0.706** (0.647–0.771)	**0.825** (0.755–0.900)	**0.911** (0.833–0.992)	**1.01** (0.923–1.10)	**1.09** (0.986–1.18)	**1.15** (1.04–1.25)	**1.21** (1.09–1.31)	**1.28** (1.15–1.39)	**1.33** (1.19–1.44)
15-min	**0.727** (0.667–0.794)	**0.864** (0.791–0.943)	**1.01** (0.927–1.11)	**1.12** (1.03–1.22)	**1.25** (1.14–1.36)	**1.34** (1.22–1.46)	**1.43** (1.29–1.55)	**1.51** (1.36–1.64)	**1.60** (1.43–1.73)	**1.67** (1.48–1.80)
30-min	**0.962** (0.882–1.05)	**1.16** (1.06–1.26)	**1.39** (1.27–1.51)	**1.56** (1.42–1.70)	**1.77** (1.61–1.92)	**1.92** (1.75–2.08)	**2.06** (1.87–2.24)	**2.20** (1.98–2.39)	**2.37** (2.12–2.57)	**2.50** (2.22–2.70)
60-min	**1.18** (1.08–1.28)	**1.42** (1.30–1.55)	**1.74** (1.59–1.90)	**1.98** (1.81–2.16)	**2.29** (2.09–2.49)	**2.53** (2.30–2.74)	**2.76** (2.50–2.99)	**2.99** (2.69–3.24)	**3.28** (2.94–3.55)	**3.51** (3.12–3.80)
2-hr	**1.38** (1.26–1.52)	**1.67** (1.53–1.83)	**2.05** (1.87–2.25)	**2.34** (2.14–2.56)	**2.72** (2.47–2.97)	**3.02** (2.74–3.29)	**3.31** (2.99–3.61)	**3.61** (3.24–3.93)	**4.00** (3.56–4.35)	**4.30** (3.80–4.68)
3-hr	**1.47** (1.34–1.62)	**1.77** (1.62–1.96)	**2.18** (1.99–2.40)	**2.50** (2.28–2.75)	**2.93** (2.66–3.21)	**3.27** (2.95–3.57)	**3.61** (3.24–3.94)	**3.96** (3.54–4.31)	**4.42** (3.92–4.82)	**4.79** (4.21–5.21)
6-hr	**1.81** (1.66–1.97)	**2.18** (2.00–2.38)	**2.67** (2.45–2.91)	**3.05** (2.79–3.32)	**3.57** (3.25–3.88)	**3.98** (3.62–4.32)	**4.40** (3.97–4.76)	**4.82** (4.33–5.22)	**5.40** (4.80–5.84)	**5.86** (5.17–6.33)
12-hr	**2.15** (1.98–2.33)	**2.58** (2.38–2.81)	**3.15** (2.90–3.42)	**3.59** (3.30–3.89)	**4.17** (3.82–4.51)	**4.63** (4.22–5.01)	**5.09** (4.62–5.50)	**5.56** (5.02–6.00)	**6.18** (5.53–6.67)	**6.68** (5.93–7.21)
24-hr	**2.51** (2.33–2.70)	**3.00** (2.79–3.24)	**3.66** (3.40–3.95)	**4.17** (3.87–4.50)	**4.85** (4.49–5.22)	**5.38** (4.97–5.80)	**5.92** (5.45–6.37)	**6.46** (5.93–6.95)	**7.19** (6.57–7.73)	**7.75** (7.06–8.34)
2-day	**2.95** (2.74–3.19)	**3.53** (3.28–3.82)	**4.29** (3.98–4.64)	**4.87** (4.52–5.27)	**5.64** (5.22–6.10)	**6.25** (5.77–6.75)	**6.85** (6.31–7.39)	**7.46** (6.84–8.04)	**8.26** (7.55–8.92)	**8.89** (8.08–9.60)
3-day	**3.14** (2.92–3.40)	**3.76** (3.49–4.06)	**4.54** (4.22–4.90)	**5.14** (4.78–5.55)	**5.95** (5.52–6.42)	**6.58** (6.08–7.10)	**7.22** (6.65–7.78)	**7.85** (7.21–8.46)	**8.70** (7.95–9.38)	**9.35** (8.51–10.1)
4-day	**3.34** (3.11–3.60)	**3.98** (3.70–4.29)	**4.79** (4.46–5.16)	**5.42** (5.04–5.84)	**6.26** (5.81–6.74)	**6.92** (6.40–7.45)	**7.58** (6.99–8.16)	**8.25** (7.58–8.87)	**9.14** (8.36–9.84)	**9.82** (8.95–10.6)
7-day	**3.94** (3.68–4.23)	**4.68** (4.37–5.02)	**5.62** (5.24–6.03)	**6.35** (5.93–6.82)	**7.36** (6.85–7.89)	**8.15** (7.56–8.74)	**8.96** (8.29–9.60)	**9.77** (9.01–10.5)	**10.9** (9.98–11.7)	**11.7** (10.7–12.6)
10-day	**4.47** (4.19–4.79)	**5.31** (4.97–5.69)	**6.35** (5.94–6.80)	**7.17** (6.70–7.68)	**8.29** (7.73–8.86)	**9.16** (8.53–9.79)	**10.1** (9.33–10.7)	**11.0** (10.1–11.7)	**12.2** (11.2–13.0)	**13.1** (12.0–14.0)
20-day	**6.11** (5.75–6.52)	**7.23** (6.81–7.70)	**8.53** (8.02–9.08)	**9.53** (8.96–10.1)	**10.9** (10.2–11.6)	**11.9** (11.1–12.7)	**12.9** (12.1–13.7)	**13.9** (13.0–14.8)	**15.3** (14.1–16.2)	**16.3** (15.0–17.3)
30-day	**7.62** (7.19–8.08)	**8.98** (8.47–9.52)	**10.5** (9.85–11.1)	**11.6** (10.9–12.3)	**13.1** (12.3–13.8)	**14.2** (13.3–15.0)	**15.3** (14.3–16.2)	**16.4** (15.3–17.4)	**17.8** (16.6–18.9)	**18.8** (17.5–20.0)
45-day	**9.60** (9.10–10.1)	**11.3** (10.7–11.9)	**13.0** (12.3–13.7)	**14.3** (13.5–15.1)	**16.0** (15.1–16.9)	**17.3** (16.3–18.2)	**18.5** (17.4–19.5)	**19.7** (18.5–20.8)	**21.2** (19.8–22.4)	**22.2** (20.8–23.6)
60-day	**11.4** (10.9–12.0)	**13.4** (12.7–14.1)	**15.4** (14.6–16.1)	**16.9** (16.0–17.7)	**18.8** (17.8–19.7)	**20.2** (19.2–21.2)	**21.6** (20.5–22.7)	**23.0** (21.7–24.1)	**24.7** (23.2–25.9)	**25.9** (24.3–27.2)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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Clear Water Pond Area - Post Phase II Final Cover						
Elevation	Area (SF)	Average (SF)	Depth (ft)	Volume (CF)	Volume (AC-ft)	Cum. Volume (AC-ft)
490.18	0					0
		12122	1.82	22062.04	0.51	
492	24244					0.51
		56721.5	1	56721.5	1.30	
493	89199					1.81
		141718.5	1	141718.5	3.25	
494	194238					5.06

Clear Water Pond Area - Post Phase I						
Elevation	Area (SF)	Average (SF)	Depth (ft)	Volume (CF)	Volume (AC-ft)	Cum. Volume (AC-ft)
471	12599					0
		18428.5	1	18428.5	0.42	
472	24258					0.42
		27213.5	1	27213.5	0.62	
473	30169					1.05
		32906.5	1	32906.5	0.76	
474	35644					1.80
		38285	1	38285	0.88	
475	40926					2.68
		43416.5	1	43416.5	1.00	
476	45907					3.68
		48359.5	1	48359.5	1.11	
477	50812					4.79
		53337	1	53337	1.22	
478	55862					6.01
		58481	1	58481	1.34	
479	61100					7.36
		63914.5	1	63914.5	1.47	
480	66729					8.82
		69727	1	69727	1.60	
481	72725					10.42
		76190.5	1	76190.5	1.75	
482	79656					12.17
		83534.5	1	83534.5	1.92	
483	87413					14.09
		91386.5	1	91386.5	2.10	
484	95360					16.19
		99422.5	1	99422.5	2.28	
485	103485					18.47
		107986.5	1	107986.5	2.48	
486	112488					20.95
		117063.5	1	117063.5	2.69	
487	121639					23.64
		146443	1	146443	3.36	
488	171247					27.00
		178583	1	178583	4.10	
489	185919					31.10
		193574.5	1	193574.5	4.44	
490	201230					35.54
		208023	1	208023	4.78	
491	214816					40.32

North American Green
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**Control Materials Design Software
Version 5.0**

**Project Name: Tanner's Creek
Project Number: 124627
Channel Name: East drainage Channel**

Discharge	28
Peak Flow Period	0
Channel Slope	0.005
Channel Bottom Width	10
Left Side Slope	50
Right Side Slope	50
Low Flow Liner	
Retardance Class	C
Vegtation Type	Mix (Sod & Bunch)
Vegetation Density	Fair 50-75%
Soil Type	Clay Loam

S75

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
S75 Unvegetated	Straight	28 cfs	1.04 ft/s	0.64 ft	0.052	1.55 lbs/ft2	0.2 lbs/ft2	7.73	STABLE	D

Unreinforced Vegetation - Class C - Mix (Sod & Bunch) - Fair 50-75%

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
Unreinforced Vegetation	Straight	28 cfs	0.41 ft/s	1.07 ft	0.176	4.2 lbs/ft2	0.33 lbs/ft2	12.62	STABLE	--
Underlying Substrate	Straight	28 cfs	0.41 ft/s	1.07 ft	--	0.05 lbs/ft2	0.001 lbs/ft2	47.87	STABLE	--

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Control Materials Design Software
Version 5.0

Project Name: Tanner's Creek
Project Number: 124627
Channel Name: East perimeter Channel

Discharge	8
Peak Flow Period	0
Channel Slope	0.002
Channel Bottom Width	10
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardance Class	C
Vegtation Type	Mix (Sod & Bunch)
Vegetation Density	Fair 50-75%
Soil Type	Clay Loam

S75

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
S75 Unvegetated	Straight	8 cfs	0.93 ft/s	0.71 ft	0.05	1.55 lbs/ft2	0.09 lbs/ft2	17.55	STABLE	D

Unreinforced Vegetation - Class C - Mix (Sod & Bunch) - Fair 50-75%

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
Unreinforced Vegetation	Straight	8 cfs	0.49 ft/s	1.2 ft	0.128	4.2 lbs/ft2	0.15 lbs/ft2	28.13	STABLE	--
Underlying Substrate	Straight	8 cfs	0.49 ft/s	1.2 ft	--	0.05 lbs/ft2	0.001 lbs/ft2	56.56	STABLE	--

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**Control Materials Design Software
Version 5.0**

**Project Name: Tanner's Creek
Project Number: 124627
Channel Name: West drainage Channel**

Discharge	28
Peak Flow Period	0
Channel Slope	0.005
Channel Bottom Width	10
Left Side Slope	50
Right Side Slope	50
Low Flow Liner	
Retardance Class	C
Vegtation Type	Mix (Sod & Bunch)
Vegetation Density	Fair 50-75%
Soil Type	Clay Loam

S75

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
S75 Unvegetated	Straight	28 cfs	1.04 ft/s	0.64 ft	0.052	1.55 lbs/ft2	0.2 lbs/ft2	7.73	STABLE	D

Unreinforced Vegetation - Class C - Mix (Sod & Bunch) - Fair 50-75%

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
Unreinforced Vegetation	Straight	28 cfs	0.41 ft/s	1.07 ft	0.176	4.2 lbs/ft2	0.33 lbs/ft2	12.62	STABLE	--
Underlying Substrate	Straight	28 cfs	0.41 ft/s	1.07 ft	--	0.05 lbs/ft2	0.001 lbs/ft2	47.87	STABLE	--

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**:ontrol Materials Design Software
Version 5.0**

**Project Name: Tanner's Creek
Project Number: 124627
Channel Name: West perimeter Channel**

Discharge	8
Peak Flow Period	0
Channel Slope	0.002
Channel Bottom Width	10
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardance Class	C
Vegtation Type	Mix (Sod & Bunch)
Vegetation Density	Fair 50-75%
Soil Type	Clay Loam

S75

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
S75 Unvegetated	Straight	8 cfs	0.93 ft/s	0.71 ft	0.05	1.55 lbs/ft2	0.09 lbs/ft2	17.55	STABLE	D

Unreinforced Vegetation - Class C - Mix (Sod & Bunch) - Fair 50-75%

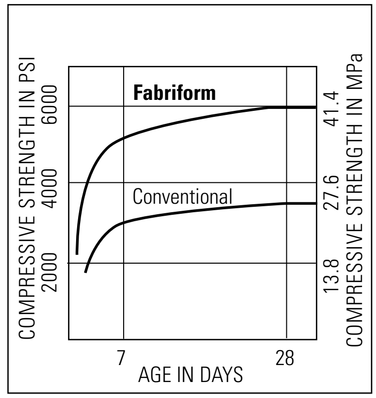
Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
Unreinforced Vegetation	Straight	8 cfs	0.49 ft/s	1.2 ft	0.128	4.2 lbs/ft2	0.15 lbs/ft2	28.13	STABLE	--
Underlying Substrate	Straight	8 cfs	0.49 ft/s	1.2 ft	--	0.05 lbs/ft2	0.001 lbs/ft2	56.56	STABLE	--

Fabriform® Technical Data: Performance

DESIGNS BASED ON OVER 35 YEARS OF EXPERIENCE

COMPRESSIVE STRENGTH

The fabric used in Fabriform construction has been designed to serve as a filter as well as a form. The highly fluid mortar pumped into the fabric forms will be mixed typically at a water/cement ratio in the 0.65 to 0.75 range. Excess mixing water is squeezed through the water permeable fabric causing a pronounced reduction in the water/cement ratio. Curves show actual compressive strength of Fabriform test specimens, averaged from ten widely separated jobs compared with tests on companion specimens cast with identical mortar in conventional molds.



DURABILITY OF FABRIC

Fabrics shall be woven with polyamide (nylon) continuous multifilament, heat and UV light resistant, industrial grade nylon fiber in which a minimum of 50% by weight shall be bulk textured fibers. Bulk textured fiber provides added bonding with the Fine Aggregate Concrete (ref. Fine Aggregate Concrete, Par. 2). Polyester fibers shall not be employed - calcium hydroxide (alkalinity) in the Fine Aggregate Concrete will result in the saponification of the ester. Staple yarns shall not be permitted. All fabrics may be affected by ultraviolet light and/or by abrasion. The utility of a FABRIFORM installation will not be impaired as evidenced by over 25 years service records. Where appearance is an important consideration, FABRIFORM revetment may be spray coated with colored acrylic emulsion to further protect the fabric nodules or crowns against UV light.

HYDRAULIC FRICTION

Carefully controlled tests conducted in England in 1972 indicated that, for 8" Filter Point revetment, the coefficient of hydraulic friction "n" as used in the Manning Formula varied from 0.023 to 0.030, depending on depth and velocity in a straight reach of trapezoidal channel. A value of 0.025 is suggested for design purposes. The "n" value of Unimat and AB revetment has not been determined experimentally. A value of 0.015 and 0.045 is suggested respectively.

STREAM VELOCITY

Water velocity over 8" Filter Point revetments at an installation in Columbia, Md., based on data from stream gauging stations, was determined to be about 13 ft./sec. (4 m/s). An installation near Bedford, Iowa, was designed for a maximum velocity of 20 ft. per second (6 m/s). Documented measurements during flood conditions at this site indicate a maximum flow of 7640 cu. ft./sec. (216 m3/s) and a velocity estimated to be in the range of 15 to 18 ft./sec. (4.5 to 5.4 m/s).

Observed Waves & Currents in Ship Channels

Site	H Wave		V Current	
	Ft.	m	FPS	m/s
Savannah R.	5	1.5	5	1.5
Thames R.	2	0.6	24	7.3

WAVES AND CURRENTS IN SHIP CHANNELS

Waves and currents generated by the piston effect of large vessels moving through ship channels represents one of the most severe challenges to the Fabriform erosion control system. Values shown here for an installation on the Savannah River were estimated by observers at the site. Wave and current data at the Thames River installation near Chatham, Ontario, are measured values.

Estimated max. wave on lakes

Site	Vw Wind		F Fetch		*H Wave	
	MPH	KPH	Mi	Km	Ft	m
Champlain	25	40	15	24	4	1.2
Allegheny	25	40	4	6	3	0.9

**H=0.17 VwF = 2.5-F*

LAKE WAVES

Actual measured maximum height of lake waves is rarely available and reported observations are often misleading. Values shown here are based on the Molitor formula using measured fetch and assumed maximum wind velocity.

EFFECT ON pH OF SURROUNDING WATER (ENVIRONMENTAL IMPACT)

Laboratory tests have demonstrated that cement lost through fabric will average about 1/4% of cement content with a maximum of 1/2%, equivalent to about 3000 gm of cement per cu. m. of mortar pumped. Tests have likewise demonstrated that the addition of 50 gms. of cement to a cubic meter of water will raise the pH value about 1.0, well within the normal range of pH variation in potable water - typically 7.0 to 9.5. From these facts it may be demonstrated the raise in pH will be limited to no more than 1.0 provided that: **1.** In stagnant water - total volume is at least 60 times the volume of concrete pumped. **2.** In moving water - the rate of concrete injection in cu. yds./hr. (m3/h) does not exceed the rate of water flow in cu. yds./min. (m3/min.)

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Technical Memorandum: **Installation**

I. ORDERING FABRIC

1. In making a preliminary estimate of the quantity of Filter Point fabric required, allow 21% in excess of protected area for contractions of the fabric assembly which occurs as a result of filling with mortar. Allow 8% for Unimat fabrics, 23% for 4" and 6" AB and 21 % for 8" AB fabrics.
2. A sketch depicting each different panel size will be prepared by the customer. From these sketches, Contech will prepare shop fabrication drawings. Customer approval of shop fabrication drawings is necessary prior to panel assembly or a firm lump sum quotation. A fee will be charged for revisions or additions to shop fabrication drawings necessitated by changes beyond the control of Contech.
3. Mill Width (MW) is the width of fabric as woven on the loom. Mill Yard (MY) is a piece of fabric 36" long by the mill width as woven. Fabric panels are assembled by sewing together parallel mill widths measuring approximately 70" (1.78 m) between seams. AB Fabric panels measure approximately 68" between seams where sewn. Panel widths must be a multiple of a full mill width. Panel length is assembled to the nearest 0.5 ft. (0.15 m).
4. Obtain a firm delivery date before scheduling installation. Delivery can generally be started within 10 working days after receipt of purchase order and approved drawings.

II. SLOPE PREPARATION

1. For the sake of appearance, revetments should be placed over relatively smooth surfaces. Minor irregularities are tolerable for the Filter Point or Articulated Block configuration, since their effect on appearance will be obscured by the deeply textured surface of the mat.
2. If backfilling is necessary, use compacted granular material. If soil contains over 20% sand or silt minus 200 mesh, it may be necessary to place a geotextile filter fabric underlayment. Consult the project engineer for approval of backfill materials.
3. Anchor and flank trench installation will be in accordance with project plans and specifications.
4. To minimize reworking surfaces to be protected, fabric should be placed and pumped immediately following slope preparation .

III. FABRIC PLACEMENT

1. To avoid field sewing as much as possible, prepare fabric assembly sketches in such detail that the great majority of the sewing can be done prior to delivery.
2. Fabric panels are joined in the field with a bag closer (portable sewing machine) using double stitches (2 passes). Lay out the first panel and fold back the leading edge. Invert the adjacent abutting panel. Join the top layers of fabric. Join the bottom layers of fabric. Fold the joined panels back on the bank with the seams down.
3. Position fabric loosely along the bank before grout injection. Stake fabric at predetermined locations to allow for fabric contraction. Do not approximate fabric locations. Measure dimensions on the bank and stake at about 20-ft. (6 m) centers. Seams should be generally perpendicular to the shoreline for best appearance.
4. Provide each job with a small quantity of uncut, unassembled fabric for special field tailoring.

IV. FINE AGGREGATE CONCRETE PREPARATION

1. Very fluid Fine Aggregate Concrete is used in all Fabriform revetment work. Air content of 5 to 8% will improve pumpability of the fluid mortar and freeze/thaw resistance of hardened mortar. Use a retarding admixture in hot weather. Substitution of pozzolanic quality fly ash for up to 20% of the cement is particularly recommended as an aid to pumpability.
2. Excess mixing water expelled through the permeable Fabriform fabric will reduce the volume of 27 cu. ft. of wet mortar to about 25 cu ft. of hardened mortar, thus rendering a denser mortar.
3. Fine Aggregate Concrete consistency should be in the 9-11 second range through the 3/4" orifice of the standard Flow Cone described in ASTM C-939 when using concrete sand. Fine Aggregate Concrete sample should be taken from the end of the grout hose. Use of concrete slump cone is not appropriate.

Range of Quantities as Delivered

Material	lb/cy	kg/m3
Cement	800-900	470-530
Sand	2030-2120	1200-1250
Water	540-550	320-325
Air	As Required	As Required

V. FINE AGGREGATE CONCRETE PUMPING

1. Insert the injection pipe through a small slit cut in the upper layer of fabric. Wrap a piece of burlap around the insert to act as a packer. Use care to avoid grout spillage.
2. First pump the upper edge of the mat which has been placed in the anchor trench, followed by injection into the lower edge, working back up the slope. Avoid overpressuring of the fabric.
3. In flowing water, pump the upstream edge of the mat first. Maximum allowable water velocity using routine installation procedures, is about 3 ft. (1 m) per second.
4. Do not walk on the mat for about one hour after pumping or when footprints will leave indentations.
5. Remove burlap from insert holes and smooth mortar by hand .
6. Clean up mortar spilled by hand or broom. Do not wash down mat with a water hose.
7. A typical crew consists of a foreman, pump operator, and three or four laborers. A diver may be necessary for injecting mortar under

VI. EQUIPMENT

1. Pumping capacity should be about 25 cu. yds. (19 m3) per hour. Equipment which has been successfully used includes the Olin Model 120525, the Mayco Model C-30 or Model 30HD. Use minimum 2 in. (50 mm) pipe or hose from the pump to the fabric.
2. Fischbein type portable sewing machines are recommended for use where field sewing of fabric is required. These machines are available in the electric model E or the air operated Model DR. Both machines use 1/2 lb. spools of nylon #138BST thread.

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WEBSITE www.fabriform1.com

JOB NAME: Tanner's Creek FAP Closure
SUBJECT: East Soil Breach Armoring Design

CUMPUTED BY: MRM DATE: 8/10/2017
CHECKED BY: WRH DATE: 8/23/2017

TASK: ESTIMATE APPROPRIATE RIPRAP SIZE (D50) USING ARS ROCK CHUTE METHOD.
SOURCE: DESIGN OF ROCK CHUTES, ROBINSON, 1998 AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.

STEP 1 - DETERMINE REQUIRED MEDIAN STONE SIZE (D50)

	English		Metric	
Bed Slope, So	0.17	ft/ft	0.17	m/m
Channel Bottom Width, B	10	ft	3.05	m
Gravity Constant, g	32.2	ft/s^2	9.8	m/s^2
Peak Flow, Q25		cfs	0.00	m^3/s
Peak Flow, Q50		cfs	0.00	m^3/s
Peak Flow, Q100	106	cfs	3.00	m^3/s

q100 = Q100/B = 0.983 m^3/s/m D50 (Q100) = 283.2 mm

$$q = 9.76E-7\, D_{50}^{1.89}\, S_o^{-1.50} \qquad S_o < 0.10 \qquad (1)$$

$$q = 8.07E-6\, D_{50}^{1.89}\, S_o^{-0.58} \qquad 0.10 \le S_o \le 0.40 \qquad (2)$$

where
q = highest stable unit discharge ($m^3/s/m$)
D_{50} = particle size for which 50% of the sample is finer (mm)
S_o = decimal slope (dimensionless)
Equations 1 and 2 apply only to rock chutes constructed with angular riprap with a rock layer thickness of $5D_{50}$

$$D_{50} = \left[\frac{(qS^{0.58})}{8.07E-6}\right]^{1/1.89} \qquad (9)$$

STEP 2 - DETERMINE MANNING'S ROUGHNESS COEFFICIENT (n)

n (Q100) = 0.051

$$n = 0.0292\,(D_{50}\, S_o)^{0.147} \qquad (7)$$

STEP 3 - DETERMINE SURFACE FLOW UNIT DISCHARGE (qs)

np = 0.45 [Typically 0.43-0.46]
K' = 4

$$V_m = n_p \left(\frac{S_o g D}{K'}\right)^{1/2} \qquad (4)$$

where
V_m = velocity through rock (m/s)
n_p = porosity
g = gravitational acceleration (9.81 m/s^2)
K' = a dimensionless friction factor
D = representative rock diameter in m (use D_{50} in m)
Abt et al. (1987) presented values for n_p of 0.44 to 0.46 for angular riprap. The factor K' is defined by Stephenson (1979) as:

$$K' = K + \frac{800}{R_e} \qquad (5)$$

where
K = 4 for crushed rock
R_e = Reynolds number ($dV/n_p\upsilon$)
υ = kinematic viscosity

Vm (Q100) = 0.153 m/s

q_s = surface unit discharge ($q_t - q_m$)
q_t = total unit discharge
q_m = unit discharge through the riprap

$(q_m) = V_m\,(2D_{50})$.

qm (Q100) = 0.087 m^3/s/m qs (Q100) = 0.897 m^3/s/m

The values of $800/R_e$ were small (< 0.01); therefore, it was assumed that K' = K = 4 . Using the measured flow depths

STEP 4 - DETERMINE FLOW DEPTH ABOVE TOP OF RIPRAP

d (Q25) = 0 m
d (Q50) = 0 m
d (Q100) = 0.27 m

$$d = \left(\frac{n\, q_s}{S_o^{0.5}}\right)^{3/5} \qquad (10)$$

STEP 5 - ESTIMATE D50 [WITH SF = 1.1-1.5] AND DEPTH OF FLOW IN ENGLISH UNITS

	Estimated D50 (mm)	Safety Factor	Conversion (mm -> in)	**D50 (in)**
D50 (Q100) =	283	1.5	0.03937	**17**

	Estimated Depth (m)	Conversion (m -> ft)	**Depth (ft)**
d (Q100) =	0.27	3.281	**0.9**

JOB NAME: Tanner's Creek FAP Closure — CUMPUTED BY: MRM — DATE: 8/10/2017
SUBJECT: West Soil Breach Armoring Design — CHECKED BY: WRH — DATE: 8/23/2017

TASK: ESTIMATE APPROPRIATE RIPRAP SIZE (D50) USING ARS ROCK CHUTE METHOD.
SOURCE: DESIGN OF ROCK CHUTES, ROBINSON, 1998 AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.

STEP 1 - DETERMINE REQUIRED MEDIAN STONE SIZE (D50)

	English		Metric	
Bed Slope, So	0.21	ft/ft	0.21	m/m
Channel Bottom Width, B	10	ft	3.05	m
Gravity Constant, g	32.2	ft/s^2	9.8	m/s^2
Peak Flow, Q25		cfs	0.00	m^3/s
Peak Flow, Q50		cfs	0.00	m^3/s
Peak Flow, Q100	105	cfs	2.98	m^3/s

q100 = Q100/B = 0.979 m^3/s/m — D50 (Q100) = 305.1 mm

$$q = 9.76E-7\, D_{50}^{1.89} S_o^{-1.50} \qquad S_o < 0.10 \qquad (1)$$

$$q = 8.07E-6\, D_{50}^{1.89} S_o^{-0.58} \qquad 0.10 \le S_o \le 0.40 \qquad (2)$$

where
q = highest stable unit discharge ($m^3/s/m$)
D_{50} = particle size for which 50% of the sample is finer (mm)
S_o = decimal slope (dimensionless)
Equations 1 and 2 apply only to rock chutes constructed with angular riprap with a rock layer thickness of SD_{50}

$$D_{50} = \left[\frac{(qS^{0.58})}{8.07E-6}\right]^{1/1.89} \qquad (9)$$

STEP 2 - DETERMINE MANNING'S ROUGHNESS COEFFICIENT (n)

n (Q100) = 0.054

$$n = 0.0292\,(D_{50} S_o)^{0.147} \qquad (7)$$

STEP 3 - DETERMINE SURFACE FLOW UNIT DISCHARGE (qs)

np = 0.45 [Typically 0.43-0.46]
K' = 4

$$V_m = n_p \left(\frac{S_o g D}{K'}\right)^{1/2} \qquad (4)$$

where
V_m = velocity through rock (m/s)
n_p = porosity
g = gravitational acceleration (9.81 m/s^2)
K' = a dimensionless friction factor
D = representative rock diameter in m (use D_{50} in m)
Abt et al. (1987) presented values for n_p of 0.44 to 0.46 for angular riprap. The factor K' is defined by Stephenson (1979) as:

$$K' = K + \frac{800}{R_e} \qquad (5)$$

where
K = 4 for crushed rock
R_e = Reynolds number ($dV/n_p\upsilon$)
υ = kinematic viscosity

Vm (Q100) = 0.18 m/s

q_s = surface unit discharge ($q_t - q_m$)
q_t = total unit discharge
q_m = unit discharge through the riprap

$$(q_m) = V_m (2D_{50}).$$

qm (Q100) = 0.11 m^3/s/m — qs (Q100) = 0.869 m^3/s/m

The values of $800/R_e$ were small (< 0.01); therefore, it was assumed that K' = K = 4 . Using the measured flow depths

STEP 4 - DETERMINE FLOW DEPTH ABOVE TOP OF RIPRAP

d (Q25) =	0	m
d (Q50) =	0	m
d (Q100) =	0.253	m

$$d = \left(\frac{n\, q_s}{S_o^{0.5}}\right)^{3/5} \qquad (10)$$

STEP 5 - ESTIMATE D50 [WITH SF = 1.1-1.5] AND DEPTH OF FLOW IN ENGLISH UNITS

	Estimated D50 (mm)	Safety Factor	Conversion (mm -> in)	**D50 (in)**
D50 (Q100) =	305	1.5	0.03937	**18**

	Estimated Depth (m)	Conversion (m -> ft)	**Depth (ft)**
d (Q100) =	0.25	3.281	**0.8**

Objective: For trapezoidal channels with a calculated equivalent pipe diameter ([illegible]), Tailwater Depth (TW) and flow (Q), solve for required riprap Class and apron dimensions.

Source: USACE, Hydraulic Engineering Circular 14 (HEC-14) Energy Dissipators, Chapter 8: Stilling Basins. Pub July 2006, Revised Oct 2012.

Project: East Soil Breach Outlet
Calc. By: MRM **Rev. By: WRH**
Date: 8-10-17 **Date: 8/23/17**

Step 1 - Determine peak flow, equivalent diameter and assumed tailwater depth

[illegible] $\frac{ft^{[illegible]}}{s}$ Flow, (cfs) from Rock Chute Design Flow

[illegible] ft Depth of flow in channel, (ft)

[illegible] ft Bottom width of channel, (ft)

[illegible] Right cotangent of bank slope

[illegible] Left cotangent of bank slope

[illegible] Cross sectional flow area, (sf)

[illegible] $\sqrt{[illegible]/\pi}$ [illegible] ft Pipe Diameter, (ft) or equivalent diameter [illegible] ft

[illegible] ft Tailwater assumption

Step 2 - Calculate D50 from Equation 10.4.

[illegible] $\sqrt{g}$ [illegible] in

[illegible] ft **For grouted riprap use 1/2 D50.**

Step 3 - Use Table 10.1 to select riprap class and to size the apron dimensions.

[illegible] ft

[illegible] ft

Table 10.1. Example Riprap Classes and Apron Dimensions

Class	D_{50} (mm)	D_{50} (in)	Apron Length[1]	Apron Depth
1	125	5	4D	$3.5D_{50}$
2	150	6	4D	$3.3D_{50}$
3	250	10	5D	$2.4D_{50}$
4	350	14	6D	$2.2D_{50}$
5	500	20	7D	$2.0D_{50}$
6	550	22	8D	$2.0D_{50}$

[1] D is the culvert rise.

Objective: For trapezoidal channels with a calculated equivalent pipe diameter ([illegible]), Tailwater Depth (TW) and flow (Q), solve for required riprap Class and apron dimensions.

Source: USACE, Hydraulic Engineering Circular 14 (HEC-14) Energy Dissipators, Chapter 8: Stilling Basins. Pub July 2006, Revised Oct 2012.

Project: East Soil Breach Outlet

Calc. By: MRM — **Rev. By: WRH**

Date: 8-10-17 — **Date: 8/23/17**

Step 1 - Determine peak flow, equivalent diameter and assumed tailwater depth

[illegible] $\frac{ft^{[illegible]}}{s}$ — Flow, (cfs) from Rock Chute Design Flow

[illegible] ft — Depth of flow in channel, (ft)

[illegible] ft — Bottom width of channel, (ft)

[illegible] — Right cotangent of bank slope

[illegible] — Left cotangent of bank slope

[illegible] — Cross sectional flow area, (sf)

[illegible] $\sqrt{\frac{[illegible]}{\pi}}$ [illegible] ft — Pipe Diameter, (ft) or equivalent diameter — [illegible] ft

[illegible] ft — Tailwater assumption

Step 2 - Calculate D50 from Equation 10.4.

[illegible] $\sqrt{g}$ [illegible] in

[illegible] ft — **For grouted riprap use 1/2 D50.**

Step 3 - Use Table 10.1 to select riprap class and to size the apron dimensions.

[illegible] ft

[illegible] ft

Table 10.1. Example Riprap Classes and Apron Dimensions

Class	D_{50} (mm)	D_{50} (in)	Apron Length[1]	Apron Depth
1	125	5	4D	$3.5D_{50}$
2	150	6	4D	$3.3D_{50}$
3	250	10	5D	$2.4D_{50}$
4	350	14	6D	$2.2D_{50}$
5	500	20	7D	$2.0D_{50}$
6	550	22	8D	$2.0D_{50}$

[1] D is the culvert rise.

Objective: **For open channel flow conditions, given a bottom width ([illegible]), maximum depth (*d*), side slopes (*SSl* and *SSr*), a bed slope ([illegible]) and Manning's (*n*), solve for flow capacity of the channel over the full range of flow depths defined by the user.**

Source: **Chow, Ven Te. "Chapter 5 - Development of Uniform Flow and Its Formulas." *Open-channel Hydraulics*. New York: McGraw-Hill, 1959. Print.**

Concrete Spillway - Lower Chute

Calc. By: MRM
Date: 8/18/17

Rev. By: WRH
Date: 8/23/17

[illegible] ft	Channel Bottom Width, (ft)	[illegible]	Energy Grade Line Slope (ft/ft)
[illegible]	Right Side Slope (XH:1V)	[illegible]	Manning's Roughness Coefficient
[illegible]	Left Side Slope (XH:1V)	[illegible]	Preferred solution increment
[illegible] ft	Channel Max Depth, (ft)	[illegible]	1.0 (Metric) or 1.486 (English)

[illegible] ft

[illegible] ft^2

[illegible] ft

[illegible] ft

[illegible] ft

[illegible] $\frac{ft}{s}$

[illegible] g [illegible]

[illegible] $\frac{ft^3}{s}$

Objective: **For open channel flow conditions, given a bottom width ([illegible]), maximum depth (*d*), side slopes (*SSl* and *SSr*), a bed slope ([illegible]) and Manning's (*n*), solve for flow capacity of the channel over the full range of flow depths defined by the user.**

Source: **Chow, Ven Te. "Chapter 5 - Development of Uniform Flow and Its Formulas."** ***Open-channel Hydraulics*****. New York: McGraw-Hill, 1959. Print.**

Concrete Spillway - Middle Chute

Calc. By: MRM
Date: 8/18/17

Rev. By: WRH
Date: 8/23/17

[illegible] ft	Channel Bottom Width, (ft)	[illegible]	Energy Grade Line Slope (ft/ft)
[illegible]	Right Side Slope (XH:1V)	[illegible]	Manning's Roughness Coefficient
[illegible]	Left Side Slope (XH:1V)	[illegible]	Preferred solution increment
[illegible] ft	Channel Max Depth, (ft)	[illegible]	1.0 (Metric) or 1.486 (English)

[illegible] ft

[illegible] ft^2

[illegible] ft

[illegible] ft

[illegible] ft

[illegible] $\frac{ft}{s}$

[illegible] g [illegible]

[illegible] $\frac{ft^3}{s}$

Objective: **For open channel flow conditions, given a bottom width ([illegible]), maximum depth (*d*), side slopes (*SSl* and *SSr*), a bed slope ([illegible]) and Manning's (*n*), solve for flow capacity of the channel over the full range of flow depths defined by the user.**

Source: **Chow, Ven Te. "Chapter 5 - Development of Uniform Flow and Its Formulas."** ***Open-channel Hydraulics*****. New York: McGraw-Hill, 1959. Print.**

Concrete Spillway - Upper Chute

Calc. By: MRM — **Rev. By: WRH**
Date: 8/18/17 — **Date: 8/23/17**

[illegible] ft	Channel Bottom Width, (ft)	[illegible]	Energy Grade Line Slope (ft/ft)
[illegible]	Right Side Slope (XH:1V)	[illegible]	Manning's Roughness Coefficient
[illegible]	Left Side Slope (XH:1V)	[illegible]	Preferred solution increment
[illegible] ft	Channel Max Depth, (ft)	[illegible]	1.0 (Metric) or 1.486 (English)

[illegible] ft

[illegible] $ft^{[illegible]}$

[illegible] ft

[illegible] ft [illegible] ft

[illegible] $\frac{ft}{s}$ [illegible] $\frac{ft}{s}$ [illegible] g [illegible]

[illegible] $\frac{ft^{[illegible]}}{s}$

<u>Objective:</u> For open channel flow conditions, given a bottom width ([illegible]), maximum depth (*d*), side slopes (*SSl* and *SSr*), a bed slope ([illegible]) and Manning's (*n*), solve for flow capacity of the channel over the full range of flow depths defined by the user.

<u>Source:</u> Chow, Ven Te. "Chapter 5 - Development of Uniform Flow and Its Formulas." *Open-channel Hydraulics*. New York: McGraw-Hill, 1959. Print.

<u>East Drainage Channel</u>

Calc. By: MRM
Date: 8/23/17

Rev. By: WRH
Date: 8/23/17

[illegible] ft	Channel Bottom Width, (ft)	[illegible]	Energy Grade Line Slope (ft/ft)
[illegible]	Right Side Slope (XH:1V)	[illegible]	Manning's Roughness Coefficient
[illegible]	Left Side Slope (XH:1V)		
[illegible] ft	Channel Depth, (ft)	[illegible]	1.0 (Metric) or 1.486 (English)

[illegible] ft

[illegible] ft^2

[illegible] ft

[illegible] ft

[illegible] ft

[illegible] $\frac{ft}{s}$

[illegible] g [illegible]

[illegible] $\frac{ft^3}{s}$

Objective: For open channel flow conditions, given a bottom width ([illegible]), maximum depth (*d*), side slopes (*SSl* and *SSr*), a bed slope ([illegible]) and Manning's (*n*), solve for flow capacity of the channel over the full range of flow depths defined by the user.

Source: Chow, Ven Te. "Chapter 5 - Development of Uniform Flow and Its Formulas." *Open-channel Hydraulics*. New York: McGraw-Hill, 1959. Print.

East Ash Breach

Calc. By: MRM
Date: 8/23/17

Rev. By: WRH
Date: 8/23/17

[illegible] *ft*	Channel Bottom Width, (ft)	[illegible]	Energy Grade Line Slope (ft/ft)
[illegible]	Right Side Slope (XH:1V)	[illegible]	Manning's Roughness Coefficient
[illegible]	Left Side Slope (XH:1V)		
[illegible] *ft*	Channel Depth, (ft)	[illegible]	1.0 (Metric) or 1.486 (English)

[illegible] *ft*

[illegible] $ft^{[illegible]}$

[illegible] *ft*

[illegible] *ft*

[illegible] *ft*

[illegible] $\frac{ft}{s}$

[illegible] *g* [illegible]

[illegible] $\frac{ft^{[illegible]}}{s}$

Manning's Equation for Open Channel Flow in a Trapezoidal Channel

Objective: **For open channel flow conditions, given a bottom width ([illegible]), maximum depth (*d*), side slopes (*SSl* and *SSr*), a bed slope ([illegible]) and Manning's (*n*), solve for flow capacity of the channel over the full range of flow depths defined by the user.**

Source: **Chow, Ven Te. "Chapter 5 - Development of Uniform Flow and Its Formulas."** ***Open-channel Hydraulics*****. New York: McGraw-Hill, 1959. Print.**

East Perimeter Channel

Calc. By: MRM
Date: 8/23/17

Rev. By: WRH
Date: 8/23/17

[illegible] ft	Channel Bottom Width, (ft)	[illegible]	Energy Grade Line Slope (ft/ft)
[illegible]	Right Side Slope (XH:1V)	[illegible]	Manning's Roughness Coefficient
[illegible]	Left Side Slope (XH:1V)		
[illegible] ft	Channel Depth, (ft)	[illegible]	1.0 (Metric) or 1.486 (English)

[illegible] ft

[illegible] ft^2

[illegible] ft

[illegible] ft

[illegible] ft

[illegible] $\frac{ft}{s}$ [illegible] $\frac{ft}{s}$

[illegible] g [illegible]

[illegible] $\frac{ft^3}{s}$

Objective: **For open channel flow conditions, given a bottom width ([illegible]), maximum depth (*d*), side slopes (*SSl* and *SSr*), a bed slope ([illegible]) and Manning's (*n*), solve for flow capacity of the channel over the full range of flow depths defined by the user.**

Source: **Chow, Ven Te. "Chapter 5 - Development of Uniform Flow and Its Formulas." *Open-channel Hydraulics*. New York: McGraw-Hill, 1959. Print.**

West Drainage Channel

Calc. By: MRM | **Rev. By: WRH**
Date: 8/23/17 | **Date: 8/23/17**

[illegible] ft — Channel Bottom Width, (ft)
[illegible] — Right Side Slope (XH:1V)
[illegible] — Left Side Slope (XH:1V)
[illegible] ft — Channel Depth, (ft)
[illegible] — Energy Grade Line Slope (ft/ft)
[illegible] — Manning's Roughness Coefficient
[illegible] — 1.0 (Metric) or 1.486 (English)

[illegible] ft

[illegible] ft^2

[illegible] ft

[illegible] ft

[illegible] ft

[illegible] $\frac{ft}{s}$

[illegible] g [illegible]

[illegible] $\frac{ft^3}{s}$

Objective: **For open channel flow conditions, given a bottom width ([illegible]), maximum depth (*d*), side slopes (*SSl* and *SSr*), a bed slope ([illegible]) and Manning's (*n*), solve for flow capacity of the channel over the full range of flow depths defined by the user.**

Source: **Chow, Ven Te. "Chapter 5 - Development of Uniform Flow and Its Formulas." *Open-channel Hydraulics*. New York: McGraw-Hill, 1959. Print.**

West Ash Breach

Calc. By: MRM
Date: 8/23/17

Rev. By: WRH
Date: 8/23/17

[illegible]	[illegible] ft	Channel Bottom Width, (ft)	[illegible]	[illegible]	Energy Grade Line Slope (ft/ft)
[illegible]	[illegible]	Right Side Slope (XH:1V)	[illegible]	[illegible]	Manning's Roughness Coefficient
[illegible]	[illegible]	Left Side Slope (XH:1V)			
[illegible]	[illegible] ft	Channel Depth, (ft)	[illegible]	[illegible]	1.0 (Metric) or 1.486 (English)

[illegible] ft

[illegible] ft^2

[illegible] ft

[illegible] ft

[illegible] ft

[illegible] $\frac{ft}{s}$

[illegible] g [illegible]

[illegible] $\frac{ft^3}{s}$

<u>Objective:</u> For open channel flow conditions, given a bottom width ([illegible]), maximum depth (*d*), side slopes (*SSl* and *SSr*), a bed slope ([illegible]) and Manning's (*n*), solve for flow capacity of the channel over the full range of flow depths defined by the user.

<u>Source:</u> Chow, Ven Te. "Chapter 5 - Development of Uniform Flow and Its Formulas." *Open-channel Hydraulics*. New York: McGraw-Hill, 1959. Print.

<u>West Perimeter Channel</u>

Calc. By: MRM | **Rev. By: WRH**
Date: 8/23/17 | **Date: 8/23/17**

[illegible] ft	Channel Bottom Width, (ft)	[illegible]	Energy Grade Line Slope (ft/ft)
[illegible]	Right Side Slope (XH:1V)	[illegible]	Manning's Roughness Coefficient
[illegible]	Left Side Slope (XH:1V)		
[illegible] ft	Channel Depth, (ft)	[illegible]	1.0 (Metric) or 1.486 (English)

[illegible] ft

[illegible] $ft^{[illegible]}$

[illegible] ft

[illegible] ft

[illegible] ft

[illegible] $\frac{ft}{s}$

[illegible] g [illegible]

[illegible] $\frac{ft^{[illegible]}}{s}$

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Project/Proposal No. 7217-17-007A Calculated By MRM Date 8/18/17
Project/Proposal Name TANNER'S CREEK FAP Checked By WRH Date 8/23/17
Subject HYDRAULIC JUMP ESTIMATE Sheet ____ of ____

☐ CONCRETE EMERGENCY SPILLWAY CHUTE HYDRAULIC JUMP ESTIMATE

☐ STEP 1 – ESTIMATE D_2 AND VERIFY THAT $D_2 < 3.0$ FT (DESIGN DEPTH)

USING EQ (2) IN SECTION 1 :

$$D_2 = -\frac{D_1}{2} + \sqrt{\frac{D_1^2}{4} + \frac{2V_1^2 D_1}{g}}$$

$D_1 \approx 0.26$ FT [FROM OPEN CHANNEL WORKSHEET FOR MIDDLE CHUTE]
$V_1 \approx 23.7$ FPS [FROM ↑]
$g = 32.2$ FT/S²

$$D_2 = -\left(\frac{0.26}{2}\right) + \sqrt{\frac{(0.26)^2}{4} + \frac{2(23.7)^2(0.26)}{32.2}}$$

$$D_2 = -0.13 + \sqrt{0.0169 + 9.07}$$

$$D_2 = 3.015 - 0.13 = \boxed{2.89 \text{ FT}} < 3.0 \text{ FT}$$

∴ EXISTING CHANNEL GEOMETRY CAN SUPPORT THE HYDRAULIC JUMP HEIGHT.

☐ STEP 2 – ESTIMATE JUMP LENGTH AND VERIFY THAT $L < 20$ FT

USING FIGURE 6 FROM SECTION 1 :

$F_1 = 8.15 \Rightarrow L/D_1 \approx 67$

$D_1 = 0.26$ FT

$$L = (0.26)(67) = \boxed{17.42 \text{ FT}} < 20 \text{ FT}$$

∴ EXISTING LOWER CHUTE LENGTH IS SUFFICIENT TO HANDLE THE FULL HYDRAULIC JUMP LENGTH.

☆ SOURCE :

PETERKA, A.J. HYDRAULIC DESIGN OF STILLING BASINS AND ENERGY DISSIPATORS, ENGINEERING MONOGRAPH NO. 25. US DEPARTMENT OF INTERIOR, BUREAU OF RECLAMATION, MAY 1984.

opening. The extreme case involved a discharge of 0.14 c.f.s. and a value of D_1 of 0.032 foot, for $F_1=8.9$, which is much smaller than any discharge or value of D_1 used in the present experiments. Thus, it is reasoned that as the gate opening decreased, in the 6-inch-wide flume, frictional resistance in the channel downstream increased out of proportion to that which would have occurred in a larger flume or a prototype structure. Thus, the jump formed in a shorter length than it should. In laboratory language, this is known as "scale effect," and is construed to mean that prototype action is not faithfully reproduced. It is quite certain that this was the case for the major portion of curve 1. In fact, Bahkmeteff and Matzke were somewhat dubious concerning the small-scale experiments.

To confirm the above conclusion, it was found that results from Flume F, which was 1 foot wide, became erratic when the value of D_1 approached 0.10. Figures 6 and 7 show three points obtained with a value of D_1 of approximately 0.085. The three points are given the symbol ⊠ and fall short of the recommended curve.

The two remaining curves, labeled "3" and "4," on Figure 7, portray the same trend as the recommended curve. The criterion used by each experimenter for judging the length of the jump is undoubtedly responsible for the displacement. The curve labeled "3" was obtained at the Technical University of Berlin on a flume ½ meter wide by 10 meters long. The curve labeled "4" was determined from experiments performed at

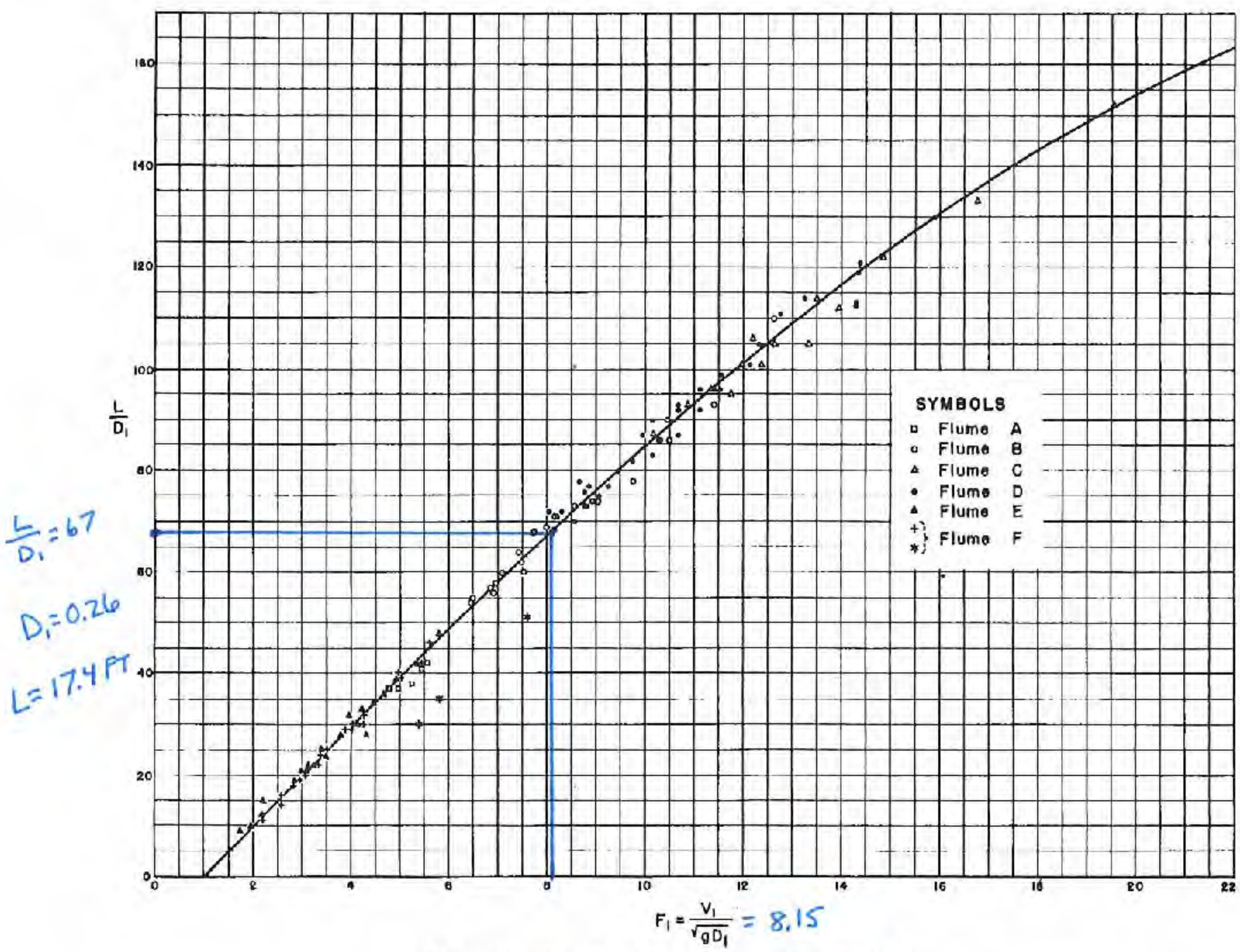

FIGURE 6.—*Length of jump in terms of D_1 (Basin I).*

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❖ Appendix B – Slope Stability Analysis

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COVER SHEET

S&ME

Project Name: Tanners Creek FAP Closure	
Subject: Slope Stability Analysis	
Project No. 7217-17-007A	Calc. No.
Discipline: Geotechnical Eng.	Sheet 1 of 7

Tanners Creek Fly Ash Pond Closure
Slope Stability Analysis

Computations By:	MICHAEL T ROMANELLO REGISTERED PE11600160 STATE OF INDIANA PROFESSIONAL ENGINEER Signature: [signature] 9-1-2017	
	Name: Michael T Romanello, P.E.	
	Title: Project Engineer	
Reviewed By:	Signature: [signature]	Date 8-12-2017
	Name: Michael Rowland, P.E.	
	Title: Senior Engineer	

Revisions:

No.	Description	By	Review	Date

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Table of Contents

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Introduction

A slope stability analysis was performed to evaluate the Fly Ash Pond closure design in general accordance with the requirements of 329 IAC 10-15-8. The analysis examined both interim and final configurations associated with the two main earthwork phases of the closure design. This calculation package focuses on global stability; shallow, or veneer, stability analysis of the cover system has been evaluated under a separate calculation package.

Evaluation of the existing PVC liner is included with this calculation package. The stability of the existing liner following removal of the anchor trench is evaluated.

Available Subsurface Information

In addition to the subsurface investigation carried out as part of the closure design, S&ME relied upon investigations, reports, and design documents from past projects as listed below to develop the subsurface stratigraphy and assign shear strength parameters:

- Fly Ash Storage Pond Elevation 518' Dam Raising Engineering Report and Design Drawings – AEP, 2002.
- Fly Ash Pond and Main Ash Pond Closure Plan – TRC, 2015.

Extensive development of shear strength parameters with supporting laboratory testing data is included in these reports. Excerpts from these documents have been appended with this calculation package as a reference.

Analysis Methods

Global Slope Stability

The global stability analyses were performed for the proposed Fly Ash Pond closure grades with the aid of the computer program Slide (Version 7.0) developed by Rocscience, Inc. The program performs 2-D limit equilibrium slope stability analyses using a deterministic approach. Spencer's method (Spencer, 1973) was selected for the analysis method. The critical slip surfaces corresponding to the lowest factor-of-safety for both circular and block failure surfaces (as appropriate) were analyzed as part of the analysis. Slip surfaces with the minimum factor of safety are automatically generated in the graphical output. In some cases, slip surfaces demonstrating the factors of safety for varying slip surface geometries have been queried.

Both static and seismic loading cases were evaluated. The static analysis was performed using drained shear strength values. The seismic slope stability analysis was performed using a pseudo-static slope stability approach. Discussion and development of the horizontal seismic coefficient (0.07g) is provided with the Liquefaction Evaluation presented as Appendix B of Attachment V. Consistent with past analyses, the seismic load cases were evaluated using drained shear strength parameters for the cohesive foundation and embankment soils as an initial screening. If low factors of safety are predicted for the seismic load case, total strength envelopes with an appropriate reduction will be developed. The end of construction load case was not evaluated, as a total stress condition is not expected to develop in the bottom ash embankment during construction of the closure activities. Stability calculations were performed in general accordance with the US Army Corps of Engineer's Slope Stability Manual (EM-1110-2-1902).

Minimum Values of Safety Factors for
Slope Stability Analyses for Liner and Final Cover Systems

	Uncertainty of Strength Measurements	
Consequences of Slope Failure	Small[1]	Large[2]
No imminent danger to human life or major environmental impact if slope fails	1.25 (1.2)*	1.5 (1.3)*
Imminent danger to human life or major environmental impact if slope fails	1.5 (1.3)*	2.0 or greater (1.7 or greater)*

[1]The uncertainty of the strength measurements is smallest when the soil conditions are uniform and high quality strength test data provide a consistent, complete, and logical picture of the strength characteristics.
[2]The uncertainty of the strength measurements is greatest when the soil conditions are complex and when the available strength data do not provide a consistent, complete, and logical picture of strength characteristics.
*Numbers without parentheses apply to static conditions and those within parentheses apply to seismic conditions.

Figure 1: 329 IAC 10-15-8 Table 1

Figure 1 presents the minimum values of safety factors for the slope stability analysis of final cover systems from 329 IAC 10, Rule 15. The following conditions were considered for selection of the minimum values of safety factors:

- There is potential imminent danger to human life or environmental impact associated with a slope failure of the original earthen embankment or raised interior dike.

- A "small uncertainty' of strength measurements was assumed as a development of these parameters has been supported by subsurface investigations and laboratory testing.

Based on the assumption listed above, a targeted minimum safety factor of 1.5 was used for static conditions, and a minimum safety factor of 1.3 was used for the seismic analysis.

PVC Liner Evaluation

The interior of the original pond is lined with a 20 mil PVC geomembrane. The geomembrane extends up the inboard slopes of the earthen embankment, then presumably terminates in a runout or anchor trench within the crest. Over the upper basin, the proposed cover system liner and geocomposite drainage layer will be extended down the outboard side of the raised embankment and into an anchor trench on the inboard side of the earthen embankment. This termination detail will require the upper portion of the PVC geomembrane to be removed. Section 5.8 of the Closure Plan narrative discusses the general use of anchor trenches for liner systems, in particular the temporary nature of the anchor needed for stability. The long-term stability of the fly ash pond's existing PVC liner was evaluating for the condition following removal of the anchor trench by examining the required runout length needed to prevent mobilize the full strength of the failure strength of the liner. Additional narrative on the evaluation approach and supporting calculations and figures are presented in Calculation 2.

Analysis Cross-Sections

S&ME selected three cross-sections for the slope stability analysis: 1) the east-west splitter dike between the clear water pond and the upper basin at the completion of Phase I, 2) a section through the upper basin's raised dike and original embankment representing the final dam configuration, and 3) the original earthen embankment in the clear water pond. The subsurface stratigraphy from the historic work was combined with the existing ground surface topographic information and proposed grades to develop the design cross-sections.

Section A – Clearwater Pond Splitter Dike

The water level within the clear water pond can fluctuate based on the balance between pumping rates and storm water inflow. During construction, an effort will be made to keep the water level as low as possible. At high pool elevations, the impounded water can have a stabilizing effect on the splitter dike for deep-seated failures. Typically, the worse-case condition for deep-seated failures occurs when the pool depth is approximately 1/3 of the slope height. As such, the pond level was set to Elevation 680 for the analysis. S&ME performed the analysis at several pond elevations to confirm this assumption. Elevation 680 is also consistent with the modeled groundwater level beneath the dike in the analysis conducted as part of 2015 Closure Plan.

In additional to a classic circular rotational failure mode, a translational failure mode was examined due to the presence of the PVC liner beneath the sluiced ash. The translational analysis modeled non-circular failure surfaces which may slide along the PVC liner interface. Both failure types were analyzed with drained conditions.

Section B – Upper Basin Raised Dike

Design Section B was developed to evaluate the final configuration of the original earthen embankment and interior raised dike in the upper basin. This design cross-section incorporates the maximum fill height within the upper basin and the general excavation configuration for the perimeter ditch (between the exterior earthen dike and interior bottom ash dike).

Section B is also used for the existing PVC liner evaluation.

Section C – Clear Water Pond Exterior Embankment

Design Section C was developed to evaluate the exterior embankments of the clear water pond where the interior bottom ash dike is not present on the south end. The cover system within the clear water pond slopes from a central drainage channel to the inboard crest of the embankment at less than a 1%. Therefore, only failure surfaces starting from within the limits of the cover system were explored.

Piezometric Conditions

Current open standpipe piezometer readings indicate the groundwater water level within the upper basin of the fly ash pond currently ranges between Elevation 490 and 495 in the upper basin (approximately 12 to 16 feet below the top of the ash). A summary of the piezometer readings are included in Attachment VI. The pond closure activities and installation of the final cover are anticipated to continue to reduce the groundwater level within the pond, although it will reach a limiting elevation due to the presence of the PVC liner. Therefore a conservative water surface Elevation of 490 feet was used for the slope stability analysis.

A second piezometric surface was included in the analysis and assigned to the soil layers beneath the PVC liner. The piezometric surface corresponds to a groundwater elevation of 454 feet based on static water level readings from the April 2012 groundwater sampling event and 2008 monitoring well information as utilized for the 2015 closure design.

Material Parameters

Table 1 summarizes the shear strength parameters used for the slope stability analysis. S&ME reviewed the shear strength parameter development from the available information. Selection of these shear strengths values by others were supported from field (SPT blow counts) and laboratory data (Atterberg limits & triaxial compression testing). Due to the inherent and observed variability in the sluiced ash characteristics, a drained friction angle of 26°, as previously developed, was maintained for the analysis. Based on the review of all information, no changes were made to the slope stability shear strength parameters.

At a minimum, the upper 5 feet of the ash placed for the closure will be compacted in a controlled manner. An increase in the friction angle was taken to account for this effort (increasing from 26° to 30°). The PVC liner interface was modeled as a 1 foot thick layer along the bottom of the pond (Elevation 458) and up the inboard sides of the earthen embankment. The drained friction angle of 18° is based on typical interface shear strength testing data representing peak shear strength conditions.

Table 1: Drained Shear Strength Parameters

Material	Total Unit Weight (psf)	Cohesion, c′ (psf)	Friction Angle
Previously Developed Parameters			
In-Place Sluiced Fly Ash	101	0	26°
Bottom Ash Dike	95	0	33°
Earthen Dike and Liner	130	0	30°
Upper Clay	125	0	28°
Upper Clay Beneath Embankment	125	0	33°
Lower Clay	125	0	32°
Natural Sand and Gravel	125	0	35°
New Parameters			
Compacted Fly Ash	105	0	30°
PVC Liner Interface	130	0	18°
Final Cover System	115	50	28°

Results

A summary of the computed safety factors for the design cross-sections are provided in Table 2. Graphical output corresponding to the analysis cases have been appended in Calculation 1. Each examined cross-section and corresponding failure modes met the minimum-targeted factor of safety.

Table 2 – Stability Analysis Summary

Design Cross-Section	Load Case	Failure Mode	Minimum FS	Computed Factor of Safety
A Splitter Dike	Static	Rotational	1.5	1.99
		Translational	1.5	1.82
B Upper Basin	Static	Rotational	1.5	1.94
	Seismic	Rotational	1.3	1.56
C Clear Water Pond	Static	Rotational	1.5	1.77
	Seismic	Rotational	1.3	1.44

Results of the PVC evaluation indicate the existing bench on the inboard slope has sufficient length to act as a runout trench following removal of the existing anchor trench.

References

(1) U.S. Army Corps of Engineers. *Slope Stability*: Engineering Manual 1110-2-1902. October, 2003.

(2) Kulhawy, F.H. and Mayne, P.W., (1990), "Manual for estimating soil properties for foundation design.", Report EL-6800, EPRI, Palo Alto, CA.

(3) Masood, T. & Mitchell, J.K. (1993), "Estimation of In-Situ Lateral Stresses in Soils by Cone Penetration Test," accepted for publication in the Journal of Geotechnical Engineering, American Society of Civil Engineers.

Attachments

- Calculation 1 – Slope stability graphical output
- Calculation 2 –PVC Liner Evaluation
- References – Summary of material parameters from previous investigations

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Calculation 1 – Slope Stability Graphical Output

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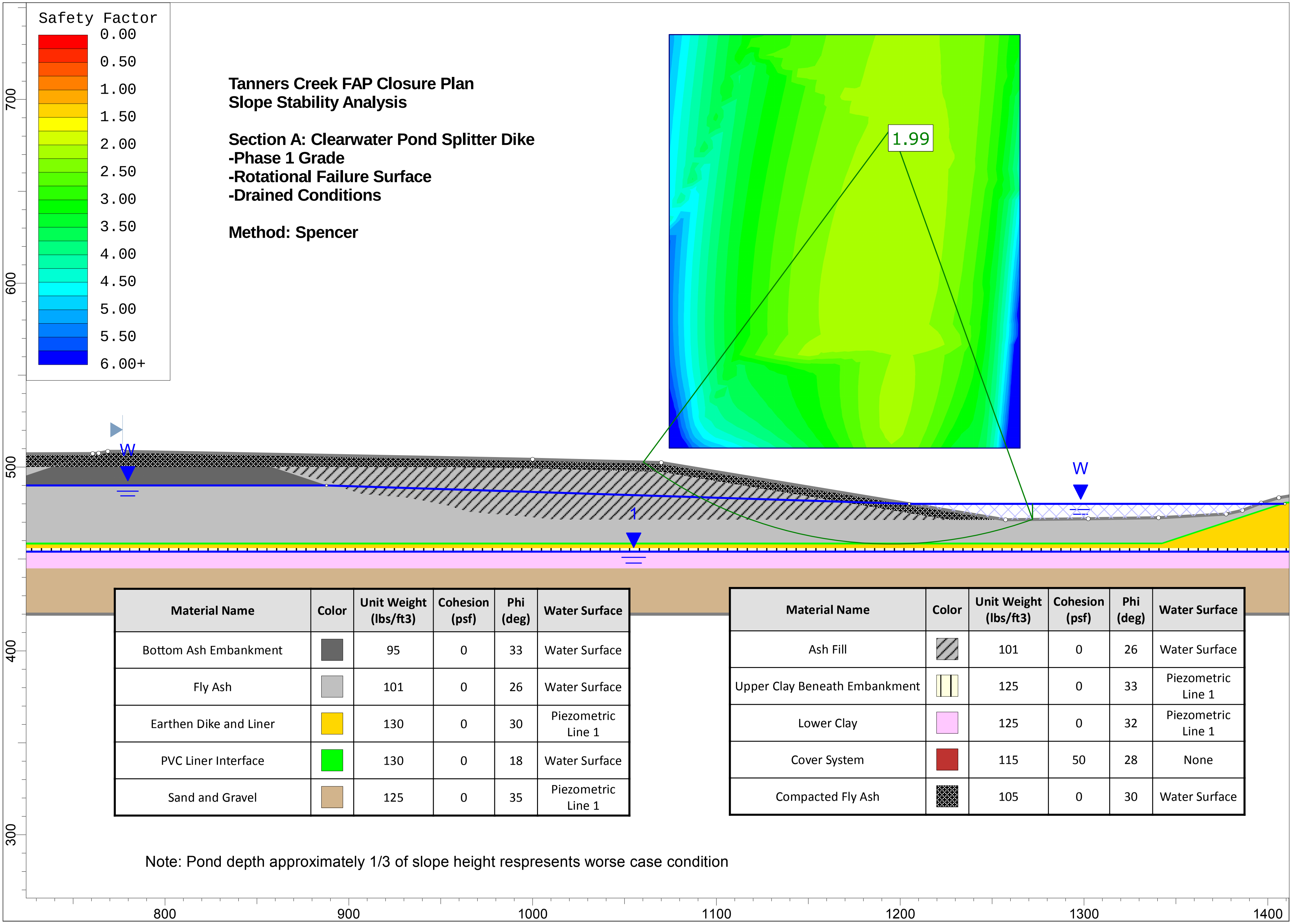
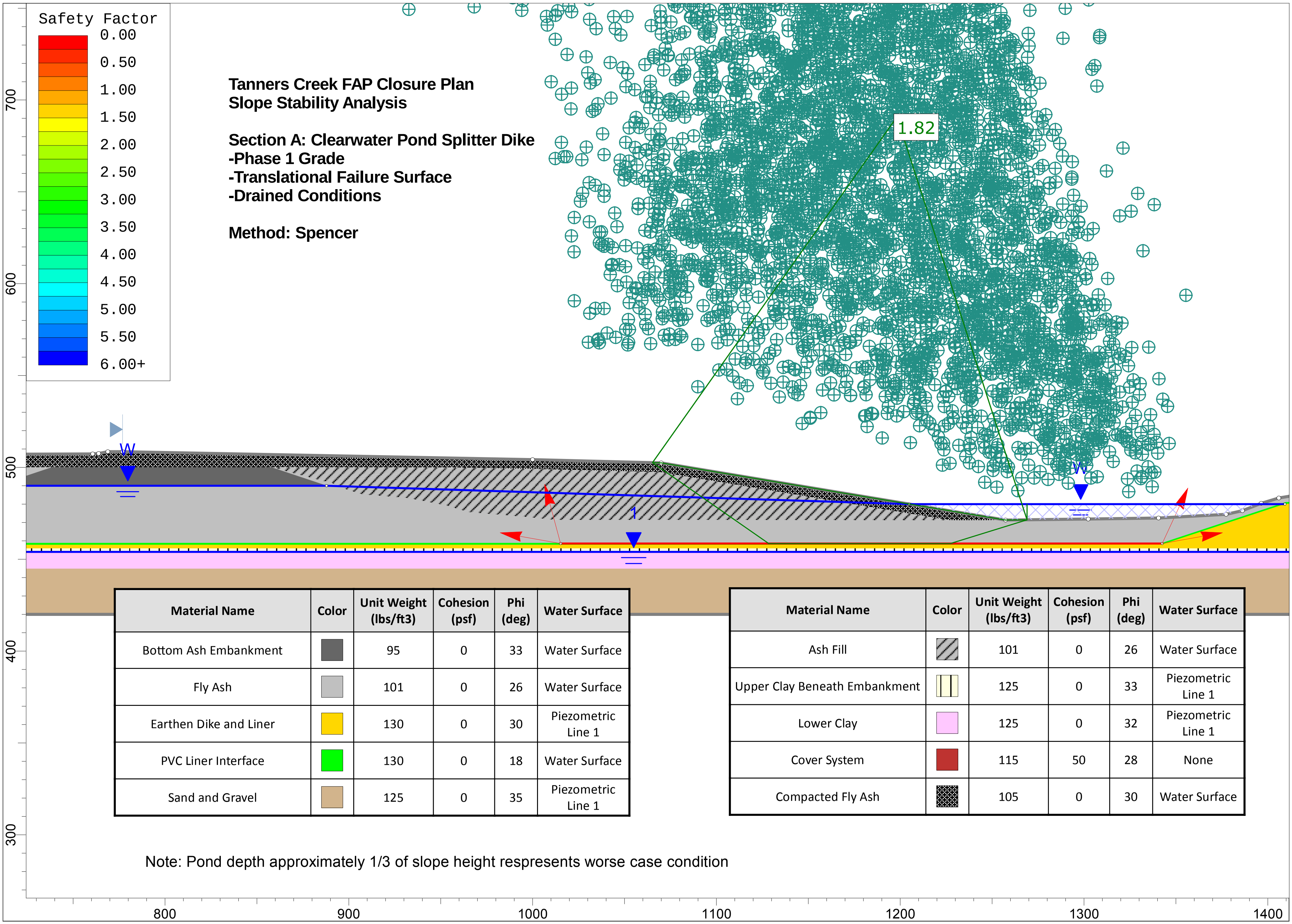


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	Water Surface
Bottom Ash Embankment		95	0	33	Water Surface
Fly Ash		101	0	26	Water Surface
Earthen Dike and Liner		130	0	30	Piezometric Line 1
PVC Liner Interface		130	0	18	Water Surface
Sand and Gravel		125	0	35	Piezometric Line 1

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	Water Surface
Ash Fill		101	0	26	Water Surface
Upper Clay Beneath Embankment		125	0	33	Piezometric Line 1
Lower Clay		125	0	32	Piezometric Line 1
Cover System		115	50	28	None
Compacted Fly Ash		105	0	30	Water Surface

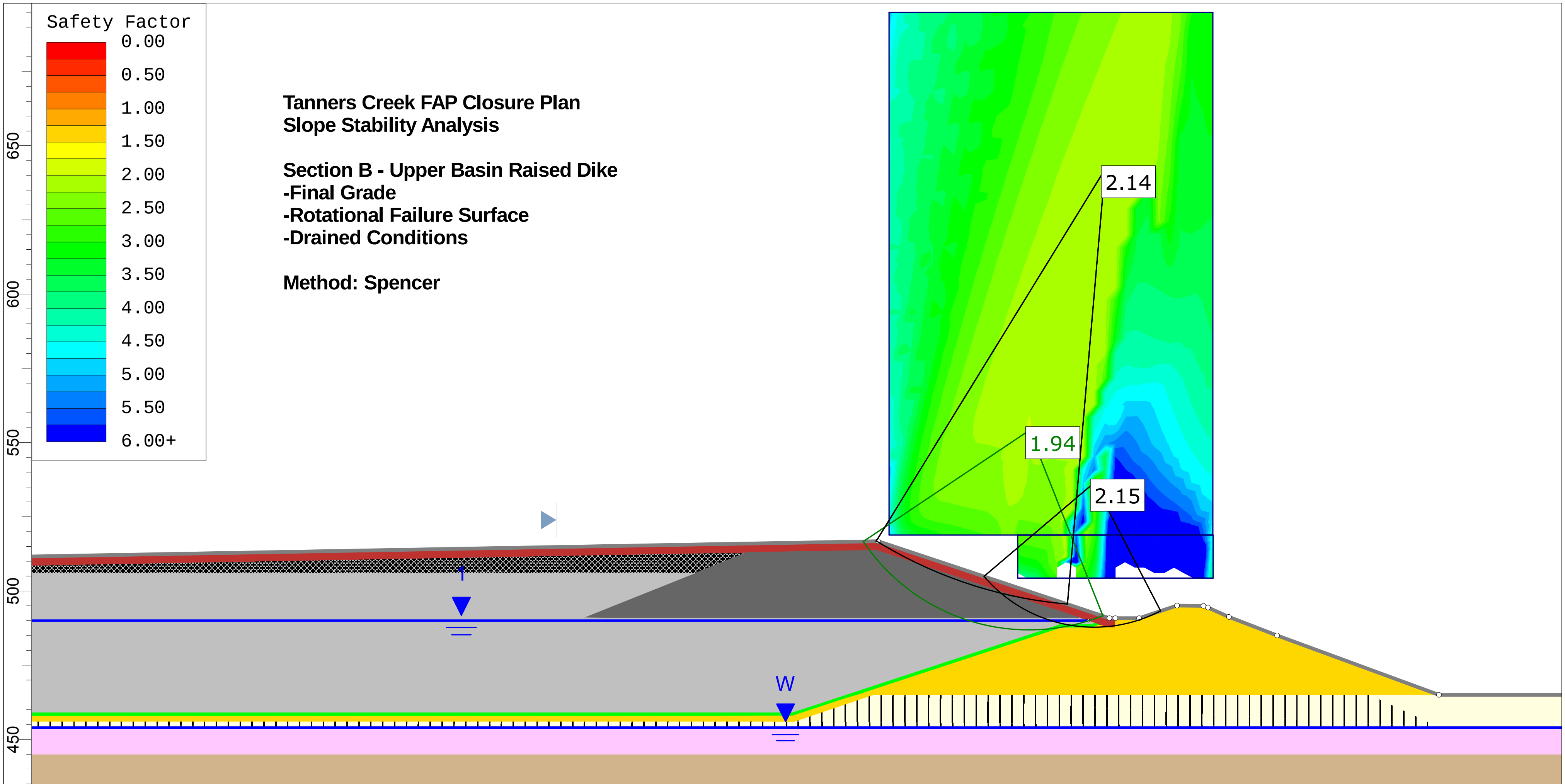
Note: Pond depth approximately 1/3 of slope height respresents worse case condition



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	Water Surface
Bottom Ash Embankment		95	0	33	Water Surface
Fly Ash		101	0	26	Water Surface
Earthen Dike and Liner		130	0	30	Piezometric Line 1
PVC Liner Interface		130	0	18	Water Surface
Sand and Gravel		125	0	35	Piezometric Line 1

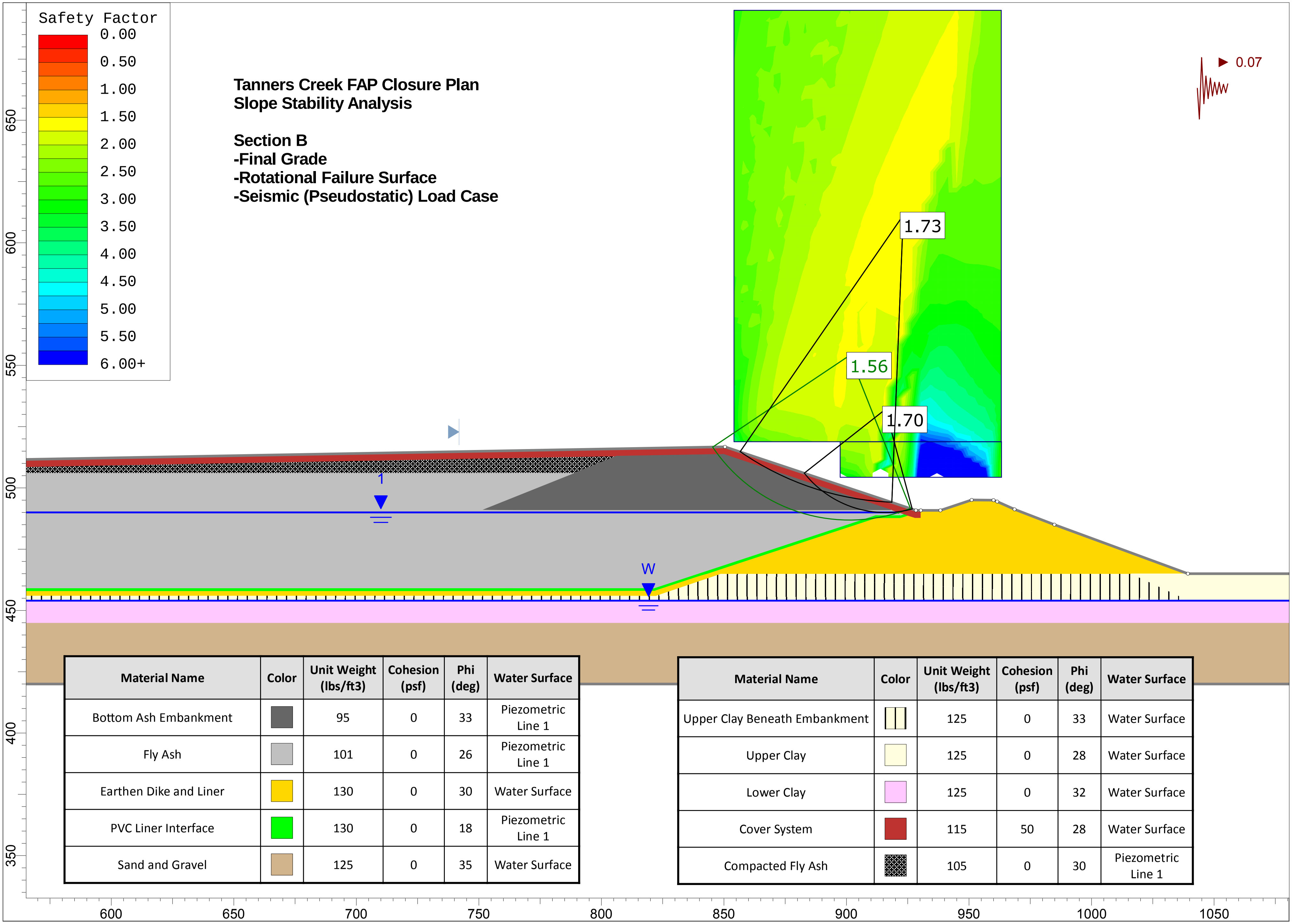
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	Water Surface
Ash Fill		101	0	26	Water Surface
Upper Clay Beneath Embankment		125	0	33	Piezometric Line 1
Lower Clay		125	0	32	Piezometric Line 1
Cover System		115	50	28	None
Compacted Fly Ash		105	0	30	Water Surface

Note: Pond depth approximately 1/3 of slope height respresents worse case condition



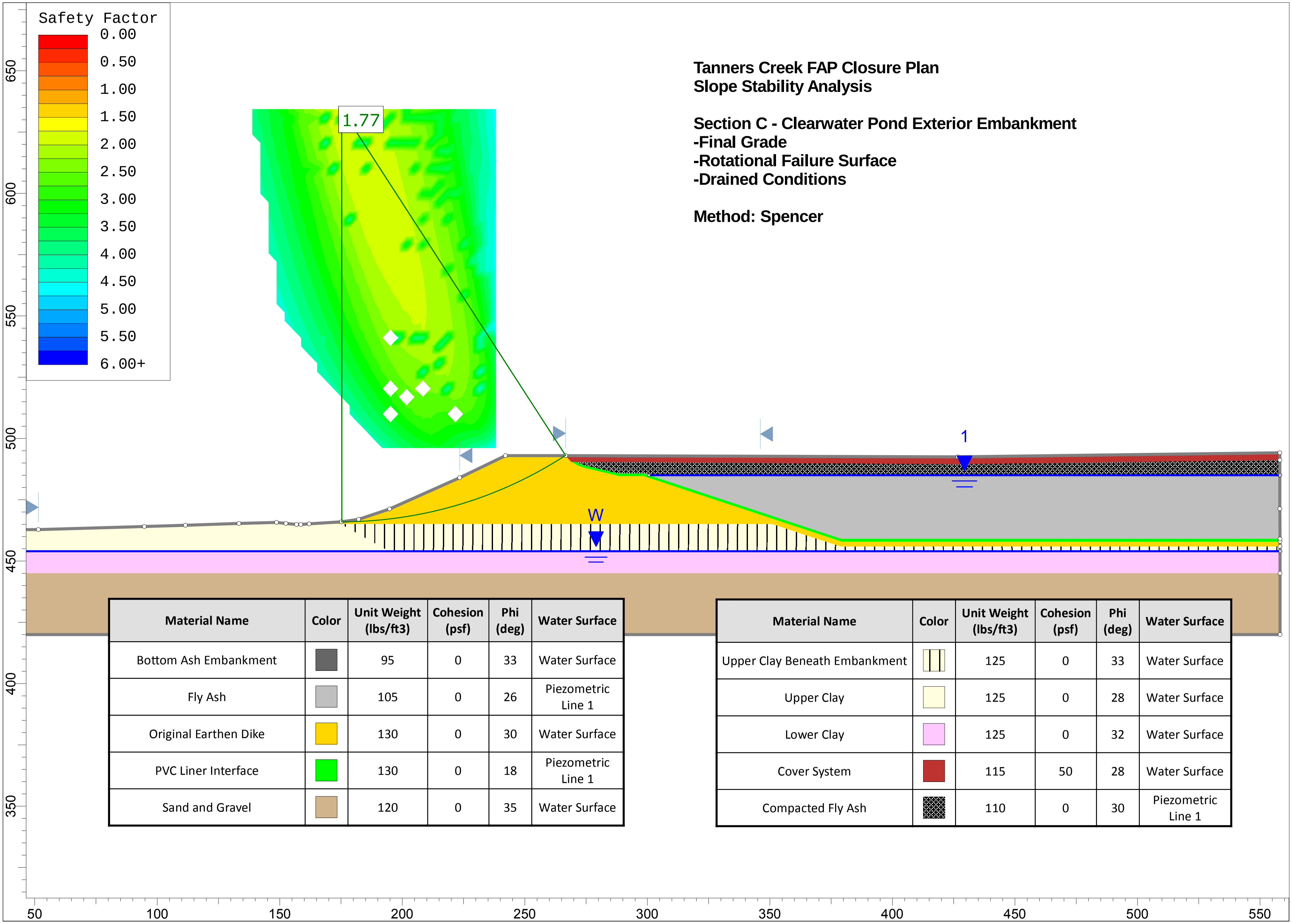
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	Water Surface
Bottom Ash Embankment		95	0	33	Piezometric Line 1
Fly Ash		101	0	26	Piezometric Line 1
Earthen Dike and Liner		130	0	30	Water Surface
PVC Liner Interface		130	0	18	Piezometric Line 1
Sand and Gravel		125	0	35	Water Surface

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	Water Surface
Upper Clay Beneath Embankment		125	0	33	Water Surface
Upper Clay		125	0	28	Water Surface
Lower Clay		125	0	32	Water Surface
Cover System		115	50	28	Water Surface
Compacted Fly Ash		105	0	30	Piezometric Line 1



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	Water Surface
Bottom Ash Embankment		95	0	33	Piezometric Line 1
Fly Ash		101	0	26	Piezometric Line 1
Earthen Dike and Liner		130	0	30	Water Surface
PVC Liner Interface		130	0	18	Piezometric Line 1
Sand and Gravel		125	0	35	Water Surface

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	Water Surface
Upper Clay Beneath Embankment		125	0	33	Water Surface
Upper Clay		125	0	28	Water Surface
Lower Clay		125	0	32	Water Surface
Cover System		115	50	28	Water Surface
Compacted Fly Ash		105	0	30	Piezometric Line 1



Tanners Creek FAP Closure Plan
Slope Stability Analysis

Section C - Clearwater Pond Exterior Embankment
-Final Grade
-Rotational Failure Surface
-Drained Conditions

Method: Spencer

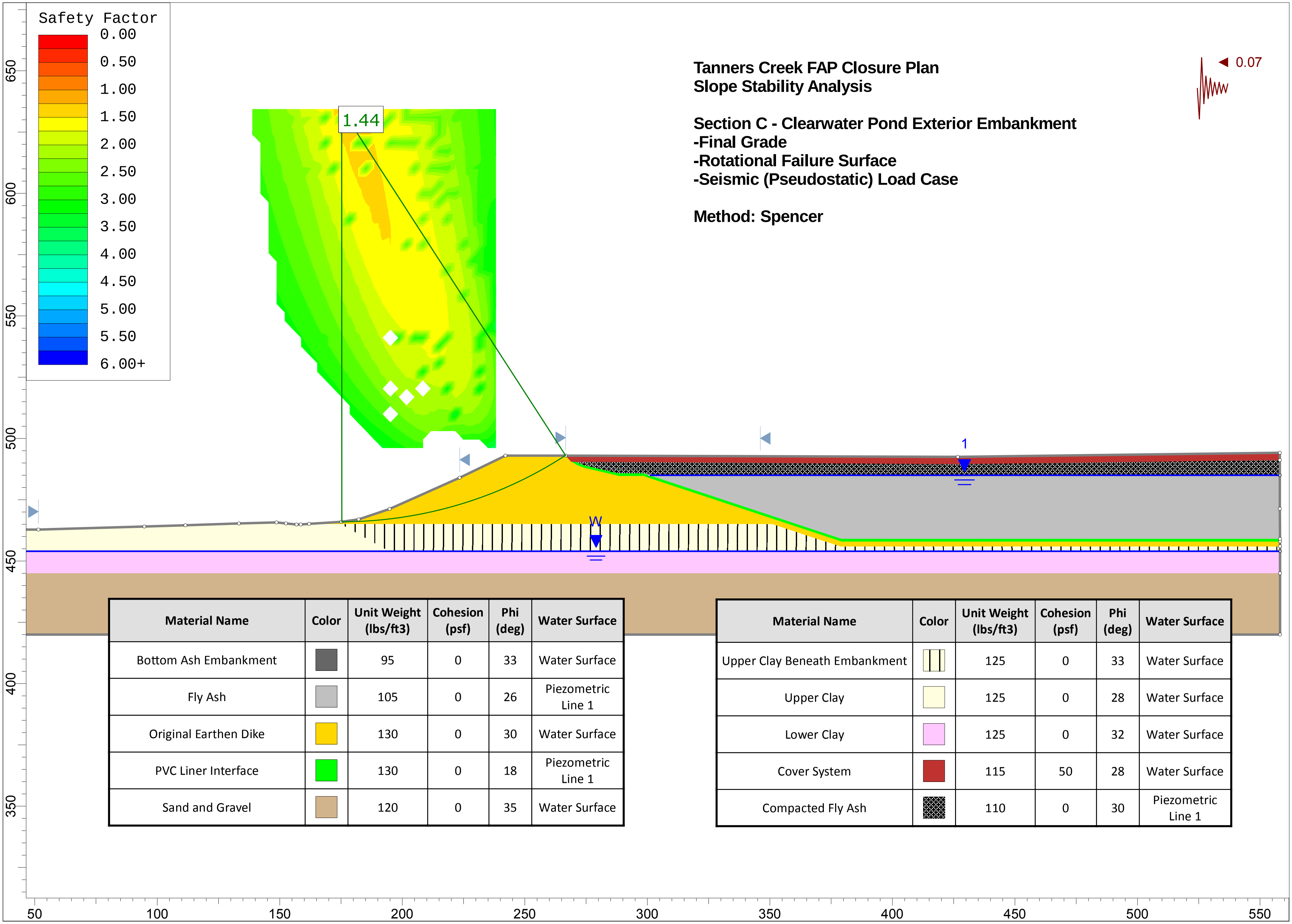
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	Water Surface
Bottom Ash Embankment		95	0	33	Water Surface
Fly Ash		105	0	26	Piezometric Line 1
Original Earthen Dike		130	0	30	Water Surface
PVC Liner Interface		130	0	18	Piezometric Line 1
Sand and Gravel		120	0	35	Water Surface

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	Water Surface
Upper Clay Beneath Embankment		125	0	33	Water Surface
Upper Clay		125	0	28	Water Surface
Lower Clay		125	0	32	Water Surface
Cover System		115	50	28	Water Surface
Compacted Fly Ash		110	0	30	Piezometric Line 1

Tanners Creek FAP Closure Plan
Slope Stability Analysis

Section C - Clearwater Pond Exterior Embankment
-Final Grade
-Rotational Failure Surface
-Seismic (Pseudostatic) Load Case

Method: Spencer



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	Water Surface
Bottom Ash Embankment		95	0	33	Water Surface
Fly Ash		105	0	26	Piezometric Line 1
Original Earthen Dike		130	0	30	Water Surface
PVC Liner Interface		130	0	18	Piezometric Line 1
Sand and Gravel		120	0	35	Water Surface

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	Water Surface
Upper Clay Beneath Embankment		125	0	33	Water Surface
Upper Clay		125	0	28	Water Surface
Lower Clay		125	0	32	Water Surface
Cover System		115	50	28	Water Surface
Compacted Fly Ash		110	0	30	Piezometric Line 1

Calculation 2 – PVC Liner Evaluation

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❖ PVC Liner Evaluation

Purpose:

Determine whether the existing bench on the inboard slope of the earthen embankment is wide enough to act as a horizontal runout trench for the existing 20 mil PVC liner following removal of the liner anchor trench to accommodate the installation of the proposed final cover.

Approach

Assume the existing horizontal bench on the inboard side of the upper basin earthen dike acts as a runout trench after the existing PVC liner anchor trench is removed. Use the Runout Anchor Trench Design procedure presented by Koerner(1) and compare the computed minimum runout length to the length of the bench.

- Design Equation: See excerpt from Koerner(1). Calculate the required horizontal runout length needed to mobilize the failure strength of the existing PVC geomembrane. Although pullout of a geomembrane is often the preferred failure method, computing the runout length needed to equal the break strength of the liner will result in a larger value.

- The specification of the existing PVC product is unknown. Use a current 20 mil PVC liner specification to estimate the strength at break.

- Determine the applied normal stress based on the typical section for the FAP closure.

Results

The minimum required runout length, L_{RO}, from using the design equation and site-specific parameters is 1.4 feet. The width of the existing bench on the inboard slope of the earthen embankment is 10. Therefore, the stability of the PVC should be maintained following the removal of the anchor trench.

Attachments:

- Runout Trench Design Procedure
- 20 mil PVC liner specification
- Typical Section

References:

(1) Koerner, Robert M., Designing with Geosynthetics, 5th Ed. 2005., pg. 500-506.

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Project/Proposal No. 7217-17-007A   Calculated By MTR   Date 8-30-17
Project/Proposal Name TANNERS CREEK EAP   Checked By MGK   Date 8-30-17
Subject RUNOUT LENGTH CALC.   Sheet 1 of 1

$$L_{RO} = \frac{T_{allow}\,(\cos\beta - \sin\beta\,\tan\delta_L)}{\sigma_n\,(\tan\delta_U + \tan\delta_L)}$$

SEE EXCERPT FROM REFERENCE

T_{allow} = 48 lb/in = 576 lb/FT FOR 20 mil PVC

β = 18.4° (3H:1V)

δ_L = 18° (CONSERVATIVE ESTIMATE)

δ_U = 0 PER REFERENCE

σ_n = 7.6 FT COVER × 110 PCF = 836 PSF ✓

$$L_{RO} = \frac{576\ \text{lbs/FT}\,(0.95 - 0.32 \cdot 0.32)}{836\ \text{lbs/SF}\,(0 + 0.32)}$$

L_{RO} = 1.8 FEET < 10 FEET (OK) ✓

Designing with Geosynthetics, 5th Edition

$$c = (N_A \tan\delta + C_a)\sin\beta \sin\left(\frac{\omega + \beta}{2}\right)\tan\phi$$
$$= (370 \tan 22 + 0)\sin 18.4 \sin\left(\frac{16 + 18.4}{2}\right)\tan 30$$
$$= 8.07 \text{ kN/m}$$
$$\text{FS} = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$
$$= \frac{62.8 + \sqrt{(-62.8)^2 - 4(37.2)(8.07)}}{2(37.2)}$$
$$\text{FS} = 1.55 \text{ (vs. 1.25 for the constant thickness cross section)}$$

Example 5.12 has also been extended to a set of design curves, as seen in Figure 5.26b. The anticipated trends are again noted, as is the agreement with the worked out example. Clearly, this type of stabilizing solution can be used if space at the toe of the slope is available. Often it is not or it occupies valuable air space and then geosynthetic reinforcement as discussed in Chapter 3 is the alternative solution.

5.3.6 Runout and Anchor Trench Design

As shown in Figure 5.18 and the profile sections of geomembrane-lined reservoirs, the liner coming up from the bottom of the excavation, covers the side slopes, and then runs over the top a short distance. It often terminates vertically down into an anchor trench. This anchor trench is typically dug by a small backhoe or trenching machine; the liner is draped over the edge, and then the trench is backfilled with the same soil that was there originally. The backfilled soil should be compacted in layers as the backfilling proceeds. Although concrete has been used as an anchorage block, it is rarely justified, at least on the basis of calculations, as will be seen in this section.

Regarding design, two separate cases will be analyzed: one with geomembrane runout only and no anchor trench at all (as is often used with canal liners), and the other as described above, with both runout and anchor trench considerations (as with reservoirs and landfills). Figure 5.27 defines the first situation, together with the forces and stresses involved. Note that the cover soil applies normal stress due to its weight but does not contribute frictional resistance above the geomembrane. This is due to the fact that the soil moves along with the geomembrane as it deforms and undoubtedly cracks, thereby losing its integrity.

From Figure 5.27, the following horizontal force summation results, which leads to the appropriate design equation:

$$\Sigma F_x = 0$$
$$T_{\text{allow}}\cos\beta = F_{U\sigma} + F_{L\sigma} + F_{LT}$$
$$= \sigma_n \tan\delta_U(L_{RO}) + \sigma_n \tan\delta_L(L_{RO}) + 0.5\left(\frac{2T_{\text{allow}}\sin\beta}{L_{RO}}\right)(L_{RO})\tan\delta_L$$
$$L_{RO} = \frac{T_{\text{allow}}(\cos\beta - \sin\beta\tan\delta_L)}{\sigma_n(\tan\delta_U + \tan\delta_L)} \tag{5.25}$$

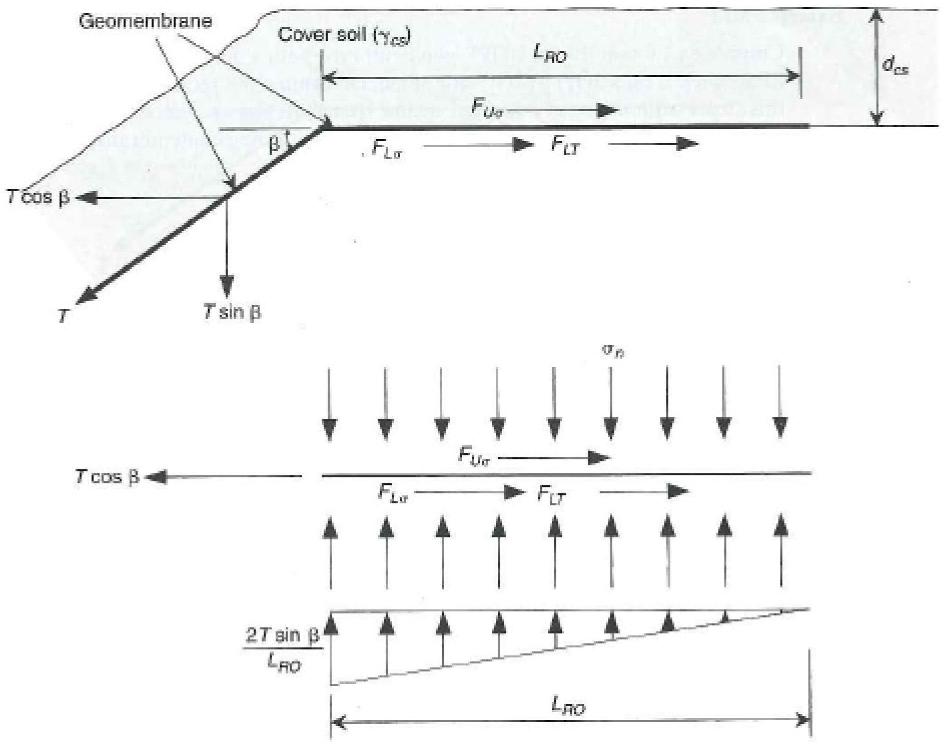

Figure 5.27 Cross section of geomembrane runout section and related stresses and forces involved.

where

T_{allow} = allowable force in geomembrane = $\sigma_{\text{allow}}\, t$, where
σ_{allow} = allowable stress in geomembrane, and
t = thickness of geomembrane;
β = side slope angle;
$F_{U\sigma}$ = shear force above geomembrane due to cover soil (note that for thin cover soils tensile cracking will occur and this value will be negligible);
$F_{L\sigma}$ = shear force below geomembrane due to cover soil;
F_{LT} = shear force below geomembrane due to vertical component of T_{allow};
σ_n = applied normal stress from cover soil;
δ = angle of shearing resistance between geomembrane and adjacent material (i.e., soil or geotextile); and
L_{RO} = length of geomembrane runout.

Example 5.13 illustrates the use of the concept and equations just developed.

Product Data

PVC Material Information

Certified Properties[2]	ASTM	PVC 10	PVC 20	PVC 30	PVC 40	PVC 50	PVC 60
Thickness	D-5199	10 ± 0.5 mil 0.25 ± 0.013 mm	20 ± 1 mil 0.51 ± 0.03 mm	30 ± 1.5 mil 0.76 ± 0.04 mm	40 ± 2 mil 1.02 ± 0.05 mm	50 ± 2.5 mil 1.27 ± 0.06 mm	60 ± 3 mil 1.52 ± 0.08 mm
Tensile Properties[3]	D-882[4] Min						
Strength at Break	(MD & TD)	24 lbs/in 4.2 kN/m	48 lbs/in 8.4 kN/m	73 lbs/in 12.8 kN/m	97 lbs/in 17.0 kN/m	116 lbs/in 20.3 kN/m	137 lbs/in 24.0 kN/m
Elongation		250%	360%	380%	430%	430%	450%
Modulus at 100%		10 lbs/in 1.8 kN/m	21 lbs/in 3.7 kN/m	32 lbs/in 5.6 kN/m	40 lbs/in 7.0 kN/m	50 lbs/in 8.8 kN/m	60 lbs/in 10.5 kN/m
Tear Strength	D-1004[4] Min	2.5 lbs 11 N	6 lbs 27 N	8 lbs 35 N	10 lbs 44 N	13 lbs 58 N	15 lbs 67 N
Dimensional Stability	D-1204[4] Max Chg (MD & TD)	4%	4%	3%	3%	3%	3%
Low Temperature Impact	D-1790[4,6] Pass	-10°F -23°C	-15°F -26°C	-20°F -29°C	-20°F -29°C	-20°F -29°C	-20°F -29°C
Index Properties[5]	ASTM	PVC 10	PVC 20	PVC 30	PVC 40	PVC 50	PVC 60
Specific Gravity	D-792 Typical	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc
Water Extraction	D-1239[4] Max Loss	0.15%	0.15%	0.15%	0.20%	0.20%	0.20%
Percent Loss (max) Average Plasticizer	D-2124[4,5,7]	400	400	400	400	400	400
Molecular Weight Volatile Loss	D-1203[4] Max Loss	1.5%	0.9%	0.7%	0.5%	0.5%	0.5%
Percent Loss (max) Soil Burial	G160[4] Max Chg						
Break Strength		5%	5%	5%	5%	5%	5%
Elongation		20%	20%	20%	20%	20%	20%
Modulus at 100%		20%	20%	20%	20%	20%	20%
Hydrostatic Resistance	D-751[4] Min	42 psi 290 kPa	68 psi 470 kPa	100 psi 690 kPa	120 psi 830 kPa	150 psi 1030 kPa	180 psi 1240 kPa
	ASTM	PVC 10	PVC 20	PVC 30	PVC 40	PVC 50	PVC 60
Seam Strengths Shear Strength[3]	D-882[4] Min	20 lbs/in 3.45 kN/m	38.4 lbs/in 6.7 kN/m	58.4 lbs/in 10 kN/m	77.6 lbs/in 14 kN/m	96 lbs/in 17 kN/m	116 lbs/in 20 kN/m
Peel Strength[3]	D-882[4] Min	10 lbs/in 1.8 kN/m	12.5 lbs/in 2.2 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m

1. FGI 1115 replaces PGI 1104 Specification effective 1/1/15.
2. Certified properties are tested by lot as specified in PGI 1104 Appendix A
3. Metric values are converted from US values and are rounded to the available significant digits
3. Modifications or further details of test are described in PGI 1104 Appendix B
5. Index properties are tested once per formulation as specified in PGI 1104 Appendix A
6. For arid climates (sheet temperature of 50°C or 120°F) passing temperatures are -17°C for PVC 20 and -20°C for all other thicknesses
7. For arid climates use average plasticizer molecular weight of 410

FOR SALES INFORMATION

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Houston Office: 888.546.4641 **California Office:** 303.951.5942

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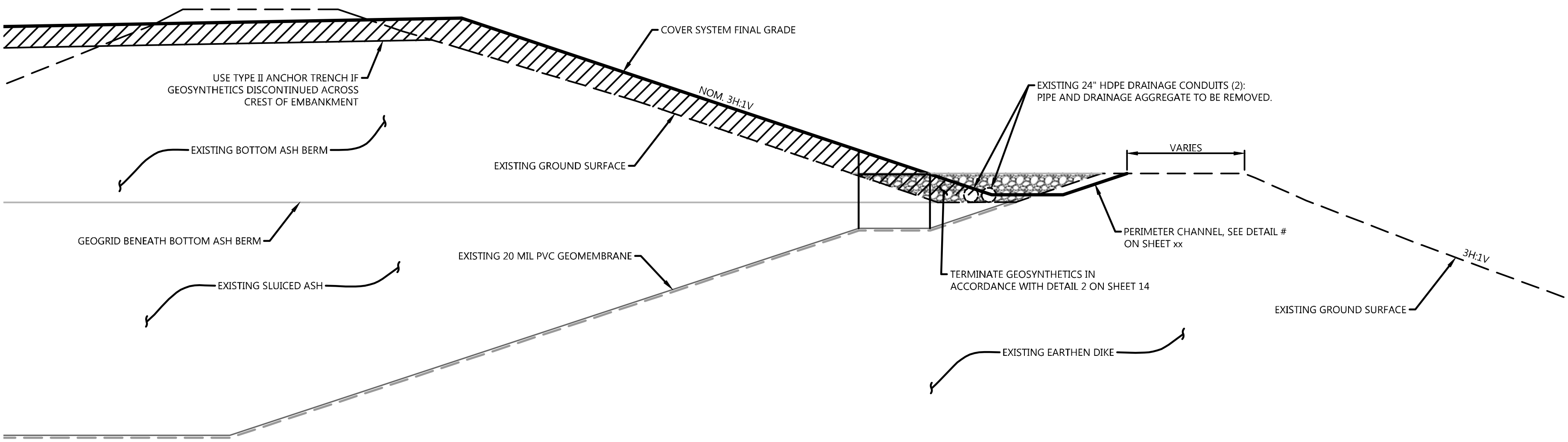
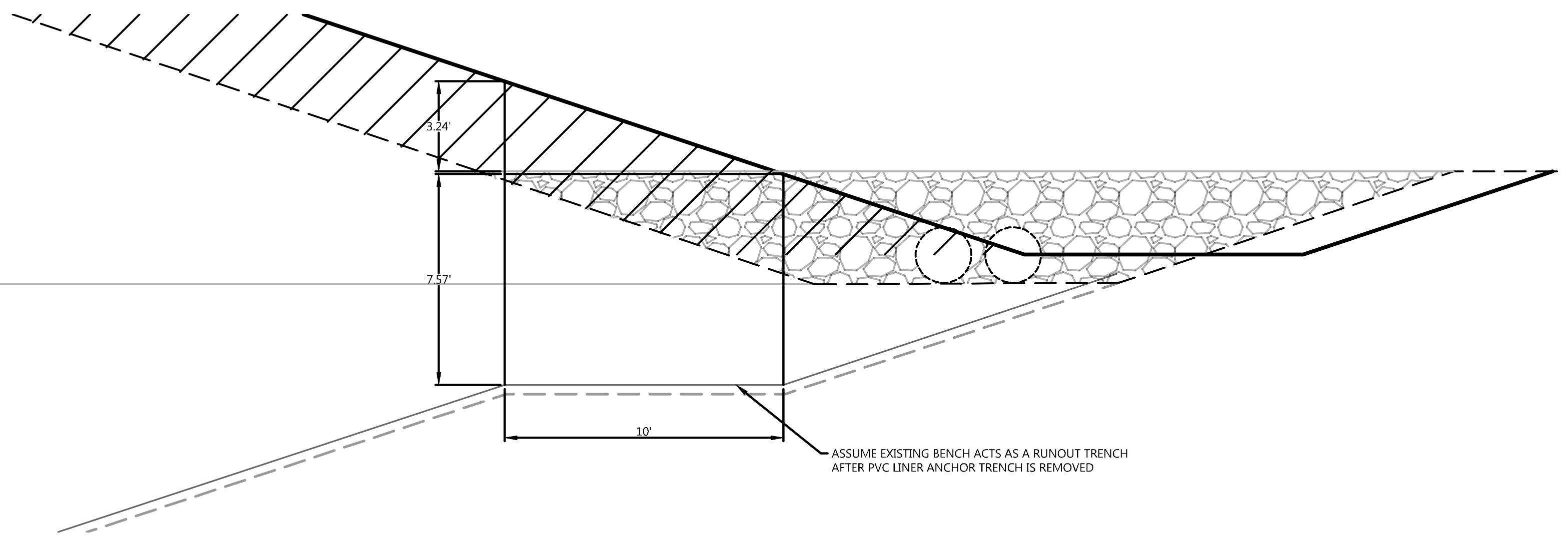
TYPICAL SECTION THROUGH UPPER BASIN EXTERIOR DIKES





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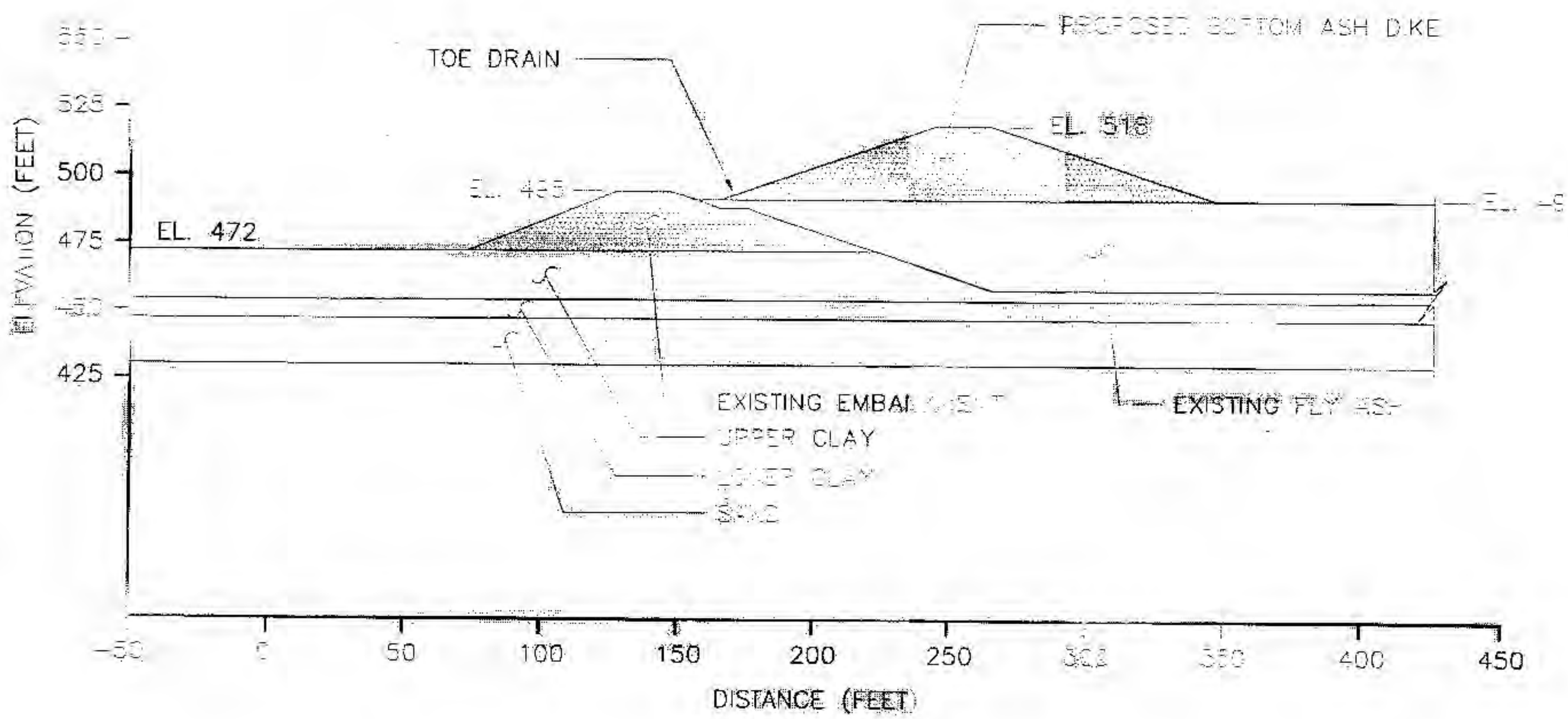

Figure 8. Fourth Lift of Bottom

AEP (15/1[illegible] [illegible]1 JXA)
Stability Analyses
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Last Saved Date: 1/24/2002
Last Saved Time: 11:44:52 AM
Analysis Method: Spencer

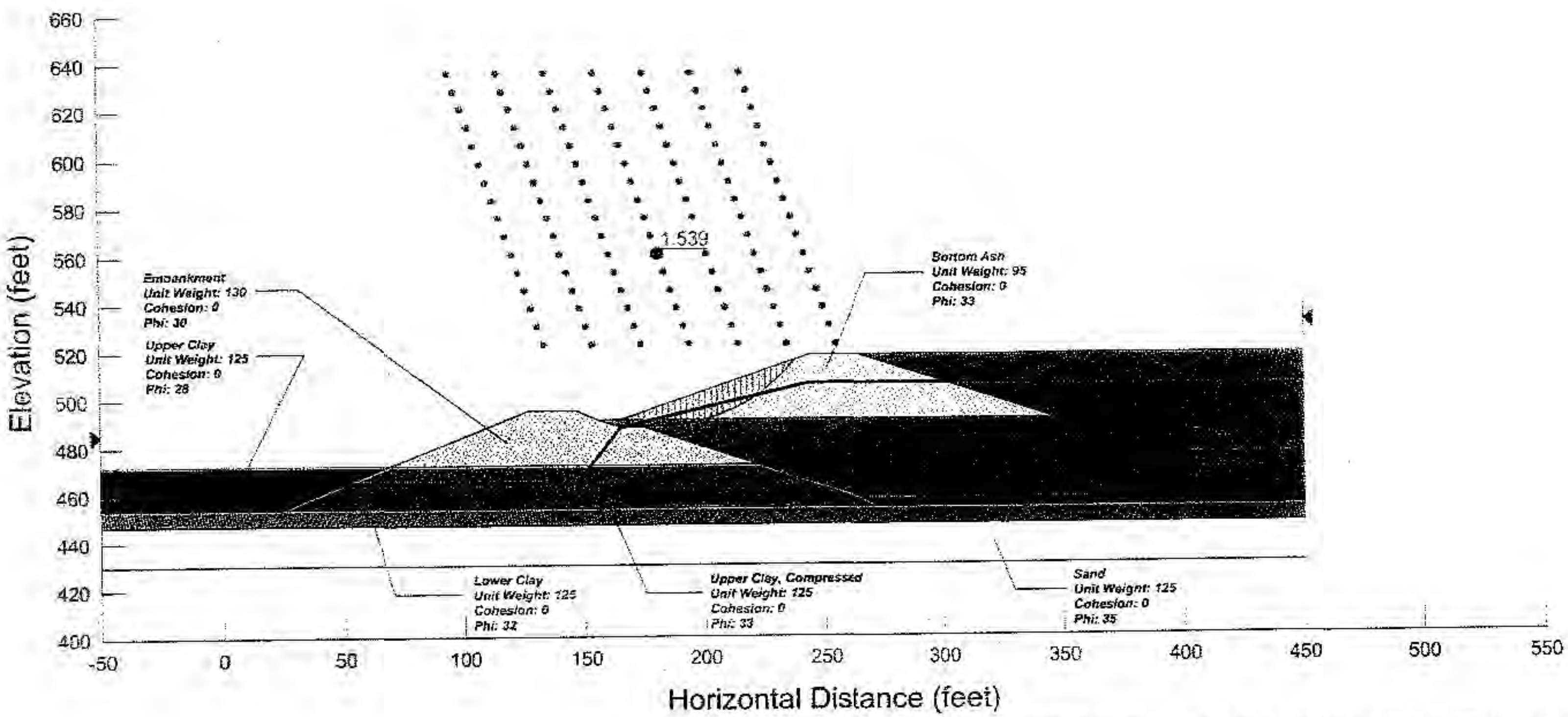

Figure 20. Factor of Safety for Proposed Dike (Downstream)

708 Heartland Trail, Suite 3000 (53717) Madison, WI (608) 826-3600 FAX: (608) 826-3941

PROJECT/PROPOSAL NAME	PREPARED		CHECKED		PROJECT/PROPOSAL NO.
Tanners Creek CCR Pond Closure	By: D. Engstrom	Date: 9/17/2014	By: J. Hotstream	Date: 10/20/14	219466.0000

Assumption Table 1
Material Properties Under Drained Conditions

MATERIAL	TOTAL UNIT WEIGHT (pcf)	APPARENT COHESION, c' (psf)	DRAINED FRICTION ANGLE, ϕ' (deg.)
FAP Bottom Ash Berm [1]	95	0	33
FAP Original Berm and Liner Material [1]	130	0	30
FAP Fly Ash [1] [2]	105	0	26
FAP Natural Clay Under Embankment [1]	125	0	33
FAP Natural Clay Outside the Influence of Embankment [1]	125	0	28
FAP Natural Sand [1]	120	0	35
MAP Ash [3]	90	0	28
MAP Soil Berm [3]	127	200	30
MAP Natural Silty Clay with Sand [3]	126	0	34
MAP Natural Sand and Gravel [3]	115	0	36 [4]
MAP Rock Fill [3]	130 [5]	0	40
Final Cover Material[6]	115	50	28

Notes:

(1) Properties provided for these materials are summarized in Table 3 of the 2002 Fly Ash Storage Pond Elevation 518' Dam Raising Engineering Report.

(2) Values were obtained from TRC laboratory test results, which were confirmed with the available historical data (TRC, 2014). Post peak values are used for the strength envelope development.

(3) Total unit weight, apparent cohesion, and drained friction angle were determined from Table 3 of the East Dike Summary Evaluation (Geo/Environmental Associates, 2010).

(4) Drained friction angle was verified using PZ-09-14A, PZ-09-15, and PZ-09-16.

(5) Total unit weight was adjusted based on the NAVFAC value for gravel with a similar friction angle.

(6) Final Cover material properties were based on assumed values.

Appendix C – Liquefaction Evaluation

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COVER SHEET

S&ME

Project Name: Tanners Creek FAP Closure	
Subject: Liquefaction Evaluation	
Project No. 7217-17-007A	Calc. No.
Discipline: Geotechnical Eng.	Sheet 1 of 4

Tanners Creek Fly Ash Pond Closure
Liquefaction Evaluation

Software Analysis By:	Name:	Bill Fox	Date: 8-1-2017
	Title:	Senior Engineer	
Computations By:	Signature:	[signature] MICHAEL T ROMANELLO REGISTERED PE11600160 STATE OF INDIANA PROFESSIONAL ENGINEER 8-18-17	
	Name:	Michael T Romanello, P.E.	
	Title:	Project Engineer	
Reviewed By:	Signature:	[signature]	Date 8-18-17
	Name:	William M Camp, III PE, D.GE	
	Title:	Technical Principal	

Revisions:

No.	Description	By	Review	Date

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Table of Contents

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Introduction

A liquefaction triggering evaluation was performed to evaluate the liquefaction potential of the sluiced fly ash within the pond in general accordance with the requirements of 329 IAC 10-16-7 - Unstable Area Siting Restrictions. The analysis is based on cone penetration test data and the mapped seismic hazard. Results of the assessment, including the development of the seismic design parameters, have been detailed in this calculation package.

Analysis Methods

The liquefaction potential of the site was evaluated in general accordance with the NCEER Simplified Procedure method (Youd et al, 2001). Specifically, the Robertson & Wride 1998 (R&W) assessment procedure based on cone penetration data, was implemented using the CPT liquefaction assessment software CLiq v. 2.0 developed by GeoLogismiki.

S&ME performed 23 Cone Penetrometer Test (CPT) soundings in the pond, as detailed in Attachment VI of the Closure Plan. Of the 23 soundings, 9 were selected for use in the liquefaction evaluation (5 where open standpipe piezometers were installed and 4 additional locations based on visual inspection of the tip and sleeve resistance). After screening out unsaturated soils (i.e., those above the water table), R&W uses the CPT data to screen out clay-like soils and to compute the cyclic resistance ratio, CRR. The screening is based on the CPT Material Index, I_c. Per R&W, soils having an $I_c \geq 2.6$ are considered clay-like and not susceptible to liquefaction. For other soils (i.e., sand-like), the CRR is computed using the cone tip resistance and the R&W relationships. The cyclic stress ratio (i.e., seismic demand) is computed using the peak ground acceleration, earthquake magnitude, and the stress reduction coefficient, as presented in Youd et al., 2001. The factor of safety against liquefaction triggering is computed as the resistance (CRR) divided by the demand (CSR).

Design Peak Ground Acceleration

Following recommendations by Youd (2008), the design seismic parameters were estimated using a probabilistic procedure based on deaggragation plots developed from the USGS Unified Hazard Tool (v. 4.1.1). A probabilistic procedure is appropriate for regions without a well-defined active fault. The Youd method considers compatible modal pairs of earthquake magnitude, M and peak acceleration, a_{max} from both a near-source and distant-source earthquake event. The modal pair with the highest Percent contribution to the seismic hazard analysis is selected, and an attenuation relation by Toro, Abrahmson, and Snider (1997) is applied to estimate the peak ground acceleration at the bedrock surface. A relationship by Seed and Idriss (1982) was then applied to estimate the maximum acceleration at the ground surface. The seismic hazard used in the liquefaction analysis was a 2 percent probability of exceedance in a 50-year period event, resulting in an earthquake magnitude of 5.0 with a design PGA of 0.07g. Development of the seismic parameters is appended in Calculation 1.

Results

The liquefaction assessment was performed using the CPT data obtained from the site; meaning only current in-situ conditions were evaluated. The assessment does not consider a stress increase due to fill placement or the expected reduction in the water table within the pond, both of which would reduce the potential for liquefaction. A liquefaction analysis summary report was generated for each CPT sounding using the CLiq output. The reports have been appended in Calculation 2. The minimum factor of safety estimated from the assessments was greater than 2.0, thus, liquefaction is not predicted under the modeled seismic demand. Based on this result, data from the remaining CPT soundings was not assessed for liquefaction potential. The following information is provided on the summary reports:

Cone Tip Resistance and Friction Ratio: Profiles of the imported CPT data.

SBTn Plot: A profile plot (yellow line) of the interpreted normalized soil behavior type (I_c) with depth. A red line indicates an abrupt transition between soil types where the underlying material may influence the CPT results. The R&W procedure uses an I_c threshold of 2.6 to separate non-liquefiable soils from potentially liquefiable soils.

CRR Plot: A profile plot of the cyclic resistance ratio (purple line) and cyclic stress ratio (red line) with depth. Due to the boundaries on the x-axis, the CRR is not visible on these plots when greater than 0.6.

FS Plot: A plot of the factor of safety (Simplified Procedure) with depth. Due to the boundaries on the x-axis, the factor of safety is not visible on these plots when greater than 2.0. This occurs for all reports.

CSR vrs Qtn (corrected CPT Tip Resistance) Plot: Curve compiled from case histories for evaluation of liquefaction potential (Youd et al, 2001). Only data points within the boundaries of this graph are visible.

CPT-Based Normalized Soil Behavior-Type Chart (Roberston, 2010): Plots of data points for the normalized (for overburden stresses) CPT penetration resistance versus the normalized friction ratio. The red curve delineates data points for soil behavior indices above and below the threshold of 2.6.

References

Youd et al, Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, Journal of Geotechnical and Geoenvironmental Engineering, October, 2001.

Youd, T. Leslie, Liquefaction Hazard Assessment, Northern Kentucky Geotechnical Group Presentation, April 8, 2008

Robertson, P.K. and Wride, C.E. 1998. Evaluating Cyclic Liquefaction Potential using the Cone Penetration Test, Canadian Geotechnical Journal, 35: 442-459.

Robertson, P.K., 2009. Interpretation of Cone Penetration Tests – A Unified Approach, Canadian Geotechnical Journal, 46: 1337-1355

Attachments

- Calculation 1 – Design Seismic Parameter Development
- Calculation 2 – CLiq Liquefaction Analysis Reports

Calculation 1 – Design Seismic Parameter Development

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Unified Hazard Tool

Please do not use this tool to obtain ground motion parameter values for the design code reference documents covered by the U.S. Seismic Design Maps web tools (e.g., the International Building Code and the ASCE 7 or 41 Standard). The values returned by the two applications are not identical.

^ Input

Edition
Dynamic: Conterminous U.S. 2014 (v4.1.1)

Latitude
Decimal degrees
39.0763

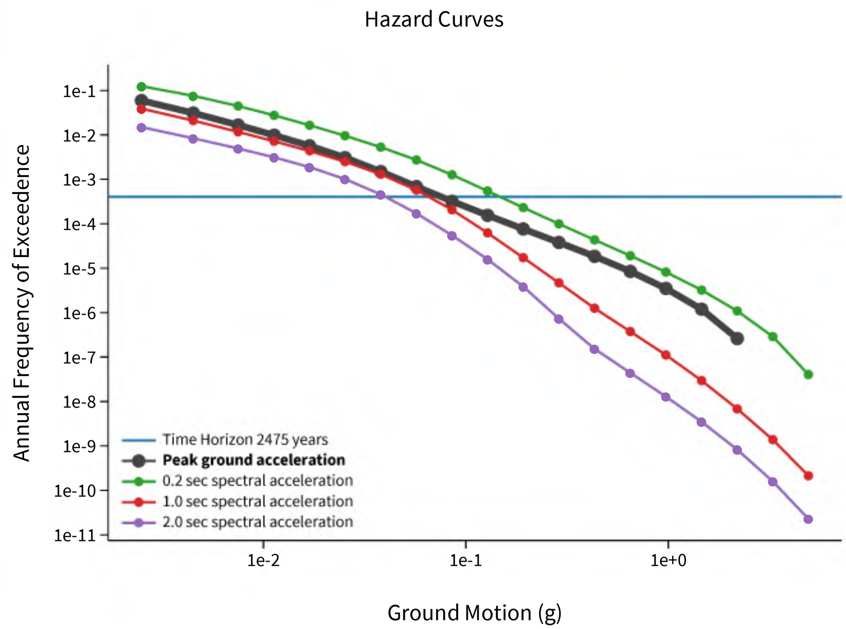
Longitude
Decimal degrees, negative values for western longitudes
-84.8814

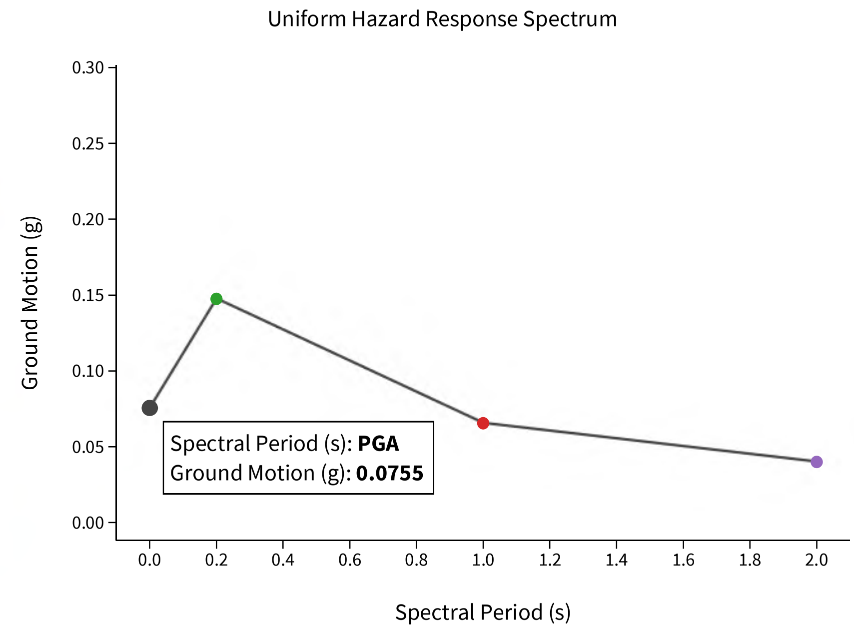
Site Class
760 m/s (B/C boundary)

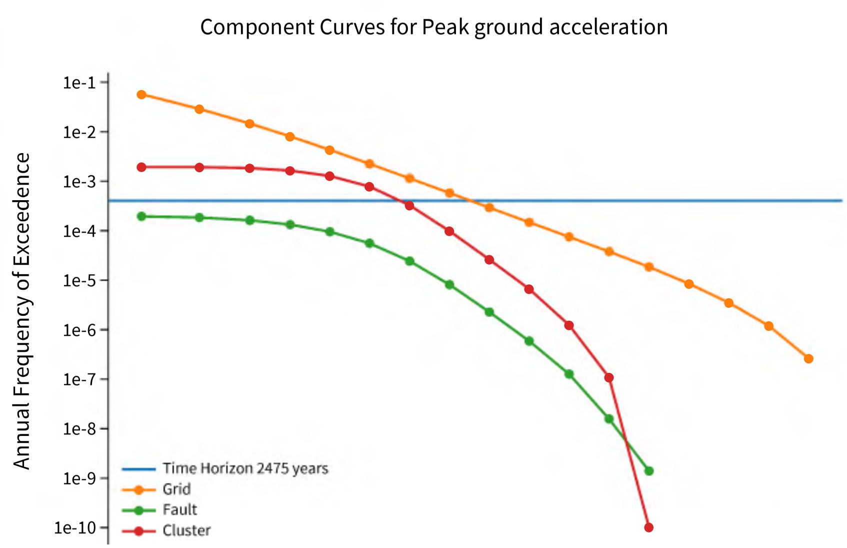
Spectral Period
Peak ground acceleration

Time Horizon
Return period in years
2475

^ Hazard Curve



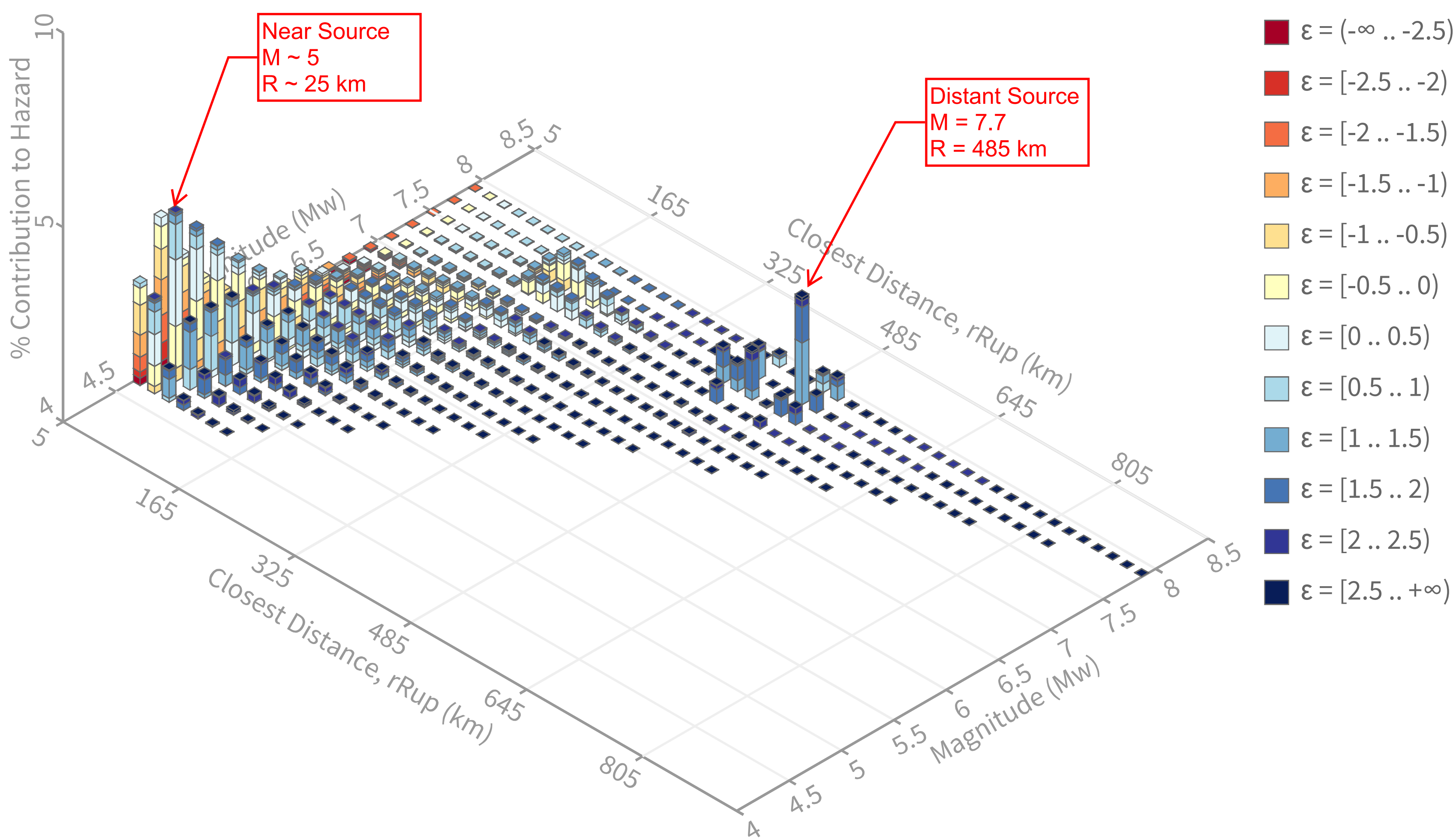




^ Deaggregation

Component

Total



Interactive Example

Toro, Abrahamson, and Schneider Attenuation

In this example, you can calculate peak ground acceleration and the psuedoacceleration spectrum at a site in eastern or central North America using attenuation relationships by Toro, Abrahamson, and Schneider, 1997. Note that the site-to-fault distance is closest horizontal distance to the vertical projection of the rupture and the relationship is valid over the range of 1 to 100 km only. The valid range of magnitudes is 5 < Mw < 8. Links to tables of coefficients can be found in Appendix A. Interactive examples for all attenuation relationships can be found in Attenuate©.

Type of analysis: PGA

Select the parameters you wish to use:

Region: Midcontinent

Site to fault distance (km): 25

Moment magnitude (Mw): 5

Calculate

Results

back to input

Parameter	Period (s)	Ln median	median	median + σ
PGA (g)	-	-2.836	0.059	0.141
Sa (g)				

to notes modify spectrum to Attenuate©

<u>Attenuation Relationship</u>

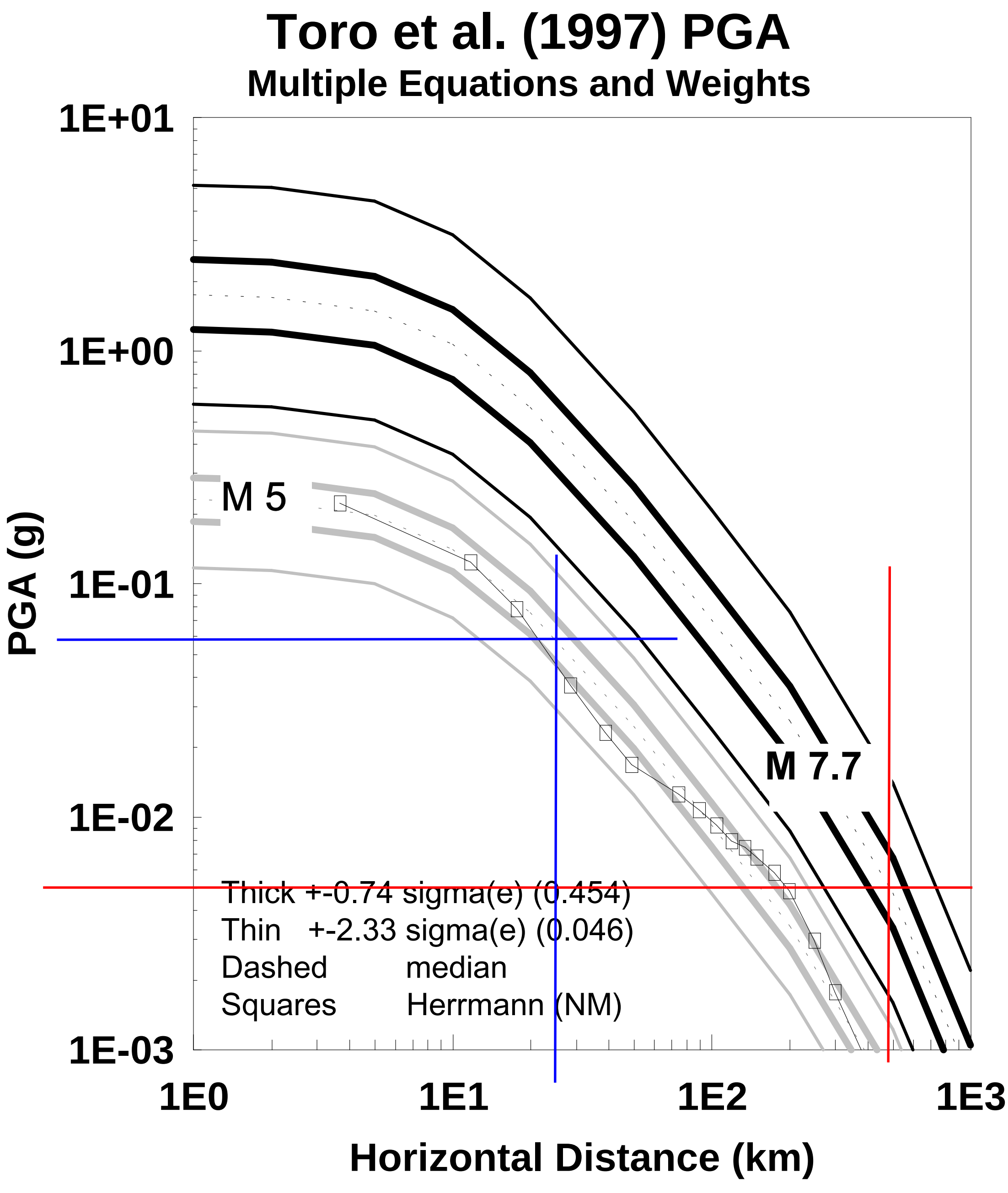


Figure 4-1. EPRI attenuation equations for PGA on rock (point-source assumption).

For M ≈ 5.0, R ≈ 25 km, a_{max} ≈ 0.059

For M = 7.7, R = 485 km, a_{max} ≈ 0.005

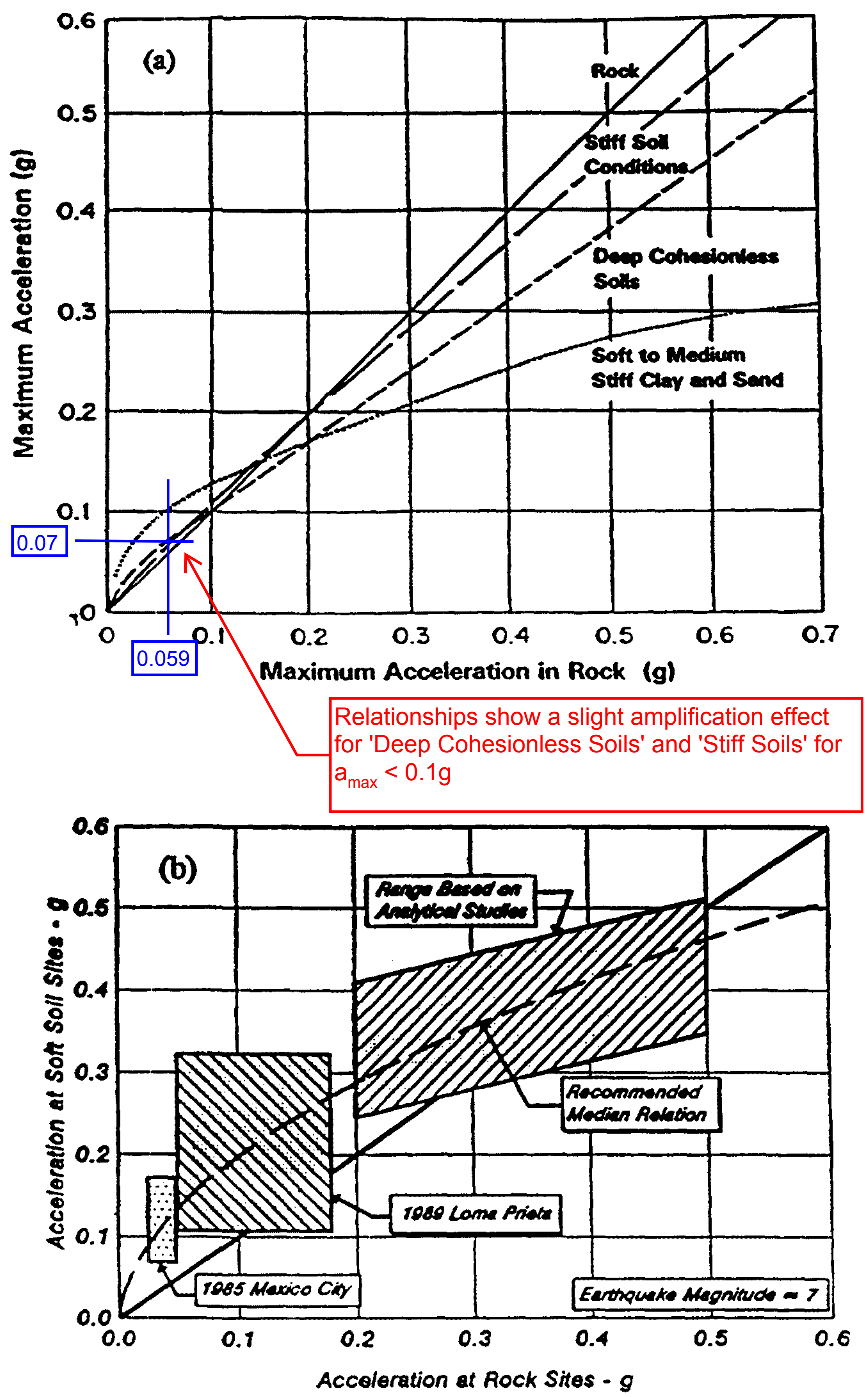


Figure 4.4 Relationship Between Maximum Acceleration on Rock and Other Local Site Conditions: (a) Seed and Idriss (1982); (b) Idriss (1990).

Calculation 2 – Cliq Liquefaction Analysis Reports

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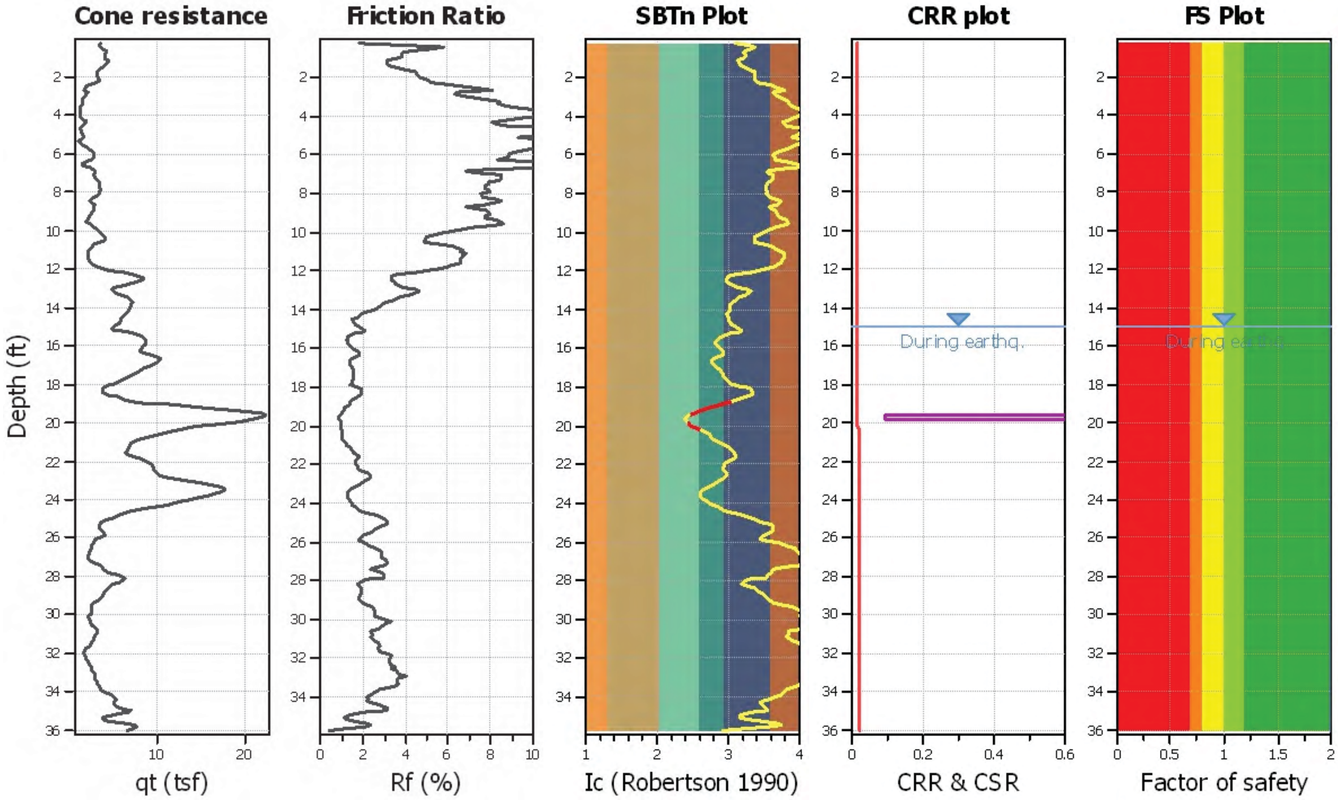
LIQUEFACTION ANALYSIS REPORT

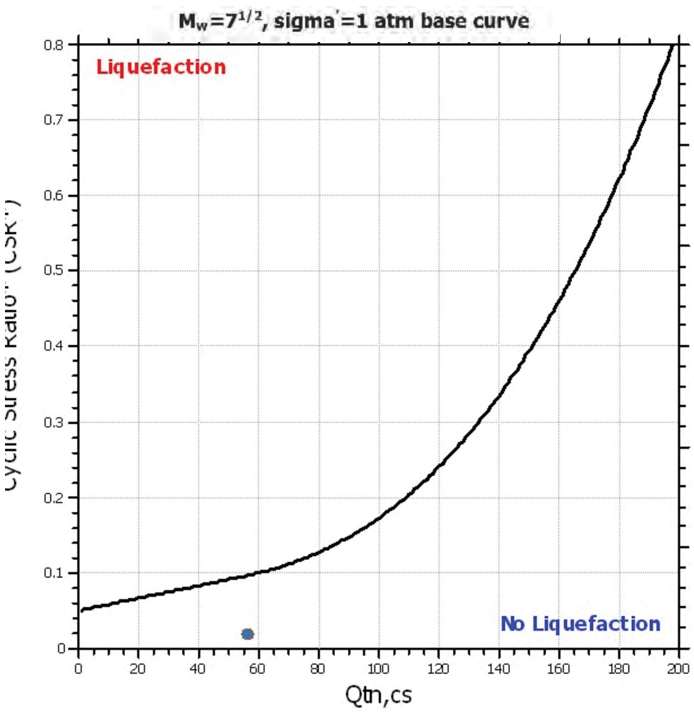
Project title : Tanners Creek Fly Ash Pond **Location : Lawrenceburg, IN**

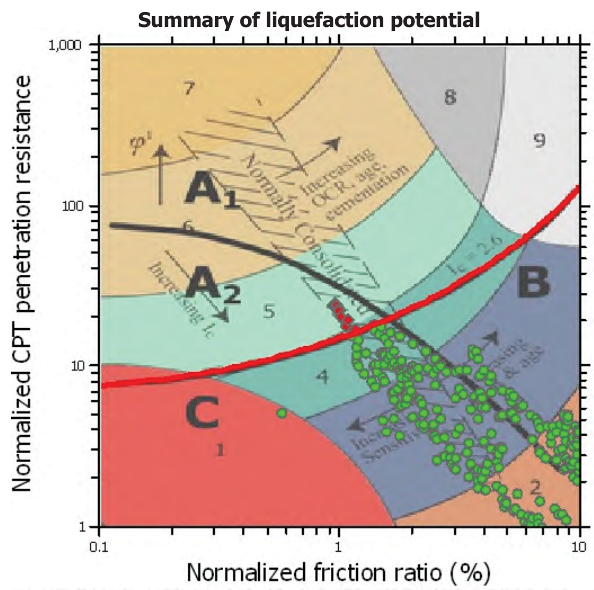
CPT file : CPT-1PA

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	15.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	15.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.07	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		







Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

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LIQUEFACTION ANALYSIS REPORT

Project title : Tanners Creek Fly Ash Pond **Location : Lawrenceburg, IN**

CPT file : CPT-2PA

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	15.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
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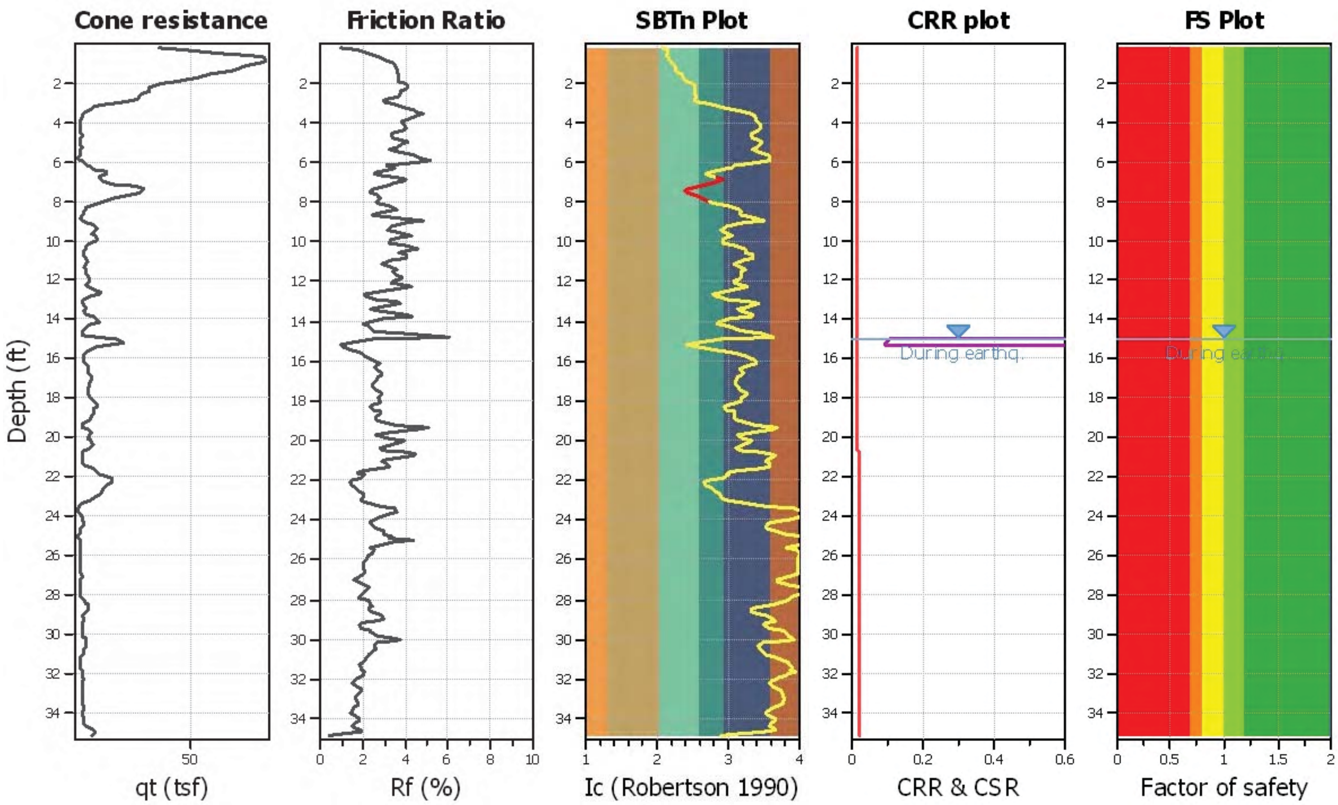
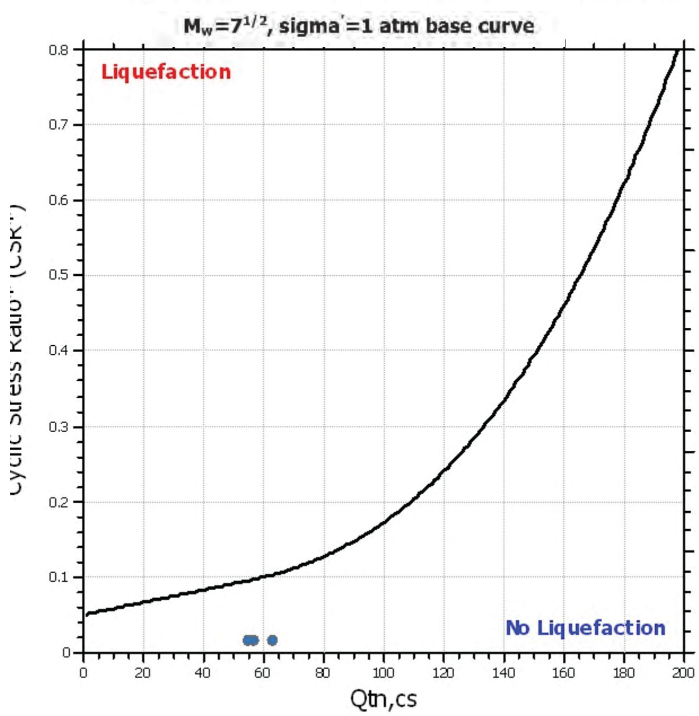
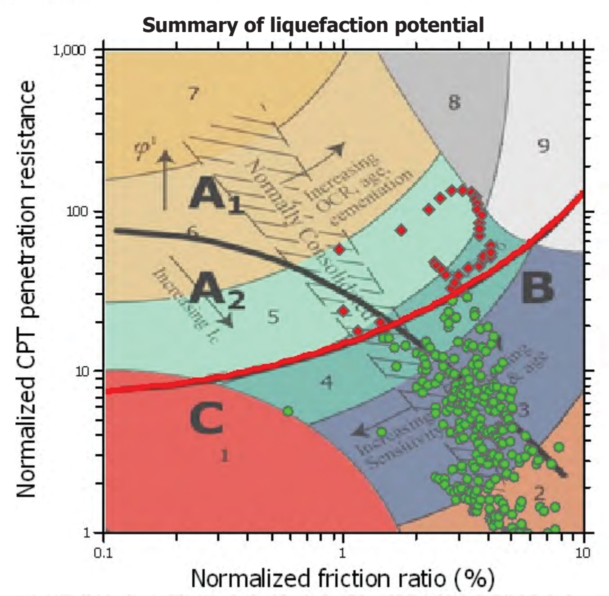
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.07	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		







Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

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LIQUEFACTION ANALYSIS REPORT

Project title : Tanners Creek Fly Ash Pond **Location : Lawrenceburg, IN**

CPT file : CPT-3PA

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	15.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
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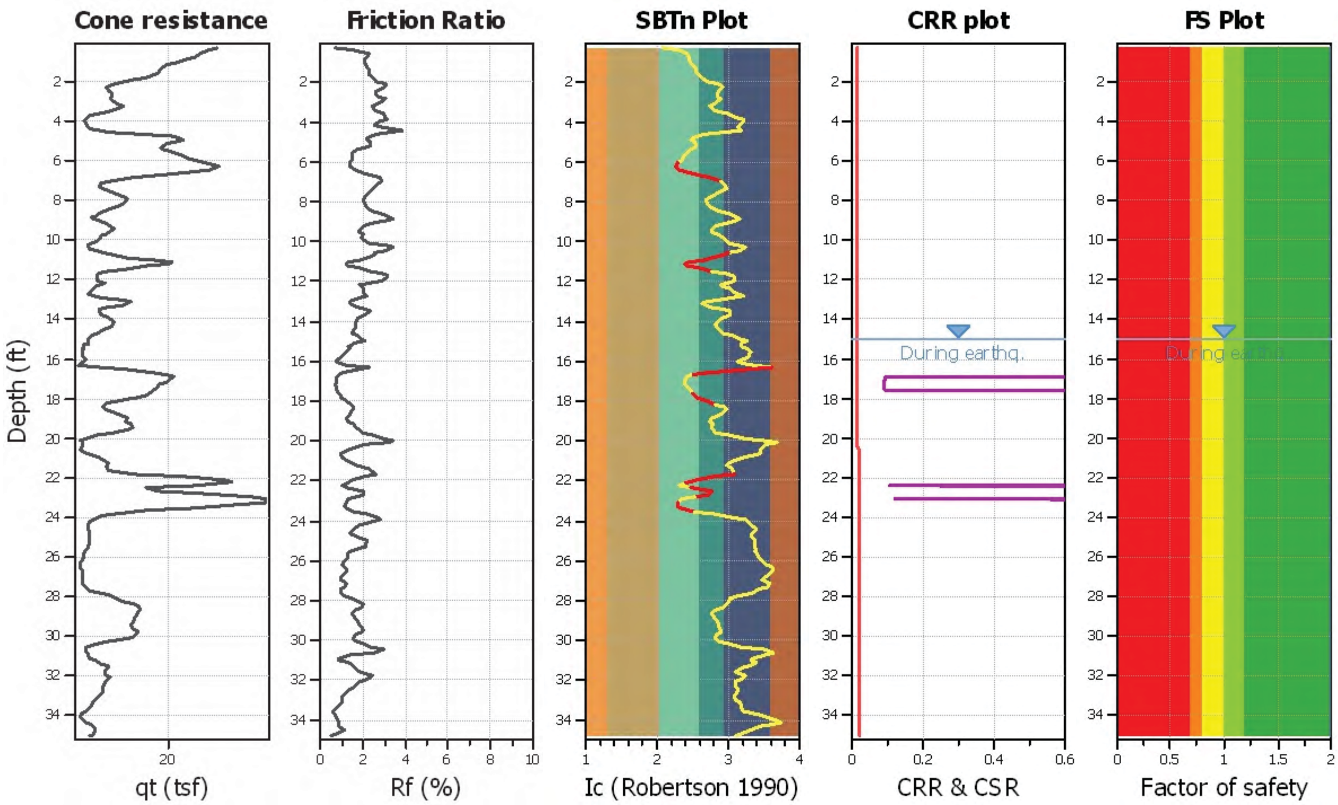
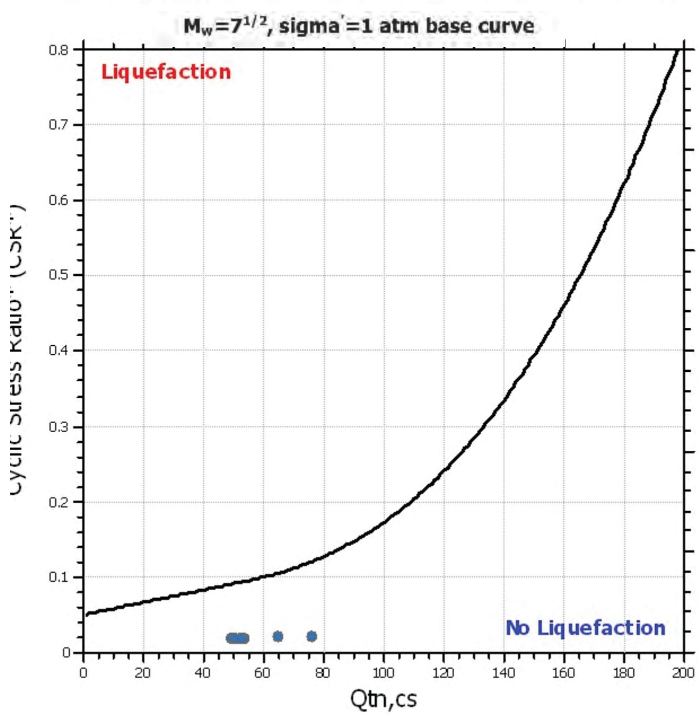
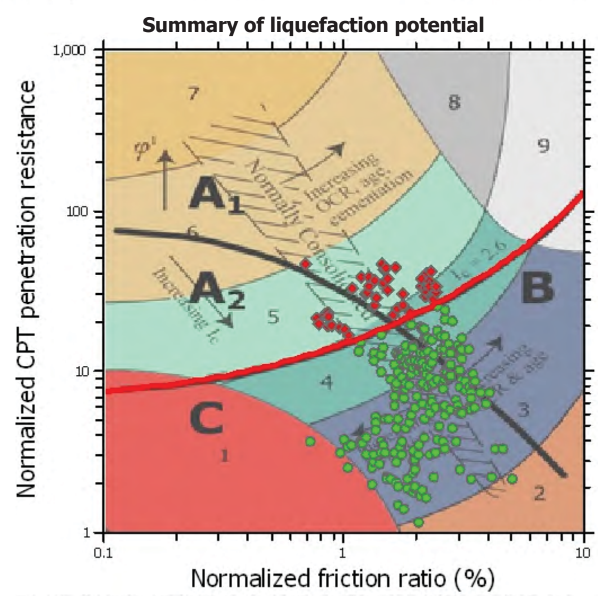
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.07	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		







Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

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LIQUEFACTION ANALYSIS REPORT

Project title : Tanners Creek Fly Ash Pond **Location : Lawrenceburg, IN**

CPT file : CPT-4PA

Input parameters and analysis data

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Earthquake magnitude M_w:	5.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
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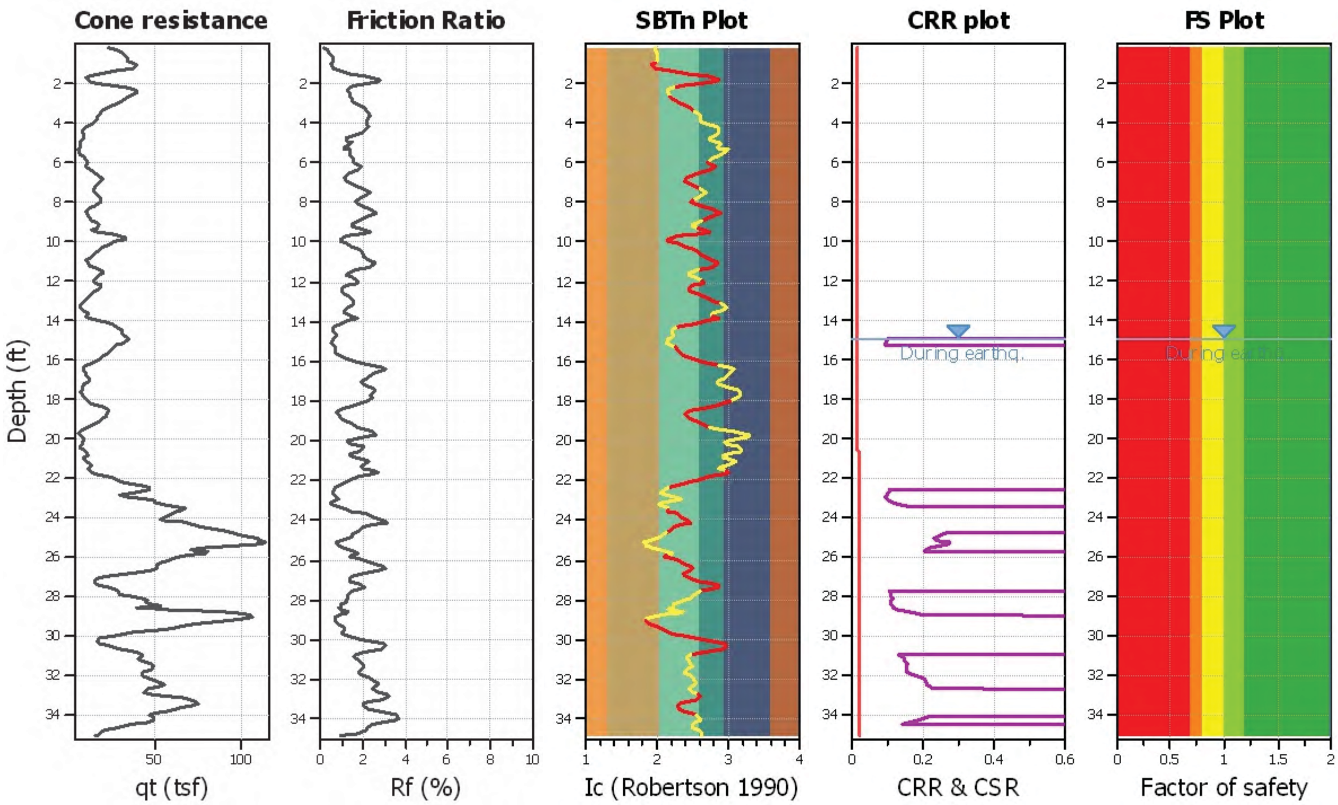
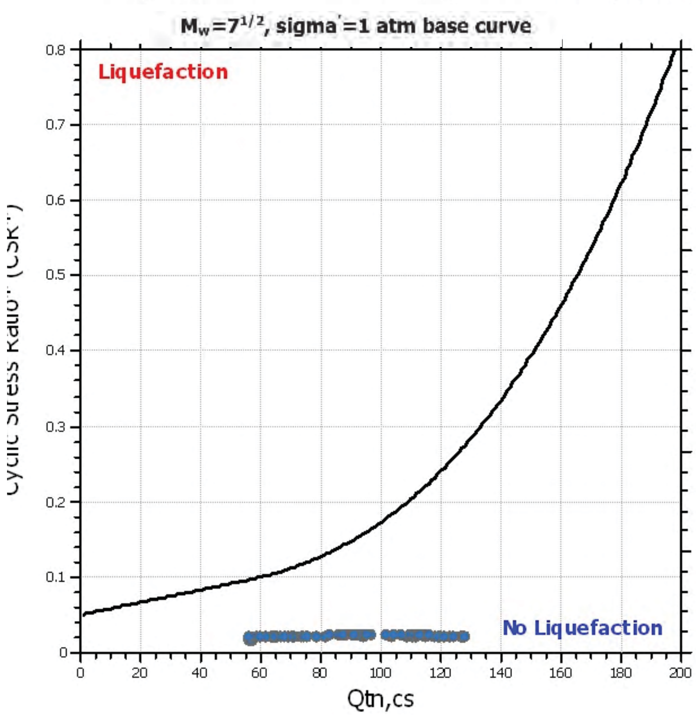
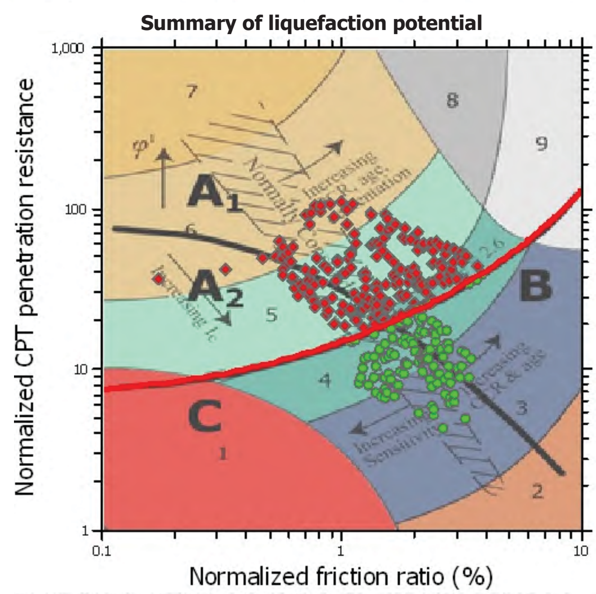




Summary of liquefaction potential



Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

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LIQUEFACTION ANALYSIS REPORT

Project title : Tanners Creek Fly Ash Pond **Location : Lawrenceburg, IN**

CPT file : CPT-5P

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	15.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
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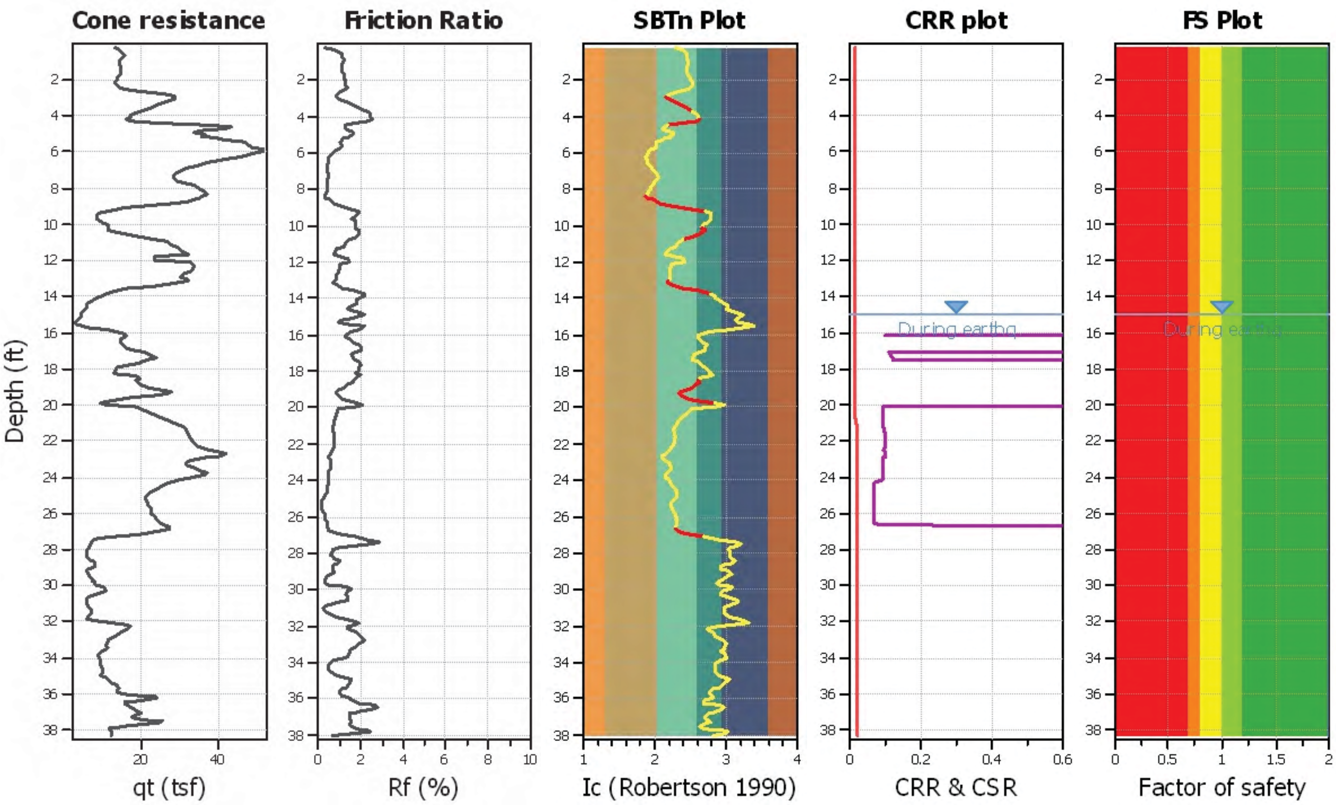
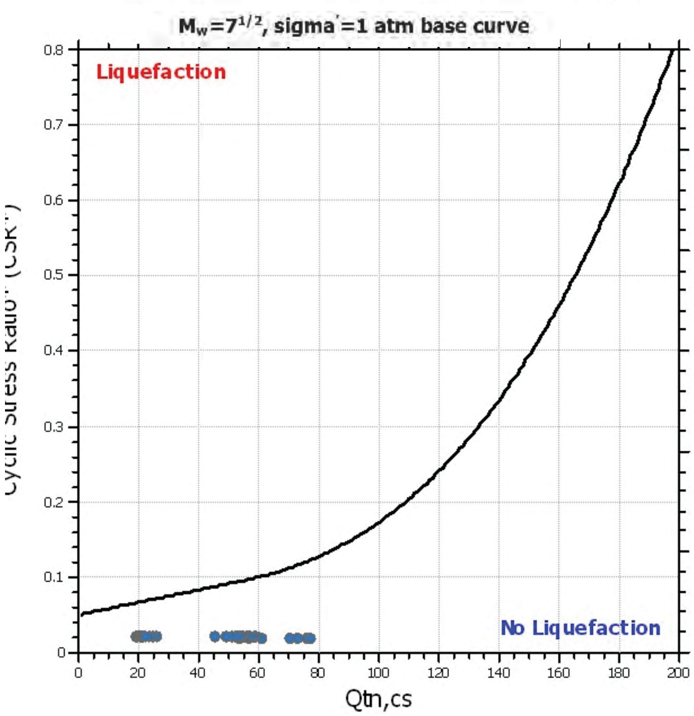
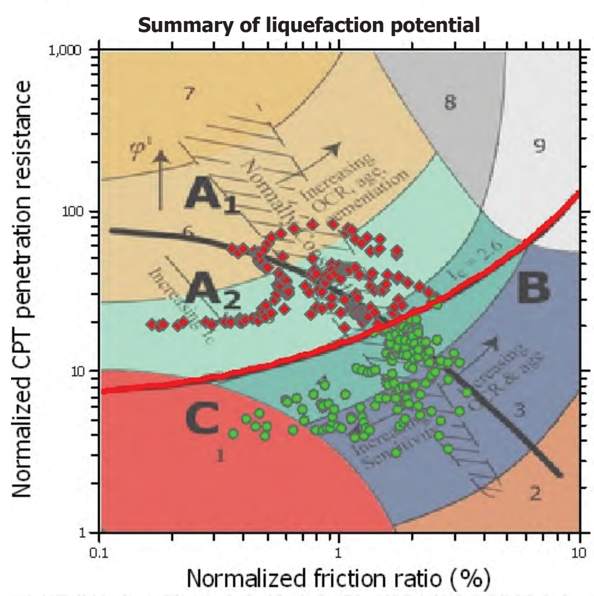
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.07	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		







Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

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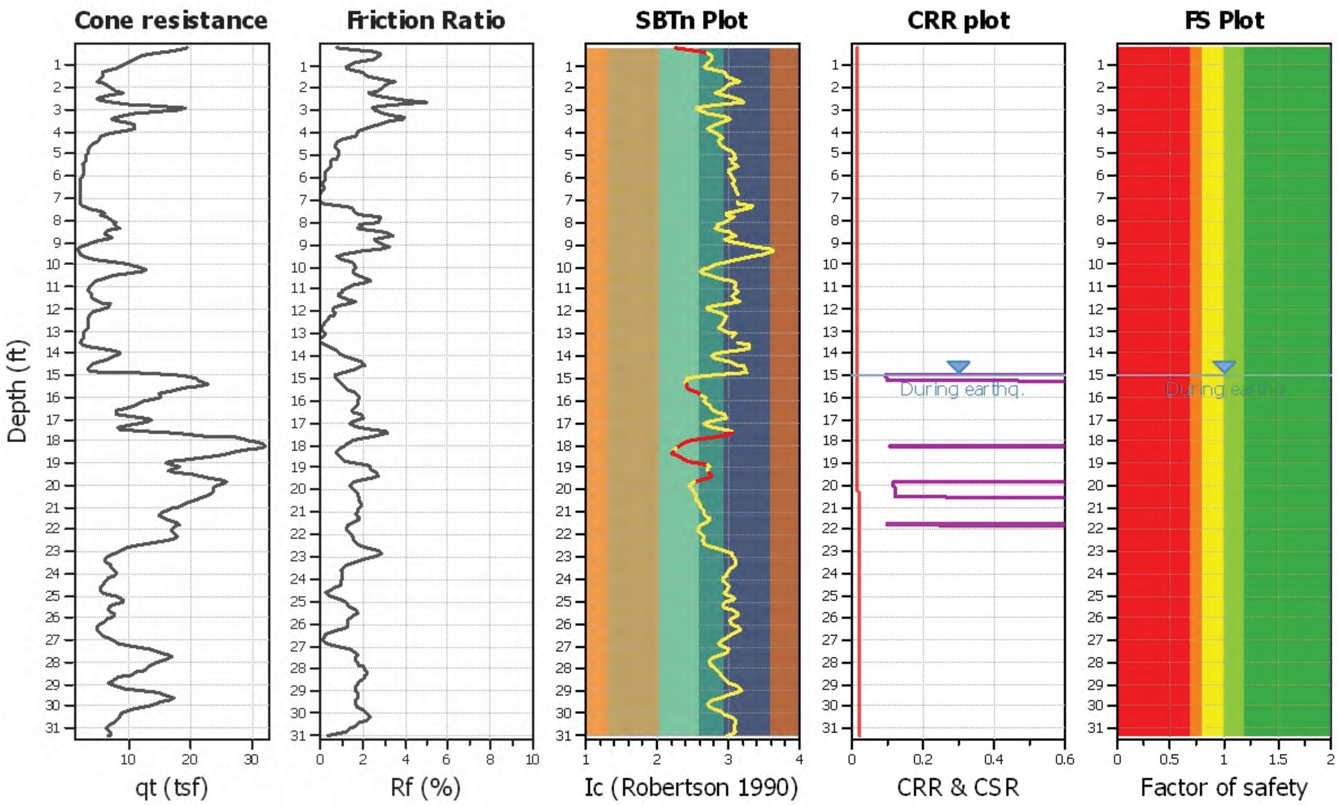
LIQUEFACTION ANALYSIS REPORT

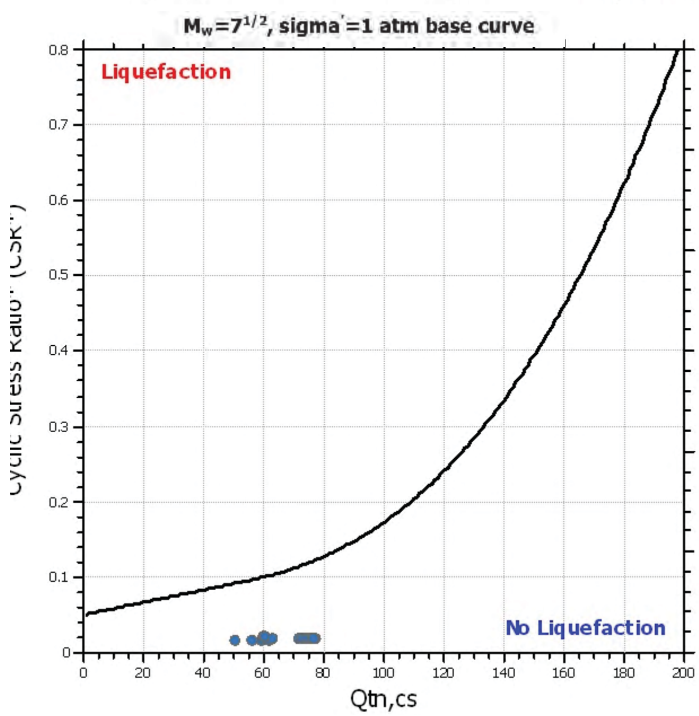
Project title : Tanners Creek Fly Ash Pond **Location : Lawrenceburg, IN**

CPT file : CPT-7

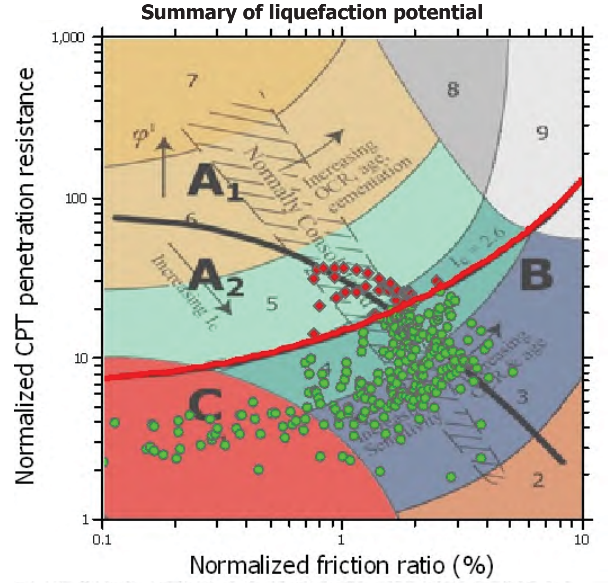
Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	15.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	15.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.07	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		





Summary of liquefaction potential



Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

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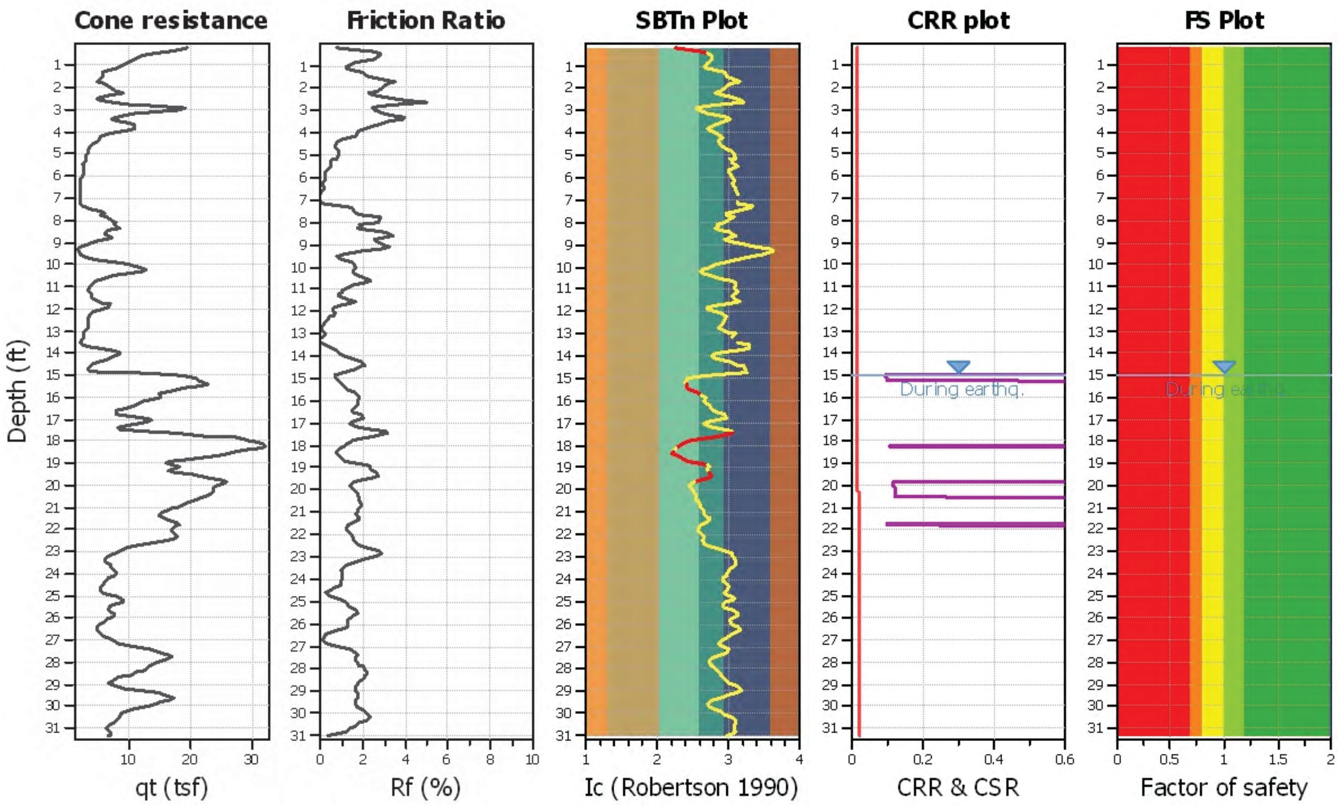
LIQUEFACTION ANALYSIS REPORT

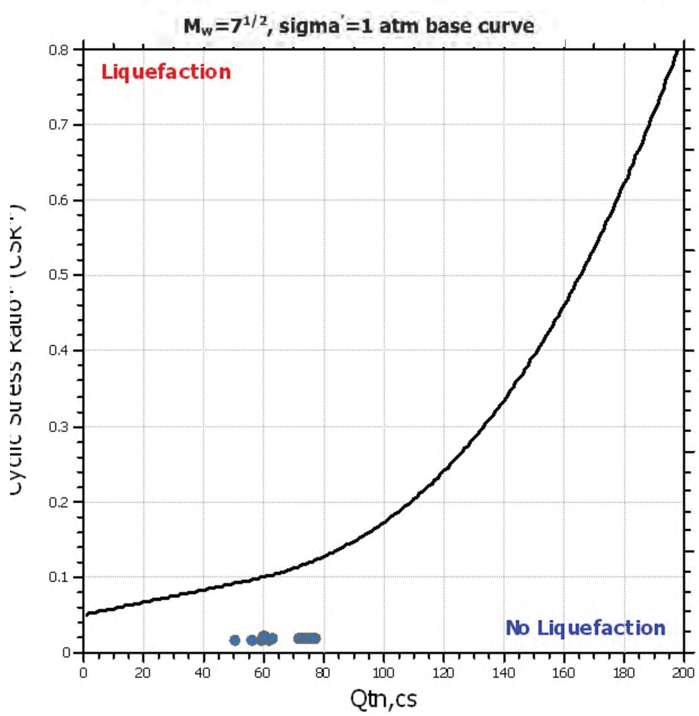
Project title : Tanners Creek Fly Ash Pond **Location : Lawrenceburg, IN**

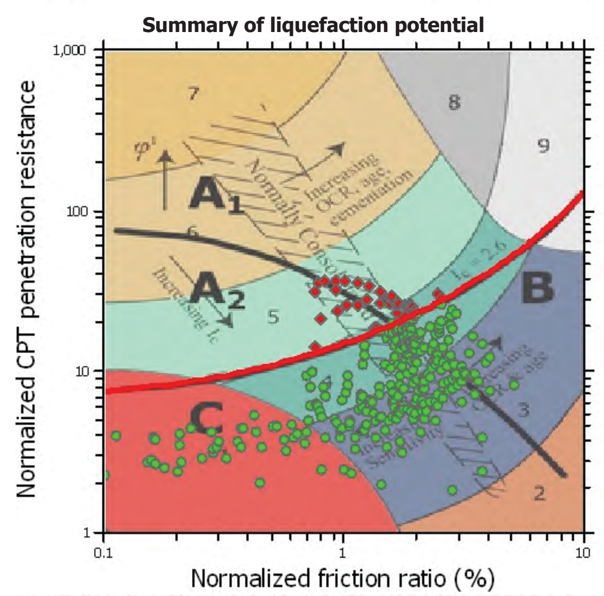
CPT file : CPT-7

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	15.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	15.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.07	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		







Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

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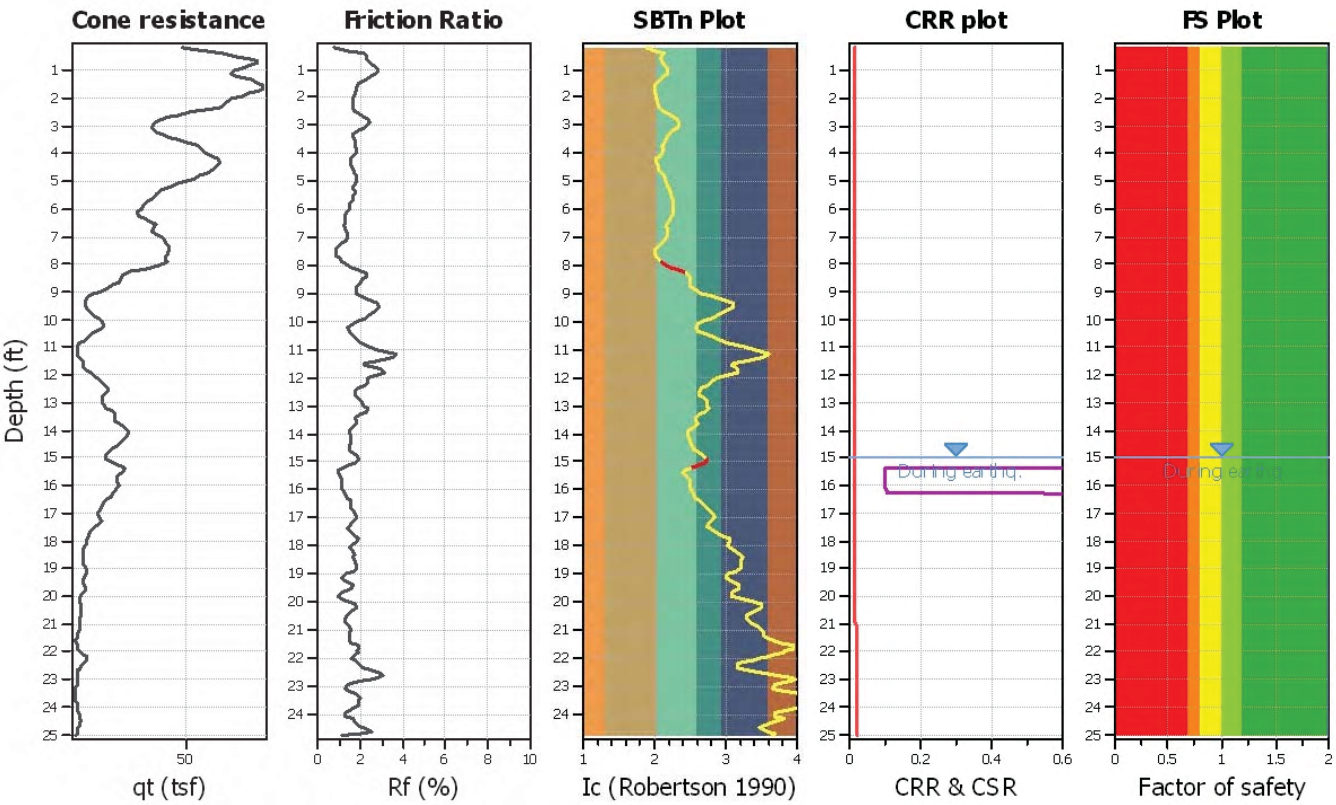
LIQUEFACTION ANALYSIS REPORT

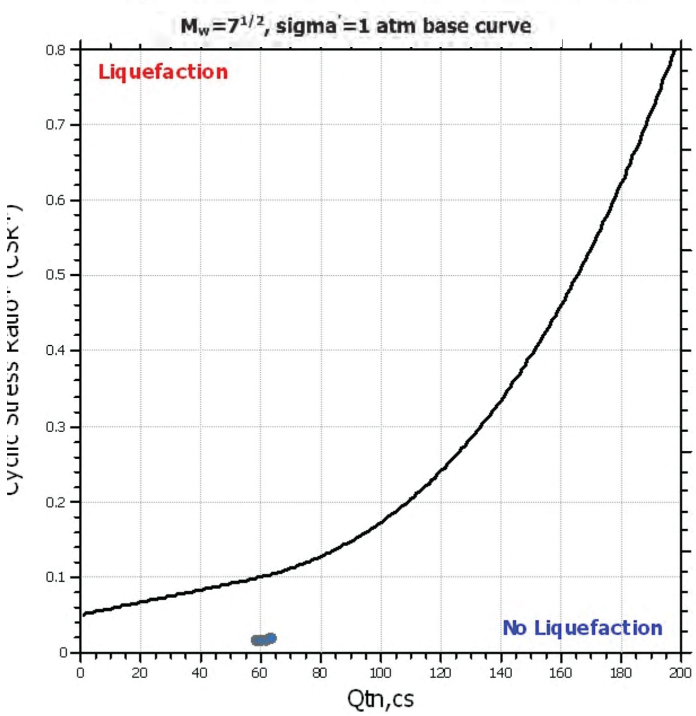
Project title : Tanners Creek Fly Ash Pond **Location : Lawrenceburg, IN**

CPT file : CPT-21

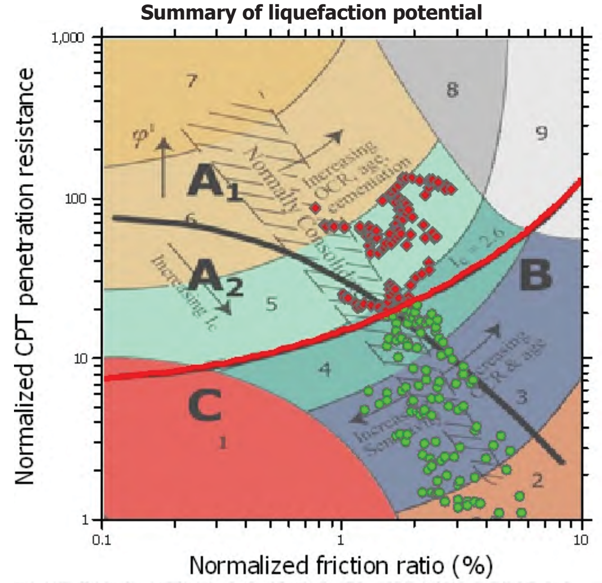
Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	15.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	15.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.07	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		





Summary of liquefaction potential



Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

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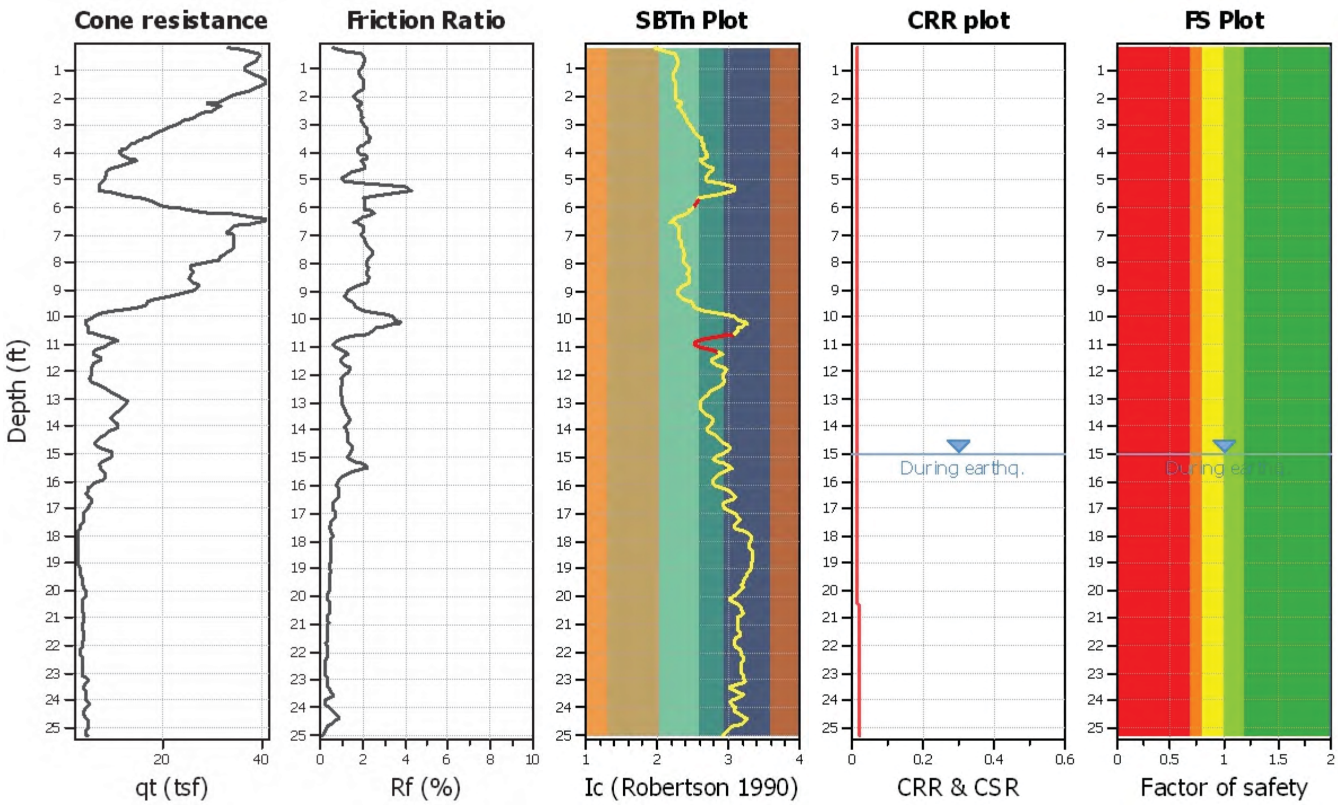
LIQUEFACTION ANALYSIS REPORT

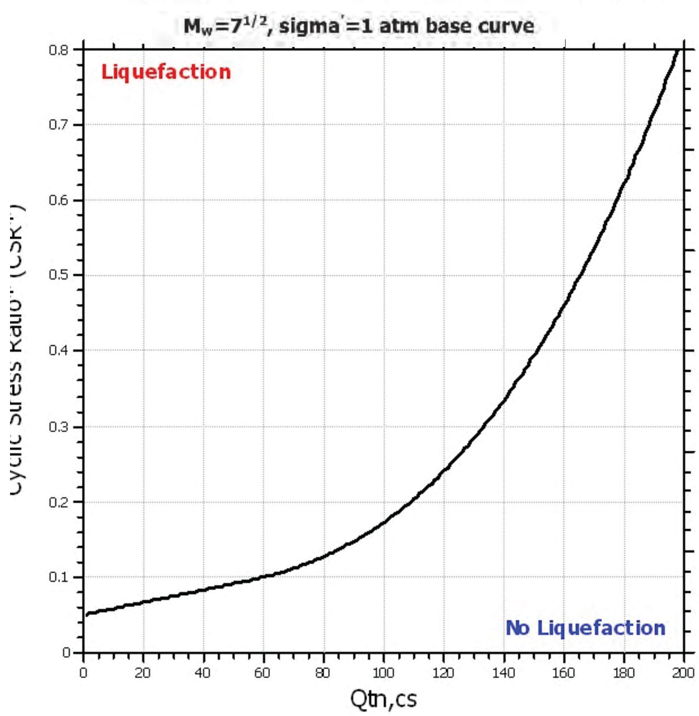
Project title : Tanners Creek Fly Ash Pond **Location : Lawrenceburg, IN**

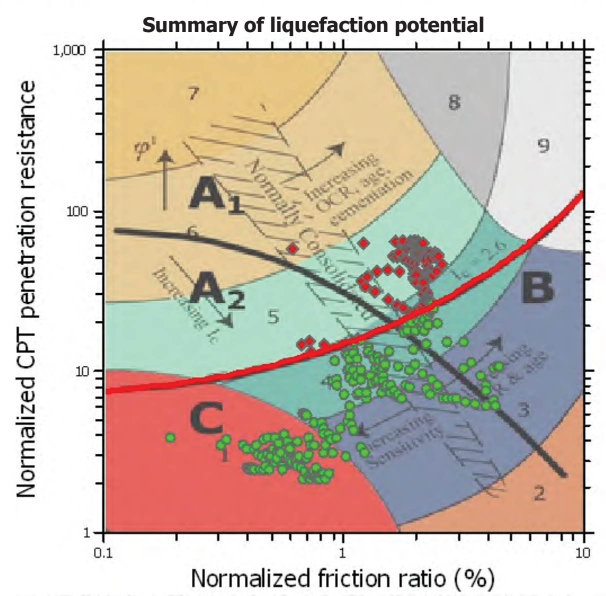
CPT file : CPT-22

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	15.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	15.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.07	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		







Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

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Appendix D – Cover System Stability

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COVER SHEET S&ME	**Project Name: Tanners Creek Fly Ash Pond Closure**	
	Subject: Veneer Stability Analysis	
	Project No. 7217-17-007A	Calc. No. 1
	Discipline Geotechnical	Sheet 1 of 9

Tanners Creek Fly Ash Pond Closure
Cover System Veneer Slope Stability Analysis

Computations By:	Signature: [seal: MICHAEL T ROMANELLO REGISTERED PE11600160 STATE OF INDIANA PROFESSIONAL ENGINEER] 9-1-2017	
	Name: Michael T. Romanello, P.E.	
	Title: Project Engineer	
Checked and Senior Reviewed By:	Signature: Michael G. Rowland	Date: 8/18/2017
	Name: Michael G. Rowland, P.E.	
	Title: Senior Engineer	

Revisions

Rev.	Date	Note	Completed by	Checked By

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Introduction

The cover system for the proposed Fly Ash Pond Closure consists of the following components, from top to bottom:

- 6 inch vegetative layer;
- 30 inch protective soil layer;
- Double-sided geocomposite drainage layer (non-woven geotextile bonded to upper and lower side of polyethylene geonet);
- 60-mil HDPE textured geomembrane;
- Existing CCP Material (regraded sluiced ash)

The cover system is to be placed on the following slope configurations:

1. Top of Pond Closure, 2% grades;
2. 3H:1V slopes over downstream side of interior embankments;
3. 5% slopes for transition Zones between top and side slopes;
4. 4H:1V slopes within breach areas.

This calculation package was prepared to determine the minimum interface friction angle for the interfaces within the cover system based on the results of veneer slope stability analyses. Additionally, the allowable hydraulic transmissivity value for the drainage layer was examined to support the selection of required geocomposite properties. S&ME performed the analysis to meet safety factors in accordance with the requirements of 329 IAC 10-15-8, Table 1.

Cover System Design Grades

The Fly Ash Pond Final Cover grades are shown on the Closure Drawings. The final grades on top of the fly ash pond closure are sloped at 2% toward one of two central drainage swales. The sides of the cover system overlay the downstream side of the interior embankments constructed as part of the Bottom Ash Dike Dam Raising. In the upper basin, the cover terminates between the downstream toe and the crest of the original, exterior embankments. The side slopes of interior embankment were designed as 3H:1V, with a height of approximately 27 feet. In the clear water pond, the cover system terminates at the inboard crest of the original earthen dike.

Two design cross-sections were selected to conduct the veneer stability analysis of the cover system:

- Section A: Downstream side of exterior embankment (3H:1V) with a maximum height of 30 feet;

- Section B: Top of Closure (2% slopes); this section was selected as the hydraulic head will exceed the geocomposite drainage core thickness and create a full water flow condition during the design storm in this low-gradient area.

Several transition zones are incorporated in the cover system design grades, but have both flatter slopes and a shorter slope length, and thus were not evaluated. Figure 1 appended with this calculation package depicts the physical locations of the design cross-sections on the final cover grade drawings.

Cover System Stability Analysis

Methodology

Static Analysis

A static translational slope stability analysis was performed for veneer, or plane failures in the cap system assuming both saturated and unsaturated conditions. S&ME used limit equilibrium equations formulated by Giroud et. al. (1995) for a geosynthetic-soil layered system which accounts for buttressing forces at the toe of the slope. The equations are considered suitable when the vertical height of the slope is less than about 30 times the thickness of the veneer cover soil. These equations start with the equation for an infinite slope and add terms for soil internal friction, soil cohesion, interface adhesion, and geosynthetic tension. Interface adhesion and geosynthetic tension, however, were not considered for these analyses. Giroud et al. also formulated equations to account for partial and full water flow through the liner system. The equations formulated by Giroud et al. for static analyses with unsaturated and saturated conditions are presented with the output sheets included with this calculation package. The equations evaluate slip surfaces both above and below the geomembrane

To determine whether the infiltration flow within the cap system will exhibit a partial or full water flow condition as a result of the design rain event, calculations were performed to estimate the head on the underlying geomembrane layer during a 100-year, 1 hour storm event. S&ME used Point Precipitation Frequency Estimates from NOAA Atlas 14 to select the 1-hour rainfall intensity for the site. The tabular data from NOAA is presented on Figure 2. For this methodology, the design storm is assumed to occur after a period of wet weather when the soil component of the cap system is already at field capacity. Therefore, no additional storage capacity is available and the infiltrating water all passes through the cap system. The precipitation level, runoff characteristics, hydraulic conductivity of the cover soil, and transmissivity of the drainage layer are evaluated to determine if the drainage capacity of the drainage layer is exceeded. If the drainage capacity is exceeded (i.e. the water flow thickness is greater than the drainage core thickness), then a full water flow condition is assumed for evaluation of saturated conditions (depth of water equals thickness of drainage layer plus thickness of cover soil). If the drainage capacity of the drainage core is not exceeded, a partial water flow condition is assumed using the water flow thickness determined from the computations.

Seismic Analysis

A seismic analysis was performed for unsaturated conditions, assuming typical head conditions in the drainage layer. The seismic analysis was performed using a method developed by Matasovic (1991) which incorporates the peak horizontal acceleration into an equation for an infinite slop. This equation therefore would be a conservative prediction since buttressing effects are not considered. The minimum interface friction angle determined from the static analysis was input into the seismic equation and the result was compared to the targeted minimum factor of safety.

Development of the seismic design parameters is provided in the Liquefaction Evaluation included in the Appendix B of Attachment V. The design peak horizontal ground acceleration (PHGA) (%g) for an event with 2% probability of exceedance in 50 years is 0.07g.

Minimum Values of Safety Factors for
Slope Stability Analyses for Liner and Final Cover Systems

Consequences of Slope Failure	Uncertainty of Strength Measurements Small[1]	Large[2]
No imminent danger to human life or major environmental impact if slope fails	1.25 (1.2)*	1.5 (1.3)*
Imminent danger to human life or major environmental impact if slope fails	1.5 (1.3)*	2.0 or greater (1.7 or greater)*

[1]The uncertainty of the strength measurements is smallest when the soil conditions are uniform and high quality strength test data provide a consistent, complete, and logical picture of the strength characteristics.
[2]The uncertainty of the strength measurements is greatest when the soil conditions are complex and when the available strength data do not provide a consistent, complete, and logical picture of strength characteristics.
*Numbers without parentheses apply to static conditions and those within parentheses apply to seismic conditions.

Figure 1: 329 IAC 10-15-8 Table 1

Figure 1 presents the minimum values of safety factors for the slope stability analysis of final cover systems from 329 IAC 10. The following conditions were considered for selection of the minimum values of safety factors:

- There is no imminent danger to human life or major environmental impact if the fly ash pond cover system slope fails.
- A large uncertainty of strength measurements was assumed as a borrow source for the cover soils has not been identified.

Based on the assumption listed above, a targeted minimum safety factor of 1.5 was used for static conditions, and a minimum safety factor of 1.3 was used for the seismic analysis.

Allowable Transmissivity

The hydraulic head calculations were performed to determine the minimum required hydraulic conductivity of the drainage layer needed to prevent the full water flow condition from developing on the side slopes of the closure (Section A). A full water flow condition would likely require a minimum interface friction angle that may not be achievable with the proposed materials. The requried transmissivity value was then determined from the minimum required hydraulic conductivity. Transmissivity is related to hydraulic conductivity through the long-term thickness of the layer as shown in Equation 1.

Equation 1: $K_d = Tr_{L(req)} / t_{LT}$

Where: K_d = hydraulic conductivity of drainage layer.
$Tr_{L\ (req)}$ = requried long-term transmissivity; and,
t_{LT} = long-term thickness of drainage layer.

For biplanar geocomposites, the long-term geonet drainage core thickness has been shown to be approximately 97 to 98% of the reported thickness when subject to low confining stress conditions. Equation 1 was then solved for the required long-term transmissivity. The allowable transmissivity is estimated by applying reduction factors to the required long-term transmissivity values to account for creep, chemical clogging, and biological clogging. A global factor of safety is also incorporated for consideration of intrusion, fines infiltration, and other variables. The allowable tested transmissivity value is typically used to develop the geocomposite specifications for the project. Therefore, the allowable tested transmissivity was determined using Equation 2 and was the end goal of this step of the analysis. A summary of the reduction factors is included in Table 1. The reduction factors were selected based on recommendations from the GRI Standard GC8[1] and the GSE Drainage Design Manual[2].

Equation 2:

$$Tr_{T(allow)} = Tr_{L(req)} \times RF_{CR} \times RF_{CC} \times RF_{BC} \times RF_{D}$$

Where: $Tr_{T(allow)}$ = allowable tested transmissivity (reported value);
$Tr_{L\,(req)}$ = required long-term transmissivity; and,
RF = reduction factors as summarized in Table 1.

Table 1: Transmissivity Reduction Factors

Reduction Factor	Typical Recommended Range	GSE Design Manual Recommendation	Value used in Analysis
Global Factor of Safety, RF_D	2.0 to 3.0	2	2
Creep, RF_{CR}	1.0 to 2.0	1.1	1.1
Chemical Clogging, RF_{CC}	1.0 to 1.2	1.2	1.2
Biological Clogging, RF_{BC}	1.2 to 3.5	varies	3.5
		Overall Reduction	9.24

Shear Strength Parameter Summary

Internal Shear Strength

At this time, a borrow source for the cover soils has not been identified. The following table summarized internal shear strength parameters for typical soil materials used for cover applications.

Table 2: Internal Shear Strength Parameters

Cover Soil Material Type	Moist Unit Weight (pcf)	Saturated Unit Weight	Cohesion[1] c′	Effective Friction Angle[1] φ′
Inorganic Clay, CL	125	135	270	28°
Silty Sand, SM	115	120	0	34°
Sand-Silt Clay, SM-SC	118	125	0	33°
Selected Properties[2]	115	120	50	28°

(1) Typical Properties of Compacted Soils, NAVFAC Design Manual 7.02, 1986

Previous borrow sources for the plant have been most similar to inorganic clay. The selected properties for the analysis reflect a reduced cohesion value for inorganic clay due to the effects of overconsolidation, compaction, desiccation, wetting, swelling, and weathering.

Interface Shear Strength

For each analysis section, the minimum required interface friction angle was determined using the Giroud equations. The highest interface friction angle needed to satisfy the minimum factors of safety for static unsaturated and static saturated conditions from the 2 design cross-sections was selected for the overall minimum required interface friction angle which applies to each interface in the cap system, as listed below.

Interfaces with the minimum required interface shear strength requirement:

- Cover soil / Upper non-woven geotextile interface
- Upper non-woven geotextile / Geonet / Lower non-woven geotextile (internal geocomposite interfaces)
- Lower non-woven geotextile / Geomembrane interface
- Geomembrane / Ash interface

Conformance testing using site-specific geosynthetics and ash and cover soil materials will be performed prior to construction. The interface friction angle for each interface must meet the overall minimum required interface friction angle to be compliant.

Results

Allowable Transmissivity

Design Section A was utilized for the determination of the minimum-required hydraulic conductivity value of the drainage layer needed to prevent a full water flow condition during the design storm. The analysis resulted in an allowable tested transmissivity value of $8.0x10^{-4}$ m^2/sec. Tabulated results for determination of the minimum-required hydraulic conductivity values and corresponding allowable transmissivity are presented in Calculation 1.

Typical transmissivity values from tests performed with boundary conditions applicable to cover systems were provided from two geocomposite manufacturers. These tests were performed between gradients of 0.25 and 0.33, under low confining stress (500 to 1,000 psf) and with the geocomposite bounded by soil on one side and a steel plate on the other. Based on the range of tested transmissivity values provided, the allowable tested transmissivity value is achievable. Correspondence from the manufacturers are appended as Figures 3 and 4.

- Allowable Tested Transmissivity for Geocomposite Drainage Layer: $8.0x10^{-4}$ m^2/sec

In accordance with 329 IAC 10-22, the allowable transmissivity value of the geocomposite drainage layer must provide an equivalent transmissivity to the required value for a 12 inch granular drainage layer ($1x10^{-3}$ cm/sec per Section 6). Using the transmissivity equivalency equation by Giroud, Zhao, and Bonaparte (2000) which considers unconfined flow, an equivalency factor of 1.19 was computed. In other words, the transmissivity of the geocomposite must be 1.19 time greater than the soil drainage transmissivity to be considered equivalent. Demonstration of the transmissivity equivalency is presented in Calculation 1.

Static Analysis

Using the Giroud equations, the minimum-required interface friction angle needed to meet the targeted minimum factors of safety for either unsaturated or saturated conditions was determined. As previously noted, the saturated condition load case was analyzed with partial water flow for Section A and with full water flow for Section B. The unsaturated analysis case controlled for Section A, while Section C was shown to exceed the minimum factors of safety with an interface friction angle as low as 1 degree. The formulated results are presented in Calculation 2, and summarized in Table 2.

Table 3: Summary of Minimum Required Interface Friction Angle

Grade	Slope Angle	Maximum Slope Length	Minimum Required Interface Friction Angle	
			Unsaturated $FS_{min} = 1.5$	Saturated $FS_{min} = 1.1$
Section A	3H:1V	95 feet	23.8°	< 23.8°
Section B	2%	250 feet	< 1°	< 1°
			Overall Minimum	**23.8°**

Table 4: Summary of Veneer Stability Factors of Safety with Overall Minimum Interface Friction Angle

Section	Slope Angle	Unsaturated Condition $FS_{min} = 1.5$		Saturated Condition $FS_{min} = 1.1$		Seismic Analysis $FS_{min} = 1.3$
		Slip Surface Above GM	Slip Surface Below GM	Slip Surface Above GM	Slip Surface Below GM	
Section A	3H:1V	1.50	1.50	1.49	1.50	1.52
Section B	2%	12.89	12.89	6.42	9.89	5.00

Due to the thin profile of the geocomposite drainage layer, the partial water flow condition for Section A has a near negligible impact on the veneer stability for the static analysis when considering saturated conditions. Additionally, the high factors of safety estimated for Section B indicate that the geocomposite drainage layer is not needed to maintain stability in the relatively flat area of the cover system.

Seismic Analysis

The seismic analysis was performed for each section using the minimum required interface friction angle determined from the static analysis. The formulated results are presented in Calculation 3 and summarized in Table 3. Since the minimum factor of safety is achieved for seismic stability, the minimum required interface friction angle of 23.8° is confirmed.

References:

Giroud, J. P., Bachus, R. C. and Bonaparte, R., 1995, "Influence of Water Flow on the Stability of Geosynthetic-Soil Layered Systems on Slopes," *Geosynthetics International*, Vol. 2, No. 6, pps. 1149-1180.

Matasovic, N., 1991, "Selection of Method for Seismic Slope Stability Analysis," Second International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, March 11-15, St. Louis, Missouri, Paper 7.20, pp. 1057 – 1062.

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Calculation 1: Head on Cover System Liner

- Drainage layer minimum-required hydraulic conductivity (Section A)
- Allowable tested transmissivity from minimum-required hydraulic conductivity
- Transmissivity Equivalency

Cover System Stability - Hydraulic Head Calculations

Objective: Determine minimum drainage layer hydraulic conductivity (k_d) required to prevent head from exceeding the long-term geocomposite thickness.

Runoff Coefficient, RC	74	
Thickness of Cover Soil, T_c	3	ft
Precipication Intensity	2.76	in/hr

								Eqn (9.2)	Eqn (9.3)	Eqn (9.4)	Computed h_{avg}	
Geocomposite Thickness T_d	T_{LT} mm	L ft	β deg.	$k_{d(min)}$ cm/sec	k_c cm/sec	P(1-RC) cm/sec	P(1-RC) > Kc	h_{avg} cm	h_{avg} cm	h_{avg} cm	mm	ft
200 mil (5.1 mm)	4.9	95.0	18.4	1.78	1.0E-04	5.1E-04	Yes	-	0.49	-	4.9	0.016
275 mil (7 mm)	6.8	95.0	18.4	1.28	1.0E-04	5.1E-04	Yes	-	0.68	-	6.8	0.022
300 mil (7.5 mm)	7.3	95.0	18.4	1.19	1.0E-04	5.1E-04	Yes	-	0.73	-	7.3	0.024
330 mil (8.4 mm)	8.1	95.0	18.4	1.07	1.0E-04	5.1E-04	Yes	-	0.81	-	8.1	0.027

Notes:

Unit conversions are embedded in the spreadsheet equations.

Excel 'Goal Seek' function used to determine minimum k_d using the long-term geocomposite thickness.

Head Caclulation on the Weakest Interface:

Geotechnical and Stability Analysis for Ohio Waste Containment Systems Ohio EPA, 2004

$$h_{avg} = \frac{P(1-RC)\cdot L(\cos\beta)}{k_d(\sin\beta)} \quad (9.2)$$

or if P(1-RC) > k_c use:

$$h_{avg} = \frac{k_c \cdot L(\cos\beta)}{k_d(\sin\beta)} \quad (9.3)$$

or if h_{avg} from the above calculation is > T_d then use:

$$h_{avg} = T_d + T_c \quad (9.4)$$

h_{avg} = average head,
P = precipitation,
β = angle of slope,
L = slope length,
T_c = thickness of cover soil,
RC = runoff coefficient (SCS Runoff Curve Number/100),
k_d = permeability of drainage layer. Apply reduction factors if geocomposite (see Richardson and Zhao, 1999; or Koerner, 1997),
T_d = thickness of drainage layer, and
k_c = permeability of cover material. Use a k_c that represents long term field conditions (assume $1x10^{-4}$ cm/sec, use USDA Soil Survey estimates, or do in-field testing of a long-term vegetated area adjacent to the facility).

T_{LT} = Long-term drainage layer thickness

Allowable Transmissivity from Minimum Hydraulic Conductivity

Geocomposite Thickness			Geocomposite Min. Req'd Hydraulic Conductivity		Transmissivity	
					Min. Req'd	Allowable
Typical Product	t_d mm	t_{LT} mm	$K_{d(min)}$ cm/sec	$K_{d(min)}$ m/s	$Tr_{L\ (allow)}$ m2/sec	$Tr_{T\ (allow)}$ m2/sec
200 mil	5.1	4.9	1.78	1.78E-02	8.81E-05	8.14E-04
275 mil	7	6.8	1.28	1.28E-02	8.69E-05	8.03E-04
300 mil	7.5	7.3	1.19	1.19E-02	8.67E-05	8.01E-04
330 mil	8.4	8.1	1.07	1.07E-02	8.70E-05	8.04E-04

Hydraulic Conductivity: $K_d = Tr_L / t_{LT}$

Where:
K_d = hydraulic conductivity of drainage layer
Tr_L = Long-term transmissivity;
t_{LT} = Long-term thickness of drainage layer*

*For biplanar geocomposites, maximim 2-3% thickness reduction for confining pressures of 1,000 psf or less

Long Term Transmissivity: $Tr_{T(allow)} = Tr_{L\ (req)} \times RF_{CR} \times RF_{CC} \times RF_{BC} \times RF_D$

Where:
$Tr_{L\ (allow)}$ = Allowable tested transmissivity;
$Tr_{L\ (req)}$ = Required long term transmissivity;
RF_{CR} = Reduction factor for creep;
RF_{CC} = Reduction factor for chemical clogging;
RF_{BC} = Reduction factor for biological clogging;
RF_D = Reduction factor for drainage/global factor of safety (intrusion, fines infiltration, other variables).

From GRI Standard GC8:

Range of Clogging Reduction Factors (modified from Koerner, 1998)

Application	Chemical Clogging (RF_{CC})	Biological Clogging (RF_{BC})
Sport fields	1.0 to 1.2	1.1 to 1.3
Capillary breaks	1.0 to 1.2	1.1 to 1.3
Roof and plaza decks	1.0 to 1.2	1.1 to 1.3
Retaining walls, seeping rock and soil slopes	1.1 to 1.5	1.0 to 1.2
Drainage blankets	1.0 to 1.2	1.0 to 1.2
Landfill caps	1.0 to 1.2	1.2 to 3.5
Landfill leak detection	1.1 to 1.5	1.1 to 1.3
Landfill leachate collection	1.5 to 2.0	1.1 to 1.3

From GSE Design Manual:

RF_{CR}: Typical range between 1.1 and 2.0. FS_{CR} of 1.1 is adequate for most landfill cover applications
RF_D: Typical range between 2.0 and 3.0

Selected Values	RF_{CR}	RF_{CC}	RF_{BC}	RF_D
	1.1	1.2	3.5	2

Transmissivity Equivalency

			Notes
Slope (s)	2	%	
Slope Length (L)	250	feet	
Soil drain thickness	1	ft	
Min. Required Equivalency Factor	1.39		from Landfill Design calculator

Required Soil Drainage Characteristics

Thickness	12	inches	=	0.3048	m
Hydraulic Conductivity	1.00E-03	cm/sec	=	1.00E-05	m/sec
Transmissivity	3.05E-06	m^2/sec	See Equation 1		

Geocomposite Drainage Layer

Tested Transmissivity	8.00E-04	m^2/sec		
Equivalency Factor	262.47		Meets minimum required:	YES

Equation 1: Transmissivity

$$T = K_d \cdot t$$

Where:
T = Transmissivity;
K_d = hydraulic conductivity of drainage layer
t = thickness of drainage layer

landfilldesign.com
Design Calculator
Transmissivity Equivalency

Problem Statement

When a granular liquid collection layer is replaced by a geosynthetic liquid collection layer, it is often assumed that two liquid collection layers having the same hydraulic transmissivity are equivalent. In the United States, this approach is often mandated by regulations for the case of leachate collection layers and leakage detection and collection layers used in landfills. This is true only in the case of confined flow (i.e. if the liquid collection layer is completely filled with liquid). In reality, liquid collection layers should be designed for unconfined flow, as demonstrated in the paper by Giroud, Zhao and Bonaparte (2000). To be equivalent under the unconfined flow condition, the geosynthetic liquid collection layer should have a greater hydraulic transmissivity than the granular liquid collection layer.

Formula

$$\Theta_{GST} = E\,\Theta_{soildrain}$$

where:

$$E = \frac{1}{0.88}\left[1 + \frac{t_{soildrain}}{0.88\,L}\;\frac{\cos\beta}{\tan\beta}\right]$$

Symbol	Name	Dimensions
E	Equivalency factor	-
$t_{soildrain}$	Thickness of soil drain	ft.
L	Slope length	ft.
s	Slope (= tan ß)	%
$Q_{soildrain}$	Soil drainage transmissivity	m^2/s
Q_{GST}	Geosynthetic drainage transmissivity	m^2/s

Input Values

Slope (s)	33	%
Slope length (L)	73	ft
Soil drain thickness ($t_{soildrain}$)	1	ft

Calculate

Solution

Equivalency Factor **1.19**

Assistance

References

Giroud, J.P., Zhao, A., and Bonaparte, R., 2000, "The Myth of Hydraulic Transmissivity Equivalency Between Geosynthetic and Granular Liquid Collection Layers", Geosynthetics International, Vol. 7, Nos. 4-5.

Transmissivity Equivalency

			Notes	
Slope (s)	2	%		
Slope Length (L)	250	feet		
Soil drain thickness	1	ft		
Min. Required Equivalency Factor	1.39		from Landfill Design calculator	

Required Soil Drainage Characteristics

Thickness	12	inches	=	0.3048	m
Hydraulic Conductivity	1.00E-03	cm/sec	=	1.00E-05	m/sec
Transmissivity	3.05E-06	m^2/sec	See Equation 1		

Geocomposite Drainage Layer

Tested Transmissivity	8.00E-04	m^2/sec		
Equivalency Factor	262.47		Meets minimum required:	YES

Equation 1: Transmissivity

$$T = K_d \cdot t$$

Where:
T = Transmissivity;
K_d = hydraulic conductivity of drainage layer
t = thickness of drainage layer

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Calculation 2: Cover System Veneer Stability

Determination of Minimum-Required Interface Friction Angle

- Static Analysis – Unsaturated Conditions (Sections A & B)
- Static Analysis – Saturated Conditions with Partial Water Flow (Section A)
- Static Analysis – Saturated Conditions with Full Water Flow (Section B)

Cover System Veneer Stability - Static Analysis

Objective: Determine minimum interface friction angle for cover system components to meet required factors of safety

Stability Parameters:

Analysis	β degrees	δ_A degrees	δ_B degrees	a_A psf	a_B psf	t ft	t_w ft	t^*_w ft	h ft	γ_t pcf	γ_b pcf	γ_{sat} pcf	φ degrees	c psf
Section A (3H:1V)	18.4	23.8	23.8	0	0	3	0.024	0.024	30	115	52.6	120	28	50
Section B (2%)	2.9	1.0	1.0	0	0	3	2.50	2.50	6	115	52.6	120	28	50

STATIC ANALYSIS - UNSATURATED CONDITION (FS_{MIN} = 1.5)

Equation 5: No Flow in finite slope with uniform soil cover - Slip Surface Above Geomembrane (Giroud)

$$FS_A = \frac{\tan\delta_A}{\tan\beta} + \left[\frac{a_A}{\gamma t \cdot \sin\beta}\right] + \left[\frac{t}{h}\cdot\frac{\tan\varphi / 2\sin\beta\cos^2\beta}{1-(\tan\beta\tan\varphi)}\right] + \left[\frac{c}{\gamma h}\cdot\frac{1/(\sin\beta\cos\beta)}{1-(\tan\beta\tan\varphi)}\right] + \frac{T}{\gamma h t}$$

Analysis	Factor of Safety						
	Interface Friction	Interface Adhesion	Internal Friction	Soil Cohesion	Geosynth. tension	FS_A	
Section A (3H:1V)	1.328	0	0.114	0	0	1.50	controlling load case
Section B (2%)	0.345	0	2.707	1	0	4.53	

Equation 6: No flow in finite slope with uniform soil cover - Slip Surface Below Geomembrane (Giroud)

$$FS_B = \frac{\tan\delta_B}{\tan\beta} + \left[\frac{a_B}{\gamma t \cdot \sin\beta}\right] + \left[\frac{t}{h}\cdot\frac{\tan\varphi / 2\sin\beta\cos^2\beta}{1-(\tan\beta\tan\varphi)}\right] + \left[\frac{c}{\gamma h}\cdot\frac{1/(\sin\beta\cos\beta)}{1-(\tan\beta\tan\varphi)}\right] + \frac{T}{\gamma h t}$$

Analysis	Factor of Safety					
	Interface Friction	Interface Adhesion	Internal Friction	Soil Cohesion	Geosynth. tension	FS_B
Section A (3H:1V)	1.326	0.000	0.114	0	0	1.50
Section B (2%)	0.345	0.000	2.707	1	0	4.53

β = slope angle
φ = internal friction angle of cover soil
δ_A = interface friction angle along a slip surface above the geomembrane
δ_B = interface friction angle along a slip surface below the geomembrane
a_a = interface adhesion along a slip surface above the geomembrane
a_b = interface adhesion along a slip surface above the geomembrane
t = thickness of soil layer
t_w = water flow thickness
t_{w*} = water flow thickness at toe
h = vertical height of slope
γ_t = unit weight of soil layer
γ_{sat} = saturated unit weight of soil layer
γ_b = unit weight of soil layer
φ = internal friction angle of cover soil
c = cohesion of cover soil
T = geosynthetic tension

Note: δ_A and δ_B were varied until the minimum factor of safety was achieved for either the unsaturated or saturated condition, whichever occurred first.

Cover System Veneer Stability - Static Analysis

Objective: Determine minimum interface friction angle for cover system components to meet required factors of safety

Stability Parameters:

Analysis	β degrees	δ_A degrees	δ_B degrees	a_A psf	a_B psf	t ft	t_w ft	t^*_w ft	h ft	γ_t pcf	γ_b pcf	γ_{sat} pcf	φ degrees	c psf
Section A (3H:1V)	18.4	23.8	23.8	0	0	3	0.024	0.024	30	115	52.6	120	28	50
Section B (2%)	2.9	1.0	1.0	0	0	3	2.50	2.50	6	115	52.6	120	28	50

STATIC ANALYSIS - SATURATED CONDITION (FS_{MIN} = 1.1)

Equation 7: Partial Flow in finite slope with uniform soil cover - Slip Surface Above Geomembrane (Giroud)

$$FS_A = \frac{\gamma_t (t - t_w) + \gamma_b t_w}{\gamma_t (t - t_w) + \gamma_{sat} t_w} \frac{\tan\delta_A}{\tan\beta} + \frac{a_A / \sin\beta}{\gamma_t (t - t_w) + \gamma_{sat}} + \frac{\gamma_t (t - t^*_w) + \gamma_b t^*_w}{\gamma_t (t - t_w) + \gamma_{sat} t_w} \frac{t}{h} \frac{\sin\phi}{2\sin\beta \cos\beta \cos(\beta + \phi)}$$

$$+ \frac{c\, t/h}{\gamma_t (t - t_w) + \gamma_{sat} t_w} \frac{\cos\phi}{\sin\beta \cos(\beta + \phi)} + \frac{T/h}{\gamma_t (t - t_w) + \gamma_{sat} t_w}$$

Analysis	Factor of Safety							
	Flow Factor x	Interface Friction	Interface Adhesion	Friction Factor x	Internal Friction	Soil Cohesion	Geosyn. tension	FS_A
Section A (3H:1V)	0.995	1.328	0	0.995	0.114	0.059	0	1.49
Section B (2%)	-	-	-	-	-	-	-	-

Equation 8: Partial Flow in finite slope with uniform soil cover - Slip Surface Below Geomembrane (Giroud)

$$FS_B = \frac{\tan\delta_B}{\tan\beta} + \frac{a_B / \sin\beta}{\gamma_t (t - t_w) + \gamma_{sat} t_w} + \frac{\gamma_t (t - t^*_w) + \gamma_b t^*_w}{\gamma_t (t - t_w) + \gamma_{sat} t_w} \frac{t}{h} \frac{\sin\phi}{2\sin\beta \cos\beta \cos(\beta + \phi)}$$

$$+ \frac{c\, t/h}{\gamma_t (t - t_w) + \gamma_{sat} t_w} \frac{\cos\phi}{\sin\beta \cos(\beta + \phi)} + \frac{T/h}{\gamma_t (t - t_w) + \gamma_{sat} t_w}$$

Analysis	Factor of Safety						
	Interface Friction	Interface Adhesion	Friction Factor x	Internal Friction	Soil Cohesion	Geosynth. tension	FS_B
Section A (3H:1V)	1.326	0	0.995	0.114	0.059	0	1.50
Section B (2%)	-	-	-	-	-	-	-

β = slope angle
φ = internal friction angle of cover soil
δ_A = interface friction angle along a slip surface above the geomembrane
δ_B = interface friction angle along a slip surface below the geomembrane
a_a = interface adhesion along a slip surface above the geomembrane
a_b = interface adhesion along a slip surface above the geomembrane
t = thickness of soil layer
t_w = water flow thickness
t_{w^*} = water flow thickness at toe
h = vertical height of slope
γ_t = unit weight of soil layer
γ_{sat} = saturated unit weight of soil layer
γ_b = unit weight of soil layer
φ = internal friction angle of cover soil
c = cohesion of cover soil
T = geosynthetic tension

Note: δ_A and δ_B were varied until the minimum factor of safety was achieved for either the unsaturated or saturated condition, whichever occurred first.

Cover System Veneer Stability - Static Analysis

Objective: Determine minimum interface friction angle for cover system components to meet required factors of safety

Stability Parameters:

Analysis	β degrees	δ_A degrees	δ_B degrees	a_A psf	a_B psf	t ft	t_w ft	t^*_w ft	h ft	γ_t pcf	γ_b pcf	γ_{sat} pcf	φ degrees	c psf
Section A (3H:1V)	18.4	23.8	23.8	0	0	3	0.024	0.024	30	115	52.6	120	28	50
Section B (2%)	2.9	1.0	1.0	0	0	3	2.50	2.50	6	115	52.6	120	28	50

STATIC ANALYSIS - SATURATED CONDITION (FS_{MIN} = 1.1)

Equation 9: Full Flow in Finite Slope with uniform soil cover - Slip Surface Above Geomembrane (Giroud)

$$FS_A = \frac{\gamma_b}{\gamma_{sat}}\frac{\tan\delta_A}{\tan\beta} + \frac{a_A}{\gamma_{sat}\ t\ \sin\beta} + \frac{\gamma_b}{\gamma_{sat}}\frac{t}{h}\frac{\sin\phi}{2\sin\beta\cos\beta\cos(\beta+\phi)} + \frac{c}{\gamma_{sat}\ h}\frac{\cos\phi}{\sin\beta\ \cos(\beta+\phi)} + \frac{T}{\gamma_{sat}\ t\ h}$$

Analysis	Flow Factor	x	Interface Friction	Interface Adhesion	Friction Factor	x	Internal Friction	Soil Cohesion	Geosyn. Tension	FS_A
Section A (3H:1V)	-		-	-	-		-	-	-	-
Section B (2%)	0.438		0.345	0	0.438		2.707	1.412	0	2.75

Controlling load case

Equation 10: Full Flow in Finite Slope with uniform soil cover - Slip Surface Below Geomembrane (Giroud)

$$FS_B = \frac{\tan\delta_B}{\tan\beta} + \frac{a_B}{\gamma_{sat}\ t\ \sin\beta} + \frac{\gamma_b}{\gamma_{sat}}\frac{t}{h}\frac{\sin\phi}{2\sin\beta\cos\beta\cos(\beta+\phi)} + \frac{c}{\gamma_{sat}\ h}\frac{\cos\phi}{\sin\beta\ \cos(\beta+\phi)} + \frac{T}{\gamma_{sat}\ t\ h}$$

Analysis	Interface Friction	Interface Adhesion	Friction Factor	x	Internal Friction	Soil Cohesion	Geosyn. Tension	FS_B
Section A (3H:1V)	-	-	-		-	-	-	-
Section B (2%)	0.34	0	0.438		2.707	0	0	1.53

β = slope angle
φ = internal friction angle of cover soil
δ_A = interface friction angle along a slip surface above the geomembrane
δ_B = interface friction angle along a slip surface below the geomembrane
a_a = interface adhesion along a slip surface above the geomembrane
a_b = interface adhesion along a slip surface above the geomembrane
t = thickness of soil layer
t_w = water flow thickness
t_{w^*} = water flow thickness at toe
h = vertical height of slope
γ_t = unit weight of soil layer
γ_{sat} = saturated unit weight of soil layer
γ_b = unit weight of soil layer
φ = internal friction angle of cover soil
c = cohesion of cover soil
T = geosynthetic tension

Calculation 3: Cover System Veneer Stability

Veneer Stability using Minimum-Required Interface Friction Angle

- Static Analysis – Unsaturated Conditions (Sections A & B)
- Static Analysis – Saturated Conditions with Partial Water Flow (Section A)
- Static Analysis – Saturated Conditions with Full Water Flow (Section B)
- Seismic Analysis – Unsaturated Conditions (Sections A & B)

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Cover System Veneer Stability - Static Analysis

Objective: Perform slope stability analysis using minimum interface friction angle.

Stability Parameters:

Analysis	β degrees	δ_A degrees	δ_B degrees	a_A psf	a_B psf	t ft	t_w ft	t^*_w ft	h ft	γ_t pcf	γ_b pcf	γ_{sat} pcf	φ degrees	c psf
Section A (3H:1V)	18.4	23.8	23.8	0	0	3	0.024	0.024	30	115	52.6	120	28	50
Section B (2%)	2.9	23.8	23.8	0	0	3	2.50	2.50	6	115	52.6	120	28	50

STATIC ANALYSIS - UNSATURATED CONDITION (FS_{MIN} = 1.5)

Equation 5: No Flow in finite slope with uniform soil cover - Slip Surface Above Geomembrane (Giroud)

$$FS_A = \frac{\tan \delta_A}{\tan \beta} + \left[\frac{a_A}{\gamma t \cdot \sin \beta}\right] + \left[\frac{t}{h} \cdot \frac{\tan \varphi / 2 \sin \beta \cos^2 \beta}{1-(\tan \beta \tan \varphi)}\right] + \left[\frac{c}{\gamma h} \cdot \frac{1/(\sin \beta \cos \beta)}{1-(\tan \beta \tan \varphi)}\right] + \frac{T}{\gamma h t}$$

Analysis	Factor of Safety						
	Interface Friction	Interface Adhesion	Internal Friction	Soil Cohesion	Geosynth. tension	FS_A	
Section A (3H:1V)	1.326	0	0.114	0	0	1.50	controlling load case
Section B (2%)	8.707	0	2.707	1	0	12.89	

Equation 6: No flow in finite slope with uniform soil cover - Slip Surface Below Geomembrane (Giroud)

$$FS_B = \frac{\tan \delta_B}{\tan \beta} + \left[\frac{a_B}{\gamma t \cdot \sin \beta}\right] + \left[\frac{t}{h} \cdot \frac{\tan \varphi / 2 \sin \beta \cos^2 \beta}{1-(\tan \beta \tan \varphi)}\right] + \left[\frac{c}{\gamma h} \cdot \frac{1/(\sin \beta \cos \beta)}{1-(\tan \beta \tan \varphi)}\right] + \frac{T}{\gamma h t}$$

Analysis	Factor of Safety					
	Interface Friction	Interface Adhesion	Internal Friction	Soil Cohesion	Geosynth. tension	FS_B
Section A (3H:1V)	1.326	0.000	0.114	0	0	1.50
Section B (2%)	8.707	0.000	2.707	1	0	12.89

β = slope angle
φ = internal friction angle of cover soil
δ_A = interface friction angle along a slip surface above the geomembrane
δ_B = interface friction angle along a slip surface below the geomembrane
a_a = interface adhesion along a slip surface above the geomembrane
a_b = interface adhesion along a slip surface above the geomembrane
t = thickness of soil layer
t_w = water flow thickness
t_{w^*} = water flow thickness at toe
h = vertical height of slope
γ_t = unit weight of soil layer
γ_{sat} = saturated unit weight of soil layer
γ_b = unit weight of soil layer
φ = internal friction angle of cover soil
c = cohesion of cover soil
T = geosynthetic tension

Note: δ_A and δ_B were varied until the minimum factor of safety was achieved for either the unsaturated or saturated condition, whichever occurred first.

Cover System Veneer Stability - Static Analysis

Objective: Perform slope stability analysis using minimum interface friction angle.

Stability Parameters:

Analysis	β degrees	δ_A degrees	δ_B degrees	a_A psf	a_B psf	t ft	t_w ft	t^*_w ft	h ft	γ_t pcf	γ_b pcf	γ_{sat} pcf	φ degrees	c psf
Section A (3H:1V)	18.4	23.8	23.8	0	0	3	0.024	0.024	30	115	52.6	120	28	50
Section B (2%)	2.9	23.8	23.8	0	0	3	2.50	2.50	6	115	52.6	120	28	50

STATIC ANALYSIS - SATURATED CONDITION (FS_{MIN} = 1.1)

Equation 7: Partial Flow in finite slope with uniform soil cover - Slip Surface Above Geomembrane (Giroud)

$$FS_A = \frac{\gamma_t (t - t_w) + \gamma_b t_w}{\gamma_t (t - t_w) + \gamma_{sat} t_w} \frac{\tan\delta_A}{\tan\beta} + \frac{a_A / \sin\beta}{\gamma_t (t - t_w) + \gamma_{sat}} + \frac{\gamma_t (t - t^*_w) + \gamma_b t^*_w}{\gamma_t (t - t_w) + \gamma_{sat} t_w} \frac{t}{h} \frac{\sin\phi}{2\sin\beta \cos\beta \cos(\beta + \phi)}$$

$$+ \frac{c\, t/h}{\gamma_t (t - t_w) + \gamma_{sat} t_w} \frac{\cos\phi}{\sin\beta \cos(\beta + \phi)} + \frac{T/h}{\gamma_t (t - t_w) + \gamma_{sat} t_w}$$

Analysis	Factor of Safety							
	Flow Factor x	Interface Friction	Interface Adhesion	Friction Factor x	Internal Friction	Soil Cohesion	Geosyn. tension	FS_A
Section A (3H:1V)	0.995	1.326	0	0.995	0.114	0.059	0	1.49
Section B (2%)	-	-	-	-	-	-	-	-

Equation 8: Partial Flow in finite slope with uniform soil cover - Slip Surface Below Geomembrane (Giroud)

$$FS_B = \frac{\tan\delta_B}{\tan\beta} + \frac{a_B / \sin\beta}{\gamma_t (t - t_w) + \gamma_{sat} t_w} + \frac{\gamma_t (t - t^*_w) + \gamma_b t^*_w}{\gamma_t (t - t_w) + \gamma_{sat} t_w} \frac{t}{h} \frac{\sin\phi}{2\sin\beta \cos\beta \cos(\beta + \phi)}$$

$$+ \frac{c\, t/h}{\gamma_t (t - t_w) + \gamma_{sat} t_w} \frac{\cos\phi}{\sin\beta \cos(\beta + \phi)} + \frac{T/h}{\gamma_t (t - t_w) + \gamma_{sat} t_w}$$

Analysis	Factor of Safety						
	Interface Friction	Interface Adhesion	Friction Factor x	Internal Friction	Soil Cohesion	Geosynth. tension	FS_B
Section A (3H:1V)	1.326	0	0.995	0.114	0.059	0	1.50
Section B (2%)	-	-	-	-	-	-	-

β = slope angle
φ = internal friction angle of cover soil
δ_A = interface friction angle along a slip surface above the geomembrane
δ_B = interface friction angle along a slip surface below the geomembrane
a_a = interface adhesion along a slip surface above the geomembrane
a_b = interface adhesion along a slip surface above the geomembrane
t = thickness of soil layer
t_w = water flow thickness
t_{w^*} = water flow thickness at toe
h = vertical height of slope
γ_t = unit weight of soil layer
γ_{sat} = saturated unit weight of soil layer
γ_b = unit weight of soil layer
φ = internal friction angle of cover soil
c = cohesion of cover soil
T = geosynthetic tension

Note: δ_A and δ_B were varied until the minimum factor of safety was achieved for either the unsaturated or saturated condition, whichever occurred first.

Cover System Veneer Stability - Static Analysis

Objective: Perform slope stability analysis using minimum interface friction angle.

Stability Parameters:

Analysis	β degrees	δ_A degrees	δ_B degrees	a_A psf	a_B psf	t ft	t_w ft	t^*_w ft	h ft	γ_t pcf	γ_b pcf	γ_{sat} pcf	φ degrees	c psf
Section A (3H:1V)	18.4	23.8	23.8	0	0	3	0.024	0.024	30	115	52.6	120	28	50
Section B (2%)	2.9	23.8	23.8	0	0	3	2.50	2.50	6	115	52.6	120	28	50

STATIC ANALYSIS - SATURATED CONDITION (FS_{MIN} = 1.1)

Equation 9: Full Flow in Finite Slope with uniform soil cover - Slip Surface Above Geomembrane (Giroud)

$$FS_A = \frac{\gamma_b}{\gamma_{sat}}\frac{\tan\delta_A}{\tan\beta} + \frac{a_A}{\gamma_{sat}\, t\, \sin\beta} + \frac{\gamma_b}{\gamma_{sat}}\frac{t}{h}\frac{\sin\phi}{2\sin\beta\cos\beta\cos(\beta+\phi)} + \frac{c}{\gamma_{sat}\, h}\frac{\cos\phi}{\sin\beta\,\cos(\beta+\phi)} + \frac{T}{\gamma_{sat}\, t\, h}$$

Analysis	Flow Factor	x	Interface Friction	Interface Adhesion	Friction Factor	x	Internal Friction	Soil Cohesion	Geosyn. Tension	FS_A
Section A (3H:1V)	-		-	-	-		-	-	-	-
Section B (2%)	0.438		8.707	0	0.438		2.707	1.412	0	6.42

Controlling load case

Equation 10: Full Flow in Finite Slope with uniform soil cover - Slip Surface Below Geomembrane (Giroud)

$$FS_B = \frac{\tan\delta_B}{\tan\beta} + \frac{a_B}{\gamma_{sat}\, t\, \sin\beta} + \frac{\gamma_b}{\gamma_{sat}}\frac{t}{h}\frac{\sin\phi}{2\sin\beta\cos\beta\cos(\beta+\phi)} + \frac{c}{\gamma_{sat}\, h}\frac{\cos\phi}{\sin\beta\,\cos(\beta+\phi)} + \frac{T}{\gamma_{sat}\, t\, h}$$

Analysis	Interface Friction	Interface Adhesion	Friction Factor	x	Internal Friction	Soil Cohesion	Geosyn. Tension	FS_B
Section A (3H:1V)	-	-	-		-	-	-	-
Section B (2%)	8.71	0	0.438		2.707	0	0	9.89

β = slope angle
φ = internal friction angle of cover soil
δ_A = interface friction angle along a slip surface above the geomembrane
δ_B = interface friction angle along a slip surface below the geomembrane
a_a = interface adhesion along a slip surface above the geomembrane
a_b = interface adhesion along a slip surface above the geomembrane
t = thickness of soil layer
t_w = water flow thickness
t_{w*} = water flow thickness at toe
h = vertical height of slope
γ_t = unit weight of soil layer
γ_{sat} = saturated unit weight of soil layer
γ_b = unit weight of soil layer
φ = internal friction angle of cover soil
c = cohesion of cover soil
T = geosynthetic tension

Cover System Veneer Stability - Seismic Analysis (Unsaturated Condition)

	Analysis	FS_{min}	n_g %g	γ_c pcf	γ_w pcf	c psf	$\varphi = \delta$ degrees	β degrees	z_c ft	d_w ft	FS
1	Section A	1.3	0.070	120	62.4	50	23.8	18.4	2.50	2.47	1.52
2	Section B	1.3	0.070	120	62.4	50	23.8	2.9	2.50	2.47	5.00
3											

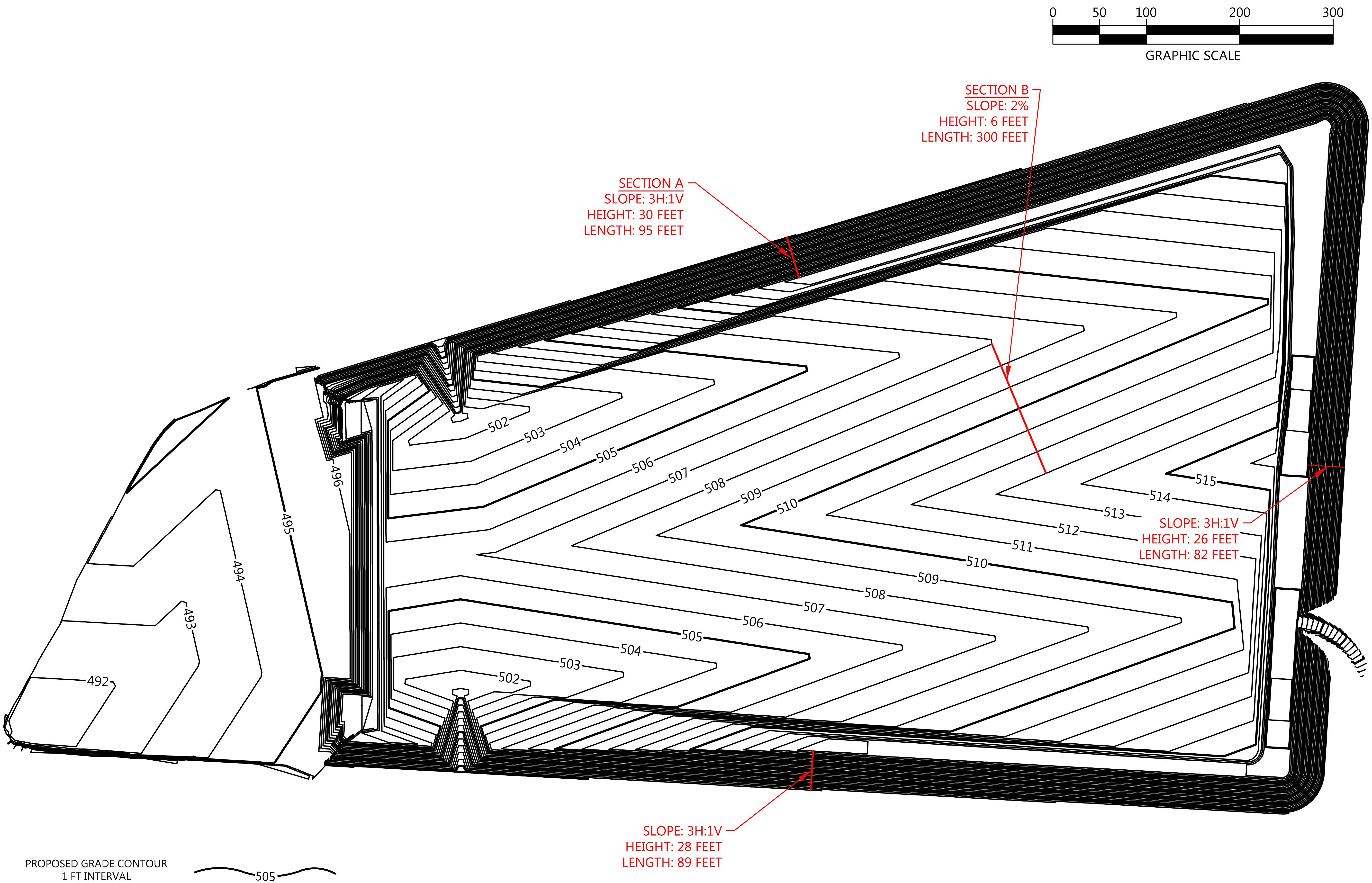
Equation 9-1: Factor of Safety for an Infinite Slope (Matasovic)

$$FS = \frac{\dfrac{c}{\gamma_c z_c \cos^2\beta} + \tan\phi\left[1 - \dfrac{\gamma_w (z_c - d_w)}{\gamma_c z_c}\right] - n_g(\tan\beta)(\tan\phi)}{n_g + \tan\beta} = \frac{A + B[C] - D}{E}$$

FS = factor of safety against shallow failure,
n_g = peak horizontal acceleration at the failure surface (%g),
γ_c = field density of cover materials,
γ_w = density of water,
c = cohesion of failure surface,
ϕ = internal angle of friction,
β = angle of slope,
z_c = depth of cover soils, and
d_w = depth to water table that is assumed parallel to slope ($d_w = z - h_{avg}$)

	Analysis	A	B	C	D	E	FS
1	Section A	0.185	0.441	1.0	0.010	0.403	1.52
2	Section B	0.167	0.441	1.0	0.002	0.121	5.00
3							

Figures



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6190 ENTERPRISE COURT
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(614) 793-2226
ENGINEERING FIRM LICENSE NUMBER: F-0176

ENVIROANALYTICS GROUP, LLC
1650 DES PERES RD., SUITE 230
ST. LOUIS, MO 63131

COVER SYSTEM FINAL GRADES
FLY ASH POND CLOSURE
TANNERS CREEK PLANT

LAWRENCEBURG, DEARBORN COUNTY, INDIANA

NO.	DATE	DESCRIPTION	BY	CHK	APV

PROJECT NUMBER
7217-17-007A

FIGURE NO.
1

DRAWING NAME
COVER SYSTEM SECTIONS

Q:\Projects\7217-Civil Columbus\7217-17-007 Tanners Creek\A FA Pond Closure\DWG\SKETCH\7217-17-007_MTR.dwg-ANSI B 11x17 (3) Aug 24, 2017 MRomanello

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NOAA Atlas 14, Volume 2, Version 3
Location name: Lawrenceburg, Indiana, USA*
Latitude: 39.0793°, Longitude: -84.8754°
Elevation: 466.04 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.382 (0.350-0.417)	0.452 (0.415-0.494)	0.531 (0.486-0.580)	0.590 (0.540-0.643)	0.663 (0.604-0.720)	0.717 (0.651-0.777)	0.765 (0.692-0.829)	0.813 (0.732-0.881)	0.874 (0.782-0.946)	0.916 (0.814-0.991)
10-min	0.594 (0.544-0.648)	0.706 (0.647-0.771)	0.825 (0.756-0.901)	0.911 (0.834-0.993)	1.01 (0.923-1.10)	1.09 (0.987-1.18)	1.15 (1.04-1.25)	1.21 (1.09-1.32)	1.28 (1.15-1.39)	1.33 (1.19-1.44)
15-min	0.728 (0.667-0.794)	0.864 (0.792-0.943)	1.01 (0.928-1.11)	1.12 (1.03-1.22)	1.25 (1.14-1.36)	1.34 (1.22-1.46)	1.43 (1.29-1.55)	1.51 (1.36-1.64)	1.60 (1.43-1.74)	1.67 (1.48-1.80)
30-min	0.963 (0.883-1.05)	1.16 (1.06-1.26)	1.39 (1.27-1.51)	1.56 (1.42-1.70)	1.77 (1.61-1.92)	1.92 (1.75-2.08)	2.07 (1.87-2.24)	2.20 (1.99-2.39)	2.38 (2.13-2.57)	2.50 (2.22-2.70)
60-min	1.18 (1.08-1.28)	1.42 (1.30-1.55)	1.74 (1.59-1.90)	1.98 (1.81-2.16)	2.29 (2.09-2.49)	2.53 (2.30-2.74)	2.76 (2.50-2.99)	2.99 (2.69-3.24)	3.29 (2.94-3.56)	3.51 (3.12-3.80)
2-hr	1.38 (1.26-1.52)	1.67 (1.53-1.83)	2.05 (1.87-2.25)	2.34 (2.14-2.56)	2.72 (2.47-2.97)	3.02 (2.74-3.29)	3.31 (2.99-3.61)	3.61 (3.24-3.93)	4.00 (3.56-4.35)	4.30 (3.80-4.68)
3-hr	1.47 (1.34-1.62)	1.77 (1.62-1.96)	2.18 (2.00-2.40)	2.50 (2.28-2.75)	2.93 (2.66-3.21)	3.27 (2.95-3.57)	3.61 (3.24-3.94)	3.96 (3.54-4.31)	4.42 (3.92-4.82)	4.79 (4.21-5.21)
6-hr	1.81 (1.66-1.97)	2.18 (2.00-2.38)	2.67 (2.45-2.91)	3.05 (2.80-3.32)	3.57 (3.26-3.88)	3.98 (3.62-4.32)	4.40 (3.97-4.76)	4.83 (4.33-5.22)	5.40 (4.80-5.84)	5.86 (5.17-6.33)
12-hr	2.15 (1.98-2.34)	2.58 (2.38-2.81)	3.15 (2.90-3.42)	3.59 (3.30-3.89)	4.17 (3.82-4.52)	4.63 (4.22-5.01)	5.09 (4.62-5.50)	5.56 (5.02-6.00)	6.19 (5.54-6.68)	6.68 (5.94-7.22)
24-hr	2.51 (2.33-2.70)	3.00 (2.79-3.24)	3.66 (3.40-3.95)	4.17 (3.87-4.50)	4.85 (4.49-5.23)	5.39 (4.97-5.80)	5.92 (5.45-6.37)	6.47 (5.93-6.95)	7.19 (6.57-7.74)	7.75 (7.06-8.34)
2-day	2.95 (2.74-3.20)	3.54 (3.28-3.83)	4.29 (3.98-4.64)	4.87 (4.52-5.27)	5.65 (5.22-6.10)	6.25 (5.77-6.75)	6.85 (6.31-7.40)	7.46 (6.85-8.05)	8.27 (7.55-8.93)	8.89 (8.08-9.61)
3-day	3.14 (2.92-3.40)	3.76 (3.49-4.06)	4.54 (4.22-4.90)	5.15 (4.78-5.55)	5.95 (5.52-6.42)	6.58 (6.08-7.10)	7.22 (6.65-7.78)	7.85 (7.21-8.46)	8.70 (7.95-9.38)	9.36 (8.51-10.1)
4-day	3.34 (3.11-3.60)	3.98 (3.70-4.30)	4.79 (4.46-5.17)	5.42 (5.04-5.84)	6.26 (5.81-6.74)	6.92 (6.40-7.45)	7.58 (6.99-8.16)	8.25 (7.58-8.88)	9.14 (8.36-9.84)	9.82 (8.95-10.6)
7-day	3.94 (3.68-4.23)	4.68 (4.38-5.03)	5.62 (5.24-6.03)	6.35 (5.93-6.82)	7.36 (6.85-7.89)	8.15 (7.57-8.74)	8.96 (8.29-9.60)	9.77 (9.02-10.5)	10.9 (9.98-11.7)	11.7 (10.7-12.6)
10-day	4.47 (4.18-4.79)	5.31 (4.97-5.69)	6.35 (5.94-6.80)	7.17 (6.70-7.68)	8.29 (7.73-8.87)	9.16 (8.53-9.79)	10.1 (9.33-10.7)	11.0 (10.1-11.7)	12.2 (11.2-13.0)	13.1 (12.0-14.0)
20-day	6.11 (5.75-6.52)	7.23 (6.81-7.70)	8.53 (8.02-9.08)	9.53 (8.96-10.2)	10.9 (10.2-11.6)	11.9 (11.1-12.7)	12.9 (12.1-13.7)	13.9 (13.0-14.8)	15.3 (14.1-16.2)	16.3 (15.0-17.3)
30-day	7.62 (7.20-8.09)	8.98 (8.47-9.52)	10.5 (9.85-11.1)	11.6 (10.9-12.3)	13.1 (12.3-13.8)	14.2 (13.3-15.0)	15.3 (14.3-16.2)	16.4 (15.3-17.4)	17.8 (16.6-18.9)	18.9 (17.5-20.0)
45-day	9.60 (9.10-10.1)	11.3 (10.7-11.9)	13.0 (12.3-13.7)	14.3 (13.5-15.1)	16.0 (15.1-16.9)	17.3 (16.3-18.2)	18.5 (17.4-19.5)	19.7 (18.5-20.8)	21.2 (19.8-22.4)	22.3 (20.8-23.6)
60-day	11.4 (10.9-12.0)	13.4 (12.7-14.1)	15.4 (14.6-16.1)	16.9 (16.0-17.7)	18.8 (17.8-19.7)	20.3 (19.2-21.3)	21.6 (20.5-22.7)	23.0 (21.7-24.1)	24.7 (23.2-25.9)	25.9 (24.3-27.3)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

Figure 2

Michael Romanello

From: Nathan Ivy <NIvy@AgruAmerica.com>
Sent: Monday, April 10, 2017 11:32 AM
To: Michael Romanello
Subject: Typical Transmissivity Results

Mike,

Per our conversation, below are typical transmissivity results for a double sided geocomposite bounded by soil on one side and SS plate on the other. These results are at pressure of 500 – 1,000 psf, gradient of 0.25 – 0.33 with seat time of 24-100 hours. At this low pressure increased seat time beyond 24 hours has limited effect on transmissivity.

200 mil – 2E-04 m^2/s
250 mil – 5E-04 m^2/s
275 mil – 8E-04 m^2/s
300 mil – 9.5E-04 m^2/s
330 mil – 2E-03 m^2/s

Please let me know if you have any other questions.

Nathan

Figure 3

19103 Gundle Rd
Houston, TX 77073

[O] 281.443.8564
[F] 281.875.6010
[TF] 800.435.2008

GSE ENVIRONMENTAL™

April 11, 2017

Stephen Loskota, P.E.
S&ME
9751 Southern Pine Blvd
Charlotte, North Carolina 28273

RE: FabriNet TRx 300-6-6 Geocomposite Transmissivity (ASTM D 4716)
AEP Conesville Power Plant, Conesville, Ohio

Dear Mr. Loskota,

As requested, GSE Environmental, LLC has summarized the certified transmissivity test results for the FabriNet TRx Geocomposites listed below. FabriNet TRx 300-6-6 Geocomposite is a 300 mil thick bi-planar geonet structure with 6 oz/SY nonwoven geotextiles bonded to each side. Testing was conducted in accordance with ASTM D 4716 *Standard Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head*.

Please note that the following Transmissivity test results are based on these boundary conditions: 100-hours using water at 20°C (68°F) between Ottawa Sand/Geocomposite/Geomembrane boundaries with a 500 pounds per square foot (psf) normal load applied.

Gradient	Transmissivity (m^2/s)
0.03	5.0×10^{-3}
0.33	1.8×10^{-3}

Please contact me at (502) 209-0325 should you wish to discuss or have questions.

Respectfully,

Steven M. Mayes, P.E.
Southeast Region Sales Manager

Figure 4

SMM2013001

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Appendix E – Settlement Analysis

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COVER SHEET

S&ME

Project Name: Tanners Creek FAP Closure	
Subject: Settlement Analysis	
Project No. 7217-17-007A	Calc. No.
Discipline: Geotechnical Eng.	Sheet 1 of 9

Tanners Creek Fly Ash Pond Closure
Settlement Analysis

Computations By:	MICHAEL T ROMANELLO REGISTERED PE11600160 STATE OF INDIANA PROFESSIONAL ENGINEER 8-17-17 Signature: Name: Michael T Romanello, P.E. Title: Project Engineer	
Reviewed By:	Signature: Name: Michael Rowland, P.E. Title: Senior Engineer	Date 8-16-2017

Revisions:

No.	Description	By	Review	Date

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Table of Contents

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Objective

The objective of this calculation package is to estimate the settlement of the in-place sluiced ash material and underlying foundation layers due to loading created by the regrading of the ash and the construction of a cover system for the ash pond closure. Two prediction methods were used for estimation of the settlement of the ash material: 1) a CPT-based modulus approach using CPT data from soundings performed within the pond, and 2) an approach using convention one-dimensional consolidation theory. Subsurface information from past investigations was available in addition to the recently obtained CPT data.

Available Subsurface Information

S&ME performed 23 Cone Penetrometer Test (CPT) soundings in the pond, as detailed in Attachment VI of the Closure Plan. Additionally, the following information was reviewed and used in the development of the subsurface profile and settlement parameter selection.

- Fly Ash Storage Pond Elevation 518' Dam Raising Engineering Report and Design Drawings – AEP, 2002
- Fly Ash Pond and Main Ash Pond Closure Plan – TRC, 2015.

Analysis Methods

CPT-Based Modulus Approach

Using procedures presented by Mayne[1], settlement of the in-placed sluiced fly ash material was estimated based on constrained modulus value correlations from CPT test data. The correlations were developed based on dialatometer testing for residual soils, but based on case histories, the relationships appear to provide a reasonable estimate of the constrained modulus, M of coal combustion product (CCP) materials. As investigated by Reeves[2], this method was shown to provide a good estimate on the settlement of in-place sluiced CCP materials for an approximately 20 foot high test fill constructed on a retired ash basin that featured as much as 55 feet of sluiced CCP materials. The test fill placement occurred over a duration of approximately 3 months. Following completion of the test fill placement, the monitored settlement (additional primary plus secondary) was negligible, suggesting the sluiced CCP materials exhibited an immediate settlement response compared to consolidation behavior for clays.

The constrained modulus correlations based on CPT data by Mayne[1] were coded into a spreadsheet for correlations to each depth increment (sublayer) along with settlement calculations. The incremental settlement calculation were summed to provide an estimate of the overall settlement at the surface of the CCP materials.

Total Settlement: $\rho_{Total} = \Sigma \frac{\Delta\sigma_v}{M'} \cdot \Delta z$

Where: M' = constrained modulus

In the Mayne procedure, correlations of the constrained modulus from CPT data are converted to equivalent DMT (Dilatometer Testing) modulus values with the following expressions:

Dilatometer Modulus, $E_D = 5\ qt$ where qt = CPT tip resistance

Material Index, $I_D = 2.0 – 0.14(FR)$ where FR = Friction Ratio

Following standard DMT data reduction procedures, $M' = R_M E_D$

Where R_M = Constrained Modulus Parameter, as defined below:

Conditions	Relationship for $R_M = M'/E_D$	Notes
If $I_D < 0.6$	$R_M = 0.14 + 2.36 \log K_D$	Clay soils
If $I_D > 3$	$R_M = 0.50 + 2.0 \log K_D$	Clean (quartz) Sands
If $0.6 < I_D < 3$	$R_M = R_{M0} + (2.5 - R_{M0}) \log K_D$ where $R_{M0} = 0.14 + 0.15(I_D - 0.6)$	Silts to silty Sands
If $K_D > 10$	$R_M = 0.32 + 2.18 \log K_D$	
If $R_M < 0.85$	Set $R_M = 0.85$	

One-Dimensional Consolidation

The consolidation settlement of the sluiced CCP and underlying clay foundation layer was estimated using traditional one-dimensional consolidation theory expressed in terms of strain versus void ratio. The settlement estimates were performed using the software Settle3D v. 4.0 developed by RocScience.

Subsurface Stratigraphy

Based on a review of the available geotechnical information, the unconsolidated soil units at the site have been characterized as natural alluvial deposits identified underlain by glacial outwash deposits of sand and gravel. The alluvial layer was delineated in an Upper Clay and Lower Clay layers via field and laboratory testing, with the contact between the layers approximated at Elevation 454 feet. For the purposes of this analysis, however, these layers were combined. The base of the fly ash pond is approximately Elevation 458. Although variation exists across the site in the stratum break between the alluvial and outwash deposits, the average is near Elevation 445 feet (B-2100 series borings).

Settlement Analysis Profile				
Layer	Description	Elevation Range	Thickness	
1	Ash	458 - 508	50 feet nom.	
3	Upper Clay	454 - 458	4 feet	
4	Lower Clay	445 - 454	9 feet	
4	Sand and Gravel	395 – 445	50 feet	
5	Bedrock	T/Rock 395	-	

Soil Parameters

Settlement parameters for the CPT-based Modulus approach come directly from the CPT data (tip stress and sleeve friction). The following subsections detail the development of the settlement parameters used in the one-dimensional consolidation calculations. Although the ash within the upper basin of the fly ash pond has been removed in the past, the current level of the ash is assumed to be near the pond's previous highest level. Therefore, the foundation layers were assumed to remain in a normally consolidated state, and an OCR of 1.0 was used in the analysis.

Ash

Unit Weight: Y_{total} = 100.8 pcf (average value from past investigations / 2015 Closure Plan)

Void Ratio:

AEP 2015 Closure Plan: e_o = 1.13

Typical range of e_o for sluiced ash: 1.0 – 1.3

Coefficient of Consolidation (C_c):

Tanners Creek Sample FA-105 (2002)

- C_c = 0.1

Ohio State/AEP Constant Rate of Strain Consolidation Testing on Class F Fly Ash (2007)

- Modified Compression Index, $C_{c\varepsilon}$ = 0.039 – 0.064, $C_{c\varepsilon\ (average)}$ = 0.052

For comparison, convert C_c to $C_{c\varepsilon}$ where $C_{c\varepsilon}$ = (C_c / 1 + e_o),

For e_o range of 1.0 to 1.3 & C_c = 0.1, $C_{c\varepsilon}$ = 0.043 – 0.05. → Ok

- Use $C_{c\varepsilon}$ = 0.05 for analysis.

Recompression Index (C_r):

Assume C_r is 10% of C_c. Note, this value will not be used as a recompression load state will not occur for the closure.

Upper and Lower Clays

Description: Stiff to hard silty clay (USCS Classification CL), few zones of clayey silt (CL-ML / ML) and silty sand (SM).

Neither the 2002 Dam Raising Design Report nor the 2015 Closure Plan evaluated consolidation settlement in this layer. Settlement within this layer is expected to be small compared to the settlement within the in-placed sluiced CCP materials. Thus, correlations to index testing are considered sufficient for estimating the settlement parameters.

FAP Boring Information

Boring	USCS Class	LL	PL	PI	% passing #200 sieve
B-2104, 40′	CL	26.6	17.6	9.1	16.9
B-2108, 18′	CL	46.9	23.4	23.5	36.6
B-2109, 14′	CL	33.4	18.0	15.4	25.2
	Average	36			

Settlement Parameters:

Unit Weight: Y_{moist} = 120 pcf

Coefficient of Consolidation (c_c):

c_c Parameter – FHWA GEC No. 5 (modified from Holtz and Kovacs, 1986)

c_c = 0.009 (LL-10) – undisturbed clays of low to medium sensitivity

For LL_{avg} = 36, C_c = 009 (36 – 10) = 0.23

Recompression Index (c_r):

Assume 10% of C_c = 0.023

Void Ratio (e_o):

2002 Dam Raising – Consolidated Undrained Triaxial Shear Testing

- Range of e_o: 0.6 – 0.9

Typical Average Values of Void Ratio (after Lambe and Whitman, 1969, as summarized by Settle3D)

- Lean Clay: 0.462
- Sandy Clay: 0.841

Design Value

- Use e_o = 0.75

Glacial Outwash Sand and Gravel

The glacial outwash sand and gravel layer is expected to exhibit an immediate settlement behavior, and thus was not modeled for primary consolidation settlement. A significant portion of the immediate settlement in the sand and gravel layer is expected to occur during construction, thus settlement of layer would not significantly impact the as-built closure grades and was not computed in the analysis.

Loading

A Fill Elevation Map of the upper basin was created by comparing the final closure grades with the existing grades as developed from the April, 2017 LiDAR flyover. The Phase 1 Fill Elevation Map is appended as Figure 1. In the upper basin, the maximum fill height is approximately 8 feet and occurs in the northeast corner. In the clear water pond, fill placement will generally be performed in two phases. In the first phase, as much as 34 feet of ash fill will be placed along the north side adjacent to the upper pond splitter dike (to Elevation 505) while the south end will not receive any fill and continue to operate as a clear water pond. In the second phase following a period of approximately 6 to 12 months, the upper approximate 10 feet of ash fill within the clear water pond placed during the first phase will be used to fill the remaining pond area. Since the ash is expected to behave more similar to sand in terms of the rate of settlement, the settlement analysis for the clear water pond area only examined the southern end, which will only receive ash fill during the second phase and may be more critical in terms of the potential impact of settlement to the final grade. A Fill Elevation Map of the clear water pond was created by comparing the grades that will exist at the end of Phase 1 with the final closure grade in Phase 2. The Phase 2 Fill Elevation Map is appended as Figure 2.

Loading for the constrained modulus approach was coded into the spreadsheet as a large square-shaped surcharge load with a height corresponding to the pond location evaluated. Similarly, the surcharge load was modeled as an embankment in Settle3D for the one-dimensional consolidation approach. For the clear water pond section, loading was applied in two stages with the first stage representing the typical historic condition (ponded water to Elevation 488). The second stage modeled the stress increase applied from the ash and cover system fill placement compared to the historic condition. The difference in settlement calculated between the 2 stages was used to estimate the settlement of the in-place sluiced ash and underlying clay foundation.

Results

Results from the clear water pond analysis provide an estimation of consolidation settlement of the in-place sluiced ash and clay foundation layer due to the final condition of the pond closure at 1.2" and 2.1", respectively. The consolidation estimate for the ash layer does not include the consolidation of the newly placed ash fill as it is being placed. The one-dimensional consolidation analysis for the upper basin yielded an estimated settlement of 7.8". Table 1 summarizes the results of the one-dimensional consolidation settlement analysis. The fill contour map presented as Figure 1 indicates that most fill areas have 5 feet or less of ash fill in the upper basin. Therefore, consolidation settlement on the order of 4 to 8 inches is likely in areas to receive fill placement.

Table 1: One-Dimensional Consolidation Settlement Analysis Results

Location	1-D Consolidation		Total
	Ash	Clay	
Clearwater Pond (Staged loading approach)	1.2″ (1)	2.1	3.3″
Upper Basin (8 ft embankment load)	7.8″	1.0″	8.8″

(1) Estimate does not include consolidation of the newly placed ash fill

Due to potential variability of the sluiced ash material, evaluation of settlement using the CPT-based modulus approach was performed to yield a range of predicted settlement. Based on a review of the CPT plots for tip stress and sleeve friction, two CPT soundings were selected to represent the range of stiffness values encountered in the soundings (CPT-1P and CPT-5P). Results from this analysis are summarized in Table 2.

Table 2: CPT-based Modulus Approach Settlement Analysis Results

Location	Predicted Settlement	
	CPT-5P Conditions	CPT-1P Conditions
Upper Basin (8 ft embankment load)	4.3″	12.4″

Results of the CPT-based modulus approach predict settlement of the sluiced fly ash in the upper basin may range between 4 and 12 inches, depending on the in-situ characteristics. The in-place sluiced ash and newly placed ash fill is expected to exhibit immediate settlement characteristics, with most of the settlement occurring by the time the vegetative cover layer is placed. Consolidation settlement of the clay foundation layer between 1 and 2 inches is not expected to appreciably affect the performance of the cover system.

Liner Strain Evaluation

The results of the settlement analysis were used to evaluate the tensile strain which may develop in the liner due to differential settlement. Average tensile strain is determined from the following equation:

$$\varepsilon_T(\%) = \frac{L_f - L_o}{L_o} \cdot 100$$

Where: ε_T (%)= tensile strain (in percent)

L_o = original distance separating two location points, and

L_f = final distance separating the same two points after settlement is complete

At the locations evaluated for settlement, the distance to the nearest point where no fill is required (i.e. no settlement expected) was measured for the L_o-value. The final distance (L_f) was determined using Pythagorean Theorem with the total settlement value previously determined. The computed liner strain, summarized in Table 3, is well below the maximum range of 2 to 5% commonly used for HDPE geoembrane. LLDPE geomembranes can tolerate even higher strain levels.

Table -3: Maximum Liner Strain

Location	Total Settlement, δ	Distance to $\delta = 0$ (L_o)	Liner Tensile Strain, ε_T
Clearwater Pond	3.3″	62 ft	0.001%
Upper Basin	8.8″	45 ft	0.013%

References

(1) Mayne, Paul W., Equivalent CPT Method for Calculating Shallow Foundation Settlement in the Piedmont Residual Soils Based on the DMT Constrained Modulus Approach, Georgia Institute of Technology, Atlanta, GA, 2002, pp. 1-5.

(2) Reeves, Jason S., and Rowland, Michael G., Characterization and Estimation of Settlement of In-Place Sluiced CCP materials Under Monotonic Loading, 2013 World of Coal Ash Conference.

Attachments

- Figure 1 – Phase 1 Fill Elevation Map
- Figure 2 – Phase 2 Fill Elevation Map
- Calculation 1 – Upper Basin Settlement Calculations
- Calculation 2 – Clearwater Pond Settlement Calculations

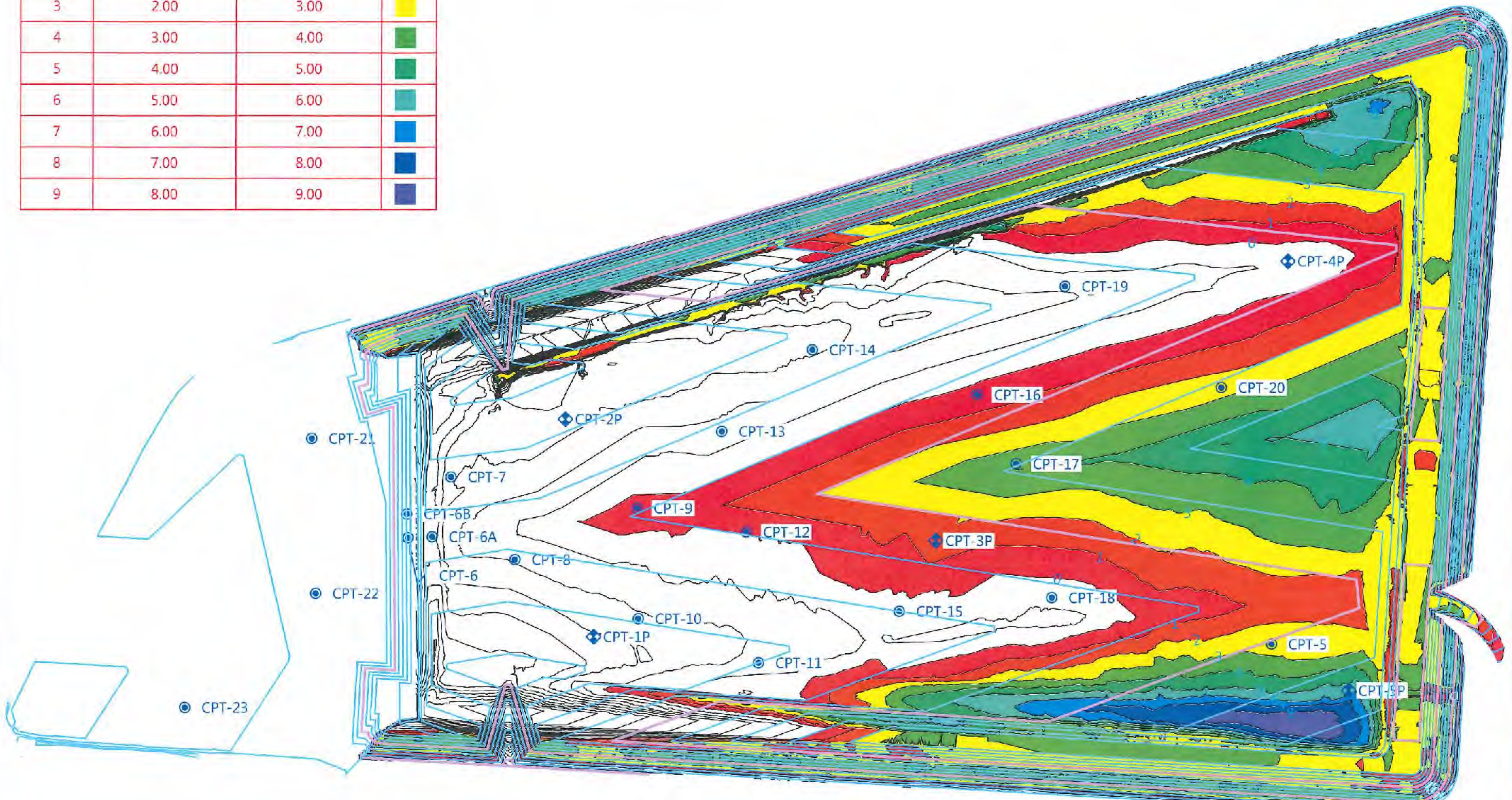
Elevations Table			
Number	Minimum Elevation	Maximum Elevation	Color
1	0.00	1.00	
2	1.00	2.00	
3	2.00	3.00	
4	3.00	4.00	
5	4.00	5.00	
6	5.00	6.00	
7	6.00	7.00	
8	7.00	8.00	
9	8.00	9.00	

BASE SURFACE: EXISTING GROUND

COMPARISON SURFACE: PH. 1 FINAL COVER

0 50 100 200 300

GRAPHIC SCALE



S&ME

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ENVIROANALYTICS GROUP, LLC
1650 DES PERES RD., SUITE 230
ST. LOUIS, MO 63131

PH 1 TOP OF COVER FILL ELEVATIONS
FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, INDIANA

NO.	DATE	DESCRIPTION	BY	CHK	APV

PROJECT NUMBER 7217-17-007A

FIGURE NO. 1

DRAWING NAME

PHASE 1 FILL ELEVATIONS

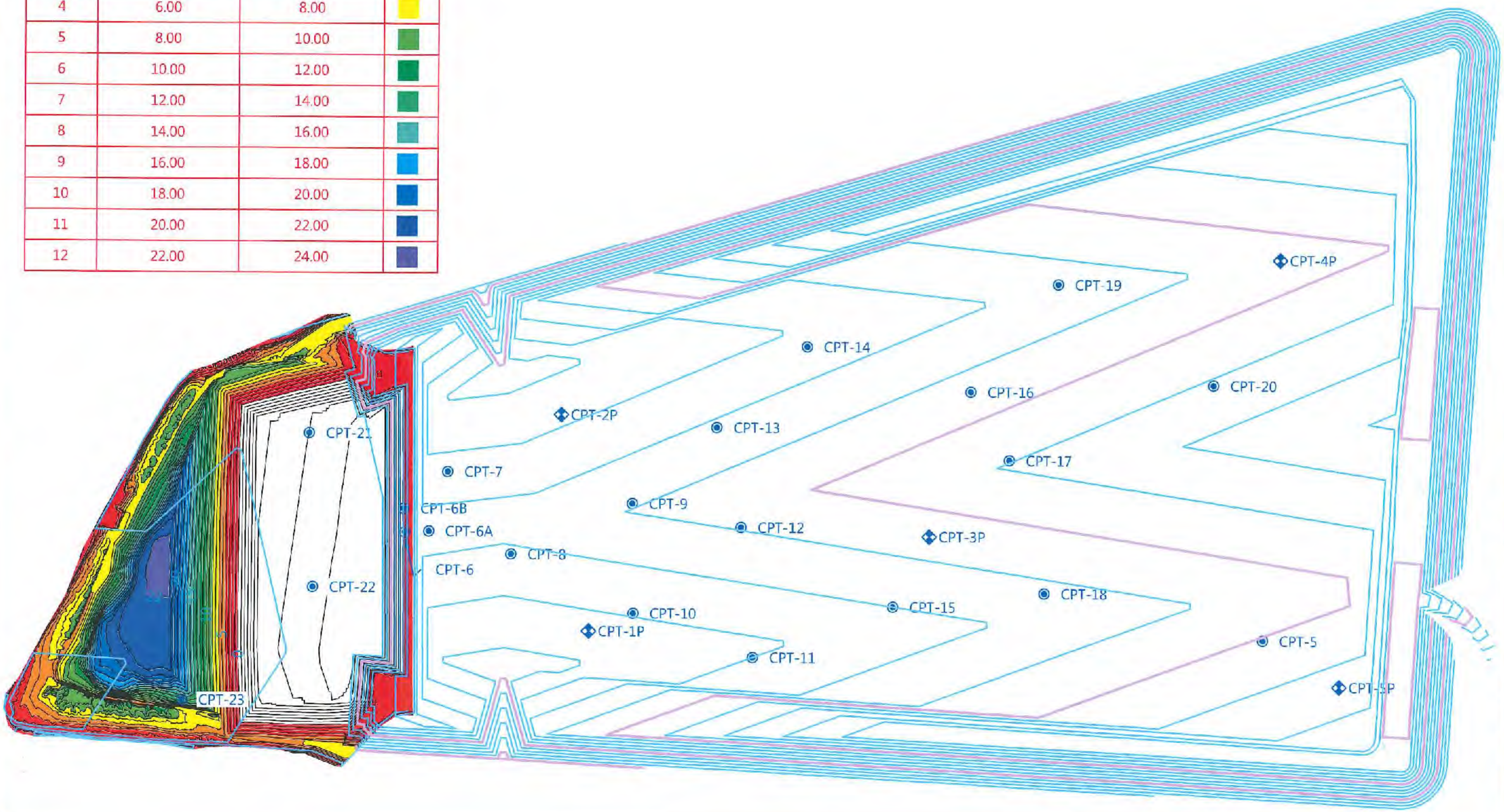
Elevations Table			
Number	Minimum Elevation	Maximum Elevation	Color
1	0.00	2.00	
2	2.00	4.00	
3	4.00	6.00	
4	6.00	8.00	
5	8.00	10.00	
6	10.00	12.00	
7	12.00	14.00	
8	14.00	16.00	
9	16.00	18.00	
10	18.00	20.00	
11	20.00	22.00	
12	22.00	24.00	

BASE SURFACE: EXISTING GROUND with PHASE 1 FINAL GRADE

COMPARISON SURFACE: PH. 2 FINAL COVER (IN CLEAR WATER POND)

0 50 100 200 300

GRAPHIC SCALE



S&ME
WWW.SMEINC.COM

ENVIROANALYTICS GROUP, LLC
1650 DES PERES RD., SUITE 230
ST. LOUIS, MO 63131

PH 2 TOP OF COVER FILL ELEVATIONS
FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, INDIANA

NO.	DATE	DESCRIPTION	BY	CHK	APV

PROJECT NUMBER
7217-17-007A

FIGURE NO.
2

DRAWING NAME
PHASE 2 FILL ELEVATIONS

Calculation 1 – Clear Water Pond Design Section Settlement Analysis

- Calculation Approach Narrative
- Staged Loading Calculations
- Stage 1 Settle3D Results – Typical Historic Conditions
- Stage 2 Settle3D Results – Final Pond Closure Condition

❖ Clear Water Pond Section

Purpose:

Estimate consolidation settlement of the in-place sluiced fly ash and underlying clay foundation layer due to the change in loading conditions resulting from the pond closure activities.

Approach

Perform a staged-loading computation whereas the Stage 1 load will mimic the stress on the in-place sluiced ash and Stage 2 will mimic the increase in stress resulting from the pond closure activities.

- Stage 1: Clear water pond with location from the southeast corner with approximately 17 feet of head based on bathymetric survey and the typical pond operating level prior to the plant ceasing power generation.

- Stage 2: Open water replaced with approximately 18 feet of ash fill and 3 feet of cover, with a corresponding drop in water table to Elevation 480

See the following sheet for a computation determining the equivalent unit weight corresponding to the stress increase going from Stage 1 to Stage 2.

Results

One-Dimensional Consolidation Settlement Analysis Results

Stage	1-D Consolidation		Total
	Ash	Clay (EL 458)	
Stage 1	4.4″	5.2″	9.6″
Stage 2	5.6″	7.3	12.9″
Difference	1.2″	2.1″	3.3″

The difference in values between Stage 1 and Stage 2 represent the predicted settlement due to the pond closure fill.

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S&ME
Cincinnati (513) 771-8471
Cleveland (216) 901-1000
Columbus (614) 793-2226

Project/Proposal No. 7217-17-007A Calculated By MTR Date 8/15/17
Project/Proposal Name TC FAP CLOSURE Checked By ______ Date ______
Subject SETTLEMENT ANALYSIS Sheet 1 of 1

PURPOSE: DETERMINE EMBANKMENT LOAD UNIT WEIGHTS FOR STAGED LOADING COMPUTATIONS FOR THE CLEARWATER POND.

TYPICAL CONDITION BEFORE CLOSURE:

POND LEVEL: EL 488

TOP OF ASH: EL 471

STRESS APPLIED TO ASH: $62.4 \text{ lb/cf} \cdot (488-471) = 1061 \text{ lb/sf}$

PROPOSED CLOSURE AT SE CORNER

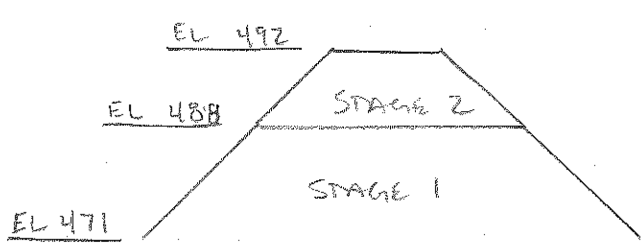
TOP OF COVER SYSTEM: EL 492 COVER UNIT WT 120 lb/cf
TOP OF ASH: EL 489 ASH UNIT WT 110 lb/cf
LONG TERM GWT: EL 480

LOAD APPLIED TO EXISTING ASH:

$$120 \frac{lb}{cf}(492-489) + 110\frac{lb}{cf}(489-480) + \left(110 - 62.4\frac{lb}{cf}\right)(480-471)$$
$$= 1778 \text{ lb/sf}$$

NET STRESS INCREASE = 717 lb/ft

STAGED LOADING



STAGE 1: $H = 17'$
$\gamma = 62.4$ lb/cf

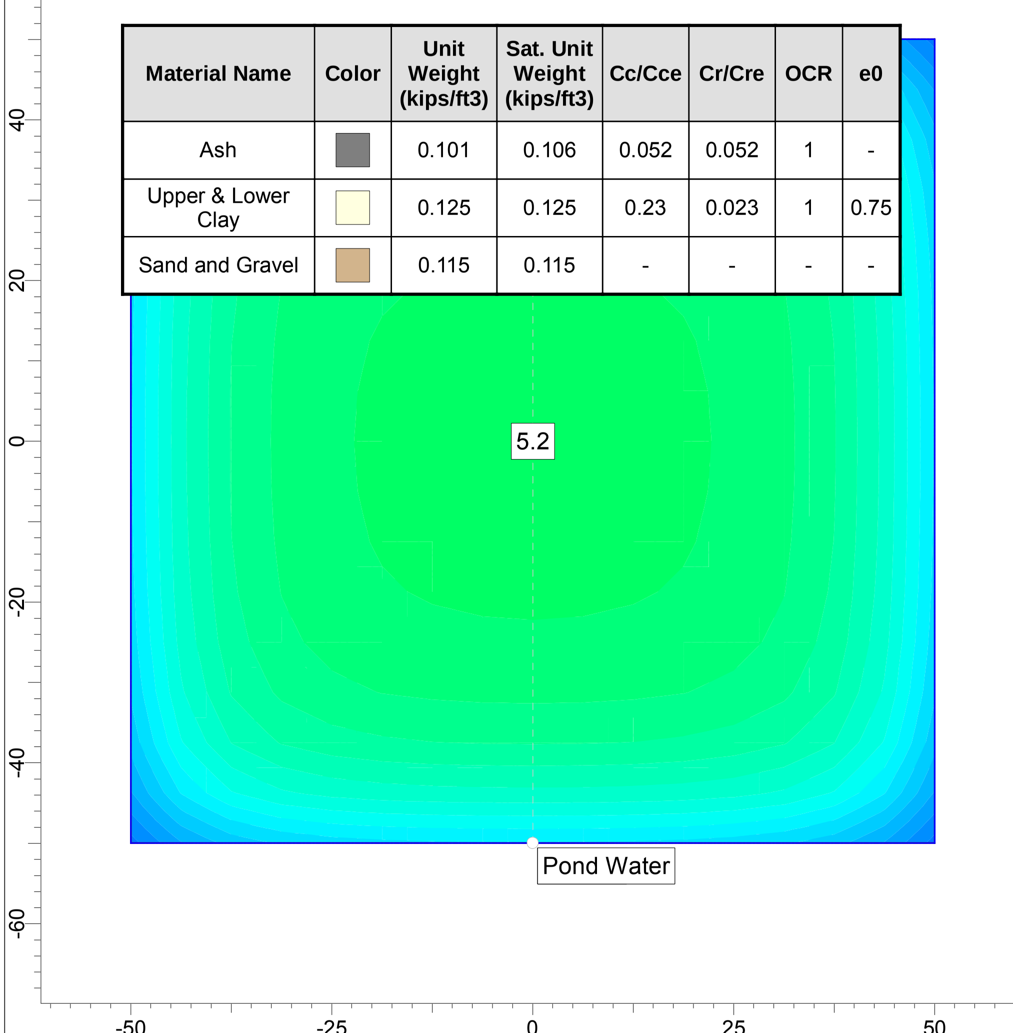
STAGE 2: $H = 4$
DETERMINE EQUIVALENT UNIT WEIGHT TO MATCH FINAL STRESS CONDITION

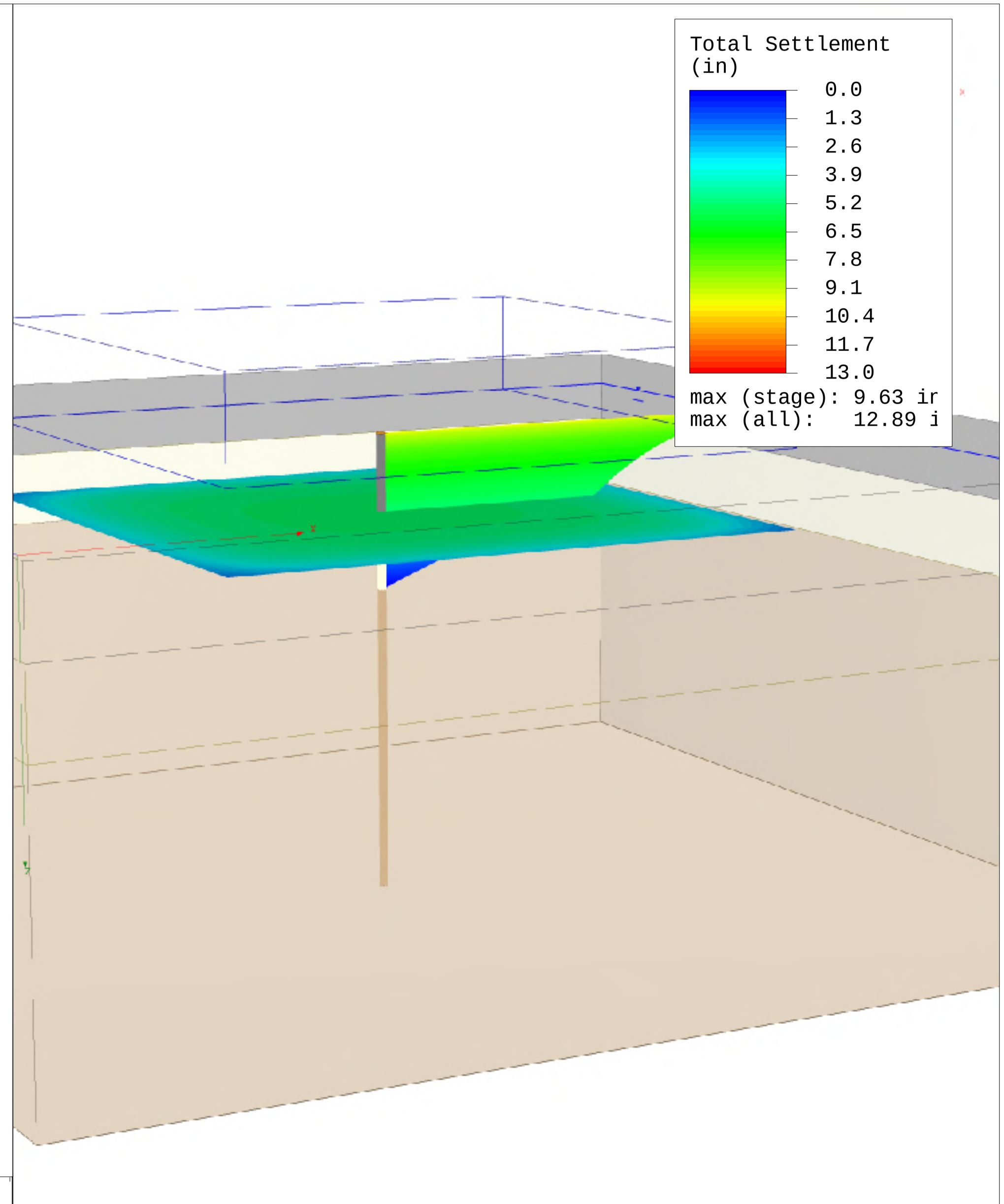
$$\gamma_{EQUIV.} = \frac{1778 \frac{lb}{SF} - 1061 \frac{lb}{SF}}{4 \text{ ft}} = 179 \text{ lb/cf}$$

Tanners Creek Fly Ash Pond Closure
Settlement Analysis

Clearwater Pond Section
-Stage 1 Loading (existing conditions)
-Consolidation settlement at top of clay (EL 458)

Material Name	Color	Unit Weight (kips/ft3)	Sat. Unit Weight (kips/ft3)	Cc/Cce	Cr/Cre	OCR	e0
Ash		0.101	0.106	0.052	0.052	1	-
Upper & Lower Clay		0.125	0.125	0.23	0.023	1	0.75
Sand and Gravel		0.115	0.115	-	-	-	-





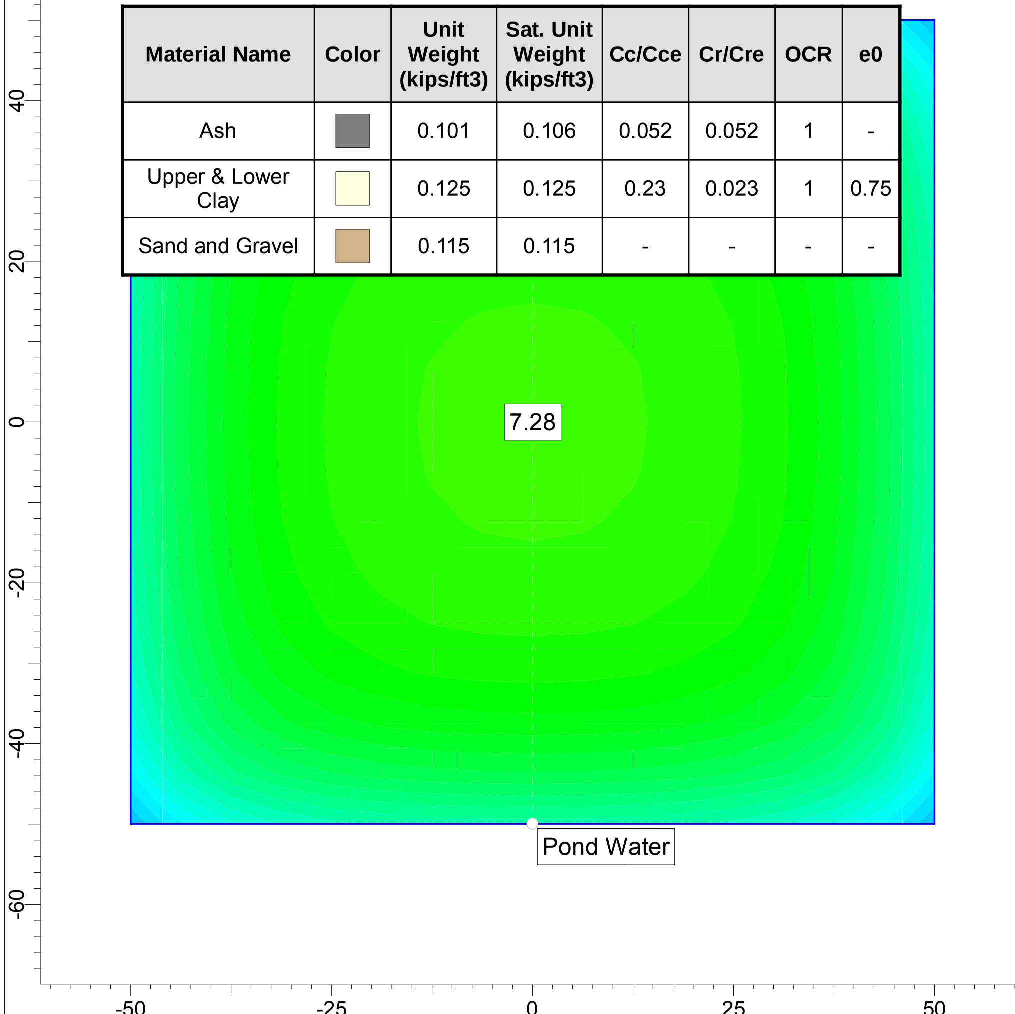
Project	Tanners Creek FAP Closure
Analysis Description	Settlement Analysis
Drawn By	mtr
Company	S&ME, Inc.
Date	
File Name	FAP CWP - Primary Consol - Staged.s3z

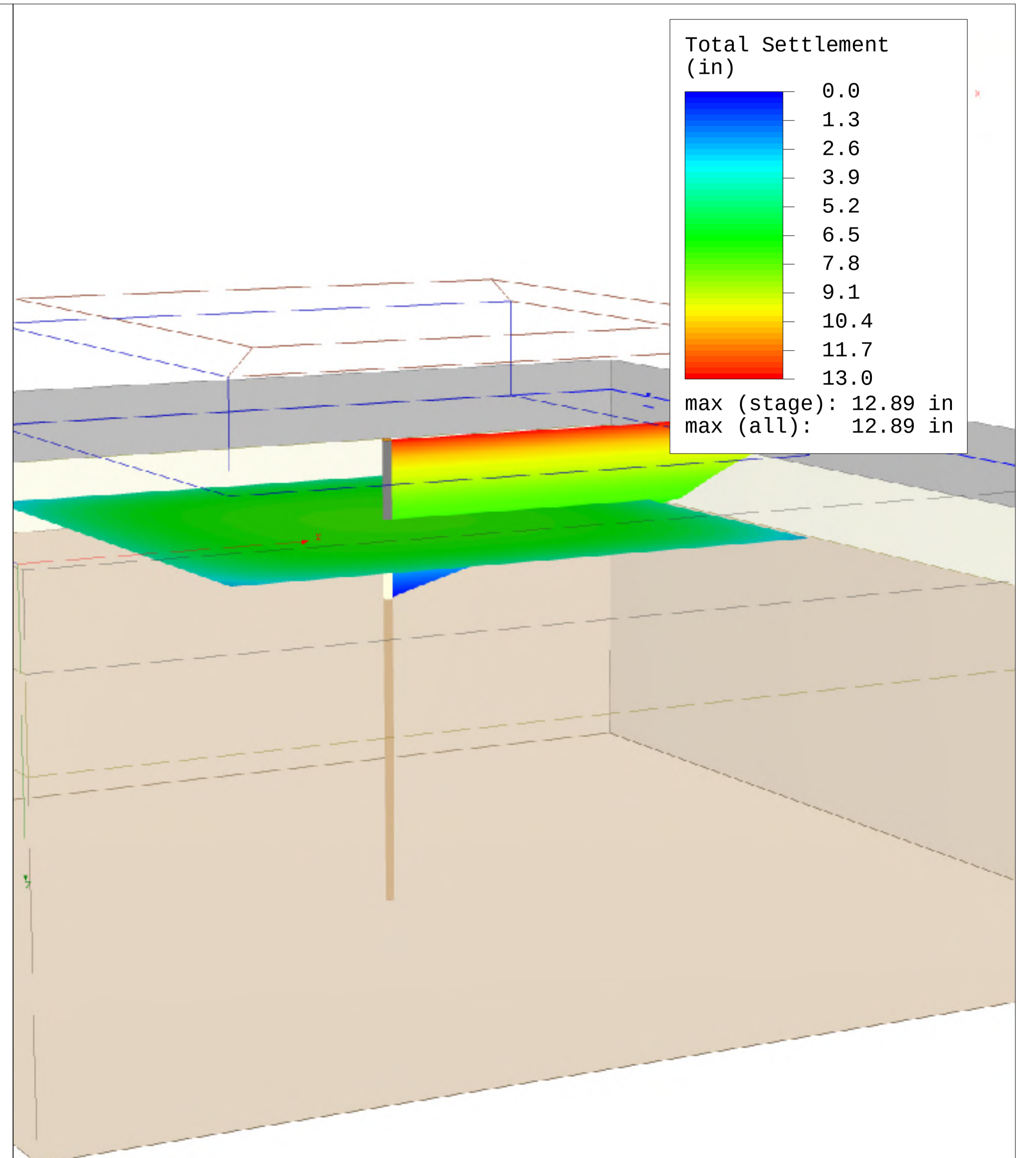
SETTLE3D 4.011

Tanners Creek Fly Ash Pond Closure
Settlement Analysis

Clearwater Pond Section
-Stage 2 Loading (post closure condition)
-Consolidation settlement at top of clay (EL 458)

Material Name	Color	Unit Weight (kips/ft3)	Sat. Unit Weight (kips/ft3)	Cc/Cce	Cr/Cre	OCR	e0
Ash		0.101	0.106	0.052	0.052	1	-
Upper & Lower Clay		0.125	0.125	0.23	0.023	1	0.75
Sand and Gravel		0.115	0.115	-	-	-	-





Project	Tanners Creek FAP Closure
Analysis Description	Settlement Analysis
Drawn By	mtr
Company	S&ME, Inc.
Date	
File Name	FAP CWP - Primary Consol - Staged.s3z

rocscience

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Settle3D Analysis Information
Tanners Creek FAP Closure

Project Settings

Document Name	FAP CWP - Primary Consol - Staged.s3z
Project Title	Tanners Creek FAP Closure
Analysis	Settlement Analysis
Author	mtr
Company	S&ME, Inc.
Stress Computation Method	Boussinesq
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name
1	Stage 1
2	Stage 2

Results

Time taken to compute: 0 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	9.62873
Total Consolidation Settlement [in]	0	9.62873
Virgin Consolidation Settlement [in]	0	9.62873
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.217231	1.0608
Loading Stress XX [ksf]	-0.00428725	0.81663
Loading Stress YY [ksf]	-0.00428725	0.81663
Effective Stress ZZ [ksf]	0.2652	4.82595
Effective Stress XX [ksf]	0.18564	4.35124
Effective Stress YY [ksf]	0.18564	4.35124
Total Stress ZZ [ksf]	0.2652	9.19395
Total Stress XX [ksf]	0.18564	8.71924
Total Stress YY [ksf]	0.18564	8.71924
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0	0.0809339
Pore Water Pressure [ksf]	0	4.368
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.2955	4.82482
Over-consolidation Ratio	1	1
Void Ratio	0	1.11989
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	0	0.0323798

Stage: Stage 2

Data Type	Minimum	Maximum
Total Settlement [in]	0	12.8946
Total Consolidation Settlement [in]	0	12.8946
Virgin Consolidation Settlement [in]	0	12.8946
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.343602	1.75736
Loading Stress XX [ksf]	-0.372446	1.24345
Loading Stress YY [ksf]	-0.171395	1.63949
Effective Stress ZZ [ksf]	0.417218	5.08445
Effective Stress XX [ksf]	0.0798149	4.72182
Effective Stress YY [ksf]	-0.00580682	5.24607
Total Stress ZZ [ksf]	0.417218	9.45245
Total Stress XX [ksf]	0.0798149	9.08982
Total Stress YY [ksf]	-0.00580682	9.61407
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0	0.0920717
Pore Water Pressure [ksf]	0	4.368
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.447918	5.08342
Over-consolidation Ratio	1	1
Void Ratio	0	1.11467
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	0	0.0465321

Embankments

1. Embankment: "Ash Fill"

Label	Ash Fill
Center Line	(0, -50) to (0, 50)
Number of Layers	1
Near End Angle	90 degrees
Far End Angle	90 degrees
Base Width	100

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft^3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 2	0	45	4	0.179	45	0

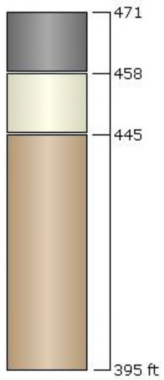
2. Embankment: "Pond Water"

Label	Pond Water
Center Line	(0, -50) to (0, 50)
Number of Layers	1
Near End Angle	90 degrees
Far End Angle	90 degrees
Base Width	100

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft^3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1	0	90	17	0.0624	90	0

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Ash	13	-471
2	Upper & Lower Clay	13	-458
3	Sand and Gravel	50	-445



Soil Properties

Property	Ash	Upper & Lower Clay	Sand and Gravel
Color			
Unit Weight [kips/ft^3]	0.101	0.125	0.115
Saturated Unit Weight [kips/ft^3]	0.106	0.125	0.115
K0	1	1	1
Primary Consolidation	Enabled	Enabled	Disabled
Material Type	Non-Linear	Non-Linear	
Cc	-	0.23	-
Cce	0.052	-	-
Cr	-	0.023	-
Cre	0.052	-	-
e0	1.13	0.75	-
OCR	1	1	-
Undrained Su A [kips/ft2]	0	0	0
Undrained Su S	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8
Piezo Line ID	0	2	2

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft^3

Piezometric Line Entities

ID	Depth (ft)
2	-465 ft

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Query Point 1	0, 0	Auto: 53

Field Point Grid

Number of points 289
Expansion Factor 2

Grid Coordinates

X [ft]	Y [ft]
100	100
100	-100
-100	-100
-100	100

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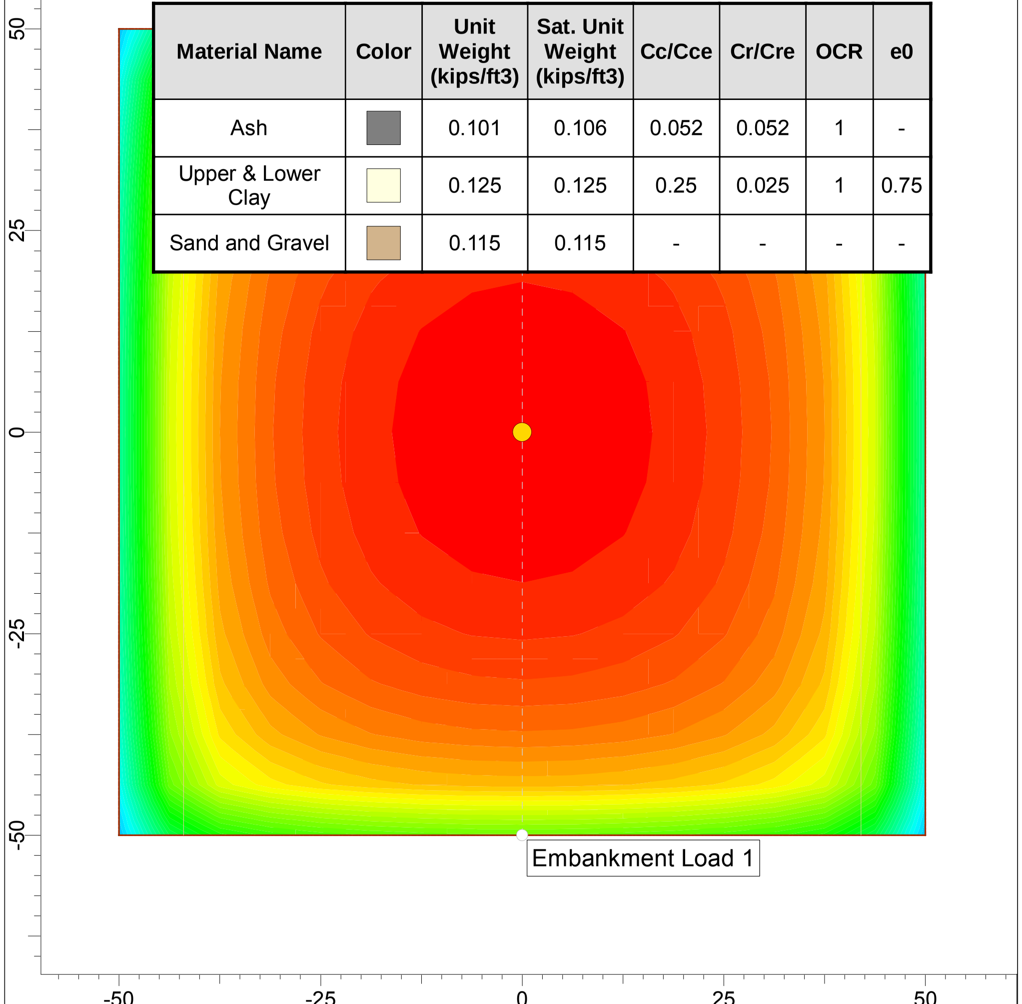
Calculation 2 – Upper Basin Section Settlement Calculations

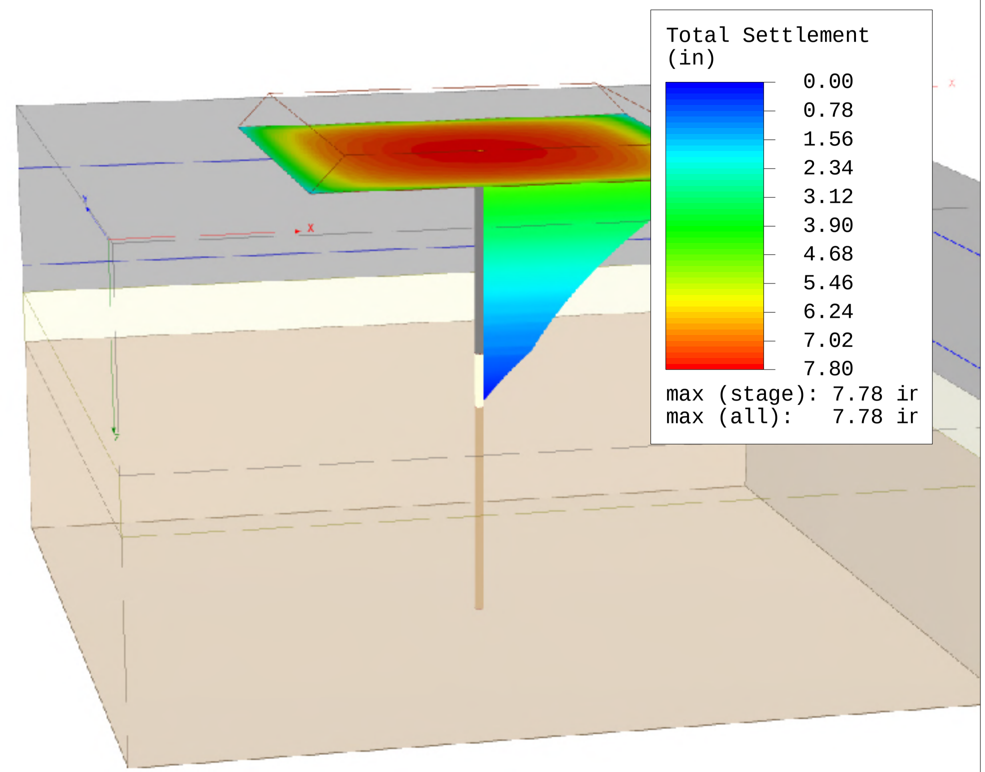
- 1-D Consolidation Analysis using Settle3D
- CPT-based Modulus Approach (CPT-1P & CPT-5P)

Tanners Creek Fly Ash Pond Closure
Settlement Analysis

Upper Basin
-Settlement at max embankment height (8')
-Consolidation at ground surface

Material Name	Color	Unit Weight (kips/ft3)	Sat. Unit Weight (kips/ft3)	Cc/Cce	Cr/Cre	OCR	e0
Ash		0.101	0.106	0.052	0.052	1	-
Upper & Lower Clay		0.125	0.125	0.25	0.025	1	0.75
Sand and Gravel		0.115	0.115	-	-	-	-





Project	Tanners Creek FAP Closure
Analysis Description	Settlement Analysis
Drawn By	mtr
Company	S&ME, Inc.
Date	
File Name	FAP Upper Basin - Primary Consol.s3z

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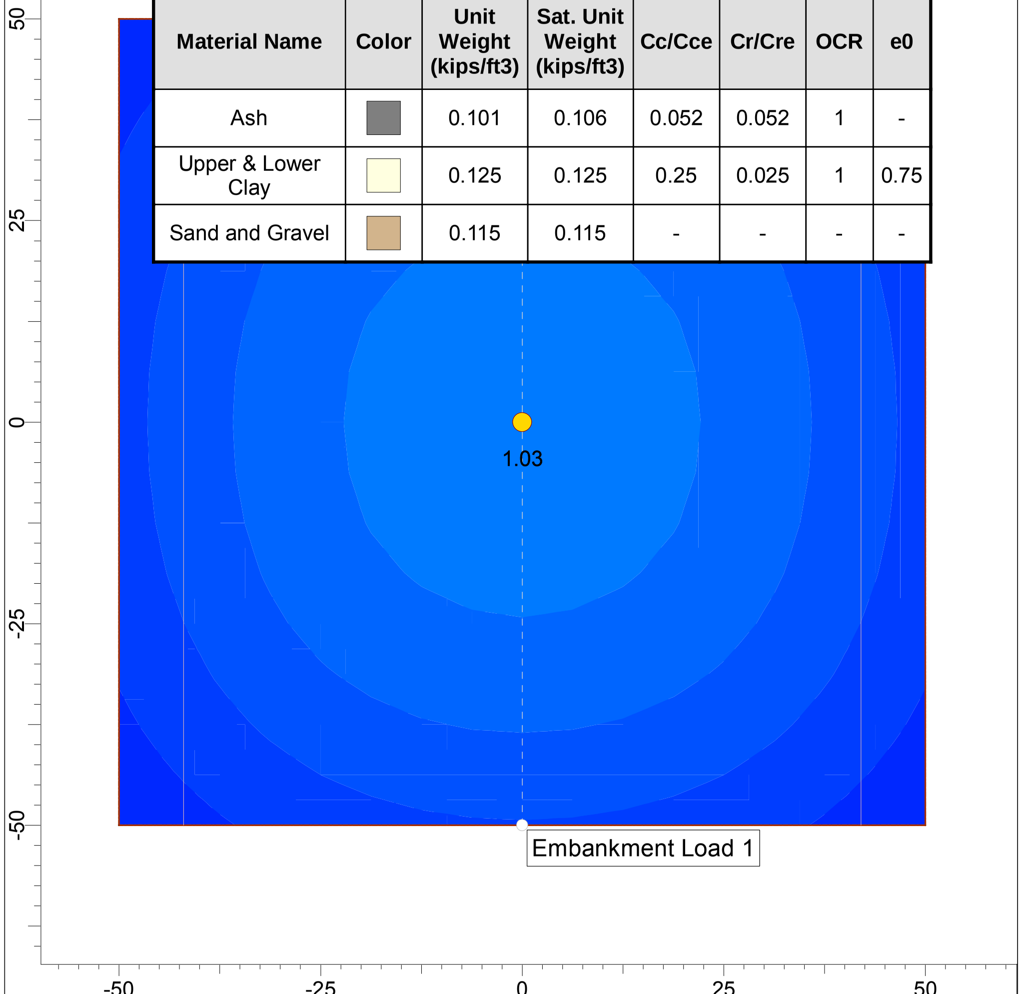
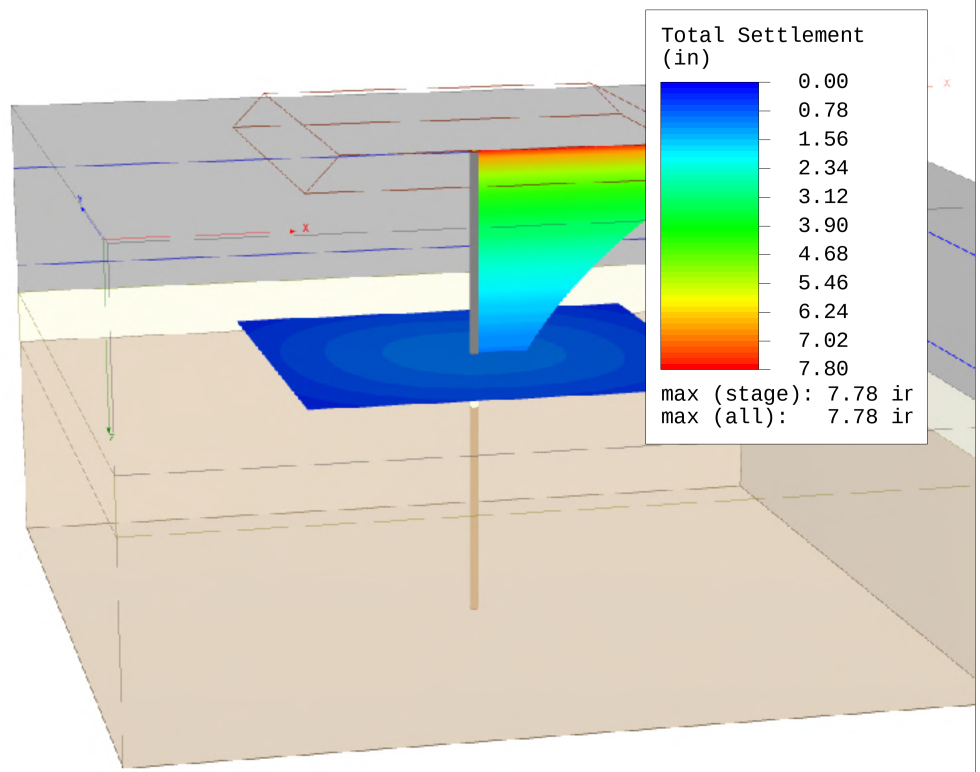
Tanners Creek Fly Ash Pond Closure
Settlement Analysis

Upper Basin
-Settlement at max embankment height (8')
-Consolidation at top of clay (EL 458)

Material Name	Color	Unit Weight (kips/ft3)	Sat. Unit Weight (kips/ft3)	Cc/Cce	Cr/Cre	OCR	e0
Ash		0.101	0.106	0.052	0.052	1	-
Upper & Lower Clay		0.125	0.125	0.25	0.025	1	0.75
Sand and Gravel		0.115	0.115	-	-	-	-





Project	Tanners Creek FAP Closure		
Analysis Description	Settlement Analysis		
Drawn By	mtr	Company	S&ME, Inc.
Date		File Name	FAP Upper Basin - Primary Consol.s3z

rocscience

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Settle3D Analysis Information
Tanners Creek FAP Closure

Project Settings

Document Name	FAP Upper Basin - Primary Consol.s3z
Project Title	Tanners Creek FAP Closure
Analysis	Settlement Analysis
Author	mtr
Company	S&ME, Inc.
Stress Computation Method	Boussinesq
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 0 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	7.78163
Total Consolidation Settlement [in]	0	7.78163
Virgin Consolidation Settlement [in]	0	7.78163
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	0.880011
Loading Stress XX [ksf]	-0.460024	0.706385
Loading Stress YY [ksf]	-0.453349	1.1957
Effective Stress ZZ [ksf]	0	8.25357
Effective Stress XX [ksf]	0.0609158	8.41462
Effective Stress YY [ksf]	-0.235931	9.15188
Total Stress ZZ [ksf]	0	12.6216
Total Stress XX [ksf]	0.0609158	12.7826
Total Stress YY [ksf]	-0.235931	13.5199
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0	0.0906851
Pore Water Pressure [ksf]	0	4.368
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.0189596	8.2511
Over-consolidation Ratio	1	1
Void Ratio	0	1.12743
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	0	0.0287472

Embankments

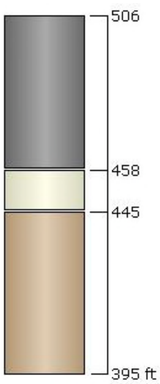
1. Embankment: "Embankment Load 1"

Label	Embankment Load 1
Center Line	(0, -50) to (0, 50)
Number of Layers	1
Near End Angle	90 degrees
Far End Angle	90 degrees
Base Width	100

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft^3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1	0	45	8	0.11	45	0

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Ash	48	-506
2	Upper & Lower Clay	13	-458
3	Sand and Gravel	50	-445



Soil Properties

Property	Ash	Upper & Lower Clay	Sand and Gravel
Color			
Unit Weight [kips/ft^3]	0.101	0.125	0.115
Saturated Unit Weight [kips/ft^3]	0.106	0.125	0.115
K0	1	1	1
Primary Consolidation	Enabled	Enabled	Disabled
Material Type	Non-Linear	Non-Linear	
Cc	-	0.25	-
Cce	0.052	-	-
Cr	-	0.025	-
Cre	0.052	-	-
e0	1.13	0.75	-
OCR	1	1	-
Undrained Su A [kips/ft2]	0	0	0
Undrained Su S	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8
Piezo Line ID	1	2	2

Groundwater

Groundwater method Piezometric Lines
Water Unit Weight 0.0624 kips/ft^3

Piezometric Line Entities

ID	Depth (ft)
1	-490 ft
2	-465 ft

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Query Point 1	0, 0	Auto: 63
2	Query Point 2	0, 0	Auto: 63

Field Point Grid

Number of points 289
Expansion Factor 2

Grid Coordinates

X [ft]	Y [ft]
100	100
100	-100
-100	-100
-100	100

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Settlement Analysis
Tanners Creek Fly Ash Pond Closure
Project No. 7217-17-007A
Date: 7/14/2017

Method: CPT Based Settlement Analysis based on Mayne "Eqivalent CPT Method for Calculating Shallow Foundations Settlements"
Subsurface Data: CPT-1PA

Input Values	
Water Depth (ft)	15
Length Area (ft)	100
Width Area (ft)	100
Surcharge Height (ft)	8
Surcharge Unit Weight (pcf)	110
Surcharge Pressure (psf)	880

Cell Shade Legend
- (green) Input values
- (gray) Imported CPT values
- (yellow) Extended CPT values (to bottom of ash); Average from final 5 feet of CPT sounding

Total Settlement, $\Sigma\Delta\rho_{total}$	
(ft)	(in)
1.03	12.4

Input Values				Computed Values														
Depth	CPT Tip Stress, q_t	Sleeve Friction, Fs	Unit Weight	Total Stress, σ_{TOT}	Insitu Effective Stress, $\sigma_{vo'}$	Friction Ratio, Fr $fs/(q_t-\sigma_{vo})x100\%$	Dialatometer Modulus, E_D	Material Index, I_D	Horizontal Stress Index, K_D	Modified Modulus Ratio, R_{Mo}	Modulus Ratio, R_M	Minimum R_M	Constrained Modulus, M'	Elastic Modulus, E' 0.9xM'	Incremental Layer Depth, ΔZ	Vertical Stress Influence Factor, I_σ	Vertical Stress Change, $\Delta\sigma_{v'}$	Incremental Settlement, $\Delta\rho$
(ft)	(tsf)	(tsf)	(pcf)	(psf)	(psf)		(tsf)					min. 0.85	(tsf)	(tsf)	(ft)		(psf)	(ft)
0				0	0													
0.235	3.540	0.000	101	23.78	23.78	0.000	17.7	2.000	21.450	0.350	3.223	3.223	57.038	51.334	0.118	0.997	877.36191	0
0.359	3.710	0.202	101	36.28	36.28	5.461	18.55	1.236	23.856	0.235	3.323	3.323	61.644	55.480	0.180	0.99543	875.97583	0.00127593
0.469	3.010	0.201	101	47.33	47.33	6.737	15.05	1.057	17.343	0.209	3.021	3.021	45.471	40.924	0.117	0.99403	874.74966	0.001121315
0.560	3.710	0.197	101	56.53	56.53	5.356	18.55	1.250	15.130	0.238	2.892	2.892	53.648	48.283	0.100	0.99287	873.72945	0.000816359
0.660	4.410	0.179	101	66.70	66.70	4.083	22.05	1.428	13.340	0.264	2.773	2.773	61.141	55.027	0.096	0.99159	872.60115	0.00068423
0.758	4.410	0.158	101	76.59	76.59	3.621	22.05	1.493	11.114	0.274	2.600	2.600	57.329	51.596	0.099	0.99035	871.5038	0.000754992
0.852	3.800	0.148	101	86.07	86.07	3.947	19	1.447	8.791	0.267	2.375	2.375	45.126	40.614	0.096	0.98915	870.45288	0.00092473
0.955	3.450	0.147	101	96.47	96.47	4.307	17.25	1.397	7.377	0.260	2.204	2.204	38.019	34.217	0.098	0.98784	869.29894	0.001125068
1.055	4.320	0.148	101	106.55	106.55	3.464	21.6	1.515	7.712	0.277	2.249	2.249	48.583	43.725	0.101	0.98657	868.18101	0.000906048
1.156	4.230	0.140	101	116.77	116.77	3.356	21.15	1.530	6.823	0.280	2.131	2.131	45.077	40.569	0.100	0.98528	867.0478	0.000966406
1.255	4.750	0.133	101	126.75	126.75	2.827	23.75	1.604	6.732	0.291	2.120	2.120	50.358	45.322	0.100	0.98402	865.94041	0.000859964
1.357	4.060	0.137	101	137.06	137.06	3.422	20.3	1.521	5.613	0.278	1.943	1.943	39.437	35.493	0.100	0.98272	864.79703	0.001101692
1.612	3.540	0.133	101	162.84	162.84	3.834	17.7	1.463	4.281	0.269	1.678	1.678	29.705	26.735	0.179	0.97948	861.93888	0.002592047
1.712	2.670	0.138	101	172.92	172.92	5.342	13.35	1.252	3.554	0.238	1.484	1.484	19.805	17.825	0.178	0.97821	860.82156	0.003857712
1.837	2.840	0.134	101	185.55	185.55	4.878	14.2	1.317	3.349	0.248	1.430	1.430	20.304	18.273	0.112	0.97662	859.4212	0.002379576
1.944	3.540	0.140	101	196.38	196.38	4.059	17.7	1.432	3.628	0.265	1.516	1.516	26.831	24.148	0.116	0.97525	858.22171	0.001857055
2.074	3.020	0.164	101	209.52	209.52	5.632	15.1	1.211	3.429	0.232	1.446	1.446	21.828	19.645	0.119	0.9736	856.76503	0.002328431
2.176	3.190	0.179	101	219.74	219.74	5.808	15.95	1.187	3.525	0.228	1.471	1.471	23.465	21.118	0.116	0.97231	855.63275	0.00210864
2.309	3.450	0.147	101	233.16	233.16	4.398	17.25	1.384	3.080	0.258	1.353	1.353	23.344	21.009	0.117	0.97062	854.14554	0.002141139
2.407	2.230	0.139	101	243.10	243.10	6.602	11.15	1.076	2.457	0.211	1.105	1.105	12.321	11.089	0.116	0.96937	853.04432	0.004003775
2.521	1.100	0.126	101	254.57	254.57	12.995	5.5	0.181	6.889	0.077	2.118	2.118	11.649	10.484	0.106	0.96792	851.77364	0.00387529
2.641	1.890	0.125	101	266.74	266.74	7.105	9.45	1.005	2.031	0.201	0.908	0.908	8.583	7.725	0.117	0.96639	850.42585	0.005797767
2.742	1.710	0.126	101	276.96	276.96	8.030	8.55	0.876	2.032	0.181	0.895	0.895	7.654	6.889	0.111	0.96511	849.29434	0.006148868
2.868	2.230	0.121	101	289.69	289.69	5.793	11.15	1.189	1.866	0.228	0.844	0.850	9.478	8.530	0.114	0.96351	847.88535	0.005080826
2.973	1.800	0.118	101	300.23	300.23	7.152	9	0.999	1.730	0.200	0.747	0.850	7.650	6.885	0.115	0.96218	846.71809	0.006375289
3.105	1.370	0.120	101	313.61	313.61	9.899	6.85	0.614	2.050	0.142	0.877	0.877	6.009	5.408	0.118	0.9605	845.23758	0.008328259
3.203	1.450	0.124	101	323.55	323.55	9.641	7.25	0.650	1.986	0.148	0.849	0.850	6.163	5.546	0.115	0.95925	844.13768	0.007905444
3.337	1.450	0.116	101	337.02	337.02	9.052	7.25	0.733	1.692	0.160	0.694	0.850	6.163	5.546	0.116	0.95755	842.64744	0.007922937
3.434	1.370	0.117	101	346.82	346.82	9.811	6.85	0.626	1.817	0.144	0.755	0.850	5.823	5.240	0.115	0.95632	841.56337	0.008324937
3.560	1.280	0.119	101	359.59	359.59	10.780	6.4	0.491	2.090	0.124	0.896	0.896	5.731	5.158	0.112	0.95472	840.15066	0.008190478

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
3.664	1.190	0.112	101	370.09	370.09	11.165	5.95	0.437	2.121	0.116	0.911	0.911	5.417	4.876	0.115	0.9534	838.98996	0.008920325
3.789	1.020	0.111	101	382.72	382.72	13.347	5.1	0.131	5.845	0.070	1.950	1.950	9.943	8.949	0.115	0.95181	837.59336	0.004822775
3.897	1.100	0.116	101	393.59	393.59	12.832	5.5	0.204	3.958	0.081	1.550	1.550	8.525	7.672	0.116	0.95045	836.39208	0.005707528
4.012	1.370	0.129	101	405.20	405.20	11.084	6.85	0.448	2.174	0.117	0.936	0.936	6.411	5.770	0.111	0.94899	835.10891	0.007248016
4.129	1.280	0.133	101	417.04	417.04	12.366	6.4	0.269	3.291	0.090	1.361	1.361	8.710	7.839	0.116	0.9475	833.8005	0.005557702
4.210	1.630	0.137	101	425.17	425.17	9.658	8.15	0.648	1.705	0.147	0.693	0.850	6.928	6.235	0.099	0.94648	832.90266	0.005943637
4.294	1.800	0.141	101	433.67	433.67	8.900	9	0.754	1.586	0.163	0.631	0.850	7.650	6.885	0.082	0.94541	831.96394	0.004476292
4.364	1.800	0.144	101	440.73	440.73	9.091	9	0.727	1.618	0.159	0.648	0.850	7.650	6.885	0.077	0.94453	831.18451	0.004184444
4.463	1.630	0.147	101	450.72	450.72	10.494	8.15	0.531	1.963	0.130	0.831	0.850	6.928	6.235	0.084	0.94327	830.08198	0.005055682
4.560	1.630	0.151	101	460.57	460.57	10.795	8.15	0.489	2.087	0.123	0.894	0.894	7.287	6.558	0.098	0.94204	828.99518	0.005585072
4.633	0.840	0.154	101	467.90	467.90	25.444	4.2	0.200	2.587	0.080	1.114	1.114	4.679	4.211	0.085	0.94112	828.18534	0.00752866
4.957	1.280	0.155	101	500.69	500.69	15.005	6.4	0.200	3.684	0.080	1.476	1.476	9.449	8.504	0.199	0.93701	824.5685	0.008667994
5.088	2.060	0.139	101	513.89	513.89	7.698	10.3	0.922	1.253	0.188	0.414	0.850	8.755	7.880	0.228	0.93536	823.11426	0.01070072
5.190	1.190	0.129	101	524.15	524.15	13.870	5.95	0.058	11.233	0.059	2.610	2.610	15.530	13.977	0.116	0.93407	821.98302	0.003073077
5.288	0.670	0.131	101	534.09	534.09	32.584	3.35	0.200	1.808	0.080	0.747	0.850	2.848	2.563	0.100	0.93283	820.88791	0.014417069
5.406	1.020	0.133	101	546.03	546.03	17.738	5.1	0.200	2.692	0.080	1.155	1.155	5.890	5.301	0.108	0.93133	819.57317	0.007534684
5.522	1.540	0.153	101	557.68	557.68	12.116	7.7	0.304	2.620	0.096	1.127	1.127	8.678	7.810	0.117	0.92987	818.28942	0.005506856
5.622	1.890	0.181	101	567.81	567.81	11.238	9.45	0.427	2.248	0.114	0.970	0.970	9.171	8.254	0.108	0.92861	817.17483	0.004804583
5.724	1.980	0.206	101	578.17	578.17	12.159	9.9	0.298	3.315	0.095	1.368	1.368	13.546	12.191	0.101	0.92731	816.03499	0.003054236
5.844	2.500	0.223	101	590.29	590.29	10.128	12.5	0.582	2.097	0.137	0.899	0.899	11.235	10.112	0.111	0.9258	814.70128	0.004035071
5.953	2.760	0.235	101	601.21	601.21	9.547	13.8	0.663	1.994	0.150	0.854	0.854	11.787	10.608	0.114	0.92443	813.50087	0.003935707
6.052	2.670	0.244	101	611.28	611.28	10.333	13.35	0.553	2.274	0.133	0.982	0.982	13.113	11.801	0.104	0.92317	812.39276	0.00321949
6.181	2.580	0.232	101	624.24	624.24	10.239	12.9	0.567	2.102	0.135	0.901	0.901	11.629	10.466	0.114	0.92156	810.96856	0.00397646
6.283	2.580	0.205	101	634.60	634.60	9.069	12.9	0.730	1.604	0.160	0.640	0.850	10.965	9.869	0.115	0.92026	809.8306	0.004262412
6.386	2.320	0.185	101	645.00	645.00	9.267	11.6	0.703	1.475	0.155	0.551	0.850	9.860	8.874	0.103	0.91896	808.68791	0.004214855
6.513	0.840	0.177	101	657.82	657.82	34.710	4.2	0.200	1.840	0.080	0.765	0.850	3.570	3.213	0.115	0.91736	807.28038	0.012999023
6.616	1.100	0.175	101	668.23	668.23	22.784	5.5	0.200	2.372	0.080	1.025	1.025	5.639	5.075	0.115	0.91607	806.13852	0.008218058
6.734	2.500	0.177	101	680.16	680.16	8.190	12.5	0.853	1.241	0.178	0.396	0.850	10.625	9.563	0.111	0.91458	804.82898	0.004188709
6.847	3.190	0.198	101	691.59	691.59	6.958	15.95	1.026	1.296	0.204	0.462	0.850	13.558	12.202	0.116	0.91315	803.57589	0.003427533
6.948	3.020	0.224	101	701.72	701.72	8.407	15.1	0.823	1.507	0.173	0.588	0.850	12.835	11.552	0.107	0.91189	802.46586	0.003335219
7.076	2.670	0.231	101	714.72	714.72	10.006	13.35	0.599	1.797	0.140	0.741	0.850	11.348	10.213	0.115	0.91027	801.04072	0.004041558
7.181	2.500	0.244	101	725.26	725.26	11.416	12.5	0.402	2.472	0.110	1.068	1.068	13.347	12.013	0.117	0.90896	799.88578	0.003493051
7.283	3.280	0.247	101	735.58	735.58	8.492	16.4	0.811	1.584	0.172	0.637	0.850	13.940	12.546	0.103	0.90768	798.75659	0.002957949
7.408	3.020	0.254	101	748.26	748.26	9.585	15.1	0.658	1.767	0.149	0.730	0.850	12.835	11.552	0.114	0.9061	797.36873	0.003535509
7.511	3.280	0.260	101	758.66	758.66	8.950	16.4	0.747	1.668	0.162	0.681	0.850	13.940	12.546	0.114	0.90481	796.23043	0.003263602
7.623	3.360	0.251	101	769.90	769.90	8.433	16.8	0.819	1.535	0.173	0.606	0.850	14.280	12.852	0.107	0.90341	795.00111	0.002982646
7.744	3.450	0.267	101	782.16	782.16	8.738	17.25	0.777	1.637	0.166	0.666	0.850	14.663	13.196	0.116	0.90189	793.66071	0.003148796
7.841	3.450	0.275	101	791.96	791.96	9.005	17.25	0.739	1.698	0.161	0.699	0.850	14.663	13.196	0.109	0.90067	792.58983	0.00295184
7.935	3.370	0.271	101	801.48	801.48	9.120	16.85	0.723	1.676	0.158	0.683	0.850	14.323	12.890	0.096	0.89949	791.54968	0.002643243
8.044	3.190	0.250	101	812.45	812.45	8.988	15.95	0.742	1.526	0.161	0.590	0.850	13.558	12.202	0.101	0.89813	790.3528	0.002955771
8.178	3.370	0.231	101	825.96	825.96	7.812	16.85	0.906	1.297	0.186	0.448	0.850	14.323	12.890	0.121	0.89645	788.87773	0.003337136
8.278	2.500	0.213	101	836.04	836.04	10.240	12.5	0.566	1.522	0.135	0.570	0.850	10.625	9.563	0.117	0.8952	787.77828	0.004330186
8.408	1.890	0.199	101	849.23	849.23	13.587	9.45	0.098	6.555	0.065	2.067	2.067	19.535	17.581	0.115	0.89357	786.34006	0.002318485
8.538	2.580	0.183	101	862.33	862.33	8.493	12.9	0.811	1.063	0.172	0.234	0.850	10.965	9.869	0.130	0.89195	784.91274	0.004657936
8.644	2.930	0.188	101	873.01	873.01	7.524	14.65	0.947	1.022	0.192	0.213	0.850	12.453	11.207	0.118	0.89062	783.74917	0.003704753
8.774	2.850	0.205	101	886.16	886.16	8.525	14.25	0.806	1.149	0.171	0.312	0.850	12.113	10.901	0.118	0.889	782.31811	0.003809381
8.907	2.410	0.205	101	899.58	899.58	10.448	12.05	0.537	1.437	0.131	0.512	0.850	10.243	9.218	0.132	0.88734	780.85764	0.005013537
9.019	2.500	0.199	101	910.91	910.91	9.733	12.5	0.637	1.241	0.146	0.366	0.850	10.625	9.563	0.123	0.88594	779.6252	0.004496328
9.140	2.410	0.180	101	923.13	923.13	9.223	12.05	0.709	1.061	0.156	0.217	0.850	10.243	9.218	0.117	0.88443	778.29757	0.004429096
9.270	2.150	0.167	101	936.22	936.22	9.923	10.75	0.611	1.084	0.142	0.224	0.850	9.138	8.224	0.125	0.88281	776.87479	0.005326959
9.396	1.980	0.160	101	949.00	949.00	10.601	9.9	0.516	1.166	0.127	0.297	0.850	8.415	7.574	0.128	0.88124	775.48805	0.005901404
9.506	1.800	0.163	101	960.10	960.10	12.341	9	0.272	1.985	0.091	0.843	0.850	7.650	6.885	0.118	0.87987	774.28354	0.005981214
9.636	1.980	0.175	101	973.20	973.20	11.712	9.9	0.360	1.627	0.104	0.639	0.850	8.415	7.574	0.120	0.87825	772.86317	0.005501197
9.768	2.670	0.187	101	986.53	986.53	8.591	13.35	0.797	0.978	0.170	0.147	0.850	11.348	10.213	0.131	0.87661	771.41851	0.004447001
9.900	3.020	0.192	101	999.95	999.95	7.603	15.1	0.936	0.930	0.190	0.118	0.850	12.835	11.552	0.132	0.87496	769.9647	0.003972502
10.008	3.460	0.191	101	1010.82	1010.82	6.451	17.3	1.097	0.899	0.215	0.109	0.850	14.705	13.235	0.120	0.87362	768.78822	0.00314351
10.132	3.720	0.196	101	1023.36	1023.36	6.115	18.6	1.144	0.916	0.222	0.135	0.850	15.810	14.229	0.116	0.87208	767.43148	0.002812702
10.264	3.540	0.191	101	1036.64	1036.64	6.328	17.7	1.114	0.883	0.217	0.094	0.850	15.045	13.541	0.128	0.87045	765.99534	0.003254526

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
10.381	4.320	0.192	101	1048.44	1048.44	5.053	21.6	1.293	0.919	0.244	0.161	0.850	18.360	16.524	0.124	0.869	764.72062	0.002585826
10.499	3.890	0.195	101	1060.38	1060.38	5.807	19.45	1.187	0.891	0.228	0.114	0.850	16.533	14.879	0.117	0.86754	763.43172	0.002712821
10.629	3.460	0.190	101	1073.57	1073.57	6.483	17.3	1.092	0.850	0.214	0.053	0.850	14.705	13.235	0.124	0.86592	762.00829	0.003222925
10.738	2.500	0.173	101	1084.53	1084.53	8.827	12.5	0.764	0.869	0.165	0.022	0.850	10.625	9.563	0.120	0.86458	760.82613	0.004280855
10.862	2.330	0.155	101	1097.07	1097.07	8.706	11.65	0.781	0.784	0.167	-0.080	0.850	9.903	8.912	0.116	0.86304	759.47444	0.004461745
10.996	2.330	0.149	101	1110.59	1110.59	8.396	11.65	0.825	0.733	0.174	-0.140	0.850	9.903	8.912	0.129	0.86138	758.0187	0.004937169
11.127	1.990	0.134	101	1123.87	1123.87	9.362	9.95	0.689	0.740	0.153	-0.153	0.850	8.458	7.612	0.133	0.85976	756.58901	0.005934181
11.226	1.730	0.132	101	1133.81	1133.81	11.366	8.65	0.409	1.076	0.111	0.215	0.850	7.353	6.617	0.115	0.85855	755.51991	0.005906722
11.292	2.180	0.133	101	1140.45	1140.45	8.274	10.9	0.842	0.655	0.176	-0.251	0.850	9.265	8.339	0.082	0.85773	754.80583	0.003343672
11.420	2.100	0.144	101	1153.41	1153.41	9.447	10.5	0.677	0.774	0.152	-0.109	0.850	8.925	8.033	0.097	0.85615	753.41327	0.004095656
11.541	2.010	0.146	101	1165.62	1165.62	10.223	10.05	0.569	0.874	0.135	0.002	0.850	8.543	7.688	0.125	0.85466	752.10162	0.005486138
11.655	2.450	0.147	101	1177.19	1177.19	7.897	12.25	0.894	0.671	0.184	-0.218	0.850	10.413	9.371	0.118	0.85325	750.86052	0.00424466
11.789	2.620	0.155	101	1190.66	1190.66	7.675	13.1	0.925	0.685	0.189	-0.191	0.850	11.135	10.022	0.124	0.85161	749.41614	0.004170583
11.923	2.710	0.168	101	1204.22	1204.22	7.980	13.55	0.883	0.735	0.182	-0.128	0.850	11.518	10.366	0.134	0.84996	747.96292	0.004345231
12.055	3.840	0.196	101	1217.60	1217.60	6.066	19.2	1.151	0.790	0.223	-0.011	0.850	16.320	14.688	0.133	0.84833	746.53072	0.003050164
12.185	6.610	0.232	101	1230.70	1230.70	3.863	33.05	1.459	1.061	0.269	0.326	0.850	28.093	25.283	0.131	0.84674	745.12934	0.001738193
12.315	8.440	0.263	101	1243.84	1243.84	3.364	42.2	1.529	1.279	0.279	0.517	0.850	35.870	32.283	0.130	0.84514	743.72418	0.001346821
12.447	8.350	0.292	101	1257.17	1257.17	3.784	41.75	1.470	1.302	0.271	0.526	0.850	35.488	31.939	0.131	0.84352	742.30027	0.001370706
12.569	8.520	0.295	101	1269.43	1269.43	3.745	42.6	1.476	1.311	0.271	0.533	0.850	36.210	32.589	0.127	0.84204	740.9914	0.001296326
12.686	7.660	0.268	101	1281.28	1281.28	3.824	38.3	1.465	1.176	0.270	0.427	0.850	32.555	29.300	0.119	0.8406	739.72819	0.00135579
12.815	6.440	0.227	101	1294.28	1294.28	3.920	32.2	1.451	0.988	0.268	0.256	0.850	27.370	24.633	0.123	0.83903	738.34205	0.001659246
12.949	4.270	0.220	101	1307.89	1307.89	6.070	21.35	1.150	0.818	0.223	0.024	0.850	18.148	16.333	0.132	0.83738	736.89282	0.002675005
13.084	4.190	0.222	101	1321.50	1321.50	6.302	20.95	1.118	0.817	0.218	0.018	0.850	17.808	16.027	0.135	0.83573	735.44483	0.002782362
13.216	5.630	0.218	101	1334.78	1334.78	4.397	28.15	1.384	0.878	0.258	0.131	0.850	23.928	21.535	0.133	0.83413	734.03263	0.002042039
13.348	5.730	0.224	101	1348.11	1348.11	4.423	28.65	1.381	0.887	0.257	0.140	0.850	24.353	21.917	0.132	0.83252	732.61668	0.001981773
13.482	6.240	0.230	101	1361.68	1361.68	4.143	31.2	1.420	0.930	0.263	0.193	0.850	26.520	23.868	0.133	0.83088	731.17731	0.00183525
13.613	7.020	0.211	101	1374.87	1374.87	3.334	35.1	1.533	0.960	0.280	0.240	0.850	29.835	26.852	0.132	0.82929	729.77848	0.001619834
13.743	7.270	0.202	101	1388.01	1388.01	3.070	36.35	1.570	0.961	0.286	0.248	0.850	30.898	27.808	0.130	0.82771	728.38588	0.001536747
13.850	6.660	0.201	101	1398.83	1398.83	3.370	33.3	1.528	0.898	0.279	0.175	0.850	28.305	25.475	0.119	0.82641	727.2402	0.001524173
13.977	6.830	0.182	101	1411.70	1411.70	2.972	34.15	1.584	0.880	0.288	0.165	0.850	29.028	26.125	0.117	0.82486	725.87927	0.0014662
14.109	7.280	0.152	101	1424.98	1424.98	2.308	36.4	1.677	0.878	0.302	0.177	0.850	30.940	27.846	0.129	0.82327	724.47535	0.001515568
14.242	6.150	0.126	101	1438.41	1438.41	2.311	30.75	1.676	0.735	0.301	0.007	0.850	26.138	23.524	0.132	0.82166	723.05797	0.001828704
14.374	6.080	0.103	101	1451.78	1451.78	1.922	30.4	1.731	0.697	0.310	-0.033	0.850	25.840	23.256	0.133	0.82005	721.64668	0.001852641
14.511	5.560	0.087	101	1465.58	1465.58	1.800	27.8	1.748	0.625	0.312	-0.134	0.850	23.630	21.267	0.135	0.8184	720.19273	0.002049867
14.802	5.560	0.079	101	1494.98	1494.98	1.650	27.8	1.769	0.606	0.315	-0.160	0.850	23.630	21.267	0.214	0.81488	717.09862	0.003244621
14.934	5.230	0.111	101	1508.31	1508.31	2.476	26.15	1.653	0.604	0.298	-0.184	0.850	22.228	20.005	0.212	0.81329	715.69775	0.003405662
15.060	4.540	0.097	101	1521.03	1517.31	2.577	22.7	1.639	0.526	0.296	-0.319	0.850	19.295	17.366	0.129	0.81177	714.36169	0.002387901
15.166	3.950	0.095	101	1531.81	1521.42	2.968	19.75	1.584	0.472	0.288	-0.433	0.850	16.788	15.109	0.116	0.81049	713.23134	0.002471509
15.224	6.370	0.095	101	1537.66	1523.66	1.698	31.85	1.762	0.684	0.314	-0.047	0.850	27.073	24.365	0.082	0.80979	712.61785	0.001083371
15.343	6.640	0.095	101	1549.65	1528.24	1.625	33.2	1.773	0.706	0.316	-0.014	0.850	28.220	25.398	0.088	0.80837	711.36235	0.001112859
15.438	7.960	0.097	101	1559.26	1531.92	1.351	39.8	1.811	0.827	0.322	0.142	0.850	33.830	30.447	0.107	0.80722	710.35588	0.001122543
15.538	8.060	0.104	101	1569.29	1535.75	1.428	40.3	1.800	0.840	0.320	0.155	0.850	34.255	30.830	0.097	0.80603	709.3064	0.001006965
15.639	8.500	0.112	101	1579.51	1539.65	1.453	42.5	1.797	0.886	0.319	0.204	0.850	36.125	32.513	0.100	0.80482	708.23828	0.000982711
15.739	8.760	0.116	101	1589.59	1543.51	1.454	43.8	1.796	0.910	0.319	0.231	0.850	37.230	33.507	0.100	0.80362	707.18551	0.000954311
15.838	8.410	0.118	101	1599.67	1547.36	1.556	42.05	1.782	0.879	0.317	0.195	0.850	35.743	32.168	0.100	0.80242	706.13344	0.000985781
15.940	8.320	0.127	101	1609.93	1551.28	1.683	41.6	1.764	0.876	0.315	0.189	0.850	35.360	31.824	0.101	0.80121	705.06289	0.001004106
16.040	8.320	0.134	101	1620.0127	1555.134	1.787	41.600	1.750	0.881	0.312	0.192	0.850	35.360	31.824	0.101	0.80001	704.01252	0.001002561
16.135	7.970	0.138	101	1629.6734	1558.826	1.926	39.850	1.730	0.852	0.310	0.157	0.850	33.873	30.485	0.098	0.79887	703.00649	0.001014064
16.235	7.620	0.145	101	1639.7522	1562.678	2.137	38.100	1.701	0.826	0.305	0.123	0.850	32.385	29.147	0.098	0.79768	701.95771	0.00105906
16.337	8.230	0.159	101	1650.0633	1566.618	2.140	41.150	1.700	0.890	0.305	0.194	0.850	34.978	31.480	0.101	0.79646	700.88559	0.001011327
16.443	9.020	0.157	101	1660.746	1570.701	1.918	45.100	1.731	0.956	0.310	0.267	0.850	38.335	34.502	0.104	0.7952	699.77572	0.000948581
16.537	10.160	0.146	101	1670.2673	1574.34	1.565	50.800	1.781	1.044	0.317	0.358	0.850	43.180	38.862	0.100	0.79408	698.7873	0.000809318
16.637	10.420	0.145	101	1680.2996	1578.174	1.514	52.100	1.788	1.064	0.318	0.377	0.850	44.285	39.857	0.097	0.79289	697.74662	0.000762582
16.713	10.230	0.143	101	1688.0564	1581.138	1.525	51.150	1.787	1.044	0.318	0.358	0.850	43.478	39.130	0.088	0.79198	696.94255	0.000705839
16.799	10.140	0.141	101	1696.7424	1584.458	1.513	50.700	1.788	1.031	0.318	0.348	0.850	43.095	38.786	0.081	0.79096	696.04274	0.00065736
16.869	9.880	0.141	101	1703.7559	1587.138	1.557	49.400	1.782	1.007	0.317	0.324	0.850	41.990	37.791	0.078	0.79013	695.31665	0.000643487
16.936	9.610	0.141	101	1710.537	1589.73	1.606	48.050	1.775	0.981	0.316	0.298	0.850	40.843	36.758	0.068	0.78934	694.61499	0.00058071
17.032	8.920	0.139	101	1720.2441	1593.44	1.726	44.600	1.758	0.917	0.314	0.232	0.850	37.910	34.119	0.082	0.78819	693.61124	0.000746716

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
17.131	8.310	0.135	101	1730.1835	1597.238	1.807	41.550	1.747	0.858	0.312	0.167	0.850	35.318	31.786	0.097	0.78703	692.58427	0.000953645
17.230	8.040	0.130	101	1740.2633	1601.091	1.812	40.200	1.746	0.829	0.312	0.133	0.850	34.170	30.753	0.099	0.78585	691.54364	0.00100286
17.297	7.950	0.129	101	1747.0445	1603.682	1.816	39.750	1.746	0.818	0.312	0.121	0.850	33.788	30.409	0.083	0.78505	690.84404	0.000853344
17.398	7.950	0.130	101	1757.1697	1607.552	1.834	39.750	1.743	0.818	0.311	0.120	0.850	33.788	30.409	0.084	0.78386	689.80015	0.000854352
17.496	7.520	0.122	101	1767.1091	1611.351	1.843	37.600	1.742	0.772	0.311	0.065	0.850	31.960	28.764	0.099	0.7827	688.77625	0.00107034
17.575	6.730	0.112	101	1775.0518	1614.386	1.910	33.650	1.733	0.693	0.310	-0.038	0.850	28.603	25.742	0.089	0.78177	687.95865	0.001064619
17.660	6.380	0.100	101	1783.6438	1617.67	1.822	31.900	1.745	0.651	0.312	-0.096	0.850	27.115	24.404	0.082	0.78077	687.07481	0.001037074
17.760	6.380	0.088	101	1793.7691	1621.539	1.610	31.900	1.775	0.639	0.316	-0.109	0.850	27.115	24.404	0.093	0.77958	686.03405	0.001172191
17.857	5.680	0.083	101	1803.5227	1625.267	1.729	28.400	1.758	0.573	0.314	-0.215	0.850	24.140	21.726	0.098	0.77845	685.03233	0.001396314
17.930	5.070	0.079	101	1810.9078	1628.09	1.890	25.350	1.735	0.517	0.310	-0.317	0.850	21.548	19.393	0.085	0.77758	684.2744	0.001347193
17.992	4.980	0.077	101	1817.1789	1630.486	1.886	24.900	1.736	0.507	0.310	-0.335	0.850	21.165	19.049	0.068	0.77685	683.63117	0.001091823
18.024	3.850	0.077	101	1820.4301	1631.729	2.612	19.250	1.634	0.416	0.295	-0.545	0.850	16.363	14.726	0.047	0.77647	683.29782	0.000984283
18.117	4.110	0.075	101	1829.8584	1635.332	2.344	20.550	1.672	0.433	0.301	-0.498	0.850	17.468	15.721	0.063	0.77538	682.33165	0.00122599
18.213	3.670	0.072	101	1839.5191	1639.024	2.611	18.350	1.635	0.395	0.295	-0.595	0.850	15.598	14.038	0.095	0.77425	681.34248	0.002064012
18.314	3.590	0.071	101	1849.6908	1642.912	2.679	17.950	1.625	0.388	0.294	-0.615	0.850	15.258	13.732	0.098	0.77307	680.30185	0.002188826
18.412	3.760	0.073	101	1859.5847	1646.693	2.576	18.800	1.639	0.401	0.296	-0.578	0.850	15.980	14.382	0.099	0.77192	679.29051	0.002111305
18.511	4.020	0.075	101	1869.6161	1650.527	2.421	20.100	1.661	0.423	0.299	-0.524	0.850	17.085	15.377	0.099	0.77076	678.26601	0.001957979
18.575	4.800	0.077	101	1876.1194	1653.012	1.989	24.000	1.722	0.486	0.308	-0.378	0.850	20.400	18.360	0.082	0.77	677.60229	0.00135944
18.667	5.320	0.081	101	1885.362	1656.544	1.857	26.600	1.740	0.532	0.311	-0.289	0.850	22.610	20.349	0.078	0.76893	676.65966	0.001166422
18.778	6.190	0.089	101	1896.6022	1660.84	1.706	30.950	1.761	0.610	0.314	-0.155	0.850	26.308	23.677	0.101	0.76763	675.51431	0.001301856
18.873	7.320	0.102	101	1906.1235	1664.479	1.596	36.600	1.777	0.713	0.316	-0.004	0.850	31.110	27.999	0.103	0.76653	674.54499	0.001114268
18.973	8.710	0.115	101	1916.2488	1668.349	1.484	43.550	1.792	0.839	0.319	0.153	0.850	37.018	33.316	0.097	0.76536	673.51508	0.000884799
19.053	10.800	0.127	101	1924.3308	1671.437	1.295	54.000	1.819	1.024	0.323	0.345	0.850	45.900	41.310	0.090	0.76442	672.69366	0.000660493
19.146	13.320	0.145	101	1933.7601	1675.041	1.176	66.600	1.835	1.249	0.325	0.535	0.850	56.610	50.949	0.087	0.76334	671.73605	0.000514333
19.245	14.890	0.168	101	1943.6985	1678.839	1.203	74.450	1.832	1.396	0.325	0.640	0.850	63.283	56.954	0.096	0.76219	670.72761	0.000508113
19.340	17.230	0.182	101	1953.3137	1682.514	1.122	86.150	1.843	1.601	0.326	0.771	0.850	73.228	65.905	0.097	0.76108	669.75281	0.000442676
19.438	20.360	0.192	101	1963.2067	1686.295	0.989	101.800	1.862	1.869	0.329	0.919	0.919	93.546	84.191	0.097	0.75994	668.75074	0.000345203
19.538	22.360	0.198	101	1973.3784	1690.182	0.925	111.800	1.871	2.038	0.331	1.001	1.001	111.964	100.768	0.099	0.75877	667.72135	0.000296187
19.635	22.890	0.205	101	1983.132	1693.91	0.934	114.450	1.869	2.083	0.330	1.022	1.022	116.967	105.270	0.099	0.75765	666.73518	0.000281134
19.736	21.760	0.209	101	1993.3047	1697.798	1.007	108.800	1.859	1.987	0.329	0.976	0.976	106.208	95.587	0.099	0.75649	665.70755	0.000309151
19.806	20.800	0.198	101	2000.4111	1700.514	1.002	104.000	1.860	1.895	0.329	0.932	0.932	96.915	87.223	0.086	0.75567	664.99025	0.000293471
19.915	20.280	0.186	101	2011.418	1704.72	0.964	101.400	1.865	1.838	0.330	0.904	0.904	91.624	82.462	0.090	0.75441	663.88015	0.000324861
20.002	19.060	0.183	101	2020.2434	1708.093	1.015	95.300	1.858	1.731	0.329	0.846	0.850	81.005	72.905	0.098	0.7534	662.99089	0.00040178
20.103	16.890	0.169	101	2030.3687	1711.963	1.066	84.450	1.851	1.536	0.328	0.733	0.850	71.783	64.604	0.094	0.75224	661.97154	0.000432577
20.206	13.500	0.148	101	2040.8191	1715.957	1.184	67.500	1.834	1.236	0.325	0.525	0.850	57.375	51.638	0.102	0.75105	660.92045	0.000586678
20.338	12.030	0.135	101	2054.1027	1721.033	1.227	60.150	1.828	1.102	0.324	0.416	0.850	51.128	46.015	0.117	0.74953	659.58589	0.00075789
20.464	10.980	0.119	101	2066.8761	1725.915	1.191	54.900	1.833	1.000	0.325	0.325	0.850	46.665	41.999	0.129	0.74807	658.30415	0.000909868
20.570	10.290	0.108	101	2077.6043	1730.015	1.172	51.450	1.836	0.934	0.325	0.261	0.850	43.733	39.359	0.116	0.74685	657.22883	0.000874239
20.671	9.680	0.103	101	2087.7306	1733.885	1.190	48.400	1.833	0.878	0.325	0.202	0.850	41.140	37.026	0.103	0.7457	656.21484	0.000823379
20.772	8.550	0.099	101	2097.9488	1737.79	1.325	42.750	1.814	0.781	0.322	0.089	0.850	36.338	32.704	0.101	0.74454	655.19264	0.000907984
20.884	7.850	0.094	101	2109.281	1742.121	1.380	39.250	1.807	0.719	0.321	0.008	0.850	33.363	30.026	0.107	0.74325	654.06016	0.001045761
21.000	7.160	0.088	101	2121.0323	1746.612	1.443	35.800	1.798	0.657	0.320	-0.078	0.850	30.430	27.387	0.114	0.74192	652.88709	0.001225907
21.111	6.810	0.088	101	2132.1797	1750.873	1.532	34.050	1.786	0.628	0.318	-0.123	0.850	28.943	26.048	0.113	0.74065	651.77554	0.001276415
21.431	6.470	0.116	101	2164.5532	1763.245	2.144	32.350	1.700	0.622	0.305	-0.148	0.850	27.498	24.748	0.215	0.73699	648.55425	0.002540795
21.557	5.950	0.109	101	2177.2328	1768.091	2.244	29.750	1.686	0.575	0.303	-0.225	0.850	25.288	22.759	0.223	0.73556	647.29536	0.002854563
21.666	6.220	0.115	101	2188.2408	1772.298	2.251	31.100	1.685	0.600	0.303	-0.184	0.850	26.435	23.792	0.117	0.73432	646.20371	0.001433272
21.795	7.350	0.124	101	2201.3384	1777.304	1.981	36.750	1.723	0.692	0.308	-0.042	0.850	31.238	28.114	0.119	0.73285	644.90637	0.001231851
21.896	7.870	0.130	101	2211.4637	1781.173	1.922	39.350	1.731	0.736	0.310	0.018	0.850	33.448	30.103	0.115	0.73171	643.90461	0.001106607
21.995	8.400	0.141	101	2221.4506	1784.99	1.930	42.000	1.730	0.784	0.309	0.078	0.850	35.700	32.130	0.100	0.73059	642.91754	0.000896528
22.091	8.840	0.153	101	2231.1577	1788.7	1.982	44.200	1.723	0.827	0.308	0.127	0.850	37.570	33.813	0.097	0.7295	641.95906	0.000832949
22.193	9.190	0.165	101	2241.4688	1792.641	2.039	45.950	1.715	0.862	0.307	0.165	0.850	39.058	35.152	0.099	0.72834	640.94196	0.000813126
22.293	9.710	0.178	101	2251.5476	1796.492	2.076	48.550	1.709	0.911	0.306	0.218	0.850	41.268	37.141	0.101	0.72721	639.94881	0.000782655
22.390	9.540	0.198	101	2261.3476	1800.238	2.350	47.700	1.671	0.914	0.301	0.215	0.850	40.545	36.491	0.098	0.72612	638.98409	0.000775465
22.485	9.280	0.218	101	2271.0082	1803.93	2.672	46.400	1.626	0.912	0.294	0.205	0.850	39.440	35.496	0.096	0.72504	638.03404	0.000779262
22.580	9.630	0.231	101	2280.5305	1807.569	2.726	48.150	1.618	0.949	0.293	0.242	0.850	40.928	36.835	0.095	0.72398	637.09851	0.000739137
22.684	10.240	0.240	101	2291.1204	1811.616	2.642	51.200	1.630	0.999	0.295	0.294	0.850	43.520	39.168	0.100	0.72279	636.05917	0.000727588
22.787	10.420	0.246	101	2301.5244	1815.592	2.654	52.100	1.628	1.016	0.294	0.309	0.850	44.285	39.857	0.104	0.72164	635.03917	0.000745169
22.889	11.720	0.250	101	2311.8355	1819.533	2.368	58.600	1.668	1.113	0.300	0.402	0.850	49.810	44.829	0.103	0.72049	634.02935	0.000652677

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
22.992	13.540	0.249	101	2322.1466	1823.474	2.008	67.700	1.719	1.245	0.308	0.516	0.850	57.545	51.791	0.102	0.71934	633.02062	0.000561518
23.119	14.840	0.246	101	2335.0119	1828.391	1.800	74.200	1.748	1.338	0.312	0.589	0.850	63.070	56.763	0.115	0.71791	631.76351	0.000574642
23.220	15.880	0.241	101	2345.1836	1832.278	1.641	79.400	1.770	1.411	0.316	0.642	0.850	67.490	60.741	0.114	0.71679	630.77081	0.00053294
23.326	17.010	0.239	101	2355.9593	1836.396	1.511	85.050	1.788	1.493	0.318	0.698	0.850	72.293	65.063	0.104	0.71559	629.72031	0.000451651
23.450	17.700	0.234	101	2368.454	1841.172	1.414	88.500	1.802	1.537	0.320	0.727	0.850	75.225	67.703	0.115	0.71421	628.50372	0.000481247
23.551	17.790	0.228	101	2378.6722	1845.077	1.375	88.950	1.807	1.537	0.321	0.728	0.850	75.608	68.047	0.112	0.71308	627.50999	0.000466602
23.653	17.180	0.222	101	2388.9833	1849.017	1.386	85.900	1.806	1.483	0.321	0.694	0.850	73.015	65.714	0.102	0.71194	626.50831	0.00043602
23.718	16.570	0.219	101	2395.4857	1851.502	1.425	82.850	1.801	1.432	0.320	0.660	0.850	70.423	63.380	0.083	0.71122	625.87719	0.000369874
23.810	15.440	0.216	101	2404.8211	1855.07	1.516	77.200	1.788	1.342	0.318	0.597	0.850	65.620	59.058	0.078	0.7102	624.97187	0.000373369
23.915	14.920	0.209	101	2415.411	1859.117	1.525	74.600	1.787	1.295	0.318	0.563	0.850	63.410	57.069	0.099	0.70903	623.94599	0.000485302
24.018	13.710	0.203	101	2425.7695	1863.076	1.627	68.550	1.772	1.197	0.316	0.486	0.850	58.268	52.441	0.104	0.70789	622.94365	0.00055436
24.143	12.580	0.191	101	2438.4491	1867.922	1.683	62.900	1.764	1.100	0.315	0.405	0.850	53.465	48.119	0.114	0.7065	621.71824	0.000663116
24.251	10.930	0.180	101	2449.3641	1872.094	1.854	54.650	1.740	0.967	0.311	0.279	0.850	46.453	41.807	0.117	0.7053	620.6647	0.000780332
24.376	9.540	0.172	101	2461.9508	1876.904	2.071	47.700	1.710	0.857	0.307	0.159	0.850	40.545	36.491	0.116	0.70392	619.45137	0.000888766
24.483	8.070	0.169	101	2472.8194	1881.058	2.477	40.350	1.653	0.748	0.298	0.020	0.850	34.298	30.868	0.116	0.70273	618.405	0.001046812
24.577	6.590	0.182	101	2482.2952	1884.679	3.403	32.950	1.524	0.661	0.279	-0.120	0.850	28.008	25.207	0.101	0.7017	617.49373	0.001110254
24.710	6.150	0.180	101	2495.6716	1889.791	3.680	30.750	1.485	0.632	0.273	-0.172	0.850	26.138	23.524	0.113	0.70024	616.20895	0.001333558
24.828	5.640	0.167	101	2507.6543	1894.371	3.798	28.200	1.468	0.584	0.270	-0.250	0.850	23.970	21.573	0.126	0.69893	615.05966	0.001610651
24.946	4.700	0.152	101	2519.545	1898.915	4.412	23.500	1.382	0.516	0.257	-0.387	0.850	19.975	17.978	0.118	0.69764	613.92069	0.001816176
25.078	3.480	0.127	101	2532.875	1904.01	5.751	17.400	1.195	0.441	0.229	-0.579	0.850	14.790	13.311	0.125	0.69619	612.64565	0.002585932
25.211	3.070	0.088	101	2546.2979	1909.14	4.881	15.350	1.317	0.352	0.248	-0.774	0.850	13.048	11.743	0.132	0.69473	611.36363	0.003102855
25.341	3.350	0.088	101	2559.4885	1914.181	4.246	16.750	1.406	0.359	0.261	-0.736	0.850	14.238	12.814	0.132	0.6933	610.10567	0.002822877
25.477	3.180	0.081	101	2573.1901	1919.417	4.289	15.900	1.400	0.341	0.260	-0.786	0.850	13.515	12.164	0.133	0.69182	608.80096	0.002998508
25.580	3.090	0.079	101	2583.5487	1923.376	4.399	15.450	1.384	0.334	0.258	-0.809	0.850	13.133	11.819	0.119	0.6907	607.81592	0.002756404
25.707	3.870	0.079	101	2596.3676	1928.275	3.052	19.350	1.573	0.368	0.286	-0.676	0.850	16.448	14.803	0.115	0.68932	606.59852	0.002115857
25.838	3.860	0.070	101	2609.6511	1933.352	2.747	19.300	1.615	0.356	0.292	-0.697	0.850	16.405	14.765	0.129	0.68789	605.33887	0.002384087
25.971	3.430	0.063	101	2623.1205	1938.5	2.983	17.150	1.582	0.322	0.287	-0.801	0.850	14.578	13.120	0.132	0.68644	604.06355	0.002744029
26.094	2.740	0.064	101	2635.5223	1943.239	4.500	13.700	1.370	0.297	0.256	-0.929	0.850	11.645	10.481	0.128	0.6851	602.89104	0.003315383
26.229	2.230	0.061	101	2649.1775	1948.458	6.715	11.150	1.060	0.311	0.209	-0.952	0.850	9.478	8.530	0.129	0.68364	601.60198	0.004094099
26.337	2.250	0.061	101	2660.0461	1952.612	6.609	11.250	1.075	0.309	0.211	-0.956	0.850	9.563	8.606	0.121	0.68247	600.57742	0.00381245
26.468	2.260	0.072	101	2673.2367	1957.653	7.743	11.300	0.916	0.363	0.187	-0.830	0.850	9.605	8.645	0.119	0.68106	599.33571	0.003715975
26.575	2.180	0.073	101	2684.0588	1961.789	8.735	10.900	0.777	0.412	0.167	-0.732	0.850	9.265	8.339	0.119	0.67991	598.31838	0.003838375
26.701	2.180	0.066	101	2696.7848	1966.652	7.912	10.900	0.892	0.358	0.184	-0.849	0.850	9.265	8.339	0.117	0.67855	597.12372	0.003756595
26.833	2.010	0.066	101	2710.1158	1971.747	10.047	10.050	0.593	0.495	0.139	-0.581	0.850	8.543	7.688	0.129	0.67713	595.87418	0.004498963
26.954	1.840	0.062	101	2722.3772	1976.433	12.970	9.200	0.184	1.456	0.078	0.525	0.850	7.820	7.038	0.127	0.67583	594.72662	0.004817704
27.067	1.850	0.070	101	2733.8034	1980.8	14.448	9.250	0.200	1.346	0.080	0.444	0.850	7.863	7.076	0.117	0.67461	593.65873	0.004427052
27.200	2.030	0.073	101	2747.2263	1985.93	11.121	10.150	0.443	0.665	0.116	-0.278	0.850	8.628	7.765	0.123	0.67319	592.40607	0.004223404
27.333	2.720	0.073	101	2760.6492	1991.06	5.471	13.600	1.234	0.319	0.235	-0.889	0.850	11.560	10.404	0.133	0.67177	591.15541	0.003398121
27.429	3.490	0.085	101	2770.3563	1994.77	4.034	17.450	1.435	0.351	0.265	-0.750	0.850	14.833	13.349	0.115	0.67074	590.25221	0.002278336
27.529	3.570	0.090	101	2780.3896	1998.604	4.124	17.850	1.423	0.362	0.263	-0.724	0.850	15.173	13.655	0.098	0.66968	589.31975	0.001897883
27.631	3.480	0.117	101	2790.7007	2002.545	5.598	17.400	1.216	0.412	0.232	-0.641	0.850	14.790	13.311	0.101	0.66859	588.36265	0.002003277
27.739	3.840	0.131	101	2801.6158	2006.717	5.350	19.200	1.251	0.441	0.238	-0.567	0.850	16.320	14.688	0.105	0.66744	587.35079	0.001890895
27.862	4.470	0.129	101	2814.0166	2011.456	4.218	22.350	1.409	0.454	0.261	-0.505	0.850	18.998	17.098	0.115	0.66614	586.2028	0.001780825
27.892	4.050	0.126	101	2817.0819	2012.627	4.770	20.250	1.332	0.435	0.250	-0.563	0.850	17.213	15.491	0.077	0.66582	585.9193	0.001303149
28.006	6.920	0.121	101	2828.6474	2017.047	2.200	34.600	1.692	0.584	0.304	-0.209	0.850	29.410	26.469	0.072	0.6646	584.85059	0.000720176
28.152	6.390	0.116	101	2843.3247	2022.657	2.331	31.950	1.674	0.544	0.301	-0.280	0.850	27.158	24.442	0.130	0.66306	583.4965	0.001395654
28.286	5.430	0.105	101	2856.887	2027.84	2.619	27.150	1.633	0.472	0.295	-0.423	0.850	23.078	20.770	0.140	0.66164	582.24744	0.001763583
28.418	4.660	0.097	101	2870.2635	2032.952	3.002	23.300	1.580	0.418	0.287	-0.551	0.850	19.805	17.825	0.133	0.66025	581.01752	0.001956185
28.553	4.150	0.087	101	2883.8722	2038.153	3.213	20.750	1.550	0.379	0.283	-0.653	0.850	17.638	15.874	0.134	0.65883	579.76831	0.002195641
28.687	3.900	0.077	101	2897.3416	2043.301	3.121	19.500	1.563	0.352	0.284	-0.720	0.850	16.575	14.918	0.134	0.65742	578.53397	0.002339441
28.826	3.650	0.069	101	2911.4149	2048.679	3.158	18.250	1.558	0.330	0.284	-0.785	0.850	15.513	13.961	0.136	0.65596	577.24647	0.002536908
28.985	3.480	0.070	101	2927.4396	2054.804	3.462	17.400	1.515	0.322	0.277	-0.816	0.850	14.790	13.311	0.149	0.6543	575.78319	0.002900328
29.116	3.410	0.071	101	2940.6766	2059.863	3.666	17.050	1.487	0.321	0.273	-0.826	0.850	14.493	13.043	0.145	0.65293	574.57666	0.002871595
29.248	2.810	0.070	101	2954.0531	2064.975	5.229	14.050	1.268	0.309	0.240	-0.911	0.850	11.943	10.748	0.132	0.65154	573.35946	0.003162659
29.384	2.540	0.067	101	2967.7547	2070.211	6.316	12.700	1.116	0.317	0.217	-0.922	0.850	10.795	9.716	0.134	0.65013	572.11479	0.003552199
29.520	2.100	0.063	101	2981.5493	2075.483	10.390	10.500	0.545	0.535	0.132	-0.502	0.850	8.925	8.033	0.136	0.64871	570.86384	0.004353276
29.674	2.210	0.064	101	2997.1094	2081.43	9.038	11.050	0.735	0.416	0.160	-0.730	0.850	9.393	8.453	0.145	0.64711	569.4554	0.004405284
29.812	2.460	0.062	101	3011.0433	2086.755	6.517	12.300	1.088	0.312	0.213	-0.943	0.850	10.455	9.410	0.146	0.64568	568.19652	0.003967593

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
29.944	2.270	0.065	101	3024.3733	2091.85	8.511	11.350	0.808	0.387	0.171	-0.789	0.850	9.648	8.683	0.135	0.64431	566.99429	0.003966168
30.078	1.740	0.071	101	3037.8891	2097.015	32.073	8.700	0.200	1.196	0.080	0.323	0.850	7.395	6.656	0.133	0.64293	565.77739	0.005083963
30.215	1.660	0.074	101	3051.7302	2102.305	54.870	8.300	0.200	1.138	0.080	0.272	0.850	7.055	6.350	0.135	0.64152	564.53338	0.00541848
30.510	2.820	0.065	101	3081.5029	2113.683	5.050	14.100	1.293	0.297	0.244	-0.944	0.850	11.985	10.787	0.216	0.63848	561.86498	0.005061004
30.641	2.660	0.072	101	3094.74	2118.742	6.453	13.300	1.097	0.330	0.214	-0.886	0.850	11.305	10.175	0.213	0.63714	560.68189	0.005279982
30.775	2.870	0.077	101	3108.3023	2123.925	5.867	14.350	1.179	0.330	0.227	-0.867	0.850	12.198	10.978	0.133	0.63576	559.47185	0.003042637
30.918	2.870	0.069	101	3122.7008	2129.428	5.242	14.350	1.266	0.307	0.240	-0.920	0.850	12.198	10.978	0.138	0.63431	558.18953	0.003167231
31.073	2.710	0.069	101	3138.3538	2135.41	6.075	13.550	1.150	0.318	0.222	-0.910	0.850	11.518	10.366	0.149	0.63273	556.79823	0.003596044
31.205	2.360	0.078	101	3151.7303	2140.523	9.896	11.800	0.615	0.517	0.142	-0.533	0.850	10.030	9.027	0.144	0.63138	555.61154	0.003980405
31.339	2.370	0.074	101	3165.2461	2145.688	9.436	11.850	0.679	0.469	0.152	-0.621	0.850	10.073	9.065	0.133	0.63002	554.4146	0.003663898
31.474	2.290	0.063	101	3178.9013	2150.907	8.993	11.450	0.741	0.414	0.161	-0.734	0.850	9.733	8.759	0.135	0.62864	553.20749	0.003822858
31.637	1.940	0.062	101	3195.2976	2157.173	18.052	9.700	0.200	1.296	0.080	0.406	0.850	8.245	7.421	0.149	0.627	551.76094	0.004977894
31.770	1.580	0.059	101	3208.767	2162.321	-239.916	7.900	35.588	0.006	5.388	-3.956	0.850	6.715	6.044	0.148	0.62565	550.57498	0.006061244
31.902	1.330	0.054	101	3222.1434	2167.433	-19.354	6.650	4.710	0.038	0.756	-2.351	0.850	5.653	5.087	0.133	0.62432	549.3993	0.006458661
32.044	1.360	0.055	101	3236.4491	2172.9	-21.144	6.800	4.960	0.036	0.794	-2.379	0.850	5.780	5.202	0.137	0.62289	548.14428	0.00649807
32.202	1.460	0.052	101	3252.3798	2178.989	-31.410	7.300	6.397	0.030	1.010	-2.540	0.850	6.205	5.585	0.150	0.62131	546.74952	0.006594698
32.331	1.620	0.062	101	3265.4785	2183.995	-482.761	8.100	69.586	0.003	10.488	-4.525	0.850	6.885	6.197	0.144	0.62001	545.60495	0.005694182
32.451	1.640	0.071	101	3277.554	2188.61	5829.998	8.200	0.200	1.080	0.080	0.219	0.850	6.970	6.273	0.125	0.61881	544.55156	0.004868346
32.567	2.090	0.082	101	3289.3054	2193.101	18.368	10.450	0.200	1.373	0.080	0.465	0.850	8.883	7.994	0.118	0.61765	543.52811	0.003608886
32.671	2.350	0.081	101	3299.7559	2197.095	11.498	11.750	0.390	0.790	0.109	-0.102	0.850	9.988	8.989	0.110	0.61661	542.61933	0.002985697
32.800	2.090	0.102	101	3312.7606	2202.065	23.500	10.450	0.200	1.368	0.080	0.461	0.850	8.883	7.994	0.116	0.61533	541.49022	0.00353927
32.898	2.040	0.092	101	3322.7	2205.864	24.376	10.200	0.200	1.333	0.080	0.434	0.850	8.670	7.803	0.114	0.61435	540.6286	0.003541367
33.030	2.140	0.101	101	3336.0765	2210.976	21.336	10.700	0.200	1.395	0.080	0.481	0.850	9.095	8.186	0.115	0.61304	539.47088	0.003423223
33.132	2.550	0.097	101	3346.2956	2214.881	11.074	12.750	0.450	0.738	0.117	-0.172	0.850	10.838	9.754	0.117	0.61203	538.58784	0.002902535
33.260	2.520	0.105	101	3359.2539	2219.834	12.471	12.600	0.254	1.287	0.088	0.399	0.850	10.710	9.639	0.115	0.61076	537.4699	0.002879052
33.361	2.400	0.109	101	3369.4721	2223.739	15.239	12.000	0.200	1.555	0.080	0.593	0.850	10.200	9.180	0.115	0.60976	536.58975	0.003017923
33.463	2.540	0.110	101	3379.7367	2227.662	12.916	12.700	0.192	1.713	0.079	0.692	0.850	10.795	9.716	0.101	0.60876	535.70685	0.002516011
33.564	2.650	0.108	101	3389.9549	2231.567	11.319	13.250	0.415	0.824	0.112	-0.058	0.850	11.263	10.136	0.101	0.60776	534.82919	0.002407622
33.659	2.770	0.096	101	3399.5691	2235.241	8.923	13.850	0.751	0.476	0.163	-0.592	0.850	11.773	10.595	0.098	0.60682	534.00454	0.002226739
33.894	2.980	0.079	101	3423.3041	2244.312	6.244	14.900	1.126	0.340	0.219	-0.850	0.850	12.665	11.399	0.165	0.60452	531.97339	0.003467278
33.998	3.180	0.082	101	3433.8	2248.324	5.584	15.900	1.218	0.335	0.233	-0.845	0.850	13.515	12.164	0.169	0.6035	531.07733	0.003329499
34.122	3.310	0.089	101	3446.2947	2253.099	5.627	16.550	1.212	0.349	0.232	-0.804	0.850	14.068	12.661	0.114	0.60229	530.01233	0.002144068
34.222	3.940	0.109	101	3456.3735	2256.951	4.910	19.700	1.313	0.383	0.247	-0.692	0.850	16.745	15.071	0.112	0.60131	529.15461	0.001765692
34.323	5.010	0.118	101	3466.6382	2260.874	3.592	25.050	1.497	0.427	0.275	-0.549	0.850	21.293	19.163	0.101	0.60032	528.28233	0.001249344
34.432	4.750	0.150	101	3477.6461	2265.081	4.968	23.750	1.304	0.463	0.246	-0.508	0.850	20.188	18.169	0.105	0.59926	527.34826	0.001375481
34.541	4.220	0.174	101	3488.6541	2269.288	7.008	21.100	1.019	0.526	0.203	-0.438	0.850	17.935	16.142	0.109	0.5982	526.41564	0.001599499
34.655	4.510	0.163	101	3500.1267	2273.672	5.902	22.550	1.174	0.487	0.226	-0.484	0.850	19.168	17.251	0.111	0.5971	525.4452	0.001525415
34.754	4.560	0.138	101	3510.1126	2277.489	4.902	22.800	1.314	0.439	0.247	-0.558	0.850	19.380	17.442	0.106	0.59614	524.6018	0.001437782
34.816	5.350	0.132	101	3516.3827	2279.885	3.672	26.750	1.486	0.455	0.273	-0.489	0.850	22.738	20.464	0.080	0.59554	524.07284	0.000927427
34.918	6.130	0.104	101	3526.7402	2283.843	2.377	30.650	1.667	0.464	0.300	-0.434	0.850	26.053	23.447	0.082	0.59455	523.20008	0.000826547
34.993	6.930	0.087	101	3534.3112	2286.737	1.681	34.650	1.765	0.495	0.315	-0.353	0.850	29.453	26.507	0.089	0.59382	522.56294	0.000787371
35.087	6.680	0.074	101	3543.7395	2290.34	1.506	33.400	1.789	0.470	0.318	-0.397	0.850	28.390	25.551	0.084	0.59292	521.77044	0.000773328
35.185	5.560	0.066	101	3553.6789	2294.139	1.753	27.800	1.755	0.398	0.313	-0.562	0.850	23.630	21.267	0.096	0.59197	520.93614	0.001056863
35.283	4.010	0.075	101	3563.6194	2297.938	3.361	20.050	1.529	0.329	0.279	-0.793	0.850	17.043	15.338	0.098	0.59103	520.10294	0.001501714
35.383	3.340	0.080	101	3573.6517	2301.772	5.144	16.700	1.280	0.327	0.242	-0.855	0.850	14.195	12.776	0.099	0.59007	519.26324	0.001808459
35.461	3.190	0.083	101	3581.5479	2304.79	5.939	15.950	1.169	0.341	0.225	-0.837	0.850	13.558	12.202	0.089	0.58932	518.60318	0.001697534
35.559	3.560	0.105	101	3591.4873	2308.588	5.935	17.800	1.169	0.380	0.225	-0.730	0.850	15.130	13.617	0.088	0.58838	517.77338	0.0015108
35.655	5.460	0.098	101	3601.1944	2312.298	2.670	27.300	1.626	0.418	0.294	-0.541	0.850	23.205	20.885	0.097	0.58746	516.96411	0.001083386
35.752	8.020	0.000	101	3610.948	2316.026	0.000	40.100	2.000	0.499	0.350	-0.299	0.850	34.085	30.677	0.096	0.58654	516.15212	0.000729442
35.860	7.800	0.000	101	3621.863	2320.197	0.000	39.000	2.000	0.484	0.350	-0.327	0.850	33.150	29.835	0.102	0.58551	515.24477	0.000795171
35.912	6.390	0.000	101	3627.111	2322.203	0.000	31.950	2.000	0.396	0.350	-0.514	0.850	27.158	24.442	0.080	0.58501	514.80903	0.000758399
36.034	6.300	0.000	101	3639.4663	2326.925	0.000	31.500	2.000	0.390	0.350	-0.529	0.850	26.775	24.098	0.087	0.58385	513.78447	0.000836111
36.034	6.300	0.000	101	3639.4663	2326.925	0.000	31.500	2.000	0.390	0.350	-0.529	0.850	26.775	24.098	0.061	0.58385	513.78447	0.000586846
36.500	3.658	0.082	101	3686.5	2344.9	4.531	18.291	1.366	0.329	0.255	-0.828	0.850	15.548	13.993	0.233	0.57943	509.90098	0.003818122
37.000	3.658	0.082	101	3737	2364.2	4.595	18.291	1.357	0.329	0.254	-0.832	0.850	15.548	13.993	0.483	0.57473	505.76087	0.007853348
37.500	3.658	0.082	101	3787.5	2383.5	4.661	18.291	1.347	0.328	0.252	-0.835	0.850	15.548	13.993	0.500	0.57006	501.65143	0.008066376
38.000	3.658	0.082	101	3838	2402.8	4.728	18.291	1.338	0.328	0.251	-0.838	0.850	15.548	13.993	0.500	0.56542	497.57269	0.008000791
38.500	3.658	0.082	101	3888.5	2422.1	4.798	18.291	1.328	0.328	0.249	-0.841	0.850	15.548	13.993	0.500	0.56082	493.52466	0.0079357

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
39.000	3.658	0.082	101	3939	2441.4	4.870	18.291	1.318	0.328	0.248	-0.844	0.850	15.548	13.993	0.500	0.55626	489.50734	0.007871103
39.500	3.658	0.082	101	3989.5	2460.7	4.944	18.291	1.308	0.328	0.246	-0.846	0.850	15.548	13.993	0.500	0.55173	485.52072	0.007807
40.000	3.658	0.082	101	4040	2480	5.020	18.291	1.297	0.328	0.245	-0.848	0.850	15.548	13.993	0.500	0.54723	481.5648	0.00774339
40.500	3.658	0.082	101	4090.5	2499.3	5.098	18.291	1.286	0.328	0.243	-0.850	0.850	15.548	13.993	0.500	0.54277	477.63956	0.007680274
41.000	3.658	0.082	101	4141	2518.6	5.180	18.291	1.275	0.328	0.241	-0.851	0.850	15.548	13.993	0.500	0.53835	473.74496	0.00761765
41.500	3.658	0.082	101	4191.5	2537.9	5.263	18.291	1.263	0.329	0.239	-0.852	0.850	15.548	13.993	0.500	0.53396	469.88098	0.007555519
42.000	3.658	0.082	101	4242	2557.2	5.350	18.291	1.251	0.330	0.238	-0.853	0.850	15.548	13.993	0.500	0.5296	466.04757	0.007493879
42.500	3.658	0.082	101	4292.5	2576.5	5.439	18.291	1.239	0.330	0.236	-0.853	0.850	15.548	13.993	0.500	0.52528	462.24469	0.00743273
43.000	3.658	0.082	101	4343	2595.8	5.531	18.291	1.226	0.331	0.234	-0.853	0.850	15.548	13.993	0.500	0.52099	458.47227	0.00737207
43.500	3.658	0.082	101	4393.5	2615.1	5.627	18.291	1.212	0.333	0.232	-0.853	0.850	15.548	13.993	0.500	0.51674	454.73026	0.0073119
44.000	3.658	0.082	101	4444	2634.4	5.726	18.291	1.198	0.334	0.230	-0.852	0.850	15.548	13.993	0.500	0.51252	451.01858	0.007252218
44.500	3.658	0.082	101	4494.5	2653.7	5.828	18.291	1.184	0.336	0.228	-0.850	0.850	15.548	13.993	0.500	0.50834	447.33717	0.007193022
45.000	3.658	0.082	101	4545	2673	5.935	18.291	1.169	0.337	0.225	-0.848	0.850	15.548	13.993	0.500	0.50419	443.68594	0.007134312
45.500	3.658	0.082	101	4595.5	2692.3	6.045	18.291	1.154	0.339	0.223	-0.845	0.850	15.548	13.993	0.500	0.50007	440.0648	0.007076085
46.000	3.658	0.082	101	4646	2711.6	6.159	18.291	1.138	0.342	0.221	-0.842	0.850	15.548	13.993	0.500	0.49599	436.47367	0.007018341
46.500	3.658	0.082	101	4696.5	2730.9	6.278	18.291	1.121	0.344	0.218	-0.838	0.850	15.548	13.993	0.500	0.49195	432.91245	0.006961078
47.000	3.658	0.082	101	4747	2750.2	6.401	18.291	1.104	0.347	0.216	-0.834	0.850	15.548	13.993	0.500	0.48793	429.38102	0.006904294
47.500	3.658	0.082	101	4797.5	2769.5	6.529	18.291	1.086	0.351	0.213	-0.828	0.850	15.548	13.993	0.500	0.48395	425.87929	0.006847987
48.000	3.658	0.082	101	4848	2788.8	6.663	18.291	1.067	0.354	0.210	-0.822	0.850	15.548	13.993	0.500	0.48001	422.40715	0.006792156

Settlement Analysis
Tanners Creek Fly Ash Pond Closure
Project No. 7217-17-007A
Date: 7/14/2017

Method: CPT Based Settlement Analysis based on Mayne "Eqivalent CPT Method for Calculating Shallow Foundations Settlements"
Subsurface information: CPT-5

Input Values	
Water Depth (ft)	15
Length Area (ft)	100
Width Area (ft)	100
Surcharge Height (ft)	8
Surcharge Unit Weight (pcf)	110
Surcharge Pressure (psf)	880

Cell Shade Legend
- Input values
- Imported CPT values
- Extended CPT values (to bottom of ash); Average from final 5 feet of CPT sounding

Total Settlement, $\Sigma\Delta\rho_{total}$	
(ft)	(in)
0.36	4.3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Input Values				Computed Values														
Depth	CPT Tip Stress, q_t	Sleeve Friction, Fs	Unit Weight	Total Stress, σ_{TOT}	Insitu Effective Stress, $\sigma_{vo'}$	Friction Ratio, Fr $fs/(q_t-\sigma_{vo})$x100%	Dialatometer Modulus, E_D	Material Index, I_D	Horizontal Stress Index, K_D	Modified Modulus Ratio, R_{Mo}	Modulus Ratio, R_M	Minimum R_M	Constrained Modulus, M'	Elastic Modulus, E' 0.9xM'	Incremental Layer Depth, ΔZ	Vertical Stress Influence Factor, I_σ	Vertical Stress Change, $\Delta\sigma_{v'}$	Incremental Settlement, $\Delta\rho$
(ft)	(tsf)	(tsf)	(pcf)	(psf)	(psf)		(tsf)					min. 0.85	(tsf)	(tsf)	(ft)		(psf)	(ft)
0				0	0													
0.196	32.340	0.000	101	19.78	19.78	0.000	161.7	2.000	235.627	0.350	5.491	5.491	887.967	799.171	0.098	0.99751	877.80605	0
0.294	36.770	0.149	101	29.71	29.71	0.405	183.85	1.943	183.534	0.341	5.255	5.255	966.114	869.502	0.147	0.99625	876.70399	6.67365E-05
0.400	35.090	0.249	101	40.44	40.44	0.711	175.45	1.901	131.589	0.335	4.940	4.940	866.706	780.035	0.102	0.9949	875.51434	5.16547E-05
0.523	35.070	0.305	101	52.78	52.78	0.870	175.35	1.878	101.941	0.332	4.698	4.698	823.830	741.447	0.114	0.99335	874.14443	6.06006E-05
0.629	41.180	0.262	101	63.55	63.55	0.636	205.9	1.911	97.711	0.337	4.658	4.658	959.099	863.189	0.114	0.99199	872.9498	5.20849E-05
0.761	71.000	0.292	101	76.88	76.88	0.412	355	1.942	137.026	0.341	4.978	4.978	1767.271	1590.544	0.119	0.99031	871.47188	2.94083E-05
0.875	81.940	0.343	101	88.39	88.39	0.418	409.7	1.941	137.603	0.341	4.982	4.982	2041.210	1837.089	0.123	0.98886	870.19478	2.62097E-05
0.964	79.070	0.375	101	97.35	97.35	0.474	395.35	1.934	121.052	0.340	4.861	4.861	1921.748	1729.573	0.101	0.98773	869.20103	2.29213E-05
1.066	83.110	0.389	101	107.70	107.70	0.468	415.55	1.934	114.954	0.340	4.812	4.812	1999.601	1799.641	0.096	0.98642	868.05287	2.07517E-05
1.166	74.780	0.429	101	117.78	117.78	0.574	373.9	1.920	95.316	0.338	4.635	4.635	1732.871	1559.584	0.101	0.98515	866.93568	2.52946E-05
1.284	65.010	0.529	101	129.71	129.71	0.814	325.05	1.886	76.584	0.333	4.427	4.427	1439.132	1295.219	0.109	0.98365	865.61259	3.27612E-05
1.364	62.800	0.542	101	137.74	137.74	0.863	314	1.879	69.922	0.332	4.341	4.341	1363.153	1226.838	0.099	0.98264	864.722	3.1345E-05
1.475	75.300	0.536	101	148.93	148.93	0.712	376.5	1.900	76.676	0.335	4.429	4.429	1667.353	1500.618	0.095	0.98123	863.4815	2.46366E-05
1.561	97.310	0.543	101	157.70	157.70	0.558	486.55	1.922	92.528	0.338	4.606	4.606	2241.283	2017.155	0.099	0.98012	862.50861	1.90153E-05
1.665	117.100	0.569	101	168.15	168.15	0.486	585.5	1.932	103.883	0.340	4.716	4.716	2761.259	2485.134	0.095	0.97881	861.35059	1.48406E-05
1.760	123.740	0.346	101	177.71	177.71	0.280	618.7	1.961	102.334	0.344	4.702	4.702	2909.032	2618.129	0.099	0.9776	860.29053	1.46461E-05
1.857	118.270	0.314	101	187.55	187.55	0.266	591.35	1.963	92.587	0.344	4.607	4.607	2724.393	2451.954	0.096	0.97636	859.19954	1.51481E-05
1.923	108.370	0.330	101	194.24	194.24	0.305	541.85	1.957	82.146	0.344	4.494	4.494	2434.966	2191.469	0.082	0.97552	858.45858	1.4423E-05
2.001	100.820	0.366	101	202.08	202.08	0.364	504.1	1.949	73.766	0.342	4.392	4.392	2213.970	1992.573	0.072	0.97453	857.58905	1.39321E-05
2.055	101.480	0.374	101	207.52	207.52	0.369	507.4	1.948	72.330	0.342	4.373	4.373	2219.020	1997.118	0.066	0.97385	856.98709	1.26925E-05
2.129	107.980	0.336	101	214.99	214.99	0.311	539.9	1.956	73.982	0.343	4.395	4.395	2372.697	2135.427	0.064	0.97291	856.15886	1.1527E-05
2.196	109.400	0.345	101	221.77	221.77	0.316	547	1.956	72.689	0.343	4.378	4.378	2394.766	2155.289	0.071	0.97205	855.4078	1.26011E-05
2.294	118.640	0.355	101	231.66	231.66	0.299	593.2	1.958	75.374	0.344	4.412	4.412	2617.405	2355.665	0.083	0.97081	854.31226	1.34647E-05
2.384	113.290	0.358	101	240.76	240.76	0.316	566.45	1.956	69.340	0.343	4.333	4.333	2454.622	2209.160	0.094	0.96966	853.30423	1.63378E-05
2.460	109.640	0.375	101	248.46	248.46	0.342	548.2	1.952	65.145	0.343	4.274	4.274	2343.149	2108.834	0.083	0.96869	852.45058	1.51334E-05
2.553	101.700	0.436	101	257.84	257.84	0.429	508.5	1.940	58.595	0.341	4.174	4.174	2122.447	1910.202	0.085	0.96751	851.41187	1.69635E-05
2.632	96.880	0.528	101	265.82	265.82	0.546	484.4	1.924	54.600	0.339	4.107	4.107	1989.469	1790.522	0.086	0.96651	850.52753	1.83735E-05
2.727	87.630	0.619	101	275.39	275.39	0.707	438.15	1.901	48.238	0.335	3.990	3.990	1748.128	1573.315	0.087	0.96531	849.46847	2.11076E-05

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2.812	78.000	0.590	101	283.98	283.98	0.758	390	1.894	41.796	0.334	3.854	3.854	1503.090	1352.781	0.090	0.96422	848.51758	2.53637E-05
2.892	65.110	0.596	101	292.05	292.05	0.917	325.55	1.872	34.328	0.331	3.668	3.668	1194.026	1074.623	0.083	0.96321	847.62326	2.92846E-05
2.987	59.390	0.661	101	301.71	301.71	1.115	296.95	1.844	30.765	0.327	3.564	3.564	1058.317	952.486	0.088	0.96199	846.55431	3.51139E-05
3.057	61.730	0.672	101	308.72	308.72	1.091	308.65	1.847	31.193	0.327	3.577	3.577	1104.054	993.649	0.083	0.96111	845.77837	3.16041E-05
3.157	72.930	0.650	101	318.84	318.84	0.893	364.65	1.875	35.156	0.331	3.690	3.690	1345.656	1211.090	0.085	0.95984	844.65839	2.66157E-05
3.238	75.400	0.610	101	327.06	327.06	0.811	377	1.887	35.217	0.333	3.692	3.692	1391.854	1252.668	0.091	0.95881	843.74911	2.75157E-05
3.325	72.670	0.550	101	335.83	335.83	0.758	363.35	1.894	32.928	0.334	3.628	3.628	1318.336	1186.502	0.084	0.9577	842.77839	2.68863E-05
3.425	67.070	0.547	101	345.91	345.91	0.818	335.35	1.885	29.636	0.333	3.529	3.529	1183.306	1064.976	0.093	0.95644	841.66403	3.31831E-05
3.489	60.420	0.563	101	352.41	352.41	0.934	302.1	1.869	26.434	0.330	3.420	3.420	1033.272	929.945	0.082	0.95562	840.94517	3.33868E-05
3.567	52.860	0.580	101	360.25	360.25	1.100	264.3	1.846	22.907	0.327	3.285	3.285	868.150	781.335	0.071	0.95463	840.0775	3.43593E-05
3.645	47.520	0.599	101	368.14	368.14	1.265	237.6	1.823	20.406	0.323	3.175	3.175	754.442	678.998	0.078	0.95364	839.20482	4.33317E-05
3.695	42.180	0.603	101	373.20	373.20	1.435	210.9	1.799	18.104	0.320	3.062	3.062	645.765	581.189	0.064	0.95301	838.64536	4.16358E-05
3.753	37.500	0.601	101	379.10	379.10	1.611	187.5	1.775	16.064	0.316	2.949	2.949	552.898	497.608	0.054	0.95227	837.9935	4.11042E-05
3.825	34.110	0.606	101	386.34	386.34	1.788	170.55	1.750	14.541	0.312	2.854	2.854	486.832	438.149	0.065	0.95136	837.19301	5.59238E-05
3.888	31.240	0.613	101	392.70	392.70	1.973	156.2	1.724	13.300	0.309	2.770	2.770	432.673	389.405	0.067	0.95056	836.49008	6.50897E-05
3.958	28.900	0.608	101	399.71	399.71	2.117	144.5	1.704	12.231	0.306	2.691	2.691	388.798	349.918	0.066	0.94968	835.71536	7.11373E-05
4.021	26.690	0.589	101	406.12	406.12	2.225	133.45	1.689	11.217	0.303	2.609	2.609	348.130	313.317	0.066	0.94887	835.00747	7.96558E-05
4.099	25.120	0.567	101	413.96	413.96	2.275	125.6	1.681	10.400	0.302	2.537	2.537	318.664	286.798	0.071	0.94789	834.14068	9.2343E-05
4.169	24.210	0.543	101	421.11	421.11	2.264	121.05	1.683	9.844	0.302	2.485	2.485	300.810	270.729	0.074	0.94699	833.35089	0.000102829
4.249	23.950	0.511	101	429.14	429.14	2.153	119.75	1.699	9.469	0.305	2.448	2.448	293.140	263.826	0.075	0.94598	832.46395	0.000106706
4.319	23.820	0.484	101	436.25	436.25	2.051	119.1	1.713	9.187	0.307	2.419	2.419	288.128	259.315	0.075	0.94509	831.67954	0.000108128
4.389	24.600	0.488	101	443.31	443.31	2.000	123	1.720	9.297	0.308	2.431	2.431	298.971	269.074	0.070	0.9442	830.90038	9.74111E-05
4.487	27.210	0.502	101	453.19	453.19	1.862	136.05	1.739	9.948	0.311	2.495	2.495	339.446	305.501	0.084	0.94296	829.80883	0.000102533
4.583	35.280	0.515	101	462.90	462.90	1.469	176.4	1.794	12.241	0.319	2.691	2.691	474.769	427.292	0.097	0.94175	828.73793	8.46465E-05
4.673	50.400	0.524	101	472.00	472.00	1.045	252	1.854	16.601	0.328	2.980	2.980	750.927	675.834	0.093	0.94061	827.73389	5.13003E-05
4.758	61.590	0.551	101	480.54	480.54	0.898	307.95	1.874	19.706	0.331	3.142	3.142	967.654	870.889	0.087	0.93954	826.79157	3.73086E-05
4.853	63.160	0.585	101	490.15	490.15	0.930	315.8	1.870	19.861	0.330	3.150	3.150	994.650	895.185	0.090	0.93833	825.73159	3.72997E-05
4.939	59.250	0.596	101	498.87	498.87	1.011	296.25	1.858	18.417	0.329	3.078	3.078	911.904	820.713	0.091	0.93724	824.76918	4.10529E-05
5.020	52.870	0.609	101	507.00	507.00	1.157	264.35	1.838	16.350	0.326	2.965	2.965	783.922	705.530	0.083	0.93622	823.87345	4.38383E-05
5.113	47.910	0.337	101	516.38	516.38	0.706	239.55	1.901	14.064	0.335	2.823	2.823	676.224	608.602	0.087	0.93505	822.83975	5.27155E-05
5.180	44.660	0.380	101	523.20	523.20	0.857	223.3	1.880	13.084	0.332	2.755	2.755	615.080	553.572	0.080	0.93419	822.08764	5.36025E-05
5.271	42.840	0.447	101	532.39	532.39	1.050	214.2	1.853	12.514	0.328	2.712	2.712	580.986	522.888	0.079	0.93304	821.07484	5.6028E-05
5.358	37.500	0.499	101	541.12	541.12	1.341	187.5	1.812	11.020	0.322	2.592	2.592	486.000	437.400	0.089	0.93195	820.11345	7.48481E-05
5.411	30.730	0.515	101	546.51	546.51	1.692	153.65	1.763	9.191	0.314	2.420	2.420	371.819	334.637	0.070	0.93127	819.52033	7.69942E-05
5.443	32.430	0.509	101	549.71	549.71	1.582	162.15	1.778	9.560	0.317	2.457	2.457	398.449	358.604	0.043	0.93087	819.16753	4.37082E-05
5.513	32.560	0.492	101	556.81	556.81	1.523	162.8	1.787	9.431	0.318	2.445	2.445	397.970	358.173	0.051	0.92998	818.3855	5.24587E-05
5.579	34.510	0.481	101	563.50	563.50	1.406	172.55	1.803	9.788	0.320	2.480	2.480	427.875	385.088	0.068	0.92915	817.64954	6.5216E-05
5.672	34.520	0.491	101	572.83	572.83	1.434	172.6	1.799	9.652	0.320	2.466	2.466	425.715	383.144	0.079	0.92798	816.62249	7.60485E-05
5.761	33.340	0.490	101	581.83	581.83	1.483	166.7	1.792	9.213	0.319	2.422	2.422	403.804	363.424	0.091	0.92685	815.63149	9.16819E-05
5.869	34.370	0.456	101	592.79	592.79	1.338	171.85	1.813	9.218	0.322	2.423	2.423	416.388	374.749	0.099	0.92548	814.42622	9.66474E-05
5.943	38.280	0.432	101	600.22	600.22	1.138	191.4	1.841	9.985	0.326	2.499	2.499	478.235	430.411	0.091	0.92456	813.60937	7.74166E-05
6.061	37.760	0.404	101	612.15	612.15	1.077	188.8	1.849	9.613	0.327	2.463	2.463	464.972	418.475	0.096	0.92307	812.29761	8.3711E-05
6.144	35.150	0.389	101	620.55	620.55	1.116	175.75	1.844	8.854	0.327	2.385	2.385	419.176	377.259	0.101	0.92202	811.37401	9.74256E-05
6.253	33.200	0.359	101	631.56	631.56	1.091	166	1.847	8.201	0.327	2.313	2.313	383.934	345.540	0.096	0.92064	810.16513	0.000101357
6.376	32.550	0.346	101	643.95	643.95	1.074	162.75	1.850	7.875	0.327	2.275	2.275	370.197	333.178	0.116	0.91909	808.80359	0.000126532
6.441	34.890	0.348	101	650.54	650.54	1.006	174.45	1.859	8.314	0.329	2.326	2.326	405.744	365.169	0.094	0.91827	808.07972	9.36053E-05
6.542	36.710	0.349	101	660.71	660.71	0.960	183.55	1.866	8.583	0.330	2.356	2.356	432.434	389.191	0.083	0.917	806.96364	7.74103E-05
6.640	36.850	0.358	101	670.60	670.60	0.980	184.25	1.863	8.501	0.329	2.347	2.347	432.427	389.185	0.099	0.91577	805.87852	9.25099E-05
6.745	34.500	0.346	101	681.23	681.23	1.013	172.5	1.858	7.854	0.329	2.272	2.272	391.966	352.769	0.102	0.91445	804.71222	0.000104273
6.840	32.680	0.335	101	690.84	690.84	1.035	163.4	1.855	7.349	0.328	2.209	2.209	361.020	324.918	0.100	0.91325	803.65828	0.000111532

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
6.938	28.640	0.302	101	700.73	700.73	1.066	143.2	1.851	6.364	0.328	2.074	2.074	296.945	267.251	0.097	0.91202	802.57425	0.000130442
7.041	23.570	0.253	101	711.13	711.13	1.091	117.85	1.847	5.171	0.327	1.878	1.878	221.271	199.144	0.100	0.91072	801.43457	0.000181877
7.110	17.980	0.284	101	718.09	718.09	1.609	89.9	1.775	4.066	0.316	1.646	1.646	148.019	133.217	0.086	0.90985	800.67159	0.000232475
7.213	14.610	0.336	101	728.49	728.49	2.359	73.05	1.670	3.461	0.300	1.487	1.487	108.595	97.735	0.086	0.90856	799.5326	0.000316423
7.303	13.700	0.363	101	737.63	737.63	2.723	68.5	1.619	3.306	0.293	1.439	1.439	98.581	88.723	0.097	0.90742	798.53124	0.00039187
7.404	16.710	0.401	101	747.75	747.75	2.454	83.55	1.656	3.888	0.298	1.597	1.597	133.408	120.067	0.095	0.90616	797.42356	0.000285044
7.475	19.980	0.427	101	755.00	755.00	2.179	99.9	1.695	4.499	0.304	1.738	1.738	173.668	156.302	0.086	0.90526	796.63107	0.000197141
7.582	18.660	0.444	101	765.81	765.81	2.428	93.3	1.660	4.230	0.299	1.678	1.678	156.513	140.862	0.089	0.90392	795.44786	0.000227191
7.671	15.910	0.431	101	774.73	774.73	2.777	79.55	1.611	3.673	0.292	1.539	1.539	122.462	110.216	0.098	0.90281	794.47327	0.000316834
7.767	14.080	0.407	101	784.43	784.43	2.975	70.4	1.584	3.267	0.288	1.425	1.425	100.317	90.285	0.092	0.90161	793.41279	0.00036443
7.857	13.690	0.387	101	793.58	793.58	2.907	68.45	1.593	3.121	0.289	1.382	1.382	94.586	85.128	0.093	0.90047	792.4135	0.000390839
7.943	15.650	0.373	101	802.21	802.21	2.445	78.25	1.658	3.391	0.299	1.466	1.466	114.731	103.258	0.088	0.8994	791.47026	0.00030362
8.031	19.690	0.370	101	811.17	811.17	1.921	98.45	1.731	4.041	0.310	1.638	1.638	161.267	145.141	0.087	0.89829	790.49195	0.000213483
8.133	19.540	0.355	101	821.48	821.48	1.857	97.7	1.740	3.939	0.311	1.614	1.614	157.729	141.956	0.095	0.89701	789.36705	0.000238656
8.230	18.230	0.342	101	831.18	831.18	1.918	91.15	1.732	3.650	0.310	1.541	1.541	140.497	126.447	0.099	0.8958	788.30839	0.000277892
8.308	17.970	0.333	101	839.12	839.12	1.900	89.85	1.734	3.559	0.310	1.517	1.517	136.345	122.710	0.087	0.89482	787.44255	0.000252196
8.397	19.020	0.337	101	848.12	848.12	1.813	95.1	1.746	3.701	0.312	1.556	1.556	147.928	133.135	0.084	0.89371	786.46062	0.000222988
8.499	23.440	0.212	101	858.38	858.38	0.922	117.2	1.871	4.206	0.331	1.684	1.684	197.376	177.638	0.095	0.89243	785.34246	0.000189745
8.599	24.480	0.146	101	868.50	868.50	0.606	122.4	1.915	4.241	0.337	1.694	1.694	207.397	186.657	0.101	0.89118	784.23997	0.00019075
8.685	21.870	0.151	101	877.14	877.14	0.705	109.35	1.901	3.779	0.335	1.585	1.585	173.334	156.000	0.093	0.89011	783.29959	0.000209796
8.758	18.090	0.159	101	884.57	884.57	0.902	90.45	1.874	3.145	0.331	1.410	1.410	127.579	114.821	0.080	0.88919	782.49102	0.000243864
8.895	13.010	0.164	101	898.35	898.35	1.305	65.05	1.817	2.297	0.323	1.109	1.109	72.127	64.914	0.105	0.88749	780.99079	0.000568607
9.028	8.590	0.169	101	911.86	911.86	2.072	42.95	1.710	1.588	0.306	0.747	0.850	36.508	32.857	0.135	0.88582	779.52166	0.001442726
9.148	6.640	0.188	101	923.98	923.98	3.040	33.2	1.574	1.315	0.286	0.550	0.850	28.220	25.398	0.127	0.88432	778.20473	0.001749237
9.261	6.530	0.190	101	935.35	935.35	3.136	32.65	1.561	1.289	0.284	0.528	0.850	27.753	24.977	0.116	0.88292	776.96923	0.001627849
9.391	7.970	0.189	101	948.54	948.54	2.525	39.85	1.646	1.471	0.297	0.666	0.850	33.873	30.485	0.122	0.88129	775.53782	0.001391778
9.493	7.460	0.182	101	958.80	958.80	2.610	37.3	1.635	1.372	0.295	0.598	0.850	31.705	28.535	0.116	0.88003	774.42455	0.001417438
9.620	5.630	0.179	101	971.66	971.66	3.485	28.15	1.512	1.104	0.277	0.373	0.850	23.928	21.535	0.114	0.87844	773.02994	0.001848778
9.725	4.070	0.178	101	982.20	982.20	4.968	20.35	1.304	0.915	0.246	0.159	0.850	17.298	15.568	0.116	0.87715	771.88767	0.002584412
9.831	3.830	0.178	101	992.92	992.92	5.331	19.15	1.254	0.887	0.238	0.120	0.850	16.278	14.650	0.105	0.87582	770.72584	0.002491986
9.947	6.590	0.174	101	1004.62	1004.62	2.860	32.95	1.600	1.182	0.290	0.450	0.850	28.008	25.207	0.111	0.87439	769.45909	0.001524838
10.056	6.970	0.165	101	1015.67	1015.67	2.549	34.85	1.643	1.204	0.296	0.474	0.850	29.623	26.660	0.113	0.87303	768.26333	0.001460342
10.120	6.040	0.159	101	1022.17	1022.17	2.883	30.2	1.596	1.067	0.289	0.351	0.850	25.670	23.103	0.087	0.87223	767.56027	0.001298827
10.196	5.250	0.159	101	1029.78	1029.78	3.360	26.25	1.530	0.961	0.279	0.241	0.850	22.313	20.081	0.070	0.87129	766.73699	0.001200405
10.290	4.210	0.162	101	1039.30	1039.30	4.387	21.05	1.386	0.842	0.258	0.091	0.850	17.893	16.103	0.085	0.87012	765.70827	0.001814612
10.353	3.310	0.169	101	1045.61	1045.61	6.060	16.55	1.152	0.792	0.223	-0.008	0.850	14.068	12.661	0.078	0.86935	765.02611	0.002130979
10.443	3.480	0.179	101	1054.71	1054.71	6.049	17.4	1.153	0.825	0.223	0.032	0.850	14.790	13.311	0.076	0.86823	764.04336	0.001970808
10.516	5.990	0.175	101	1062.09	1062.09	3.202	29.95	1.552	1.047	0.283	0.327	0.850	25.458	22.912	0.082	0.86733	763.24649	0.001223008
10.586	6.740	0.170	101	1069.15	1069.15	2.740	33.7	1.616	1.124	0.292	0.404	0.850	28.645	25.781	0.071	0.86646	762.48491	0.000951276
10.654	5.930	0.170	101	1076.02	1076.02	3.151	29.65	1.559	1.019	0.284	0.302	0.850	25.203	22.682	0.069	0.86562	761.74365	0.001042004
10.718	5.390	0.165	101	1082.52	1082.52	3.393	26.95	1.525	0.941	0.279	0.220	0.850	22.908	20.617	0.066	0.86482	761.04273	0.001099496
10.753	5.000	0.169	101	1086.09	1086.09	3.783	25	1.470	0.902	0.271	0.171	0.850	21.250	19.125	0.050	0.86438	760.65735	0.000892564
10.820	5.270	0.176	101	1092.78	1092.78	3.734	26.35	1.477	0.941	0.272	0.213	0.850	22.398	20.158	0.051	0.86356	759.93677	0.000861641
10.912	9.470	0.182	101	1102.16	1102.16	2.045	47.35	1.714	1.445	0.307	0.658	0.850	40.248	36.223	0.080	0.86242	758.92638	0.000749734
10.982	17.280	0.186	101	1109.21	1109.21	1.111	86.4	1.844	2.434	0.327	1.166	1.166	100.767	90.690	0.081	0.86155	758.16649	0.000306056
11.060	22.070	0.202	101	1117.11	1117.11	0.939	110.35	1.869	3.047	0.330	1.380	1.380	152.297	137.068	0.074	0.86059	757.31688	0.000183987
11.151	23.870	0.224	101	1126.25	1126.25	0.959	119.35	1.866	3.274	0.330	1.448	1.448	172.769	155.492	0.084	0.85947	756.33279	0.000184619
11.216	20.470	0.235	101	1132.80	1132.80	1.179	102.35	1.835	2.838	0.325	1.310	1.310	134.125	120.712	0.078	0.85867	755.62873	0.000218816
11.294	17.720	0.259	101	1140.69	1140.69	1.508	88.6	1.789	2.503	0.318	1.187	1.187	105.210	94.689	0.071	0.8577	754.7802	0.000256382
11.378	16.290	0.287	101	1149.14	1149.14	1.827	81.45	1.744	2.342	0.312	1.120	1.120	91.263	82.137	0.081	0.85667	753.87214	0.000334133
11.447	15.120	0.278	101	1156.15	1156.15	1.909	75.6	1.733	2.175	0.310	1.049	1.049	79.305	71.375	0.077	0.85582	753.11906	0.000363406
11.548	14.600	0.244	101	1166.36	1166.36	1.741	73	1.756	2.054	0.313	0.997	0.997	72.780	65.502	0.085	0.85457	752.02247	0.000440512
11.643	17.730	0.226	101	1175.97	1175.97	1.317	88.65	1.816	2.393	0.322	1.148	1.148	101.731	91.558	0.098	0.8534	750.9913	0.000362203
11.716	22.150	0.145	101	1183.35	1183.35	0.673	110.75	1.906	2.830	0.336	1.314	1.314	145.498	130.948	0.084	0.8525	750.1995	0.000216852
11.813	26.440	0.081	101	1193.10	1193.10	0.315	132.2	1.956	3.265	0.343	1.452	1.452	191.910	172.719	0.085	0.85131	749.15438	0.000165526
11.912	31.520	0.084	101	1203.08	1203.08	0.271	157.6	1.962	3.848	0.344	1.606	1.606	253.097	227.787	0.098	0.8501	748.08484	0.00014435
12.013	37.120	0.100	101	1213.3433	1213.343	0.273	185.600	1.962	4.494	0.344	1.751	1.751	325.019	292.517	0.100	0.84885	746.98619	0.00011515
12.046	33.470	0.105	101	1216.6389	1216.639	0.320	167.350	1.955	4.055	0.343	1.654	1.654	276.880	249.192	0.067	0.84845	746.63342	9.04774E-05

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
12.077	34.770	0.110	101	1219.7497	1219.75	0.321	173.850	1.955	4.202	0.343	1.688	1.688	293.431	264.088	0.032	0.84807	746.30049	4.03313E-05
12.179	38.930	0.125	101	1230.1022	1230.102	0.325	194.650	1.955	4.666	0.343	1.786	1.786	347.653	312.887	0.067	0.84681	745.19296	7.14321E-05
12.279	39.980	0.142	101	1240.2224	1240.222	0.362	199.900	1.949	4.766	0.342	1.806	1.806	360.921	324.829	0.101	0.84558	744.11093	0.000104477
12.379	38.550	0.167	101	1250.2507	1250.251	0.439	192.750	1.939	4.584	0.341	1.769	1.769	340.880	306.792	0.100	0.84436	743.03938	0.000108711
12.508	39.330	0.164	101	1263.2959	1263.296	0.425	196.650	1.941	4.623	0.341	1.777	1.777	349.384	314.446	0.114	0.84278	741.64641	0.000121234
12.608	38.800	0.152	101	1273.4161	1273.416	0.398	194.000	1.944	4.516	0.342	1.755	1.755	340.449	306.405	0.115	0.84155	740.56653	0.000124729
12.719	40.500	0.143	101	1284.6503	1284.65	0.360	202.500	1.950	4.660	0.342	1.785	1.785	361.364	325.228	0.106	0.84019	739.36855	0.000108149
12.838	41.540	0.148	101	1296.6279	1296.628	0.363	207.700	1.949	4.737	0.342	1.800	1.800	373.811	336.430	0.115	0.83874	738.09221	0.000113445
12.939	43.370	0.151	101	1306.7946	1306.795	0.353	216.850	1.951	4.903	0.343	1.832	1.832	397.325	357.593	0.110	0.83751	737.00958	0.000101673
13.074	45.060	0.157	101	1320.4437	1320.444	0.353	225.300	1.951	5.042	0.343	1.858	1.858	418.679	376.812	0.118	0.83586	735.55719	0.000103566
13.172	44.020	0.157	101	1330.3781	1330.378	0.363	220.100	1.949	4.892	0.342	1.830	1.830	402.793	362.514	0.117	0.83466	734.50087	0.000106448
13.282	43.240	0.149	101	1341.5204	1341.52	0.349	216.200	1.951	4.761	0.343	1.805	1.805	390.165	351.148	0.104	0.83331	733.31689	9.80538E-05
13.395	42.840	0.141	101	1352.894	1352.894	0.334	214.200	1.953	4.672	0.343	1.787	1.787	382.795	344.515	0.111	0.83194	732.1092	0.00010659
13.504	40.760	0.136	101	1363.9434	1363.943	0.340	203.800	1.952	4.411	0.343	1.733	1.733	353.229	317.906	0.111	0.83061	730.93678	0.000114851
13.606	37.890	0.125	101	1374.203	1374.203	0.337	189.450	1.953	4.069	0.343	1.658	1.658	314.037	282.634	0.105	0.82937	729.84892	0.000122584
13.705	35.290	0.112	101	1384.1838	1384.184	0.325	176.450	1.955	3.759	0.343	1.584	1.584	279.416	251.474	0.100	0.82817	728.79132	0.000130674
13.806	34.640	0.107	101	1394.3979	1394.398	0.315	173.200	1.956	3.660	0.343	1.559	1.559	269.964	242.968	0.100	0.82694	727.7097	0.000134745
13.904	36.340	0.104	101	1404.2858	1404.286	0.293	181.700	1.959	3.807	0.344	1.596	1.596	289.928	260.935	0.100	0.82575	726.66333	0.00012471
14.001	36.720	0.108	101	1414.1283	1414.128	0.299	183.600	1.958	3.822	0.344	1.599	1.599	293.616	264.254	0.098	0.82457	725.62246	0.000120694
14.107	34.770	0.120	101	1424.805	1424.805	0.353	173.850	1.951	3.605	0.343	1.544	1.544	268.456	241.611	0.102	0.82329	724.49413	0.000137069
14.203	32.810	0.132	101	1434.4616	1434.462	0.411	164.050	1.942	3.393	0.341	1.487	1.487	243.912	219.521	0.101	0.82213	723.4743	0.000149285
14.304	31.120	0.135	101	1444.6747	1444.675	0.443	155.600	1.938	3.203	0.341	1.432	1.432	222.886	200.597	0.098	0.82091	722.39643	0.000159406
14.403	29.820	0.131	101	1454.7495	1454.749	0.449	149.100	1.937	3.050	0.341	1.386	1.386	206.689	186.020	0.100	0.8197	721.3339	0.000175257
14.503	29.170	0.135	101	1464.8232	1464.823	0.475	145.850	1.933	2.968	0.340	1.361	1.361	198.439	178.595	0.100	0.81849	720.27222	0.000181022
14.600	28.400	0.155	101	1474.6182	1474.618	0.561	142.000	1.922	2.888	0.338	1.334	1.334	189.440	170.496	0.098	0.81732	719.24062	0.00018672
14.699	25.400	0.166	101	1484.5536	1484.554	0.675	127.000	1.906	2.588	0.336	1.229	1.229	156.134	140.521	0.098	0.81613	718.19495	0.000224646
14.799	19.410	0.164	101	1494.6738	1494.674	0.878	97.050	1.877	1.994	0.332	0.981	0.981	95.243	85.719	0.099	0.81492	717.13058	0.000373781
14.897	14.190	0.176	101	1504.6081	1504.608	1.308	70.950	1.817	1.496	0.323	0.703	0.850	60.308	54.277	0.099	0.81373	716.08649	0.000589421
14.995	11.470	0.167	101	1514.497	1514.497	1.563	57.350	1.781	1.225	0.317	0.510	0.850	48.748	43.873	0.098	0.81255	715.04791	0.000719742
15.092	10.320	0.185	101	1524.3385	1518.569	1.932	51.600	1.729	1.132	0.309	0.428	0.850	43.860	39.474	0.098	0.81138	714.01504	0.000795046
15.168	14.160	0.178	101	1531.9993	1521.497	1.332	70.800	1.814	1.479	0.322	0.692	0.850	60.180	54.162	0.087	0.81047	713.21153	0.000513428
15.270	15.320	0.218	101	1542.2589	1525.418	1.500	76.600	1.790	1.617	0.318	0.774	0.850	65.110	58.599	0.089	0.80925	712.13615	0.000485157
15.363	12.690	0.235	101	1551.6367	1529.002	1.971	63.450	1.724	1.387	0.309	0.620	0.850	53.933	48.539	0.097	0.80813	711.15389	0.000640938
15.427	10.880	0.237	101	1558.0896	1531.468	2.348	54.400	1.671	1.225	0.301	0.495	0.850	46.240	41.616	0.078	0.80736	710.47839	0.000602078
15.470	12.530	0.232	101	1562.4993	1533.153	1.977	62.650	1.723	1.367	0.308	0.606	0.850	53.253	47.927	0.054	0.80684	710.01696	0.000358492
15.537	11.370	0.211	101	1569.2774	1535.744	1.995	56.850	1.721	1.240	0.308	0.513	0.850	48.323	43.490	0.055	0.80603	709.30799	0.000406488
15.589	10.880	0.204	101	1574.5233	1537.749	2.018	54.400	1.717	1.187	0.308	0.471	0.850	46.240	41.616	0.060	0.80541	708.75952	0.000456195
15.661	11.030	0.196	101	1581.765	1540.516	1.913	55.150	1.732	1.191	0.310	0.476	0.850	46.878	42.190	0.062	0.80455	708.00274	0.000466842
15.713	11.680	0.192	101	1587.012	1542.521	1.761	58.400	1.753	1.244	0.313	0.521	0.850	49.640	44.676	0.062	0.80393	707.45467	0.000440556
15.800	11.940	0.181	101	1595.7859	1545.875	1.627	59.700	1.772	1.256	0.316	0.532	0.850	50.745	45.671	0.069	0.80288	706.53868	0.000483209
15.883	11.020	0.175	101	1604.1426	1549.068	1.717	55.100	1.760	1.165	0.314	0.459	0.850	46.835	42.152	0.085	0.80189	705.66679	0.000638882
15.974	10.400	0.181	101	1613.3801	1552.599	1.891	52.000	1.735	1.112	0.310	0.412	0.850	44.200	39.780	0.087	0.8008	704.70366	0.00069434
16.050	10.030	0.187	101	1621.0409	1555.527	2.030	50.150	1.716	1.083	0.307	0.383	0.850	42.628	38.365	0.084	0.79989	703.90542	0.000690695
16.137	9.280	0.184	101	1629.8148	1558.88	2.172	46.400	1.696	1.012	0.304	0.315	0.850	39.440	35.496	0.081	0.79885	702.99177	0.000725094
16.214	8.410	0.176	101	1637.5675	1561.843	2.312	42.050	1.676	0.926	0.301	0.228	0.850	35.743	32.168	0.082	0.79794	702.18497	0.000803655
16.306	8.080	0.165	101	1646.9454	1565.427	2.274	40.400	1.682	0.885	0.302	0.185	0.850	34.340	30.906	0.085	0.79683	701.20968	0.000865843
16.378	7.710	0.145	101	1654.1871	1568.194	2.112	38.550	1.704	0.831	0.306	0.130	0.850	32.768	29.491	0.082	0.79597	700.45704	0.000879379
16.474	7.300	0.130	101	1663.8902	1571.903	2.007	36.500	1.719	0.779	0.308	0.070	0.850	31.025	27.923	0.084	0.79483	699.44924	0.000945581
16.541	7.310	0.129	101	1670.6683	1574.493	1.997	36.550	1.720	0.778	0.308	0.069	0.850	31.068	27.961	0.082	0.79403	698.74569	0.000917529
16.640	7.710	0.158	101	1680.6026	1578.29	2.306	38.550	1.677	0.839	0.302	0.134	0.850	32.768	29.491	0.083	0.79286	697.7152	0.000880834
16.711	7.990	0.172	101	1687.7989	1581.04	2.401	39.950	1.664	0.875	0.300	0.172	0.850	33.958	30.562	0.085	0.79201	696.96924	0.000870301
16.801	8.670	0.124	101	1696.8515	1584.5	1.590	43.350	1.777	0.887	0.317	0.203	0.850	36.848	33.163	0.080	0.79094	696.03145	0.000759736
16.872	24.310	0.126	101	1704.0932	1587.267	0.538	121.550	1.925	2.293	0.339	1.118	1.118	135.863	122.277	0.081	0.79009	695.28174	0.000206402
16.974	42.540	0.145	101	1714.3528	1591.188	0.347	212.700	1.951	3.948	0.343	1.629	1.629	346.550	311.895	0.087	0.78889	694.22033	8.678E-05
17.074	43.170	0.161	101	1724.474	1595.056	0.381	215.850	1.947	4.007	0.342	1.643	1.643	354.595	319.136	0.101	0.7877	693.1741	9.86164E-05
17.160	40.020	0.178	101	1733.155	1598.374	0.456	200.100	1.936	3.727	0.340	1.574	1.574	315.003	283.503	0.093	0.78668	692.27742	0.00010228
17.238	35.190	0.206	101	1741.0471	1601.39	0.601	175.950	1.916	3.305	0.337	1.460	1.460	256.936	231.243	0.082	0.78575	691.46276	0.000110399
17.341	31.670	0.247	101	1751.3996	1605.347	0.803	158.350	1.888	3.012	0.333	1.371	1.371	217.052	195.347	0.090	0.78454	690.39493	0.000143644

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
17.439	28.150	0.239	101	1761.335	1609.144	0.876	140.750	1.877	2.685	0.332	1.262	1.262	177.604	159.844	0.100	0.78338	689.37097	0.000194919
17.539	27.120	0.215	101	1771.4087	1612.994	0.820	135.600	1.885	2.570	0.333	1.221	1.221	165.604	149.044	0.099	0.7822	688.3336	0.000205861
17.615	27.640	0.224	101	1779.0685	1615.921	0.838	138.200	1.883	2.618	0.332	1.238	1.238	171.156	154.041	0.088	0.7813	687.54538	0.000176329
17.706	29.320	0.240	101	1788.2606	1619.434	0.844	146.600	1.882	2.773	0.332	1.292	1.292	189.453	170.508	0.083	0.78023	686.60016	0.000151171
17.805	26.570	0.254	101	1798.2878	1623.266	0.988	132.850	1.862	2.534	0.329	1.206	1.206	160.180	144.162	0.095	0.77906	685.56986	0.00020361
17.900	19.800	0.229	101	1807.9444	1626.957	1.213	99.000	1.830	1.916	0.325	0.939	0.939	92.966	83.669	0.097	0.77793	684.57847	0.00035878
18.004	13.160	0.184	101	1818.4363	1630.967	1.502	65.800	1.790	1.299	0.318	0.566	0.850	55.930	50.337	0.100	0.77671	683.50223	0.000609476
18.096	7.840	0.161	101	1827.6748	1634.497	2.329	39.200	1.674	0.826	0.301	0.118	0.850	33.320	29.988	0.098	0.77563	682.55535	0.001000429
18.174	5.020	0.144	101	1835.6134	1637.531	3.503	25.100	1.510	0.585	0.276	-0.241	0.850	21.335	19.202	0.085	0.77471	681.74229	0.001358612
18.267	3.690	0.111	101	1844.9912	1641.115	4.011	18.450	1.438	0.450	0.266	-0.508	0.850	15.683	14.114	0.086	0.77362	680.78253	0.001860675
18.337	4.650	0.092	101	1852.0471	1643.812	2.481	23.250	1.653	0.493	0.298	-0.378	0.850	19.763	17.786	0.081	0.7728	680.06092	0.001399781
18.432	7.260	0.094	101	1861.6108	1647.467	1.484	36.300	1.792	0.709	0.319	-0.007	0.850	30.855	27.770	0.082	0.77169	679.08352	0.00090539
18.526	6.180	0.126	101	1871.128	1651.104	2.393	30.900	1.665	0.648	0.300	-0.115	0.850	26.265	23.639	0.094	0.77058	678.11167	0.001219388
18.601	4.480	0.149	101	1878.7414	1654.014	4.220	22.400	1.409	0.554	0.261	-0.313	0.850	19.040	17.136	0.085	0.7697	677.3348	0.00150844
18.662	3.480	0.155	101	1884.8226	1656.338	6.088	17.400	1.148	0.528	0.222	-0.410	0.850	14.790	13.311	0.068	0.76899	676.71465	0.001550976
18.694	5.980	0.157	101	1888.1193	1657.598	3.108	29.900	1.565	0.664	0.285	-0.109	0.850	25.415	22.874	0.046	0.76861	676.3786	0.000617763
18.729	7.070	0.158	101	1891.6472	1658.946	2.578	35.350	1.639	0.749	0.296	0.020	0.850	30.048	27.043	0.034	0.7682	676.01908	0.000380053
18.794	8.830	0.171	101	1898.1465	1661.43	2.174	44.150	1.696	0.903	0.304	0.207	0.850	37.528	33.775	0.050	0.76745	675.35704	0.000446669
18.851	10.910	0.192	101	1903.95	1663.648	1.925	54.550	1.730	1.092	0.310	0.393	0.850	46.368	41.731	0.061	0.76678	674.7662	0.000443162
18.904	12.500	0.208	101	1909.2878	1665.688	1.802	62.500	1.748	1.237	0.312	0.515	0.850	53.125	47.813	0.055	0.76616	674.22303	0.000349993
18.963	13.100	0.219	101	1915.2307	1667.959	1.806	65.500	1.747	1.295	0.312	0.558	0.850	55.675	50.108	0.056	0.76548	673.6186	0.000337838
19.027	12.960	0.231	101	1921.6836	1670.426	1.928	64.800	1.730	1.292	0.310	0.553	0.850	55.080	49.572	0.061	0.76473	672.96265	0.000374876
19.095	12.180	0.241	101	1928.6011	1673.069	2.144	60.900	1.700	1.234	0.305	0.506	0.850	51.765	46.589	0.066	0.76393	672.25989	0.000429797
19.162	11.140	0.249	101	1935.3782	1675.659	2.452	55.700	1.657	1.156	0.299	0.437	0.850	47.345	42.611	0.068	0.76315	671.57181	0.000480824
19.228	10.230	0.253	101	1942.0179	1678.197	2.736	51.150	1.617	1.086	0.293	0.372	0.850	43.478	39.130	0.066	0.76238	670.89808	0.000512461
19.298	9.860	0.248	101	1949.0738	1680.894	2.785	49.300	1.610	1.050	0.292	0.338	0.850	41.905	37.715	0.068	0.76157	670.18256	0.000542159
19.364	9.610	0.233	101	1955.8054	1683.466	2.699	48.050	1.622	1.014	0.293	0.307	0.850	40.843	36.758	0.068	0.7608	669.50034	0.000559426
19.426	9.100	0.235	101	1962.026	1685.844	2.890	45.500	1.595	0.975	0.289	0.265	0.850	38.675	34.808	0.064	0.76008	668.87028	0.000554466
19.497	8.860	0.240	101	1969.1758	1688.576	3.050	44.300	1.573	0.961	0.286	0.248	0.850	37.655	33.890	0.066	0.75926	668.14655	0.000587234
19.586	8.860	0.238	101	1978.1355	1692	3.026	44.300	1.576	0.957	0.286	0.245	0.850	37.655	33.890	0.080	0.75823	667.24026	0.000706578
19.659	8.340	0.237	101	1985.563	1694.839	3.227	41.700	1.548	0.916	0.282	0.198	0.850	35.445	31.901	0.081	0.75737	666.48951	0.000762716
19.724	7.830	0.232	101	1992.1089	1697.341	3.401	39.150	1.524	0.872	0.279	0.147	0.850	33.278	29.950	0.069	0.75662	665.82831	0.000692039
19.812	7.720	0.224	101	2000.9767	1700.73	3.328	38.600	1.534	0.853	0.280	0.126	0.850	32.810	29.529	0.076	0.75561	664.93318	0.000773205
19.890	8.130	0.229	101	2008.8678	1703.746	3.212	40.650	1.550	0.887	0.283	0.167	0.850	34.553	31.097	0.083	0.7547	664.13725	0.00079734
19.956	10.720	0.237	101	2015.5994	1706.318	2.441	53.600	1.658	1.092	0.299	0.383	0.850	45.560	41.004	0.072	0.75393	663.45873	0.000527083
20.032	14.200	0.232	101	2023.2603	1709.246	1.761	71.000	1.754	1.365	0.313	0.609	0.850	60.350	54.315	0.071	0.75305	662.68706	0.000391189
20.125	16.120	0.223	101	2032.5907	1712.812	1.478	80.600	1.793	1.513	0.319	0.711	0.850	68.510	61.659	0.084	0.75199	661.74797	0.000406239
20.200	18.710	0.217	101	2040.1586	1715.704	1.224	93.550	1.829	1.719	0.324	0.836	0.850	79.518	71.566	0.084	0.75112	660.98685	0.00034769
20.288	21.690	0.209	101	2049.1183	1719.128	1.013	108.450	1.858	1.957	0.329	0.962	0.962	104.301	93.871	0.082	0.7501	660.08646	0.000258906
20.374	24.280	0.199	101	2057.7528	1722.428	0.857	121.400	1.880	2.161	0.332	1.057	1.057	128.372	115.535	0.087	0.74911	659.21947	0.000223638
20.456	26.230	0.223	101	2066.0631	1725.604	0.886	131.150	1.876	2.335	0.331	1.130	1.130	148.211	133.390	0.084	0.74817	658.38569	0.000186317
20.543	28.570	0.279	101	2074.8834	1728.975	1.012	142.850	1.858	2.563	0.329	1.216	1.216	173.719	156.347	0.085	0.74716	657.50145	0.000160488
20.620	24.530	0.322	101	2082.6362	1731.938	1.369	122.650	1.808	2.257	0.321	1.092	1.092	133.881	120.493	0.082	0.74628	656.72485	0.000201227
20.717	16.590	0.333	101	2092.3857	1735.664	2.141	82.950	1.700	1.620	0.305	0.765	0.850	70.508	63.457	0.087	0.74517	655.74903	0.000402917
20.785	11.120	0.347	101	2099.3022	1738.308	3.449	55.600	1.517	1.215	0.278	0.466	0.850	47.260	42.534	0.083	0.74438	655.05732	0.000571789
20.885	8.130	0.351	101	2109.3769	1742.158	4.959	40.650	1.306	1.030	0.246	0.275	0.850	34.553	31.097	0.084	0.74324	654.05058	0.000796114
20.952	6.860	0.281	101	2116.2005	1744.766	4.840	34.300	1.322	0.857	0.248	0.097	0.850	29.155	26.240	0.084	0.74247	653.36926	0.000937362
21.019	5.750	0.222	101	2122.9321	1747.338	4.739	28.750	1.337	0.710	0.250	-0.085	0.850	24.438	21.994	0.067	0.7417	652.69757	0.000896149
21.095	4.570	0.173	101	2130.5455	1750.248	4.928	22.850	1.310	0.574	0.247	-0.296	0.850	19.423	17.480	0.071	0.74084	651.93842	0.00119185
21.167	4.370	0.194	101	2137.8811	1753.052	5.874	21.850	1.178	0.610	0.227	-0.261	0.850	18.573	16.715	0.074	0.74001	651.20749	0.001297418
21.242	6.010	0.220	101	2145.4481	1755.944	4.462	30.050	1.375	0.717	0.256	-0.068	0.850	25.543	22.988	0.074	0.73915	650.45406	0.000939361
21.325	13.520	0.240	101	2153.8048	1759.137	1.932	67.600	1.730	1.281	0.309	0.545	0.850	57.460	51.714	0.079	0.73821	649.62263	0.000445612
21.439	10.760	0.251	101	2165.3178	1763.537	2.589	53.800	1.638	1.074	0.296	0.364	0.850	45.730	41.157	0.098	0.73691	648.47829	0.000697437
21.539	8.910	0.243	101	2175.3915	1767.387	3.105	44.550	1.565	0.928	0.285	0.213	0.850	37.868	34.081	0.107	0.73577	647.47807	0.000913616
21.615	8.170	0.221	101	2183.1453	1770.351	3.121	40.850	1.563	0.851	0.284	0.129	0.850	34.723	31.250	0.088	0.7349	646.70887	0.000821878
21.717	7.320	0.186	101	2193.4503	1774.289	2.986	36.600	1.582	0.752	0.287	0.013	0.850	31.110	27.999	0.089	0.73374	645.68749	0.000927748
21.813	5.370	0.153	101	2203.1534	1777.997	3.577	26.850	1.499	0.581	0.275	-0.251	0.850	22.823	20.540	0.099	0.73264	644.72673	0.001399062
21.905	3.880	0.132	101	2212.4383	1781.546	4.748	19.400	1.335	0.470	0.250	-0.487	0.850	16.490	14.841	0.094	0.7316	643.80824	0.00183499

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
22.190	19.370	0.166	101	2241.1749	1792.528	0.908	96.850	1.873	1.663	0.331	0.810	0.850	82.323	74.090	0.188	0.72838	640.97094	0.000732769
22.280	28.300	0.194	101	2250.3204	1796.023	0.713	141.500	1.900	2.390	0.335	1.154	1.154	163.313	146.982	0.188	0.72735	640.06968	0.000367502
22.380	29.680	0.217	101	2260.3941	1799.873	0.759	148.400	1.894	2.509	0.334	1.200	1.200	178.007	160.207	0.095	0.72622	639.07791	0.000170794
22.478	28.750	0.226	101	2270.2366	1803.635	0.818	143.750	1.885	2.436	0.333	1.171	1.171	168.325	151.492	0.099	0.72512	638.10989	0.000186884
22.576	27.430	0.215	101	2280.171	1807.432	0.818	137.150	1.885	2.320	0.333	1.125	1.125	154.259	138.833	0.098	0.72402	637.13382	0.000202188
22.675	25.730	0.183	101	2290.1528	1811.247	0.745	128.650	1.896	2.160	0.334	1.058	1.058	136.173	122.556	0.099	0.7229	636.15409	0.000230301
22.782	23.640	0.157	101	2300.9689	1815.38	0.698	118.200	1.902	1.973	0.335	0.974	0.974	115.134	103.621	0.103	0.7217	635.0936	0.00028397
22.887	26.500	0.153	101	2311.5537	1819.425	0.603	132.500	1.916	2.191	0.337	1.074	1.074	142.320	128.088	0.106	0.72052	634.05694	0.000236001
22.997	29.490	0.158	101	2322.696	1823.684	0.556	147.450	1.922	2.424	0.338	1.170	1.170	172.478	155.230	0.108	0.71928	632.9669	0.000197365
23.108	27.790	0.155	101	2333.8838	1827.96	0.582	138.950	1.919	2.284	0.338	1.113	1.113	154.679	139.211	0.111	0.71804	631.87368	0.000225792
23.207	25.320	0.150	101	2343.9121	1831.792	0.622	126.600	1.913	2.082	0.337	1.026	1.026	129.889	116.900	0.105	0.71693	630.89485	0.000255074
23.308	22.450	0.132	101	2354.1252	1835.695	0.619	112.250	1.913	1.842	0.337	0.911	0.911	102.241	92.017	0.100	0.71579	629.89904	0.000308676
23.403	22.060	0.123	101	2363.7343	1839.368	0.591	110.300	1.917	1.803	0.338	0.891	0.891	98.278	88.451	0.098	0.71473	628.96309	0.000314007
23.538	23.750	0.148	101	2377.3835	1844.584	0.654	118.750	1.908	1.944	0.336	0.961	0.961	114.124	102.712	0.115	0.71322	627.63526	0.00031661
23.631	23.620	0.171	101	2386.7613	1848.168	0.764	118.100	1.893	1.946	0.334	0.960	0.960	113.381	102.043	0.114	0.71219	626.72407	0.00031506
23.737	17.890	0.193	101	2397.3926	1852.231	1.156	89.450	1.838	1.514	0.326	0.718	0.850	76.033	68.429	0.099	0.71101	625.6922	0.000407575
23.838	12.560	0.194	101	2407.6057	1856.134	1.704	62.800	1.761	1.107	0.314	0.411	0.850	53.380	48.042	0.103	0.70989	624.70201	0.000603812
23.948	10.010	0.194	101	2418.747	1860.392	2.208	50.050	1.691	0.917	0.304	0.221	0.850	42.543	38.288	0.106	0.70866	623.62306	0.000774829
24.068	7.680	0.177	101	2430.864	1865.023	2.738	38.400	1.617	0.734	0.293	-0.004	0.850	32.640	29.376	0.115	0.70733	622.4511	0.001097871
24.164	5.760	0.137	101	2440.6135	1868.749	3.018	28.800	1.578	0.563	0.287	-0.265	0.850	24.480	22.032	0.108	0.70626	621.50923	0.00137415
24.270	4.710	0.107	101	2451.2902	1872.83	3.068	23.550	1.570	0.461	0.286	-0.458	0.850	20.018	18.016	0.101	0.70509	620.47892	0.001567199
24.369	5.830	0.126	101	2461.3185	1876.662	2.740	29.150	1.616	0.554	0.292	-0.274	0.850	24.778	22.300	0.102	0.70399	619.51228	0.001281405
24.469	14.730	0.164	101	2471.3922	1880.512	1.215	73.650	1.830	1.234	0.324	0.523	0.850	62.603	56.342	0.100	0.70289	618.54232	0.000491628
24.567	15.690	0.202	101	2481.2811	1884.292	1.399	78.450	1.804	1.330	0.321	0.591	0.850	66.683	60.014	0.099	0.70181	617.5912	0.000457642
24.670	12.430	0.242	101	2491.6336	1888.248	2.166	62.150	1.697	1.118	0.305	0.411	0.850	52.828	47.545	0.100	0.70068	616.59659	0.000584791
24.790	8.430	0.255	101	2503.7506	1892.879	3.558	42.150	1.502	0.855	0.275	0.123	0.850	35.828	32.245	0.111	0.69936	615.43391	0.000955381
25.067	4.630	0.125	101	2531.7902	1903.595	3.716	23.150	1.480	0.474	0.272	-0.451	0.850	19.678	17.710	0.199	0.69631	612.74933	0.003095198
25.153	4.320	0.105	101	2540.4712	1906.913	3.453	21.600	1.517	0.430	0.277	-0.536	0.850	18.360	16.524	0.182	0.69536	611.9199	0.003029353
25.226	4.880	0.101	101	2547.8068	1909.716	2.798	24.400	1.608	0.458	0.291	-0.458	0.850	20.740	18.666	0.079	0.69457	611.21963	0.001168361
25.287	9.990	0.112	101	2553.9809	1912.076	1.283	49.950	1.820	0.827	0.323	0.144	0.850	42.458	38.212	0.067	0.6939	610.63069	0.00048094
25.332	18.110	0.124	101	2558.531	1913.815	0.735	90.550	1.897	1.437	0.335	0.676	0.850	76.968	69.271	0.053	0.69341	610.19692	0.000210448
25.430	26.830	0.165	101	2568.4189	1917.594	0.644	134.150	1.910	2.111	0.336	1.039	1.039	139.331	125.398	0.071	0.69234	609.25506	0.00015627
25.495	22.380	0.206	101	2575.0112	1920.113	0.977	111.900	1.863	1.803	0.329	0.885	0.885	99.030	89.127	0.082	0.69162	608.62771	0.000250707
25.583	15.370	0.199	101	2583.878	1923.502	1.416	76.850	1.802	1.278	0.320	0.553	0.850	65.323	58.790	0.077	0.69066	607.78463	0.000356032
25.666	9.480	0.161	101	2592.2812	1926.713	1.970	47.400	1.724	0.822	0.309	0.123	0.850	40.290	36.261	0.085	0.68976	606.98642	0.00064401
25.761	6.550	0.141	101	2601.8448	1930.368	2.677	32.750	1.625	0.602	0.294	-0.193	0.850	27.838	25.054	0.089	0.68873	606.07889	0.000968257
25.839	9.200	0.143	101	2609.6905	1933.367	1.806	46.000	1.747	0.785	0.312	0.082	0.850	39.100	35.190	0.086	0.68788	605.33514	0.000667146
25.927	16.680	0.140	101	2618.6038	1936.773	0.912	83.400	1.872	1.326	0.331	0.596	0.850	70.890	63.801	0.083	0.68692	604.49098	0.000353728
26.019	20.070	0.151	101	2627.9352	1940.34	0.806	100.350	1.887	1.579	0.333	0.763	0.850	85.298	76.768	0.090	0.68592	603.60815	0.000319575
26.092	21.990	0.156	101	2635.3162	1943.16	0.757	109.950	1.894	1.722	0.334	0.845	0.850	93.458	84.112	0.083	0.68513	602.91051	0.000266869
26.180	19.510	0.161	101	2644.183	1946.549	0.886	97.550	1.876	1.540	0.331	0.738	0.850	82.918	74.626	0.080	0.68417	602.07322	0.000292024
26.277	13.590	0.160	101	2654.0255	1950.311	1.304	67.950	1.817	1.105	0.323	0.417	0.850	57.758	51.982	0.093	0.68312	601.14481	0.000481998
26.361	8.930	0.147	101	2662.4277	1953.522	1.937	44.650	1.729	0.762	0.309	0.051	0.850	37.953	34.157	0.090	0.68222	600.35309	0.000714365
26.431	5.900	0.134	101	2669.5775	1956.254	2.929	29.500	1.590	0.547	0.288	-0.292	0.850	25.075	22.568	0.077	0.68145	599.67998	0.000920625
26.523	4.190	0.107	101	2678.8624	1959.803	3.750	20.950	1.475	0.418	0.271	-0.574	0.850	17.808	16.027	0.081	0.68046	598.80671	0.001367932
26.615	3.500	0.075	101	2688.1473	1963.351	3.460	17.500	1.516	0.339	0.277	-0.767	0.850	14.875	13.388	0.092	0.67947	597.93438	0.001847667
26.690	3.530	0.050	101	2695.6678	1966.226	2.291	17.650	1.679	0.308	0.302	-0.822	0.850	15.003	13.502	0.083	0.67867	597.22851	0.001655938
26.787	3.520	0.030	101	2705.5092	1969.987	1.398	17.600	1.804	0.285	0.321	-0.866	0.850	14.960	13.464	0.086	0.67762	596.30575	0.001712984
26.884	3.390	0.021	101	2715.2588	1973.713	1.043	16.950	1.854	0.267	0.328	-0.918	0.850	14.408	12.967	0.097	0.67658	595.39265	0.002003962
26.957	3.530	0.023	101	2722.6398	1976.534	1.065	17.650	1.851	0.278	0.328	-0.880	0.850	15.003	13.502	0.085	0.6758	594.70206	0.001680843
27.045	3.940	0.044	101	2731.5541	1979.94	1.701	19.700	1.762	0.326	0.314	-0.751	0.850	16.745	15.071	0.081	0.67485	593.86884	0.001430499
27.124	6.150	0.060	101	2739.4927	1982.974	1.249	30.750	1.825	0.490	0.324	-0.351	0.850	26.138	23.524	0.083	0.67401	593.12755	0.000946621
27.222	8.970	0.078	101	2749.4271	1986.771	1.030	44.850	1.856	0.701	0.328	-0.007	0.850	38.123	34.310	0.088	0.67296	592.20088	0.000687231
27.324	9.560	0.095	101	2759.6866	1990.692	1.158	47.800	1.838	0.753	0.326	0.058	0.850	40.630	36.567	0.100	0.67187	591.24502	0.000727378
27.384	9.430	0.103	101	2765.8143	1993.034	1.280	47.150	1.821	0.749	0.323	0.050	0.850	40.078	36.070	0.081	0.67122	590.67468	0.000597823
27.476	9.560	0.105	101	2775.0528	1996.565	1.281	47.800	1.821	0.758	0.323	0.061	0.850	40.630	36.567	0.076	0.67024	589.81559	0.000552145
27.559	9.300	0.104	101	2783.4095	1999.758	1.315	46.500	1.816	0.738	0.322	0.035	0.850	39.525	35.573	0.087	0.66936	589.03931	0.000649061
27.643	9.160	0.086	101	2791.9521	2003.023	1.109	45.800	1.845	0.714	0.327	0.009	0.850	38.930	35.037	0.084	0.66846	588.24658	0.000632067

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
27.718	8.910	0.074	101	2799.4726	2005.897	0.988	44.550	1.862	0.688	0.329	-0.024	0.850	37.868	34.081	0.080	0.66767	587.54937	0.000616913
27.794	8.910	0.063	101	2807.1789	2008.843	0.834	44.550	1.883	0.679	0.332	-0.032	0.850	37.868	34.081	0.075	0.66686	586.83558	0.000584085
27.884	9.040	0.050	101	2816.2779	2012.32	0.653	45.200	1.909	0.678	0.336	-0.028	0.850	38.420	34.578	0.083	0.6659	585.99365	0.000634458
27.951	8.110	0.046	101	2823.0561	2014.911	0.693	40.550	1.903	0.610	0.335	-0.130	0.850	34.468	31.021	0.079	0.66519	585.36707	0.000667438
28.021	6.310	0.043	101	2830.1119	2017.607	0.883	31.550	1.876	0.480	0.331	-0.359	0.850	26.818	24.136	0.068	0.66445	584.71537	0.000746606
28.115	5.040	0.037	101	2839.5827	2021.227	1.011	25.200	1.858	0.387	0.329	-0.567	0.850	21.420	19.278	0.082	0.66346	583.8415	0.001115009
28.185	4.170	0.033	101	2846.6396	2023.924	1.205	20.850	1.831	0.324	0.325	-0.739	0.850	17.723	15.950	0.082	0.66272	583.19102	0.001346218
28.269	3.940	0.043	101	2855.1811	2027.188	1.712	19.700	1.760	0.318	0.314	-0.773	0.850	16.745	15.071	0.077	0.66182	582.40443	0.001342887
28.349	4.350	0.047	101	2863.2126	2030.258	1.624	21.750	1.773	0.348	0.316	-0.684	0.850	18.488	16.639	0.082	0.66098	581.66556	0.001290676
28.415	5.240	0.051	101	2869.9443	2032.83	1.330	26.200	1.814	0.410	0.322	-0.522	0.850	22.270	20.043	0.073	0.66028	581.04684	0.000953431
28.503	5.970	0.059	101	2878.8111	2036.219	1.293	29.850	1.819	0.465	0.323	-0.402	0.850	25.373	22.835	0.077	0.65936	580.23265	0.000882955
28.572	5.830	0.066	101	2885.7286	2038.863	1.509	29.150	1.789	0.461	0.318	-0.416	0.850	24.778	22.300	0.078	0.65863	579.59807	0.00091393
28.634	7.810	0.071	101	2891.9956	2041.258	1.114	39.050	1.844	0.598	0.327	-0.159	0.850	33.193	29.873	0.065	0.65798	579.02363	0.000569298
28.703	7.980	0.073	101	2899.0525	2043.955	1.110	39.900	1.845	0.610	0.327	-0.140	0.850	33.915	30.524	0.066	0.65725	578.37732	0.000562432
28.803	8.250	0.061	101	2909.0798	2047.787	0.902	41.250	1.874	0.620	0.331	-0.120	0.850	35.063	31.556	0.085	0.6562	577.45994	0.000696452
28.867	8.130	0.055	101	2915.5327	2050.253	0.817	40.650	1.886	0.606	0.333	-0.139	0.850	34.553	31.097	0.082	0.65553	576.87018	0.00068105
28.941	7.750	0.048	101	2923.0541	2053.128	0.757	38.750	1.894	0.574	0.334	-0.188	0.850	32.938	29.644	0.069	0.65475	576.18335	0.000605091
29.034	6.840	0.038	101	2932.3845	2056.693	0.715	34.200	1.900	0.504	0.335	-0.308	0.850	29.070	26.163	0.083	0.65379	575.33223	0.000825543
29.100	5.410	0.032	101	2939.1162	2059.266	0.802	27.050	1.888	0.401	0.333	-0.527	0.850	22.993	20.693	0.080	0.65309	574.71879	0.000993775
29.173	4.530	0.022	101	2946.4983	2062.087	0.730	22.650	1.898	0.334	0.335	-0.698	0.850	19.253	17.327	0.070	0.65233	574.04667	0.001041648
29.267	3.910	0.017	101	2955.968	2065.707	0.683	19.550	1.904	0.286	0.336	-0.840	0.850	16.618	14.956	0.083	0.65135	573.18538	0.001438784
29.336	3.540	0.013	101	2962.8855	2068.35	0.632	17.700	1.912	0.258	0.337	-0.936	0.850	15.045	13.541	0.081	0.65063	572.55686	0.001543658
29.432	3.300	0.011	101	2972.5886	2072.059	0.595	16.500	1.917	0.239	0.337	-1.005	0.850	14.025	12.623	0.082	0.64963	571.67618	0.001676917
29.498	3.310	0.007	101	2979.2738	2074.614	0.390	16.550	1.945	0.236	0.342	-1.010	0.850	14.068	12.661	0.081	0.64894	571.07004	0.001646736
29.590	3.440	0.005	101	2988.6052	2078.18	0.262	17.200	1.963	0.243	0.344	-0.980	0.850	14.620	13.158	0.079	0.64798	570.22483	0.001546277
29.666	3.310	0.005	101	2996.2185	2081.089	0.281	16.550	1.961	0.234	0.344	-1.017	0.850	14.068	12.661	0.084	0.6472	569.53596	0.001698082
29.744	3.430	0.005	101	3004.1571	2084.123	0.265	17.150	1.963	0.242	0.344	-0.985	0.850	14.578	13.120	0.077	0.64638	568.81838	0.001502086
29.830	3.290	0.007	101	3012.7916	2087.423	0.387	16.450	1.946	0.233	0.342	-1.022	0.850	13.983	12.584	0.082	0.6455	568.03872	0.001666538
29.897	3.160	0.008	101	3019.6162	2090.032	0.467	15.800	1.935	0.225	0.340	-1.058	0.850	13.430	12.087	0.077	0.6448	567.4231	0.001616712
29.973	3.160	0.008	101	3027.2296	2092.941	0.468	15.800	1.935	0.225	0.340	-1.059	0.850	13.430	12.087	0.071	0.64402	566.73695	0.001508098
30.061	3.160	0.010	101	3036.1893	2096.365	0.591	15.800	1.917	0.227	0.338	-1.057	0.850	13.430	12.087	0.082	0.6431	565.93031	0.001728658
30.129	3.320	0.006	101	3043.0139	2098.974	0.350	16.600	1.951	0.234	0.343	-1.020	0.850	14.110	12.699	0.078	0.64241	565.31653	0.001565338
30.196	3.460	0.007	101	3049.792	2101.564	0.362	17.300	1.949	0.243	0.342	-0.982	0.850	14.705	13.235	0.067	0.64171	564.70745	0.001293009
30.287	3.470	0.008	101	3058.984	2105.077	0.397	17.350	1.944	0.244	0.342	-0.979	0.850	14.748	13.273	0.079	0.64078	563.88231	0.001511461
30.362	3.480	0.008	101	3066.5509	2107.969	0.396	17.400	1.945	0.245	0.342	-0.978	0.850	14.790	13.311	0.083	0.64	563.20378	0.001579655
30.424	3.610	0.008	101	3072.8644	2110.382	0.371	18.050	1.948	0.253	0.342	-0.946	0.850	15.343	13.808	0.069	0.63936	562.63816	0.001259954
30.492	3.610	0.010	101	3079.7354	2113.008	0.464	18.050	1.935	0.254	0.340	-0.944	0.850	15.343	13.808	0.065	0.63866	562.02311	0.001195478
30.560	3.480	0.010	101	3086.6065	2115.634	0.532	17.400	1.926	0.246	0.339	-0.977	0.850	14.790	13.311	0.068	0.63796	561.4086	0.001291164

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
30.633	3.480	0.008	101	3093.9411	2118.437	0.424	17.400	1.941	0.244	0.341	-0.982	0.850	14.790	13.311	0.070	0.63722	560.75324	0.001333163
30.698	3.750	0.008	101	3100.4869	2120.939	0.350	18.750	1.951	0.261	0.343	-0.915	0.850	15.938	14.344	0.069	0.63656	560.16889	0.001207592
30.789	4.010	0.008	101	3109.6789	2124.452	0.314	20.050	1.956	0.278	0.343	-0.855	0.850	17.043	15.338	0.078	0.63562	559.34914	0.001278536
30.858	4.000	0.006	101	3116.6893	2127.131	0.258	20.000	1.964	0.276	0.345	-0.861	0.850	17.000	15.300	0.080	0.63491	558.72462	0.001318097
30.926	3.990	0.007	101	3123.5129	2129.739	0.280	19.950	1.961	0.275	0.344	-0.863	0.850	16.958	15.262	0.068	0.63422	558.11728	0.001127013
30.994	3.750	0.011	101	3130.4304	2132.382	0.499	18.750	1.930	0.263	0.340	-0.915	0.850	15.938	14.344	0.068	0.63353	557.50214	0.001189775
31.081	3.750	0.015	101	3139.1578	2135.718	0.665	18.750	1.907	0.265	0.336	-0.911	0.850	15.938	14.344	0.077	0.63264	556.72685	0.001352737
31.158	3.760	0.020	101	3146.9115	2138.681	0.915	18.800	1.872	0.271	0.331	-0.900	0.850	15.980	14.382	0.082	0.63186	556.03879	0.0014195
31.247	4.190	0.016	101	3155.9642	2142.141	0.613	20.950	1.914	0.294	0.337	-0.811	0.850	17.808	16.027	0.083	0.63095	555.23636	0.001297085
31.324	4.470	0.018	101	3163.7634	2145.121	0.616	22.350	1.914	0.314	0.337	-0.752	0.850	18.998	17.098	0.083	0.63017	554.5458	0.001217607
31.414	4.630	0.017	101	3172.8625	2148.599	0.552	23.150	1.923	0.323	0.338	-0.723	0.850	19.678	17.710	0.084	0.62925	553.74105	0.00117706
31.488	5.180	0.021	101	3180.3365	2151.455	0.574	25.900	1.920	0.361	0.338	-0.618	0.850	22.015	19.814	0.082	0.6285	553.08074	0.001030604
31.584	5.180	0.025	101	3189.9466	2155.128	0.709	25.900	1.901	0.364	0.335	-0.614	0.850	22.015	19.814	0.085	0.62754	552.23268	0.001060756
31.656	5.210	0.029	101	3197.2813	2157.931	0.814	26.050	1.886	0.369	0.333	-0.606	0.850	22.143	19.928	0.084	0.6268	551.58615	0.001044819
31.739	5.200	0.037	101	3205.6834	2161.142	1.023	26.000	1.857	0.373	0.329	-0.600	0.850	22.100	19.890	0.078	0.62596	550.84629	0.000970898
31.999	8.140	0.052	101	3231.9142	2171.167	0.802	40.700	1.888	0.572	0.333	-0.192	0.850	34.595	31.136	0.171	0.62334	548.54186	0.001359264
32.063	8.100	0.055	101	3238.3206	2173.616	0.842	40.500	1.882	0.571	0.332	-0.196	0.850	34.425	30.983	0.162	0.6227	547.98027	0.001285943
32.101	7.540	0.055	101	3242.2202	2175.106	0.924	37.700	1.871	0.534	0.331	-0.260	0.850	32.045	28.841	0.051	0.62232	547.63866	0.000435958
32.164	6.920	0.053	101	3248.5337	2177.519	0.997	34.600	1.860	0.492	0.329	-0.339	0.850	29.410	26.469	0.051	0.62169	547.08598	0.00047026
32.196	6.300	0.052	101	3251.8293	2178.778	1.113	31.500	1.844	0.452	0.327	-0.423	0.850	26.775	24.098	0.048	0.62136	546.79766	0.000485736
32.266	5.670	0.050	101	3258.8862	2181.475	1.247	28.350	1.825	0.410	0.324	-0.518	0.850	24.098	21.688	0.051	0.62066	546.18073	0.000580802
32.361	5.190	0.044	101	3268.4964	2185.148	1.237	25.950	1.827	0.375	0.324	-0.604	0.850	22.058	19.852	0.083	0.61971	545.34153	0.001019973
32.428	5.100	0.037	101	3275.2745	2187.739	1.057	25.500	1.852	0.363	0.328	-0.629	0.850	21.675	19.508	0.081	0.61903	544.75028	0.001019506
32.513	4.960	0.027	101	3283.816	2191.003	0.820	24.800	1.885	0.346	0.333	-0.666	0.850	21.080	18.972	0.076	0.61819	544.00599	0.000978591
32.629	4.940	0.021	101	3295.5149	2195.474	0.635	24.700	1.911	0.339	0.337	-0.679	0.850	20.995	18.896	0.100	0.61703	542.98797	0.001295723
32.734	4.790	0.020	101	3306.1461	2199.537	0.644	23.950	1.910	0.329	0.336	-0.709	0.850	20.358	18.322	0.111	0.61598	542.06426	0.001471755
32.835	4.880	0.014	101	3316.3138	2203.423	0.425	24.400	1.940	0.329	0.341	-0.702	0.850	20.740	18.666	0.103	0.61498	541.18207	0.001343366
32.955	4.980	0.010	101	3328.4762	2208.071	0.311	24.900	1.957	0.332	0.343	-0.689	0.850	21.165	19.049	0.111	0.61378	540.12841	0.001410548
33.070	4.710	0.008	101	3340.0821	2212.507	0.253	23.550	1.965	0.312	0.345	-0.745	0.850	20.018	18.016	0.118	0.61264	539.1246	0.001584516
33.193	4.600	0.007	101	3352.5243	2217.262	0.246	23.000	1.966	0.304	0.345	-0.769	0.850	19.550	17.595	0.119	0.61142	538.05023	0.001638232
33.301	4.880	0.006	101	3363.3879	2221.414	0.178	24.400	1.975	0.321	0.346	-0.718	0.850	20.740	18.666	0.115	0.61036	537.11367	0.001493961
33.391	5.010	0.007	101	3372.4405	2224.873	0.220	25.050	1.969	0.330	0.345	-0.693	0.850	21.293	19.163	0.099	0.60947	536.3343	0.001241749
33.520	5.030	0.005	101	3385.5311	2229.876	0.153	25.150	1.979	0.329	0.347	-0.694	0.850	21.378	19.240	0.110	0.60819	535.20901	0.001372228
33.622	4.880	0.006	101	3395.8382	2233.815	0.189	24.400	1.974	0.319	0.346	-0.723	0.850	20.740	18.666	0.116	0.60719	534.32443	0.001492064
33.721	4.600	0.010	101	3405.8654	2237.648	0.335	23.000	1.953	0.303	0.343	-0.775	0.850	19.550	17.595	0.101	0.60621	533.46507	0.001373434
33.829	4.510	0.015	101	3416.6825	2241.782	0.539	22.550	1.925	0.301	0.339	-0.788	0.850	19.168	17.251	0.103	0.60516	532.53937	0.001433487
33.954	6.490	0.041	101	3429.3096	2246.607	0.867	32.450	1.879	0.443	0.332	-0.435	0.850	27.583	24.824	0.116	0.60393	531.46053	0.001118124
34.045	10.020	0.053	101	3438.5945	2250.156	0.640	50.100	1.910	0.672	0.337	-0.037	0.850	42.585	38.327	0.108	0.60303	530.66845	0.000675875
34.145	7.480	0.063	101	3448.6682	2254.006	1.102	37.400	1.846	0.518	0.327	-0.294	0.850	31.790	28.611	0.096	0.60206	529.81024	0.00079859
34.255	6.060	0.073	101	3459.7176	2258.229	1.677	30.300	1.765	0.438	0.315	-0.468	0.850	25.755	23.180	0.105	0.60099	528.87029	0.001073655
34.356	5.700	0.069	101	3469.9308	2262.132	1.728	28.500	1.758	0.413	0.314	-0.526	0.850	24.225	21.803	0.105	0.6	528.00279	0.001147112
34.451	5.190	0.051	101	3479.5864	2265.822	1.487	25.950	1.792	0.368	0.319	-0.627	0.850	22.058	19.852	0.098	0.59907	527.18378	0.001175423
34.552	5.230	0.032	101	3489.754	2269.708	0.918	26.150	1.871	0.355	0.331	-0.645	0.850	22.228	20.005	0.098	0.59809	526.32254	0.001161864
34.652	5.470	0.036	101	3499.8742	2273.576	0.954	27.350	1.866	0.371	0.330	-0.603	0.850	23.248	20.923	0.100	0.59712	525.46654	0.001135073
34.752	5.730	0.032	101	3509.9954	2277.444	0.815	28.650	1.886	0.384	0.333	-0.567	0.850	24.353	21.917	0.100	0.59615	524.61169	0.001079329
34.834	5.830	0.058	101	3518.2582	2280.602	1.422	29.150	1.801	0.409	0.320	-0.526	0.850	24.778	22.300	0.091	0.59536	523.9147	0.000962193
34.920	5.180	0.076	101	3526.8937	2283.902	2.222	25.900	1.689	0.387	0.303	-0.602	0.850	22.015	19.814	0.084	0.59453	523.18715	0.000994032
35.015	4.990	0.083	101	3536.5029	2287.574	2.564	24.950	1.641	0.383	0.296	-0.622	0.850	21.208	19.087	0.090	0.59361	522.37862	0.001112371
35.116	5.750	0.082	101	3546.7635	2291.496	2.060	28.750	1.712	0.422	0.307	-0.514	0.850	24.438	21.994	0.098	0.59263	521.51649	0.001049595
35.182	7.310	0.082	101	3553.3557	2294.015	1.475	36.550	1.794	0.512	0.319	-0.315	0.850	31.068	27.961	0.083	0.592	520.96325	0.000699509
35.251	6.420	0.071	101	3560.3651	2296.694	1.526	32.100	1.786	0.451	0.318	-0.437	0.850	27.285	24.557	0.067	0.59134	520.37558	0.000642102
35.334	5.630	0.069	101	3568.7219	2299.888	1.784	28.150	1.750	0.403	0.313	-0.551	0.850	23.928	21.535	0.076	0.59054	519.67571	0.000826073
35.416	5.450	0.072	101	3576.9857	2303.046	1.958	27.250	1.726	0.395	0.309	-0.575	0.850	23.163	20.846	0.082	0.58976	518.98445	0.000921793
35.510	6.830	0.064	101	3586.5484	2306.701	1.271	34.150	1.822	0.468	0.323	-0.394	0.850	29.028	26.125	0.088	0.58885	518.18556	0.000787699
35.612	7.120	0.053	101	3596.8544	2310.639	0.996	35.600	1.861	0.477	0.329	-0.368	0.850	30.260	27.234	0.098	0.58787	517.32579	0.000840783
35.711	6.560	0.052	101	3606.7888	2314.436	1.089	32.800	1.848	0.442	0.327	-0.443	0.850	27.880	25.092	0.100	0.58693	516.49823	0.000928141
35.801	6.710	0.056	101	3615.8889	2317.914	1.148	33.550	1.839	0.454	0.326	-0.421	0.850	28.518	25.666	0.094	0.58607	515.74121	0.000852078
35.892	6.470	0.045	101	3625.1274	2321.445	0.975	32.350	1.864	0.431	0.330	-0.464	0.850	27.498	24.748	0.091	0.5852	514.9737	0.000850112

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
36.000	6.390	0.035	101	3635.9899	2325.596	0.766	31.950	1.893	0.418	0.334	-0.486	0.850	27.158	24.442	0.100	0.58417	514.07257	0.000941828
36.087	6.420	0.033	101	3644.7648	2328.95	0.711	32.100	1.900	0.418	0.335	-0.485	0.850	27.285	24.557	0.097	0.58335	513.34566	0.000914512
36.178	6.820	0.029	101	3653.9568	2332.463	0.581	34.100	1.919	0.439	0.338	-0.435	0.850	28.985	26.087	0.089	0.58248	512.58518	0.000786474
36.282	6.670	0.026	101	3664.4941	2336.49	0.542	33.350	1.924	0.428	0.339	-0.459	0.850	28.348	25.513	0.098	0.58149	511.71466	0.000881545
36.378	6.560	0.024	101	3674.1972	2340.198	0.502	32.800	1.930	0.419	0.339	-0.478	0.850	27.880	25.092	0.100	0.58058	510.91423	0.000918106
36.477	6.820	0.022	101	3684.1326	2343.995	0.448	34.100	1.937	0.433	0.341	-0.445	0.850	28.985	26.087	0.097	0.57965	510.09582	0.000855469
36.577	7.080	0.024	101	3694.2528	2347.863	0.451	35.400	1.937	0.449	0.341	-0.411	0.850	30.090	27.081	0.099	0.57871	509.26339	0.000840183
36.678	7.430	0.027	101	3704.5123	2351.784	0.491	37.150	1.931	0.471	0.340	-0.366	0.850	31.578	28.420	0.101	0.57775	508.42076	0.000812201
36.776	7.250	0.031	101	3714.4013	2355.563	0.567	36.250	1.921	0.462	0.338	-0.387	0.850	30.813	27.731	0.100	0.57683	507.60978	0.000821607
36.866	6.760	0.030	101	3723.5003	2359.041	0.606	33.800	1.915	0.431	0.337	-0.453	0.850	28.730	25.857	0.094	0.57598	506.8646	0.00082919
36.950	6.740	0.029	101	3731.949	2362.27	0.593	33.700	1.917	0.429	0.338	-0.457	0.850	28.645	25.781	0.087	0.5752	506.17358	0.000767521
37.054	6.480	0.029	101	3742.4409	2366.279	0.627	32.400	1.912	0.413	0.337	-0.495	0.850	27.540	24.786	0.094	0.57422	505.31664	0.000860222
37.161	6.650	0.024	101	3753.2115	2370.396	0.492	33.250	1.931	0.419	0.340	-0.477	0.850	28.263	25.436	0.105	0.57323	504.43831	0.000939357
37.238	6.970	0.011	101	3761.0107	2373.376	0.218	34.850	1.969	0.430	0.345	-0.445	0.850	29.623	26.660	0.092	0.5725	503.80317	0.000781747
37.337	6.860	0.007	101	3771.0845	2377.226	0.143	34.300	1.980	0.420	0.347	-0.464	0.850	29.155	26.240	0.088	0.57157	502.98388	0.000763231
37.440	8.990	0.057	101	3781.3905	2381.165	0.809	44.950	1.887	0.577	0.333	-0.185	0.850	38.208	34.387	0.101	0.57062	502.14696	0.00066298
37.540	18.040	0.098	101	3791.5117	2385.033	0.608	90.200	1.915	1.138	0.337	0.459	0.850	76.670	69.003	0.101	0.56969	501.32629	0.000330616
37.613	17.450	0.115	101	3798.8928	2387.854	0.740	87.250	1.896	1.110	0.334	0.433	0.850	74.163	66.746	0.087	0.56901	500.72859	0.000292504
37.707	11.210	0.125	101	3808.41	2391.491	1.345	56.050	1.812	0.746	0.322	0.044	0.850	47.643	42.878	0.084	0.56814	499.95886	0.000438936
37.809	7.400	0.134	101	3818.7161	2395.43	2.437	37.000	1.659	0.537	0.299	-0.296	0.850	31.450	28.305	0.098	0.56719	499.12658	0.000778725
37.924	6.520	0.125	101	3830.322	2399.866	2.704	32.600	1.621	0.483	0.293	-0.405	0.850	27.710	24.939	0.108	0.56613	498.19084	0.000975122
38.042	5.950	0.070	101	3842.2531	2404.425	1.740	29.750	1.756	0.406	0.313	-0.542	0.850	25.288	22.759	0.117	0.56503	497.23058	0.001145572
38.168	5.850	0.042	101	3854.9731	2409.287	1.076	29.250	1.849	0.378	0.327	-0.590	0.850	24.863	22.376	0.122	0.56387	496.20872	0.001217794
38.301	5.870	0.000	101	3868.4364	2414.432	0.000	29.350	2.000	0.350	0.350	-0.629	0.850	24.948	22.453	0.130	0.56265	495.12926	0.001286274
38.401	6.020	0.000	101	3878.5111	2418.282	0.000	30.100	2.000	0.359	0.350	-0.607	0.850	25.585	23.027	0.117	0.56173	494.32292	0.001125679
38.499	6.290	0.000	101	3888.3525	2422.044	0.000	31.450	2.000	0.374	0.350	-0.568	0.850	26.733	24.059	0.099	0.56084	493.53643	0.000910132
38.534	5.210	0.000	101	3891.9269	2423.41	0.000	26.050	2.000	0.310	0.350	-0.744	0.850	22.143	19.928	0.066	0.56051	493.25107	0.000739737
38.534	5.210	0.000	101	3891.9269	2423.41	0.000	26.050	2.000	0.310	0.350	-0.744	0.850	22.143	19.928	0.018	0.56051	493.25107	0.000197089
39.000	6.825	0.046	101	3939	2441.4	0.951	34.125	1.867	0.432	0.330	-0.462	0.850	29.006	26.106	0.233	0.55626	489.50734	0.001966341
39.500	6.825	0.046	101	3989.5	2460.7	0.956	34.125	1.866	0.428	0.330	-0.469	0.850	29.006	26.106	0.483	0.55173	485.52072	0.004042637
40.000	6.825	0.046	101	4040	2480	0.961	34.125	1.865	0.425	0.330	-0.476	0.850	29.006	26.106	0.500	0.54723	481.5648	0.004150526
40.500	6.825	0.046	101	4090.5	2499.3	0.966	34.125	1.865	0.422	0.330	-0.483	0.850	29.006	26.106	0.500	0.54277	477.63956	0.004116695
41.000	6.825	0.046	101	4141	2518.6	0.971	34.125	1.864	0.419	0.330	-0.490	0.850	29.006	26.106	0.500	0.53835	473.74496	0.004083128
41.500	6.825	0.046	101	4191.5	2537.9	0.976	34.125	1.863	0.416	0.329	-0.497	0.850	29.006	26.106	0.500	0.53396	469.88098	0.004049825
42.000	6.825	0.046	101	4242	2557.2	0.982	34.125	1.863	0.413	0.329	-0.504	0.850	29.006	26.106	0.500	0.5296	466.04757	0.004016786
42.500	6.825	0.046	101	4292.5	2576.5	0.987	34.125	1.862	0.410	0.329	-0.511	0.850	29.006	26.106	0.500	0.52528	462.24469	0.003984009
43.000	6.825	0.046	101	4343	2595.8	0.992	34.125	1.861	0.407	0.329	-0.518	0.850	29.006	26.106	0.500	0.52099	458.47227	0.003951496
43.500	6.825	0.046	101	4393.5	2615.1	0.998	34.125	1.860	0.404	0.329	-0.525	0.850	29.006	26.106	0.500	0.51674	454.73026	0.003919244
44.000	6.825	0.046	101	4444	2634.4	1.003	34.125	1.860	0.401	0.329	-0.531	0.850	29.006	26.106	0.500	0.51252	451.01858	0.003887253
44.500	6.825	0.046	101	4494.5	2653.7	1.009	34.125	1.859	0.399	0.329	-0.538	0.850	29.006	26.106	0.500	0.50834	447.33717	0.003855524
45.000	6.825	0.046	101	4545	2673	1.014	34.125	1.858	0.396	0.329	-0.545	0.850	29.006	26.106	0.500	0.50419	443.68594	0.003824055
45.500	6.825	0.046	101	4595.5	2692.3	1.020	34.125	1.857	0.393	0.329	-0.551	0.850	29.006	26.106	0.500	0.50007	440.0648	0.003792845
46.000	6.825	0.046	101	4646	2711.6	1.026	34.125	1.856	0.391	0.328	-0.558	0.850	29.006	26.106	0.500	0.49599	436.47367	0.003761893
46.500	6.825	0.046	101	4696.5	2730.9	1.032	34.125	1.856	0.388	0.328	-0.564	0.850	29.006	26.106	0.500	0.49195	432.91245	0.0037312
47.000	6.825	0.046	101	4747	2750.2	1.037	34.125	1.855	0.386	0.328	-0.571	0.850	29.006	26.106	0.500	0.48793	429.38102	0.003700763
47.500	6.825	0.046	101	4797.5	2769.5	1.043	34.125	1.854	0.383	0.328	-0.577	0.850	29.006	26.106	0.500	0.48395	425.87929	0.003670582
48.000	6.825	0.046	101	4848	2788.8	1.049	34.125	1.853	0.381	0.328	-0.583	0.850	29.006	26.106	0.500	0.48001	422.40715	0.003640656
48.500	6.825	0.046	101	4898.5	2808.1	1.055	34.125	1.852	0.378	0.328	-0.590	0.850	29.006	26.106	0.500	0.4761	418.96447	0.003610984
49.000	6.825	0.046	101	4949	2827.4	1.061	34.125	1.851	0.376	0.328	-0.596	0.850	29.006	26.106	0.500	0.47222	415.55113	0.003581565

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❖ Appendix F – Universal Soil Loss

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COVER SHEET

S&ME

Project Name: Tanners Creek Conceptual FA Pond Closure Design	
Subject: USLE Calculations for Universal Soil Loss	
Project No. 7217-17-007A	Calc. No. 1
Discipline: Water Resources	Sheet 1 of 5

PROJECT NAME Tanners Creek Conceptual FA Pond Closure Design		SUBJECT USLE Calculations for Universal Soil Loss	
PROJECT NO. 7217-17-007A	CALC. NO. 1	DISCIPLINE Water Resources	SHEET 1 OF 5

COMPUTATIONS BY: Signature [signature] Date: 8-8-2016

Name David C. Ver Hulst, E.I.

Title Staff Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY: Signature [signature] Date: 8-8-2017

Name Patrick L. McMahon

Title Engineer

COMPUTATIONS CHECKED BY: Signature " Date: "

Name "

Title "

REVIEWED BY: Signature [signature] Date:

Name

Title

NO.	DESCRIPTION		BY	AS & PR	COMP	REVIEW	DATE

WILLIAM K. BARRY REGISTERED 10700184 STATE OF INDIANA PROFESSIONAL ENGINEER

William Barry

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Introduction

The purpose of these calculations is to estimate the annual erosion yield from the terraced slope of the Tanners Creek Pond Closure Design in Lawrenceburg, Indiana using the Universal Soil Loss Equation (USLE).

The USLE equation was developed for predicting average annual soil loss (Value A in USLE equation), to determine the erodibility of a site based on the variables listed below:

- **R**: Rainfall-runoff erosivity factor (100 ft·tonf·in/acre·hr·yr)- Determined by the erosion index (EI), based on the kinetic energy of the storm and the maximum 30-minute intensity of the rainfall in the area;
- **K**: Soil erodibility factor (ton·acre·hr/100 acre·ft·tonf·in) - Based on classification of the soil content under investigation;
- **L:** The slope length factor;
- **S**: The slope steepness factor;
- **C**: Cover management factor - Based on the history of how the soil has been maintained, and vegetative state;
- **P**: Support practice factor- To account for terracing in this application.

These variables are multiplied together to estimate the average annual soil loss (A) in tons per year. Individual values assigned to the USLE variables in this calculation are described below.

USLE Equation Variables

R Factor

The rainfall-runoff erosivity factor (R) was estimated using Figure 1 from USDA Agriculture Handbook No. 282, provided in the appendix, (A.1). In the appendix (A.1) the location has been marked, and an approximate value of 180 has been estimated.

K Factor

The soil erodibility factor (K) is based on the soil's ability to resist erosion due to raindrop impact and runoff. The value for K was estimated using USDA Web Soil Survey data, (A.2-A.4), and reviewing the predominate soil characteristics. Since more detailed information on the soil profile characteristics was not available, a value was estimated by using a USDA table developed for estimating K values based on textural classification. The description chosen for the topsoil is a "Silt loam, silty clay loam, very fine sandy loam" with a K Factor value of 0.37. This estimate is highlighted in table 8.4 in the appendix, (A.5).

L – Factor

The slope length factor is an empirical factor calculated according to the following relations from Haan, Barfield, and Hayes (1994).

$\theta := \text{atan}(.3333) = 0.32$ Angle of the slope to horizontal (radians)

$\beta_{mod} := 11.16 \cdot \dfrac{\sin(\theta)}{3 \cdot (\sin(\theta))^{0.8} + 0.56} = 2.01$ Ratio of rill to inter-rill erosion

$m := \dfrac{\beta_{mod}}{1 + \beta_{mod}} = 0.67$

$\lambda := 32 \cdot 3$ Horizontal Slope Length

$L := \left(\dfrac{\lambda}{72.6}\right)^m = 1.21$ L Factor

The subject slope has a proposed grade of 3:1 grade (horizontal: vertical), according to final design specifications from the permit modification drawings, with a maximum height of 32 feet (see appendix A.6).

S – Factor

S factor was calculated using equation 8.40 in Haan, Barfield, and Hayes (1994) for slopes greater than 15%

$$S := 16.8 \cdot \sin(\theta) - 0.50 = 4.81$$

C – Factor

The cover factor (C) is determined by above ground effects, surface texture effects, and subsurface effects such as vegetative root characteristics. An approximate value was estimated using the table provided in the appendix (A.7). It's assumed that the vegetative state of the Tanners Creek Closure will be equivalent to a "Permanent Pasture and Brush Cover" a grass cover producing an estimate of 0.013.

P – Factor

The P factor accounts for the influence of contour cropping and or terracing of slopes. Referencing Table 8.14 (see appendix A.8) in Haan, Barfield, and Hayes (1994) a value of 0.5 was selected to represent terraces with intervals less than 110 feet and with level terraces and open outlets to reflect discharge to armored slope drains.

Results

$R := 180 \quad K := 0.37 \quad L := 1.205 \quad S := 4.81 \quad C := 0.013 \quad P := 0.5$

$$A := (R \cdot K \cdot L \cdot S \cdot C \cdot P)\ \frac{ton}{acre \cdot yr} = 2.51\ \frac{ton}{acre \cdot yr}$$

References

Haan, C.T., Barfield, B.J., Hayes, J.C. (1994). Erosion and Sediment Yield. *Design Hydrology and Sedimentology for Small Catchments*, (Pages 248-285). San Diego, California: Academic Press, Inc.

United States Department of Agriculture – Agriculture Handbook No. 282, 1965

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Appendices

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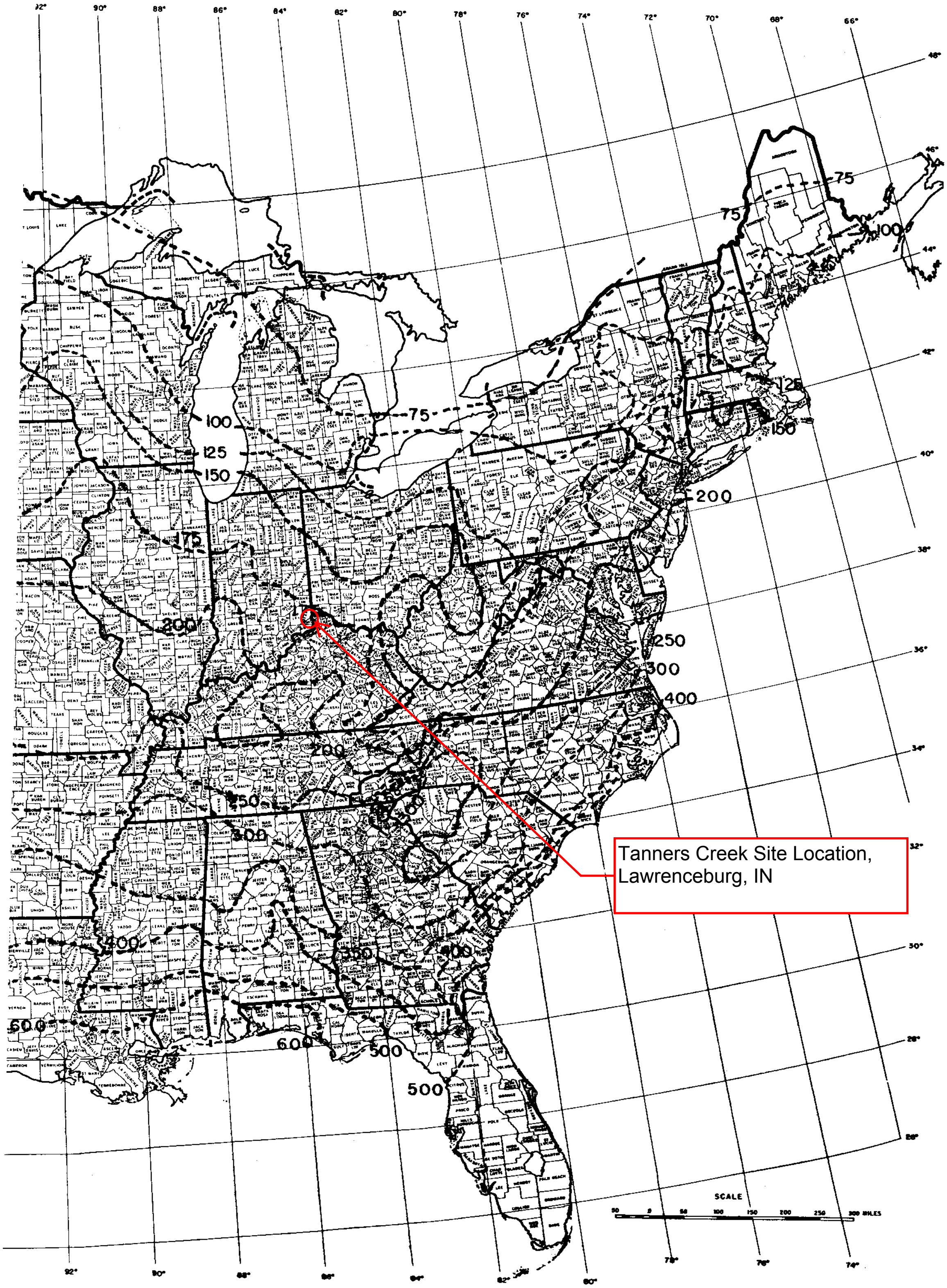


values of the rainfall factor, *R*.

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Dearborn County, Indiana

Tanners Creek Analysis

July 31, 2017


84° 53' 20" W
84° 52' 38" W
39° 5' 20" N
39° 4' 58" N
682600
682700
682800
682900
683000
683100
683200
683300
683400
683500
683600
4328700
4328600
4328500
4328400
4328300
4328200
CaD2
EcE2
SwC2
CaE2
PaE2
SwD2
CaE2
EdF
EdF
50
Soil Map may not be valid at this scale.
N
Map Scale: 1:4,610 if printed on A landscape (11" x 8.5") sheet.
Meters
0 50 100 200 300
Feet
0 200 400 800 1200
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

Map Unit Legend

Dearborn County, Indiana (IN029)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
CaD2	Carmel silt loam, 12 to 18 percent slopes, eroded	2.8	6.6%
CaE2	Carmel silt loam, 18 to 25 percent slopes, eroded	9.4	22.0%
EcE2	Eden silty clay loam, 15 to 25 percent slopes, eroded	1.4	3.4%
EdF	Eden flaggy silty clay, 25 to 50 percent slopes	15.4	36.0%
PaE2	Pate silty clay loam, 18 to 25 percent slopes, eroded	0.3	0.7%
SwC2	Switzerland silt loam, 6 to 12 percent slopes, eroded	7.9	18.4%
SwD2	Switzerland silt loam, 12 to 18 percent slopes, eroded	5.5	12.9%
Totals for Area of Interest		**42.7**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit greater than 15 ft, the S factor from the USLE was modified significantly by McCool *et al.* (1987, 1993) after extensive evaluation of the original USLE data base. The modified version is

$$S = 10.8 \sin\theta + 0.03; \qquad \sin\theta < 0.09 \qquad (8.39)$$

$$S = 16.8 \sin\theta - 0.50; \qquad \sin\theta \geq 0.09, \qquad (8.40)$$

where θ is the slope angle. Based on an evaluation of data from disturbed lands with slopes up to 84%, McIssac *et al.* (1987) developed an equation similar to (8.39) and (8.40) with exponents in the same range; thus McCool *et al.* (1993) recommend that Eqs. (8.39) and (8.40) also be used for disturbed lands.

For slope lengths less than 15 ft, the S factor is not as strongly related to slope (slope exponent less than 1.0) since rilling would not have been initiated. The recommended factor is

$$S = 3.0(\sin\theta)^{0.8} + 0.56. \qquad (8.41)$$

Under conditions where thawing of recently tilled soils is occurring and surface runoff is the primary factor causing erosion (typical of the Pacific Northwest in the spring), the S factor should be (McCool *et al.*, 1987, 1993)

$$S = 4.25(\sin\theta)^{0.6}, \qquad \sin\theta \geq 0.09. \qquad (8.42)$$

For thawing soils with slopes less than 9%, Eq. (8.39) should be used.

The S factor in the RUSLE is significantly modified from the original USLE as a result of an extensive reevaluation of the original data base, addition of the factors for short slope lengths, and new values for thawing soils (McCool *et al.*, 1987). The original data base did not include values beyond 20%. When using the quadratic form of the equation for S developed for the original USLE, projections beyond 20% yielded unreasonably high values for erosion. The RUSLE equation with the linear function corrects this problem.

Table 8.4 K Value Estimates based on Textural Information (English Units) (Soil Conservation Service, 1978)

Texture	Estimated K value[a]
Topsoil	
Clay, clay loam, loam, silty clay	0.32[b]
Fine sandy loam, loamy very fine sand, sandy loam	0.24
Loamy fine sand, loamy sand	0.17
Sand	0.15
Silt loam, silty clay loam, very fine sandy loam	0.37
Subsoil and Residual Material	
Outwash Soils	
Sand	0.17
Loamy sand	0.24
Sandy loam	0.43
Gravel, fine to moderate fine	0.24
Gravel, medium to moderate coarse	0.49
Lacrustrine Soils	
Silt loam and very fine sandy loam	0.37
Silty clay loam	0.28
Clay and silty clay	0.28
Glacial Till	
Loam, fine to moderate fine subsoil	0.32
Loam, medium subsoil	0.37
Clay loam	0.32
Clay and silty clay	0.28
Loess	0.37
Residual	
Sandstone	0.49
Siltstone, nonchannery	0.43
Siltstone, channery	0.32
Acid clay shale	0.28
Calcareous clay shale or limestone residuum	0.24

[a]These values are typical based only on textural information. Values for an actual soil can be considerably different due to different structure and infiltration.

[b]Units on K in this table are English units (tons•acre•hr/hundreds•acre•ft•tonsf•in.). To convert to metric units (t•ha•h/ha•MJ•mm), multiply K values by 0.1317.

Slope Length Factor

The slope length factor was developed by McCool *et al.* (1989, 1993) from the original USLE data base augmented with theoretical considerations. The L factor retains its original form

$$L = \left[\frac{\lambda}{72.6}\right]^m, \qquad (8.43)$$

where λ is the slope length in feet, 72.6 ft is the length of a standard erosion plot, and m is a variable slope length exponent. Slope length, λ, is the horizontal projection of plot length, not the length measured along the slope. The difference in horizontal projections and slope lengths becomes important on steeper slopes.

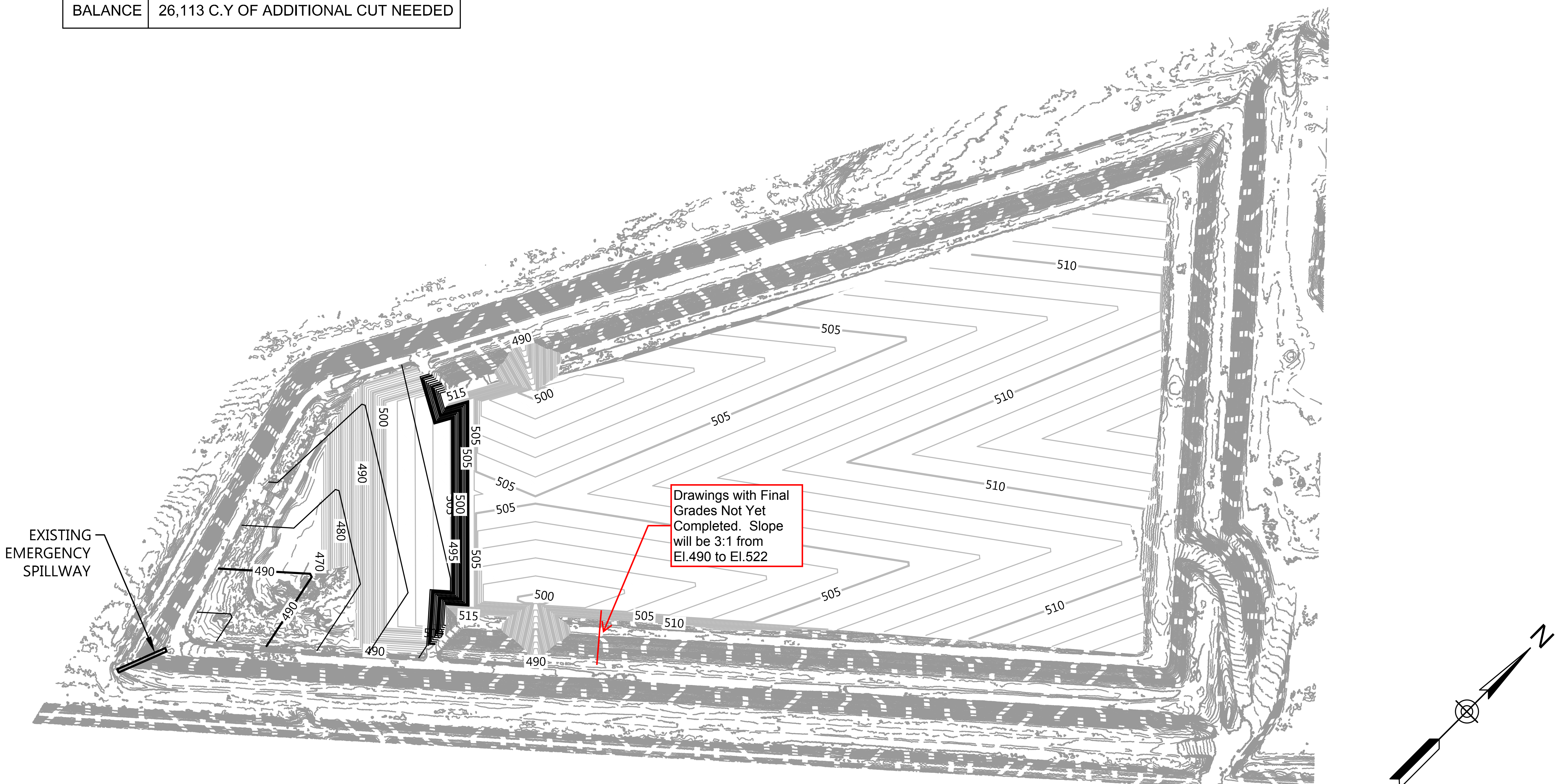
The slope length exponent is related to the ratio of rill to interrill erosion, β (Foster *et al.*, 1977b; McCool *et al.*, 1989, 1993), by

$$m = \frac{\beta}{1+\beta}. \qquad (8.44)$$

APPROXIMATE EARTHWORK QUANTITIES	
ASH CUT	57,475 C.Y.
ASH FILL	83,589 C.Y.
BALANCE	26,113 C.Y OF ADDITIONAL CUT NEEDED

LEGEND

- – – – EXISTING CONTOURS - 1 FOOT INTERVAL
- ——— PROPOSED CONTOURS - 1 FOOT INTERVAL



0 100 200 300 600 900
GRAPHIC SCALE

S&ME
WWW.SMEINC.COM
6190 ENTERPRISE COURT
DUBLIN, OH 43016
(614) 793-2226

EnviroAnalytics Group
ENVIROANALYTICS GROUP, LLC
1650 DES PERES RD., SUITE 230
ST. LOUIS, MO 63131

TOP OF ASH GRADES, CLEAR WATER POND
FAP CONCEPTUAL CLOSURE
TANNERS CREEK POWER PLANT

LAWRENCEBURG, DEARBORN COUNTY, INDIANA

NO.	DATE	DESCRIPTION	BY	CHK	APV

PROJECT NUMBER
7217-17-007
DRAWING NUMBER

DRAWING NAME
PLATE 2

Q:\Projects\7217-Civil Columbus\7217-17-007 Tanners Creek\FA Pond Closure\DWG\CONSTRUCTION\7217-17-007_GRADING.dwg-PLATE 2 Apr 07, 2017 rthompson

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From Eq. (8.50b)

$$LS = \Sigma/n = 10.84/3 = 3.61.$$

4. *Summary.*

Concave $LS = 3.61$
Uniform $LS = 4.33$
Convex $LS = 5.07$.

Thus the convex shape has the highest LS factor.

Estimating Slope Lengths for Watersheds

Slope length estimates for fields or watersheds with nonplanar surfaces require considerable professional judgment. A large number of slope lengths occur in any given real watershed. Erosion can be estimated for each of these and area weighted to determine average erosion on a watershed.

Slope length is defined as the slope distance from the point of origin of overland flow to the point of

Table 8.8 Selected USLE *C* Values for Construction, Mining, and Forest Lands.

Condition	*C* factor	References	Condition	*C* factor	References
1. Bare soil conditions			5. Undisturbed forest		
Undisturbed except scraped	0.66–1.30	a	100–75% canopy, 100–90% litter	0.0001–0.001	c
Compacted			35–20% canopy, 70–40% litter	0.003–0.009	c
Smooth	1.00–1.40	a,b	6. Permanent pasture and brush cover		
Root raked	0.90–1.20	a	0% canopy, 80% ground cover		
Disk tillage			Grass	0.013	c
Fresh	1.00	a	Weeds	0.043	c
After one rain	0.89	a	50% Brush, 80% ground cover		
2. Mulch			Grass	0.012	c
Straw			7. Mechanically prepared woodland sites		
0.5 tons/ac	0.30	a,d	Burned, 10% cover at ground		
1.0 tons/ac	0.18	a,d	Good soil	0.240	c
2.0 tons/ac	0.09	a,d	Poor soil	0.360	c
4.0 tons/ac	0.02	a,d	Burned, 0% cover at ground		
Wood chips			Good soil	0.260	c
0.5 tons/ac	0.90	a,d	Poor soil	0.450	c
2.0 tons/ac	0.70	a,d	Disked, 0% cover at ground		
4.0 tons/ac	0.42	a,d	Good soil	0.720	c
6.0 tons/ac	0.22	a,d	Poor soil	0.940	
3. Chemical binders					
Asphalt emulsion, 605 gal/ac	0.14-0.52	a			
Aquatan, Terra-tack	0.67	a			
4. Seedings					
No prepared seedbed					
New planting	0.64	a			
After 60 days	0.54	a			
Prepared seedbed					
New planting	0.40	a			
After 60 days	0.05	a			

Note. Additional values are given in Appendix 8B.
[a]Transportation Research Board (1980).
[b]Barfield *et al.* (1988).
[c]Wischmeier and Smith (1978).
[d]Meyer *et al.* (1972). C factors for mulch vary depending on slope length and steepness. Slope length limits apply (see Appendix 8B, Table 8B.5).

Table 8.14 Selected P Subfactors for the RUSLE (after Foster *et al.*, 1993)

A. P_b, Contouring subfactors for tillage along the contour when slope lengths are less than critical[a]

Downhill slope	Ridge of oriented roughness height (in.): Low 1–3	Moderate 3–5	Ridge system >5	Critical slope length (ft)
0.5	1.0	0.8	0.8	1000+
3.0	0.9	0.5	0.3	630
5.0	0.8	0.5	0.2	323
10.0	0.8	0.6	0.2	125
15.0	1.0	0.6	0.3	78
20.0		0.8	0.4	57
25.0		1.0	0.7	45[b]
32.0			1.0	30[b]

[a]To determine the contour factor value, use the base P_b value from above in Fig. 8.20. For locations with a 10-yr storm EI less than 50 or greater than 160, use 50 or 160. The P_s value obtained in Fig. 8.20 is used to determine the contour P_c factor value in Fig. 8.21.
[b]Projections beyond the values presented by Foster *et al.* (1991).

B. P_b effective, contouring subfactors for tillage along the contour when slope lengths are greater than critical[a]

(Upslope P value)/(Slope length exponent m)[b]

Critical slope:	0.2			0.4			0.6			0.8			1.0
Length ratio[c]:	0.1	0.5	1.0	0.1	0.5	1.0	0.1	0.5	1.0	0.1	0.5	1.0	All
0.5	0.63	0.72	0.80	0.72	0.79	0.85	0.81	0.86	0.90	0.91	0.93	0.95	1.0
00.6	0.54	0.63	0.71	0.66	0.72	0.78	0.77	0.81	0.86	0.89	0.91	0.93	1.0
0.7	0.46	0.53	0.61	0.59	0.65	0.71	0.73	0.77	0.80	0.86	0.88	0.90	1.0
0.8	0.37	0.43	0.49	0.53	0.57	0.62	0.69	0.71	0.74	0.84	0.86	0.87	1.0
0.9	0.29	0.32	0.35	0.47	0.49	0.51	0.64	0.66	0.68	0.82	0.83	0.84	1.0
1.0	0.20	0.20	0.20	0.40	0.40	0.40	0.60	0.60	0.60	0.80	0.80	0.80	1.0

[a]Use these values instead of P_b values in Item A when the slope length exceeds the critical slope length from Item A.
[b]Slope length exponent in the RUSLE slope length factor [see Table 8.6 or Eq. (8.44)].
[c]Ratio of critical slope length to total slope length.

C. P_t subfactor for terracing with conservation planning[a]

Horiz. Ter. int. (ft)	Closed outlets[b]	Open outlets with percentage grade[c] (%): 0.1–0.3	0.4–0.7	>0.8
<110	0.5	0.6	0.7	1.0
150	0.7	0.8	0.9	1.0
300	1.0	1.0	1.0	1.0

[a]Multiply values by other P subfactor values for practices on terrace interval.
[b]Values also apply to terraces with underground outlets and to level terraces with open outlets.
[c]Channel grade measured on the 300 ft closest to the outlet or one-third of the channel length, whichever is less.

D. Terracing impact on sediment yield.[a]

Terrace grade	Delivery subfactor
Closed outlet[b]	0.05
0 (level)	0.10
0.2	0.13
0.4	0.17
0.6	0.29
0.7	0.49
0.8	0.83
0.9	1.0

[a]To be used only to evaluate the impact of terracing on sediment yield from the field. Not to be included in gross erosion estimate or conservation planning. Sediment deposited in the terrace channel outlet is not effective in maintaining soil productivity.
[b]Includes terraces with underground outlets.

E. P_{sc} subfactor for stripcropping[a]

System[b]	P_{sc} for conservation planning[c]	Impact on sediment delivery from field[d]
Rotation stripcropping		
RC-WSG-M1-M2	0.78	0.53
RS-SSG-RC-SSG	0.91	0.75
RC-RCrt-RCrt-M1	0.84	0.65
RC-WSG	0.86	0.71
0.1 Filter	0.91	0.24
Buffer strip[f]	0.67	0.15
Buffer strip[g]	0.75	

[a]Used to evaluate the impact for selected stripcropping, buffer and filter strips.
[b]Rotation stripcropping is cropping in strips parallel to the contour. RC, row crop; WSG, winter small grain; SSG, spring small grain; M1, 1st year meadow; M2, second year meadow; C, corn; SB, soybeans; rt, reduced tillage; nt, no till.
[c]Use as an estimate of the impact of practice on gross erosion value.
[d]Use as an estimate of the impact on sediment yield from the field erosion.
[e]Permanent meadow filter strip that covers 10% of slope below row crop.
[f]Permanent meadow buffer strips located at 40–50% and 90–100% slope length.
[g]Permanent meadow buffer strip located at 40–50% slope length.

Attachment VI – Geotechnical Data

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Geotechnical Data Report – Rev 1
Tanners Creek Fly Ash Pond Closure
Lawrenceburg, IN
S&ME Project No. 7217-17-007A

S&ME

Prepared for:

Tanners Creek Development, LLC
1515 Des Peres Rd, Suite 300
St. Louis, MO 63131

Prepared by:

S&ME, Inc.
6190 Enterprise Court
Dublin, OH 43016

October 4, 2017
Revised: June 22, 2018

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June 22, 2018

Tanners Creek Development, LLC
1515 Des Peres Rd, Suite 300
St. Louis, MO 63131

Attention: Mr. Daniel Dunn

Reference: **Geotechnical Data Report, Rev 1**
Tanners Creek Fly Ash Pond Closure
Lawrenceburg, IN
S&ME Project No. 7217-17-007A

Dear Mr. Dunn:

In accordance with our proposal dated May 16, 2017, which was authorized by PO 5979, Change Order #1 on May 17, 2017, S&ME has prepared a Geotechnical Data Report for the field work conducted for the closure design of the Fly Ash Pond (FAP) complex at Tanners Creek Station located in Lawrenceburg, Indiana. The field work consisted of the Cone Penetration Test soundings and extended groundwater level readings within the ash.

We appreciate having been given the opportunity to be of service on this project. If during your review of this submittal you have any questions, please do not hesitate to contact our office.

Sincerely,

S&ME, Inc.

Michael T. Romanello, P.E.
Project Engineer

Michael G. Rowland, P.E.
Senior Engineer

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Table of Contents

Appendix

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1.0 Introduction

S&ME is currently preparing a Closure Plan for the Fly Ash Pond facility at the Tanners Creek Plant. To support the development of this Plan, S&ME performed field work to obtain geotechnical data from the impounded ash to supplement the historical data available from the original design and other investigations. This Geotechnical Data Report describes the field investigation procedures and presents the results. Historic geotechnical data has not been included with this report.

Revision 1 of the report was modified from the original October 4, 2017 version of the report to incorporate the geotechnical data associated with on-site Borrow Area 4. The Borrow Area 4 data has been included in response to the IDEM RAI dated May 10, 2018.

2.0 Subsurface Exploration

2.1 CPT Soundings

S&ME performed a total of 24 Cone Penetrometer Test (CPT) soundings in the fly ash pond (FAP) on the dates of June 13 and 14, 2017. Three soundings were performed in the Clearwater Pond, and 21 soundings were performed in the Upper Basin. A Plan of Explorations showing the locations of the soundings has been included as Figure 1 in Appendix I. The CPT soundings were performed to depths of 25 to 38.5 feet, using a low pressure track-mounted vehicle to hydraulically advance the electronically instrumented cone penetrometer. The CPT termination depths were set to target Elevation 470, providing an approximate 10 foot buffer above the existing PVC liner. During penetration, the tip resistance, pore water pressure and sleeve friction were continuously measured and recorded in general accordance with ASTM D-5778. CPT logs graphically showing results of these parameters with depth are included in Appendix I. Using theoretical and empirical correlations, the CPT data is also used to characterize the subsurface material by estimating the soil behavior type (SBT). Correlations to both the friction ratio and tip resistance are shown on the logs. The estimated water depths shown on the logs were interpreted by the driller during the investigation using the CPT rig’s onboard software, and are rounded to the nearest foot.

S&ME’s CPT equipment consists of a VERTEK seismic system mounted on a Gyro-Trac/Mesek track carrier, which has a push capacity of 20 tons. Additional cone penetration specifications are included in Appendix I.

Ground surface elevations of the CPT locations were estimated by interpolating from the existing topographic information from the March 2017 survey performed by GEOPRO Consultants, LLC. At the time of our investigation, Tanners Creek Development, LLC was actively working within the fly ash pond. General work to date has consisted of excavating the south bottom ash dike of the upper basin and pushing the material into the clear water pond. CPT-6 through CPT-8, and CPT-21 through CPT-23 were located within the active work area, and the elevations provided in this report reflect the rough grade at the time of our investigation as provided by Tanners Creek Development, LLC.

2.2 Pore Pressure Dissipation

At locations CPT-1P through CPT-5P in the Upper Basin, the pore pressure response of the impounded ash was observed by halting the advancement of the cone, and recording the rate of pore pressure dissipation. Pore pressure dissipation data can be used in correlations to hydraulic conductivity and other hydrogeologic properties. Pore pressure dissipation testing was generally performed at 5 foot intervals starting at a depth of 15 feet below the basin surface. Plots of the pore pressure dissipation are included in Appendix II.

2.3 Shear Wave Velocity

Shear wave velocity testing was performed at CPT-1P, CPT-3P, and CPT-5P by pausing at the desired CPT depth to perform the test. Shear and compressive wave profiles were measured by generating a seismic wave at the ground surface by using an instrumented hammer and plate and using a geophone incorporated into the CPT equipment to measure the seismic wave arrival times. Shear wave velocity calculations and plots with depth are provided in Appendix III.

3.0 Extended Water Level Readings

At locations CPT-1P through CPT-5P, open standpipe piezometers were installed to permit extended groundwater level readings within the FAP upper basin. The open standpipes were installed in offset holes to the same depths as the CPT soundings. Piezometer construction consisted of a 5-foot long PVC section of slotted screen filled with filter sand. Above the screened section, a 5/8-inch inside diameter PVC riser pipe was extended to approximately 24-inches above the ground surface. Water level readings were obtained on 3 occasions during a 10-week period following completion of the field work. A summary of the water level readings is provided in Table 3-1.

Table 3-1: Extended Water Level Readings – FAP Upper Basin

Peizometer No.	Ground Elevation (ft)†	Stand Pipe Height (ft)	Est. Water Elevation from CPT Data*	Ground Water Elevation Readings		
			6/14/17	7/3/17	8/2/17	8/28/17
1P	506.6	2.25	494	492.2	490.6	491.1
2P	507.1	3.38	494	492.7	492.2	490.2
3P	508.7	1.83	495	497.2	496.3	Disturbed
4P	509.4	2.16	498	498.0	496.7	493.0
5P	508.5	2.31	495	492.9	492.6	494.8

† GeoPro 8-8-17 Survey. Vertical Datum: NAVD88

* Depth to water interpreted from CPT Rig's onboard software and rounded to the near foot.

4.0 Borrow Area 4

Borrow Area 4 is a field located immediately southwest of and adjacent to the Fly Ash Pond. The location and extent of the borrow area and the locations of the borrow area explorations are depicted on the Fly Ash Pond Closure Drawings.

Borrow Area 4 was investigated by FMSM Engineers in 2007. Exploration logs and laboratory test results are included as Appendix IV of this Data Report. The logs and laboratory test results were originally presented to American Electric Power in a report by FMSM titled "Report of Borrow Area Study, Fly Ash Landfill, Tanners Creek Power Plant" dated January 17, 2008.

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Appendices

Appendix I – CTP Sounding Logs

- Plan of Explorations
- Cone Penetration Specifications
- CPT Sounding Logs

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CONE PENETROMETER-SPECIFICATIONS

S&ME's CPT equipment consists of a VERTEK seismic system using 10-cm^2 cone, designed for a 20 ton loading. This cone system is capable of measuring tip resistance, sleeve friction, pore pressure, inclination, and/or seismic waves (S- and P-waves). As the cone is advanced into the soil at a rate of 2 cm/s, data is collected every second and displayed on screen allowing "real time" verification.

VERTEK'S cone combines high load capacity with sensitive resolution by decoupling the tip and sleeve load cells, that is sensing each strain gage bridge independently. Independent measurement of each load cell and accurate temperature compensation results in a higher degree of accuracy in friction sleeve measurement (when compared to subtraction type cones). Subtraction type cones measure the tip resistance and total load (tip and sleeve resistance) and computes sleeve friction by subtracting the tip resistance from the total.

For pore pressure measurement, we use silicon oil and pre-saturate our porous filters. Silicon oil has a higher viscosity than other saturation mediums (i.e., water or glycerin); thus, our porous filters remain saturated for longer periods of time. Pore pressure readings are continuously monitored during penetration. Where zones of high pore pressures are developed, dissipation tests can be performed by monitoring and recording pore pressure readings with time. Pore pressure readings and dissipation tests can be used to determine the piezometric head as well as a soil's coefficient of consolidation and hydraulic conductivity.

The seismic cone can be used to quickly and accurately measure shear and compression wavespeed profiles while performing a standard CPT test. Our seismic system uses VERTEK'S specially designed triaxial velocity gauges for monitoring, software modules for data acquisition and interpretation, and special heavy duty trigger assemblies. Seismic information can be obtained during a CPT test simply by pausing at the desired depth.

Cone Specifications	
Dimensions	
Cone Base Area	10 cm^2
Sleeve Area	150 cm^2
Range and Accuracy	
Tip Load Cell	
Range	22,000 lbs
Overload Capacity	150 %
Accuracy	0.2 %
Sleeve Load Cell	
Range	4,400 lbs
Overload Capacity	150 %
Accuracy	0.2 %
Pore Pressure Transducer	
Range	500 psi
Overload Capacity	150 %
Accuracy	0.1 %
Inclinometer	
Range	15 degrees
Accuracy	0.5 degrees

S&ME
ENGINEERING • TESTING
ENVIRONMENTAL SERVICES

Cone Penetration Test

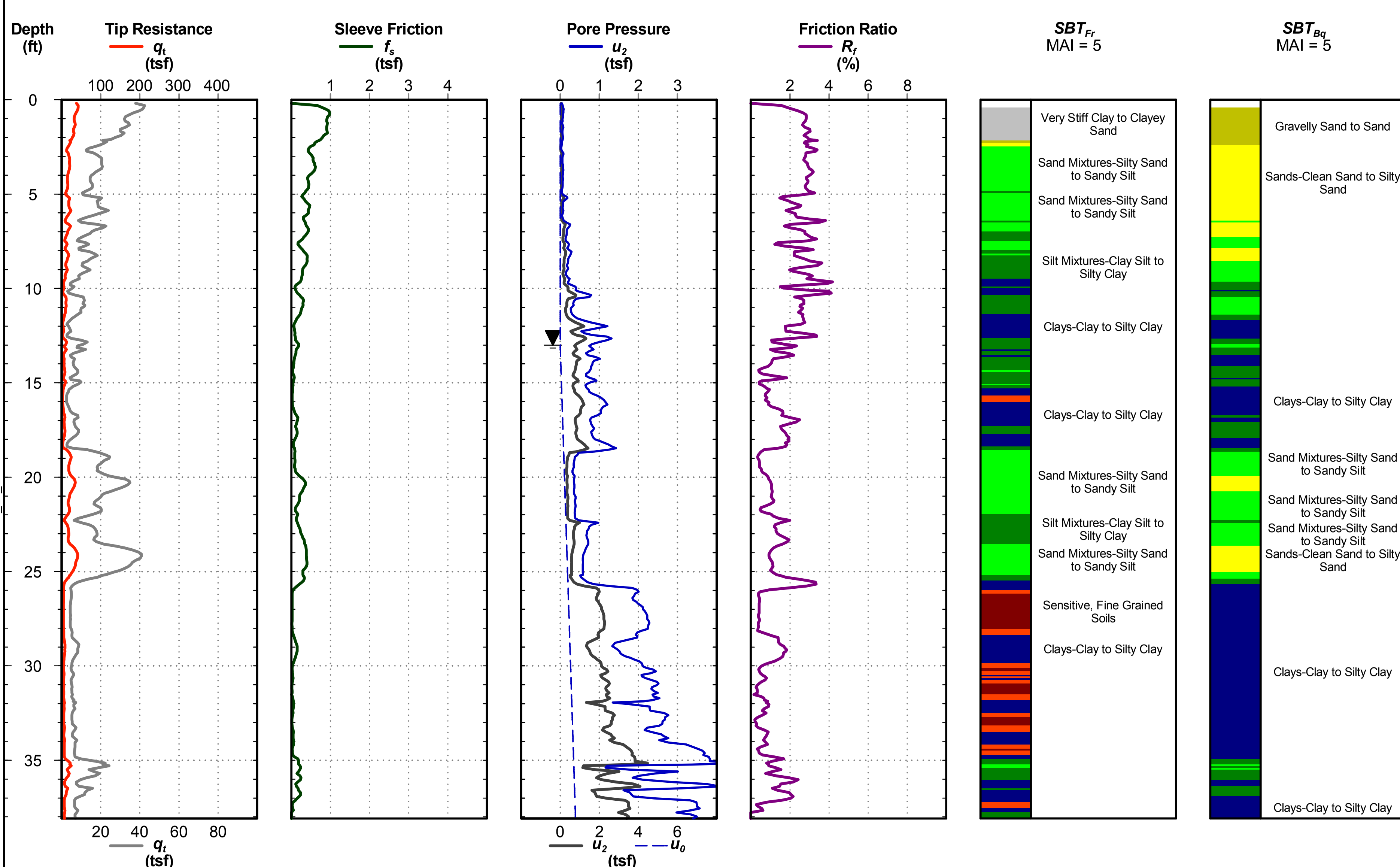
CPT-01P

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

Date: Jun. 14, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 38.1 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-01P

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

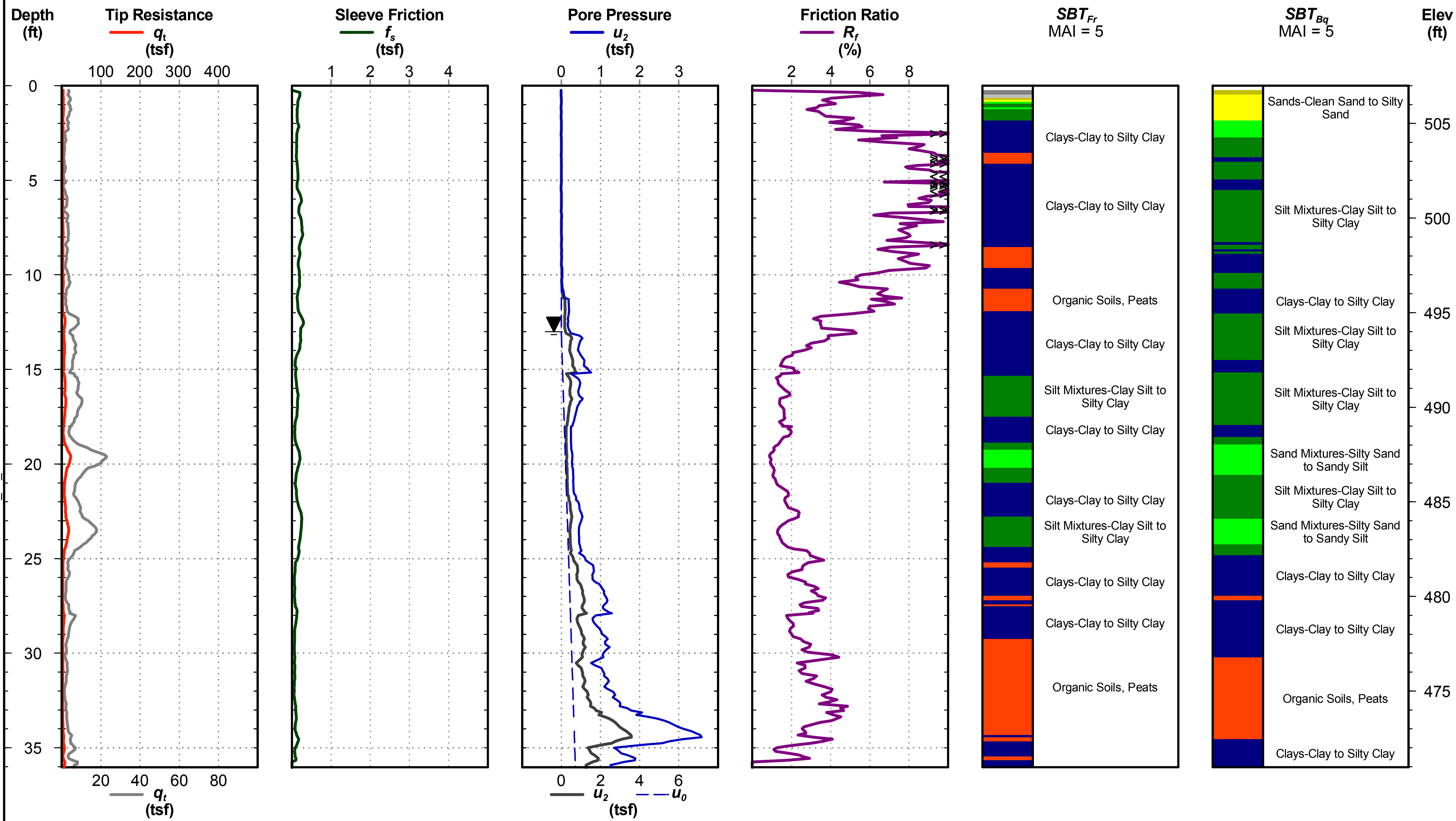
Cone Penetration Test

CPT-01PA

Date: Jun. 14, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 36.0 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-01PA

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

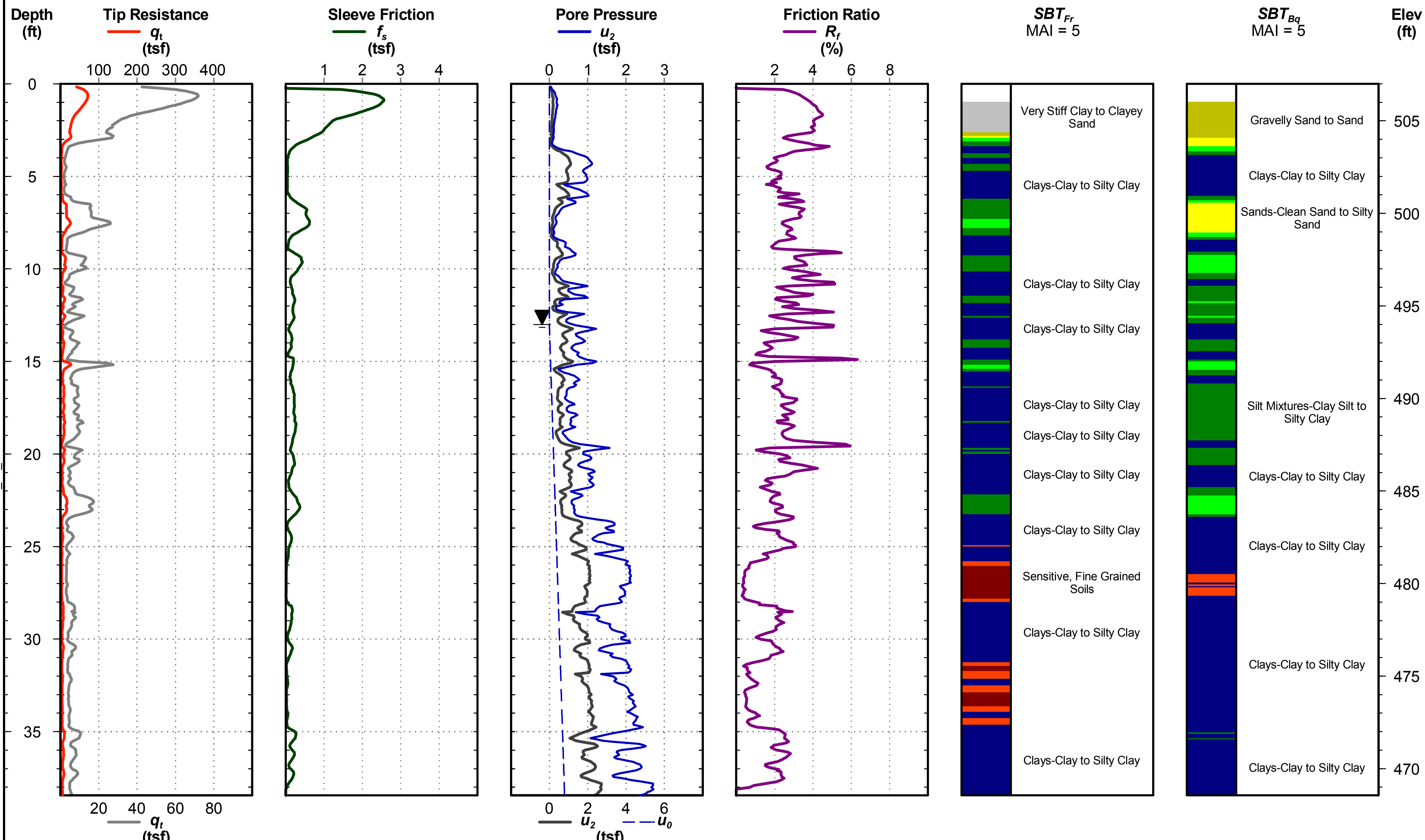
Cone Penetration Test

CPT-02P

Date: Jun. 14, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 38.4 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-02P

Electronic Filename: 7217-17-007A

CPT REPORT - DYNAMIC 7217-17-007A P50 T52 CPT.GPJ LIBRARY 2011_06_28.GDT 6/22/17

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

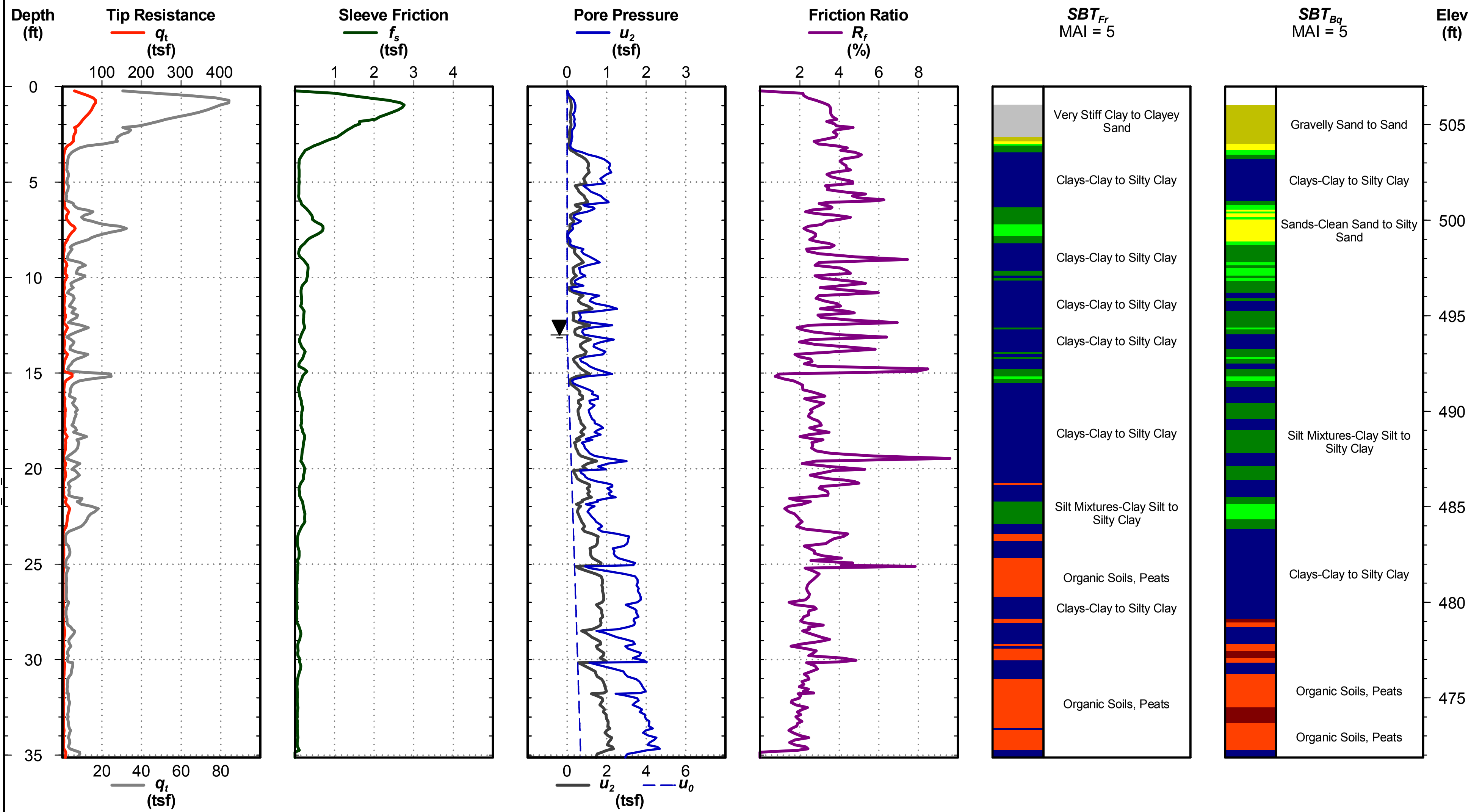
Cone Penetration Test

CPT-02PA

Date: Jun. 14, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Cone Size: 1.75



CPT-02PA

Note: Estimated water depth is based on onboard controls information and considered approximate.

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

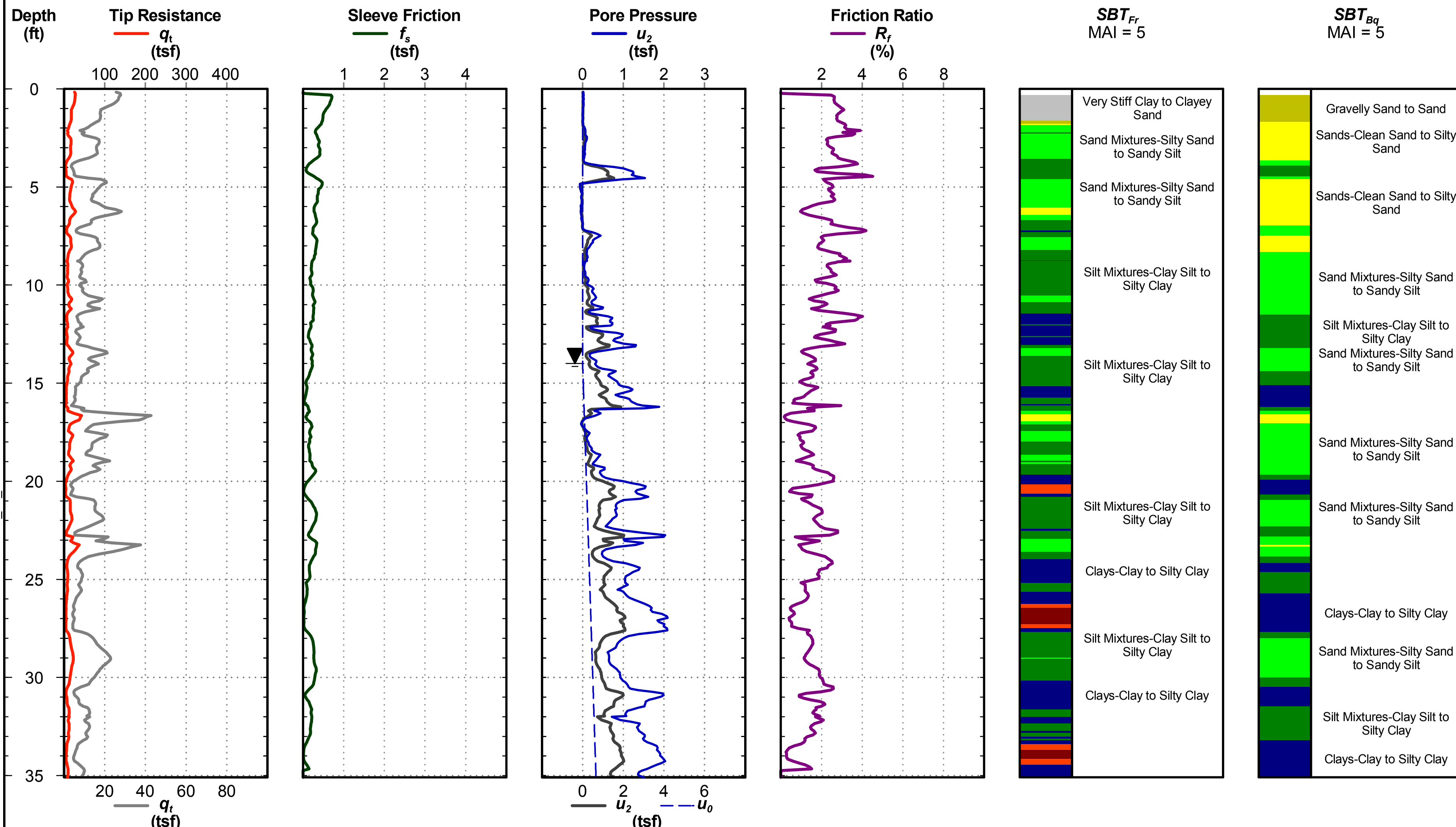
Cone Penetration Test

CPT-03P

Date: Jun. 14, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-03P

Electronic Filename: 7217-17-007A

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

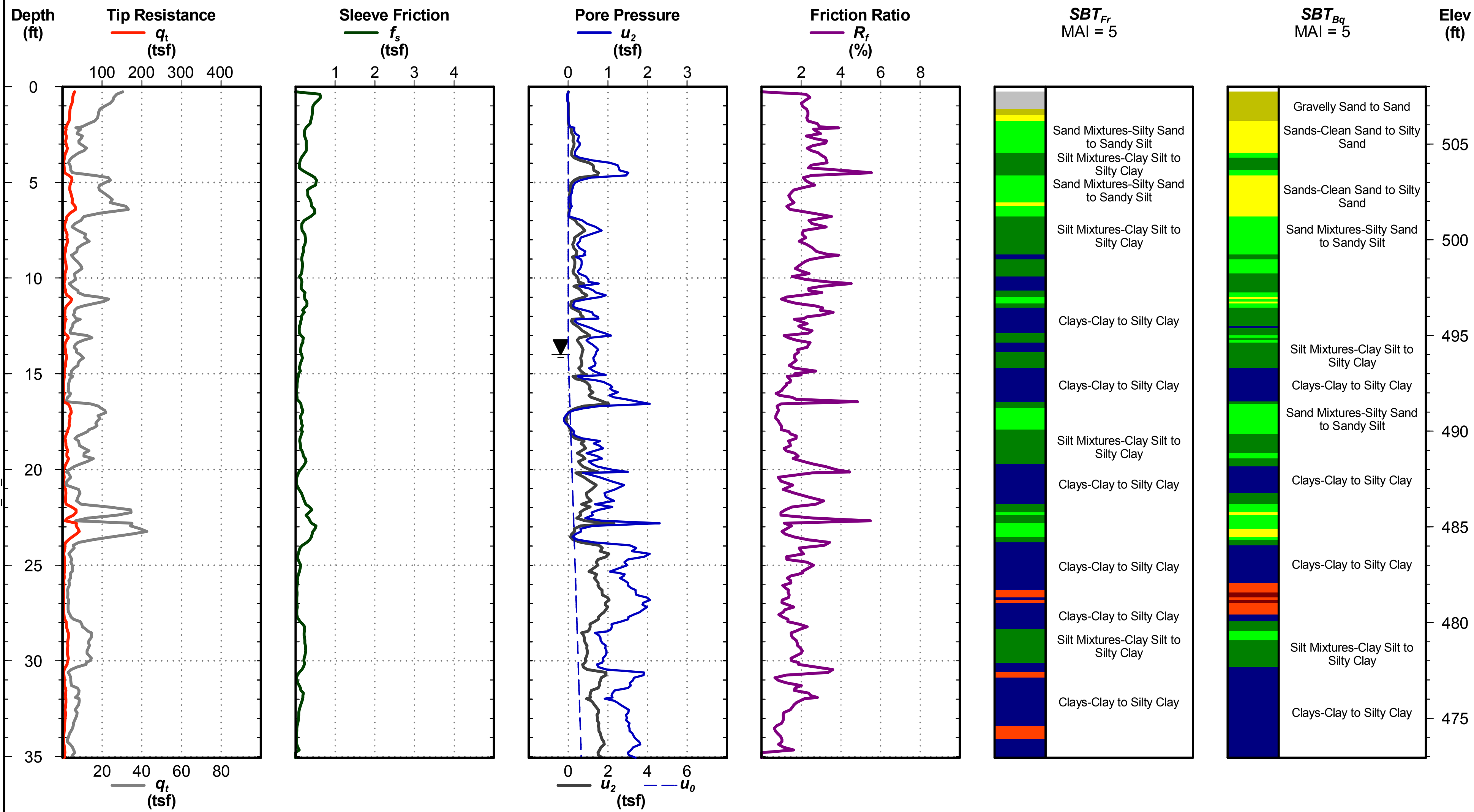
Cone Penetration Test

CPT-03PA

Date: Jun. 14, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Cone Size: 1.75



CPT-03PA

Note: Estimated water depth is based on onboard controls information and considered approximate.

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

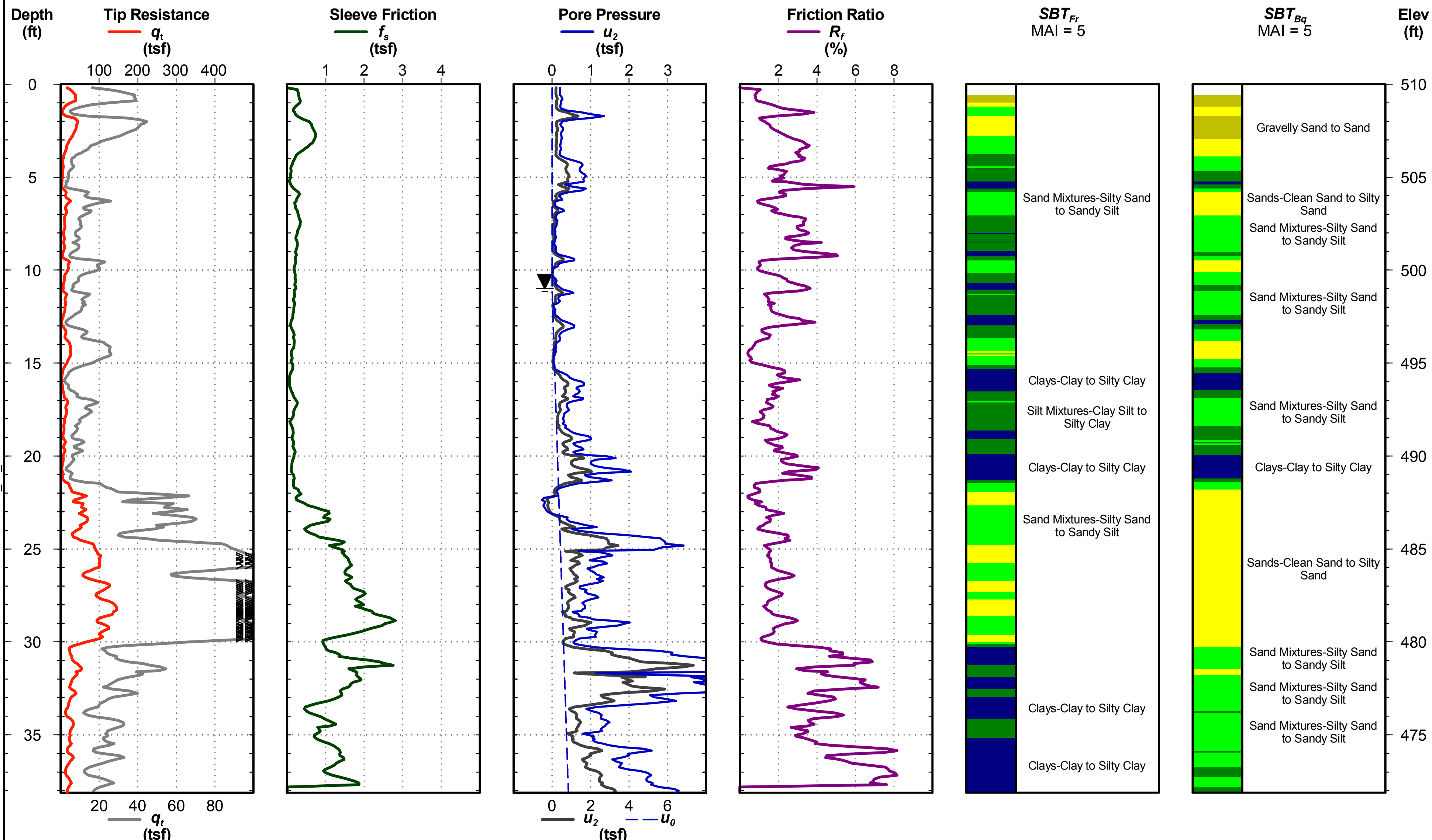
Cone Penetration Test

CPT-04P

Date: Jun. 13, 2017
Estimated Water Depth: 11 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 38.1 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-04P

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

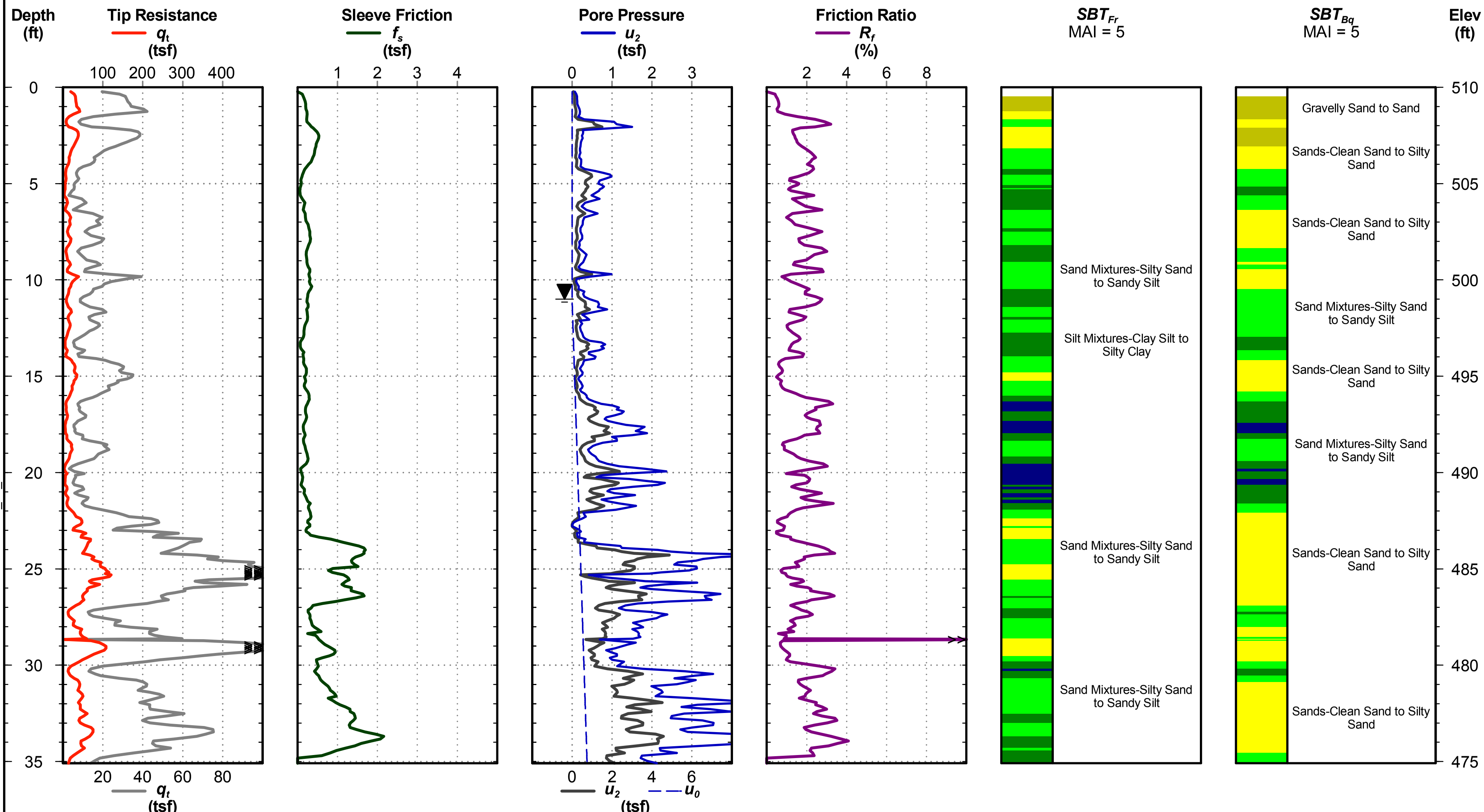
Cone Penetration Test

CPT-04PA

Date: Jun. 14, 2017
Estimated Water Depth: 11 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-04PA

Electronic Filename: 7217-17-007A

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

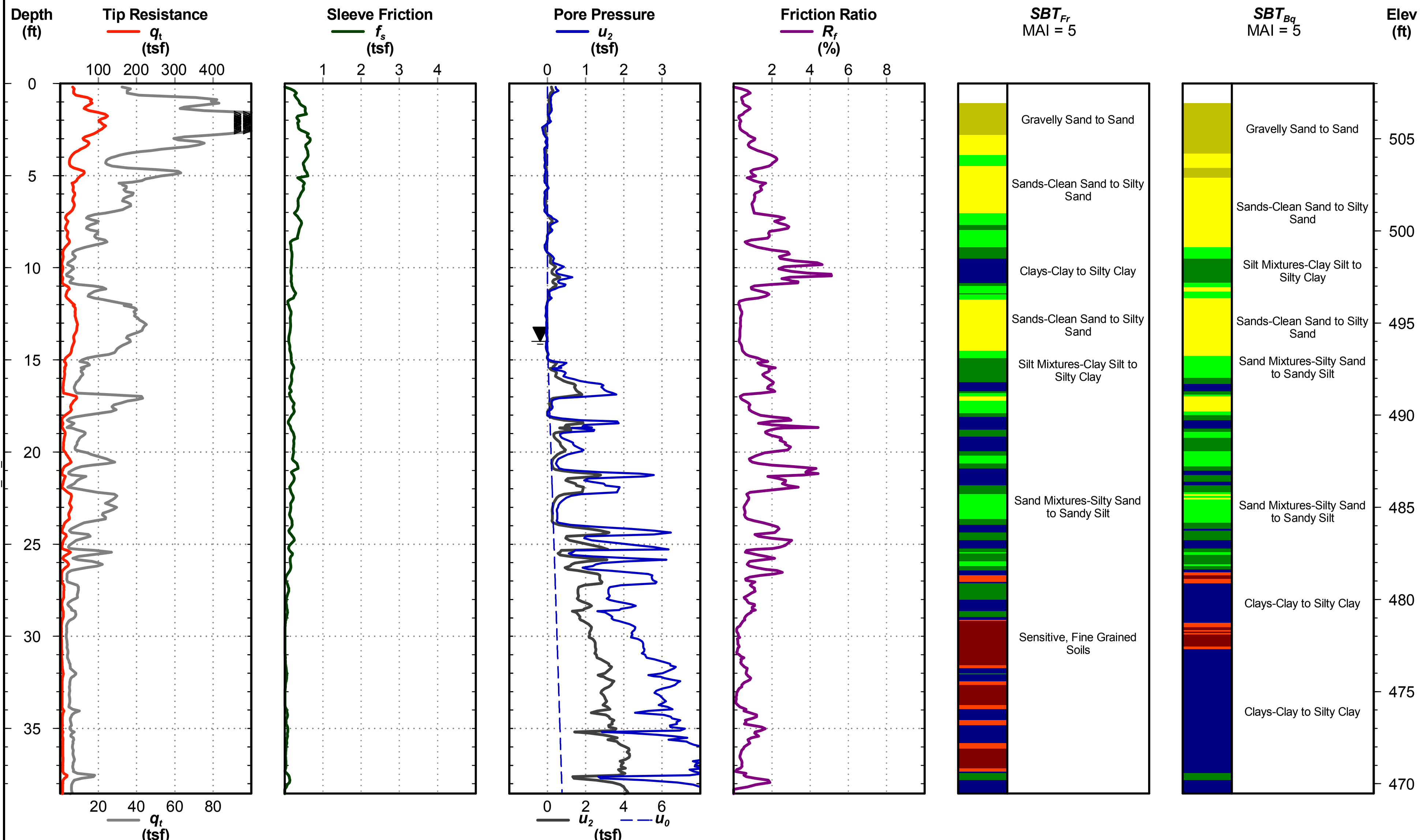
Cone Penetration Test

CPT-05

Date: Jun. 13, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 38.5 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-05

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

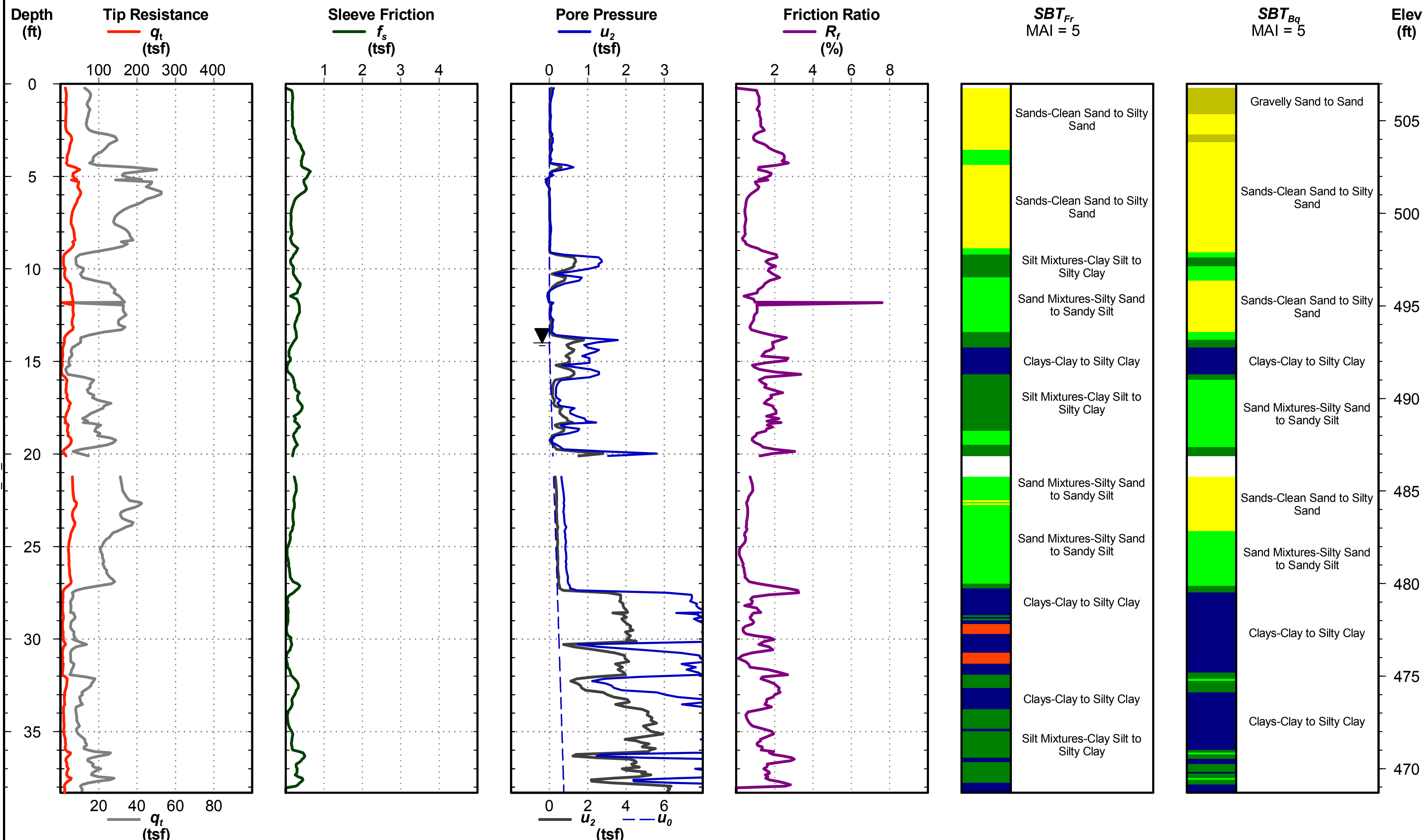
Cone Penetration Test

CPT-05P

Date: Jun. 14, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 38.3 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-05P

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

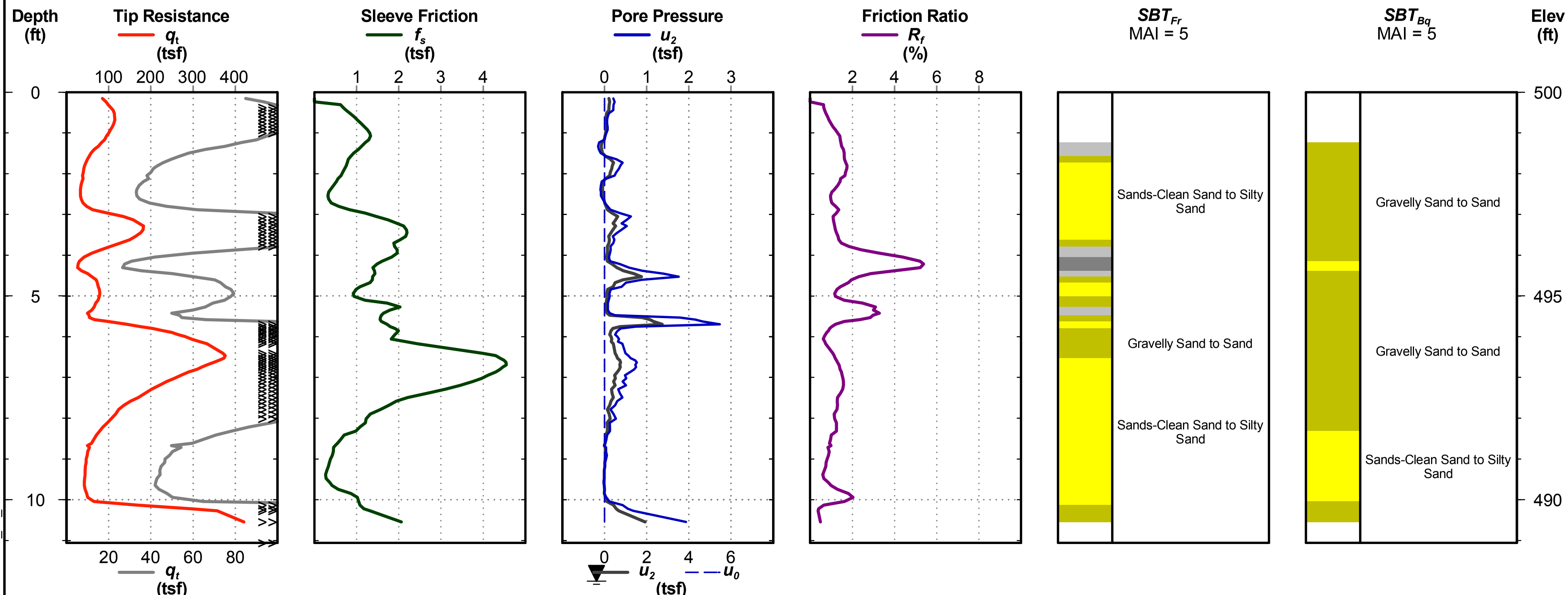
Cone Penetration Test

CPT-06

Date: Jun. 14, 2017
Estimated Water Depth: 12 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 11.1 ft
Termination Criteria: Maximum Reaction Force
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

Electronic Filename: 7217-17-007A

CPT-06

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

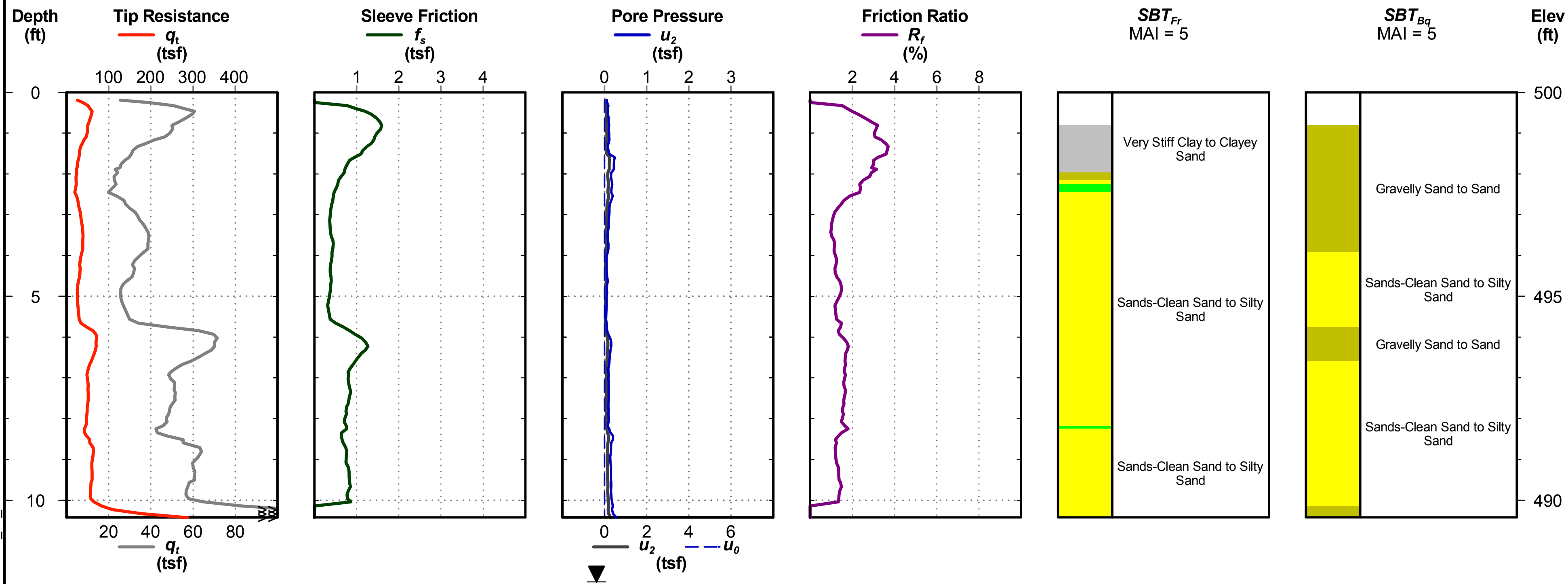
Cone Penetration Test

CPT-06A

Date: Jun. 14, 2017
Estimated Water Depth: 12 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 10.4 ft
Termination Criteria: Maximum Reaction Force
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

Electronic Filename: 7217-17-007A

CPT-06A

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

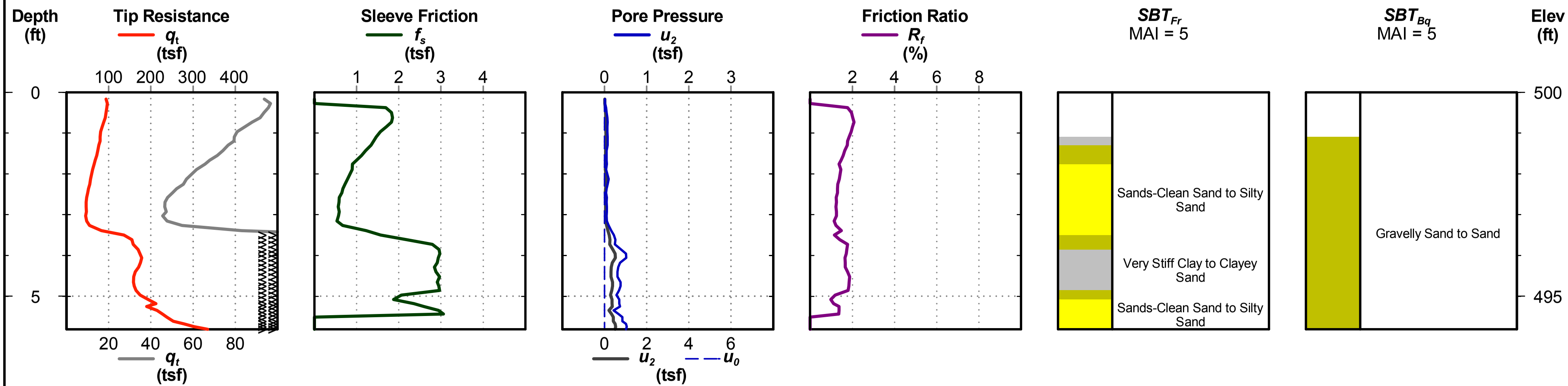
Cone Penetration Test

CPT-06B

Date: Jun. 14, 2017
Estimated Water Depth: 12 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 5.8 ft
Termination Criteria: Maximum Reaction Force
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

Electronic Filename: 7217-17-007A

CPT-06B

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

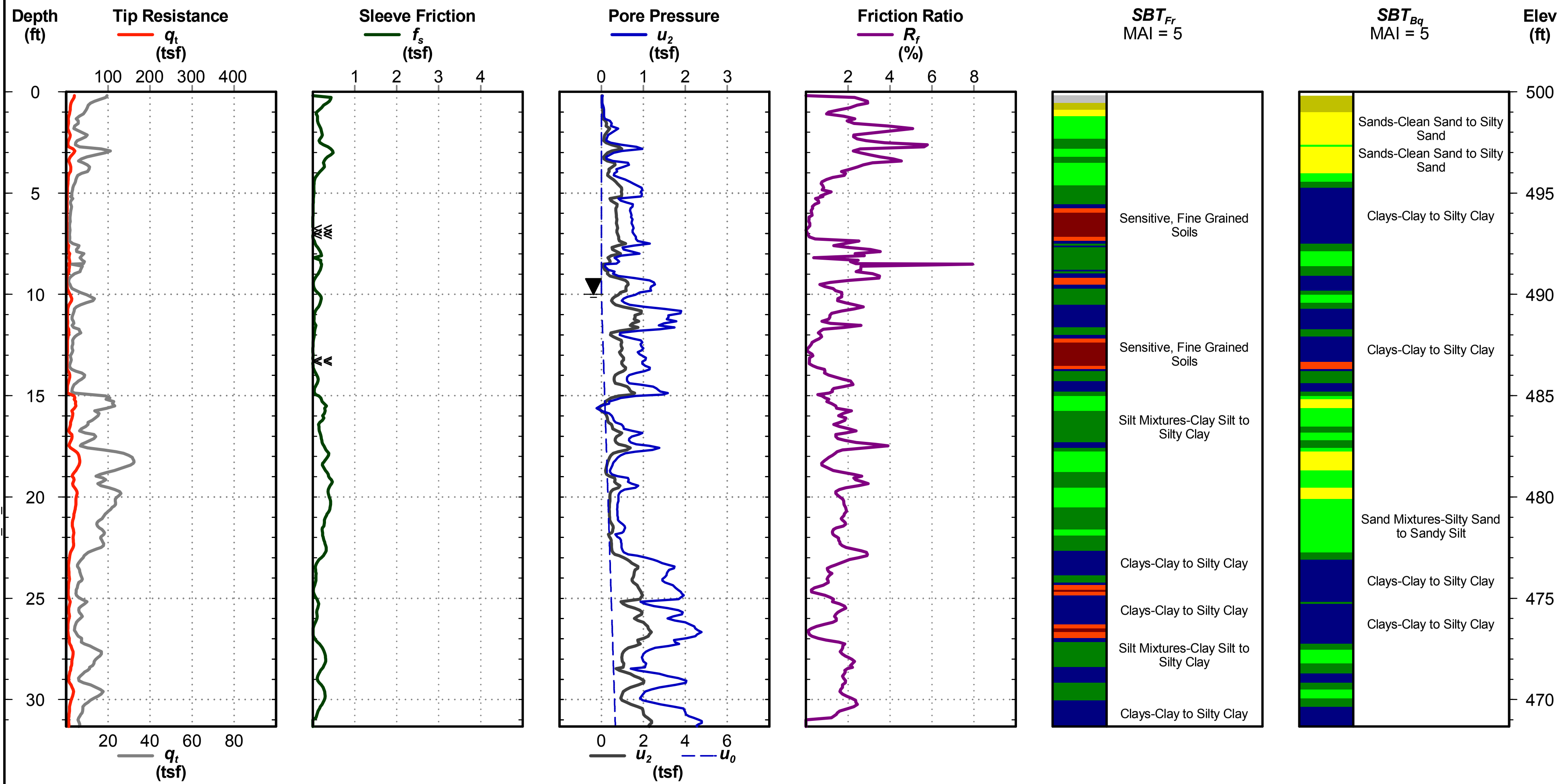
Cone Penetration Test

CPT-07

Date: Jun. 13, 2017
Estimated Water Depth: 10 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 31.3 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-07

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

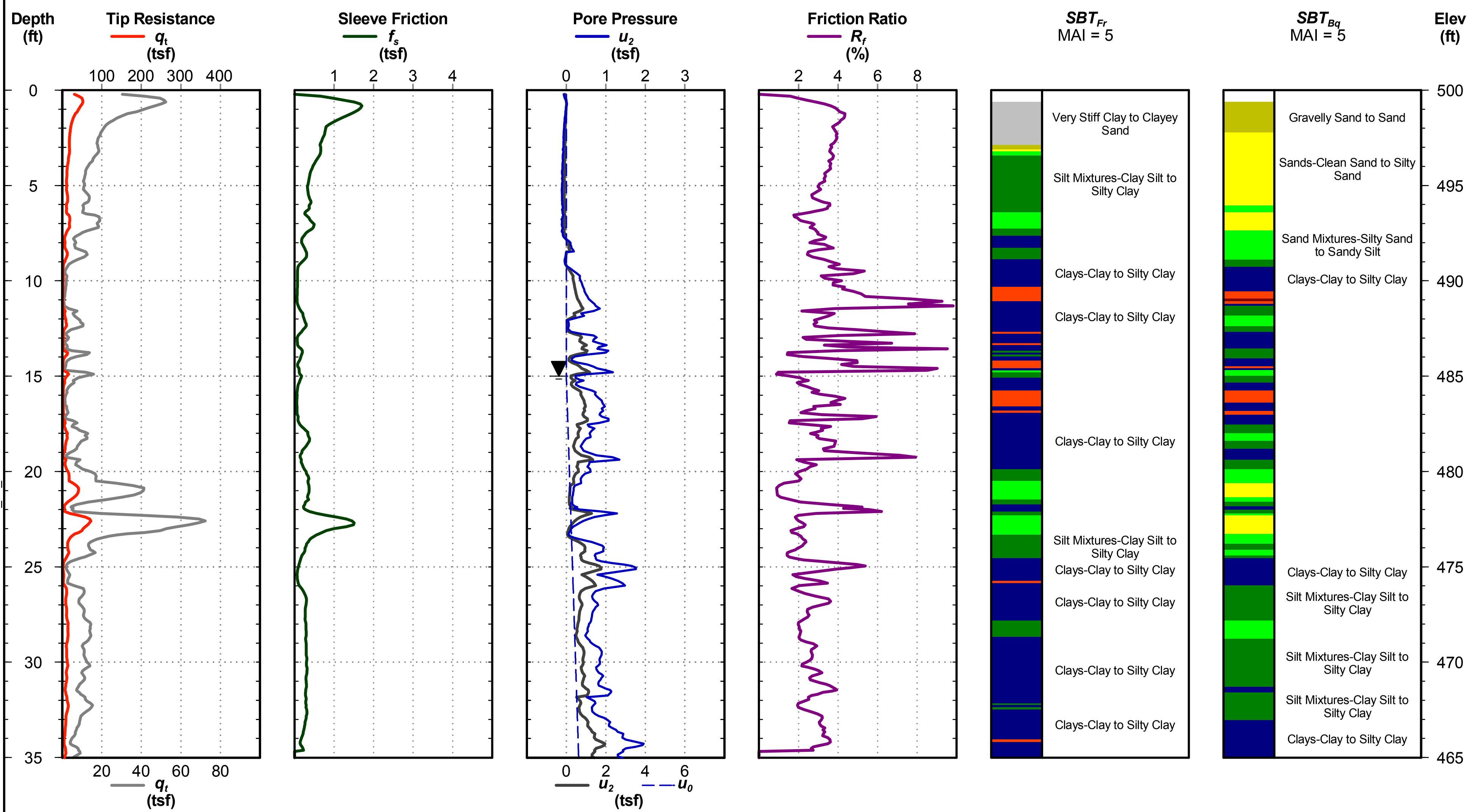
Cone Penetration Test

CPT-08

Date: Jun. 13, 2017
Estimated Water Depth: 15 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 35.0 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-08

Electronic Filename: 7217-17-007A

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

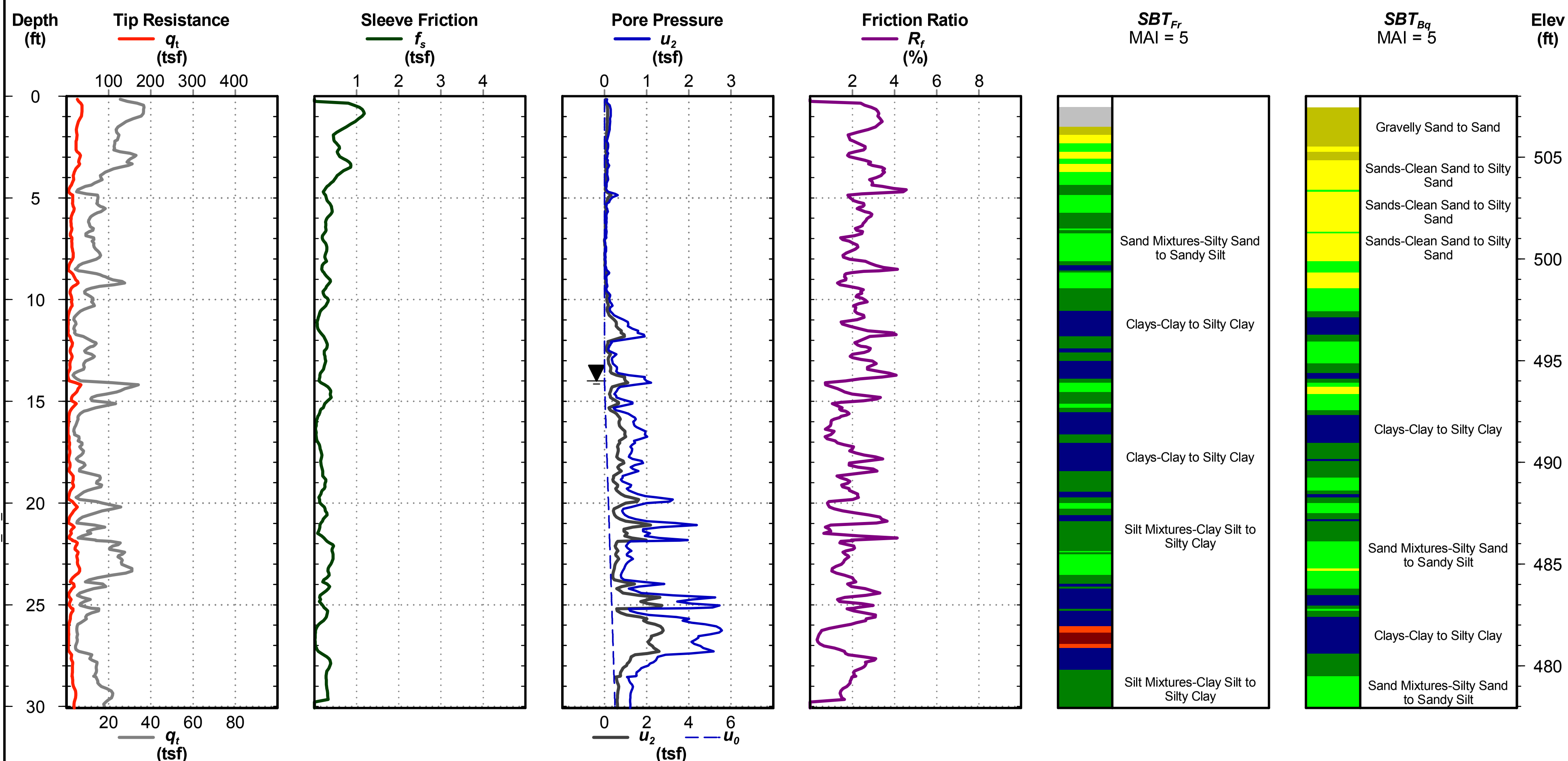
Cone Penetration Test

CPT-09

Date: Jun. 14, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 30.1 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-09

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

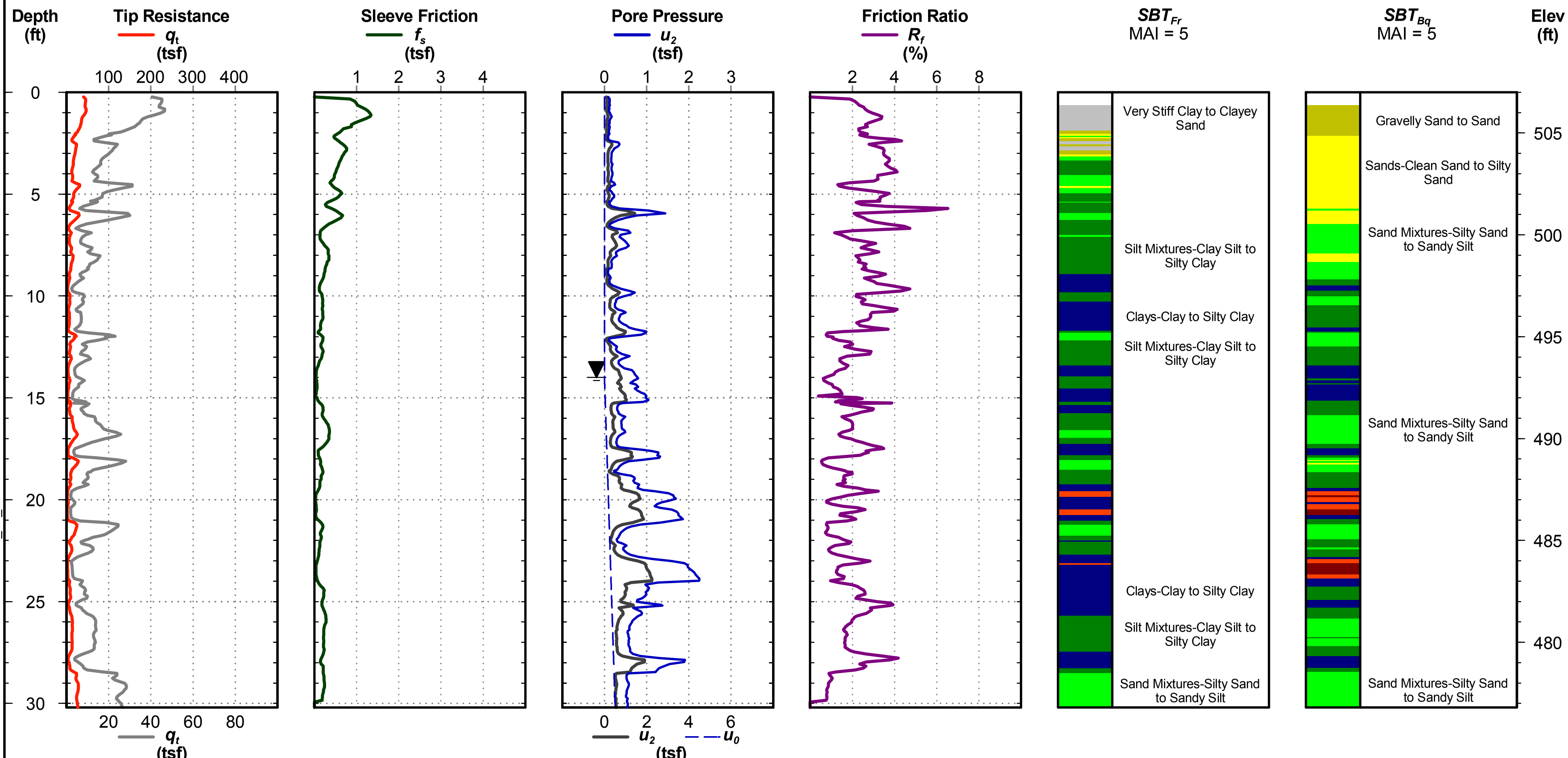
Cone Penetration Test

CPT-10

Date: Jun. 14, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 30.2 ft
Termination Criteria: Target Depth
Cone Size: 1.75



CPT-10

Note: Estimated water depth is based on onboard controls information and considered approximate.

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

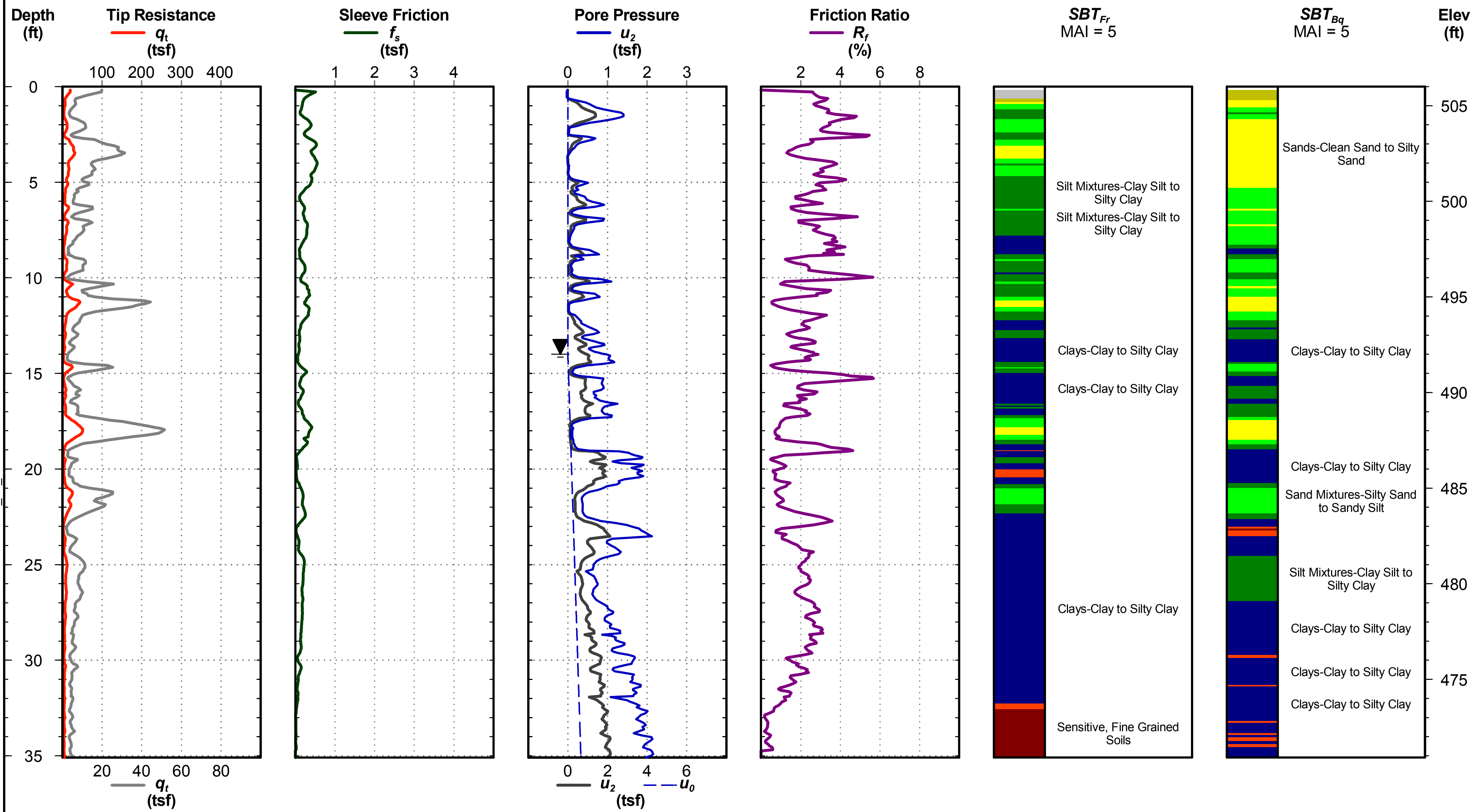
Cone Penetration Test

CPT-11

Date: Jun. 13, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-11

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

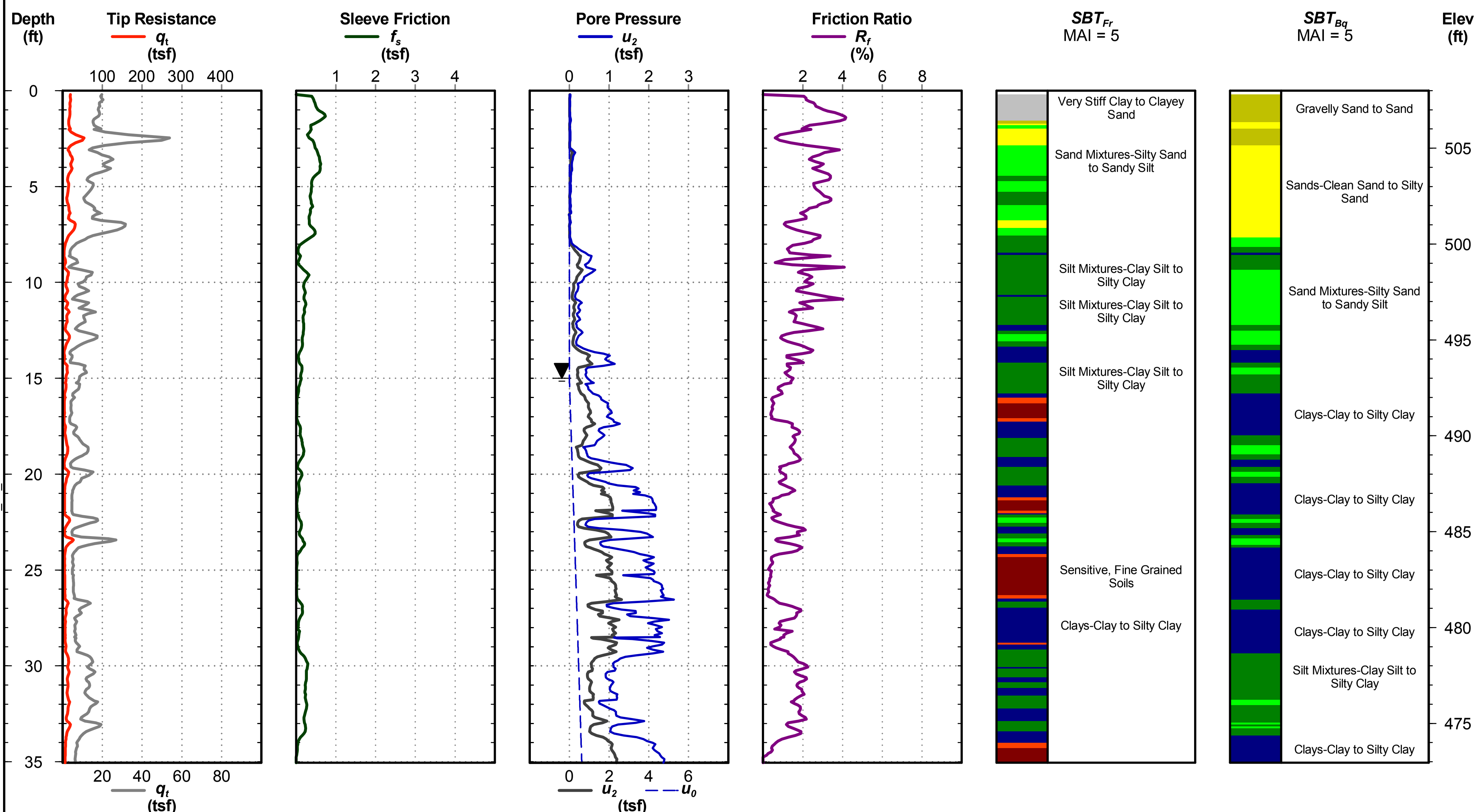
Cone Penetration Test

CPT-12

Date: Jun. 14, 2017
Estimated Water Depth: 15 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-12

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

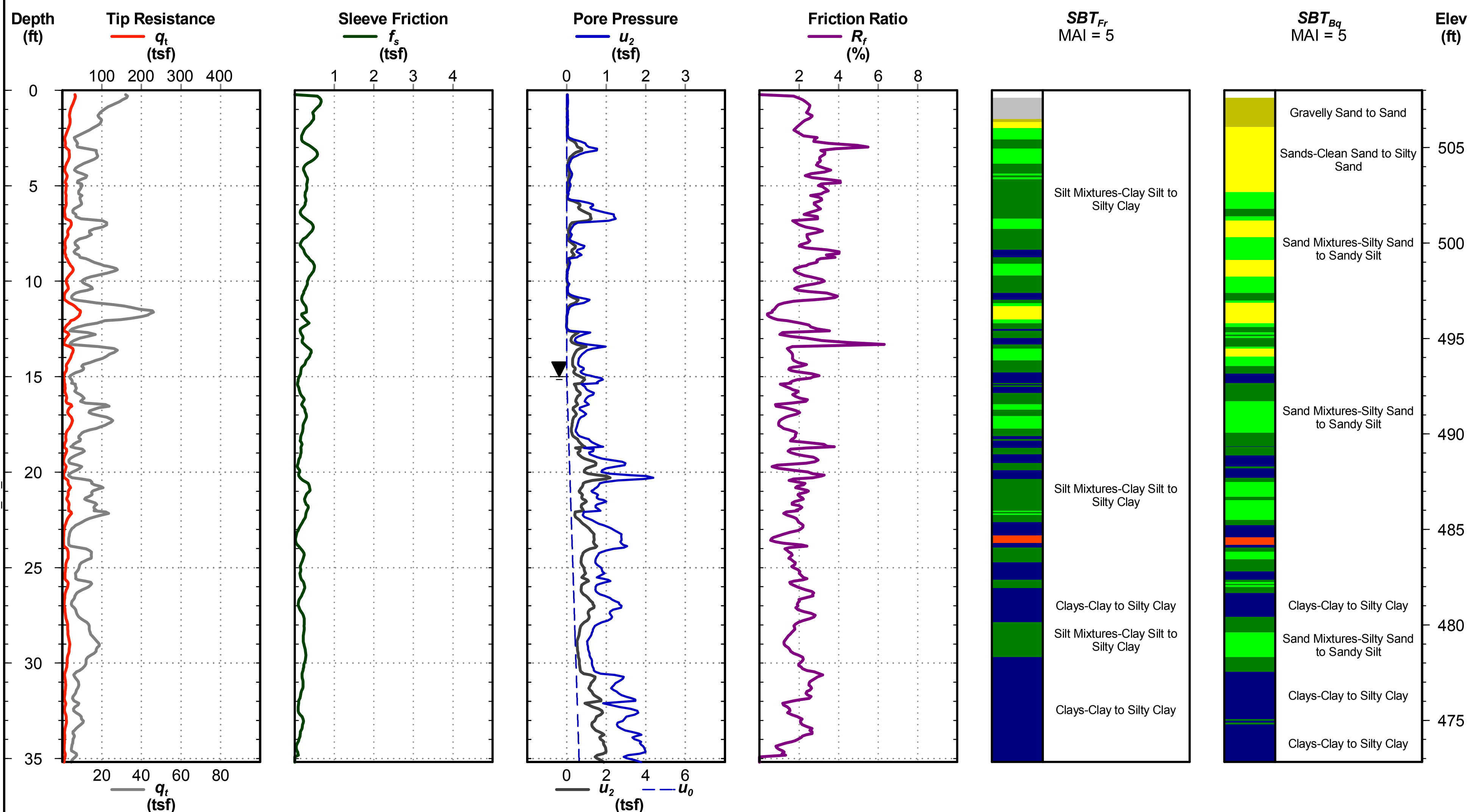
Cone Penetration Test

CPT-13

Date: Jun. 14, 2017
Estimated Water Depth: 15 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 35.2 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-13

Electronic Filename: 7217-17-007A

Cone Penetration Test

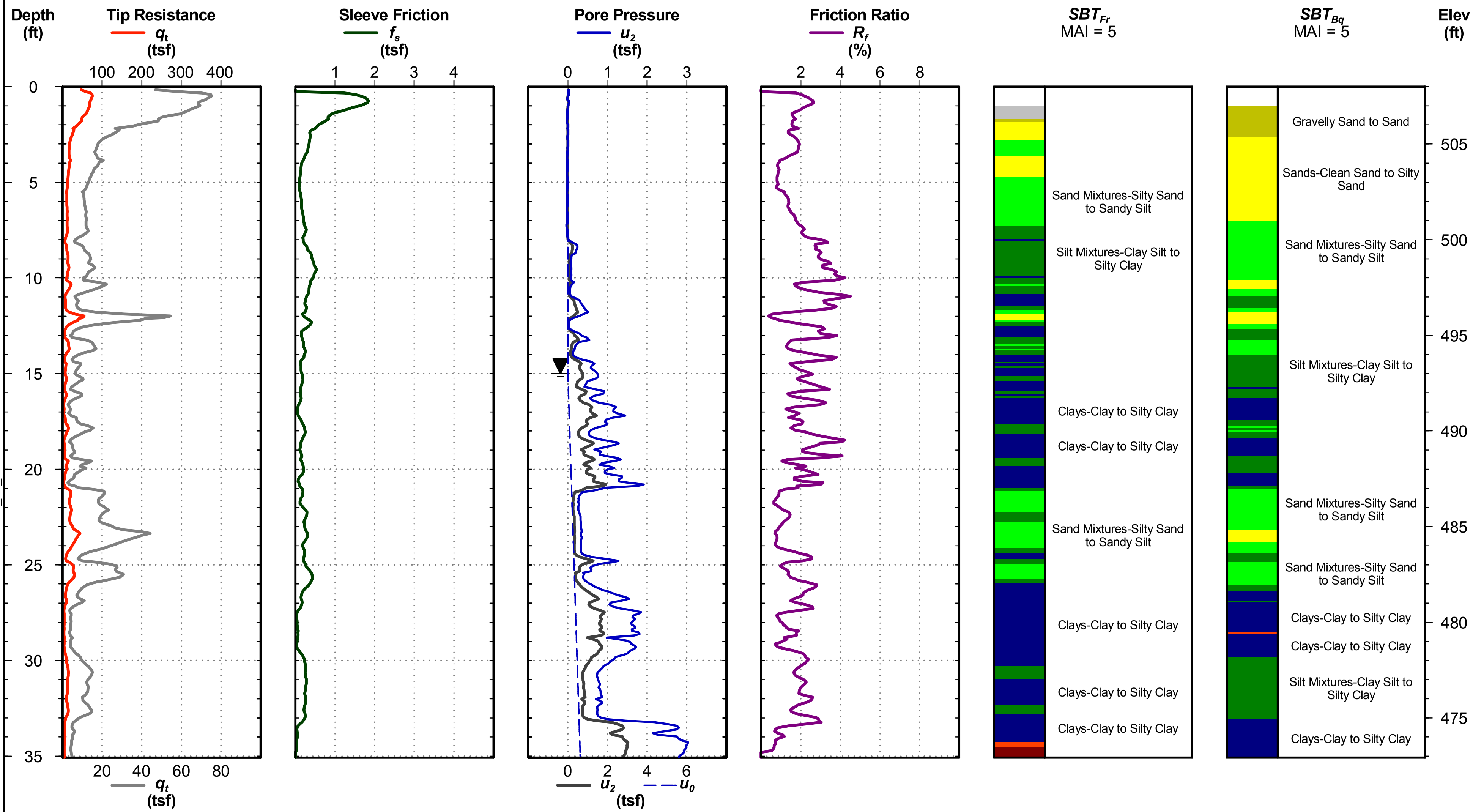
CPT-14

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

-PRELIMINARY-

Date: Jun. 14, 2017
Estimated Water Depth: 15 ft
Rig/Operator: Track

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-14

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

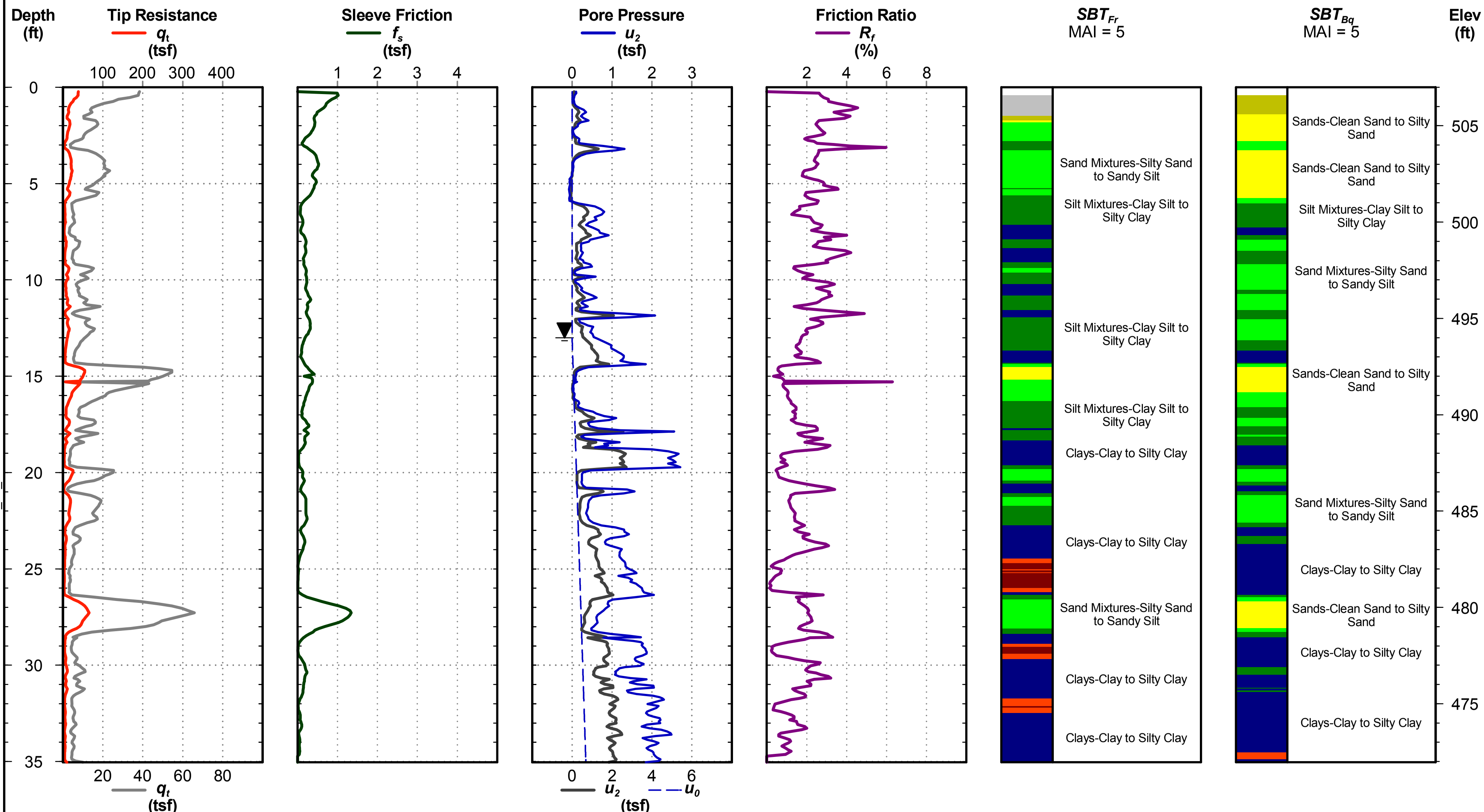
Cone Penetration Test

CPT-15

Date: Jun. 13, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 35.0 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-15

Electronic Filename: 7217-17-007A

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

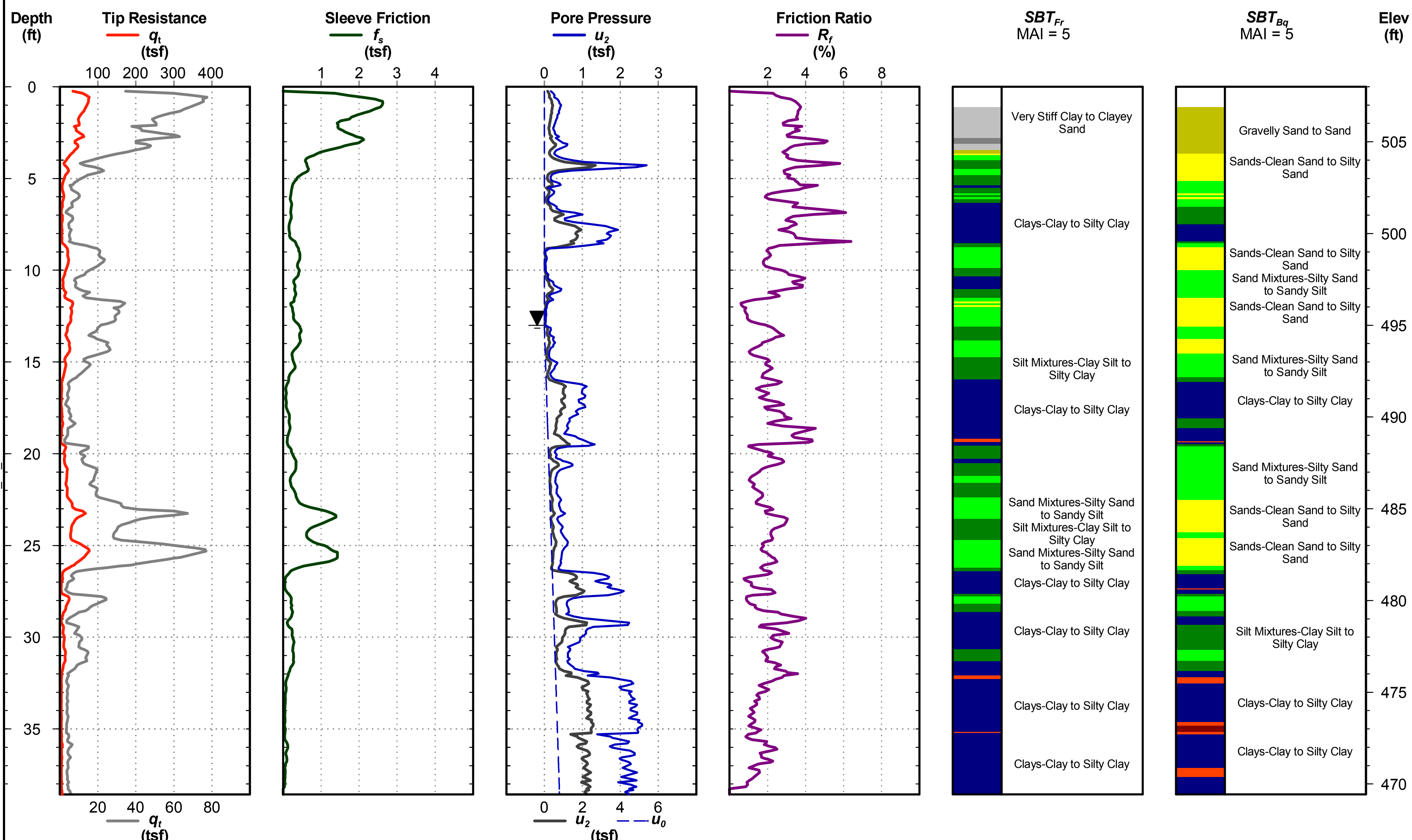
Cone Penetration Test

CPT-16

Date: Jun. 13, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 38.6 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

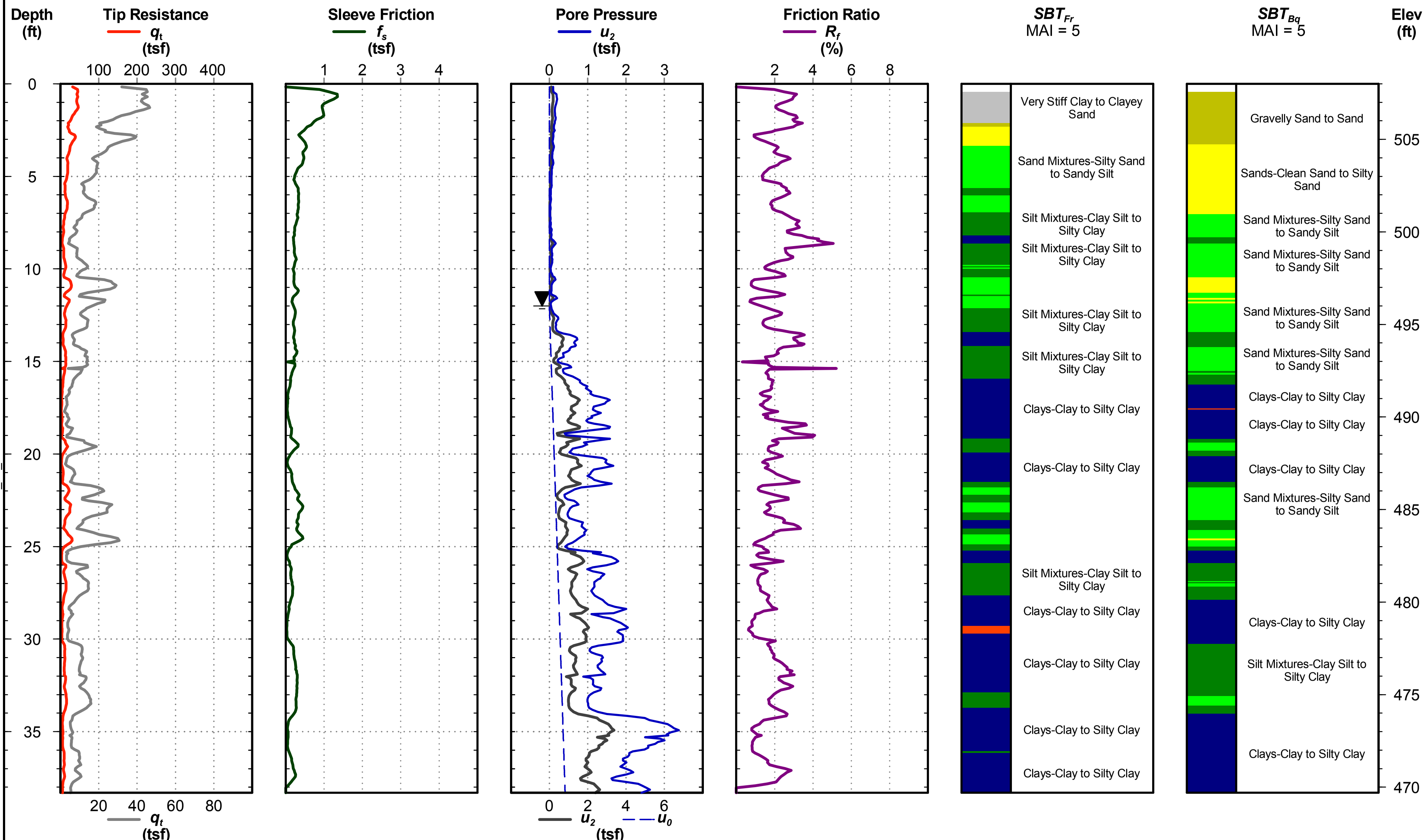
Cone Penetration Test

CPT-17

Date: Jun. 13, 2017
Estimated Water Depth: 12 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 38.3 ft
Termination Criteria: Target Depth
Cone Size: 1.75



CPT-17

Note: Estimated water depth is based on onboard controls information and considered approximate.

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

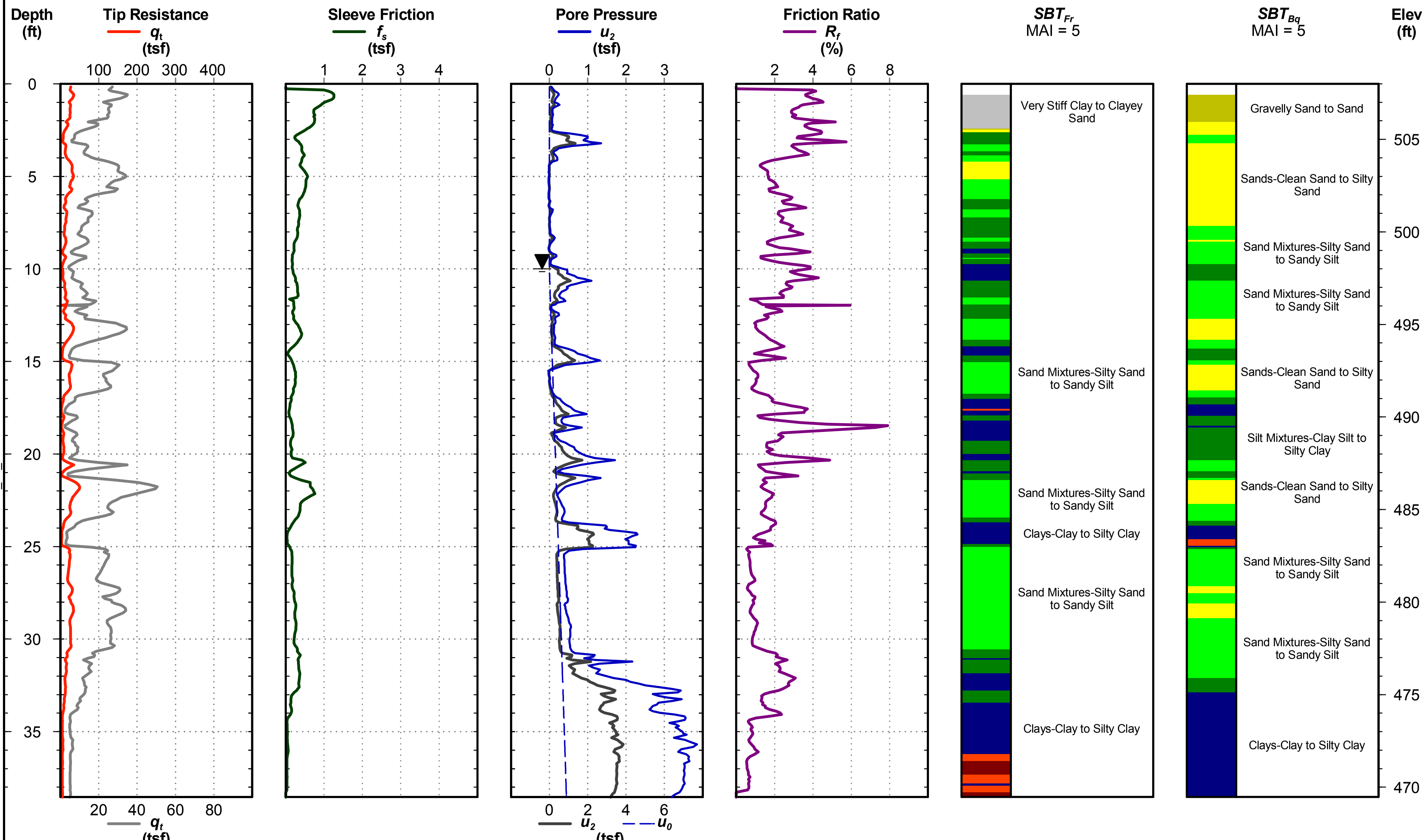
Cone Penetration Test

CPT-18

Date: Jun. 13, 2017
Estimated Water Depth: 10 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 38.5 ft
Termination Criteria: Target Depth
Cone Size: 1.75



CPT-18

Note: Estimated water depth is based on onboard controls information and considered approximate.

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

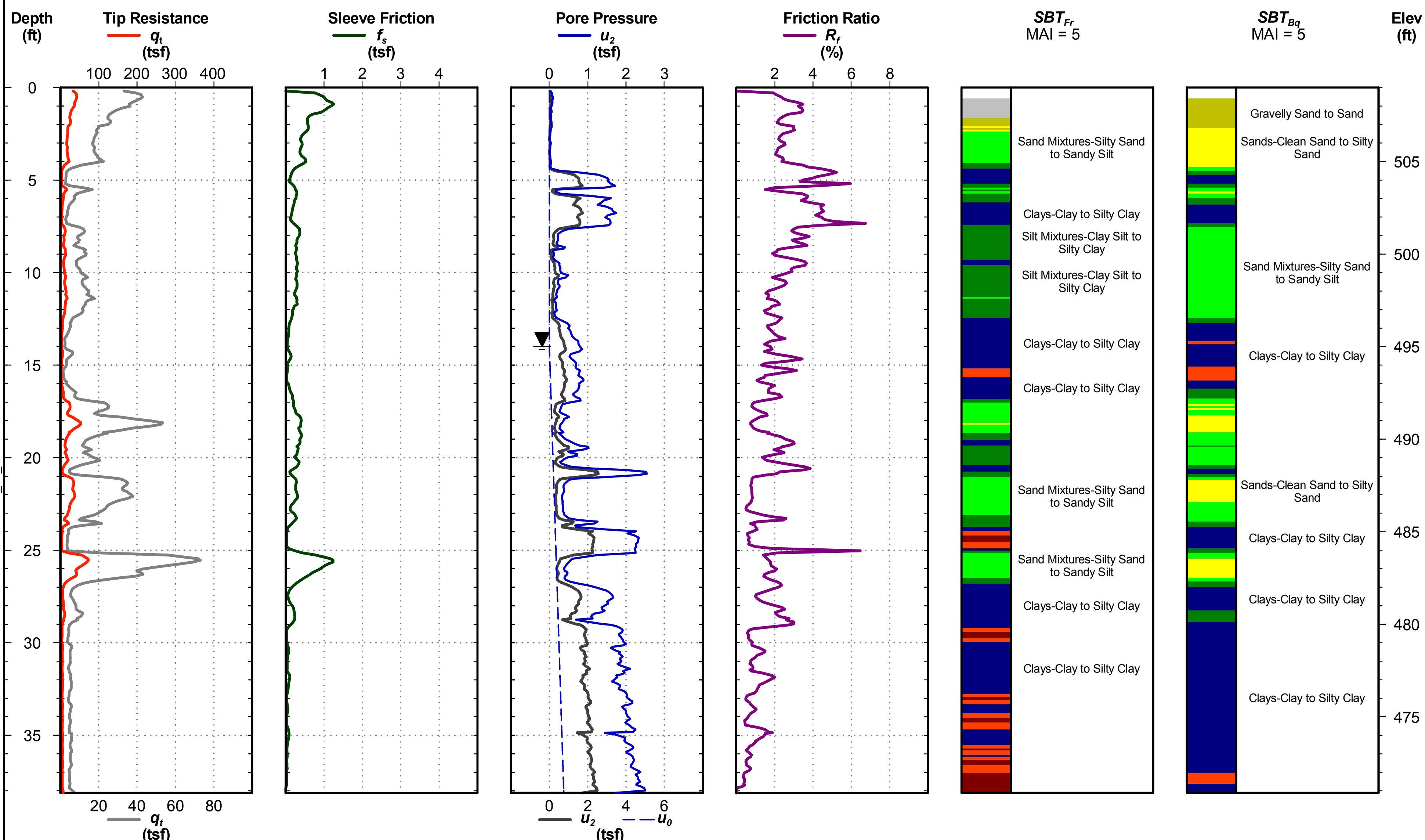
Cone Penetration Test

CPT-19

Date: Jun. 13, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 38.1 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-19

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

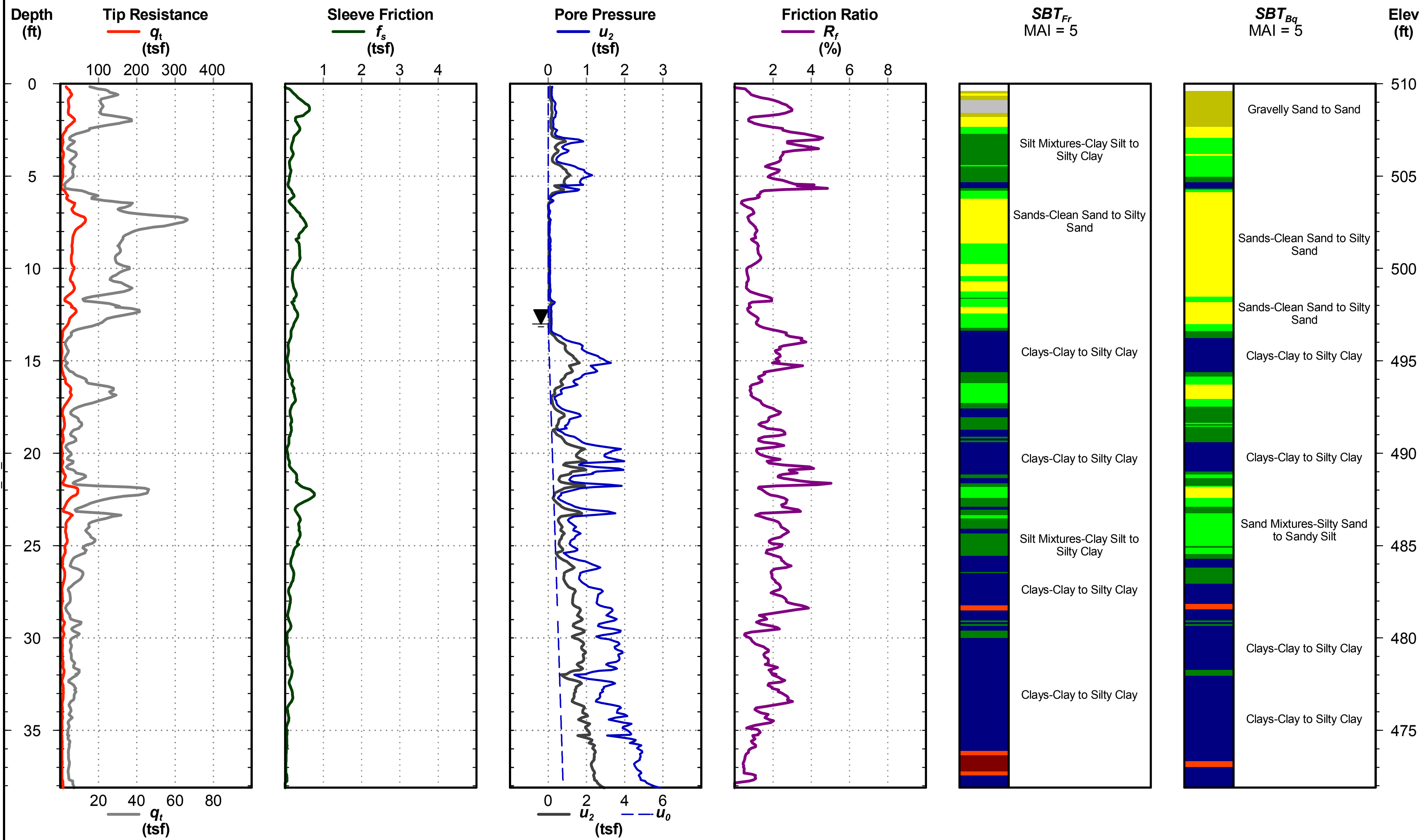
Cone Penetration Test

CPT-20

Date: Jun. 13, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 38.1 ft
Termination Criteria: Target Depth
Cone Size: 1.75



CPT-20

Note: Estimated water depth is based on onboard controls information and considered approximate.

Electronic Filename: 7217-17-007A

Cone Penetration Test

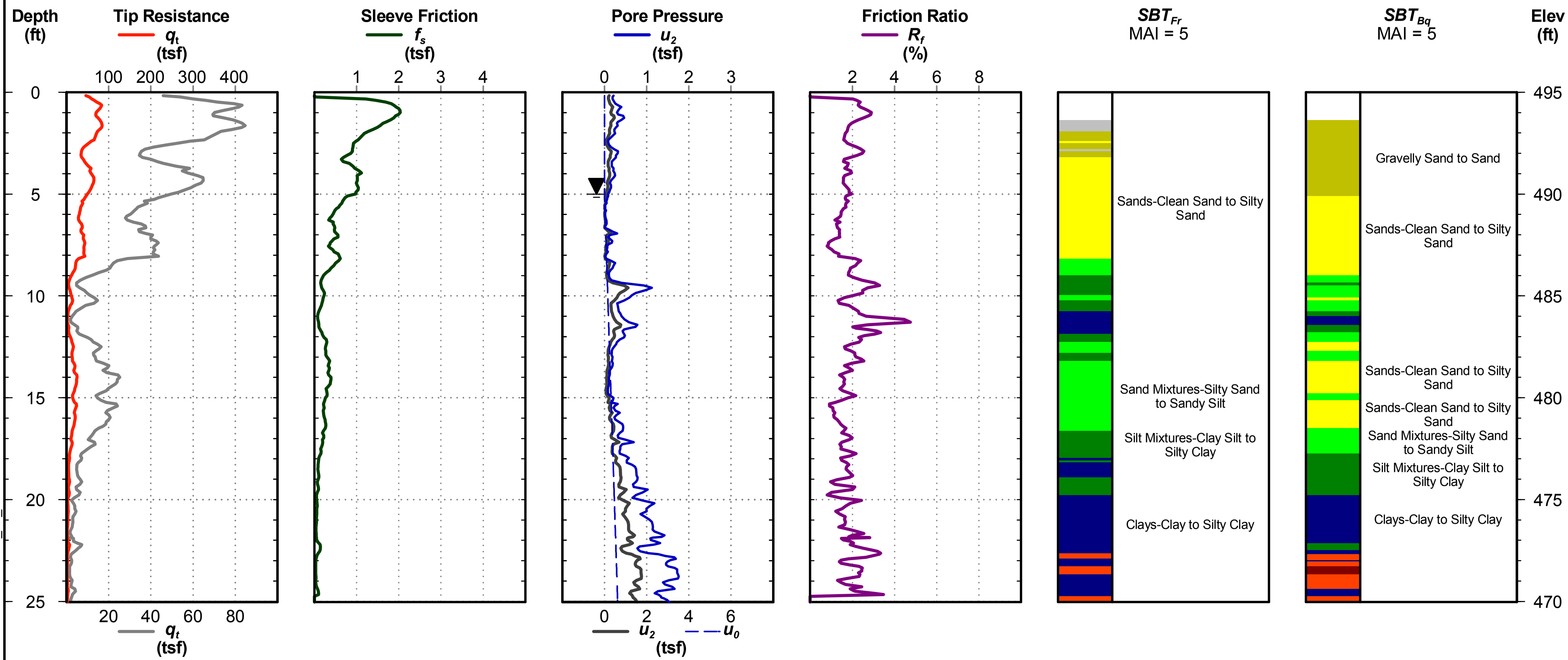
CPT-21

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

Date: Jun. 13, 2017
Estimated Water Depth: 5 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 25.0 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-21

Electronic Filename: 7217-17-007A

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

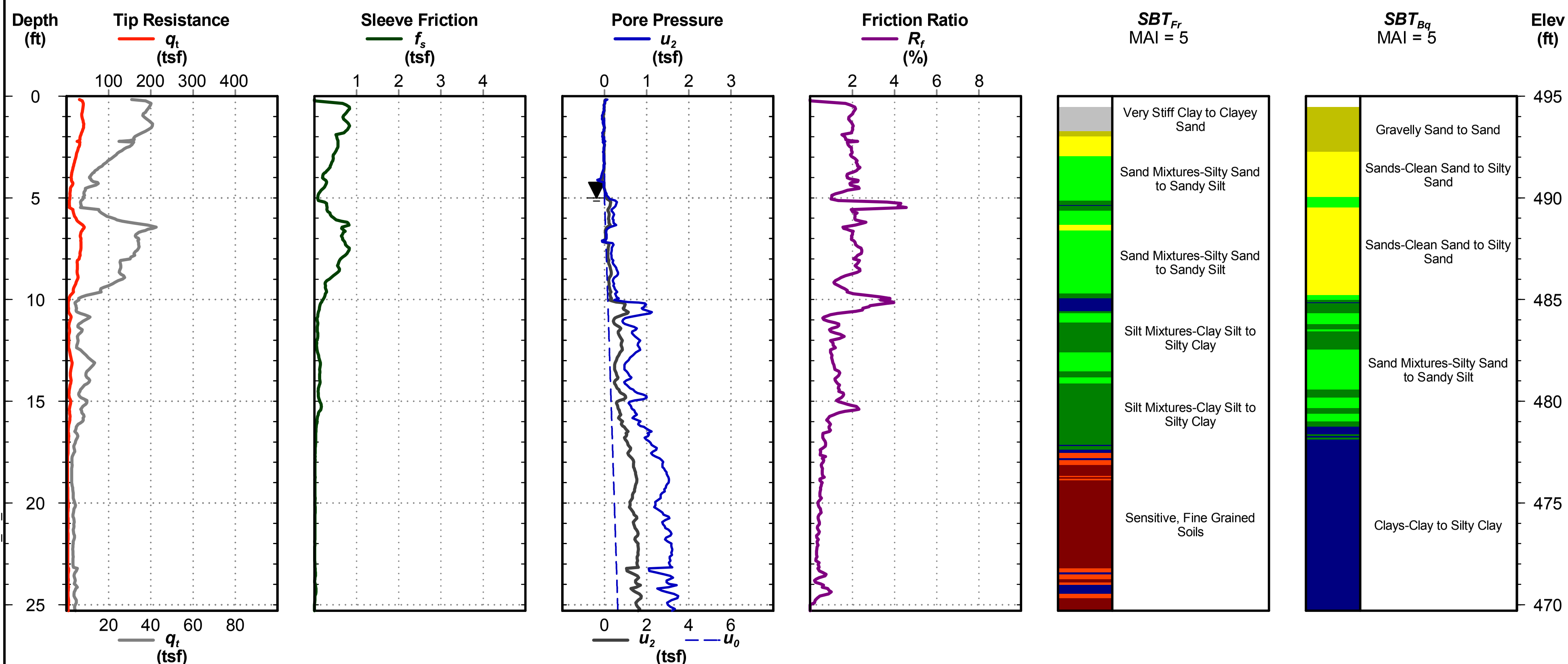
Cone Penetration Test

CPT-22

Date: Jun. 13, 2017
Estimated Water Depth: 5 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 25.3 ft
Termination Criteria: Target Depth
Cone Size: 1.75



CPT-22

Note: Estimated water depth is based on onboard controls information and considered approximate.

Electronic Filename: 7217-17-007A

S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
S&ME Project No: 7217-17-007A

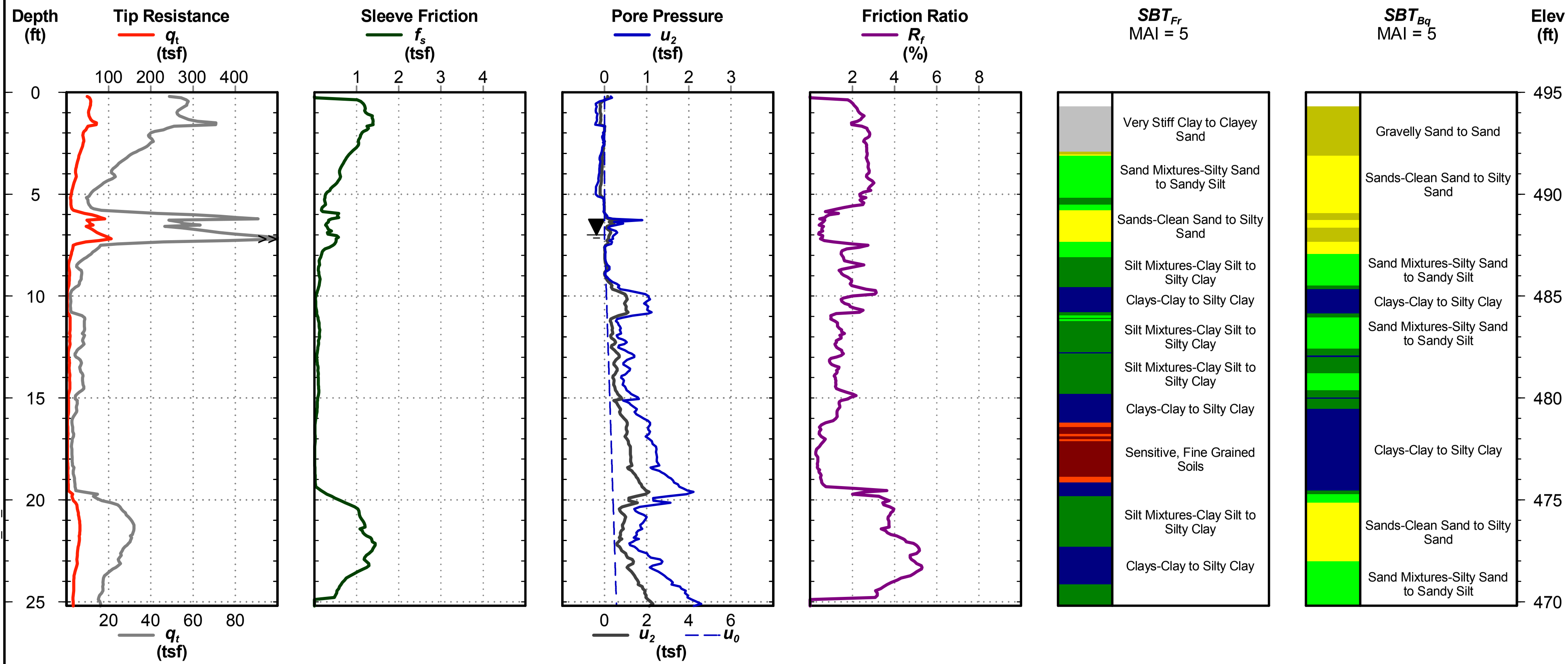
Cone Penetration Test

CPT-23

Date: Jun. 13, 2017
Estimated Water Depth: 7 ft
Rig/Operator: Track

-PRELIMINARY-

Total Depth: 25.2 ft
Termination Criteria: Target Depth
Cone Size: 1.75



Note: Estimated water depth is based on onboard controls information and considered approximate.

CPT-23

Electronic Filename: 7217-17-007A

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Appendix II – Pore Pressure Dissipation Data

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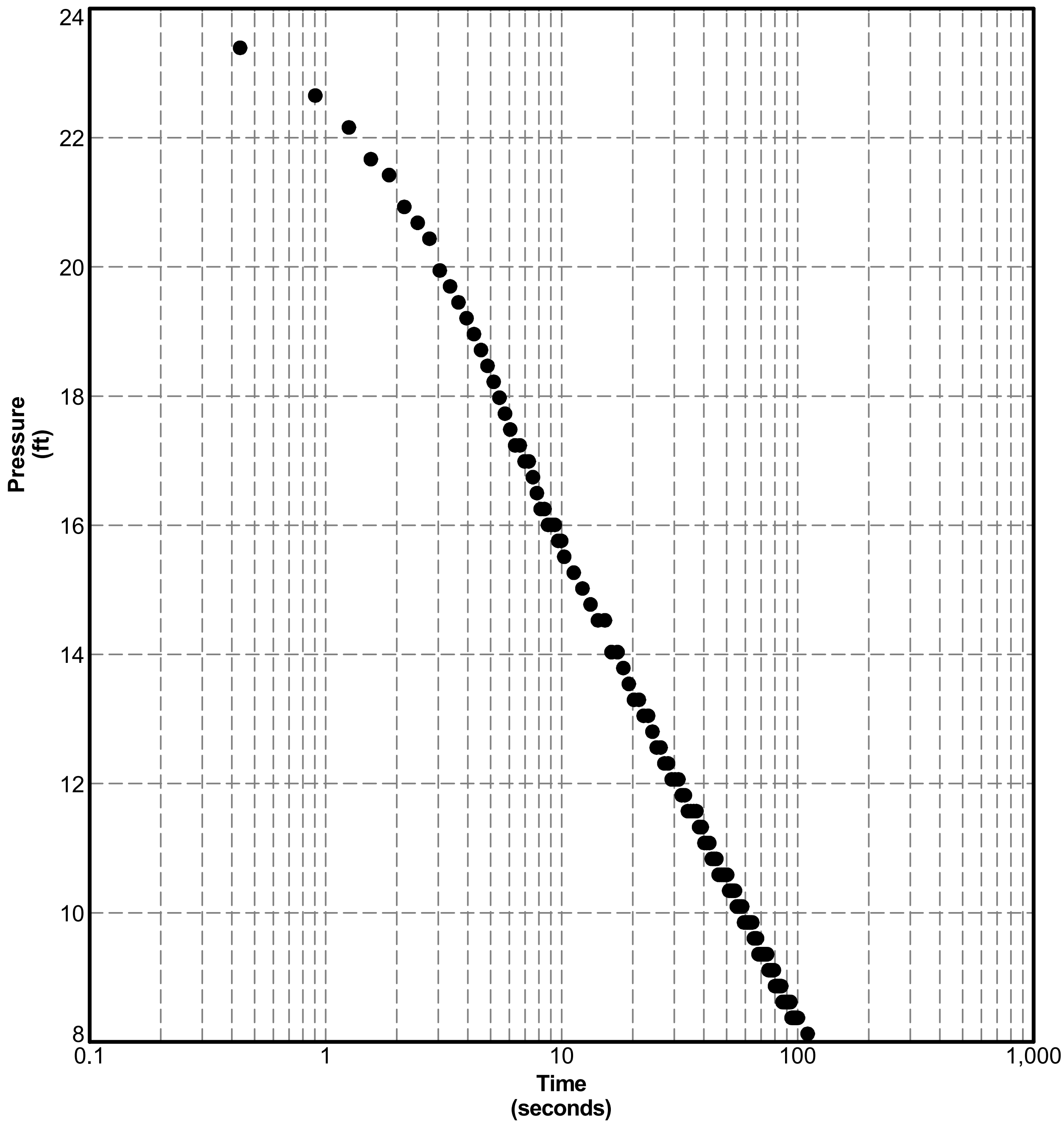
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Andy/Daniel

Total Depth: 36.0 ft
Termination Criteria: Target Depth
Test Depth: 15.2 ft



CPT-01PA

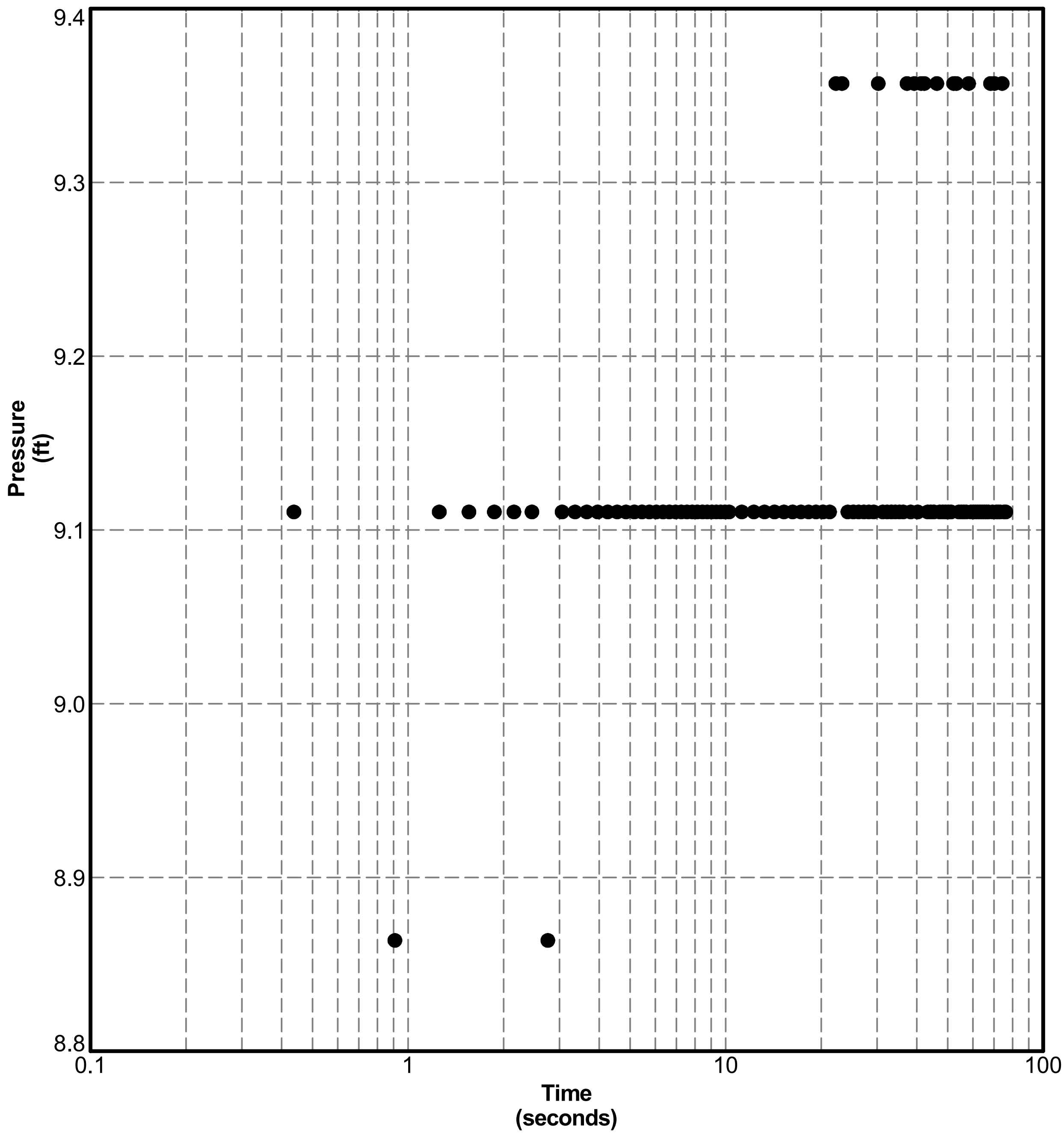
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Andy/Daniel

Total Depth: 36.0 ft
Termination Criteria: Target Depth
Test Depth: 20.2 ft



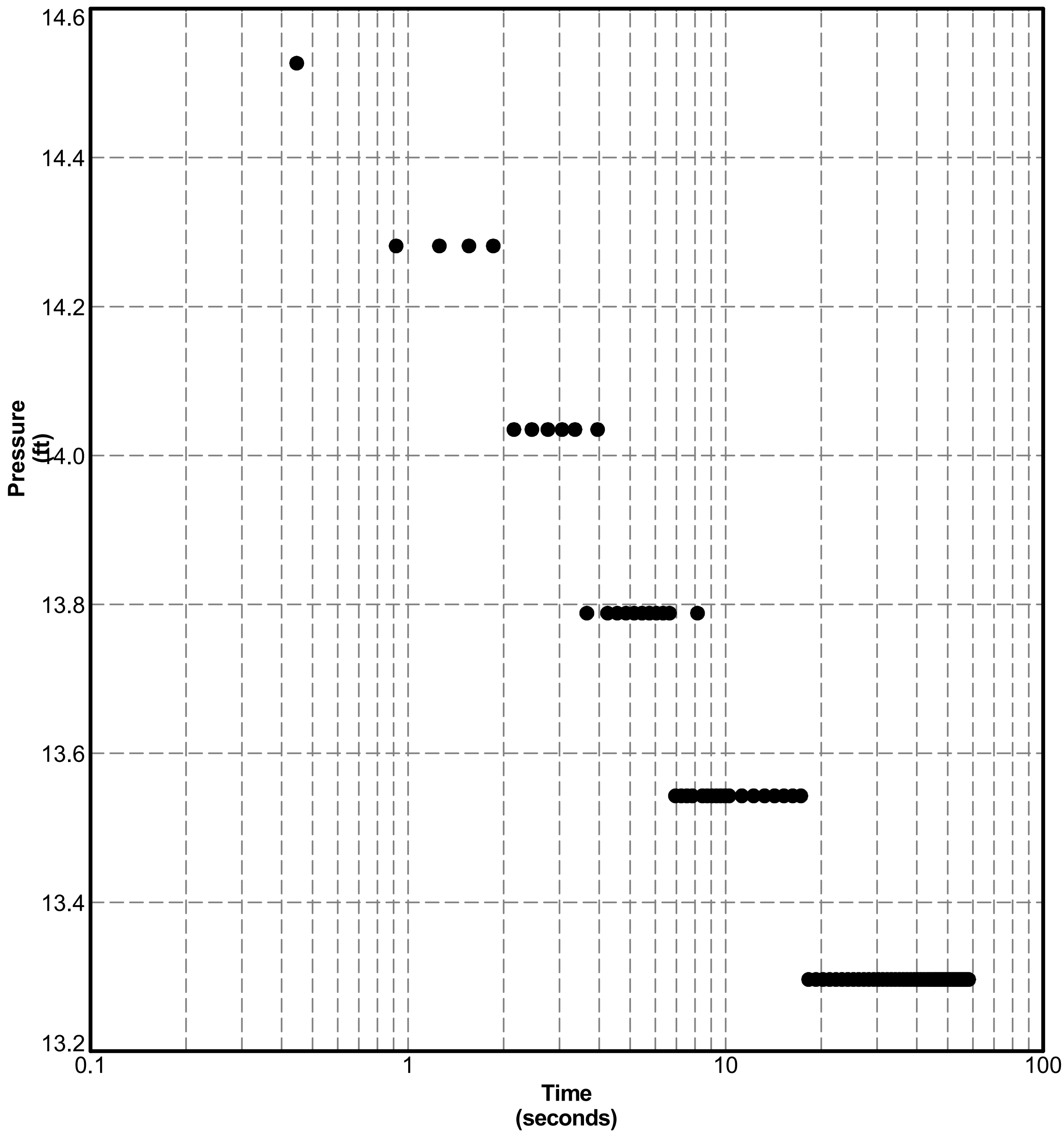
CPT-01PA

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Andy/Daniel

Total Depth: 36.0 ft
Termination Criteria: Target Depth
Test Depth: 24.6 ft



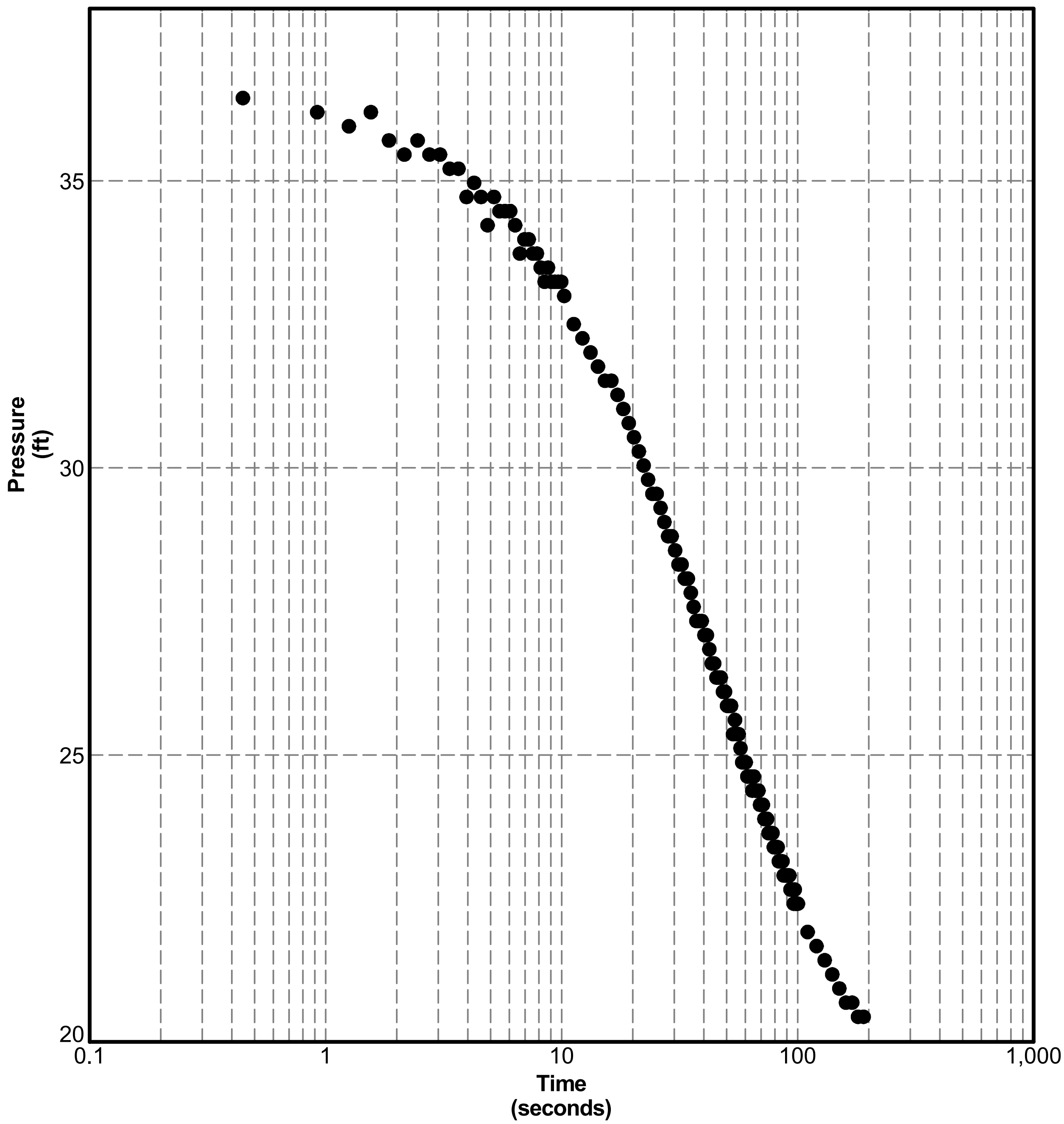
CPT-01PA

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Andy/Daniel

Total Depth: 36.0 ft
Termination Criteria: Target Depth
Test Depth: 30.3 ft



CPT-01PA

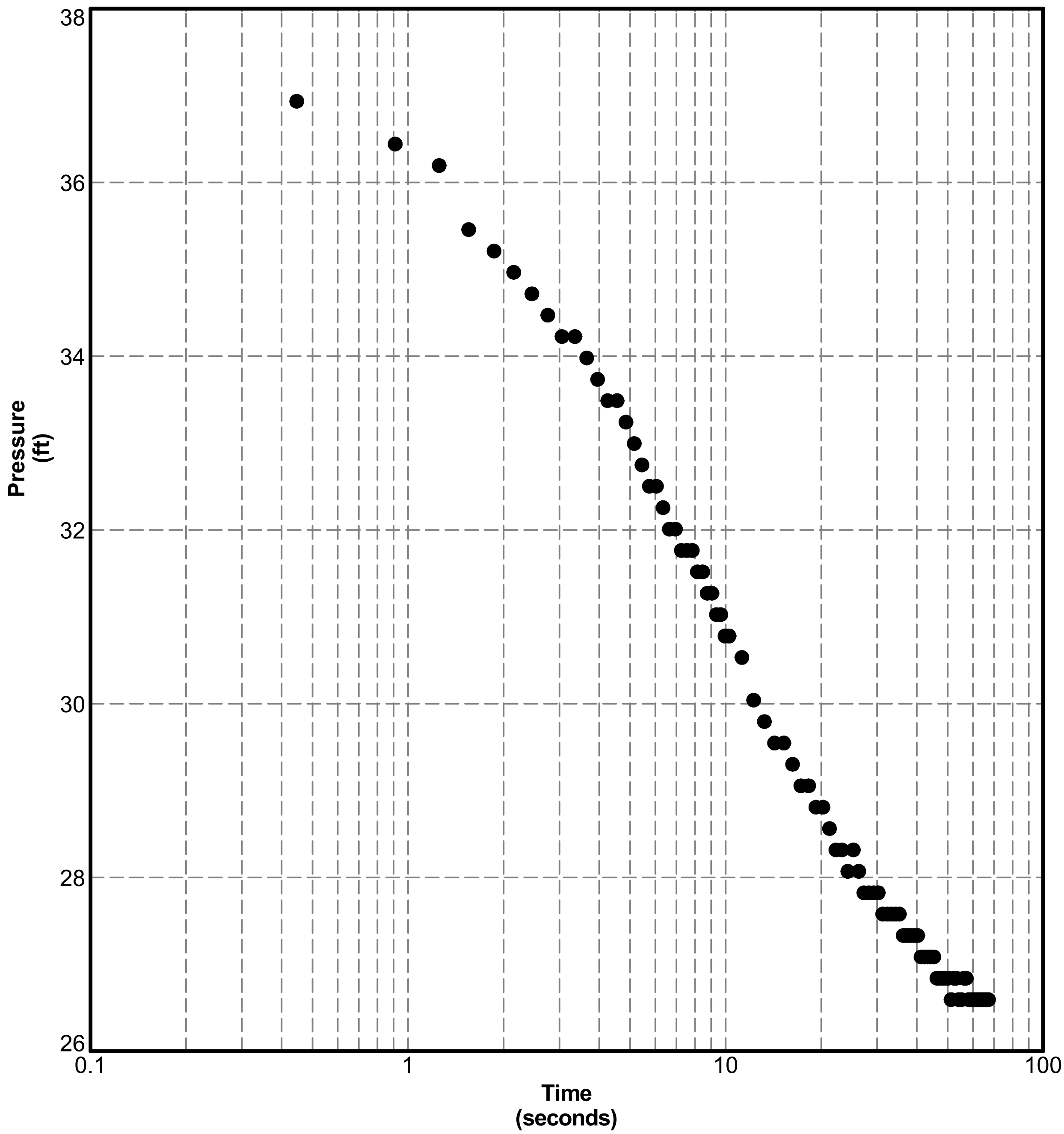
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Andy/Daniel

Total Depth: 36.0 ft
Termination Criteria: Target Depth
Test Depth: 36.1 ft



CPT-01PA

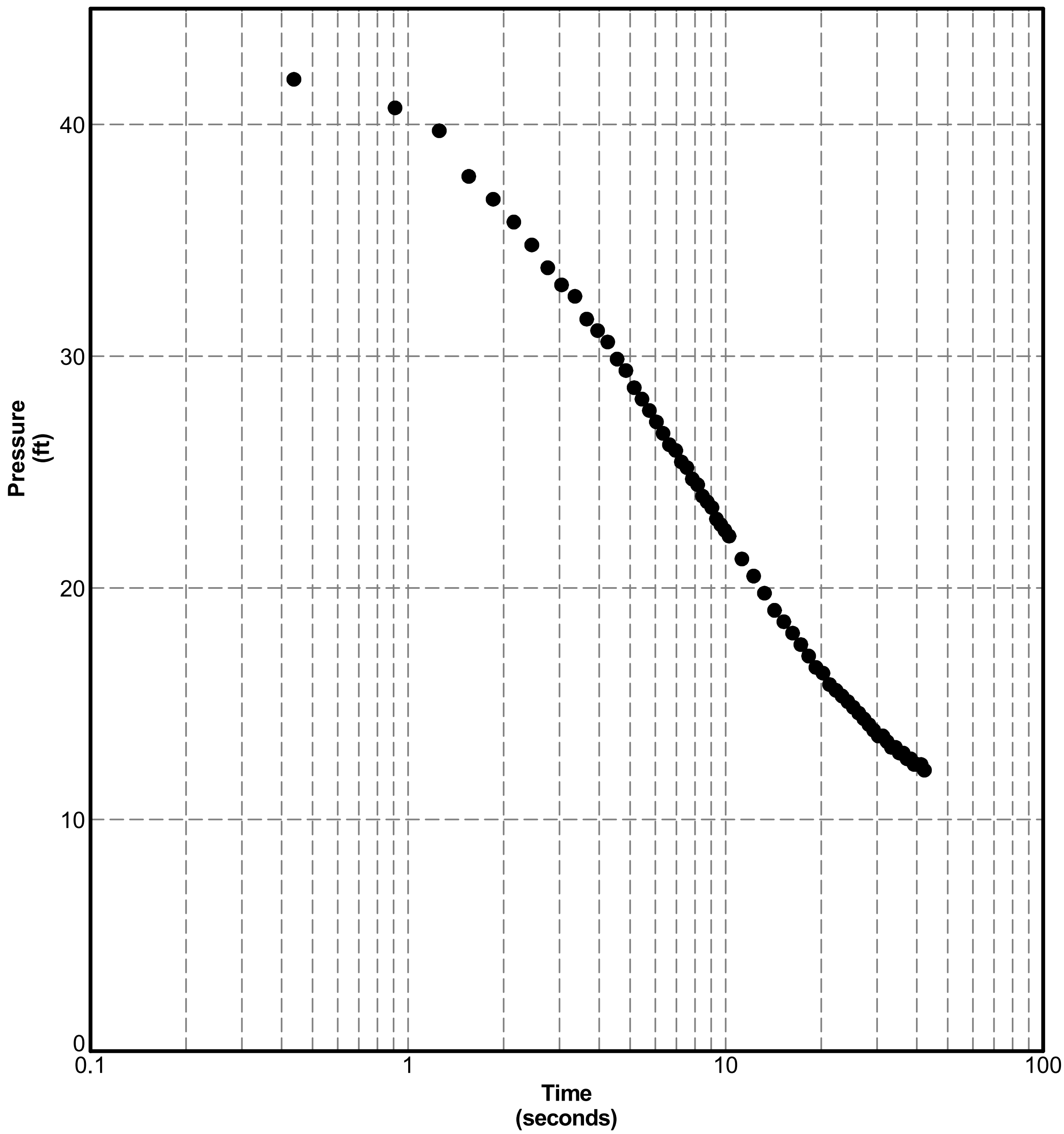
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Andy/Daniel

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Test Depth: 20.1 ft



CPT-02PA

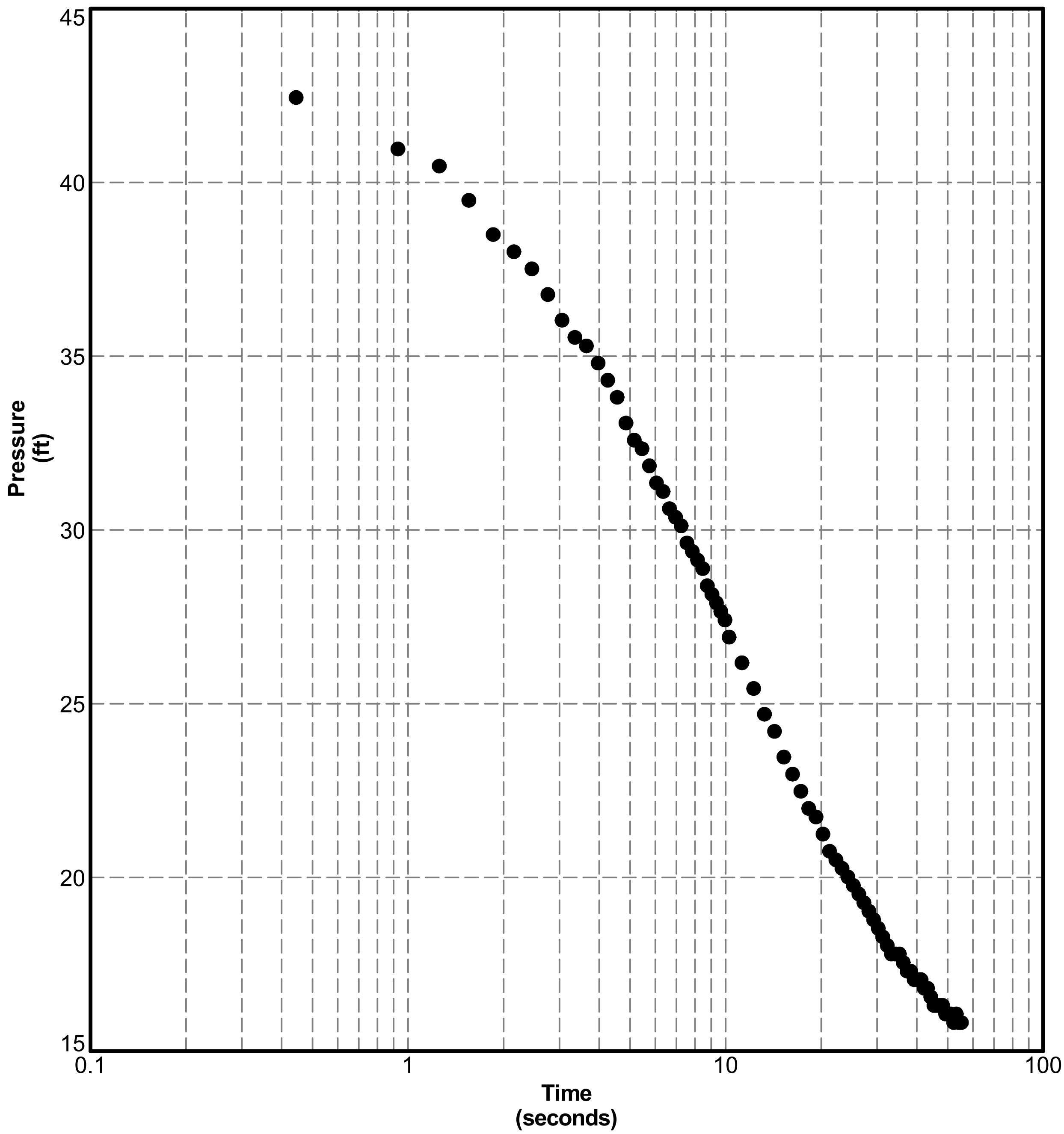
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Andy/Daniel

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Test Depth: 25.1 ft



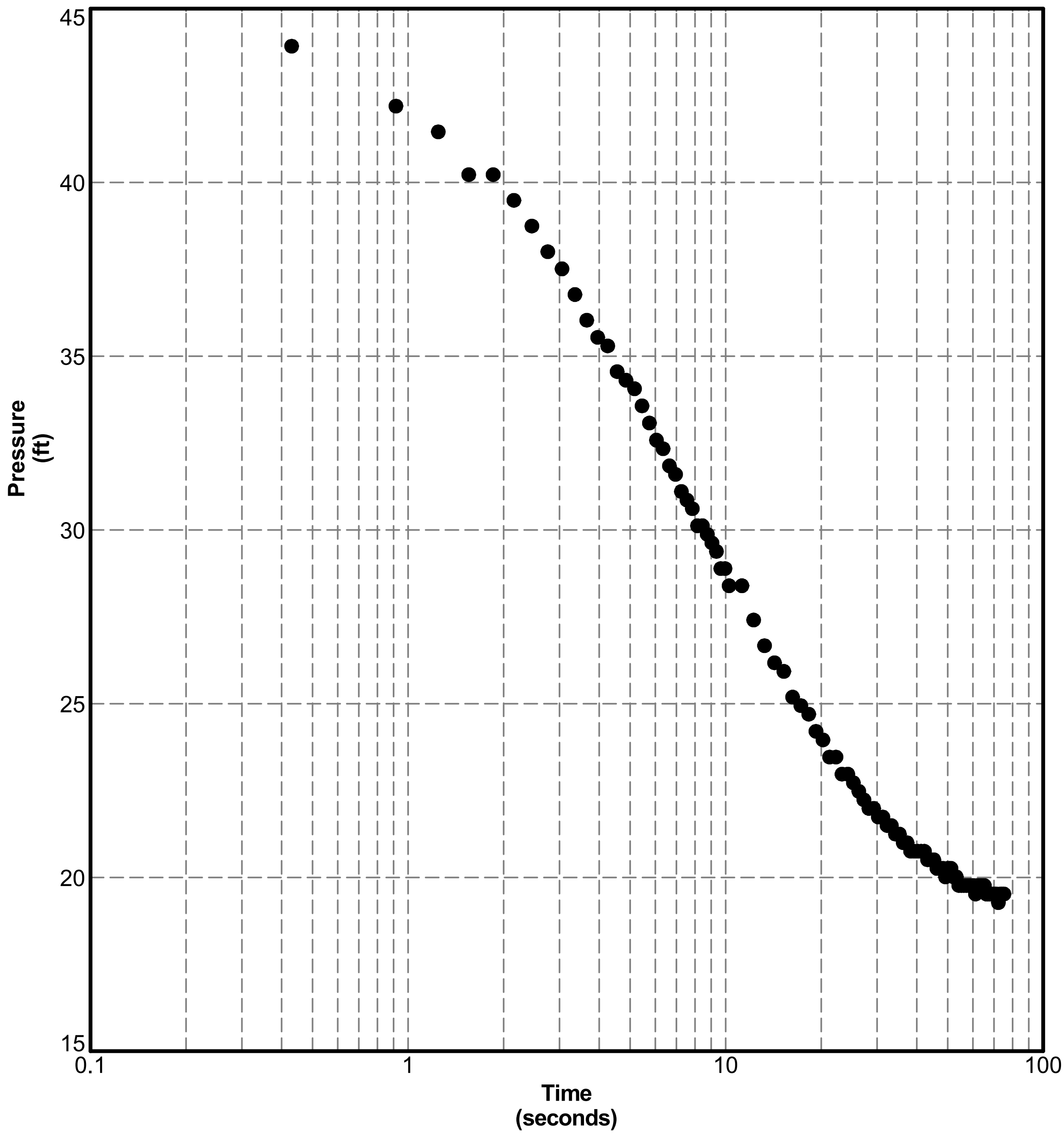
CPT-02PA

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Andy/Daniel

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Test Depth: 30.1 ft



CPT-02PA

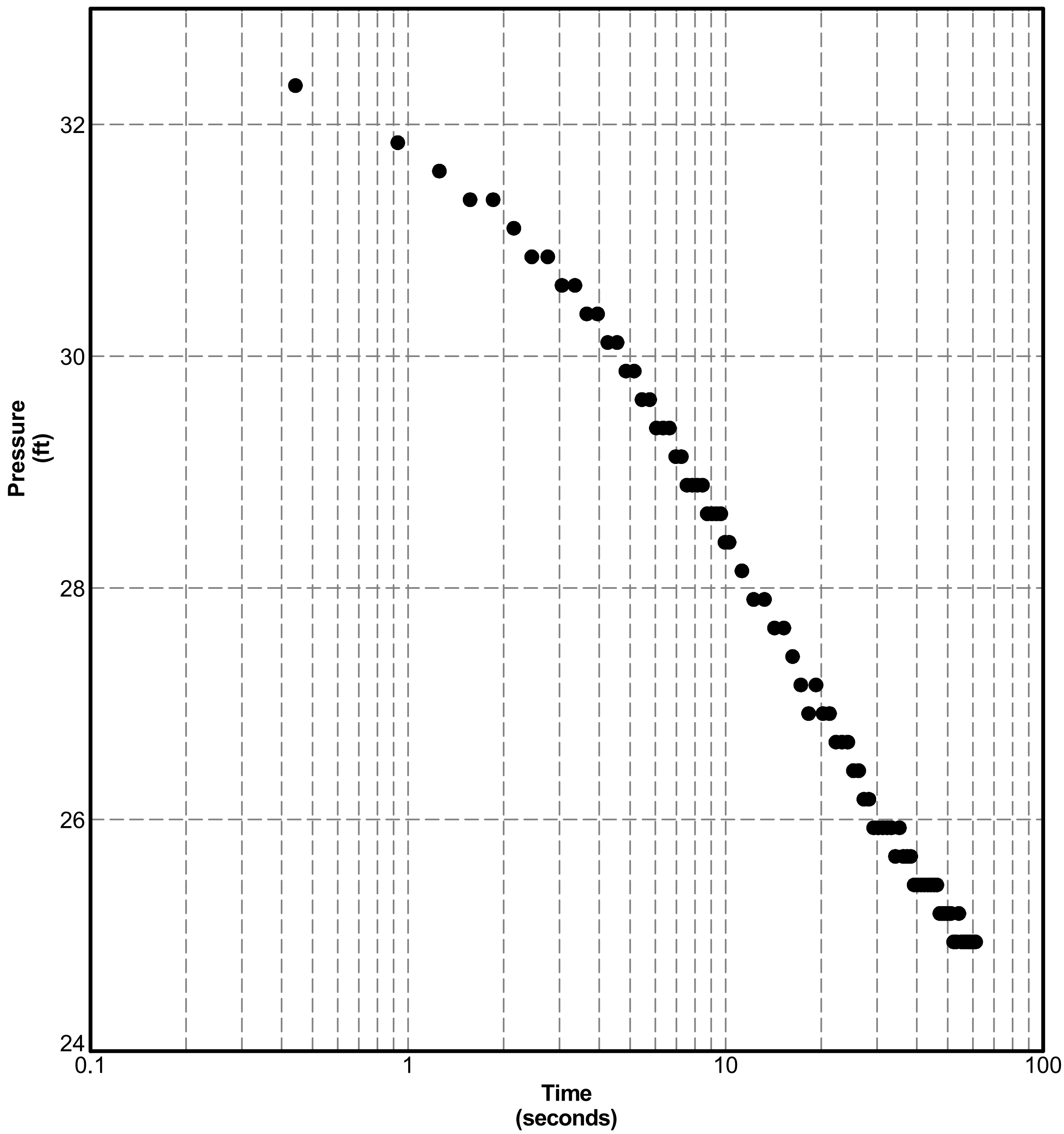
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 13 ft
Rig/Operator: Andy/Daniel

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Test Depth: 35.2 ft



CPT-02PA

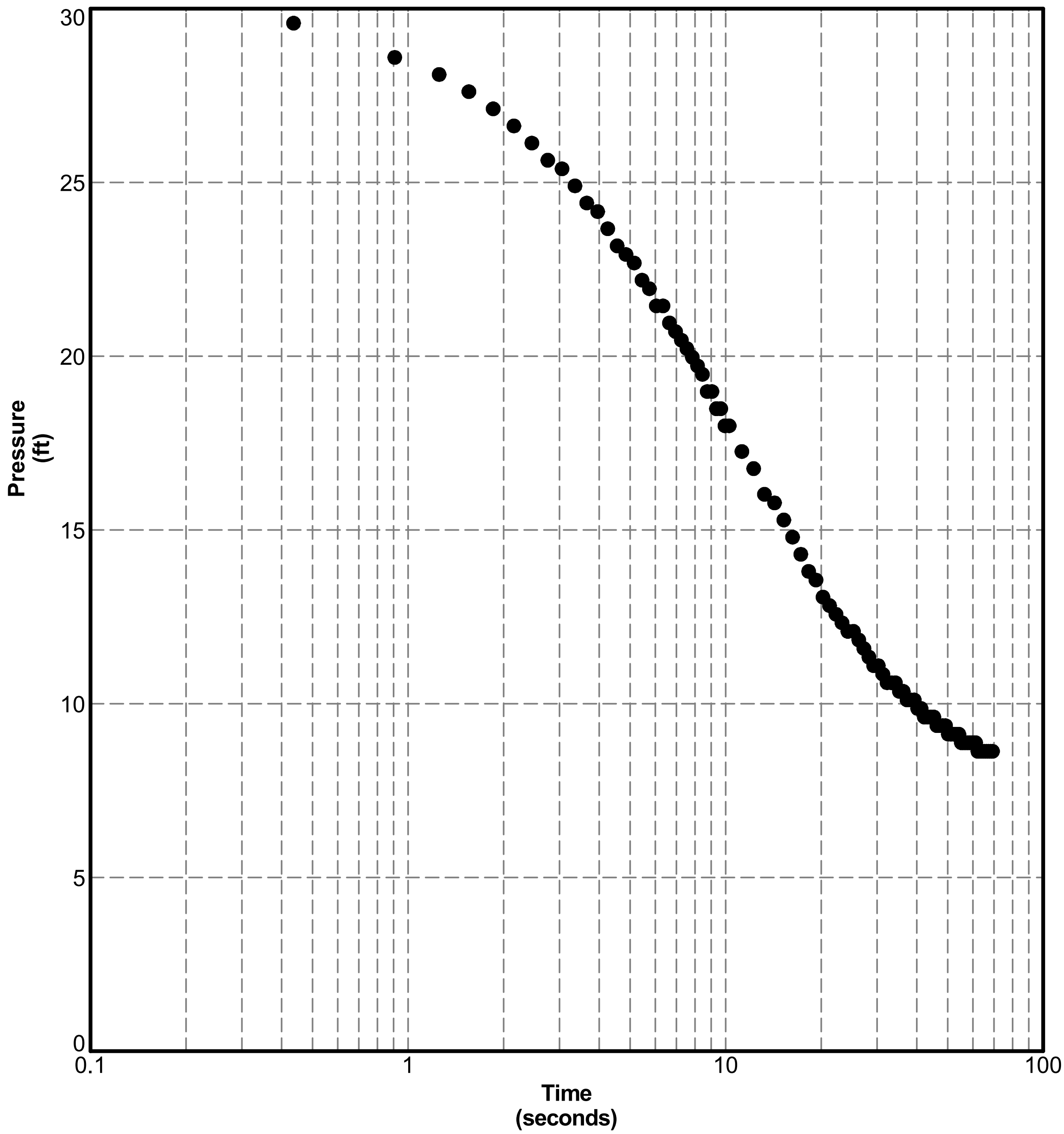
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Andy/Daniel

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Test Depth: 15.1 ft



CPT-03PA

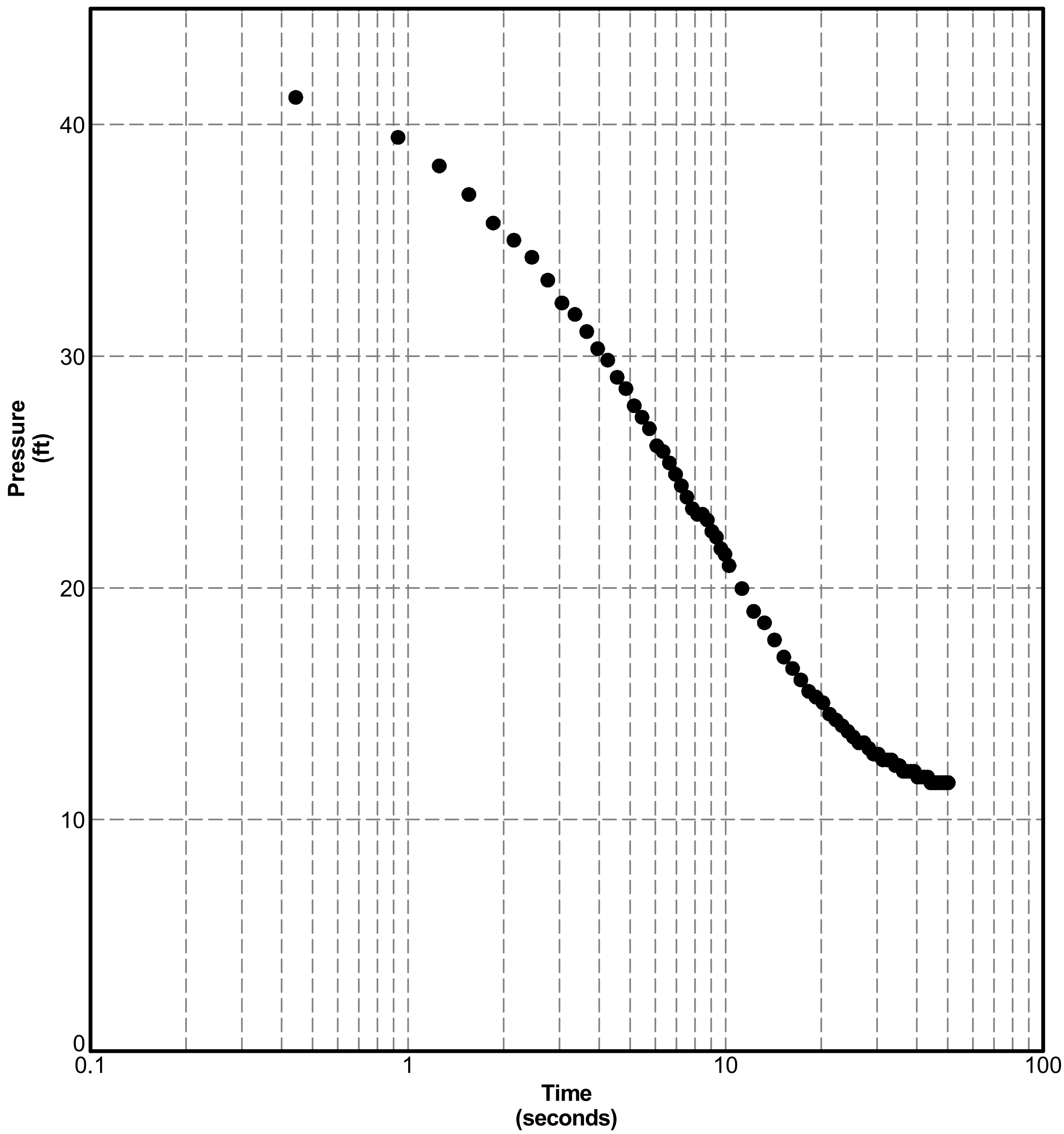
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Andy/Daniel

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Test Depth: 20.1 ft



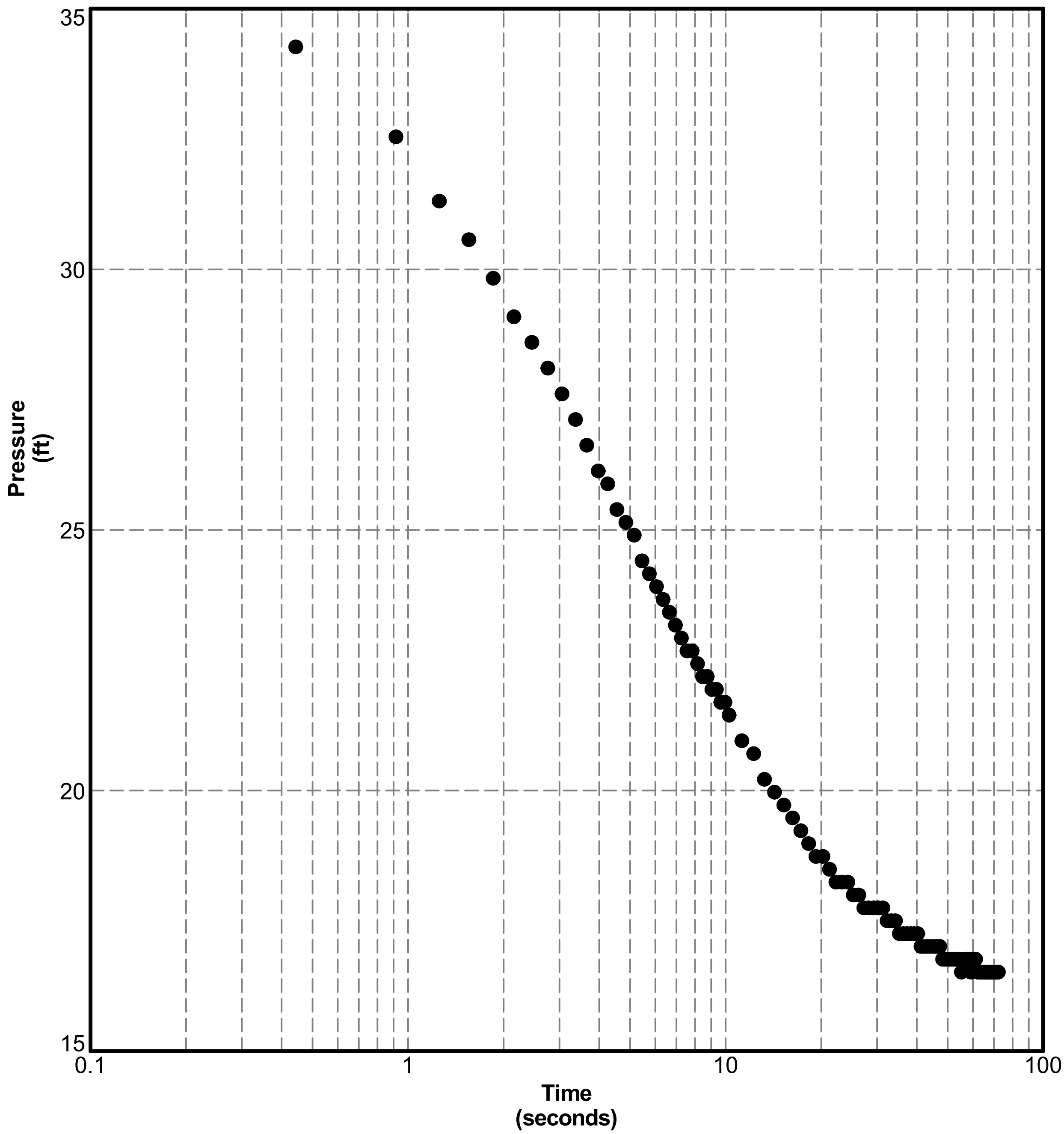
CPT-03PA

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Andy/Daniel

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Test Depth: 25.1 ft



CPT-03PA

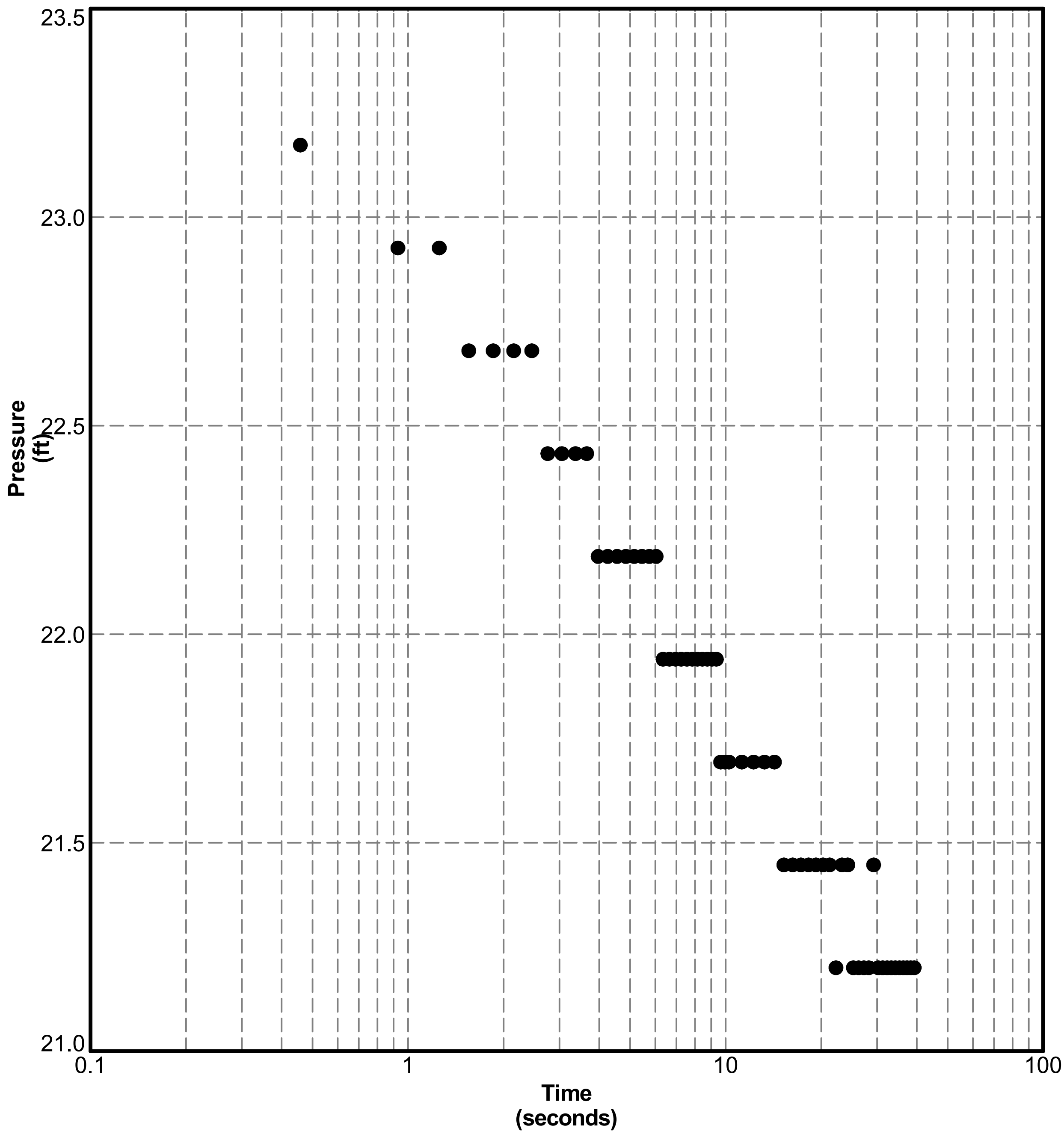
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Andy/Daniel

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Test Depth: 30.1 ft



CPT-03PA

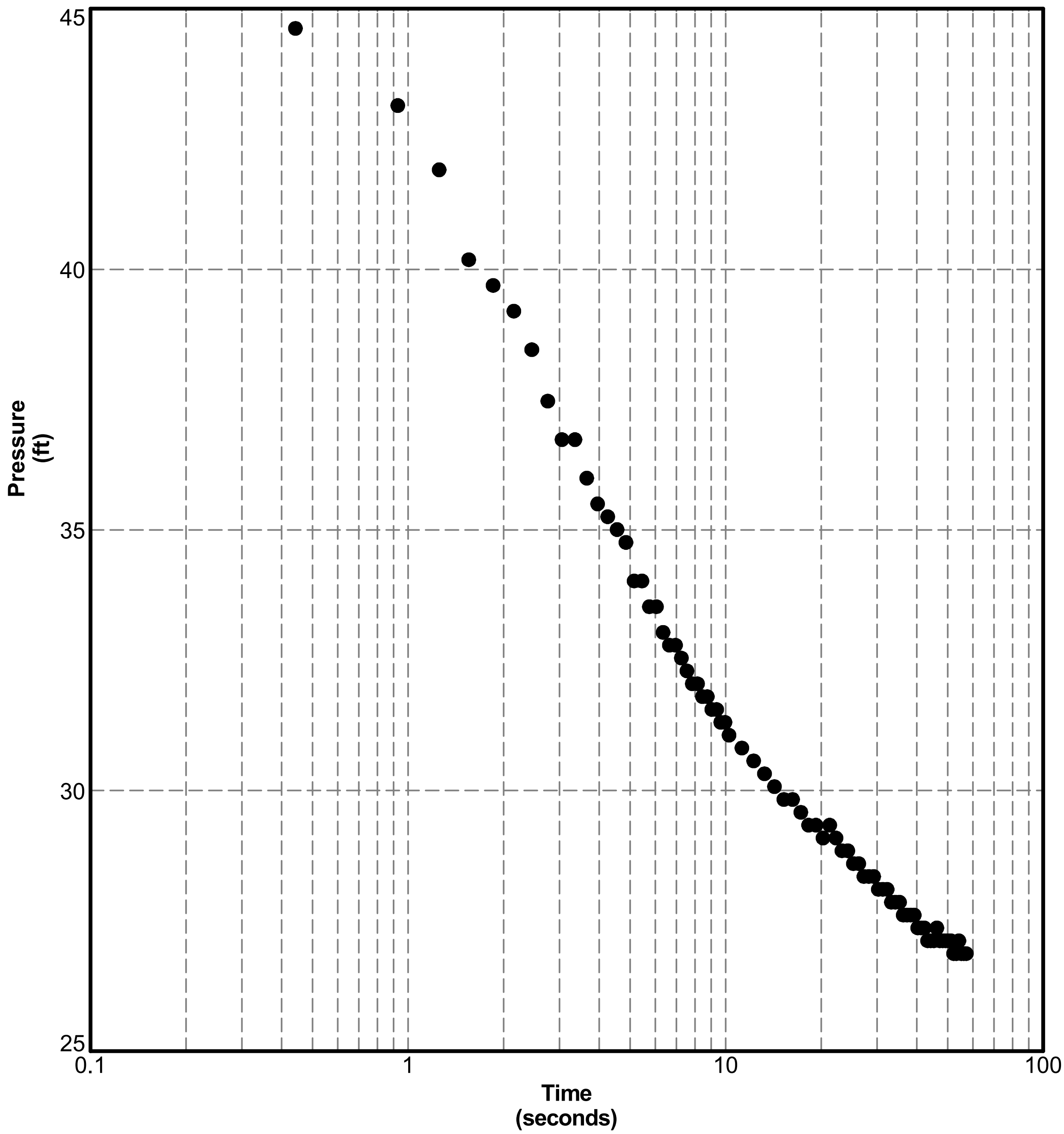
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Andy/Daniel

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Test Depth: 35.1 ft



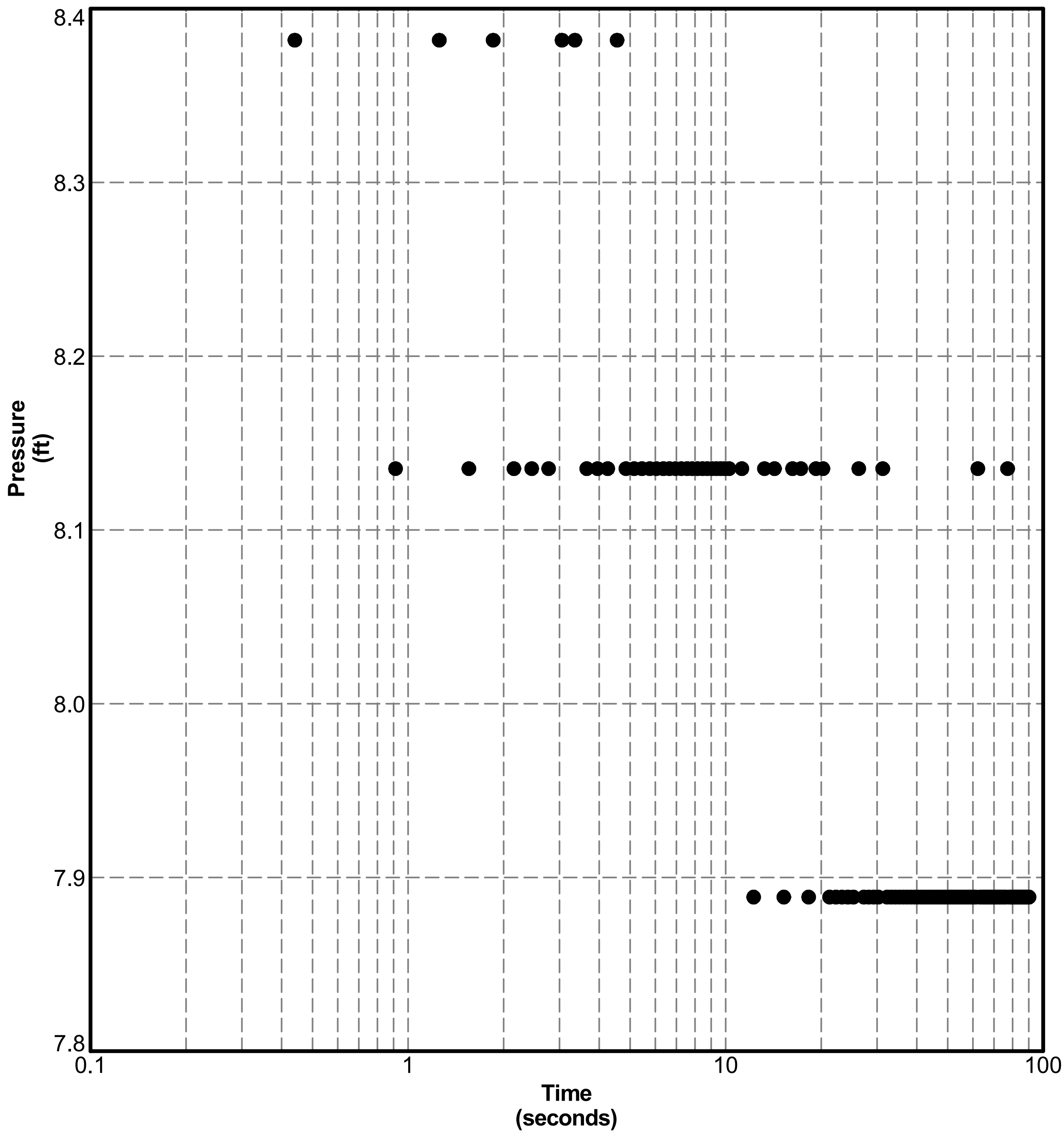
CPT-03PA

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 11 ft
Rig/Operator: Andy/Daniel

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Test Depth: 15.2 ft



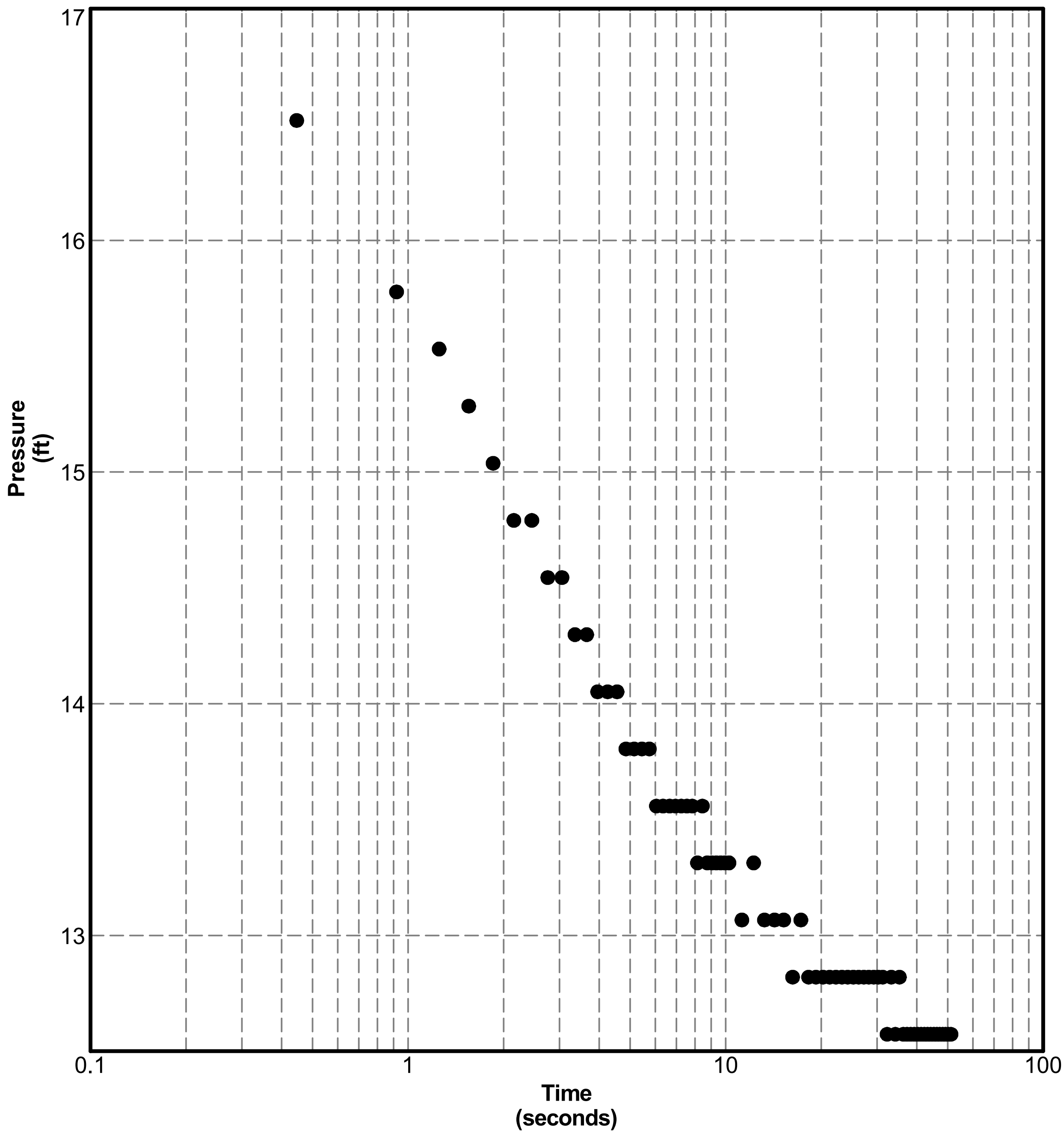
CPT-04PA

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 11 ft
Rig/Operator: Andy/Daniel

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Test Depth: 20.1 ft



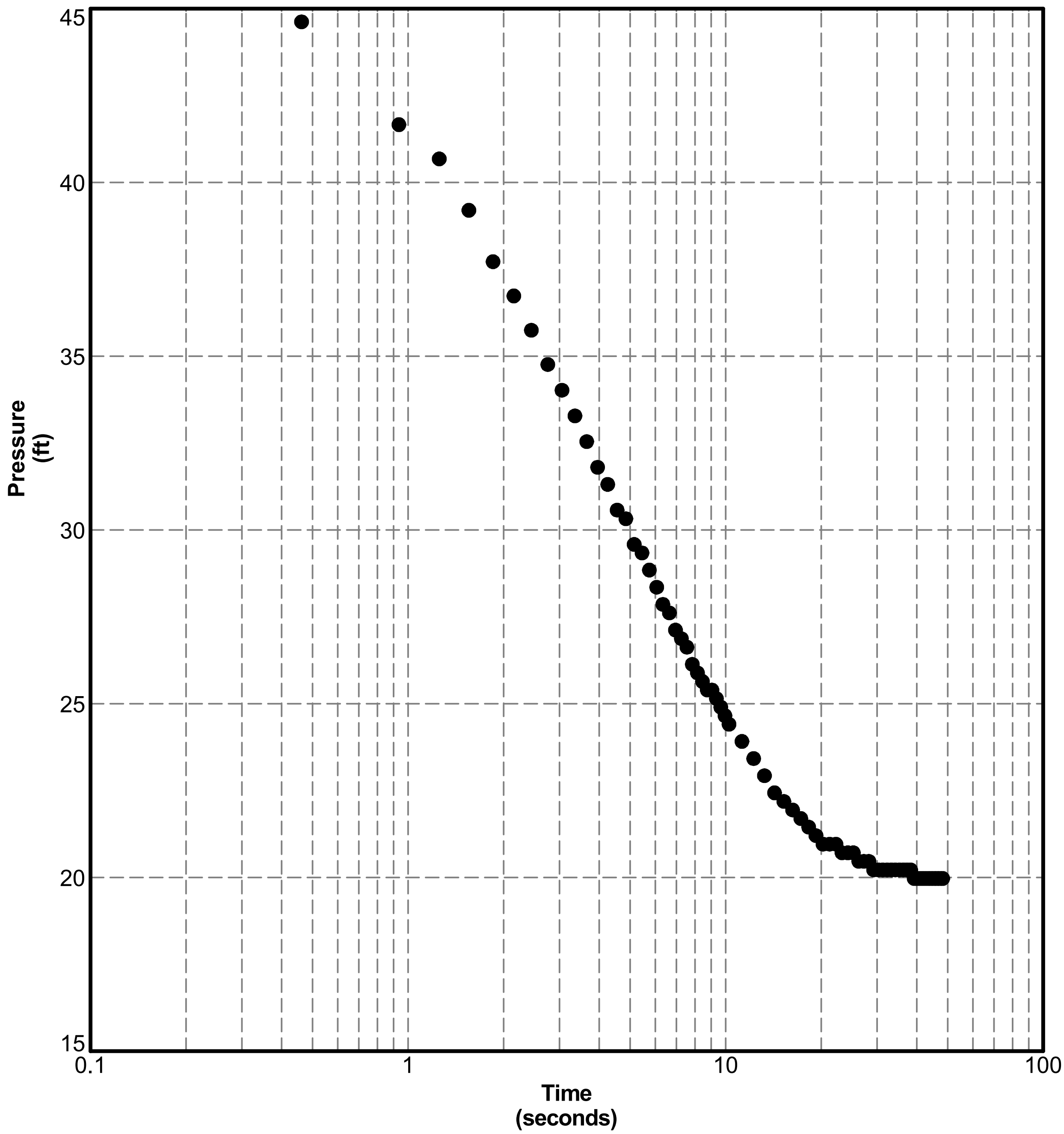
CPT-04PA

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 11 ft
Rig/Operator: Andy/Daniel

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Test Depth: 25.2 ft



CPT-04PA

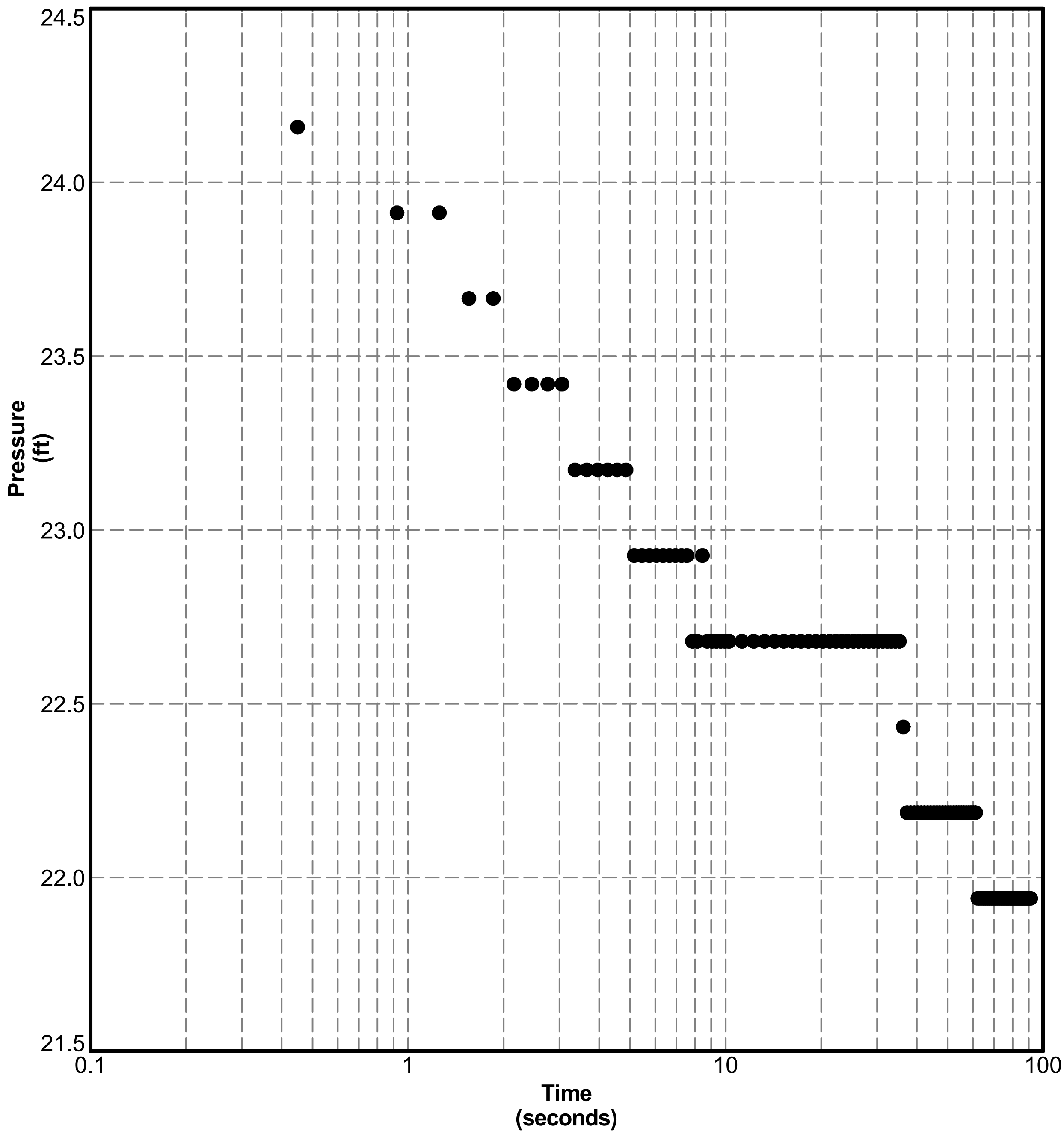
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 11 ft
Rig/Operator: Andy/Daniel

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Test Depth: 29.8 ft



CPT-04PA

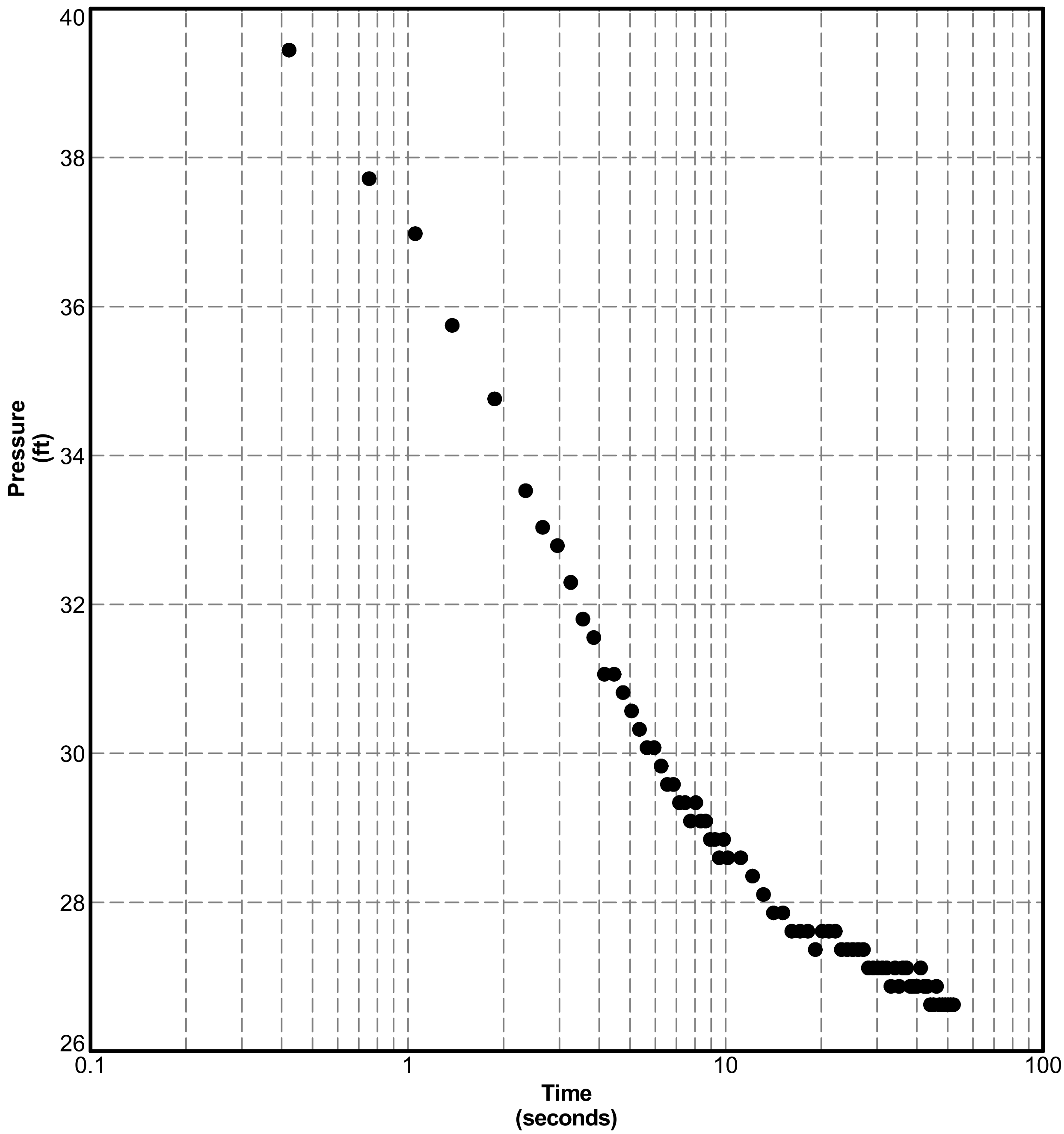
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 11 ft
Rig/Operator: Andy/Daniel

Total Depth: 35.1 ft
Termination Criteria: Target Depth
Test Depth: 35.2 ft



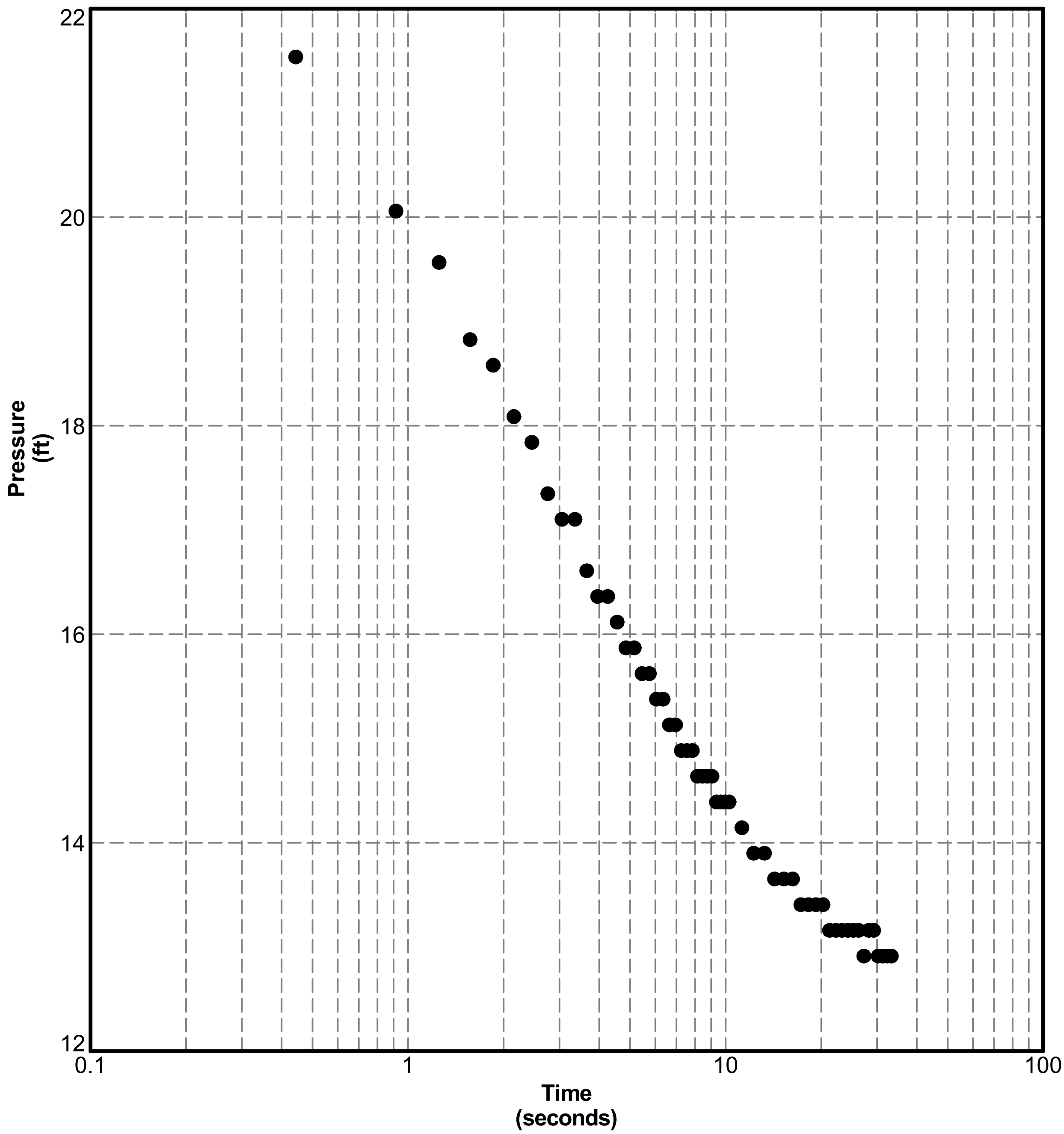
CPT-04PA

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Andy/Daniel

Total Depth: 38.3 ft
Termination Criteria: Target Depth
Test Depth: 20.2 ft



CPT-05P

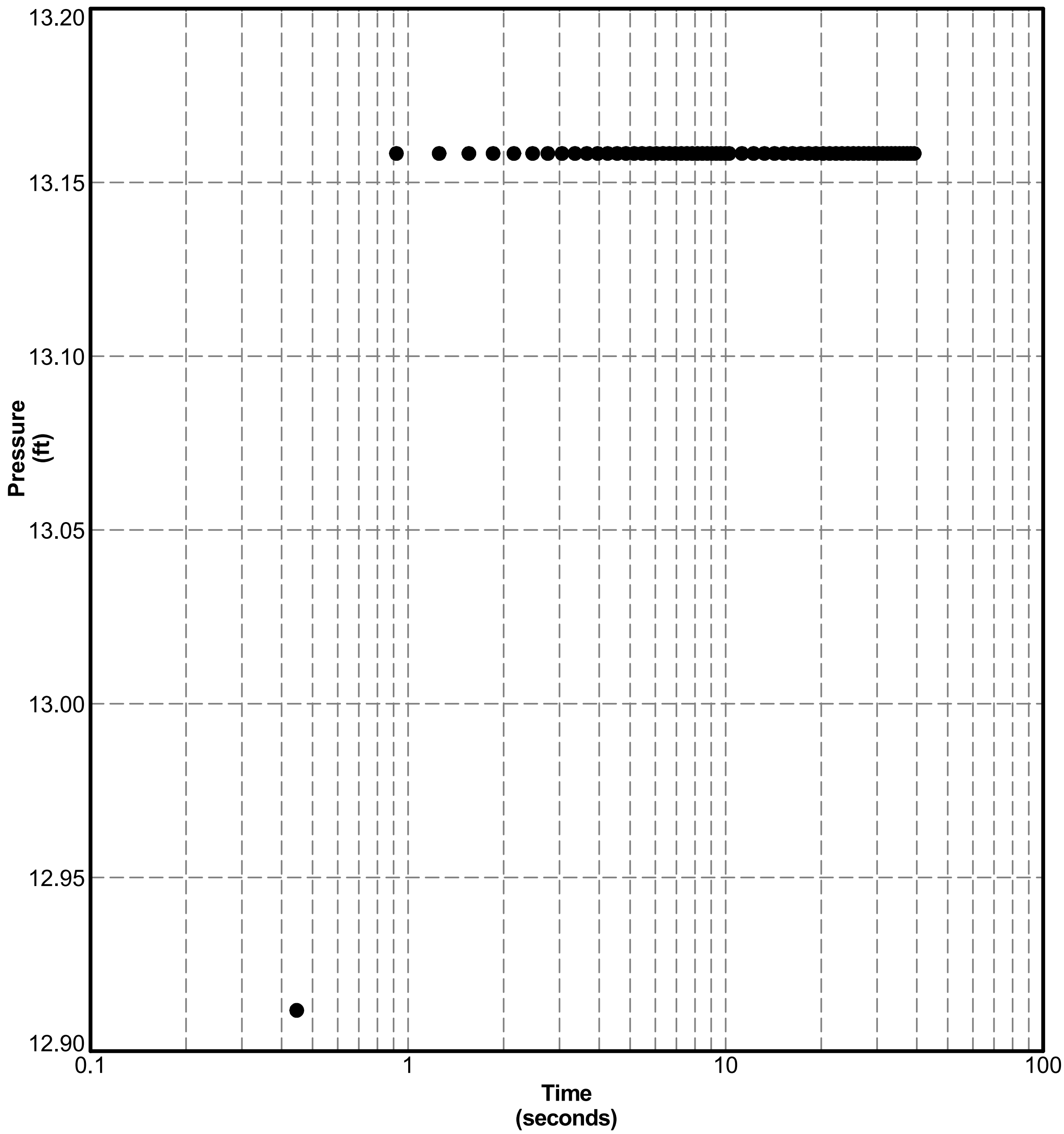
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Andy/Daniel

Total Depth: 38.3 ft
Termination Criteria: Target Depth
Test Depth: 25.1 ft



CPT-05P

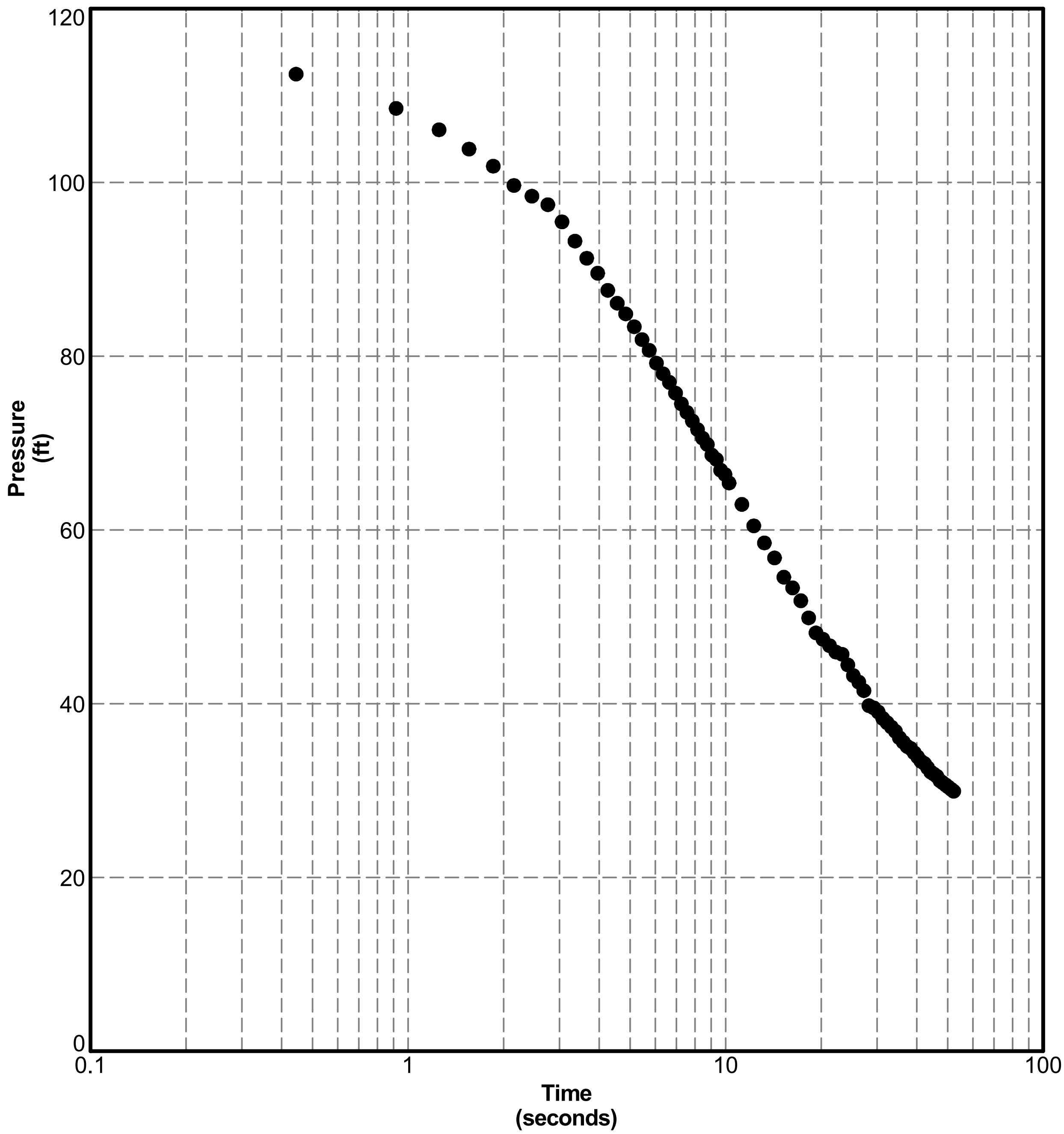
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Andy/Daniel

Total Depth: 38.3 ft
Termination Criteria: Target Depth
Test Depth: 30.1 ft



CPT-05P

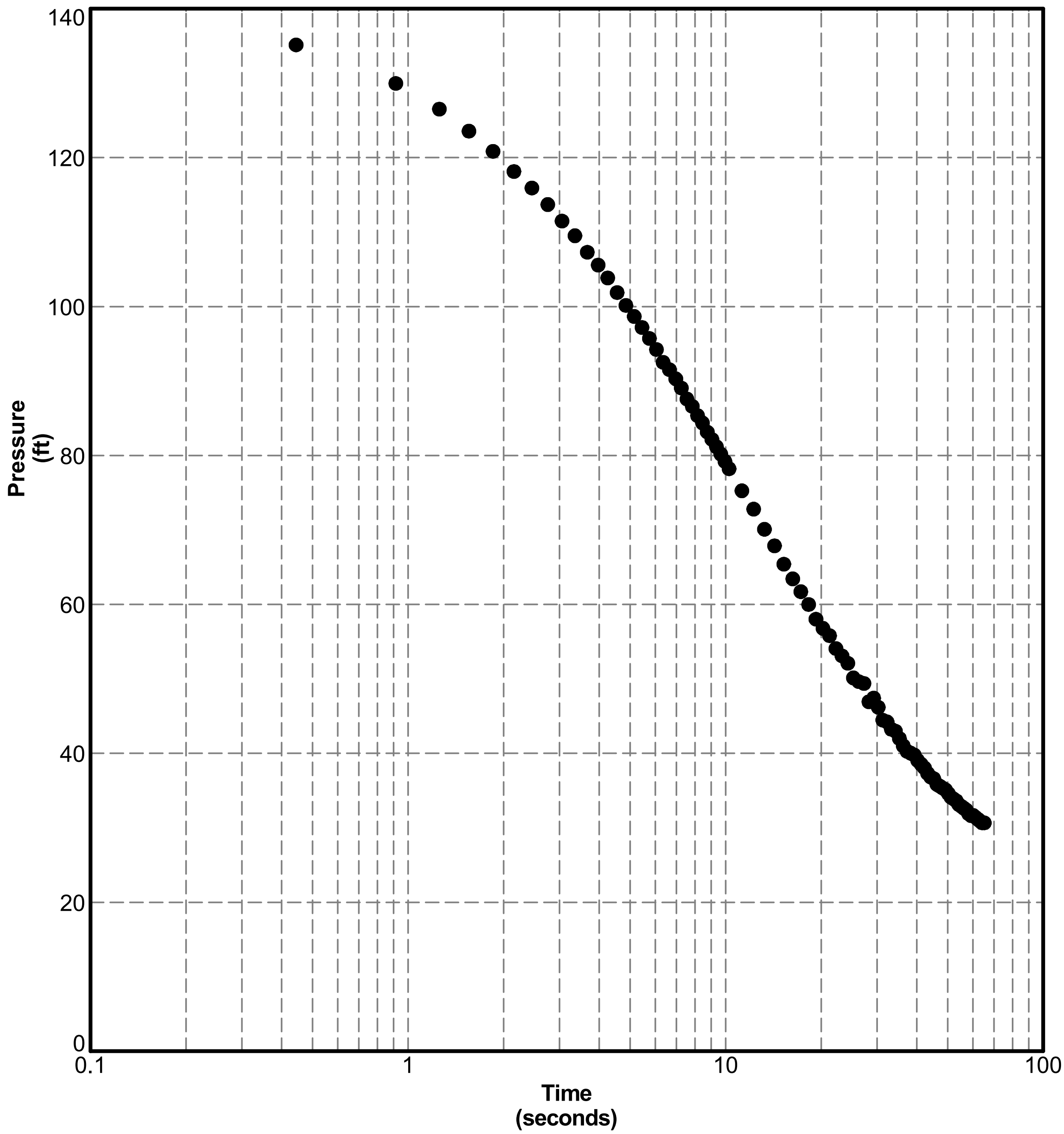
S&ME

Fly Ash Pond Closure Design
Lawrenceburg, IN
Project No: 7217-17-007A

PRELIMINARY
Pore Pressure Dissipation

Date: Jun. 14, 2017
Estimated Water Depth: 14 ft
Rig/Operator: Andy/Daniel

Total Depth: 38.3 ft
Termination Criteria: Target Depth
Test Depth: 35.2 ft



CPT-05P

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Appendix III – Shear Wave Velocity Data

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S&ME

Shear Wave Velocity Calculations

Fly Ash Pond Closure Design
Lawrenceburg, IN

Sounding ID: **CPT-01PA** Project Number: **7217-17-007A**

Geophone Offset: 1.85 Feet Date: 5/14/2017
Source Offset: 5.50 Feet Rig: Track

Test Depth (feet)	Geophone Depth (feet)	Waveform Ray Path (feet)	Incremental Distance (feet)	Characteristic Arrival Time (seconds)	Incremental Time Interval (seconds)	Interval Velocity (ft/s)	Interval Depth (feet)	di/dv
5.16	3.31	6.42	6.42	0.0253				
10.43	8.58	10.19	3.77	0.0374	0.0122	310.2	5.95	0.01699
15.24	13.39	14.48	4.28	0.0507	0.0133	322.6	10.99	0.01491
20.10	18.25	19.06	4.59	0.0655	0.0148	309.8	15.82	0.01569
25.11	23.26	23.90	4.84	0.0796	0.0141	343.8	20.76	0.01457
30.12	28.27	28.80	4.90	0.0927	0.0131	373.4	25.77	0.01342
35.19	33.34	33.79	4.99	0.1066	0.0139	358.5	30.81	0.01414

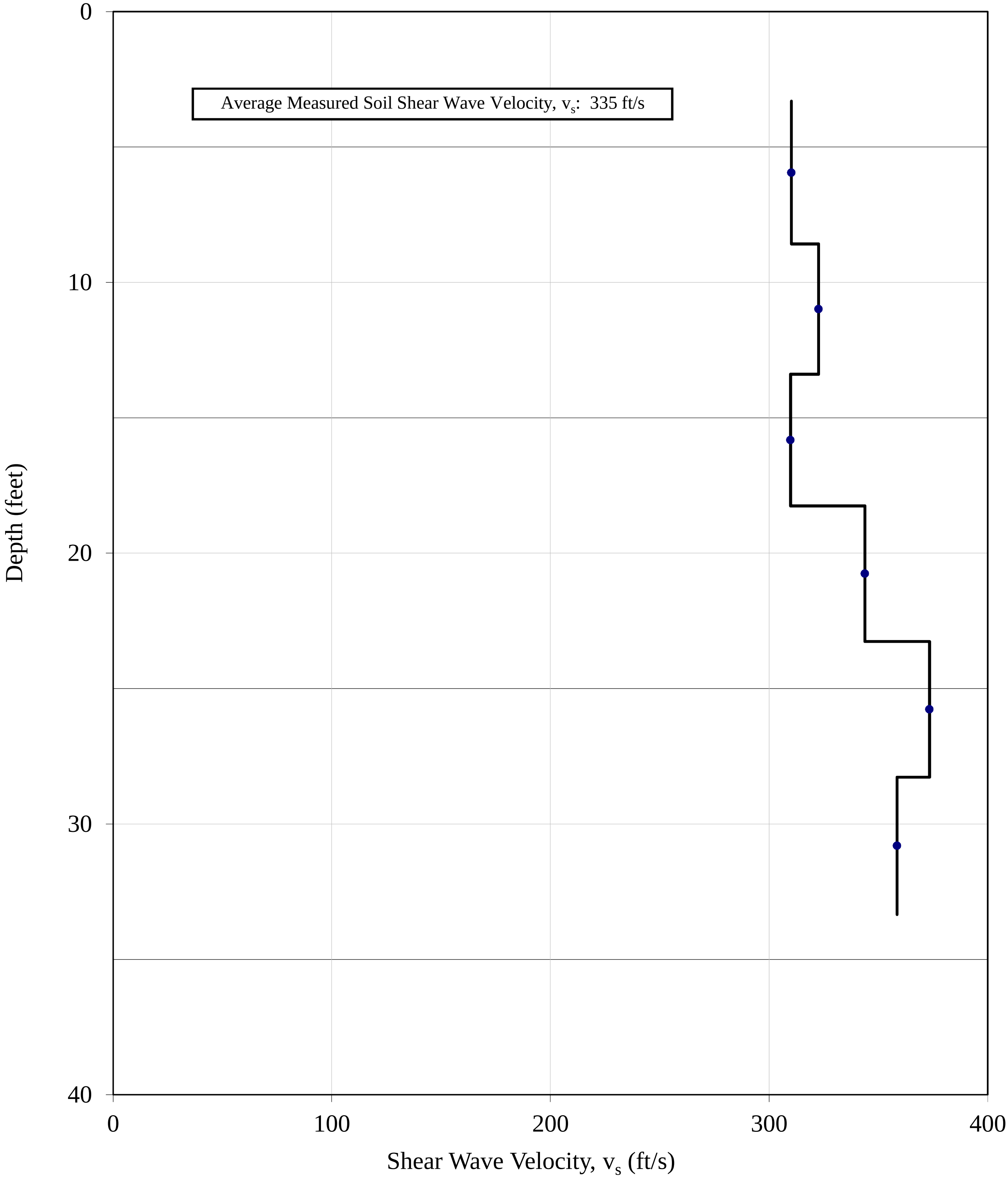
Average Measured Soil Shear Wave Velocity, v_s (ft/s): 335

Shear Wave Velocity Calculations

Fly Ash Pond Closure Design
Lawrenceburg, IN

Sounding ID: **CPT-01PA**
Date: 05/14/17

Project Number: **7217-17-007A**



S&ME

Shear Wave Velocity Calculations

Fly Ash Pond Closure Design

Lawrenceburg, IN

Sounding ID: **CPT-03PA** — Project Number: **7217-17-007A**

Geophone Offset: 1.85 Feet — Date: 5/14/2017

Source Offset: 5.50 Feet — Rig: Track

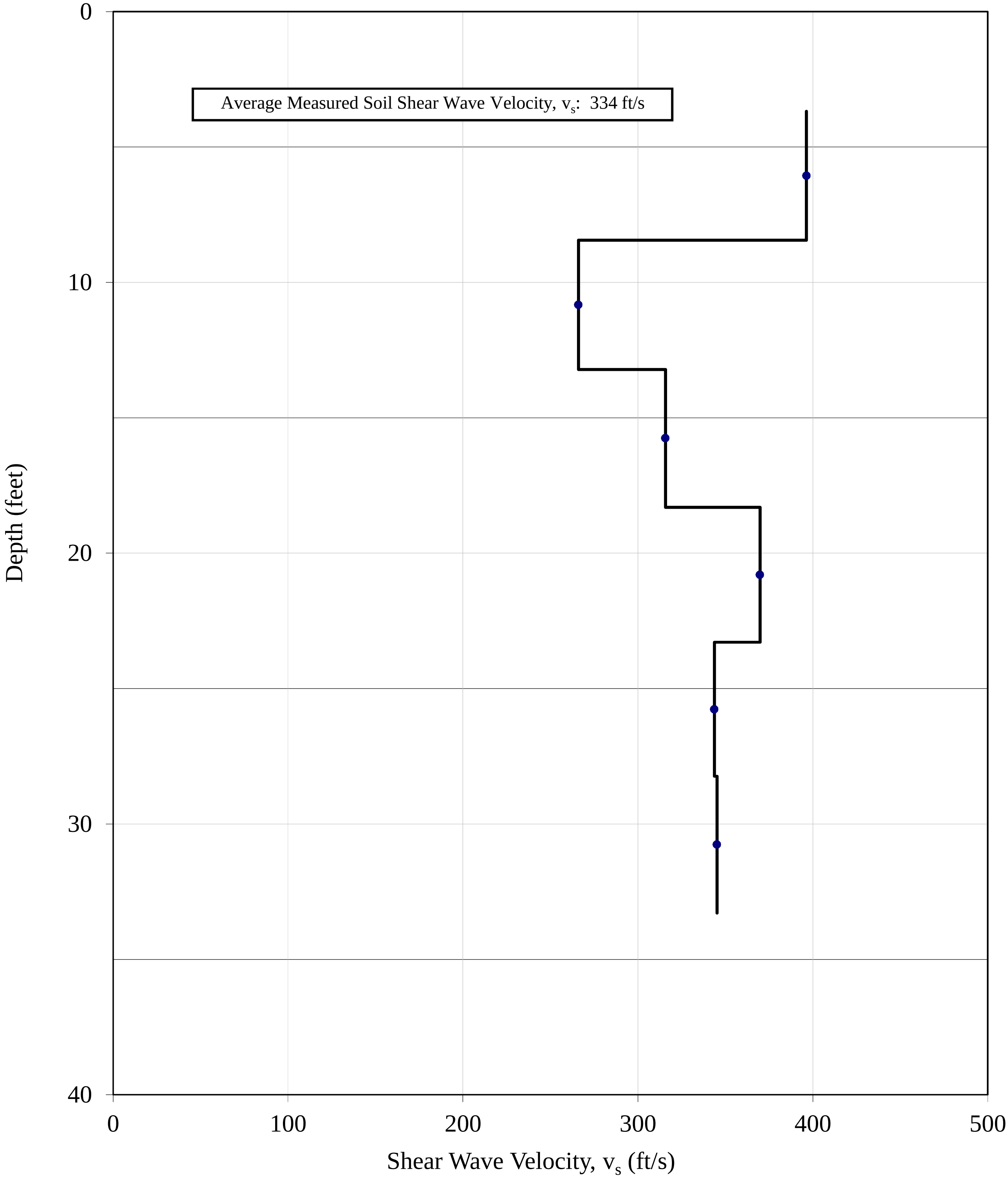
Test Depth (feet)	Geophone Depth (feet)	Waveform Ray Path (feet)	Incremental Distance (feet)	Characteristic Arrival Time (seconds)	Incremental Time Interval (seconds)	Interval Velocity (ft/s)	Interval Depth (feet)	di/dv
5.53	3.68	6.62	6.62	0.0291				
10.29	8.44	10.07	3.46	0.0378	0.0087	396.4	6.06	0.01201
15.06	13.21	14.31	4.24	0.0538	0.0159	266.0	10.83	0.01793
20.15	18.30	19.11	4.80	0.0690	0.0152	315.8	15.76	0.01612
25.14	23.29	23.93	4.82	0.0820	0.0130	369.8	20.80	0.01349
30.09	28.24	28.77	4.84	0.0961	0.0141	343.7	25.77	0.01440
35.14	33.29	33.74	4.97	0.1105	0.0144	345.2	30.77	0.01463

Average Measured Soil Shear Wave Velocity, v_s (ft/s): 334

Shear Wave Velocity Calculations

Fly Ash Pond Closure Design
Lawrenceburg, IN

Sounding ID: **CPT-03PA** Project Number: **7217-17-007A**
Date: 05/14/17



S&ME

Shear Wave Velocity Calculations

Fly Ash Pond Closure Design
Lawrenceburg, IN

Sounding ID: **CPT-05P** Project Number: **7217-17-007A**

Geophone Offset: 1.85 Feet Date: 5/14/2017
Source Offset: 5.50 Feet Rig: Track

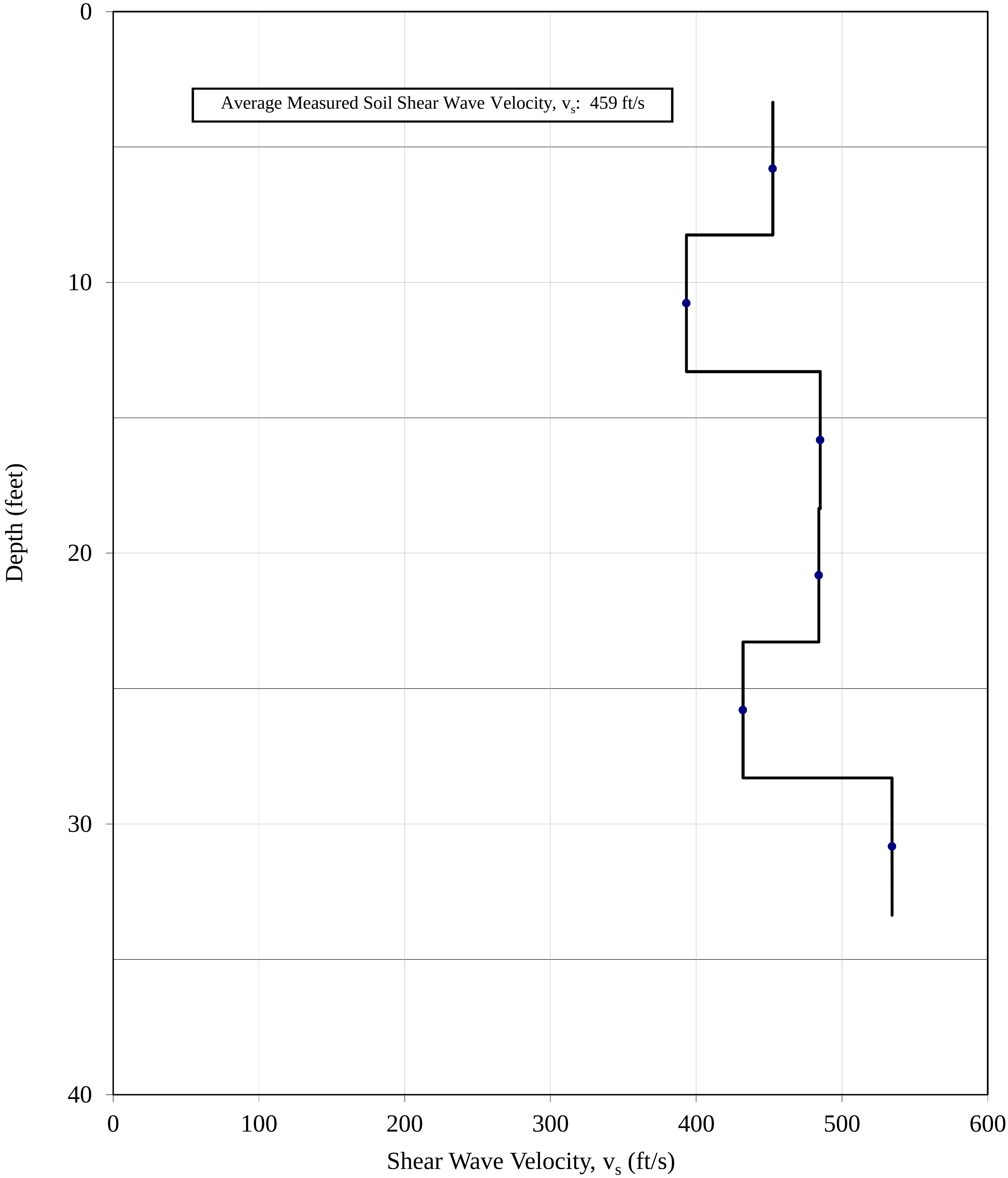
Test Depth (feet)	Geophone Depth (feet)	Waveform Ray Path (feet)	Incremental Distance (feet)	Characteristic Arrival Time (seconds)	Incremental Time Interval (seconds)	Interval Velocity (ft/s)	Interval Depth (feet)	di/dv
5.20	3.35	6.44	6.44	0.0244				
10.10	8.25	9.92	3.48	0.0321	0.0077	452.5	5.80	0.01083
15.14	13.29	14.38	4.47	0.0434	0.0114	393.3	10.77	0.01281
20.20	18.35	19.16	4.77	0.0533	0.0098	485.1	15.82	0.01043
25.13	23.28	23.92	4.76	0.0631	0.0098	484.2	20.82	0.01018
30.15	28.30	28.83	4.91	0.0745	0.0114	432.1	25.79	0.01162
35.22	33.37	33.82	4.99	0.0838	0.0093	534.3	30.84	0.00949

Average Measured Soil Shear Wave Velocity, v_s (ft/s): 459

Shear Wave Velocity Calculations

Fly Ash Pond Closure Design
Lawrenceburg, IN

Sounding ID: **CPT-05P** Project Number: **7217-17-007A**
Date: 05/14/17



Appendix IV – Borrow Area 4 Geotechnical Data

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FMSM ENGINEERS

SUBSURFACE LOG

Project Number	CN2006032	Location	(See Boring Layout)		
Project Name	Tanners Creek - Borrow Area Study	Boring No.	**B-4-1**	Total Depth	16.0 ft
County	Dearborn County, Indiana	Surface Elevation	473.0 ft		
Project Type		Date Started	4/2/07	Completed	4/3/07
Supervisor	Colwyn Sayers Driller	Depth to Water	Dry	Date/Time	4/3/07
Logged By	Colwyn Sayers	Depth to Water	N/A	Date/Time	N/A

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	Remarks
473.0	0.0	Top of Hole							
470.0	3.0	Fat clay (ch), dark brown, plastic, moist, stiff, (Soil 1)		1	1.5 - 3.5			--	
461.0	12.0	Lean clay (cl), light brown to orangish brown, moist, stiff, (Soil 2)		2 3	4.5 - 5.5 8.0 - 9.0			-- --	
457.0	16.0	Sandy lean clay (cl), light brown, moist to wet, soft to medium stiff, (Soil 3)		4	14.0 - 15.0			--	

No Refusal / Bottom of Hole

FMSM_LEGACY_TEST_PIT TANNERS CREEK COAL ASH LANDFILL - BORROW AREA STUDY.GPJ FMSM.GDT 5/31/07

FMSM ENGINEERS

SUBSURFACE LOG

Project Number	CN2006032	Location	(See Boring Layout)
Project Name	Tanners Creek - Borrow Area Study	Boring No.	**B-4-2** Total Depth 16.0 ft
County	Dearborn County, Indiana	Surface Elevation	470.5 ft
Project Type		Date Started	4/2/07 Completed 4/3/07
Supervisor	Colwyn Sayers Driller	Depth to Water	Dry Date/Time 4/3/07
Logged By	Colwyn Sayers	Depth to Water	N/A Date/Time N/A

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	Remarks
470.5	0.0	Top of Hole							
470.0	0.5	Topsoil							
467.5	3.0	Fat clay (ch), dark brown, plastic, moist, stiff, (Soil 1)		1	1.5 - 2.5			26	
		Lean clay (cl), light brown to orangish brown, moist, stiff, (Soil 2)		2	4.0 - 5.0			--	
458.5	12.0			3	10.0 - 11.0			--	
454.5	16.0	Sandy lean clay (cl), light brown, moist to wet, soft to medium stiff, (Soil 3)		4	15.0 - 16.0			26	
		No Refusal / Bottom of Hole							

FMSM_LEGACY_TEST_PIT TANNERS CREEK COAL ASH LANDFILL - BORROW AREA STUDY.GPJ FMSM.GDT 5/31/07

FMSM ENGINEERS

SUBSURFACE LOG

Project Number	CN2006032	Location	(See Boring Layout)
Project Name	Tanners Creek - Borrow Area Study	Boring No.	**B-4-3** Total Depth 16.0 ft
County	Dearborn County, Indiana	Surface Elevation	470.5 ft
Project Type		Date Started	4/2/07 Completed 4/3/07
Supervisor	Colwyn Sayers Driller	Depth to Water	Dry Date/Time 4/3/07
Logged By	Colwyn Sayers	Depth to Water	N/A Date/Time N/A

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD	Depth / Run	Rec. Ft. / Rec. Ft.	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
470.5	0.0	Top of Hole							
470.0	0.5	Topsoil							
467.5	3.0	Fat clay (ch), dark brown, plastic, moist, stiff, (Soil 1)		1	1.5 - 2.5			--	
		Lean clay (cl), light brown to orangish brown, moist, stiff, (Soil 2)		2	4.0 - 5.0			25	
454.5	16.0			3	15.0 - 16.0			--	

No Refusal / Bottom of Hole

FMSM_LEGACY_TEST_PIT TANNERS CREEK COAL ASH LANDFILL - BORROW AREA STUDY.GPJ FMSM.GDT 5/31/07

SUBSURFACE LOG

FMSM ENGINEERS

Project Number	CN2006032	Location	(See Boring Layout)
Project Name	Tanners Creek - Borrow Area Study	Boring No.	**B-4-4** Total Depth 18.0 ft
County	Dearborn County, Indiana	Surface Elevation	469.5 ft
Project Type		Date Started	4/2/07 Completed 4/3/07
Supervisor	Colwyn Sayers Driller	Depth to Water	Dry Date/Time 4/3/07
Logged By	Colwyn Sayers	Depth to Water	N/A Date/Time N/A

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD	Depth / Run	Rec. Ft. / Rec. Ft.	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
469.5	0.0	Top of Hole							
469.0	0.5	Topsoil							
467.0	2.5	Fat clay (ch), dark brown, plastic, moist, stiff, (Soil 1)		1	1.5 - 2.5			--	
		Lean clay (cl), light brown to orangish brown, moist, stiff, (Soil 2)		2	4.0 - 5.0			--	
				3	10.0 - 11.0			--	
454.5	15.0								
451.5	18.0	Sandy lean clay (cl), light brown, moist to wet, soft, (Soil 3)		4	17.0 - 18.0			--	

No Refusal /
Bottom of Hole

FMSM_LEGACY_TEST_PIT TANNERS CREEK COAL ASH LANDFILL - BORROW AREA STUDY.GPJ FMSM.GDT 5/31/07

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Summary of Soil Tests

Project Name	Tanners Creek Coal Ash Landfill	Project Number	CN2006032
Source	B-4-2, 1.5'-2.5'	Lab ID	450
County	Dearborn, IN	Date Received	4-16-07
Sample Type	Bag	Date Reported	4-27-07

Test Results

Natural Moisture Content

Test Method: ASTM D 2216-98

Moisture Content (%): 25.8

Particle Size Analysis

Preparation Method: ASTM D 421-85

Gradation Method: ASTM D 422-63

Hydrometer Method: ASTM D 422-63

Particle Size		%
Sieve Size	(mm)	Passing
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	
3/4"	19	
3/8"	9.5	
No. 4	4.75	
No. 10	2	100.0
No. 40	0.425	100.0
No. 200	0.075	99.6
	0.02	96.2
	0.005	64.8
	0.002	47.3
estimated	0.001	38.9

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.0
Coarse Sand	0.0	0.0
Medium Sand	0.0	---
Fine Sand	0.4	0.4
Silt	34.8	52.3
Clay	64.8	47.3

Atterberg Limits

Test Method: ASTM D 4318-00

Prepared: Dry

Liquid Limit: 56

Plastic Limit: 25

Plasticity Index: 31

Activity Index: 0.66

Moisture-Density Relationship

Test Method: ASTM D 698-00 Method A

Maximum Dry Density (lb/ft^3): 96.6

Maximum Dry Density (kg/m^3): 1547.5

Optimum Moisture Content (%): 24

OverSize Correction %: 0

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A

Compacted Dry Density (lb/ft^3): N/A

Compacted Moisture Content (%): N/A

Specific Gravity

Result was Estimated

Particle Size: No. 10

Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: CH

Group Name: Fat clay

AASHTO Classification: A-7-6 (36)

Visual Description:

Comments:

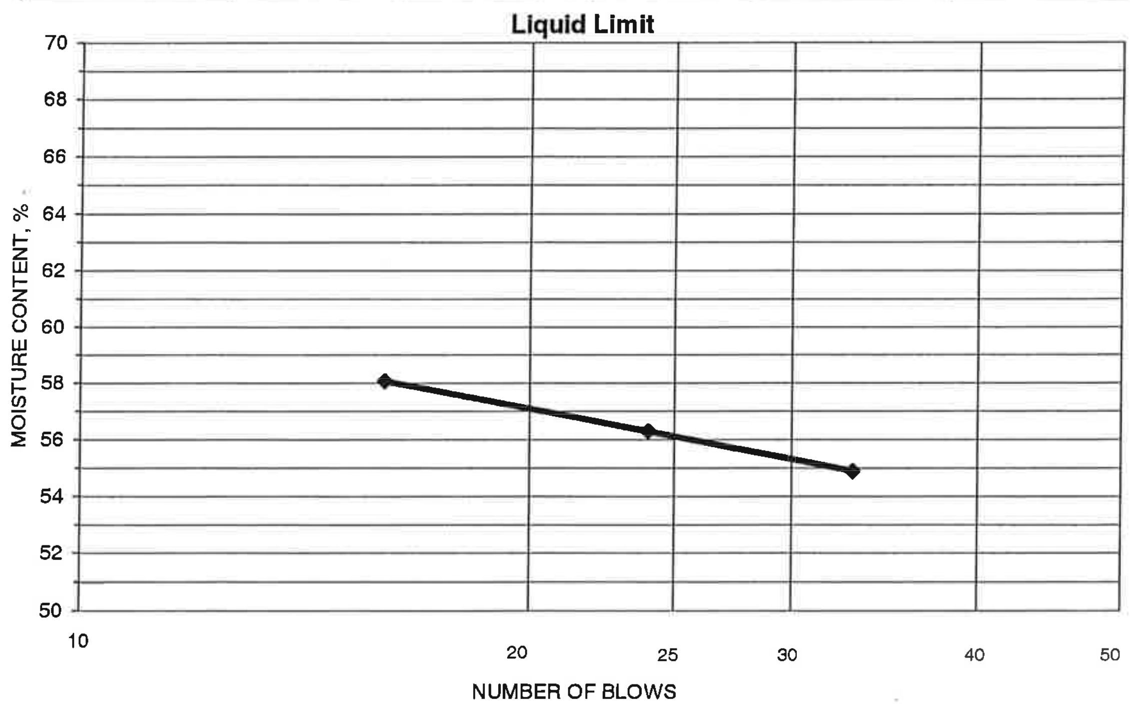
Reviewed by:

Fuller Mossbarger Scott & May
FMSM
ENGINEERS

ATTERBERG LIMITS

Project	Tanners Creek Coal Ash Landfill	Project No.	CN2006032
Source	B-4-2, 1.5'-2.5'	Lab ID	450
Tested By	JM	Test Method	ASTM D 4318-00
% + No. 40	0.0		
Test Date	4-26-07	Prepared	Dry
Input By	PBE		

Weight of Can and Wet Soil	Weight of Can and Dry Soil	Weight of Can	Number of Blows	Percentage of Water	Liquid Limit
26.82	22.62	14.97	33	54.9	56
23.25	18.87	11.09	24	56.3	
24.39	19.50	11.08	16	58.1	



PLASTIC LIMIT AND PLASTICITY INDEX

Weight of Can and Wet Soil	Weight of Can and Dry Soil	Weight of Can	Percentage of Water	Plastic Limit	Plasticity Index
24.70	22.84	15.46	25.2	25	31
25.13	23.18	15.34	24.9		

Remarks:

Reviewed By

Limit-Report
CN2006032_Sum-450.xls

Fuller, Mossbarger, Scott and May Engineers, Inc.

FMSM ENGINEERS
Fuller Mossbarger Scott & May

Particle-Size Analysis of Soils
ASTM D 422-63

Project Name: Tanners Creek Coal Ash Landfill
Project Number: CN2006032
Source: B-4-2, 1.5'-2.5'
Lab ID: 450

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 421-85
Prepared using: ASTM D 421-85

Particle Shape: N/A
Particle Hardness: N/A

Tested By: CW
Test Date: 4-23-07

Maximum Particle size: No. 10 Seive

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	
No. 4	
No. 10	100.0

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

Specific Gravity: 2.7

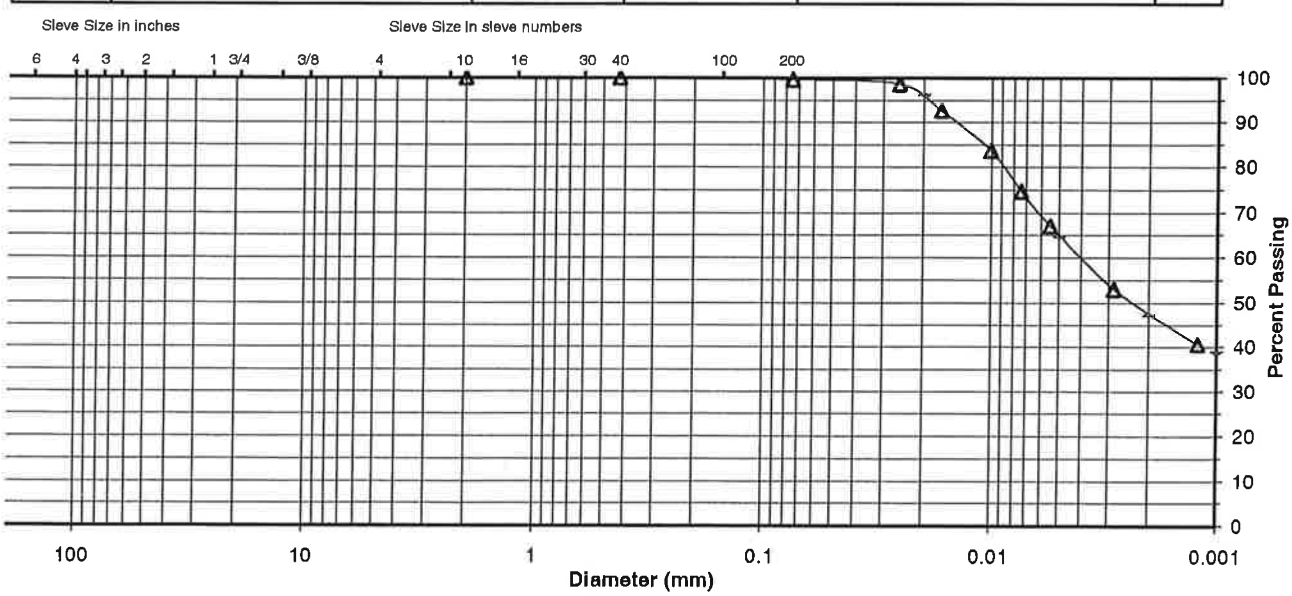
Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	100.0
No. 200	99.6
0.02 mm	96.2
0.005 mm	64.8
0.002 mm	47.3
0.001 mm	38.9

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.0	0.0	0.4	34.8	64.8

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.4	52.3	47.3



Comments

Reviewed By

Fuller Mossbarger Scott & May

FMSM ENGINEERS

Summary of Soil Tests

Project Name	Tanners Creek Coal Ash Landfill	Project Number	CN2006032
Source	B-4-3, 4.0'-5.0'	Lab ID	452
County	Dearborn, IN	Date Received	4-16-07
Sample Type	Bag	Date Reported	4-27-07

Test Results

Natural Moisture Content

Test Method: ASTM D 2216-98

Moisture Content (%): 24.6

Particle Size Analysis

Preparation Method: ASTM D 421-85

Gradation Method: ASTM D 422-63

Hydrometer Method: ASTM D 422-63

Particle Size		%
Sieve Size	(mm)	Passing
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	
3/4"	19	
3/8"	9.5	
No. 4	4.75	
No. 10	2	100.0
No. 40	0.425	100.0
No. 200	0.075	99.8
	0.02	90.9
	0.005	61.4
	0.002	44.3
estimated	0.001	35.7

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.0
Coarse Sand	0.0	0.0
Medium Sand	0.0	---
Fine Sand	0.2	0.2
Silt	38.4	55.5
Clay	61.4	44.3

Atterberg Limits

Test Method: ASTM D 4318-00

Prepared: Dry

Liquid Limit: 52

Plastic Limit: 23

Plasticity Index: 29

Activity Index: 0.66

Moisture-Density Relationship

Test Method: ASTM D 698-00 Method A

Maximum Dry Density (lb/ft^3): 99.7

Maximum Dry Density (kg/m^3): 1597.2

Optimum Moisture Content (%): 22

OverSize Correction %: 0

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A

Compacted Dry Density (lb/ft^3): N/A

Compacted Moisture Content (%): N/A

Specific Gravity

Result was Estimated

Particle Size: No. 10

Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: CH

Group Name: Fat clay

AASHTO Classification: A-7-6 (33)

Visual Description:

Comments:

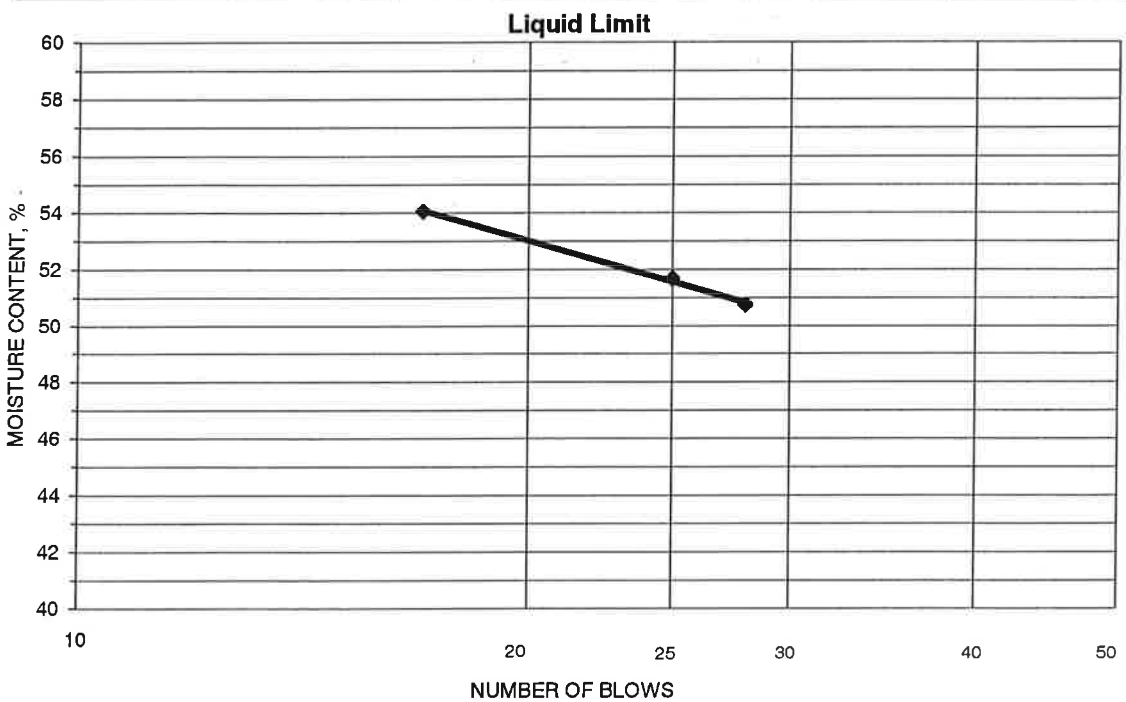
Reviewed by:

Laboratory Document
Prepared By: MW
Approved By: TLK

ATTERBERG LIMITS

Project	Tanners Creek Coal Ash Landfill	Project No.	CN2006032
Source	B-4-3, 4.0'-5.0'	Lab ID	452
Tested By	JM / Test Method ASTM D 4318-00	% + No. 40	0.0
Test Date	4-26-07 / Prepared Dry	Input By	PBE

Weight of Can and Wet Soil	Weight of Can and Dry Soil	Weight of Can	Number of Blows	Percentage of Water	Liquid Limit
27.36	23.19	14.97	28	50.7	52
26.66	22.64	14.86	25	51.7	
25.99	22.24	15.30	17	54.0	



PLASTIC LIMIT AND PLASTICITY INDEX

Weight of Can and Wet Soil	Weight of Can and Dry Soil	Weight of Can	Percentage of Water	Plastic Limit	Plasticity Index
25.83	23.87	15.43	23.2	23	29
24.59	22.82	15.14	23.0		

Remarks: ______

Reviewed By ______

Limit-Report
CN2006032_Sum-452.xls

Fuller, Mossbarger, Scott and May Engineers, Inc.

Fuller Mossbarger Scott & May

FMSM ENGINEERS

Particle-Size Analysis of Soils
ASTM D 422-63

Project Name: Tanners Creek Coal Ash Landfill
Project Number: CN2006032
Source: B-4-3, 4.0'-5.0'
Lab ID: 452

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 421-85
Prepared using: ASTM D 421-85

Particle Shape: N/A
Particle Hardness: N/A

Tested By: CW
Test Date: 4-23-07

Maximum Particle size: No. 10 Seive

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	
No. 4	
No. 10	100.0

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

Specific Gravity 2.7

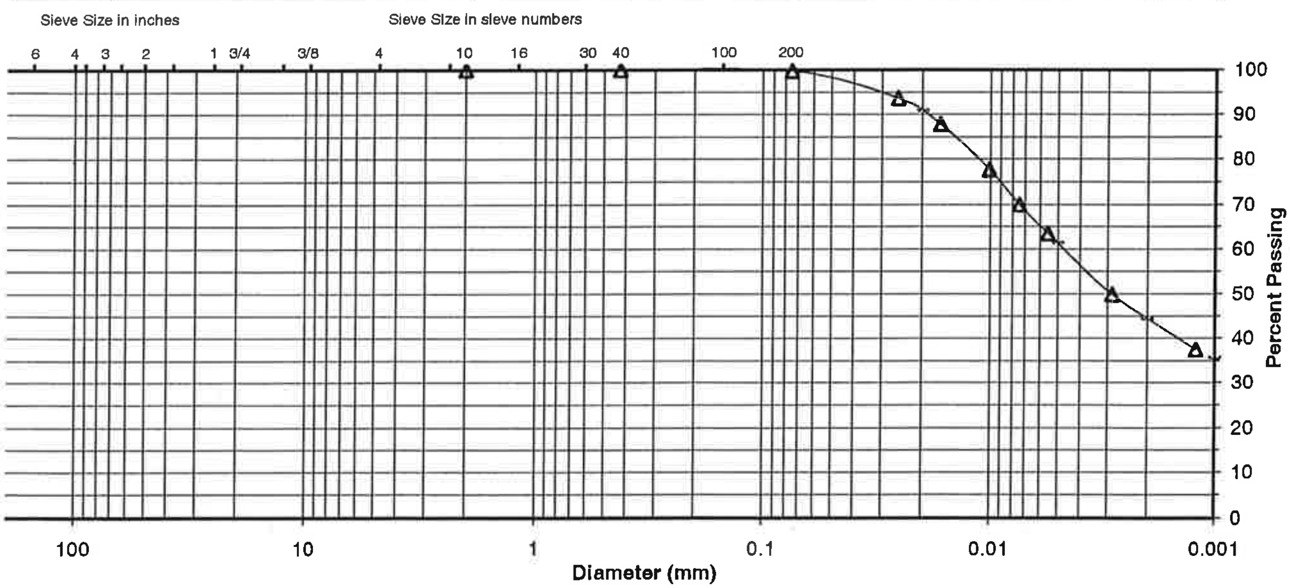
Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	100.0
No. 200	99.8
0.02 mm	90.9
0.005 mm	61.4
0.002 mm	44.3
0.001 mm	35.7

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.0	0.0	0.2	38.4	61.4

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.2	55.5	44.3



Comments

Reviewed By

Hydro-Report
CN2006032_Sum-452.xls

Fuller, Mossbarger, Scott and May Engineers, Inc.

Fuller Mossbarger Scott & May ENGINEERS

Summary of Soil Tests

Project Name	Tanners Creek Coal Ash Landfill	Project Number	CN2006032
Source	B-4-2, 15.0'-16.0'	Lab ID	451
County	Dearborn, IN	Date Received	4-16-07
Sample Type	Bag	Date Reported	4-27-07

Test Results

Natural Moisture Content

Test Method: ASTM D 2216-98

Moisture Content (%): 25.8

Particle Size Analysis

Preparation Method: ASTM D 421-85

Gradation Method: ASTM D 422-63

Hydrometer Method: ASTM D 422-63

Particle Size		%
Sieve Size	(mm)	Passing
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	
3/4"	19	
3/8"	9.5	
No. 4	4.75	100.0
No. 10	2	100.0
No. 40	0.425	99.0
No. 200	0.075	67.4
	0.02	41.9
	0.005	24.5
	0.002	19.0
estimated	0.001	16.3

Plus 3 in. material, not included: 0 (%)

	ASTM	AASHTO
Range	(%)	(%)
Gravel	0.0	0.0
Coarse Sand	0.0	1.0
Medium Sand	1.0	---
Fine Sand	31.6	31.6
Silt	42.9	48.4
Clay	24.5	19.0

Atterberg Limits

Test Method: ASTM D 4318-00

Prepared: Dry

Liquid Limit: 26

Plastic Limit: 16

Plasticity Index: 10

Activity Index: 0.53

Moisture-Density Relationship

Test Method: ASTM D 698-00 Method A

Maximum Dry Density (lb/ft^3): 115.7

Maximum Dry Density (kg/m^3): 1853.5

Optimum Moisture Content (%): 13

OverSize Correction %: 0

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A

Compacted Dry Density (lb/ft^3): N/A

Compacted Moisture Content (%): N/A

Specific Gravity

Result was Estimated

Particle Size: No. 10

Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: CL

Group Name: Sandy lean clay

AASHTO Classification: A-4 (4)

Visual Description:

Comments:

Reviewed by: [signature]

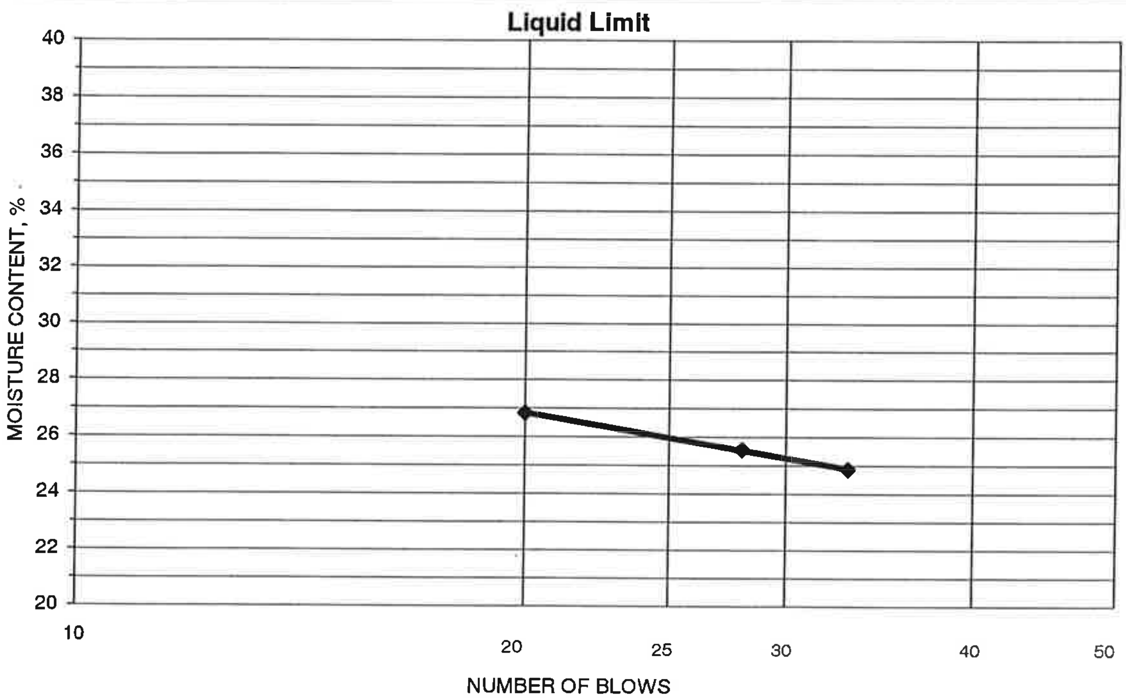
Fuller Mossbarger Scott & May

FMSM ENGINEERS

ATTERBERG LIMITS

Project	Tanners Creek Coal Ash Landfill	Project No.	CN2006032
Source	B-4-2, 15.0'-16.0'	Lab ID	451
Tested By	CW Test Method ASTM D 4318-00	% + No. 40	1.0
Test Date	4-25-07 Prepared Dry	Input By	PBE

Weight of Can and Wet Soil	Weight of Can and Dry Soil	Weight of Can	Number of Blows	Percentage of Water	Liquid Limit
29.41	26.45	14.87	28	25.6	26
26.10	23.72	14.85	20	26.8	
22.88	20.53	11.08	33	24.9	



PLASTIC LIMIT AND PLASTICITY INDEX

Weight of Can and Wet Soil	Weight of Can and Dry Soil	Weight of Can	Percentage of Water	Plastic Limit	Plasticity Index
26.43	24.89	15.45	16.3	16	10
25.46	24.06	15.35	16.1		

Remarks:

Reviewed By

Limit-Report
CN2006032_Sum-451.xls

Fuller, Mossbarger, Scott and May Engineers, Inc.

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Particle-Size Analysis of Soils
ASTM D 422-63

Project Name: Tanners Creek Coal Ash Landfill
Project Number: CN2006032
Source: B-4-2, 15.0'-16.0'
Lab ID: 451

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 421-85
Prepared using: ASTM D 421-85

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: PBE
Test Date: 4-23-07

Maximum Particle size: No. 4 Seive

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	
No. 4	100.0
No. 10	100.0

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

Specific Gravity: 2.7

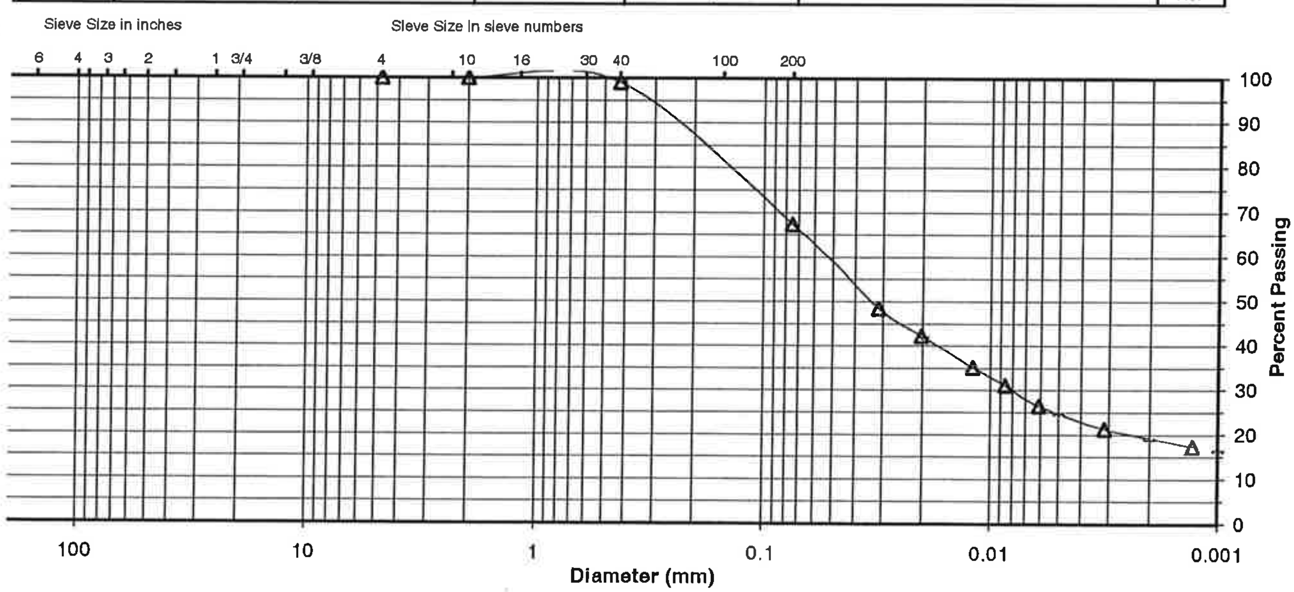
Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	99.0
No. 200	67.4
0.02 mm	41.9
0.005 mm	24.5
0.002 mm	19.0
0.001 mm	16.3

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.0	1.0	31.6	42.9	24.5

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	0.0	1.0	31.6	48.4	19.0



Comments

Reviewed By

Hydro-Report
CN2006032_Sum-451.xls

Fuller Mossbarger Scott & May
FMSM ENGINEERS

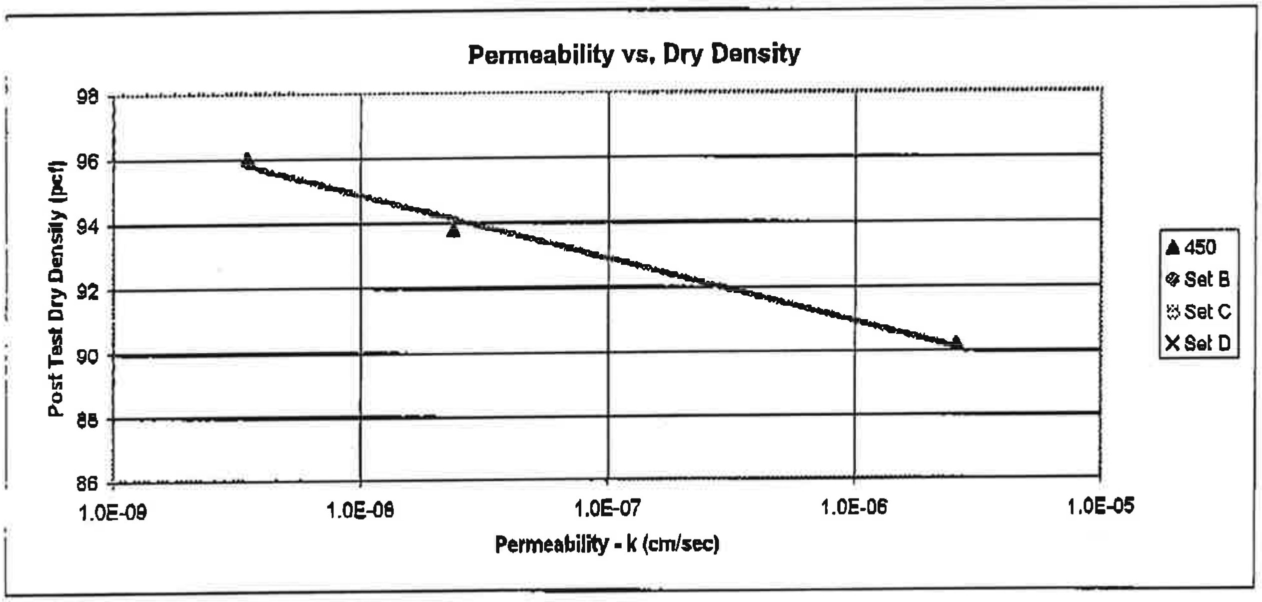
Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
ASTM D 5084-00

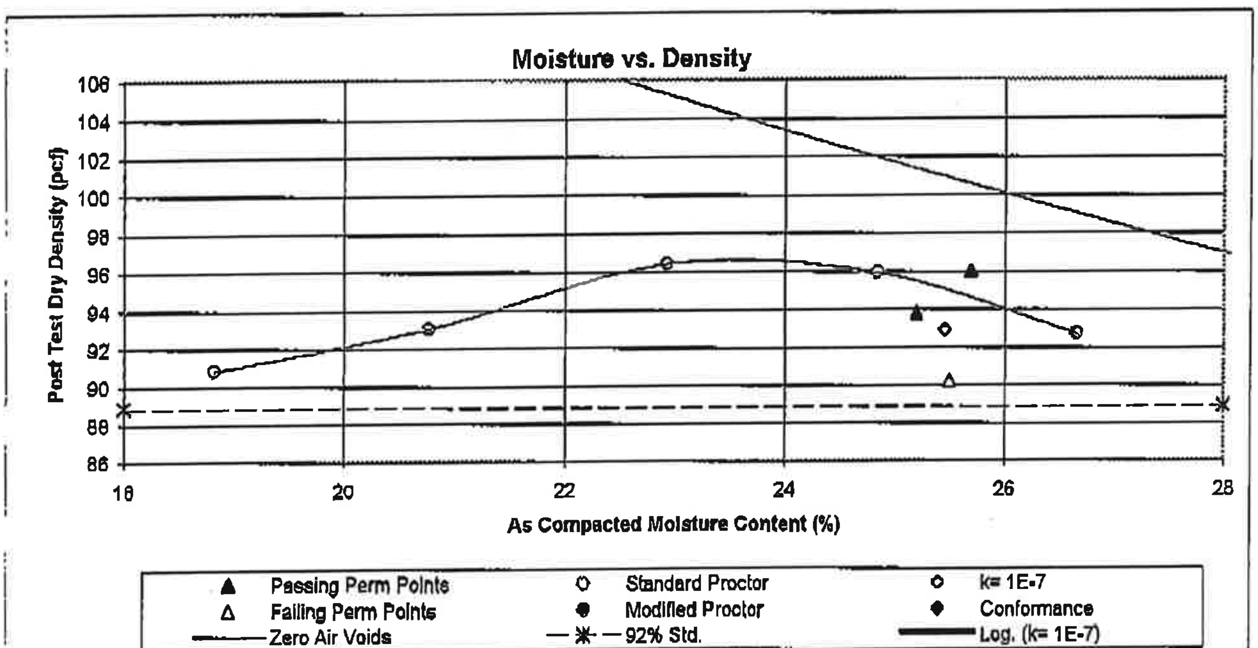
Project Name Tanners Creek Borrow Study Area — Project No. CN2006032
Source B-4-2, 1.5' - 2.5' — Test ID 450
Visual Classification fat Clay (CH), brown — Specific Gravity 2.75

Maximum Dry Density (pcf)
Standard: 96.6
Modified:

Optimum Moisture Content (%)
Standard: 23.6
Modified:

	Set A	Set B	Set C	Set D
Lab ID	450	Set B	Set C	Set D
Average Moisture Content (%)	25.5			
Dry Density (pcf) at 1E-7 cm/sec	92.9			





CN2006032_450_Window Plots

KDG

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Hydraulic Conductivity of Saturated Porous Materials
Using a Flexible Wall Permeameter
ASTM D 5084-90

Project Name Tanners Creek Borrow Study Area
Project No. CN2006032
Source B-4-2, 1.5' - 2.5'
Test ID 450@295
Visual Classification fat Clay (CH), brown
Prepared By KDG
Compacted Std. 0 in. spacer
Specific Gravity 2.75 ASTM D854-A
Date 5-7-07
Maximum Dry Density (pcf) 96.6
Percent of Maximum 103.1

Permeant: De-aired tap water
Selection and Preparation Comments: Standard Effort, -No.4 material.

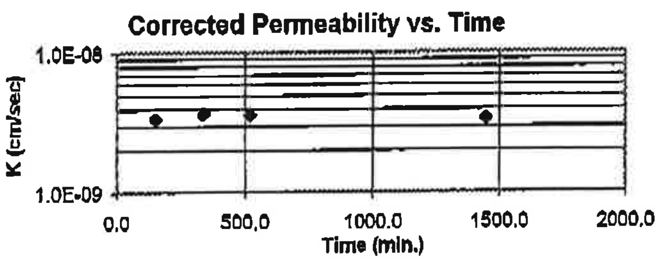
Specimens (if compacted) were compacted in a Proctor Mold as follows: The Maximum Dry Density was converted to Wet Density, this mass was divided by 4 (layers) and 3 of the 4 layers were compacted into the mold using a Proctor Hammer using 19 blows per layer. The density was varied by reducing the height of the drop by the amount listed beside "Compacted". The specimen was trimmed from the bottom two layers.

	Initial Specimen Data	After Consolidation Data	After Test Data
Height (in.)	1.4818	1.4692	1.4693
Diameter (in.)	2.8053		2.8698
Moisture Content (%)	23.3		30.0
Dry Unit Weight (pcf)	99.6		98.0
Void Ratio	0.724		0.789
Degree of Saturation (%)	88.6		104.6
Trimmings MC (%)	25.7		

Final Pressures (psi)	
Chamber	75
Influent	70
Effluent	65

Applied Head Difference (psi) 5
Back Pressure Saturated to (psi) 65
Maximum Effective Consolidation Stress (psi) 10
Minimum Effective Consolidation Stress (psi) 5

						Hydraulic Conductivity			
Date	Clock (24H:M)	Temp. °F	Bottom Head	Top Head	Test Time (sec)	k (m/s)	k (cm/s)	K @ 20° C (m/s)	K @ 20° C (cm/s)
5-17-07	7:58	72.0	18.98	2.68	0	—	—	—	—
5-17-07	10:32	72.0	18.84	2.86	9.24E+03	3.6E-11	3.6E-09	3.4E-11	3.4E-09
5-17-07	13:39	72.0	18.66	3.10	1.12E+04	3.8E-11	3.8E-09	3.6E-11	3.6E-09
5-17-07	16:41	72.0	18.50	3.34	1.09E+04	3.8E-11	3.8E-09	3.6E-11	3.6E-09
5-18-07	8:09	72.0	17.60	4.34	5.57E+04	3.5E-11	3.5E-09	3.4E-11	3.4E-09



A gradient of approximately 93.1 was used for this test. This gradient exceeds ASTM guidelines for maximum gradient, but was used to achieve the requestors desired test duration. Examination of the sample shows no signs of material loss or clogging that may affect test results.

Average Hydraulic Conductivity @ 20° C (last 4 determinations) m/s 3.49E-11 cm/s 3.49E-09
Average Hydraulic Conductivity @ 20° C (last run) m/s 3.49E-11 cm/s 3.49E-09

Reviewed by: _________

Prepared by KGilbert 5/30/2007

FMSM ENGINEERS

Hydraulic Conductivity of Saturated Porous Materials
Using a Flexible Wall Permeameter
ASTM D 5084-90

Project Name: Tanners Creek Borrow Area Study
Project No. CN2006032
Source: B-4-2, 1.5' - 2.5'
Test ID 450@262
Visual Classification: fat Clay (CH), brown
Prepared By KDG
Compacted: 7.5 in. spacer
Specific Gravity 2.75 ASTM D854-A
Date 5-7-07
Maximum Dry Density (pcf) 96.6
Percent of Maximum 95.5

Permeant: De-aired tap water
Selection and Preparation Comments: Standard Effort, -No.4 material.

Specimens (if compacted) were compacted in a Proctor Mold as follows: The Maximum Dry Density was converted to Wet Density, this mass was divided by 4 (layers) and 3 of the 4 layers were compacted into the mold using a Proctor Hammer using 19 blows per layer. The density was varied by reducing the height of the drop by the amount listed beside "Compacted". The specimen was trimmed from the bottom two layers.

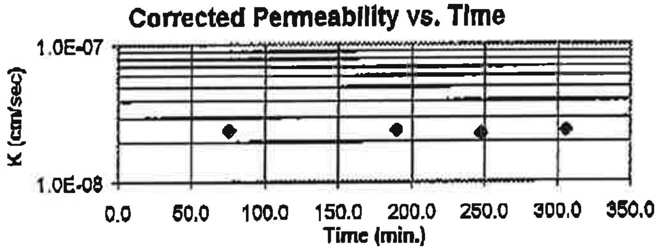
	Initial Specimen Data	After Consolidation Data	After Test Data
Height (in.)	1.4016	1.3693	1.3655
Diameter (in.)	2.8003		2.7927
Moisture Content (%)	25.7		31.7
Dry Unit Weight (pcf)	92.2		93.8
Void Ratio	0.862		0.830
Degree of Saturation (%)	82.1		105.1
Trimmings MC (%)	25.2		

Final Pressures (psi)	
Chamber	75
Influent	70
Effluent	65

Applied Head Difference (psi) 5
Back Pressure Saturated to (psi) 65
Maximum Effective Consolidation Stress (psi) 10
Minimum Effective Consolidation Stress (psi) 5

						Hydraulic Conductivity			
Date	Clock (24H:M)	Temp. °F	Bottom Head	Top Head	Test Time (sec)	k (m/s)	k (cm/s)	k @ 20° C (m/s)	k @ 20° C (cm/s)
5-17-07	9:57	71.0	18.79	4.00	0	—	—	—	—
5-17-07	11:13	71.0	18.65	4.14	4.56E+03	2.5E-10	2.5E-08	2.4E-10	2.4E-08
5-17-07	13:07	71.0	18.44	4.35	6.84E+03	2.5E-10	2.5E-08	2.4E-10	2.4E-08
5-17-07	14:05	71.0	18.29	4.40	3.48E+03	2.3E-10	2.3E-08	2.3E-10	2.3E-08
5-17-07	15:03	71.0	18.19	4.51	3.48E+03	2.5E-10	2.5E-08	2.4E-10	2.4E-08

Corrected Permeability vs. Time



A gradient of approximately 98.5 was used for this test. This gradient exceeds ASTM guidelines for maximum gradient, but was used to achieve the requestors desired test duration. Examination of the sample shows no signs of material loss or clogging that may affect test results.

Average Hydraulic Conductivity @ 20° C (last 4 determinations) m/s 2.36E-10 cm/s 2.36E-08
Average Hydraulic Conductivity @ 20° C (last run) m/s 2.36E-10 cm/s 2.36E-08

Reviewed by: ________

Prepared by KGilbert 5/29/2007

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Hydraulic Conductivity of Saturated Porous Materials
Using a Flexible Wall Permeameter
ASTM D 5084-90

Project Name: Tanners Creek Borrow Study Area
Source: B-4-2, 1.5' - 2.5'
Visual Classification: fat clay (CH), brown
Compacted: 9 in. spacer
Specific Gravity: 2.75 ASTM D854-A
Maximum Dry Density (pcf): 96.6
Project No.: CN2006032
Test ID: 450@250
Prepared By: KDG
Date: 5-7-07
Percent of Maximum: 92.1

Permeant: De-aired tap water
Selection and Preparation Comments: Standard Effort, -No.4 material.

Specimens (if compacted) were compacted in a Proctor Mold as follows: The Maximum Dry Density was converted to Wet Density, this mass was divided by 4 (layers) and 3 of the 4 layers were compacted into the mold using a Proctor Hammer using 19 blows per layer. The density was varied by reducing the height of the drop by the amount listed beside "Compacted". The specimen was trimmed from the bottom two layers.

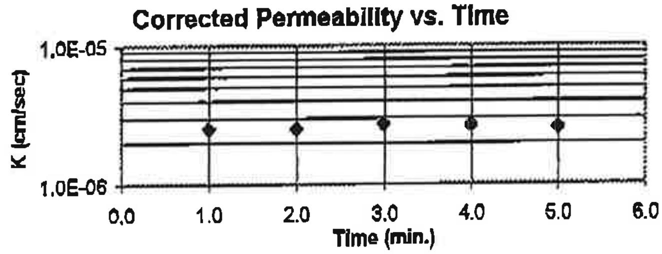
	Initial Specimen Data	After Consolidation Data	After Test Data
Height (in.)	1.3979	1.3827	1.3829
Diameter (in.)	2.8027		2.7974
Moisture Content (%)	24.6		32.7
Dry Unit Weight (pcf)	88.9		90.2
Void Ratio	0.931		0.903
Degree of Saturation (%)	72.6		99.7
Trimmings MC (%)	25.5		

Final Pressures (psi)	
Chamber	75
Influent	70
Effluent	65

Applied Head Difference (psi): 5
Back Pressure Saturated to (psi): 65
Maximum Effective Consolidation Stress (psi): 10
Minimum Effective Consolidation Stress (psi): 5

Date	Clock (24H:M)	Temp. °F	Bottom Head	Top Head	Test Time (sec)	Hydraulic Conductivity k (m/s)	k (cm/s)	k @ 20° C (m/s)	k @ 20° C (cm/s)
5-9-07	11:30	72.0	6.22	18.99	0	—	—	—	—
5-9-07	11:31	72.0	6.04	19.20	6.00E+01	2.6E-08	2.6E-06	2.5E-08	2.5E-06
5-9-07	11:32	72.0	5.84	19.39	6.00E+01	2.6E-08	2.6E-06	2.5E-08	2.5E-06
5-9-07	11:33	72.0	5.64	19.61	6.00E+01	2.8E-08	2.8E-06	2.7E-08	2.7E-06
5-9-07	11:34	72.0	5.43	19.81	6.00E+01	2.8E-08	2.8E-06	2.6E-08	2.6E-06
5-9-07	11:35	72.0	5.22	19.99	6.00E+01	2.7E-08	2.7E-06	2.6E-08	2.6E-06

Corrected Permeability vs. Time



A gradient of approximately 98.7 was used for this test. This gradient exceeds ASTM guidelines for maximum gradient, but was used to achieve the requestors desired test duration. Examination of the sample shows no signs of material loss or clogging that may affect test results.

Average Hydraulic Conductivity @ 20° C (last 4 determinations) m/s 2.59E-08 cm/s 2.59E-06
Average Hydraulic Conductivity @ 20° C (last run) m/s 2.57E-08 cm/s 2.57E-06

Reviewed by: ________

Prepared by KGilbert 5/29/2007

Fuller Mossbarger Scott & May
FMSM ENGINEERS

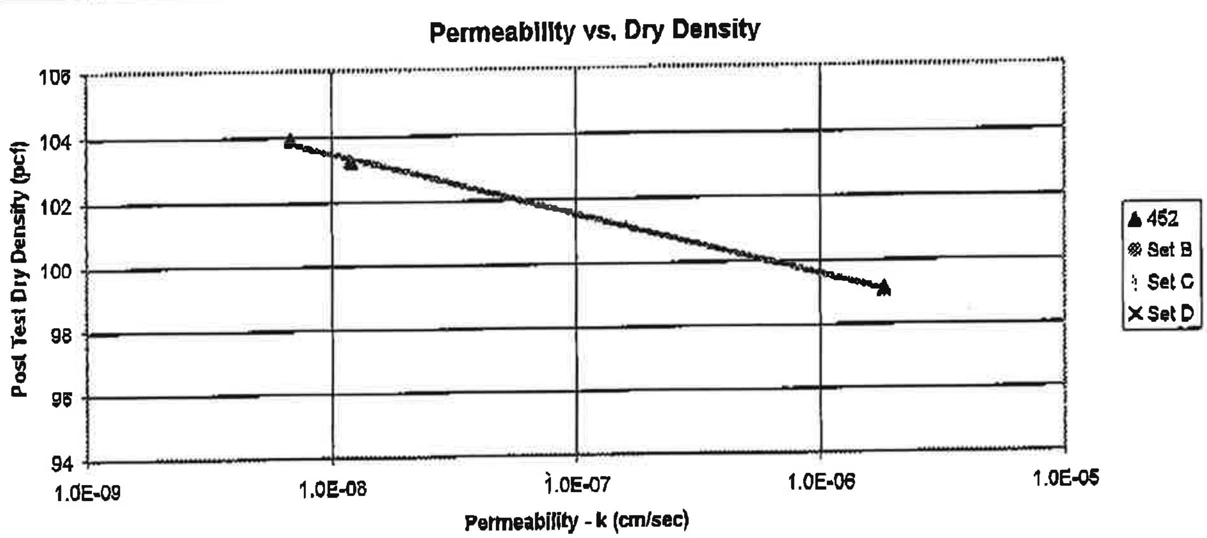
Hydraulic Conductivity of Saturated Porous Materials
Using a Flexible Wall Permeameter
ASTM D 5084-00

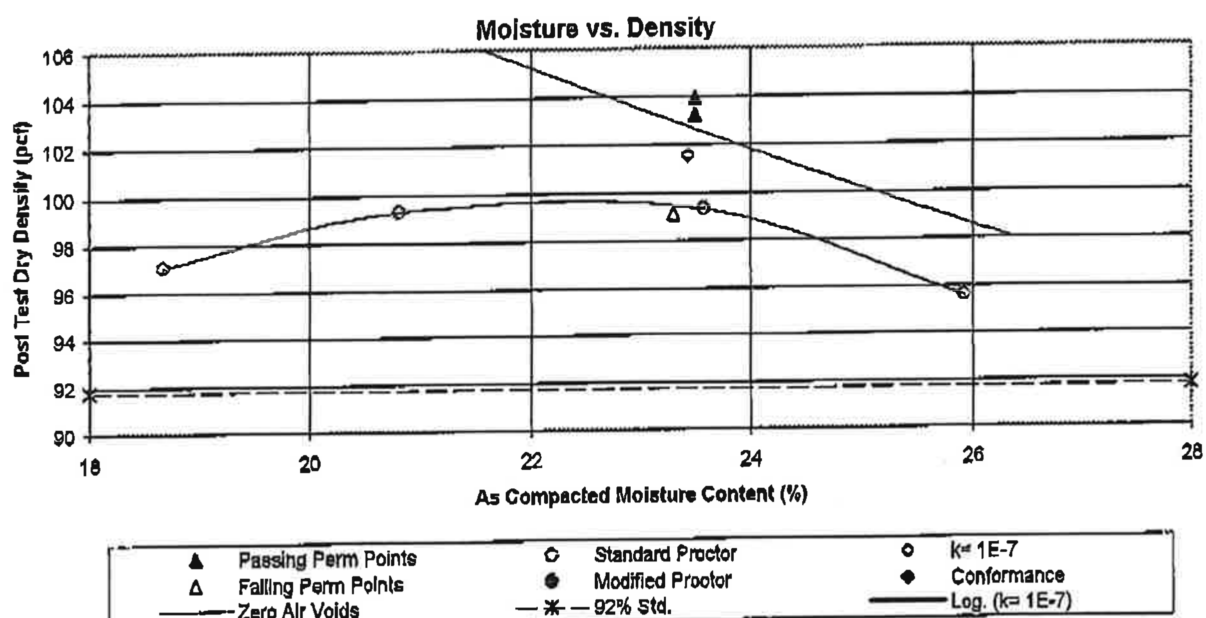
Project Name Tanners Creek Borrow Area Study
Project No. CN2006032
Source B-4-3, 4.0' - 5.0'
Test ID 452
Visual Classification lean Clay (CL), brown
Specific Gravity 2.68

Maximum Dry Density (pcf)
Standard: 99.7
Modified:

Optimum Moisture Content (%)
Standard: 23.8
Modified:

	Set A	Set B	Set C	Set D
Lab ID	452	Set B	Set C	Set D
Average Moisture Content (%)	23.4			
Dry Density (pcf) at 1E-7 cm/sec	101.5			





CN2006032_452_Window Plots

KDG

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Hydraulic Conductivity of Saturated Porous Materials
Using a Flexible Wall Permeameter
ASTM D 5084-90

Project Name: Tanners Creek Borrow Area Study
Project No. CN2006032
Source: B-4-3, 4.0' - 5.0'
Test ID 452@278
Visual Classification: lean Clay (CL), brown
Prepared By KDG
Compacted: Std. 0 in. spacer
Specific Gravity 2.68 ASTM D854-A
Date 5-4-07
Maximum Dry Density (pcf) 99.7
Percent of Maximum 100.6

Permeant: De-aired tap water

Selection and Preparation Comments: Standard Effort, -No.4 material.

Specimens (if compacted) were compacted in a Proctor Mold as follows: The Maximum Dry Density was converted to Wet Density, this mass was divided by 4 (layers) and 3 of the 4 layers were compacted into the mold using a Proctor Hammer using 19 blows per layer. The density was varied by reducing the height of the drop by the amount listed beside "Compacted". The specimen was trimmed from the bottom two layers.

	Initial Specimen Data	After Consolidation Data	After Test Data
Height (in.)	1.3940	1.3531	1.3602
Diameter (in.)	2.7953		2.7801
Moisture Content (%)	23.8		23.8
Dry Unit Weight (pcf)	100.3		103.9
Void Ratio	0.669		0.610
Degree of Saturation (%)	95.6		104.7
Trimmings MC (%)	23.5		

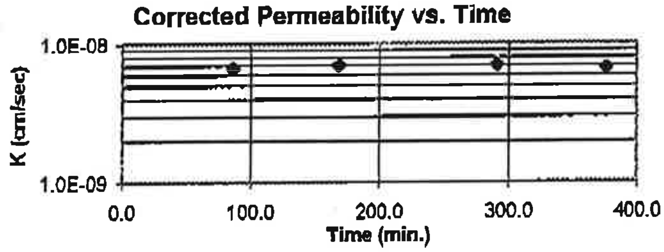
Final Pressures (psi)

Chamber	75
Influent	70
Effluent	65

Applied Head Difference (psi) 5
Back Pressure Saturated to (psi) 65
Maximum Effective Consolidation Stress (psi) 10
Minimum Effective Consolidation Stress (psi) 5

Date	Clock (24H:M)	Temp. °F	Bottom Head	Top Head	Test Time (sec)	Hydraulic Conductivity k (m/s)	k (cm/s)	k @ 20° C (m/s)	k @ 20° C (cm/s)
5-17-07	8:12	72.0	19.70	5.29	0	—	—	—	—
5-17-07	9:39	72.0	19.52	5.47	5.22E+03	7.0E-11	7.0E-09	6.6E-11	6.6E-09
5-17-07	11:01	72.0	19.36	5.67	4.92E+03	7.4E-11	7.4E-09	7.0E-11	7.0E-09
5-17-07	13:03	72.0	19.11	5.95	7.32E+03	7.4E-11	7.4E-09	7.0E-11	7.0E-09
5-17-07	14:28	72.0	18.96	6.15	5.10E+03	7.0E-11	7.0E-09	6.6E-11	6.6E-09

Corrected Permeability vs. Time



A gradient of approximately 99 was used for this test. This gradient exceeds ASTM guidelines for maximum gradient, but was used to achieve the requestors desired test duration. Examination of the sample shows no signs of material loss or clogging that may affect test results.

Average Hydraulic Conductivity @ 20° C (last 4 determinations) m/s 6.82E-11 cm/s 6.82E-09
Average Hydraulic Conductivity @ 20° C (last run) m/s 6.82E-11 cm/s 6.82E-09

Reviewed by: KDG

Prepared by KGilbert 5/29/2007

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Hydraulic Conductivity of Saturated Porous Materials
Using a Flexible Wall Permeameter
ASTM D 5084-90

Project Name Tanners Creek Borrow Area Study — Project No. CN2006032
Source B-4-3, 4.0' - 5.0' — Test ID 452@279
Visual Classification lean Clay (CL), brown — Prepared By KDG
Compacted 7.5 in. spacer — Specific Gravity 2.68 ASTM D854-A — Date 5-4-07
Maximum Dry Density (pcf) 99.7 — Percent of Maximum 90.9

Permeant: De-aired tap water
Selection and Preparation Comments: Standard Effort, -No.4 material.

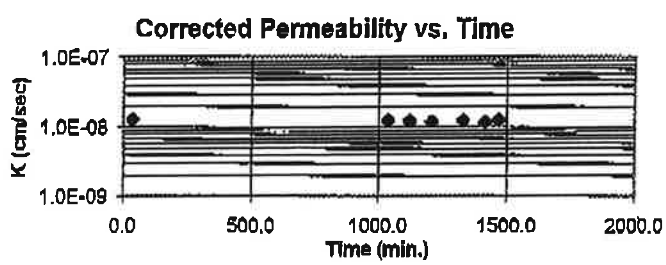
Specimens (if compacted) were compacted in a Proctor Mold as follows: The Maximum Dry Density was converted to Wet Density, this mass was divided by 4 (layers) and 3 of the 4 layers were compacted into the mold using a Proctor Hammer using 19 blows per layer. The density was varied by reducing the height of the drop by the amount listed beside "Compacted". The specimen was trimmed from the bottom two layers.

	Initial Specimen Data	After Consolidation Data	After Test Data
Height (in.)	1.5466	1.3690	1.3738
Diameter (in.)	2.7977		2.7827
Moisture Content (%)	23.6		24.3
Dry Unit Weight (pcf)	90.6		103.2
Void Ratio	0.846		0.622
Degree of Saturation (%)	74.9		104.8
Trimmings MC (%)	23.5		

Final Pressures (psi)	
Chamber	75
Influent	70
Effluent	65

Applied Head Difference (psi) 5
Back Pressure Saturated to (psi) 65
Maximum Effective Consolidation Stress (psi) 10
Minimum Effective Consolidation Stress (psi) 5

						Hydraulic Conductivity			
Date	Clock (24H:M)	Temp. °F	Bottom Head	Top Head	Test Time (sec)	k (m/s)	k (cm/s)	k @ 20° C (m/s)	k @ 20° C (cm/s)
5-16-07	14:52	72.0	22.19	3.60	0	—	—	—	—
5-16-07	15:30	72.0	22.04	3.75	2.28E+03	1.3E-10	1.3E-08	1.3E-10	1.3E-08
5-17-07	8:12	72.0	18.37	7.42	6.01E+04	1.3E-10	1.3E-08	1.2E-10	1.2E-08
5-17-07	9:36	72.0	18.07	7.71	5.04E+03	1.3E-10	1.3E-08	1.2E-10	1.2E-08
5-17-07	11:01	72.0	17.78	8.00	5.10E+03	1.2E-10	1.2E-08	1.2E-10	1.2E-08
5-17-07	13:04	72.0	17.33	8.42	7.38E+03	1.3E-10	1.3E-08	1.2E-10	1.2E-08
5-17-07	14:29	72.0	17.05	8.71	5.10E+03	1.2E-10	1.2E-08	1.1E-10	1.1E-08
5-17-07	15:22	72.0	16.87	8.90	3.18E+03	1.3E-10	1.3E-08	1.2E-10	1.2E-08



A gradient of approximately 89.2 was used for this test. This gradient exceeds ASTM guidelines for maximum gradient, but was used to achieve the requestors desired test duration. Examination of the sample shows no signs of material loss or clogging that may affect test results.

Average Hydraulic Conductivity @ 20° C (last 4 determinations) m/s 1.20E-10 cm/s 1.20E-08
Average Hydraulic Conductivity @ 20° C (last run) m/s 1.21E-10 cm/s 1.21E-08

Reviewed by: [signature]

Prepared by KGilbert 5/29/2007

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Hydraulic Conductivity of Saturated Porous Materials
Using a Flexible Wall Permeameter
ASTM D 5084-90

Project Name: Tanners Creek Borrow Area Study
Project No. CN2006032
Source: B-4-3, 4.0' - 5.0'
Test ID 452@257
Visual Classification: lean Clay (CL), brown
Prepared By KDG
Compacted: 10.5 in. spacer
Specific Gravity 2.68 ASTM D854-A
Date 6-4-07
Maximum Dry Density (pcf) 99.7
Percent of Maximum 92.8
Permeant: De-aired tap water
Selection and Preparation Comments: Standard Effort, -No.4 material.

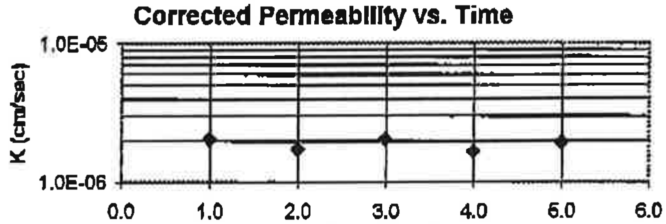
Specimens (if compacted) were compacted in a Proctor Mold as follows: The Maximum Dry Density was converted to Wet Density, this mass was divided by 4 (layers) and 3 of the 4 layers were compacted into the mold using a Proctor Hammer using 19 blows per layer. The density was varied by reducing the height of the drop by the amount listed beside "Compacted". The specimen was trimmed from the bottom two layers.

	Initial Specimen Data	After Consolidation Data	After Test Data	Final Pressures (psi)	
Height (in.)	1.3954	1.3153	1.3351	Chamber	75
Diameter (in.)	2.7993		2.7644	Influent	70
Moisture Content (%)	23.2		26.9	Effluent	65
Dry Unit Weight (pcf)	92.5		99.1		
Void Ratio	0.809		0.687		
Degree of Saturation (%)	77.0		104.7		
Trimmings MC (%)	23.3				

Applied Head Difference (psi) 5
Back Pressure Saturated to (psi) 65
Maximum Effective Consolidation Stress (psi) 10
Minimum Effective Consolidation Stress (psi) 5

						Hydraulic Conductivity			
Date	Clock (24H:M)	Temp. °F	Bottom Head	Top Head	Test Time (sec)	k (m/s)	k (cm/s)	k @ 20° C (m/s)	k @ 20° C (cm/s)
5-9-07	13:36	72.0	16.18	7.94	0	—	—	—	—
5-9-07	13:37	72.0	16.03	8.11	6.00E+01	2.1E-08	2.1E-06	2.0E-08	2.0E-06
5-9-07	13:38	72.0	15.89	8.24	6.00E+01	1.8E-08	1.8E-06	1.7E-08	1.7E-06
5-9-07	13:39	72.0	15.74	8.41	6.00E+01	2.1E-08	2.1E-06	2.0E-08	2.0E-06
5-9-07	13:40	72.0	15.61	8.54	6.00E+01	1.7E-08	1.7E-06	1.7E-08	1.7E-06
5-9-07	13:41	72.0	15.46	8.69	6.00E+01	2.0E-08	2.0E-06	1.9E-08	1.9E-06

Corrected Permeability vs. Time



A gradient of approximately 98.9 was used for this test. This gradient exceeds ASTM guidelines for maximum gradient, but was used to achieve the requestor's desired test duration. Examination of the sample shows no signs of material loss or clogging that may affect test results.

Average Hydraulic Conductivity @ 20° C (last 4 determinations) m/s 1.83E-08 cm/s 1.83E-06
Average Hydraulic Conductivity @ 20° C (last run) m/s 1.86E-08 cm/s 1.86E-06

Reviewed by: [signature]

Prepared by KGilbert 5/29/2007

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Attachment VII – Comments & Response Log

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Comment & Response Log
FAP Closure Plan

Comments: May 10, 2018, RAI Insufficient Response, IDEM Engineering, Michelle Lu
Responses: June 26, 2018, S&ME

Section 5.7 Cover System

1. In response to IDEM's comment regarding the cover system design, you modified the soil cover to include a six-inch vegetative layer over 30 inches of protective soil. The typical sections (Sheet 13), final cover details (Detail 1 on Sheet 14), and closure cost estimate have been modified for 36-inch final cover, but neither the Ash Grading Plan nor the Final Cover System Plan was changed. Please modify these drawings to reflect the 36-inch soil cover, and update the soil and/or ash cut-fill volume on the drawings and in the report (Table 5-1 and Table 5-2). Please verify the surface water control design will accommodate the 36-inch final cover.

Response: *Revised as recommended, see discussion below.*

Grading Plans – Proposed grades on Drawings 7 and 9 have been modified to reflect the 36-inch cover system thickness. Additionally, the background topographic maps on Drawings 8, 9, and 10 have been modified to reflect the 36-inch cover system.

Closure Design Components – The quantities presented in Tables 5-1 and 5-2 have been updated along with the quantity tables on Drawings 7 and 9. No changes were made to the quantities in Report Section 9 (cost estimate) as these already reflected the 36-inch cover system.

Surface Water Controls – Thickening the cover system from 30-inch to 36-inches changes neither the cross sectional area nor slope of the surface water controls. Therefore, the capacity and erosion protection are adequate as prior designed. No changes made in response to this comment.

2. Your response to our comment regarding the type and source of cover soil states the majority of cover soil will be obtained from the open field area adjacent to the Fly Ash Pond, designated as Borrow Area 4. Please depict Borrow Area 4 on the plans, and provide the test pits results for the borrow area.

Response: *Revised as recommended. Drawing 3 has been modified to show the location of Borrow Area 4 including the location of explorations. Exploration logs and laboratory test results for Borrow Area 4 have been added to Closure Plan Appendix VI (Geotechnical Data).*

3. For cover system designs with a flatter grade (2%), preventing infiltration is of particular concern. Please provide an analysis of the transmissivity for the geotextile cushion drainage layer, and demonstrate how the use of 16-oz. non-woven geotextile in the flatter area can provide enough transmissivity to remove the moisture from the final cover system. We recommend a minimum transmissivity of 3×10^{-5} m^2 per second for geosynthetic drainage material.

Response: The standard cover system has been modified to include a geocomposite drainage layer in all areas except the small area directly beneath the perimeter drainage channels at the outboard toe of the bottom ash dike. Drawings 6, 11, 14, 15, and 17 have been modified to reflect this change.

<u>Section 6.4 Cover System Stability</u>

4. This section states that the minimum cover system interface friction angle is 24.5°. However, the supporting calculation in Appendix D of Attachment V shows the minimum interface friction angle is 23.8°. Please clarify the discrepancy.

Response: The calculation (and QA/QC Plan) correctly depicted the interface friction angle of 23.8°; Section 6.4 has been modified to match.

<u>Section 7.0 Closure Plan</u>

5. For IDEM Closure Form Parts III through VIII, please address the following:

a. Part V Item A, please revise the narrative in sub-items (2), (3), and (4) as follows:

Sub-item (2) Soil obtained from on-site borrow area
Sub-item (3) 100%
Sub-item (4) Soil obtained from off-site

Response: Revised as recommended.

b. Part V Item B, please change the title for "Two Feet of Final Cover" to "30 Inches of Final Cover".

Response: Revised as recommended.

c. Part VI Item B (Other Costs), please remove the activity and cost for items 4 (Phase 1 Soil Excavation) and 5 (Phase 2 Soil Excavation and Fill). These two costs have been included in the cost estimates for the 30 inches of final cover and the 6 inches of topsoil.

Response: Revised as recommended.

d. We have noted that some costs submitted and shown below are lower than the commonly accepted amounts generally used by other facilities. Please revisit these costs and make necessary adjustments, or provide supporting documentation to justify that the submitted cost is still valid.

- Excavation unit cost: \$1.50 per yd^3
- Placement/Spreading unit cost: \$0.50 per yd^3

We generally see a unit cost of \$ 2.5 to \$ 3.5 per yd^3 for excavation of soil or placement of topsoil.

Response: Owner will be completing these activities using their own equipment and personnel rather than retaining an earthwork contractor. The lower than normal unit rates reflect self-performing the activities. No change has been made to the cost estimate based on this comment.

e. Please include 10% contingency cost in the closure cost estimate.

Response: Revised as recommended.

Attachment IV. Post Closure Care Plan

6. For IDEM Post Closure Form Parts III through V, please address the following:

a. Part V Item B(1)(a), please note the final cover will include geosynthetic material (geomembrane, geocomposite or geotextile) and 36 inches of soil cover and vegetation. Revise this item to add 10% (\$/acre) of cost for replacement of geosynthetic material.

Response: Revised as recommended.

b. Part V Item H (cost for groundwater monitoring), please verify the number of required monitoring wells is adequate. Table 4-1 for Summary of Monitoring Wells in Attachment II appears to show more than 17 monitoring wells.

Response: The vast majority of costs associated with monitoring are related to sample collection and chemical analysis. Seventeen of the wells in the Fly Ash Pond monitoring system were to be sampled with the remainder to be monitored for water levels only. So even though the system included more than 17 wells, the cost estimate was based on 17 wells to be sampled. The GWMP has been revised based on Geology comment Nos. 1 & 2 (see separate responses). The cost estimate has been revised based on these changes and both Table 4-1 and Figure 2 have been updated accordingly. The revised cost estimate is based on the sampling of 19 wells.

Additionally, the prior submitted Groundwater Monitoring Plan Table 4-1 identified 21 wells as part of the groundwater monitoring system for the Fly Ash Pond whereas Figure 2 of the Plan listed 23 wells associated with the Fly Ash Pond. Wells MW-3 and MW-5 have been added to Table 4-1 to correct the discrepancy. Wells MW-3 and MW-5 are to be monitored for water levels only.

The other wells listed on Figure 2 are present at Tanners Creek; but as noted in the facility designation columns, are not part of the Fly Ash Pond Monitoring System as they are not in close proximity to the Fly Ash Pond. These other wells are listed only for informational purposes. Table 4-1 denotes the wells to be monitored for the Fly Ash Pond.

7. Please submit a dust control plan detailing the control measures used, and any corrective actions taken during the entire closure period, particularly for soil excavation from borrow area, the fly ash cut-fill and soil placement.

Response: Revise as recommended; a Dust Control Plan has been included as Appendix VII of the Closure Plan.

Comments: May 10, 2018, RAI Insufficient Response, IDEM Geology, Andrew Najafiarab
Responses: June 26, 2018, S&ME

1. The *Phase I Ground Water Monitoring Plan, Rev 3* (GWMP) dated March 9, 2018 (VFC #80633887, pg. 59), does not include ground water monitoring wells along the northeast boundary of the Fly Ash Pond (FAP). The northeast boundary of the FAP is hydrogeologically upgradient, as shown in the potentiometric maps included in Appendix A of the GWMP. However the hydrogeologic study for the adjacent Tanners Creek Plant Type I Restricted Waste Landfill (landfill) dated January 31, 2007 (VFC #27877050, pg. 10), indicates ground water flow direction may reverse depending on the water elevation of the Ohio River.

   Due to the potential flux of the ground water flow direction and the lack of ground water quality monitoring points in this area, you need to revise the GWMP to include nested monitoring wells along the northeastern boundary of the FAP. The nested wells need to meet the same spacing and specifications as proposed wells MW-22S through MW-25D.

Response: Additional nested wells have been added along the northeast side of the Fly Ash Pond, see Groundwater Monitoring Plan Table 4-1, Figure 1, and Figure 2. The additional up-gradient wells will be installed, developed, and sampled to establish baseline groundwater quality. The additional wells will then be monitored for water levels only, unless a flow reversal is identified. If a flow reversal is identified, the additional wells would be sampled as down-gradient wells.

2. The original ground water monitoring plan dated February 12, 2014 (VFC #80020801, pg. 142), included ground water sampling at the adjacent municipal ground water supply wells owned by the City of Aurora and the Lawrenceburg, Manchester, Sparta Water Conservancy District (Aurora/LMS).

   We have identified site-wide ground water flow directions that appear radially influenced towards the Aurora/LMS wells. Additionally, the Aurora/LMS wells terminate in the same aquifer lithologies that underlie the Tanners Creek landfill that contains unlined coal combustion residual storage areas. Due to the influence of the municipal supply wells on ground water flow from the Tanners Creek landfill, you need to revise the current GWMP to include ground water monitoring at the Aurora/LMS wells adjacent to the FAP.

Response: Indiana Michigan Power Co ("AEP") has retained responsibility for ground water monitoring at the Aurora/LMS wells. We currently do not have access to these wells and will promptly inform AEP of your request for such monitoring and have AEP get in touch with you as soon as possible. However, in response to your request, the GWMP has been modified to include sampling of Wells GM-1D & GM-1S which are located between the FAP and the Aurora/LMS production wells. Please refer to Figure 1 of Appendix A of the GWMP and specifically the monitoring well nest identified as GM-1D/1S.

Comments: February 6, 2018, RAI, IDEM Engineering, Michelle Lu
Responses: March 9, 2018, S&ME

Section 5.7 Cover System

1. This section states the cover system will include 6 inches of vegetative layer and 24 inches of protective soil layer. The cover system stability calculations provided in Appendix D of Attachment V use 3 feet of thickness for cover soil. Please clarify this discrepancy. Since the proposed cover design includes use of a geomembrane, we recommend 36 inches of protective cover and vegetation layer placed above the geomembrane.

Response: The soil cover system has been modified to include a 6-inch vegetative layer over 30 inches of protective soil.

2. The report states the majority of the cover soil will come from an off-site borrow source. Please specify the type and source of this soil.

Response: Section 5.7 – 'Cover System' has been revised and now includes a discussion of the proposed borrow source.

3. The design proposes use of a geotextile cushion drainage layer in the relatively flat area of the upper basin. Please provide a specification for the geotextile cushion, if available, and demonstrate how use of the geotextile cushion alone can provide sufficient drainage. We recommend you use both a geocomposite drainage layer and a geotextile cushion layer.

Response: The cover system, as designed, incorporates a layer of geosynthetic material at all locations above the geomembrane. The purpose of this layer is twofold: 1) to reduce the potential for damage to geomembrane during installation of the overlying cover soil; and, 2) to provide a drainage mechanism to convey rainwater which infiltrates into the cover soil (as opposed to losses due to runoff and evapotranspiration) to the low points in the cover. In steeper areas where slope stability is a concern, a geocomposite was selected for this purpose. Conversely, beneath the swales and in the flattest areas of the cover (former Clearwater pond area) a geocomposite was also used as drainage will be more difficult with flatter slopes. The proposed geocomposite consists of a geonet covered above and below with a heat bonded non-woven geotextile. In areas between these two extremes (principally the higher points of the upper basin cover) a 16 oz. non-woven geotextile was selected for this purpose. Attached to this letter is a color figure illustrating the extent of each type of material.

Section 3.5 of the QA/QC Plan, included as Appendix IV of the Closure Plan, contains the requirements for the geotextile cushion layer, including material properties, testing requirements, and installation procedures. Paragraph 5.7.1 of the Closure Plan has been modified to provide a more detailed discussion as to the rationale for substituting the geocomposite drainage layer with a geotextile cushion layer. The RAI recommends use of both a cushion layer and a geocomposite drainage layer. The design has not been modified per this recommendation as the geocomposite drainage layer includes a geotextile on both sides of the drainage core and as such will adequately serve as a cushion layer.

Section 7.0 Closure Plan

4. The application includes a Table 7.1 for Engineer's Opinion of Probable Construction Cost for the closure. We recommend you use the attached Closure Form to update your closure plan.

Response: The completed form has been included with the IDEM Closure Form presented in Section 9.0 of the Closure Plan narrative and Table 7.1 has been removed.

Attachment I. Closure Drawings

5. Please include a statement that a legal description of the fly ash pond's solid waste boundary will be provided with the closure certification report.

Response: The requested statement has been added to the QA/QC Plan in Section 2.2.2, as well as Section 7.3 of the Closure Plan narrative.

6. Please include the solid waste boundary on the engineering drawings.

Response: Revised as requested.

7. Drawing 17, Cross Sections. Please show where the geocomposite drainage net or geotextile cushion layer is placed, and the location of the surface water collection channel in all the cross section details.

Response: Revised as requested. Two figures have been prepared in color for further clarification of the limits of the geosynthetics (smooth and textured geomembrane, geocomposite drainage layer and geotextile cushion layer). The figures, labeled as Figures 1A and 1B, are appended with this letter and are based on the Phase I Ash Grading Plan and Phase II Ash Grading Plan, respectively.

Attachment Ill. Quality Assurance/Quality Control Plan

8. Section 3.10, Soil Cover Layer. Please address the material testing to be conducted. At a minimum, the following tests should be conducted before placing these soils. Also, specify the testing frequency.

   a. Particle size (ASTM D1140, D422).

   b. Atterberg limits (ASTM D4318).

Response: Revised as requested.

9. Section 3.10.1, Construction. This section states that the soil shall be spread and compacted. At a minimum, the first 12 inches of soil should not be compacted. Please revise it.

Response: Revised as requested.

10. This section states the post-closure care period will last for 10 years. However, Item 3(E) for In-Place Closure in the IDEM Office of Land Quality Surface Impoundment Closure Guidance

specifies a post-closure care period of 30 years following 329 IAC 10-31-2(b). Please adjust cost estimate to reflect 30 years of post-closure care. We recommend you use the attached post closure form to update your post-closure plan. Include dike maintenance costs in the post-closure cost estimate. Also, use 25% contingency in the revised post-closure cost estimate.

Response: Revised as Requested.

Comments: February 6, 2018, RAI, IDEM Geology, Andrew Najafiarab
Responses: March 9, 2018, S&ME

1. The Post Closure Care Plan in Attachment IV of the closure plan details the post- closure activities, including ground water monitoring, for a 10-year period. However, Item 3(E) for In-Place Closure in the IDEM Office of Land Quality Surface Impoundment Closure Guidance (Closure Guidance) specifies a post-closure care period of 30 years following 329 IAC 10-31-2(b). Therefore, the facility needs to modify the closure plan to include specifications for maintenance and monitoring for a 30-year post-closure care period.

Response: Revised as recommended

2. Regarding the Phase I Ground Water Monitoring Plan, Rev 2 (Ground Water Monitoring Plan) in the closure plan, we agree with your submitting a work plan before abandoning any ground water monitoring wells or installing proposed monitoring wells as detailed in Section 4.3. Additionally, please note other existing monitoring wells, such as those associated with the adjacent Type I Restricted Waste Landfill (SW Program ID 15-12) or the Main Ash Pond, may need to be included into the FAP's monitoring well network to ascertain the background ground water quality due to site-specific hydrogeologic conditions.

Response: A statement has been added to Paragraph 4.2 of the Ground Water Monitoring Plan acknowledging the existence (no specific well details included) of other on-site wells including a statement that if needed in the future, the FAP monitoring system could be expanded to include other existing wells.

   a. We concur with the Section 9.1 (Table 9-1) list of monitoring parameters following Item 5 of the Geology Enclosure in the July 24, 2015 RAI (VFC # 80120595). Table 9-1 reflects all constituents included in Indiana's draft coal combustion residuals (CCR) constituent list. Consistent with similar CCR monitoring programs, IDEM will review proposals to remove constituents from the full list based on site-specific information, including eight quarterly non-detect results and no history of maximum contaminate level exceedances.

   Response: The minimum criteria, as stated in the comment, for requesting removal of a constituent from the list of parameters has been added to the Ground Water Monitoring Plan.

b. Following future correspondence with the facility, IDEM will include finalized ground water monitoring requirements, including the monitoring well network and the constituent list, in its approval letter for the Closure Plan

Response: Understood.

3. We agree with your submitting a Statistical Evaluation Plan (StEP) after completing eight quarterly sampling events. However, we recommend the facility submit the StEP under a separate cover from the Ground Water Monitoring Plan. This will allow for more efficient filing of the most current version, if revisions are necessary in the future.

   Response: Revised as recommended.

Other S&ME Changes, March 9, 2018, S&ME

During revision of the QA/QC Plan, the following changes were made to align the requirements with industry standards:

- *Table 3-7, Tensile Strength of geonet changed to ASTM D7179 from incorrect ASTM D5035 referenced previously.*
- *Table 3-11, Trapezoidal Tear Strength (ASTM D4533) for geotextiles was revised to a required value of 150 lbs to match industry standard for 16 oz. nonwoven geotextiles. Previous value required was incorrectly listed at 200 lbs.*
- *Table 3-11, UV Resistance testing method for geotextiles changed to ASTMD4355 from incorrect ASTM D7238 referenced previously.*

Revisions 0 and 1 of the Groundwater Monitoring Plan included monitoring of the public well field in addition to the Fly Ash Pond. The Well field monitoring is no longer required and was removed from Revision 2 of the Plan. However, two references to the well field monitoring were overlooked during the preparation of Revision 2. Those two references were located in Paragraphs 5.7 and 6.4 and have been removed from Revision 3.

Comments: July 24, 2015 RAI, IDEM Engineering, Daniela J. Klesmith
Responses: October 18, 2017, S&ME

1. A 100-year flood elevation for the main ash pond (MAP) area was established at 488.53 MSL. Cross Sectional Drawing BB of MAP perimeter dike indicates top elevation of the dike at 484 MSL. Please discuss how the MAP cover will be protected from 100-year flooding. Provide evaluation of uplift pressure/hydrostatic pore water pressure on the cover system during 100-year flood. Please note that DNR floodway construction permit maybe required to perform closure work.

Response: Not applicable to the closure of the fly ash pond (FAP).

2. Cross sectional drawings of Fly Ash Pond show existing 20-mil PVC liner cut where the new cover system intersects with the old liner system. Provide evaluation of slope/fill stability with the old liner no longer properly anchored.

Response: The stability of the existing liner system is discussed in Section 5.8 of the Closure Plan.

3. The final cover design indicates a total of 30 inches of soil/gravel thickness above the geomembrane. We recommend 30 inches of soil fill and 6 inches of vegetative cover for a total thickness of 36 inches above the geomembrane to adequately protect the synthetic cover and provide for root systems. This thickness may need to be adjusted based on the responses to Item #1.

Response: As discussed during our August 9, 2017 meeting, as the final cover over the fly ash pond is located above the 100-year flood elevation, 30-inches of cover soil is proposed. This is discussed in more detail in Section 5.7.2 of the Closure Plan.

4. The construction Quality Assurance Plan (CQA) provided in Appendix C does not address all standard CQA procedures and material testing. We recommend reviewing information in 329 IAC 10-15-7 (CQA/CQC plan and requirements), 329 IAC 10-17-7 (Geomembrane component of liner; construction and quality assurance/quality control requirements) and applicable parts of 329 IAC 10-17-8 thru 18 and revising your CQA Plan as needed.

Response: The CQA Plan has been extensively modified in consideration of these requirements.

Comments: July 24, 2015 RAI, IDEM Geology, John Guerrettaz
Responses: October 18, 2017, S&ME

1. The proposed, individual ground water monitoring systems for the fly ash pond (FAP) and the main ash pond (MAP), which includes the old ash pond, need additional, multi-depth ground water monitoring locations. Based on lithologic information from PZ-4 and other site borehole logs, there is approximately 15 feet of clay and silt directly underneath both the FAP and MAP, under which there is approximately 30 to 70 feet of sand and gravel. Due to the thickness of the sand and gravel aquifer, the monitoring system for both the FAP and MAP needs to monitor the entire sand and gravel aquifer. Each pond's proposed monitoring system does not fully cover the expected vertical monitoring zones of the aquifer and the horizontal extent of each pond.

Response: Additional nests of wells will be installed as shown on the Monitoring Well Location Map included with the Groundwater Monitoring Plan.

a. Comments of the FAP's monitoring system are as follows:
The geologic cross section in the report titled *Ground-Water Monitoring Program, Tanners Creek Plant, Lawrenceburg, Indiana* dated March 1988 (Appendix A, Sampling and Analysis Plan) shows two well nests, MP-1S/MP-1D and MP-2S/MP-2D, and an individual well MP-3. We assume these well nests and the individual well are currently referred to MW-1S/MW-1D and MW-2S/MW-2D, and MW-3D, respectively. Additionally, the TCPP lists the wells' installation date as November of 1987, which makes them almost 28 years old. We are concerned that the integrity of these wells may be suspect due to their age; therefore, the TCPP should replace these wells with well nests described in paragraph D below to ensure the collection of representative ground water samples. We have the following concerns if their placements monitor the sand and gravel aquifer effectively:

Response: We believe the interpretation of the well identification is correct; the wells are also at times referred to as GM-1S/1D, GM-2S/2D, and GM-3. In the Ground Water Monitoring Plan, GM-1S/1D is to be monitored for water levels only and new wells are to be installed to more fully monitoring groundwater. However, it is proposed to continue to monitor GM-2S/2D, and GM-3 as long as the pumps remain functional.

A. The upper monitoring zone wells MW-1S and MW-2S each have a 5-foot screened interval approximately 25 feet below the top of the sand and gravel aquifer and 20 feet below the water table. Additionally, based on the engineering drawings in the C/PCP, i.e., Drawing 14-30612-A, the screened interval for each of these wells begin approximately 40 feet below the base of the FAP at 458 feet above mean sea level.

Response: We believe this screen is the 1" stand-pipe from which water levels are measured. The pump intake (sampling depth) for the buried pumps is reported as follows:

- GM-1S El 424
- GM-2S El 422

B. The deeper monitoring zone wells MW-1D, MW-2D, and MW-3D each have a 5-foot screened interval approximately 10 feet below the upper monitoring zone. The application does not provide an explanation as to why the 10-foot separation is appropriate.

Response: The basis for the screen depth selection is unknown. But historic data are available, no changes are proposed. Similar to the shallow GM wells, the screened zone is believed to be for measurement of water levels. The pump intake (sampled depth) reported is as follows:

- GM 1D El 403
- GM 1S El 404
- GM-3 El 403

C. These well locations are northwest of the FAP; but there are no wells proposed for monitoring on the north and northeast sides of the pond. For adequate ground water monitoring, the TCPP needs to place additional well nests as follows: one well nest along the north side and another well nest further east, approximately 500 feet apart; one well nest on the eastside; and one well nest on the southwest side, south of proposed well MW-25. Please note that MW-25 needs to be a nested location.

Response: Proposed new nested well locations are depicted on the Monitoring Well Site Plan included in the Ground Water Monitoring Plan.

With respect to describing the orientaion (sides) of the FAP, "true north" is at a inconvient direction. We interpret the reviewer to be referring to "north" as toward US 50. Using this same direction reference, groundwater flow is generally from south-southeast to west-northwest. The south side of the FAP (landfill side) is the predominate up-gradient side with the east side (Station side) being lateral to upgradient with respect to groundwater flow. The proposed 4 new well nests are intended to monitor the north side (US 50 side) and west side which are down-gradient of the FAP.

D. Based on the thickness of the sand and gravel aquifer at each monitoring location, the TCPP needs to do the following:

i. Install well nests, including existing and future monitoring locations. Spacing for each well nest should be between 500 to 800 feet apart. Please provide an explanation for the screen placements in each shallow, intermediate, and deep monitoring zone.

Response: Spacing of existing and proposed wells generally conforms to the comment. A discussion of screens and screen installation depths is provided in the response to the next comment.

ii. Include a shallow, intermediate, and deep zone monitoring well at each well nest, unless the TCPP adequately justifies the nest is not necessary. The shallow wells should have a 10-foot screen that intersects the water table where unconfined conditions exist. We recommend five-foot screens in all other places.

Response: As detailed in the Groundwater Monitoring Plan, where the aquifer is confined, the top of the upper screen will be set approximately approximately 5 feet below the top of the aquifer. The bottom of the lowest screen will be set approximately 5 feet above the bottom of the aquifer. The intermediate screen will be set approximately half way between the upper and lower screens.

iii. The TCPP needs to construct each monitoring well similar to the well diagram for MW-13 in Appendix D (Main Ash Pond Monitoring Well Information) of Appendix B. Construction details of each well needs to be documented.

Response: All proposed monitoring wells will be "conventional" 2-inch diameter PVC casing and screen similar to MW-13. Well completion diagrams will be prepared for each well.

iv. Each well nest should be within approximately 50 feet of each ash pond's boundary, except where 50 feet is not possible because of site topography or geology.

Response: The proposed location of the new wells are as close as practical to the outboard toe of the FAP.

v. The TCPP should install at least one upgradient well nest south of the FAP. Upgradient wells will establish background ground water quality.

Response: Groundwater generally flows beneath the landfill before reaching the FAP footprint. On this basis, two of the down-gradient landfill monitoring wells are proposed for use as up-gradient FAP wells. The alternative would be to install upgradient/background wells on the Station side of the FAP. While this location may (or may not) provide better characterization of the natural aquifer, it would not, in our opinion, be representative of the ground water flowing toward the FAP.

vi. All wells need adequate protection from flooding to ensure well integrity and representative results.

Response: Expandible air-tight/water tight caps will be used for all new wells to protect from inundation during flooding. Additionally, weep holes will be drilled in the protective covers so that floodwater can drain from the annular space between the well casing and protective cover.

b. Comment of the MAP's monitoring system is as follows:
Based on the C/PCP narrative and its Drawing 14-30602-A (DWG02), which shows proposed well locations for the MAP monitoring system, the TCPP is not proposing to install well nests with shallow, intermediate, and deep wells at each monitoring location. Additionally, DWG02 shows the well locations ranging in distance from about 500 feet to 1300 feet apart, with the greatest distance between the three proposed wells on the north side. The proposed well spacing is too large. Therefore, the TCPP should adjust the proposed locations to include additional wells along the Northside, with well spacing approximately 500 feet to 800 feet apart. The TCPP needs to follow the monitoring well placement and installation similar to the paragraphs A, B, C, and D presented above for the FAP.

Response: A Ground Water Monitoring Plan for the MAP has not yet been developed. When developed, the MAP GWMP will address this comment.

2. We recommend the TCPP submit a work plan for our review that details the ground water monitoring systems presented in 1a. and 1b. above.

Response: Upon reaching agreement to the FAP Ground Water Monitoring Plan, including the number of wells and general screen configuration requirements, a Work Plan will be prepared detailing the drilling, sampling, and well installation procedures. A similar approach will be taken with respect to new wells for the MAP.

3. The statistical evaluation plan (StEP) (Appendix A of Appendix A) refers to the TCPP landfill facility. We assume the TCPP will employ the StEP for each monitoring system for the FAP and MAP since the StEP is included in the C/PCP. The statistical evaluation needs to be a stand-alone evaluation for each pond (FAP and MAP) and the StEP needs to refer to each pond to ensure clarity for its application. Generally, the procedures presented in the statistical evaluation plan (StEP) are acceptable, but greater detail needs to be included for each ash pond. These details include identifying the ground water monitoring system, the constituent list, the verification resample strategy (1 of 1, 1 of 2, or 2 of 2), and the site-wide false positive rates.

Response: Separate statistical analysis is proposed for the FAP and MAP (and landfill). The Statistical Evaluation Plan has been removed from the FAP Ground Water Monitoring Plan and replaced with a general discussion of the statistical analysis to be completed. Because of the significant number new wells being installed, it is desired to review the water quality data prior to identifying specific statistical methods Additionally, it has not yet been determined if "MANAGESs" will be used for the analysis. The FAP StEP will be submitted for IDEM Review and Comment after 8 sets of quarterly groundwater samples have been collected and analyzed from the new wells.

The StEP's flow chart lists three different statistical methods: prediction intervals, Shewhart-CUSUM Control Limits, and tolerance intervals. Based on the narrative of the StEP, intrawell prediction intervals will be applied. We assume that any reference to any of the other methods in Attachment A is part of the general MANGES narrative and will not be applied. We recommend the StEP only reference those methods and procedures that will actually be applied to each pond's ground water monitoring system. Additionally, intrawell prediction intervals may not be appropriate because the ponds have been in-place for several years with possible impacts to the ground water already occurring. The TCPP should strongly consider the application of interwell prediction intervals until the TCPP can show the respective ponds do not impact the ground water quality.

Response: The FAP StEP will reference the specific wells and parameters to be used for statistical comparisions based on the FAP GWMP. We agree that intra-well analysis is inappropriate given the lack of groundwater quality data prior to pond construction.

The TCPP needs to resubmit a StEP for the FAP and one for MAP; or show better detail in one StEP how statistics will be separately applied for each of the ponds.

Response: StEP will be re-submitted at a later date.

4. The C/PCP contains the sampling and analysis plan (SAP) (Appendix A of Appendix A) for the TCPP landfill facility and one for the FAP and MAP. To alleviate confusion, the C/PCP should not include the SAP for the landfill.

Response: The landfill Sampling and Analysis Plan has been removed. The SAP has been incorporated into the body of the GWMP and is now limited to the FAP.

Greater detail in procedures and equipment needs to be specified for sampling the monitoring points identified in the second column of Table 2. Section 5.2 of the SAP is incomplete in the details for sampling these monitoring points.

Response: With the addition of new wells in close proximity to the FAP, these sampling points are no longer needed and have been removed from the Plan.

The last sentence of the first paragraph in Section 5.2 states that sample filtration will not be conducted; however, Bullet 5 under Section 6.6 states filtering will occur. The TCPP needs clarify if filtration will occur. Please note that at this time filtering metals samples in the field is consistent with Indiana's rules and permits for the Solid and Hazardous Waste Programs. Therefore, the TCPP should anticipate field-filtering metals samples and write the filtering procedure and identify the equipment into the SAP.

Response: This discrepency has been corrected. Filtering of the metals fraction of the samples will be completed. The GWMP has been modified accordingly.

5. The TCPP needs to add the following constituents to the constituent list for each pond: cyanide, fluoride, lithium, silver, sulfide, total dissolved solids, and radium 226 and 228 combined. Please ensure the SAP details the procedure for collecting samples for the radium.

Response: Revised as recommended.

Attachment VIII – Dust Control Plan

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Fugitive Dust Suppression Plan

for

Tanners Creek Development Site

Prepared for:

Tanners Creek Development, LLC

1650 Des Peres Road Suite 303

St Louis MO 63131

Prepared by:

EnviroAnalytics Group

May 18 2018

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Table of Contents

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1 INTRODUCTION

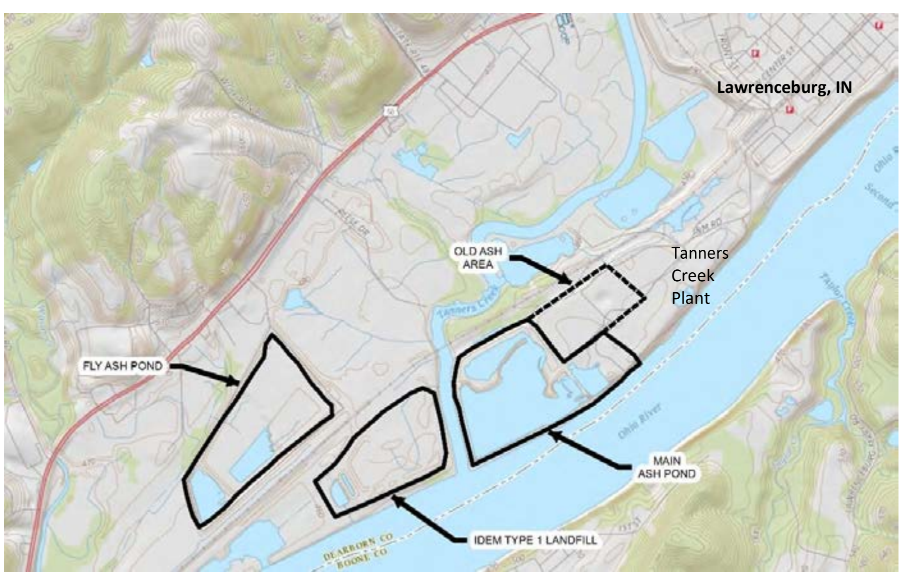
This Fugitive Dust Suppression Plan (Plan) provides the measures to be implemented by Tanners Creek Development, LLC (TCD) and its contractors to minimize fugitive dust emissions during the construction projects associated with the closure of the former coal ash surface impoundments and landfill at the former Tanners Creek Power Plant site. The Plan has been prepared in compliance with 326 IAC 6-4 (Fugitive Dust Emissions) and associated requirements as outlined in the Indiana Department of Environmental Management (IDEM) air permit for the site (T029-34394-00002).

The Tanners Creek site is located adjacent to the Ohio River on State Route 50 approximately one mile southwest of Lawrenceburg, Indiana. The power plant, while active, was operated by the Indiana Michigan Power Company (a subsidiary of American Electric Power). Power generation ceased in May of 2015. Tanners Creek Development, LLC acquired the Tanners Creek plant site in October of 2016 with the objective to redevelop portions of the property. Work is proceeding to demolish the former power plant structures and equipment and provide closure of the ash ponds and landfill in accordance with requirements and approvals issued by IDEM.

The facilities that will undergo closure construction work at the Tanners Creek site include the following:

- the "Old" ash disposal area;
- the Main Ash Pond;
- the Fly Ash Pond complex; and,
- an IDEM permitted Ash Landfill constructed over a former ash pond (aka overfill).

Figure 1 shows the location of these features.



1.1 Site Information

- Site Name: Tanners Creek Development Site
- Facility Address: 800 AEP Drive, Lawrenceburg, Indiana 47025
- Owner: Tanners Creek Development, LLC

1.2 Project Summary

The work will involve the demolition of structures and equipment and the in-place closure of the various ash ponds and landfill. Closure tasks will generally include regrading of existing ash surfaces and placement of cover systems installed above all areas where ash is exposed, as well as down the outboard slopes of the ash pond dikes. The cover system generally may include, from top to bottom:

6-inches of vegetative layer;
24-30 inches of protective soil layer;
Geocomposite drainage layer or geotextile cushion layer; and
40-mil LLDPE or 60 mil HDPE geomembrane or clay materials.

The soil material for the cover system will be obtained from on and off-site borrow sources.

.

2 FUGITIVE DUST CONTROL MEASURES

Fugitive dust has the potential to become airborne at the facility during construction activities associated with the various demolition and closure projects. This section identifies and describes the control measures selected and adopted by the site to minimize dust from becoming airborne at the site. The control measures may be adjusted or modified based on observed effectiveness of minimizing dust from becoming airborne and weather conditions.

TCD will employ a variety of best management practices (BMPs) during construction to reduce the potential for fugitive dust emissions and maintain compliance with the above referenced regulation and permit conditions. In addition to BMPs, fugitive dust emissions shall be controlled by limiting the speed of all vehicles on unpaved roads or roads subject to fugitive dust emissions to 15 mph. This speed limit will be enforced through routine notices provided to operators at the daily safety tailgates including locations where speed limits are required and through routine observations by supervisory personnel.

The BMP practices specific to each work area are described individually and in further detail under each section below.

2.1 Power Plant Demolition Work

Dust control is an important part of the demolition project. Water trucks will be regularly utilized on roadways for fugitive dust control. To minimize the run-off of water, the water supply will be used only when necessary. A proper backflow device will be installed at the hydrant locations, if utilized.

The frequency and amount of water required to control the dust will be determined by the characteristics of the debris and the ambient temperature. The degree of dust control will increase if the project is performed during the summer months. All water used for dust control will come from an onsite source.

The following equipment or equivalent will be onsite for the duration of demolition activities.

- Water truck,
- dust misters
- Poly tanks with pumps and hoses (if necessary)

The water truck will be utilized in the event of excessive dust or on a regular schedule during prolonged periods of little or no precipitation. The dust misters and pumps and hoses will be utilized to suppress dust in areas that are not reachable by the water truck travel. Chemical dust suppression will be used as necessary during periods of the year for which water control is not practicable.

2.2 Fly Ash Pond

Construction activities are planned at the Fly Ash Pond to regrade the ash surface and provide final cover materials. The following dust suppression BMPs will be utilized in this area.

2.2.1 Track-Out Controls

Fugitive dust can be generated from soil and debris being tracked out onto paved surfaces. TCD will minimize track-out by installing gravel aprons or similar control devices at intersections of unpaved project areas and existing paved roadways being used during construction.

2.2.2 Water Trucks

Water trucks will be utilized to apply water to exposed construction areas unless existing conditions are sufficiently wet to prevent dust (during or immediately following a rain event). Water will be regularly applied prior to, during and after earthmoving operations and vegetative clearing as necessary to reduce fugitive emissions. Water trucks and related equipment will be dedicated to the projects and available during all work hours when construction-related activities are occurring. Chemical dust suppression will be used as necessary during periods of the year for which water control is not practicable.

2.2.3 Material Storage And Handling

Soil stockpiles generated as part of the project will be maintained to reduce fugitive dust. Soil stockpiles may be stabilized by wetting to form a crust or other treatment including chemical soil stabilizers as further detailed below.
Any project-related person operating a vehicle on a public roadway with a load of dirt, sand, gravel or other loose material that is susceptible to generate dust will cover the load or maintain two feet or more of freeboard during transportation.

2.2.4 Chemical Soil Stabilizers

Dust control during construction will be achieved primarily through the application of water; however, chemical soil stabilizers will also be used in some instances and locations. Chemical soil stabilizers will be applied in lieu of water to form and maintain a crust on inactive construction areas and specifically areas of exposed ash subject to dust generation in the Fly Ash Pond. Chemical soil stabilizers are not suitable for use on roadways or active areas as these materials provide a tackified surface that is easily broken down with traffic. As such, this BMP for dust control is unsuitable for use in traffic areas.

Chemical soil stabilizers to be placed on inactive areas will include the use of HF5000 Tack™ High Performance Tackifier or equivalent products. This product is an environmentally safe organic tackifier specifically formulated to be used as a stand-alone spray for dust control to prevent wind/water erosion.

Additional details regarding the HF5000 Tack ™ including application guidelines and application rates have been included in Appendix A.

The application rates to be used will follow established guidelines to ensure proper dust control on inactive construction areas. The frequency of application of the chemical soil stabilizer will be adjusted as necessary to ensure fugitive dust emissions are minimized. Chemical soil stabilizers will be applied to all inactive construction areas that have the potential to produce fugitive dust.

2.3 Landfill

The on-site landfill was formerly used to landfill ash. This landfill has been inactive since 2015. A vegetated intermediate soil cover has been installed on the landfill surface and as such the landfill is not currently a potential source of fugitive dust emissions. The landfill will require the placement of final cover in the future that will consist of the placement of clay, topsoil and vegetation. Dust suppression measures will be employed during this construction project consisting of the following BMPs:

2.3.1 Track-Out Controls

Fugitive dust can be generated from soil and debris being tracked out onto paved surfaces. TCD will minimize track-out by installing gravel aprons or similar control devices at intersections of unpaved project areas and existing paved roadways being used during construction.

2.3.2 Water Trucks

Water trucks will be utilized to apply water to exposed construction areas unless existing conditions are sufficiently wet to prevent dust (during or immediately following a rain event). Water will be regularly applied prior to, during and after earthmoving operations and vegetative clearing as necessary to reduce fugitive emissions. Water trucks and related equipment will be dedicated to the projects and available during all work hours when construction-related activities are occurring. Chemical dust suppression will be used as necessary during periods of the year for which water control is not practicable.

2.3.3 Material Storage And Handling

Soil stockpiles generated as part of the project will be maintained to reduce fugitive dust. Soil stockpiles may be stabilized by wetting to form a crust or other treatment including chemical soil stabilizers as further detailed below.

Any project-related person operating a vehicle on a public roadway with a load of dirt, sand, gravel or other loose material that is susceptible to generate dust will cover the load or maintain two feet or more of freeboard during transportation.

2.4 Main Ash Pond/Old Ash Area

Construction activities are planned at the Main Ash Pond/Old Ash Area to regrade the ash surface and provide final cover materials. The following dust suppression BMPs will be utilized in this area.

2.4.1 Track-Out Controls

Fugitive dust can be generated from soil and debris being tracked out onto paved surfaces. TCD will minimize track-out by installing gravel aprons or similar control devices at intersections of unpaved project areas and existing paved roadways being used during construction.

2.4.2 Water Trucks

Water trucks will be utilized to apply water to exposed construction areas unless existing conditions are sufficiently wet to prevent dust (during or immediately following a rain event). Water will be regularly applied prior to, during and after earthmoving operations and vegetative clearing as necessary to reduce fugitive emissions. Water trucks and related equipment will be dedicated to the projects and available during all work hours when construction-related activities are occurring. Chemical dust suppression will be used as necessary during periods of the year for which water control is not practicable.

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Soil stockpiles generated as part of the project will be maintained to reduce fugitive dust. Soil stockpiles may be stabilized by wetting to form a crust or other treatment including chemical soil stabilizers as further detailed below.
Any project-related person operating a vehicle on a public roadway with a load of dirt, sand, gravel or other loose material that is susceptible to generate dust will cover the load or maintain two feet or more of freeboard during transportation.

2.4.4 Chemical Soil Stabilizers

Dust control during construction will be achieved primarily through the application of water; however, chemical soil stabilizers will also be used in some instances and locations. Chemical soil stabilizers will be applied in lieu of water to form and maintain a crust on inactive construction areas and specifically areas of exposed ash subject to dust generation in the Fly Ash Pond. Chemical soil stabilizers are not suitable for use on roadways or active areas as these materials provide a tackified surface that is easily broken down with traffic. As such, this BMP for dust control is unsuitable for use in traffic areas.

Chemical soil stabilizers to be placed on inactive areas will include the use of HF5000 Tack™ High Performance Tackifier or equivalent products. This product is an environmentally safe organic tackifier specifically formulated to be used as a stand-alone spray for dust control to prevent wind/water erosion. Additional details regarding the HF5000 Tack ™ including application guidelines and application rates have been included in Appendix A.

The application rates to be used will follow established guidelines to ensure proper dust control on inactive construction areas. The frequency of application of the chemical soil stabilizer will be adjusted as necessary to ensure fugitive dust emissions are minimized. Chemical soil stabilizers will be applied to all inactive construction areas that have the potential to produce fugitive dust.

3 PLAN IMPLEMENTATION

3.1 Responsible Personnel

TCD will have responsible individuals on-site during all periods of construction activity. On-site individuals responsible for the application of fugitive dust control measures and visible emission notations will include:

Artie Toms- (618) 340-0755

Tim Johnson – (812) 907—0073

Assessments will be completed and dust control measures implemented as necessary during off-days when construction activity is not occurring. Back up personnel will be provided as necessary.

3.2 Procedures for Periodic Assessment of Plan

The site will routinely perform inspections to verify the effectiveness of the Plan. Inspections are conducted during daylight working hours and include observing for the presence of fugitive dust emissions from vehicles on site roads, and emission from active or inactive construction areas. Visible emission notations shall be performed daily to confirm compliance with the requirements of this Plan. Inspection records include information such as the name of the person conducting the inspection, the date and time of the inspection, the results of the inspection, and any corrective action taken.

The plan also will be reassessed in the event of material changes in site conditions potentially resulting in fugitive dust becoming airborne at the facility.

3.3 Amendments

The Plan may be amended at any time as site conditions warrant or if there is a change in conditions that substantially affect the written plan in effect. Plan amendments will be forwarded to IDEM as necessary.

APPENDIX A

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RANTEC

innovative turf solutions

HF5000 Tack™

High Performance Tackifier

HF5000 Tack™

Description: HF5000 Tack™ is an organic tackifier specially formulated to provide long-term strength and erosion control. HF5000 Tack ™ may be utilized with fiber or as a stand-alone over-spray for dust control or to tack straw/hay to prevent wind/water erosion.

Application Guideline: HF5000 Tack™ may be prepared for application by mixing at 10 to 35-lb per 1000 gallons of water. Higher concentrations may be used with equipment capable of mixing and pumping higher viscosity.
HF5000 Tack™ reduces pumping friction and improves spray patterns due to its unique polymer properties.

Application Rates:

Slope:	FLAT	4:1	3:1	2:1	1:1
Lb./acre:	15-40	40-60	60-80	80-120	120-220

Loading Sequence: Refer to the equipment manufacturers loading sequence instructions.

Site Preparation: Grade preparation should divert water flow away from the face of the slope.

Storage: Maintain packaging integrity. Protect from weather, moisture, and high temperatures.

Handling: Slippery when wet. Clean up spills immediately.

Manufactured by: Rantec Corp.
P.O. Box 729
Ranchester, WY 82839

Distributed by: Innovative Turf Solutions
513-317-8311
www.innovativeturfsolutions.com

HF5000 Tack™ is packaged in 50-lb bags, 40 per pallet.

innovative turf solutions

HF5000 Tack™

innovative turf solutions

Application

Flat	15-40 lbs. per Acre
4:1 Slope	40-60 lbs. per Acre
3:1 Slope	60-80 lbs. per Acre
2:1 Slope	80-120 lbs. per Acre
1:1 Slope	120-220 lbs. per Acre

HF5000 Tack™ meets or exceeds the requirements for non-asphaltic mulching emulsions.
Contains: Polysaccharide

Directions For Use: When the hydraulic hydroseeder is approximately one-third full of water, Slowly add HF5000 Tack™ to form a uniform slurry.
Manufacturers Instructions: Refer to the equipment manufacturers additional loading sequence instructions.

Net Wt. 50 lb. bag

Manufactured by: Rantec Corp. P.O. Box 729 Ranchester, WY 82839

Distributed by: Innovative Turf Solutions www.innovativeturfsolutions.com 513-317-8311

HF5000 Tack™

innovative turf solutions

Application

Flat	15-40 lbs. per Acre
4:1 Slope	40-60 lbs. per Acre
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Distributed by: Innovative Turf Solutions www.innovativeturfsolutions.com 513-317-8311

FLY ASH POND CLOSURE
TANNERS CREEK PLANT

LAWRENCEBURG, DEARBORN COUNTY, INDIANA
S&ME PROJECT NO. 7217-17-007
JUNE 22, 2018

VICINITY MAP
SCALE: NTS

PROJECT DESCRIPTION:

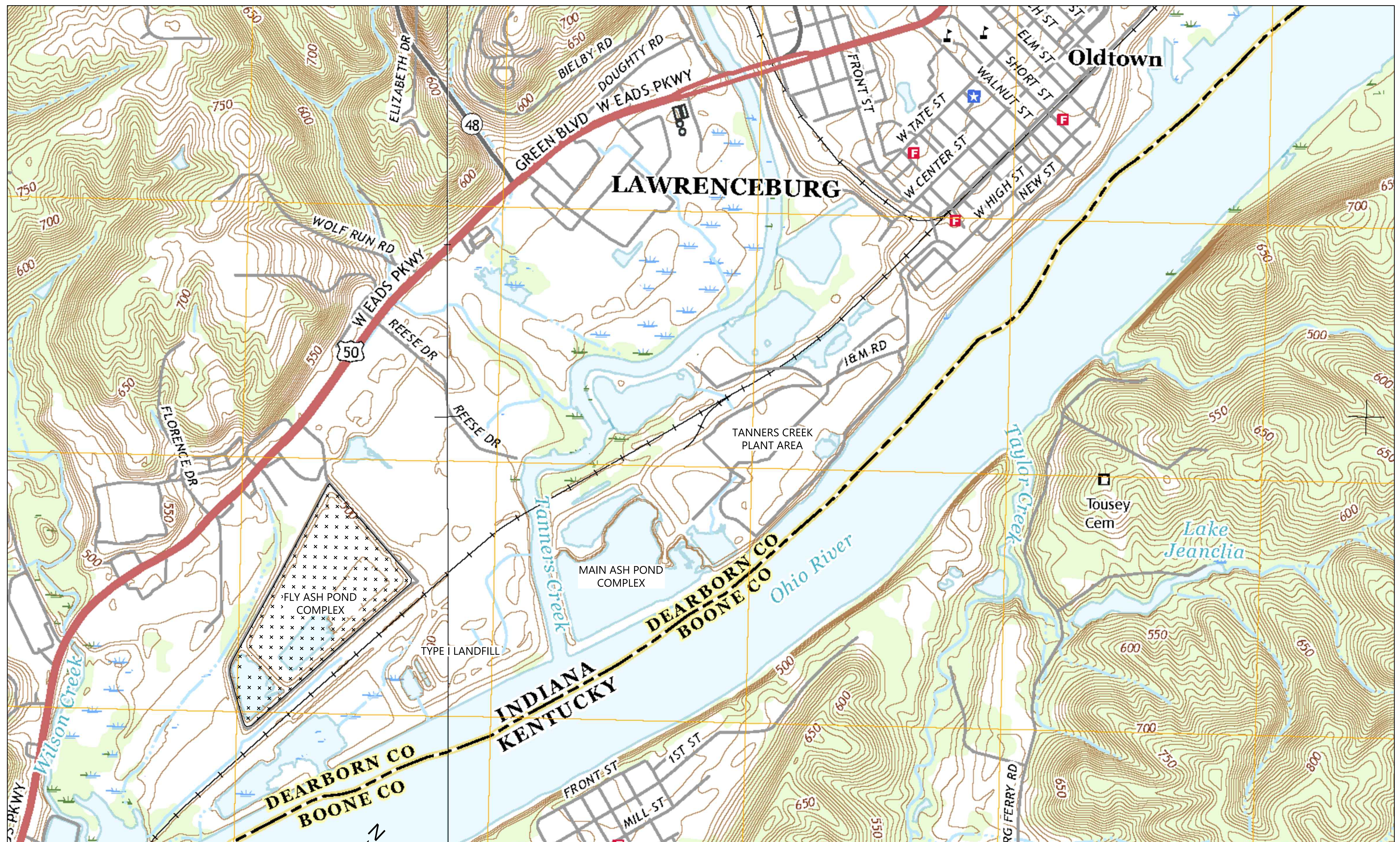
PROJECT CONSISTS OF THE FINAL CLOSURE OF THE FLY ASH POND BY GRADING THE ASH AND INSTALLING A GEOSYNTHETIC-LINED COVER SYSTEM. WORK TO BE CARRIED OUT IN TWO PHASES:

PHASE I:

- EXCAVATION OF A STORMWATER CHANNEL ALONG THE INBOARD SLOPE OF THE EXISTING SOIL DIKE AT THE TOE OF THE ASH DIKE.
- EXCAVATION OF EAST AND WEST BREACH CHANNELS THROUGH THE EXISTING ASH DIKE.
- REGRADING ASH WITHIN THE FLY ASH POND (FAP) UPPER BASIN TO MATCH FINAL CONFIGURATION.
- INSTALLATION OF FINAL COVER SYSTEM OVER THE FLY ASH POND UPPER BASIN.
- INSTALLATION OF TEMPORARY AND PERMANENT EROSION AND SEDIMENT CONTROL MEASURES.

PHASE II

- EXCAVATION OF SOIL DIKE BREACHES IN CONJUNCTION WITH FILL PLACEMENT WITHIN THE PERIMETER STORM WATER CHANNEL TO CUT OFF FAP STORMWATER FROM REACHING THE CLEAR WATER POND.
- REGRADING ASH WITHIN THE CLEAR WATER POND TO MATCH FINAL CONFIGURATION.
- INSTALLATION OF FINAL COVER SYSTEM OVER THE CLEAR WATER POND AREA.
- INSTALLATION OF TEMPORARY AND PERMANENT EROSION AND SEDIMENT CONTROL MEASURES.



0 200 400 600 800 1000 2000 3000
GRAPHIC SCALE IN FEET

SITE LOCATION MAP
SCALE: 1" = 1000'

SHEET LIST

△	01	COVER SHEET
	02	GENERAL NOTES
△	03	EXISTING CONDITIONS
	04	DEMOLITION PLAN
	05	INITIAL SURFACE WATER CONTROLS
△	06	PHASE I ASH GRADING
△	07	PHASE I COVER SYSTEM
△	08	FINAL SURFACE WATER CONTROLS
△	09	PHASE II ASH GRADING
△	10	PHASE II COVER SYSTEM
△	11	ASH BREACH PLAN, PROFILE AND DETAILS
	12	SOIL BREACH PLAN, PROFILE AND DETAILS
	13	TYPICAL SECTIONS
△	14	GENERAL DETAILS
△	15	GENERAL DETAILS
	16	GENERAL DETAILS
△	17	CROSS-SECTIONS

OWNER
TANNERS CREEK DEVELOPMENT, LLC
1650 DES PERES RD., SUITE 303
ST. LOUIS, MO 63131

PREPARED BY
S&ME
WWW.SMEINC.COM
6190 ENTERPRISE COURT
DUBLIN, OH 43016
(614) 793-2226

MICHAEL T ROMANELLO REGISTERED PE11600160 STATE OF INDIANA PROFESSIONAL ENGINEER 10-13-17

ISSUED FOR APPROVAL

S&ME
WWW.SMEINC.COM
6190 ENTERPRISE COURT
DUBLIN, OH 43016
(614) 793-2226
ENGINEERING FIRM LICENSE NUMBER: 03530

TANNERS CREEK DEVELOPMENT, LLC
1650 DES PERES RD., SUITE 303
ST. LOUIS, MO 63131

FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
2	06/22/18	UPDATED FOR IDEM 5/10/18 RAI	PSS	MGR	MTR
1	03/09/18	IDEM RAI NO. 1	DCV	MGR	MTR
0	10/31/17	ISSUED FOR APPROVAL	IDT	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
1

DRAWING NAME
COVER SHEET

T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\01_COVER SHEET.dwg-Cover Sheet Jun 21, 2018 - 12:18pm psimko

1 GENERAL

1.1 ANY DISCREPANCY FOUND BETWEEN THE DRAWINGS AND SITE CONDITIONS OR ANY INCONSISTENCIES OR AMBIGUITIES IN DRAWINGS SHALL BE IMMEDIATELY REPORTED TO THE OWNER'S REPRESENTATIVE, IN WRITING, WHO SHALL PROMPTLY ADDRESS SUCH PROBLEMS. WORK DONE BY THE CONTRACTOR AFTER THE DISCOVERY OF SUCH DISCREPANCIES, INCONSISTENCIES OR AMBIGUITIES BEFORE THE OWNER'S REPRESENTATIVE ADDRESSES THE PROBLEMS SHALL BE DONE AT THE CONTRACTOR'S RISK.

1.2 THIS PROJECT INVOLVES GRADING OF COAL COMBUSTION RESIDUALS (CCR) GENERATED AT THE TANNERS CREEK POWER PLANT. CCR GENERATED AT COAL BURNING POWER PLANTS IS KNOWN TO CONTAIN HAZARDOUS MATERIALS AND HAS THE POTENTIAL TO IMPACT HEALTH IF IMPROPERLY HANDLED. THE CONTRACTOR IS RESPONSIBLE FOR DEVELOPMENT OF A HEALTH AND SAFETY PLAN SPECIFIC TO THIS PROJECT THAT ADDRESSES THE SPECIFIC MEANS AND METHODS SELECTED BY THE CONTRACTOR TO ACCOMPLISH THE PROJECT AND CONSIDERS POTENTIAL EXPOSURES OF THEIR EMPLOYEES TO THE FLY ASH MATERIALS. NEITHER S&ME, INC. NOR OUR CLIENT IS RESPONSIBLE FOR THE CONTRACTOR'S HEALTH AND SAFETY PROGRAM FOR THIS WORK.

1.3 THE CONTRACTOR ACKNOWLEDGES ACCEPTANCE CONCERNING THE NATURE AND LOCATION OF THE WORK, THE GENERAL AND LOCAL CONDITIONS, PARTICULARLY THOSE BEARING UPON TRANSPORTATION, DISPOSAL, HANDLING AND STORAGE OF MATERIALS, AVAILABILITY OF LABOR, WATER, ELECTRIC, POWER, ROADS, AND UNCERTAINTY OF WEATHER, GROUNDWATER TABLE OR SIMILAR PHYSICAL CONDITIONS AT THE SITE, THE SUBSURFACE MATERIALS TO BE ENCOUNTERED, THE PRESENCE AND LOCATION OF SUBSURFACE UTILITIES, THE CHARACTER OF EQUIPMENT AND FACILITIES NEEDED PRIOR TO AND DURING THE PROSECUTION OF THE WORK OR THE COST THEREOF UNDER THIS CONTRACT.

1.4 TOPOGRAPHIC INFORMATION SHOWN WITHIN THE PROJECT AREA IS BASED ON AN AERIAL TOPOGRAPHIC SURVEY PERFORMED BY GEOPRO CONSULTANTS IN MARCH, 2017. SUBSEQUENT TO THE TOPOGRAPHIC SURVEY, GRADING ACTIVITIES HAVE BEEN PERFORMED BY THE OWNER WHICH ARE NOT REFLECTED ON THESE DRAWINGS . DATUM: INDIANA STATE PLANE - SOUTH NAD 83 / NAVD 88. GEOPRO SUPPLEMENTED THE AERIAL FLYOVER SURVEY WITH GROUND SURVEY SHOTS.

1.5 WHERE 'OWNER' IS REFERRED TO IN THE PLANS IT SHALL MEAN TANNERS CREEK DEVELOPMENT, LLC. WHERE OWNER'S REPRESENTATIVE IS REFERRED TO IT SHALL MEAN THE FIELD REPRESENTATIVE DESIGNATED BY THE OWNER. INDOT REFERS TO THE 'STATE OF INDIANA DEPARTMENT OF TRANSPORTATION'.

1.6 'INDOT ITEMS' REFER TO THE INDOT STANDARD SPECIFICATIONS, 2016 EDITION. THIS DOCUMENT SHALL GOVERN MATERIALS AND WORKMANSHIP INVOLVED IN THE IMPROVEMENTS SHOWN ON THESE PLANS, EXCEPT WHERE MODIFIED BY THE GENERAL NOTES, CONSTRUCTION DETAILS, OR QA/QC PLAN.

1.7 ALL TRENCHING AND RELATED CONSTRUCTION ACTIVITIES SHALL BE PERFORMED IN ACCORDANCE WITH OSHA 29 CFR 1926 SUBPART P, EXCAVATIONS.

1.8 THE CONTRACTOR SHALL CHECK ALL EXISTING CONDITIONS, (i.e. INVERTS, UTILITY ROUTINGS, UTILITY CROSSINGS, AND DIMENSIONS) IN THE FIELD PRIOR TO COMMENCEMENT OF WORK. REPORT ANY DISCREPANCIES TO THE ENGINEER.

1.9 THE CONTRACTOR SHALL VERIFY THE EXACT LOCATION OF ALL EXISTING UTILITIES. TAKE CARE TO PROTECT UTILITIES OR STRUCTURES THAT ARE TO REMAIN. REPAIR ANY DAMAGE ACCORDING TO LOCAL STANDARDS AND AT THE CONTRACTOR'S EXPENSE. COORDINATE ALL CONSTRUCTION WITH THE APPROPRIATE UTILITY COMPANY. THE CONTRACTOR SHALL CALL NATIONAL ONE CALL (811) 72 HOURS PRIOR TO PROCEEDING WITH ANY EXCAVATION.

1.10 THE CONTRACTOR SHALL CONFORM TO ALL LOCAL CODES AND RECEIVE APPROVAL WHERE NECESSARY BEFORE CONSTRUCTION.

1.11 ANY WORK UNACCEPTABLE TO THE OWNER'S REPRESENTATIVE OR TO THE LOCAL GOVERNING AUTHORITY SHALL BE REPAIRED OR REPLACED BY THE CONTRACTOR AT NO ADDITIONAL EXPENSE TO THE OWNER.

2 TEMPORARY FACILITIES AND CONTROLS

2.1 THE CONTRACTOR SHALL KEEP THE SITE FREE OF TRASH, LITTER AND WASTE MATERIAL, AND SHALL MAINTAIN THE SITE IN A NEAT AND ORDERLY CONDITION THROUGHOUT THE ENTIRE PROJECT. THE CONTRACTOR SHALL REMOVE ALL ASH, MUD, SOIL AND DEBRIS THAT MAY BE TRACKED ONTO EXISTING STREETS, DRIVES OR WALKS BY THEIR EQUIPMENT OR THAT OF SUBCONTRACTORS OR SUPPLIERS ON A DAILY BASIS.

2.2 ALL WORK IS TO BE COMPLETED IN ACCORDANCE WITH THE PLANS AS DEEMED ACCEPTABLE TO THE OWNER. NO WORK SHALL COMMENCE UNTIL ARRANGEMENTS HAVE BEEN MADE WITH THE OWNER FOR CONSTRUCTION OBSERVATION AND DOCUMENTATION.

2.3 THE CONTRACTOR AND ALL THE SUBCONTRACTORS SHALL BE RESPONSIBLE FOR COMPLYING WITH ALL FEDERAL, STATE AND LOCAL SAFETY REQUIREMENTS TOGETHER WITH EXERCISING PRECAUTIONS AT ALL TIMES FOR THE PROTECTION OF PERSONS (INCLUDING EMPLOYEES) AND PROPERTY. IT IS ALSO THE RESPONSIBILITY OF THE CONTRACTOR AND SUBCONTRACTORS TO INITIATE, MAINTAIN AND SUPERVISE ALL SAFETY REQUIREMENTS, PRECAUTIONS AND PROGRAMS IN CONNECTION WITH THE WORK. THE CONTRACTOR AND SUBCONTRACTORS SHALL ALSO ABIDE BY ALL ORDINANCES OF DEARBORN COUNTY.

2.4 CONTRACTOR SHALL PROVIDE AND MAINTAIN TEMPORARY SANITARY FACILITIES AND ENCLOSURES. USE OF EXISTING FACILITIES IS NOT PERMITTED. THE FACILITY SHALL BE MAINTAINED IN CLEAN AND SANITARY CONDITION DAILY. AT END OF CONSTRUCTION, CONTRACTOR SHALL REMOVE ALL TEMPORARY FACILITIES AND RETURN SITE TO SAME OR BETTER CONDITION.

2.5 CONTRACTOR SHALL PROVIDE WASTE REMOVAL FACILITIES AND SERVICES AS REQUIRED TO MAINTAIN THE SITE IN A CLEAN AND ORDERLY CONDITION. CONTAINERS SHALL HAVE LIDS. AT END OF CONSTRUCTION, REMOVE ALL TEMPORARY WASTE CONTAINERS AND RETURN SITE TO SAME OR BETTER CONDITION.

2.6 CONTRACTOR SHALL PROVIDE BARRIERS TO PREVENT UNAUTHORIZED ENTRY TO CONSTRUCTION AREAS. CONTRACTOR SHALL KEEP AUTOMOBILES AWAY FROM CONSTRUCTION AREAS, AND SHALL NOT BLOCK ACCESS TO EXISTING FACILITIES. CONTRACTOR SHALL PROTECT STORED MATERIALS, AND PROTECT EXISTING FACILITIES AND ADJACENT PROPERTIES FROM DAMAGE FROM CONSTRUCTION OPERATIONS.

2.7 CONTRACTOR SHALL OBTAIN OWNER'S APPROVAL FOR USE AND OWNER'S PERMISSION FOR LOCATION PRIOR TO USE OF SITE TRAILERS OR SHEDS, IF NECESSARY.

2.8 CONTRACTOR SHALL NOT DISTURB ADJACENT PROPERTY OWNERS' PROPERTY, EXCEPT WHERE INDICATED ON THE PLANS.

3 EROSION CONTROL NOTES

3.1 SURFACE WATER CONTROLS HAVE BEEN DESIGNED TO MANAGE ALL CONTACT WATER RUNOFF THROUGH THE EXISITNG CLEAR WATER POND. THE CONTRACTOR IS RESPONSIBLE FOR DISCHARGING WATER FROM THE CLEAR WATER POND TO THE MAIN ASH POND VIA PUMPING. THE CONTRACTOR MAY COORDINATE WITH THE OWNER REGARDING THE USE OF EXISTING EQUIPMENT TO PERFORM PUMPING OPERATIONS.

3.2 SURFACE WATER RUNOFF FROM FINAL GRADES WILL BE INITIALLY MANAGED THROUGH THE EXISTING CLEAR WATER POND. AS PART OF THE FINAL SURFACE WATER CONTROL IMPLEMENTATION, EROSION AND SEDIMENT CONTROL MEASURES SHALL BE USED FOR SURFACE WATER RUNOFF NOT ENTERING THE CLEAR WATER POND, AS DETAILED ON THE PLANS.

3.3 EROSION PREVENTION AND SEDIMENT CONTROL MEASURES MUST BE IN PLACE AND FUNCTIONAL BEFORE THE SOIL BREACH EXCAVATION IS CONDUCTED AND MUST BE MAINTAINED THROUGHOUT THE CONSTRUCTION PERIOD. TEMPORARY MEASURES MAY BE REMOVED AT THE BEGINNING OF THE WORKDAY BUT MUST BE REPLACED AT THE END OF THE WORKDAY.

3.4 THE FOLLOWING RECORDS SHALL BE MAINTAINED ON OR NEAR SITE: THE DATES WHEN MAJOR GRADING ACTIVITIES OCCUR; THE DATES WHEN CONSTRUCTION ACTIVITIES TEMPORARILY OR PERMANENTLY CEASE ON A PORTION OF THE SITE; THE DATES WHEN STABILIZATION MEASURES ARE INITIATED; INSPECTION RECORDS AND RAINFALL RECORDS.

3.5 THE CONTRACTOR SHALL MAINTAIN A RAIN GAUGE AND DAILY RAINFALL RECORDS AT THE SITE OR USE A REFERENCE SITE FOR A RECORD OF DAILY AMOUNT OF PRECIPITATION.

3.6 PRE-CONSTRUCTION VEGETATIVE GROUND COVER SHALL NOT BE DESTROYED, REMOVED OR DISTURBED MORE THAN 10 DAYS PRIOR TO GRADING OR EARTH MOVING UNLESS THE AREA IS SEEDED AND/OR MULCHED OR OTHER TEMPORARY COVER IS INSTALLED.

3.7 CONSTRUCTION MUST BE SEQUENCED TO MINIMIZE THE EXPOSURE TIME OF GRADED OR DENUDED AREAS.

3.8 SEDIMENT SHOULD BE REMOVED FROM SEDIMENT TRAPS, SILT FENCES, SEDIMENTATION PONDS AND OTHER SEDIMENT CONTROLS AS NECESSARY AND MUST BE REMOVED WHEN DESIGN CAPACITY HAS BEEN REDUCED BY 50% OR AS DIRECTED BY OWNERS REPRESENTATIVE.

3.9 THE CONTRACTOR SHALL REMOVE SEDIMENT FROM ALL DRAINAGE STRUCTURES BEFORE ACCEPTANCE BY LOCAL GOVERNING AGENCY OR AS DIRECTED BY THE OWNER'S REPRESENTATIVE.

3.10 THE CONTRACTOR SHALL REMOVE THE TEMPORARY EROSION AND WATER POLLUTION CONTROL DEVICES ONLY AFTER A SOLID STAND OF GRASS HAS BEEN ESTABLISHED ON GRADED AREAS AND WHEN IN THE OPINION OF THE OWNER'S REPRESENTATIVE, THEY ARE NO LONGER NEEDED.

3.11 THE CONTRACTOR IS RESPONSIBLE FOR THE CONTROL OF DUST AT THE SITE BY USE OF WATER SPRINKLERS. OTHER DUST CONTROL MEASURES SHALL BE APPROVED BY THE OWNER. ALL WORK SHALL BE PERFORMED TO MINIMIZE DUST TO THE GREATEST EXTENT PRACTICAL.

4 DEMOLITION NOTES

4.1 ALL MATERIALS BEING REMOVED AND NOT RELOCATED UNDER THE NEW CONSTRUCTION, INCLUDING TREES AND SHRUBS, SIGNS, UTILITY STRUCTURES, ETC., SHALL BE FIRST OFFERED TO THE OWNER'S REPRESENTATIVE AND IF NOT ACCEPTED SHALL THEN BE PROPERLY DISPOSED OF BY THE CONTRACTOR.

4.2 THE CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL CHARTED AND UNCHARTED UTILITIES. TAKE CARE TO PROTECT UTILITIES THAT ARE TO REMAIN. REPAIR ANY DAMAGE ACCORDING TO LOCAL STANDARDS AND AT THE CONTRACTOR'S EXPENSE. COORDINATE ALL CONSTRUCTION WITH THE APPROPRIATE UTILITY COMPANY.

4.3 THE CONTRACTOR SHALL VERIFY THE LIMITS OF DEMOLITION WITH THE OWNER'S REPRESENTATIVE PRIOR TO COMMENCEMENT OF WORK.

4.4 CAVITIES LEFT BY STRUCTURE REMOVAL SHALL BE SUITABLY BACKFILLED AND COMPACTED IN ACCORDANCE WITH THESE PLANS.

4.5 THE CONTRACTOR SHALL USE WATER SPRINKLING AND OTHER SUITABLE METHODS AS NECESSARY TO CONTROL DUST AND DIRT CAUSED BY THE DEMOLITION WORK.

4.6 THE CONTRACTOR IS RESPONSIBLE FOR ALL DEMOLITION AND REMOVAL NECESSARY TO ACCOMPLISH THE PROPOSED CLOSURE ACTIVITIES SHOWN ON THESE PLANS.

4.7 THE CONTRACTOR SHALL PRESERVE AND PROTECT SURVEY CONTROL POINTS AND SHALL BE RESPONSIBLE FOR REPLACEMENT OF ANY DISTURBED CONTROL POINTS.

5 CONSTRUCTION SEQUENCE

5.1 PLAN SHEETS 4 THROUGH 10 HAVE BEEN SEQUENTIALLY NUMBERED TO FOLLOW THE GENERAL SEQUENCE OF CONSTRUCTION. THE FOLLOWING IS A GENERAL DESCRIPTION OF THE INTENDED CONSTRUCTION SEQUENCE FOR THE POND CLOSURE:

PHASE 1

- DEMOLITION OF STRUCTURES AND MATERIALS (SHEET 4);
- EXCAVATION OF A STORMWATER CHANNEL ALONG THE INBOARD SLOPE OF THE EXISTING SOIL DIKE AT THE TOE OF THE BOTTOM ASH DIKE (SHEET 5);
- EXCAVATION OF TWO BREACH CHANNELS THROUGH THE EXISTING BOTTOM ASH DIKE (SHEET 6);
- REGRADING ASH WITHIN THE FLY ASH POND UPPER BASIN IN ACCORDANCE WITH THE PHASE 1 TOP OF ASH GRADING PLAN (SHEET 6).
- INSTALLATION OF PHASE 1 FINAL COVER SYSTEM OVER THE FLY ASH POND UPPER BASIN (SHEETS 6 & 7).

PHASE 2

- EXTENSION OF THE BREACH CHANNELS THROUGH THE SOIL DIKE IN CONJUNCTION WITH FILL PLACEMENT WITHIN THE PERIMETER STORM WATER CHANNEL TO CUT OFF FAP STORMWATER FROM REACHING THE CLEAR WATER POND (SHEET 8).
- REGRADING ASH WITHIN THE CLEAR WATER POND IN ACCORDANCE WITH PHASE 2 TOP OF ASH GRADING PLAN (SHEET 9).
- INSTALLATION OF PHASE 2 FINAL COVER SYSTEM OVER THE CLEAR WATER POND AREA (SHEETS 9 & 10).
- IMPROVEMENTS TO EXISTING PERIMETER DITCHES AT THE TOE OF THE SOIL DIKES IN CONJUNCTION WITH THE INSTALLATION OF TEMPORARY AND PERMANENT EROSION AND SEDIMENT CONTROL MEASURES.

6 SITE GRADING NOTES

6.1 THE DISTURBED AREA FOR THIS PROJECT IS APPROXIMATELY 75 ACRES.

6.2 THE SUBJECT PROPERTY DOES LIE WITHIN A SPECIAL FLOOD HAZARD ZONE ACCORDING TO COMMUNITY PANEL NO. FEMA PANEL 0184C OF THE F.E.M.A. FLOOD INSURANCE RATE MAPS FOR DEARBORN COUNTY, INDIANA, WITH AN EFFECTIVE DATE OF APRIL 16, 2014 .

6.3 MULCH AND SEED ALL DISTURBED AREAS AS SOON AS POSSIBLE AFTER FINAL GRADING IS COMPLETED, UNLESS OTHERWISE INDICATED. CONTRACTOR SHALL TAKE WHATEVER MEANS NECESSARY TO ESTABLISH PERMANENT SOIL STABILIZATION.

6.4 MAINTAIN PUBLIC ROADWAYS FREE OF TRACKED MUD, DIRT AND ASH.

6.5 PROPOSED CONTOUR LINES ARE THE RESULT OF AN ENGINEERED GRADING DESIGN AND REFLECT A PLANNED INTENT WITH REGARD TO DRAINAGE AND MOVEMENT OF MATERIALS. SHOULD THE CONTRACTOR HAVE ANY QUESTION OF THE INTENT OR ANY PROBLEM WITH THE CONTINUITY OF GRADES, THE ENGINEER SHALL BE CONTACTED IMMEDIATELY.

6.6 CUT AND FILL SLOPES VARY AND SHALL BE AS INDICATED ON THE PLANS.

6.7 IN NO CASE SHALL SLOPE, HEIGHT, SLOPE INCLINATION, OR EXCAVATION DEPTH, INCLUDING TRENCH CONSTRUCTION, EXCEED THOSE SPECIFIED IN LOCAL, STATE AND FEDERAL REGULATIONS, SPECIFICALLY THE CURRENT OSHA HEALTH AND SAFETY STANDARDS FOR EXCAVATIONS (29 CRF PART 1926) SHALL BE FOLLOWED.

6.8 POSITIVE DRAINAGE SHALL BE ESTABLISHED AS THE FIRST ORDER OF WORK AND SHALL BE MAINTAINED AT ALL TIMES DURING AND AFTER CONSTRUCTION. GROUNDWATER INFILTRATION INTO EXCAVATIONS SHOULD BE EXPECTED, AND THE WATER SHALL BE REMOVED USING GRAVITY DRAINAGE OR PUMPING.

6.9 ALL CONSTRUCTION PROCEDURES, INCLUDING SUBGRADE PREPARATION, ASH AND EARTH FILL PLACEMENT, AND INSTALLATION OF GEOSYNTHETIC MATERIALS SHALL FOLLOW THE QA/QC MANUAL DATED SEPTEMBER 1, 2017 PREPARED AS PART OF THE FLY ASH POND CLOSURE PLAN.

6.10 SEDIMENT REMOVED FROM SEDIMENT CONTROL STRUCTURES IS TO BE PLACED AT A SITE APPROVED BY THE OWNER. IT SHALL BE TREATED IN A MANNER SO THAT THE AREA AROUND THE DISPOSAL SITE WILL NOT BE CONTAMINATED OR DAMAGED BY THE SEDIMENT IN THE RUN-OFF. COST FOR THIS TREATMENT IS TO BE INCLUDED IN PRICE BID FOR EROSION AND SEDIMENT CONTROL.

6.11 STOCKPILED TOPSOIL OR FILL MATERIAL IS TO BE TREATED SO THE SEDIMENT RUN-OFF WILL NOT CONTAMINATE SURROUNDING AREAS OR ENTER NEARBY STREAMS.

6.12 IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO WASTE, IF NECESSARY, EXCESS ASH MATERIAL OFF SITE TO THE TANNERS CREEK LANDFILL WITH ADVANCED NOTIFICATION TO THE OWNER AND OWNER'S REPRESENTATIVE.

7 FABRIC FORMED CONCRETE CHANNEL

7.1 PLACE GEOTEXTILE LAYER AND FABRIC LAYER OVER THE GRADED AND COMPACTED AREAS IMMEDIATELY FOLLOWING SLOPE PREPARATION. THE GEOTEXTILE LAYER SHOULD BE PLACED LOOSELY BUT WITHOUT WRINKLES, AND WITH A MINIMUM OVERLAP OF 2 FEET.

7.2 PLACING, JOINING, AND ANCHORING OF CONCRETE FABRIC SHALL BE PERFORMED IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS AND THE APPROVED SUBMITTALS, AND TO THE LINES AND GRADES SHOWN ON THE DRAWINGS.

7.3 CONCRETE PLACEMENT WITHIN THE CONCRETE FABRIC SHALL BE PERFORMED IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS.

7.4 ALLOW CONCRETE TO CURE 48 HOURS. FINE GRADE ALONG EDGES OF FABRIC FORMED CONCRETE CHANNEL.

7.5 REPAIR, SEED, AND MULCH ALL DISTURBED AREAS IN ACCORDANCE WITH THE QA/QC PLAN.

7.6 FABRIC FOR CONCRETE CHANNEL (CONCRETE FABRIC): CHANNEL LINING SHALL CONSIST OF NOMINAL 6-INCH THICK FILTER POINT STYLE FABRIC-FORMED CONCRETE LINING (10" FILTER POINT SPACING). MATERIAL SHALL BE FABRIFORM FPNN BY CONSTRUCTION TECHNIQUES, HYDROTEX FP600 BY SYNTHETEX, OR APPROVED EQUAL.

7.7 CONCRETE: FINE AGGREGATE CONCRETE SHALL BE PROPORTIONED AND MIXED AS TO PROVIDE A PUMPABLE CONCRETE WITH A MINIMUM 28-DAY COMPRESSIVE STRENGTH OF 2,500 PSI; OR, AS RECOMMENDED BY FABRIC MANUFACTURER WITH ENGINEER'S APPROVAL. PROVIDE FINE AGGREGATE CONCRETE WITHIN THE FOLLOWING MIX PROPORTIONS, OR IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS:

7.8 TYPICAL RANGE OF MIX PROPERTIES:

MATERIAL	MIX PROPORTIONS AS DELIVERED (LB/CY)	STANDARD / SPECIFICIATION
CEMENT	750 - 900	ASTM C150, TYPE I OR II
SAND	2030 - 2120	ODOT CMS 703.03
WATER	540 - 555	ASTM C 1602
ENTRAINED AIR CONTENT	RANGE PER MANUFACTUR'S RECOMMENTADATION (MIN. 4%)	ASTM C 260

7.9 FIELD QUALITY CONTROL: CONTRACTOR SHALL MEASURE THE CONSISTENCY OF THE FINE AGGREGATE CONCRETE VIA THE FLOW CONE METHOD (ASTM C939). CONCRETE SAMPLES SHALL BE OBTAINED FROM THE END OF THE GROUT HOSE. RESULTS OF THE FLOW CONE METHOD SHALL BE USED TO ADJUST THE CONSISTENCY OF THE CONCRETE MIX, IF NECESSARY. THE TARGET TIME OF EFFLUX SHALL BE 9 TO 11 SECONDS, OR IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS.

7.10 FIELD QUALITY ASSURANCE: AS PART OF THE OWNER'S QUALITY ASSURANCE PROGRAM, THE OWNER'S REPRESENTATIVE WILL SAMPLE AND TEST GROUT IN ACCORDANCE WITH ASTM C1019 FOR ACCEPTANCE.

8 MATERIALS

8.1 ALL OFF-SITE FILL MATERIAL SHALL BE PREQUALIFIED, PLACED, AND COMPACTED IN ACCORDANCE WITH THE QA/QC MANUAL.

8.2 ALL ASPECTS OF THE GEOSYNTHETIC MATERIALS, INCLUDING PREQUALIFICATION, TESTING, AND INSTALLION, SHALL BE IN ACCORDANCE WITH THE QA/QC MANUAL.

8.3 DRAINAGE TUBING PIPE SHALL BE IN ACCORDANCE WITH IDOT ITEM 907.17(a). HDPE SHALL BE 6" DIAMETER SINGLE WALL CORRUGATED PIPE WITH PERFORATIONS. PERFORATIONS TO BE SLOTS WITH MAXIMUM SLIDE WIDTH OF 0.125 INCHES, AND SHALL PROVIDE AT LEAST 1.9 INCHES OF OPEN AREA PER LINEAR FOOT OF PIPE. TEE CONNECTION SHALL CONSIST OF HDPE FITTINGS.

8.4 OUTLET PIPE SHALL BE IN ACCORDANCE WITH IDOT ITEM 907.25(a) - SOLID WALL HDPE LINER PIPE. HDPE SHALL BE NOMIMAL 6" DIAMETER SDR-17 WITH BUTT FUSION JOINTS . ALL BENDS SHALL CONSIST OF SOLID WALL MOLDED HDPE FITTINGS. HDPE TO CORRUGATED PE CONNECTION SHALL CONSIST OF A FABRICATED COUPLING.

8.5 DRAINAGE AGGREGATE SHALL BE IN ACCORDANCE WITH IDOT ITEM 904.03. COARSE AGGREGATE STONE SIZE SHALL BE EITHER SIZE NO. 57, 67, OR 8.

8.6 CHANNEL LINING COVER MATERIAL SHALL MEET THE SAME MATRIAL AND INSTALLATION REQUIREMENT AS THE PROTECTIVE SOIL LAYER.

9 SUBMITTALS & RECORD DOCUMENTS

9.1 CONTRACTOR SHALL SUBMIT TO THE PROJECT TEAM ELECTRONIC COPIES OF SUBMITTALS, INCLUDING CONSTRUCTION SCHEDULE, MATERIAL CUT SHEETS AND AGGREGATE CERTIFICATES A MINIMUM OF 7 DAYS PRIOR THE SCHEDULED CONSTRUCTION ACTIVITY. GENERAL SUBMITTALS INCLUDE THE FOLLOWING:

- CONTRACTOR'S HEALTH AND SAFETY PLAN
- DUST CONTROL PLAN
- STORM WATER POLLUTION PREVENTION PLAN (SWPPP)
- WORK PLAN

9.2 CONTRACTOR SHALL PREPARE SUBMITTALS FOR ALL WORK ASSOCIATED WITH THE FABRIC-FORMED CONCRETE CHANNEL, WHICH INCLUDES, BUT MAY NOT BE LIMITED TO THE FOLLOWING:

- PRODUCT DATA
- MANUFACTURER SHOP FABRICATION DRAWINGS
- WORK INSTALLATION PLAN
- CONCRETE/GROUT MIX DESIGN
- CONCRETE PLACEMENT AND CURING PROCEDURES, INCLUDING PROPOSED PUMPING AND QUALITY CONTROL EQUIPMENT

9.3 THE CONTRACTOR SHALL BE RESPONSIBLE FOR RECORDING ALL THE APPROVED CHANGES TO THESE PLANS ON A SET OF RECORD DRAWINGS DURING CONSTRUCTION. THE PLANS ARE TO BE SUBMITTED TO THE OWNER'S REPRESENTATIVE AT COMPLETION OF THE PROJECT. ANY MODIFICATION TO THE WORK AS SHOWN ON THESE DRAWING MUST HAVE PRIOR WRITTEN APPROVAL OF OWNER OR OWNER'S REPRESENTATIVE.

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TANNERS CREEK
DEVELOPMENT, LLC
1650 DES PERES RD., SUITE 303
ST. LOUIS, MO 63131

FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

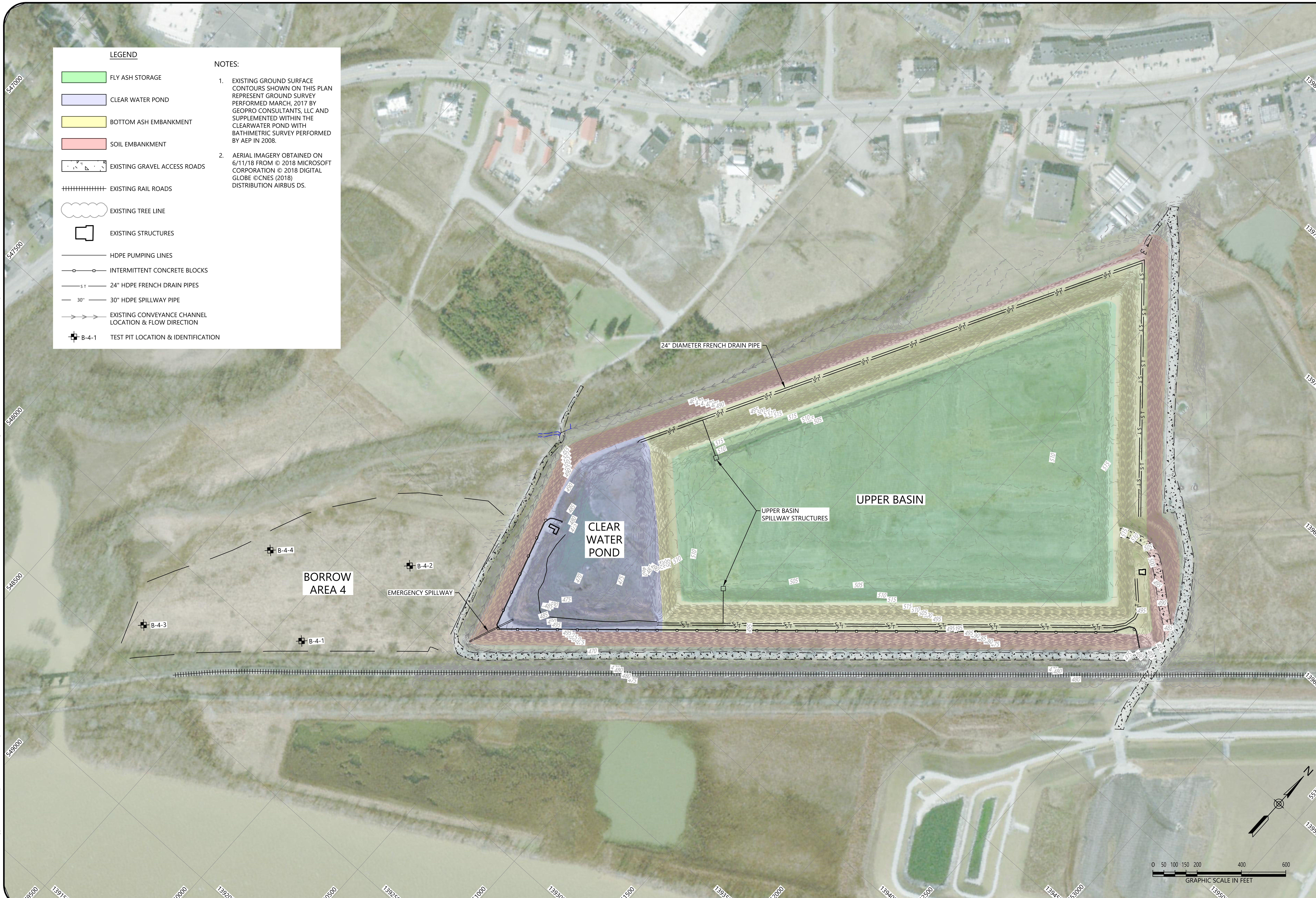
MICHAEL T ROMANELLO
REGISTERED
PE11600160
STATE OF
INDIANA
PROFESSIONAL ENGINEER
10-13-17

NO.	DATE	DESCRIPTION	BY	CHK	APV
0	10/31/17	ISSUED FOR APPROVAL	MTR	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
2

DRAWING NAME
GENERAL NOTES



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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

MICHAEL T. ROMANELLO REGISTERED PE11600160 STATE OF INDIANA PROFESSIONAL ENGINEER 10-13-17

NO.	DATE	DESCRIPTION	BY	CHK	APV
2	06/22/18	BORROW AREA 4 & TEST PITS ADDED	PSS	MGR	MTR
1	10/31/17	ISSUED FOR APPROVAL	JDT	MGR	MTR

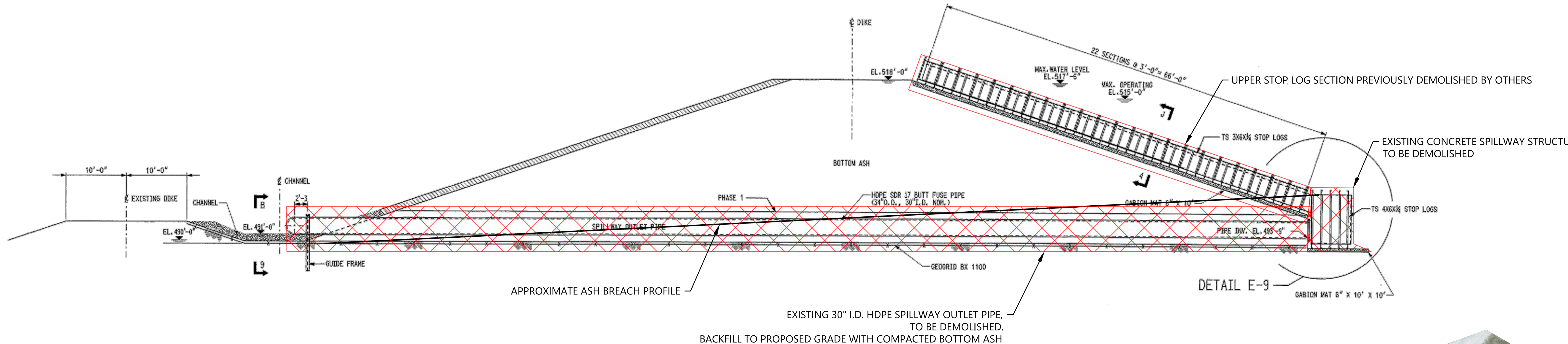
PROJECT NUMBER 7217-17-007A

DRAWING NUMBER 3

DRAWING NAME EXISTING CONDITIONS

NOTE: BACKFILL VOIDS FROM DEMOLITION WITH COMPACTED SOIL FILL. MATCH ADJACENT GRADES.

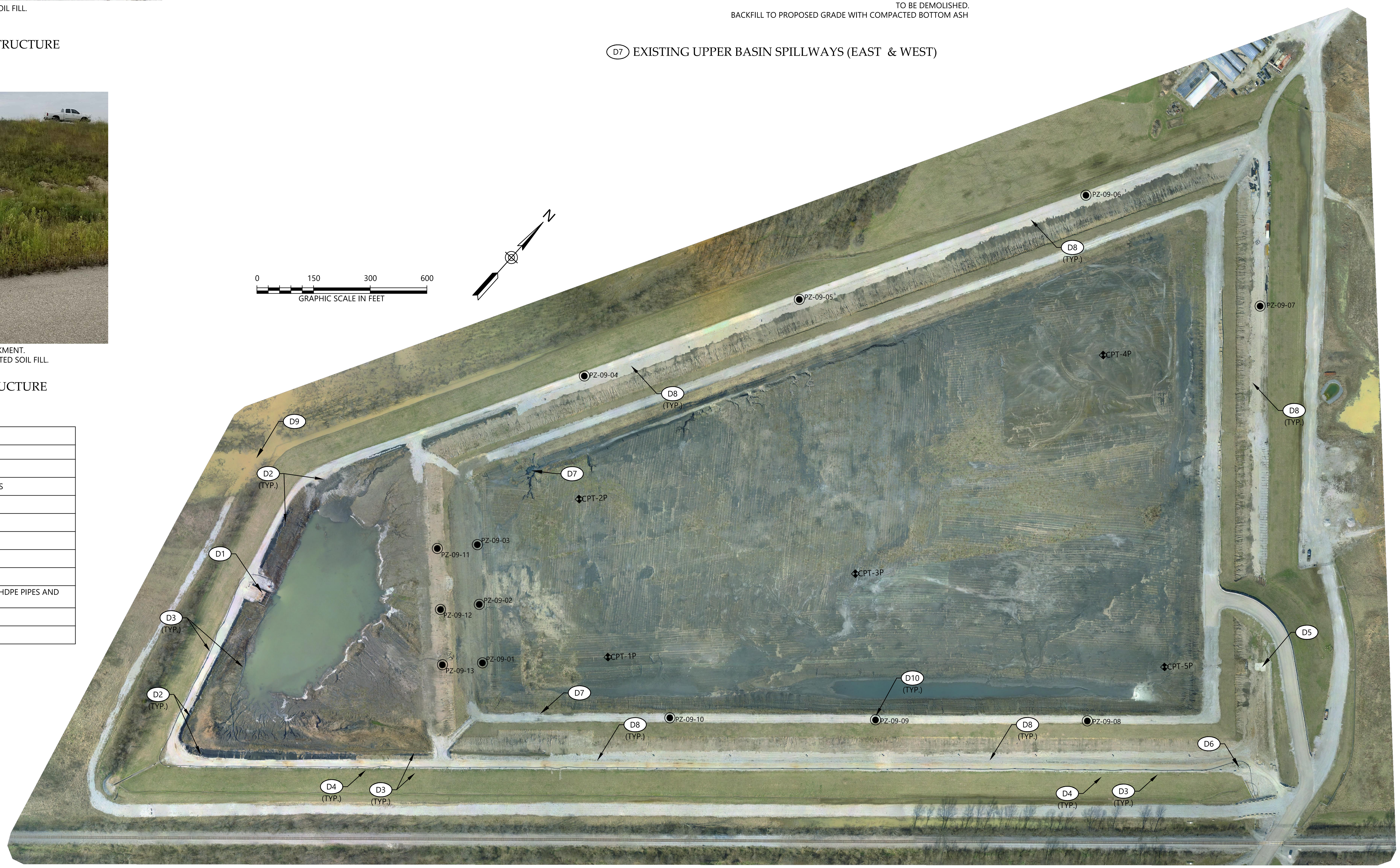
(D1) EXISTING PUMP STATION STRUCTURE



(D7) EXISTING UPPER BASIN SPILLWAYS (EAST & WEST)

NOTE: REMOVE PIPES TO A MINIMUM 3 FEET INTO EMBANKMENT. BACKFILL VOIDS FROM DEMOLITION WITH COMPACTED SOIL FILL. MATCH ADJACENT GRADES.

(D5) EXISTING CONCRETE STRUCTURE



NOTE: AERIAL IMAGERY OBTAINED IN MARCH 2017 BY GEOPRO CONSULTANTS.

DEMOLITION KEYNOTES

CODE	DESCRIPTION
D1	REMOVE PUMP STATION STRUCTURE & STAGING AREA
D2	REMOVE CWP INBOARD SLOPE PROTECTION MATERIALS
D3	REMOVE ALL HDPE PUMPING LINES
D4	REMOVE CONCRETE BLOCKS ON CREST
D5	REMOVE CONCRETE STRUCTURES & HDPE PIPE
D6	REMOVE BOLLARDS
D7	REMOVE UPPER BASIN SPILLWAY STRUCTURES
D8	REMOVE PERIMETER FRENCH DRAIN SYSTEM: TWO 24" HDPE PIPES AND STONE
D9	REMOVE 12" DIAM. CULVERT
D10	REMOVE PIEZOMETERS. SEE NOTE D10

LEGEND

CPT-2P OPEN STANDPIPE PIEZOMETER (1" PVC)

PZ-09-11 PIEZOMETER NUMBER AND APPROXIMATE LOCATION

NOTE D10: DEMOLISH ALL PIEZOMETERS. REMOVE PIPES TO A MINIMUM 3 FEET INTO EMBANKMENT. BACKFILL VOIDS FROM DEMOLITION WITH COMPACTED SOIL FILL.

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TANNERS CREEK DEVELOPMENT, LLC
1650 DES PERES RD., SUITE 303
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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

MICHAEL T. ROMANELLO, REGISTERED PE11400140, STATE OF INDIANA, PROFESSIONAL ENGINEER 10-13-17

NO.	DATE	DESCRIPTION	BY	CHK	APV
A	10/31/17	ISSUED FOR APPROVAL	MTR	MGR	MTR

PROJECT NUMBER 7217-17-007A

DRAWING NUMBER 4

DRAWING NAME DEMOLITION PLAN

NOTES:

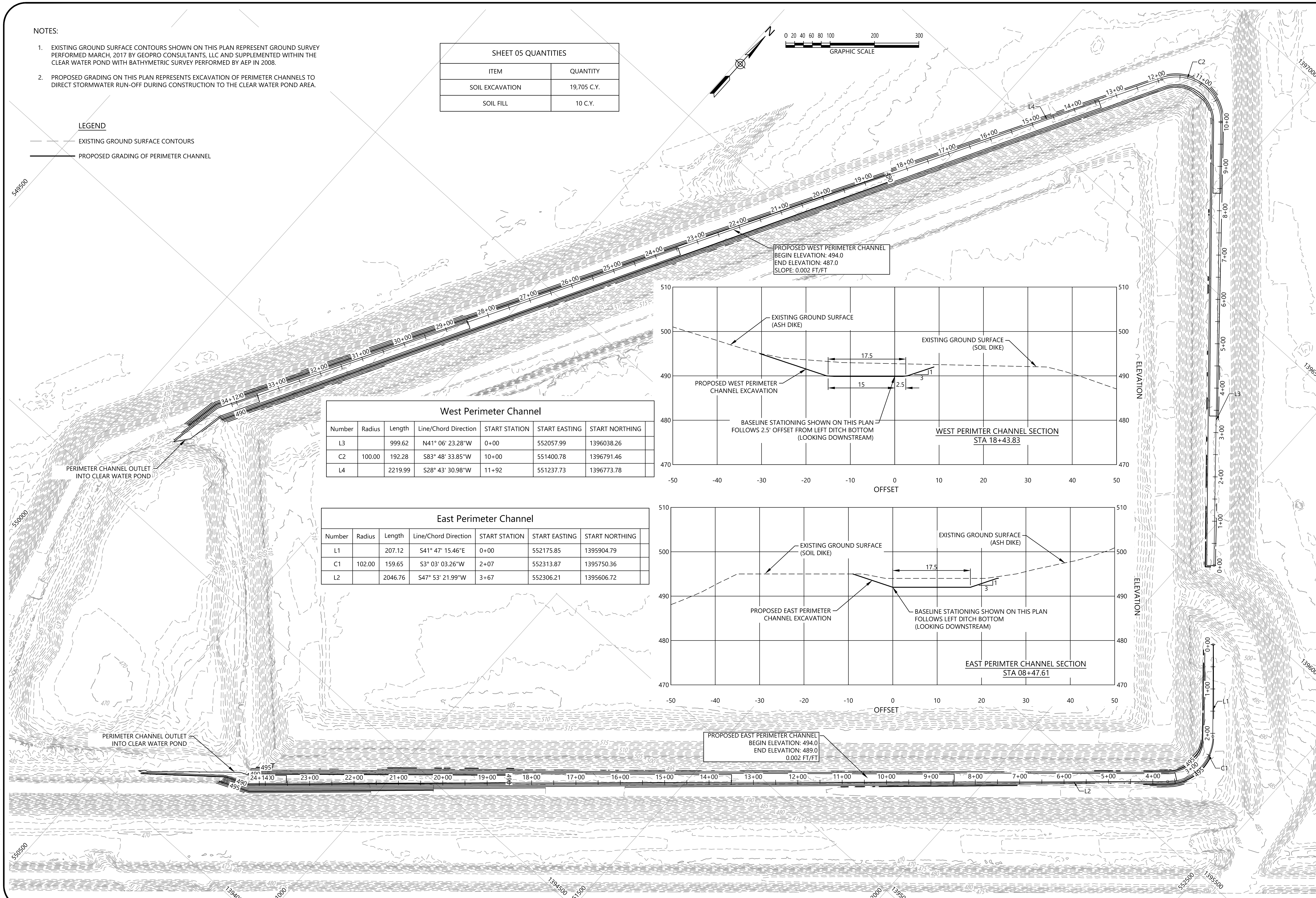
1. EXISTING GROUND SURFACE CONTOURS SHOWN ON THIS PLAN REPRESENT GROUND SURVEY PERFORMED MARCH, 2017 BY GEOPRO CONSULTANTS, LLC AND SUPPLEMENTED WITHIN THE CLEAR WATER POND WITH BATHYMETRIC SURVEY PERFORMED BY AEP IN 2008.
2. PROPOSED GRADING ON THIS PLAN REPRESENTS EXCAVATION OF PERIMETER CHANNELS TO DIRECT STORMWATER RUN-OFF DURING CONSTRUCTION TO THE CLEAR WATER POND AREA.

SHEET 05 QUANTITIES

ITEM	QUANTITY
SOIL EXCAVATION	19,705 C.Y.
SOIL FILL	10 C.Y.

LEGEND

- EXISTING GROUND SURFACE CONTOURS
- PROPOSED GRADING OF PERIMETER CHANNEL



West Perimeter Channel

Number	Radius	Length	Line/Chord Direction	START STATION	START EASTING	START NORTHING
L3		999.62	N41° 06' 23.28"W	0+00	552057.99	1396038.26
C2	100.00	192.28	S83° 48' 33.85"W	10+00	551400.78	1396791.46
L4		2219.99	S28° 43' 30.98"W	11+92	551237.73	1396773.78

East Perimeter Channel

Number	Radius	Length	Line/Chord Direction	START STATION	START EASTING	START NORTHING
L1		207.12	S41° 47' 15.46"E	0+00	552175.85	1395904.79
C1	102.00	159.65	S3° 03' 03.26"W	2+07	552313.87	1395750.36
L2		2046.76	S47° 53' 21.99"W	3+67	552306.21	1395606.72

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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

MICHAEL T. ROMANELLO, REGISTERED PROFESSIONAL ENGINEER, STATE OF INDIANA, PE11400160 — 10-13-17

NO.	DATE	DESCRIPTION	BY	CHK	APV
	10/31/17	ISSUED FOR APPROVAL	MRM	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
5

DRAWING NAME
INITIAL SURFACE WATER CONTROLS

NOTES:

1. EXISTING GROUND SURFACE CONTOURS SHOWN ON THIS PLAN REPRESENT THE GROUND SURFACE UPON COMPLETION OF INITIAL SITE GRADING FROM SHEET 04.
2. PROPOSED GRADING ON THIS PLAN REPRESENTS TOP OF ASH GRADES ACROSS THE FLY ASH STORAGE AREA AND STOCKPILING (FILLING) WITHIN THE CLEAR WATER POND AREA.

KEYNOTES:

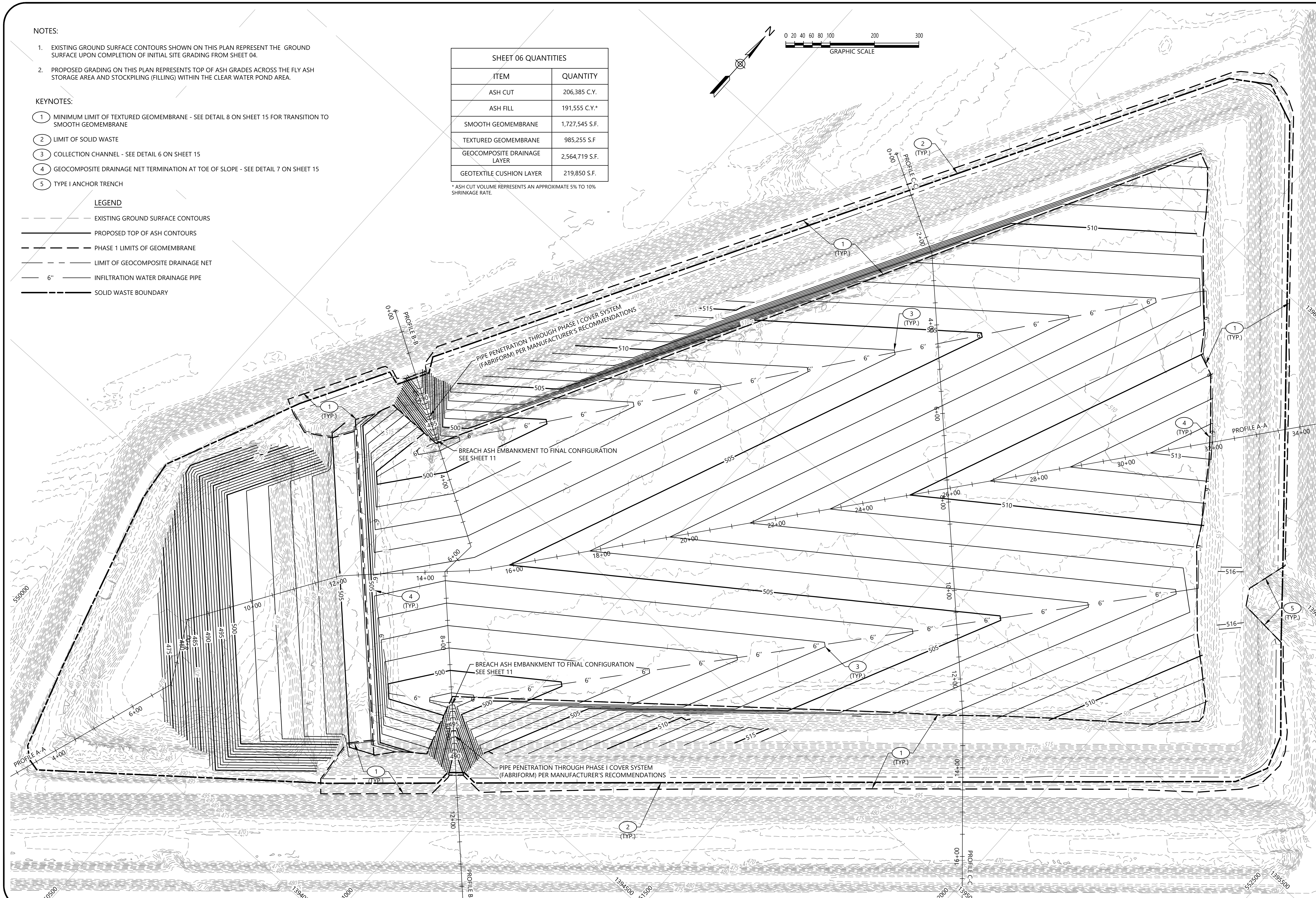
1. MINIMUM LIMIT OF TEXTURED GEOMEMBRANE - SEE DETAIL 8 ON SHEET 15 FOR TRANSITION TO SMOOTH GEOMEMBRANE
2. LIMIT OF SOLID WASTE
3. COLLECTION CHANNEL - SEE DETAIL 6 ON SHEET 15
4. GEOCOMPOSITE DRAINAGE NET TERMINATION AT TOE OF SLOPE - SEE DETAIL 7 ON SHEET 15
5. TYPE I ANCHOR TRENCH

LEGEND

- EXISTING GROUND SURFACE CONTOURS
- PROPOSED TOP OF ASH CONTOURS
- PHASE 1 LIMITS OF GEOMEMBRANE
- LIMIT OF GEOCOMPOSITE DRAINAGE NET
- 6" INFILTRATION WATER DRAINAGE PIPE
- SOLID WASTE BOUNDARY

SHEET 06 QUANTITIES	
ITEM	QUANTITY
ASH CUT	206,385 C.Y.
ASH FILL	191,555 C.Y.*
SMOOTH GEOMEMBRANE	1,727,545 S.F.
TEXTURED GEOMEMBRANE	985,255 S.F
GEOCOMPOSITE DRAINAGE LAYER	2,564,719 S.F.
GEOTEXTILE CUSHION LAYER	219,850 S.F.

* ASH CUT VOLUME REPRESENTS AN APPROXIMATE 5% TO 10% SHRINKAGE RATE.



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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
	06/22/18	PROPOSED ASH GRADE REVISED	PSS	MGR	MTR
	10/31/17	ISSUED FOR APPROVAL	IDT	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
6

DRAWING NAME
PHASE I ASH GRADING

KEYNOTES:

1. EXISTING GROUND SURFACE CONTOURS SHOWN ON THIS PLAN REPRESENT THE GROUND SURFACE UPON COMPLETION OF PHASE I ASH GRADING.
2. PROPOSED GRADING ON THIS PLAN REPRESENTS PHASE I FINAL COVER ACROSS THE FLY ASH POND AND PERIMETER DITCH AREAS.
3. SEE SHEET 17 FOR PROFILE VIEWS.

KEYNOTES:

(1) SURFACE WATER COLLECTION CHANNEL - SEE DETAIL 6 ON SHEET 15

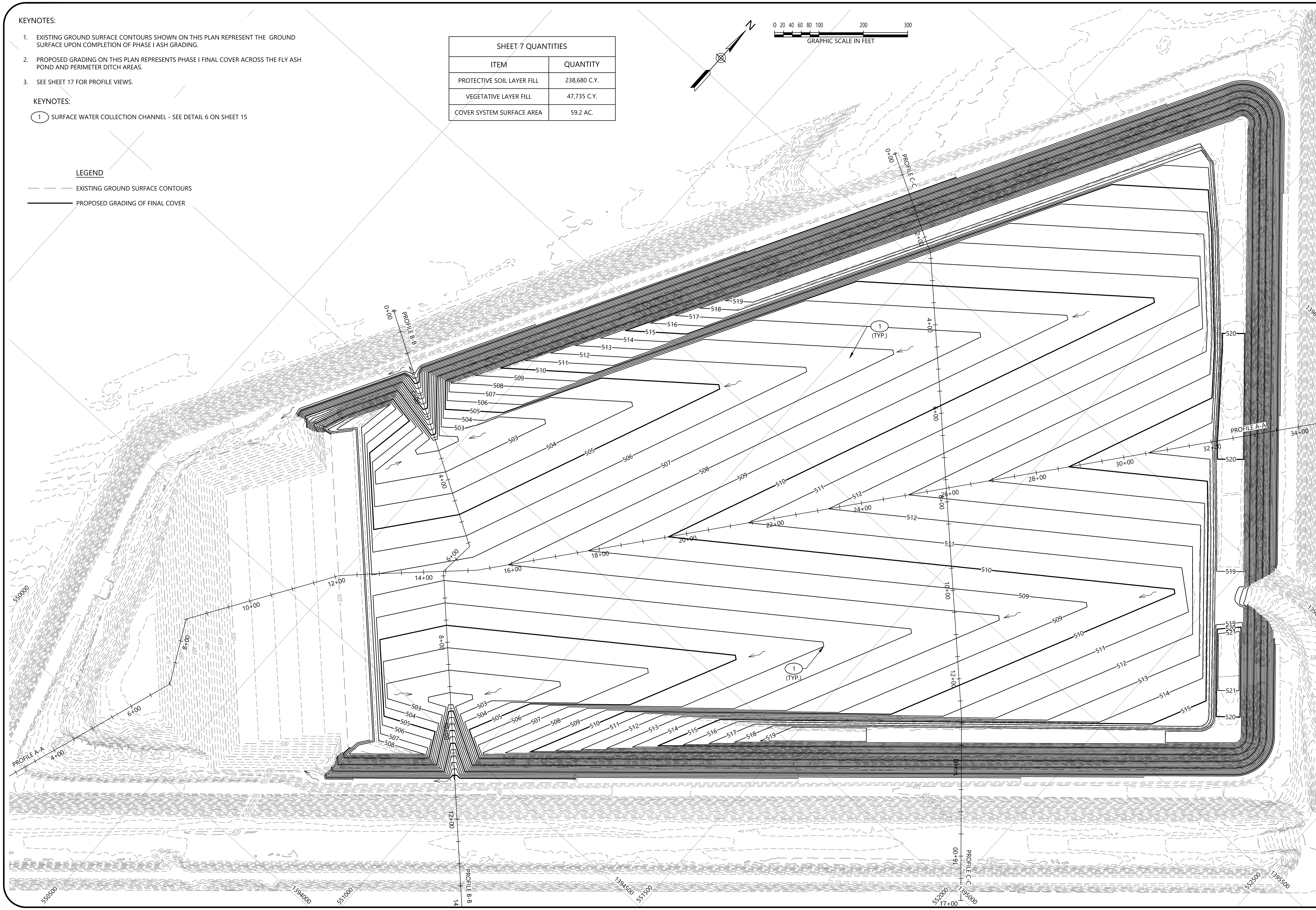
LEGEND

EXISTING GROUND SURFACE CONTOURS

PROPOSED GRADING OF FINAL COVER

SHEET 7 QUANTITIES

ITEM	QUANTITY
PROTECTIVE SOIL LAYER FILL	238,680 C.Y.
VEGETATIVE LAYER FILL	47,735 C.Y.
COVER SYSTEM SURFACE AREA	59.2 AC.



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FLY ASH POND CLOSURE TANNERS CREEK PLANT

LAWRENCEBURG, DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
△	06/22/18	FINAL GRADE RAISED 6 INCHES; BACKGROUND GRADES UPDATED; ROAD GRADE REVISED	PSS	MGR	MTR
△	10/31/17	ISSUED FOR APPROVAL	IDT	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
7

DRAWING NAME
PHASE I COVER SYSTEM

T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\07_PHASE I COVER SYSTEM.dwg-Phase I Cover System Jun 21, 2018 - 11:05am psimko

NOTES:

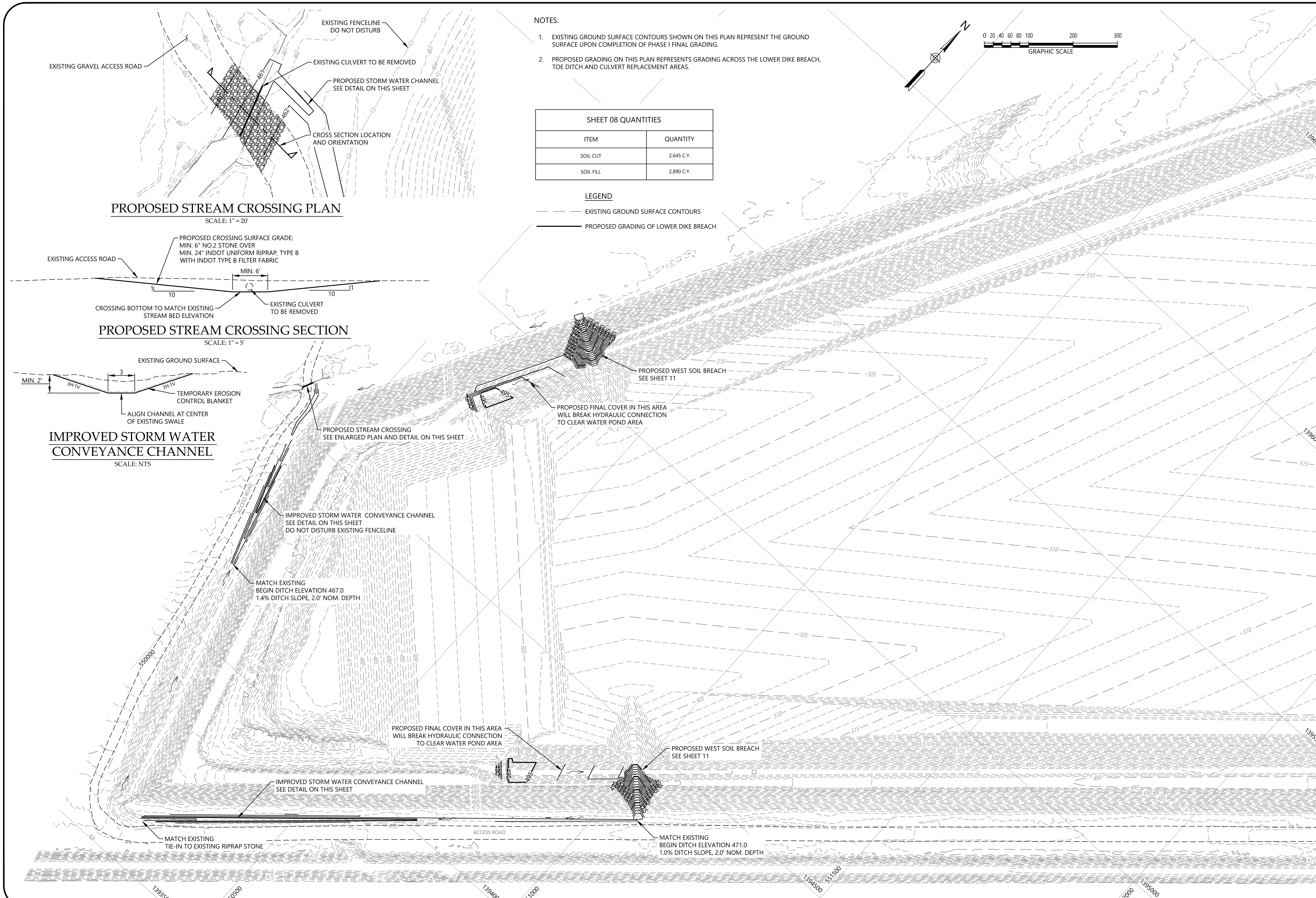
1. EXISTING GROUND SURFACE CONTOURS SHOWN ON THIS PLAN REPRESENT THE GROUND SURFACE UPON COMPLETION OF PHASE I FINAL GRADING.
2. PROPOSED GRADING ON THIS PLAN REPRESENTS GRADING ACROSS THE LOWER DIKE BREACH, TOE DITCH AND CULVERT REPLACEMENT AREAS.

SHEET 08 QUANTITIES	
ITEM	QUANTITY
SOIL CUT	2,645 C.Y.
SOIL FILL	2,890 C.Y.

LEGEND

EXISTING GROUND SURFACE CONTOURS

PROPOSED GRADING OF LOWER DIKE BREACH



T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\08_FINAL SURFACE WATER CONTROLS.dwg-Final Surface Water Controls Jun 21, 2018 - 11:12am psimko

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TANNERS CREEK DEVELOPMENT, LLC
1650 DES PERES RD., SUITE 303
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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

MICHAEL T ROMANELLO REGISTERED PE11600160 STATE OF INDIANA PROFESSIONAL ENGINEER
10-13-17

NO.	DATE	DESCRIPTION	BY	CHK	APV
1	06/22/18	BACKGROUND GRADES UPDATED	PSS	MGR	MTR
0	10/31/17	ISSUED FOR APPROVAL	MRM	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
8

DRAWING NAME
FINAL SURFACE WATER CONTROLS

NOTES:

1. EXISTING GROUND SURFACE CONTOURS SHOWN ON THIS PLAN REPRESENT THE GROUND SURFACE UPON COMPLETION OF PHASE 1 FINAL GRADES AND THE FINAL SURFACE WATER CONTROLS.
2. PROPOSED GRADING ON THIS PLAN REPRESENTS TOP OF ASH GRADING ACROSS THE CLEAR WATER POND.

KEYNOTES:

1. MINIMUM LIMIT OF TEXTURED GEOMEMBRANE - SEE DETAILS 2 AND 3 ON SHEET 14 FOR TRANSITION TO SMOOTH GEOMEMBRANE
2. MAXIMUM LIMIT OF SMOOTH GEOMEMBRANE
3. BEGIN/END TYPE III LINER TERMINATION. SEE DETAIL 5 ON SHEET 14
4. BEGIN/END TYPE II LINER TERMINATION. SEE DETAIL 5 ON SHEET 14
5. COLLECTION CHANNEL - SEE DETAIL 6 ON SHEET 15
6. INFILTRATION WATER OUTLET PIPE. SEE CLEAR WATER POND CHANNEL OUTLET DETAIL ON SHEET 16

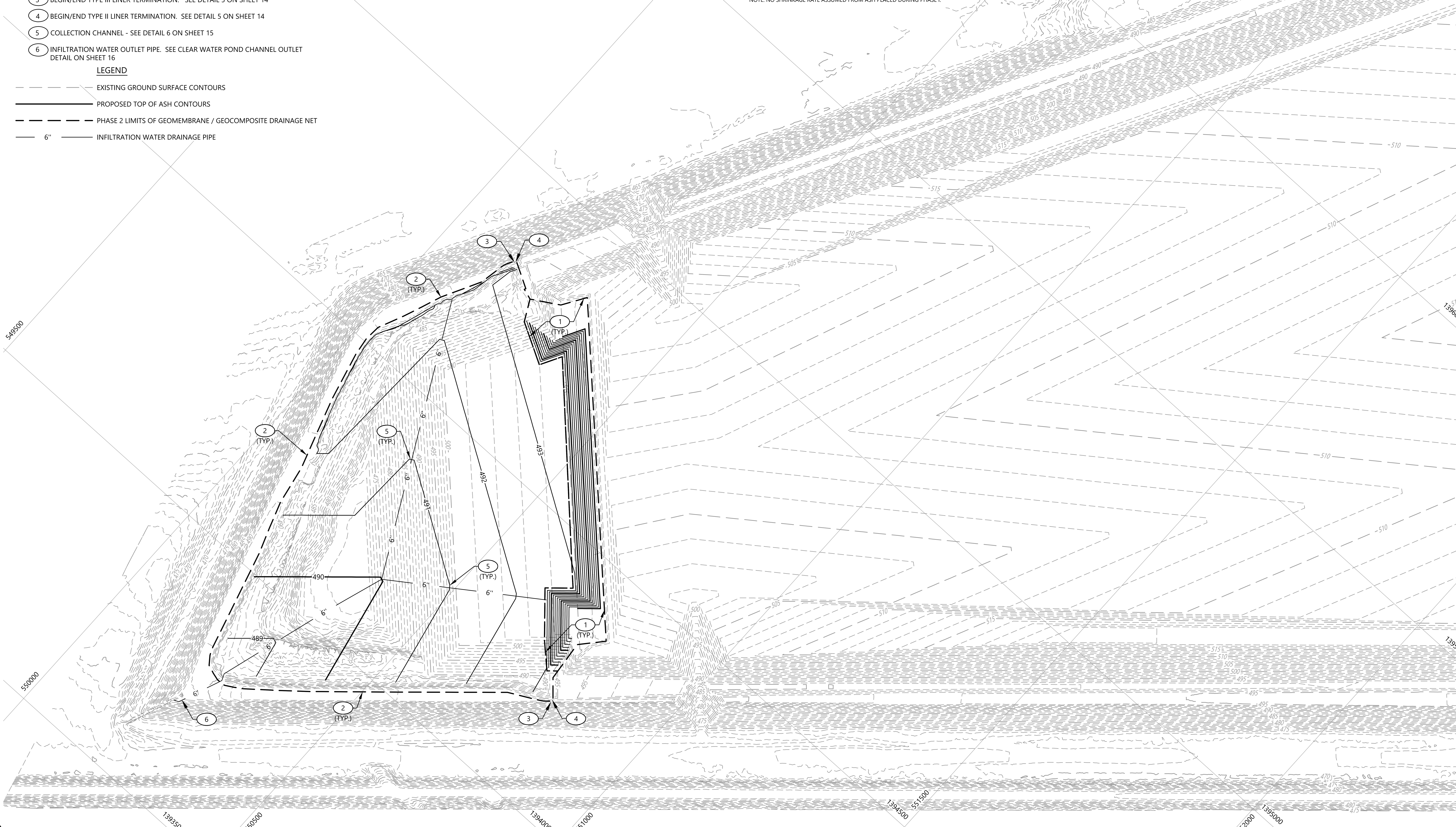
LEGEND

- EXISTING GROUND SURFACE CONTOURS
- PROPOSED TOP OF ASH CONTOURS
- PHASE 2 LIMITS OF GEOMEMBRANE / GEOCOMPOSITE DRAINAGE NET
- 6" INFILTRATION WATER DRAINAGE PIPE

SHEET 09 QUANTITIES

ITEM	QUANTITY
ASH CUT	65,915 C.Y.
ASH FILL	66,255 C.Y.
SMOOTH GEOMEMBRANE	435,560 S.F.
TEXTURED GEOMEMBRANE	57,810 S.F.
GEOCOMPOSITE DRAINAGE LAYER	486,190 S.F

NOTE: NO SHRINKAGE RATE ASSUMED FROM ASH PLACED DURING PHASE I.



T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\09_PHASE II ASH GRADING.dwg-Phase II Ash Grading Jun 21, 2018 - 11:15am psimko

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ST. LOUIS, MO 63131

FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

MICHAEL T. ROMANELLO, REGISTERED PE11400160, STATE OF INDIANA, PROFESSIONAL ENGINEER 10-13-17

NO.	DATE	DESCRIPTION	BY	CHK	APV
2	06/22/18	BACKGROUND GRADES UPDATED	PSS	MGR	MTR
1	10/31/17	ISSUED FOR APPROVAL	IDT	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
9

DRAWING NAME
PHASE II ASH GRADING

NOTES:

1. EXISTING GROUND SURFACE CONTOURS SHOWN ON THIS PLAN REPRESENT THE GROUND SURFACE UPON COMPLETION OF PHASE II ASH GRADING.
2. PROPOSED GRADING ON THIS PLAN REPRESENTS FINAL GRADING ACROSS CLEAR WATER POND.

KEYNOTES:

(1) SURFACE WATER COLLECTION CHANNEL - SEE DETAIL 6 ON SHEET 15

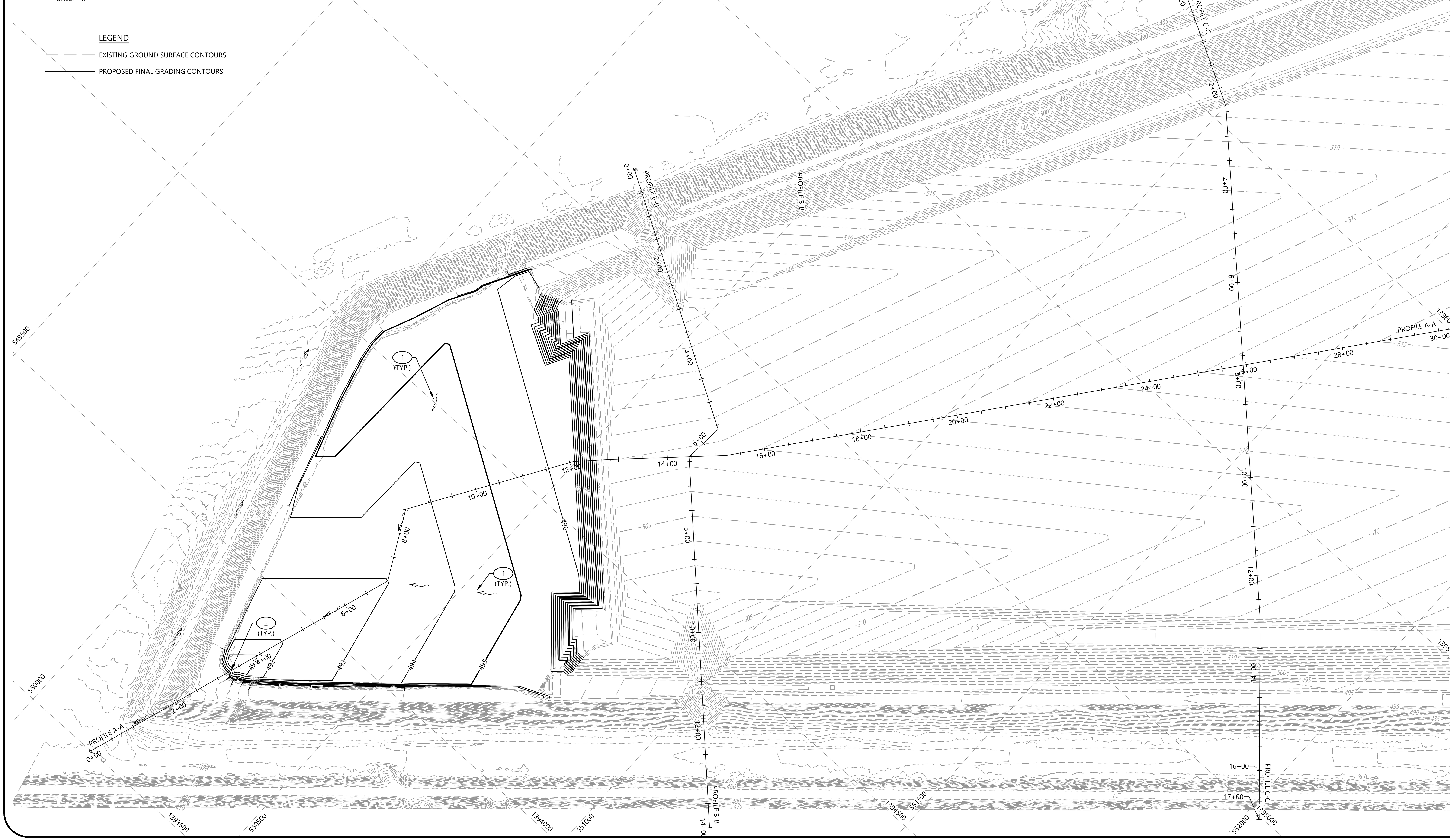
(2) SURFACE WATER COLLECTION CHANNEL OUTLET THROUGH EXISTING EMERGENCY SPILLWAY. SEE CLEAR WATER POND CHANNEL OUTLET DETAIL ON SHEET 16

SHEET 10 QUANTITIES	
ITEM	QUANTITY
PROTECTIVE SOIL LAYER	46,450 C.Y.
VEGETATIVE LAYER	9290 C.Y.
COVER SYSTEM SURFACE AREA	11.5 AC.

LEGEND

EXISTING GROUND SURFACE CONTOURS

PROPOSED FINAL GRADING CONTOURS



T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\10_PHASE II COVER SYSTEM.dwg-10 Phase II Cover System Jun 21, 2018 - 11:21am psimko

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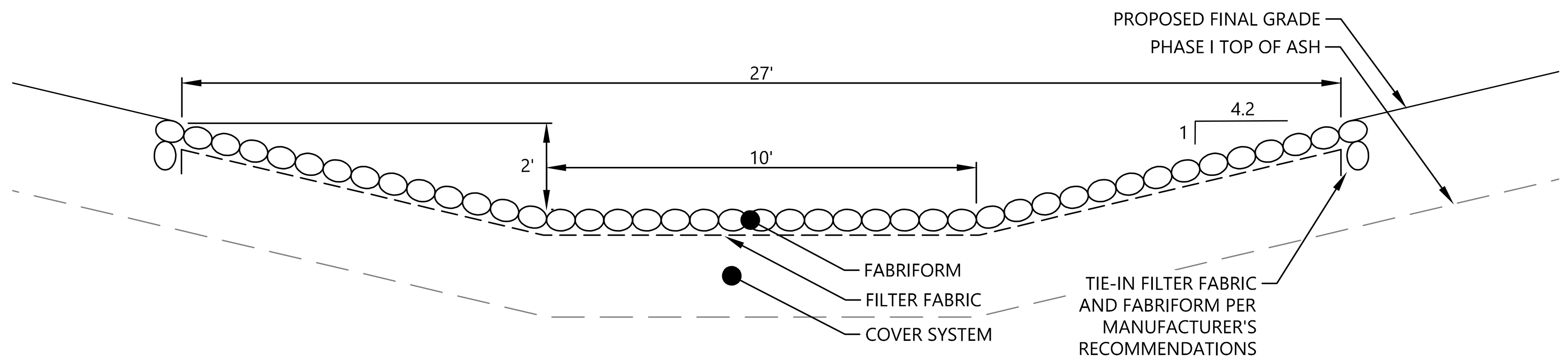
FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
6	06/22/18	FINAL GRADE RAISED 6 INCHES; BACKGROUND GRADES UPDATED	PSS	MGR	MTR
	10/31/17	ISSUED FOR APPROVAL	JDT	MGR	MTR

PROJECT NUMBER
7217-17-007A

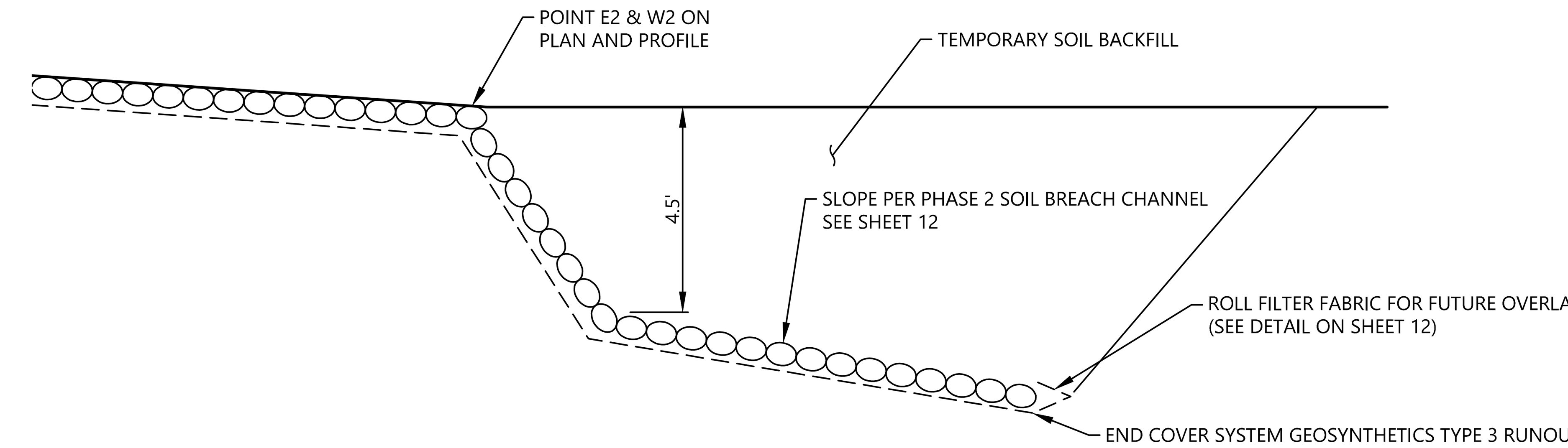
DRAWING NUMBER
10

DRAWING NAME
PHASE II COVER SYSTEM



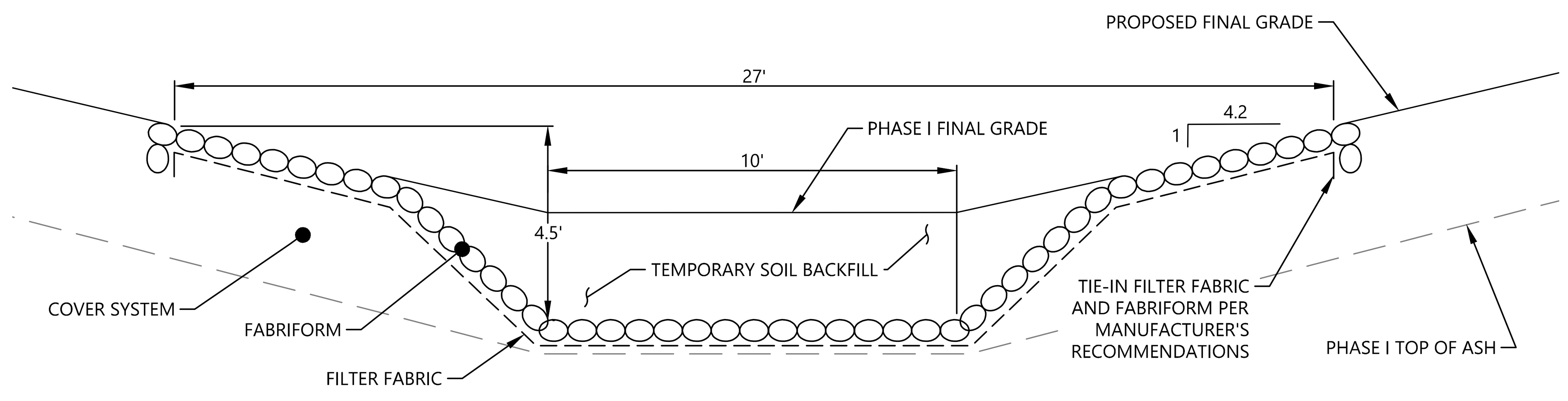
SECTION A-A
ASH BREACH TYPICAL SECTION

SCALE: 1" = 3'



SECTION C-C
ASH BREACH DOWNSTREAM TERMINATION DETAIL

SCALE: 1" = 3'

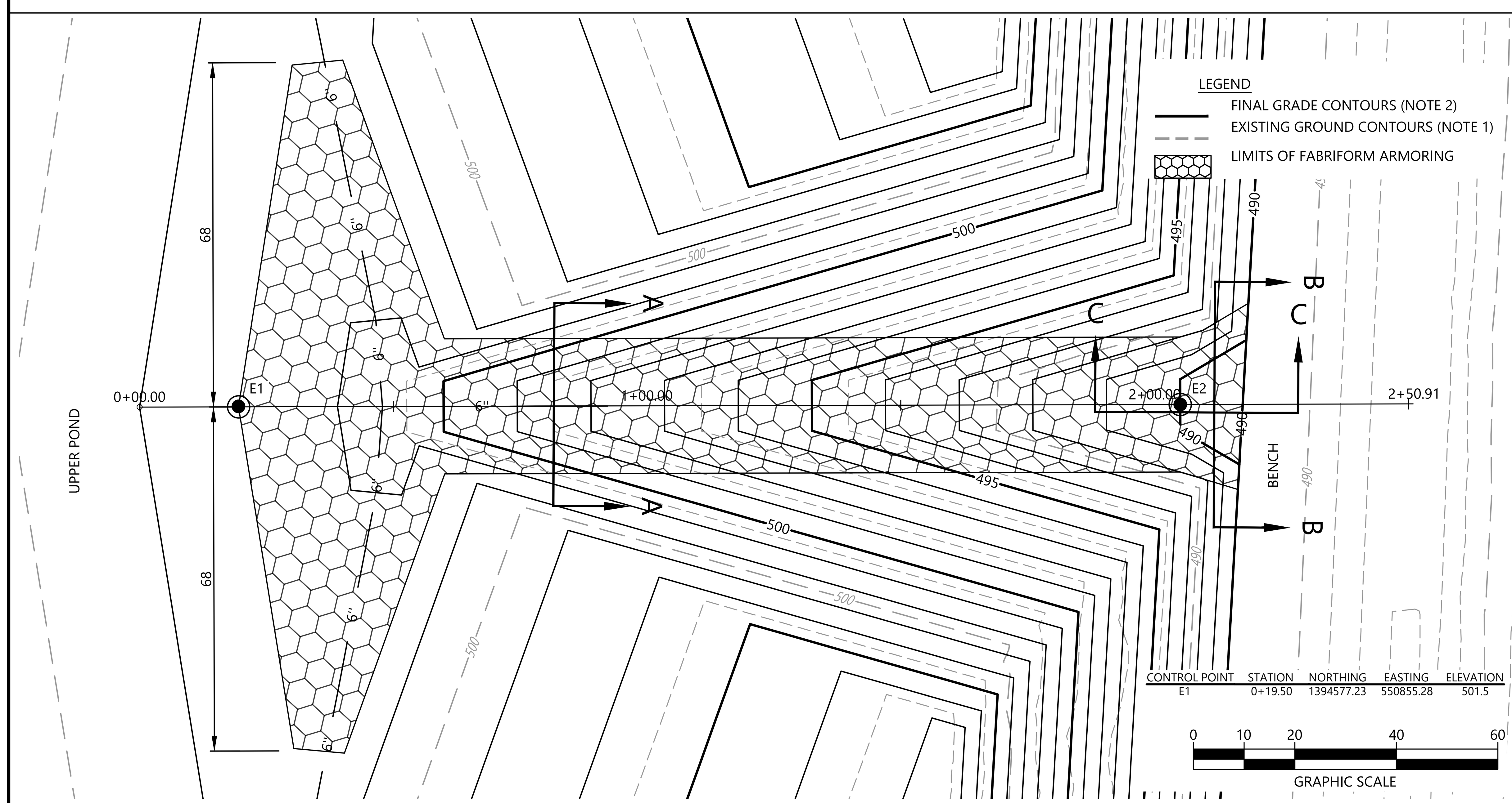


SECTION B-B
ASH BREACH OULET TRANSITION

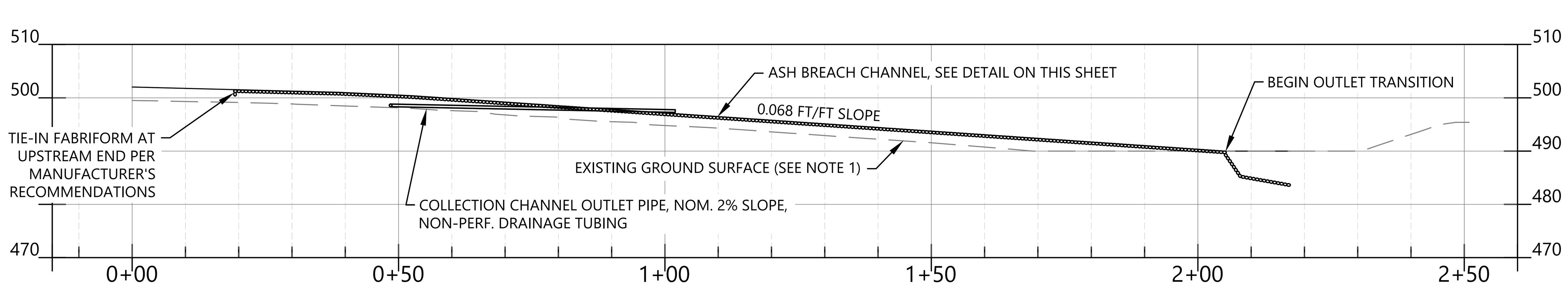
SCALE: 1" = 3'

NOTES:

1. EXISTING GROUND SURFACE CONTOURS AND PROFILE ELEMENTS SHOWN ON THIS SHEET REPRESENT A COMPOSITE SURFACE INCLUDING PHASE I ASH GRADES AND EXISTING GROUND SURVEY.
2. PROPOSED GRADES AND PROFILE ELEMENTS SHOWN ON THIS SHEET REPRESENT FINAL COVER ELEVATIONS FOR ASH BREACHES ON BOTH SIDES OF THE ASH POND.
3. FABRIFORM SHALL BE 10-INCH FILTERPOINT AS MANUFACTURED BY FABRIFORM INC. OR APPROVED EQUAL.
4. FILTER FABRIC TYPE 3 FOR FABRIFORM CHANNELS SHALL BE INSTALLED IN ACCORDANCE WITH INDOT SECTION 616.11.

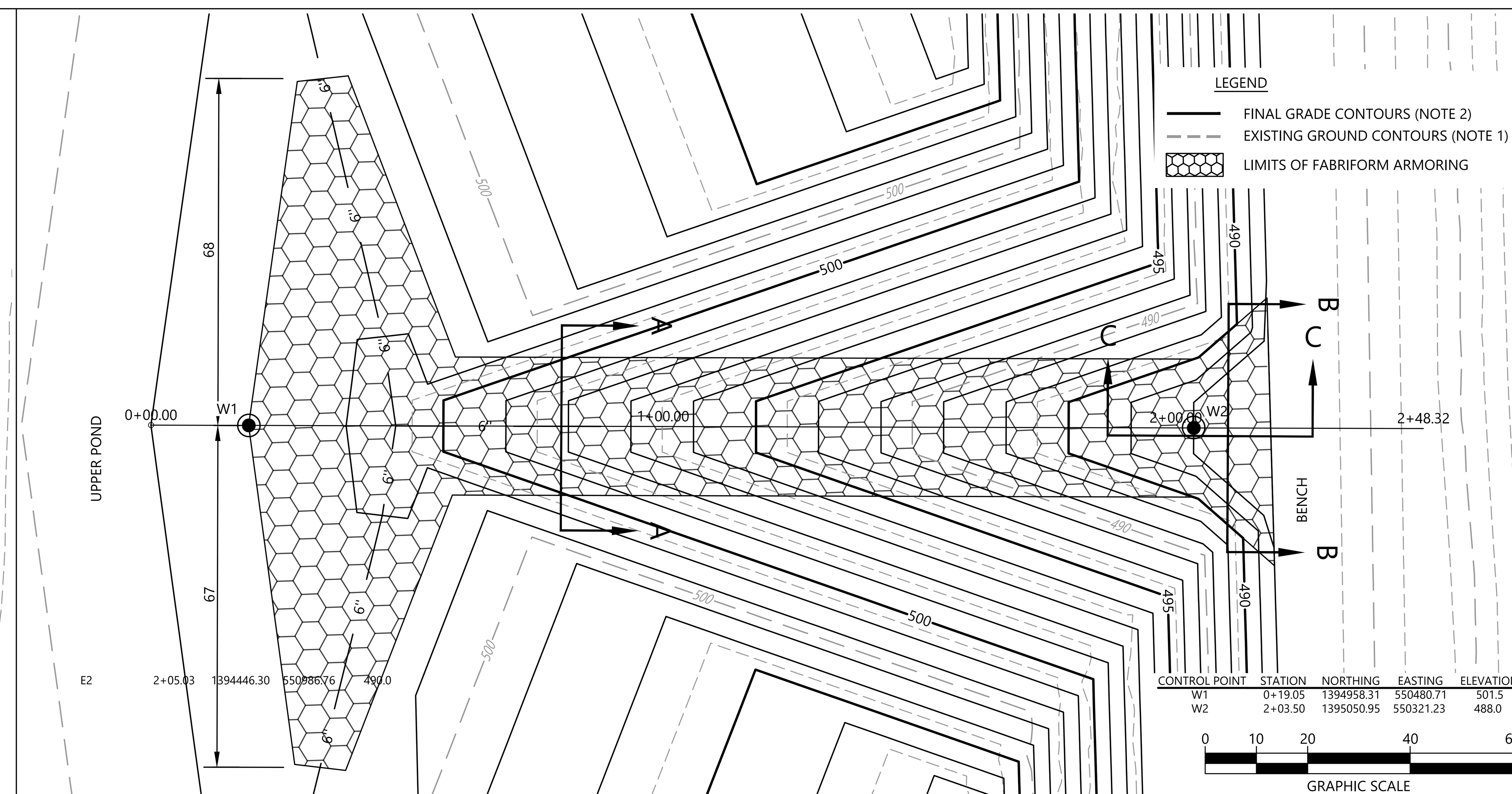


CONTROL POINT	STATION	NORTHING	EASTING	ELEVATION
E1	0+19.50	1394577.23	550855.28	501.5

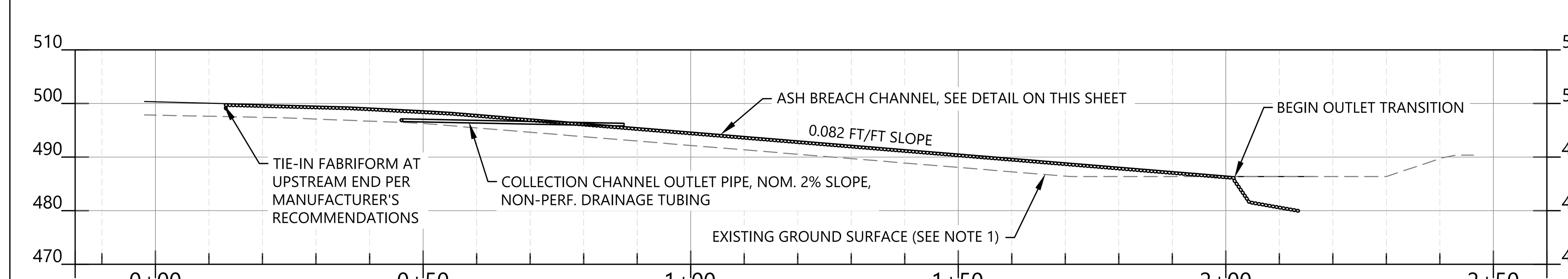


EAST ASH BREACH PLAN AND PROFILE

SCALE H:1"=20'; V:1"=20'



CONTROL POINT	STATION	NORTHING	EASTING	ELEVATION
W1	0+19.05	1394958.31	550480.71	501.5
W2	2+03.50	1395050.95	550321.23	488.0



WEST ASH BREACH PLAN AND PROFILE

SCALE H:1"=20'; V:1"=20'

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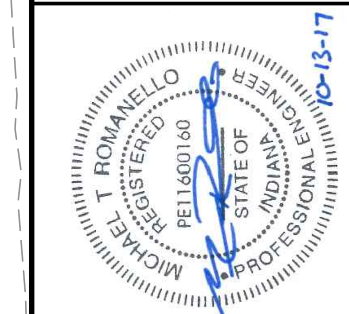
1650 DES PERES RD., SUITE 303
ST. LOUIS, MO 63131

FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

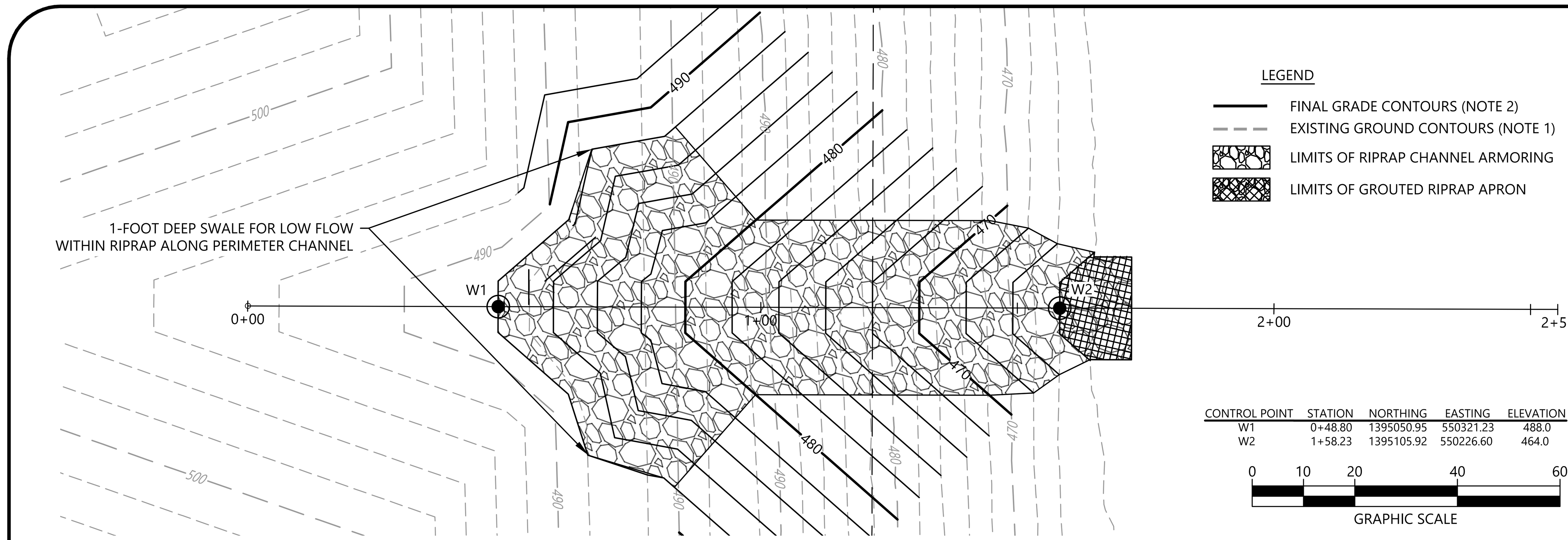


NO.	DATE	DESCRIPTION	BY	CHK	APV
△	06/22/18	MODIFIED SECTION C-C	PSS	MGR	MTR
△	10/31/17	ISSUED FOR APPROVAL	MRM	MGR	MTR

PROJECT NUMBER
7217-17-007A

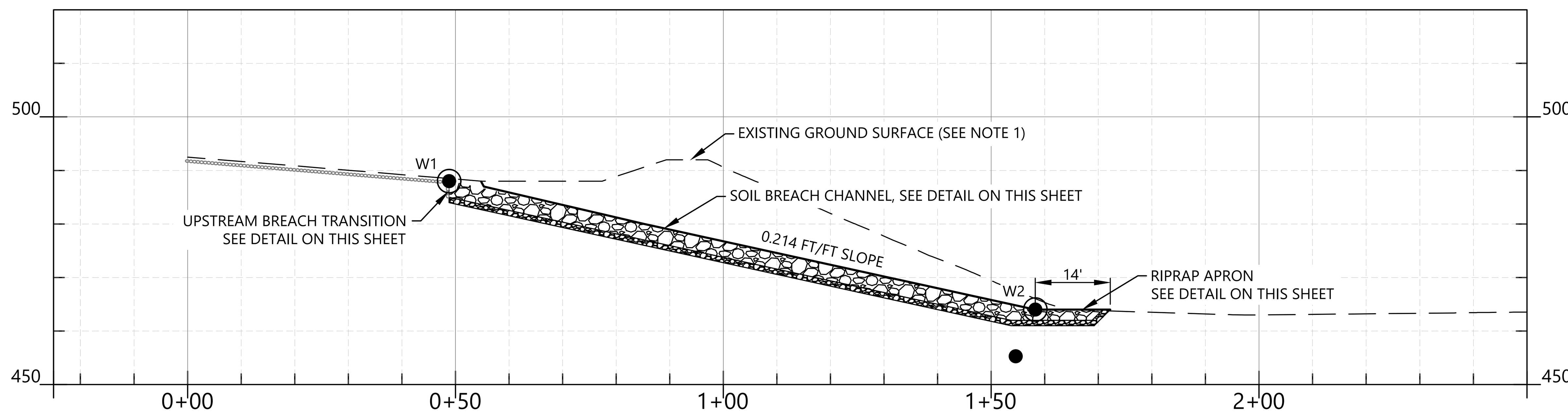
DRAWING NUMBER
11

DRAWING NAME
ASH BREACH PLAN PROFILE AND DETAILS



CONTROL POINT	STATION	NORTHING	EASTING	ELEVATION
W1	0+48.80	1395050.95	550321.23	488.0
W2	1+58.23	1395105.92	550226.60	464.0

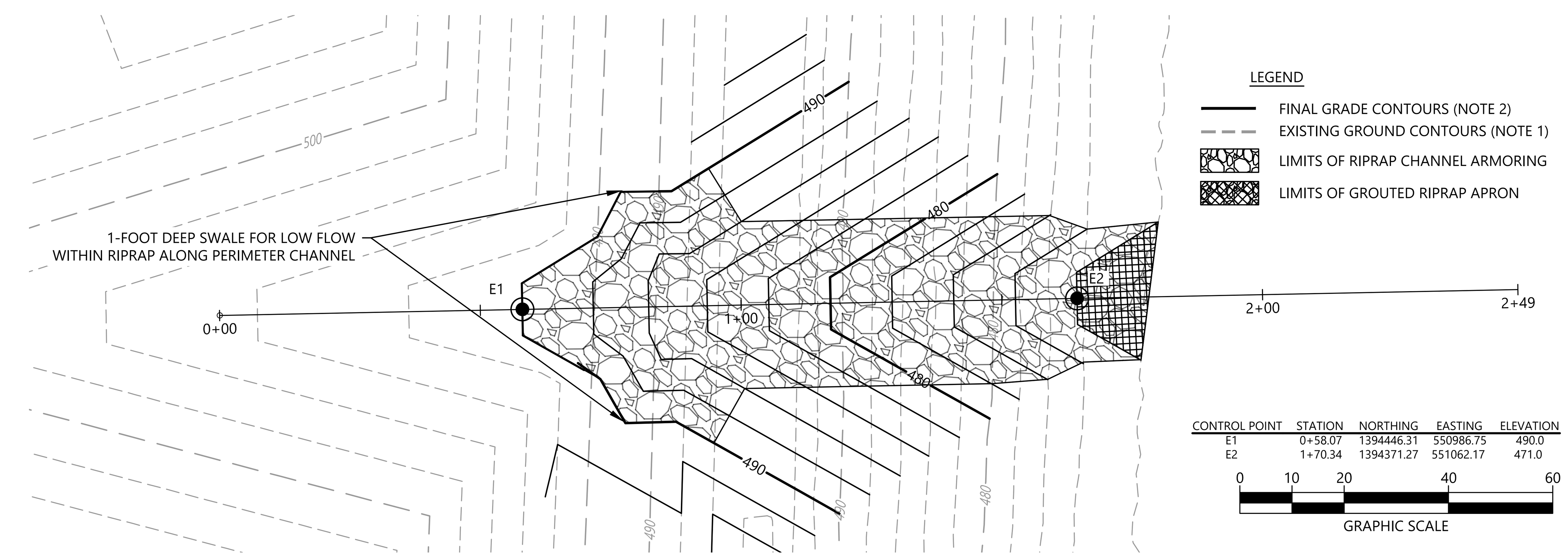
GRAPHIC SCALE 0 10 20 40 60



WEST SOIL BREACH PLAN AND PROFILE

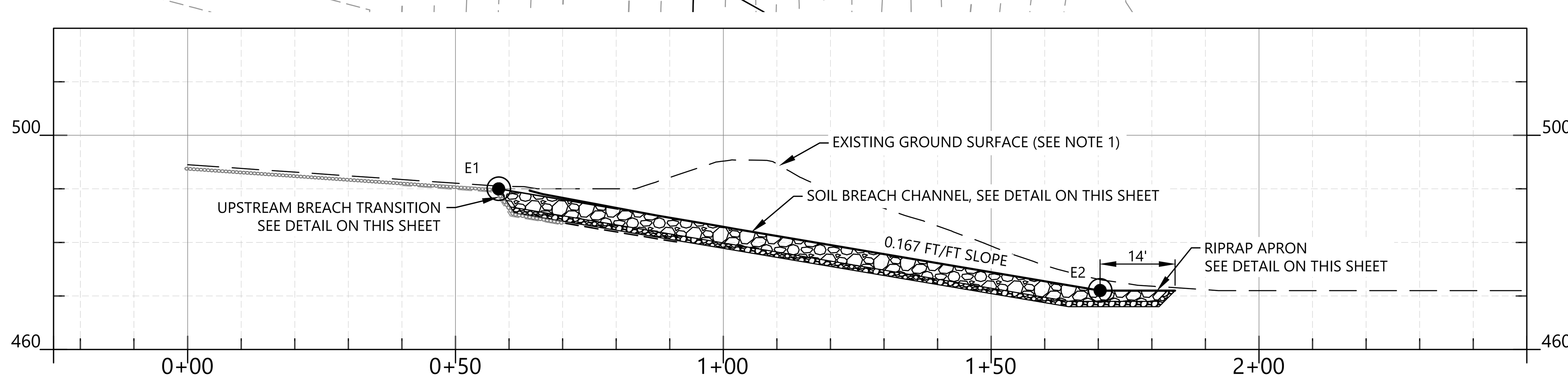
SCALE H:1"=20'; V:1"=20'

GRAPHIC SCALE 0 10 20 40 60



CONTROL POINT	STATION	NORTHING	EASTING	ELEVATION
E1	0+58.07	1394446.31	550986.75	490.0
E2	1+70.34	1394371.27	551062.17	471.0

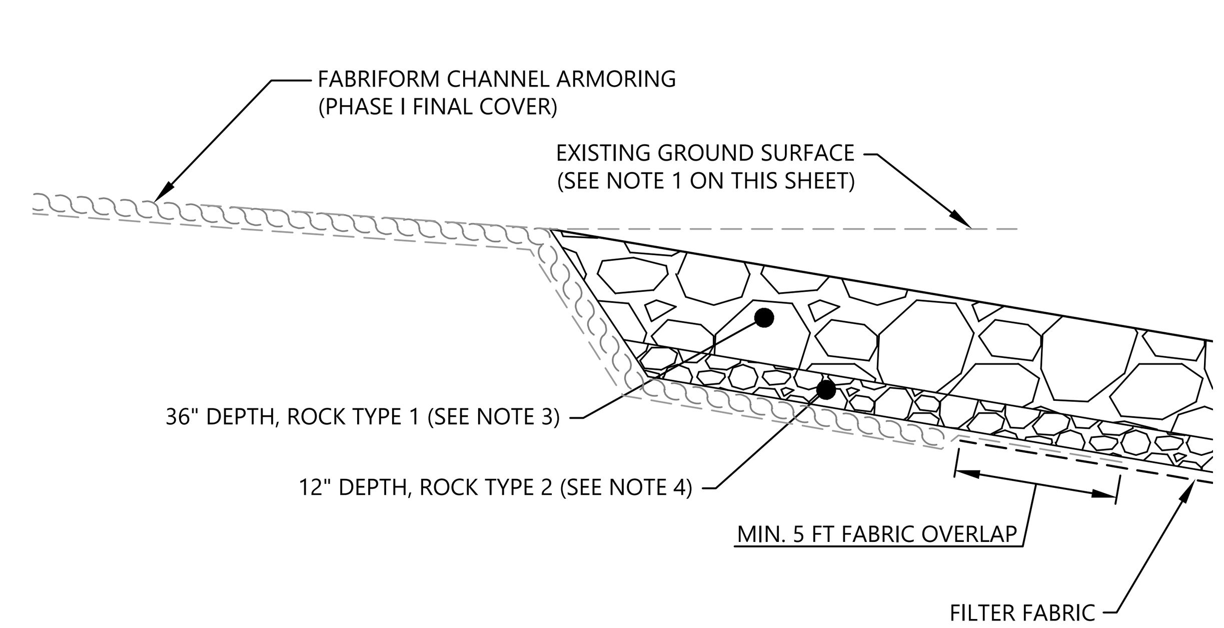
GRAPHIC SCALE 0 10 20 40 60



EAST SOIL BREACH PLAN AND PROFILE

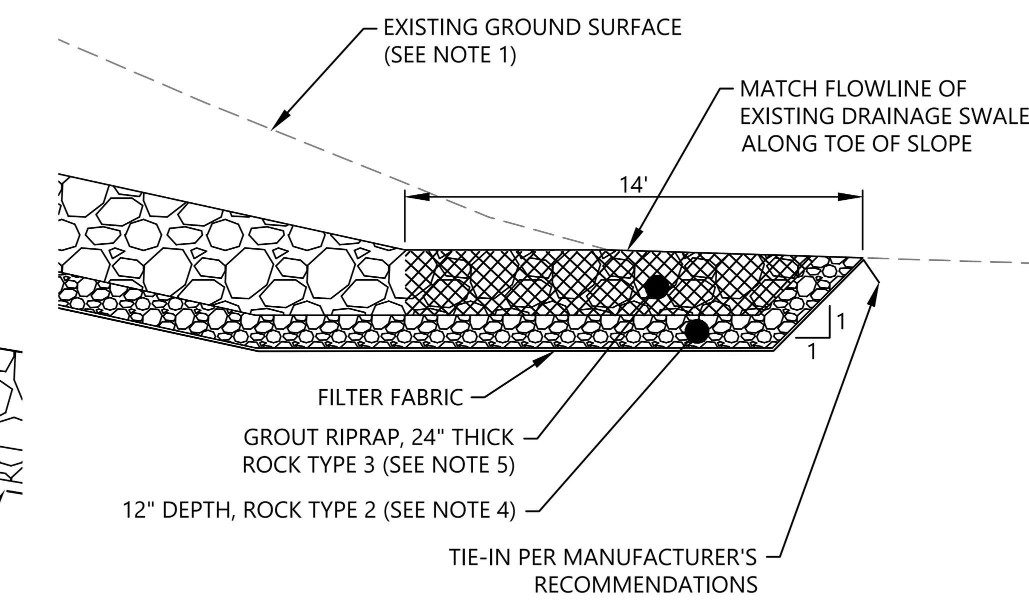
SCALE H:1"=20'; V:1"=20'

GRAPHIC SCALE 0 10 20 40 60



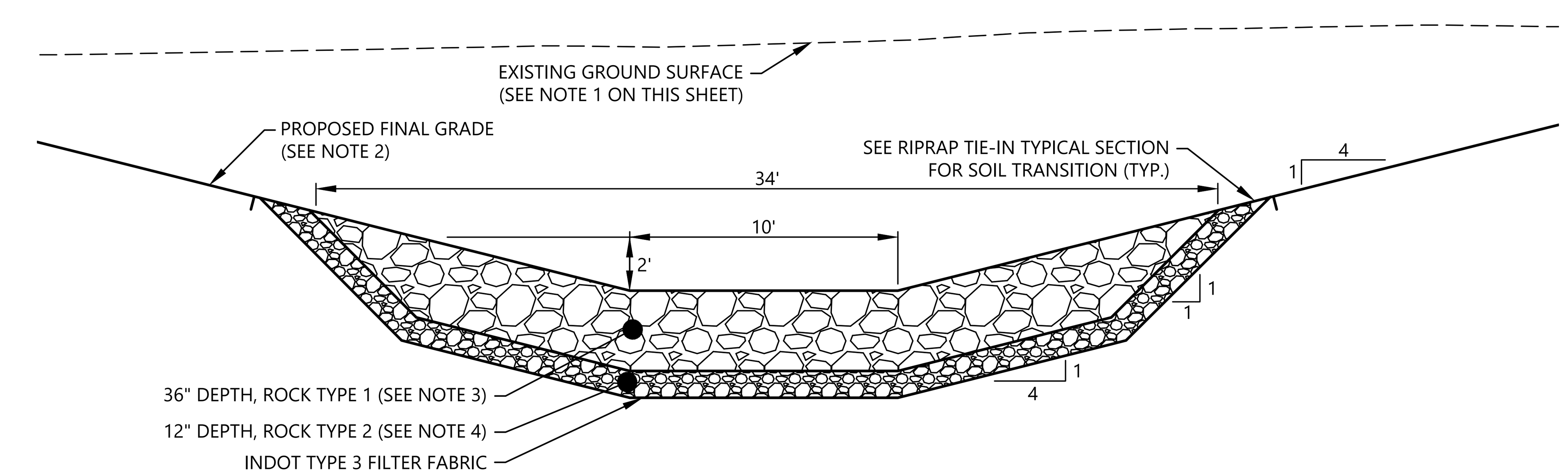
UPSTREAM BREACH TRANSITION DETAIL

SCALE: 1"=5'



RIPRAP APRON DETAIL (APPLIES ON EAST AND WEST SIDES)

SCALE: 1"=5'

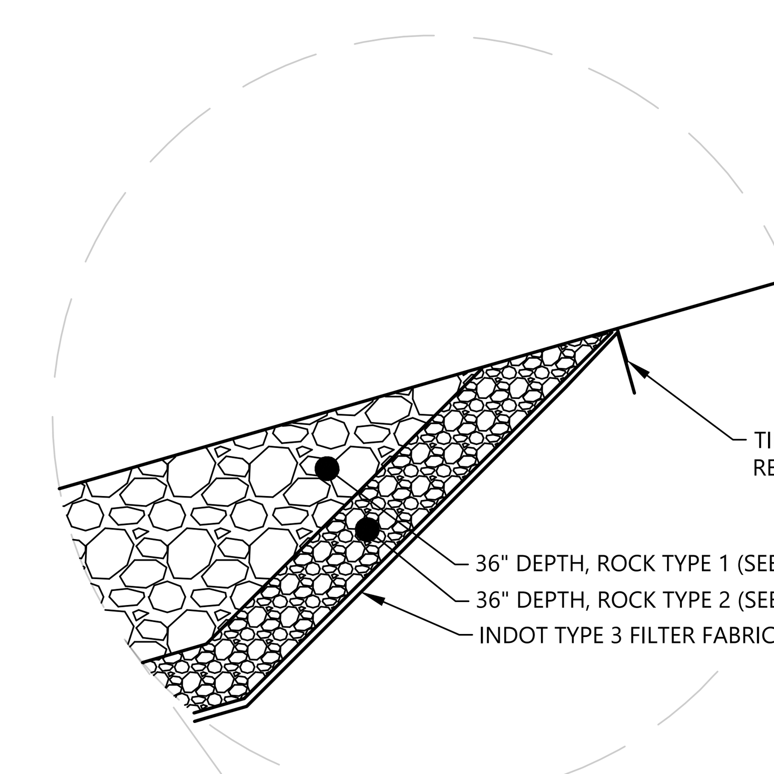


WEST SOIL BREACH TYPICAL SECTION

SCALE: 1"=5'

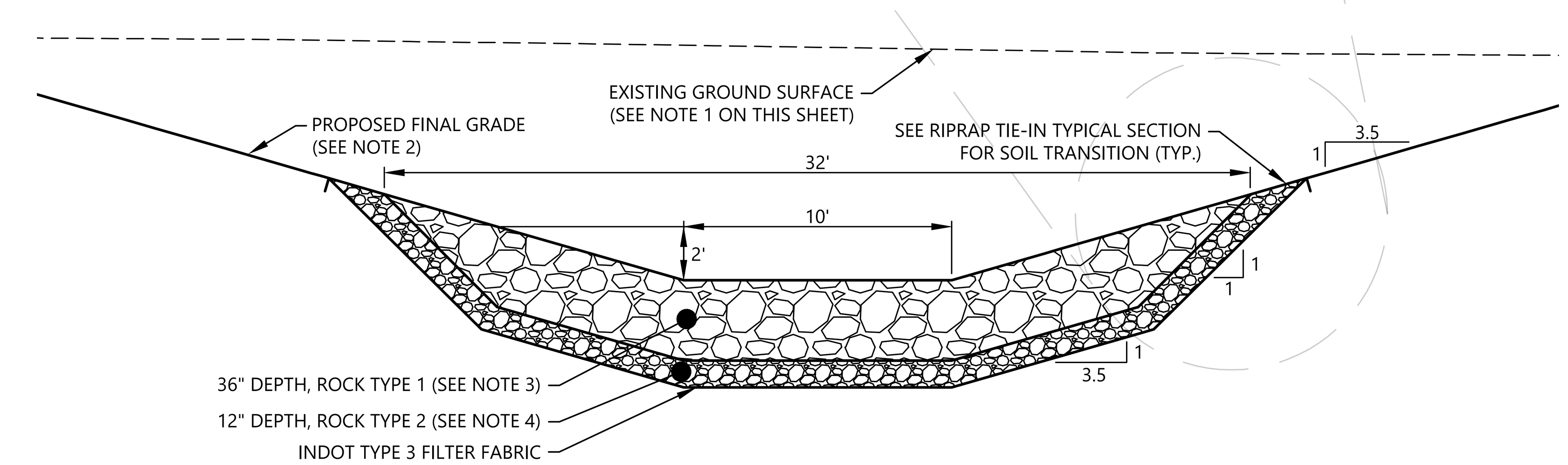
NOTES:

1. EXISTING GROUND SURFACE CONTOURS AND PROFILE ELEMENTS SHOWN ON THIS SHEET REPRESENT A COMPOSITE SURFACE INCLUDING PHASE I COVER GRADES AND EXISTING GROUND SURVEY.
2. PROPOSED GRADES AND PROFILE ELEMENTS SHOWN ON THIS SHEET REPRESENT FINAL COVER ELEVATIONS FOR SOIL BREACHES ON BOTH SIDES OF THE ASH POND.
3. ROCK TYPE 1 SHALL BE IN ACCORDANCE WITH INDIANA DOT SECTION 616 WITH THE FOLLOWING EXCEPTION: MATERIAL SHALL HAVE AT LEAST 85 PERCENT OF THE TOTAL MATERIAL BY WEIGHT LARGER THAN 12-INCH (0.3m) BUT LESS THAN 24-INCH (0.6m) SQUARE OPENING AND AT LEAST 50% OF THE TOTAL MATERIAL BY WEIGHT LARGER THAN 18-INCH (0.5m) SQUARE OPENING. FURNISH MATERIAL SMALLER THAN A 12-INCH (0.3m) SQUARE OPENING THAT CONSISTS PREDOMINANTLY OF ROCK SPALLS AND ROCK FINES, AND THAT IS FREE OF SOIL.
4. ROCK TYPE 2 SHALL BE UNIFORM RIPRAP TYPE B INSTALLED IN ACCORDANCE WITH INDIANA DOT SECTION 616 AND SECTION 904.04(f).
5. ROCK TYPE 3 (GROUTED RIPRAP) SHALL BE IN ACCORDANCE WITH INDIANA DOT SECTION 616 WITH THE FOLLOWING EXCEPTION: MATERIAL SHALL HAVE AT LEAST 85 PERCENT OF THE TOTAL MATERIAL BY WEIGHT LARGER THAN 6-INCH (150mm) BUT LESS THAN 18-INCH (0.5m) SQUARE OPENING AND AT LEAST 50% OF THE TOTAL MATERIAL BY WEIGHT LARGER THAN 12-INCH (0.3m) SQUARE OPENING. FURNISH MATERIAL SMALLER THAN A 6-INCH (150mm) SQUARE OPENING THAT CONSISTS PREDOMINANTLY OF ROCK SPALLS AND ROCK FINES, AND THAT IS FREE OF SOIL. GROUT MIX AND INSTALLATION SHALL BE IN ACCORDANCE WITH INDOT SECTION 616.04.
6. FILTER FABRIC TYPE 3 FOR RIPRAP CHANNELS SHALL BE INSTALLED IN ACCORDANCE WITH INDIANA DOT SECTION 616.11.



RIPRAP TIE-IN TYPICAL SECTION

SCALE: NTS



EAST SOIL BREACH TYPICAL SECTION

SCALE: 1"=5'

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1650 DES PERES RD., SUITE 303
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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG, DEARBORN COUNTY, IN

MICHAEL T. ROMANELLO, REGISTERED PE11400160, STATE OF INDIANA, PROFESSIONAL ENGINEER 10-13-17

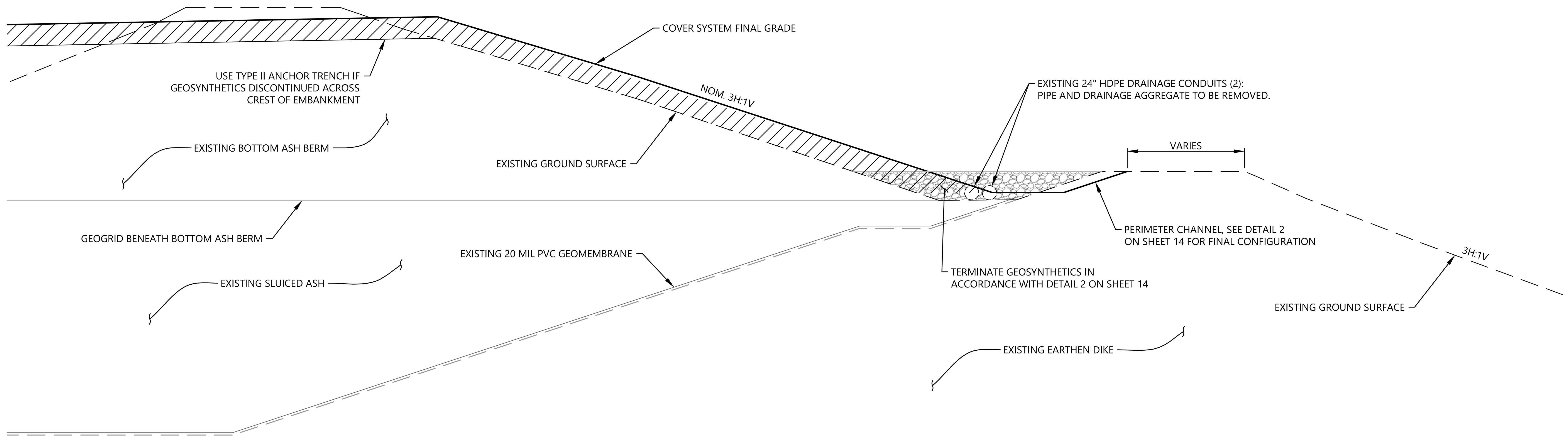
NO.	DATE	DESCRIPTION	BY	CHK	MGR	MTR	APV
△	10/31/17	ISSUED FOR APPROVAL	MRM				

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
12

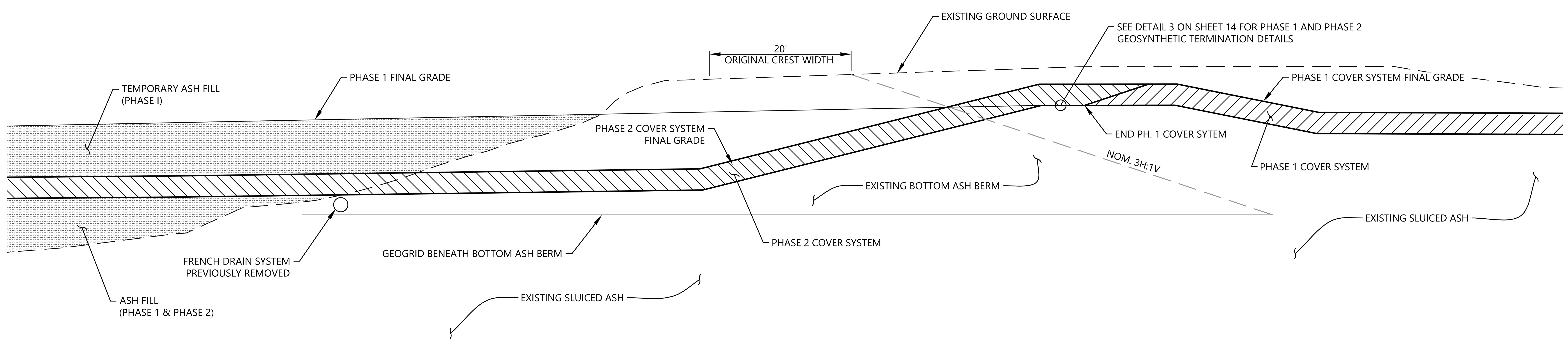
DRAWING NAME
SOIL BREACH PLAN PROFILE AND DETAILS

MODIFIED FOR 36" COVER SYSTEM



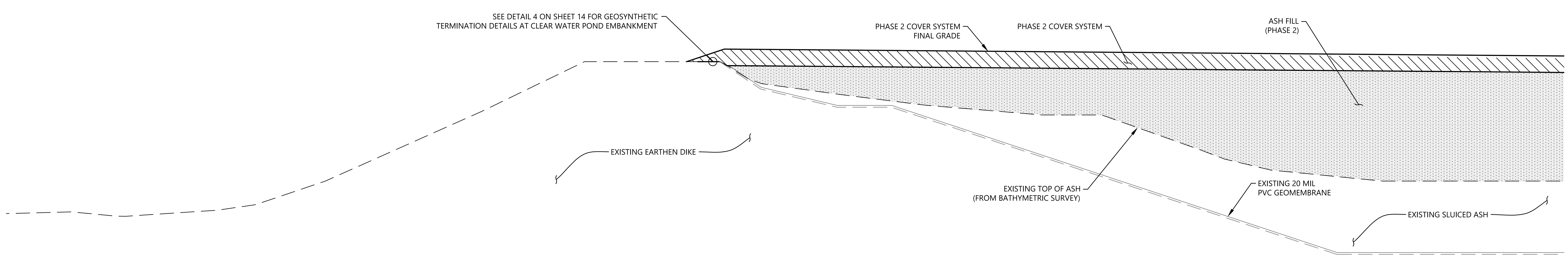
TYPICAL SECTION THROUGH UPPER BASIN EXTERIOR DIKES

SCALE: 1" = 10'



TYPICAL SECTION THROUGH BOTTOM ASH SPLITTER DIKE

SCALE: 1" = 10'



TYPICAL SECTION THROUGH CLEAR WATER POND EXTERIOR EMBANKMENT

SCALE: 1" = 10'

0 2 4 6 8 10 20 30

GRAPHIC SCALE IN FEET

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FLY ASH POND CLOSURE
TANNERS CREEK PLANT

LAWRENCEBURG,DEARBORN COUNTY, IN

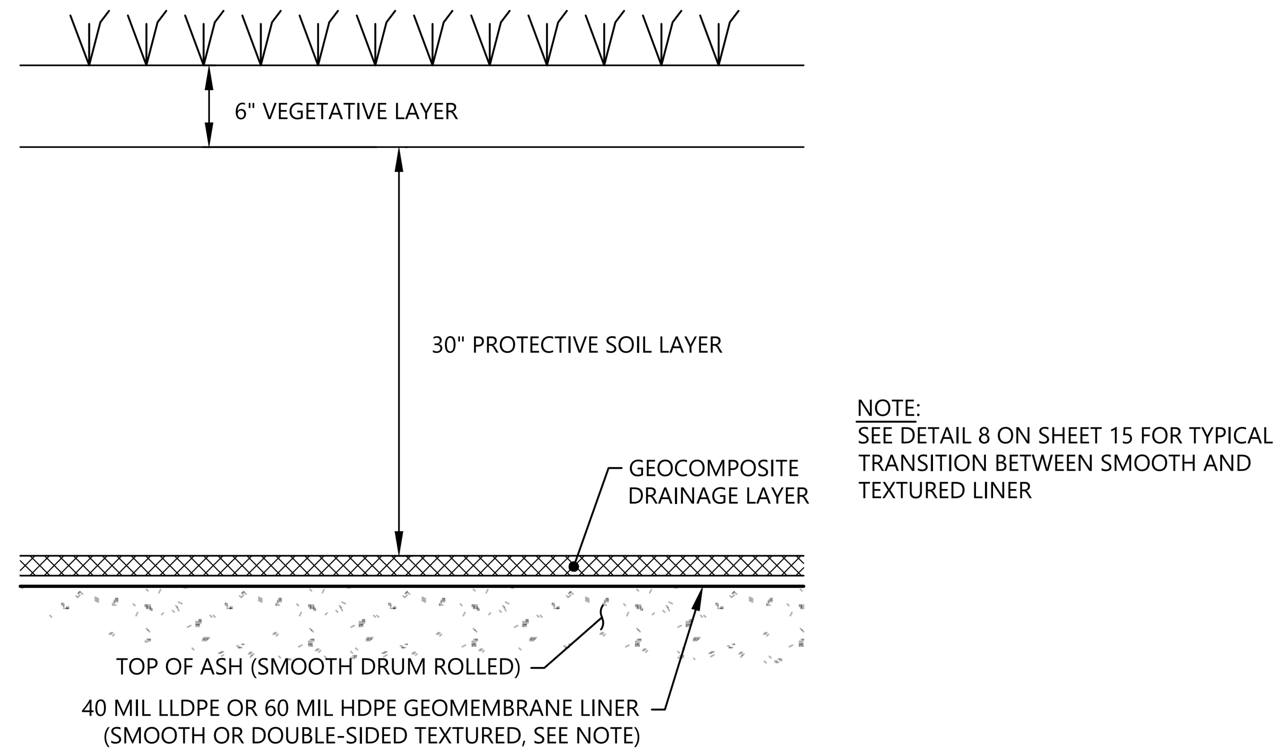
NO.	DATE	DESCRIPTION	BY	CHK	APV
1	03/09/18	IDEM RAI NO. 1	DCV	MGR	MTR
	10/31/17	ISSUED FOR APPROVAL	MTR	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
13

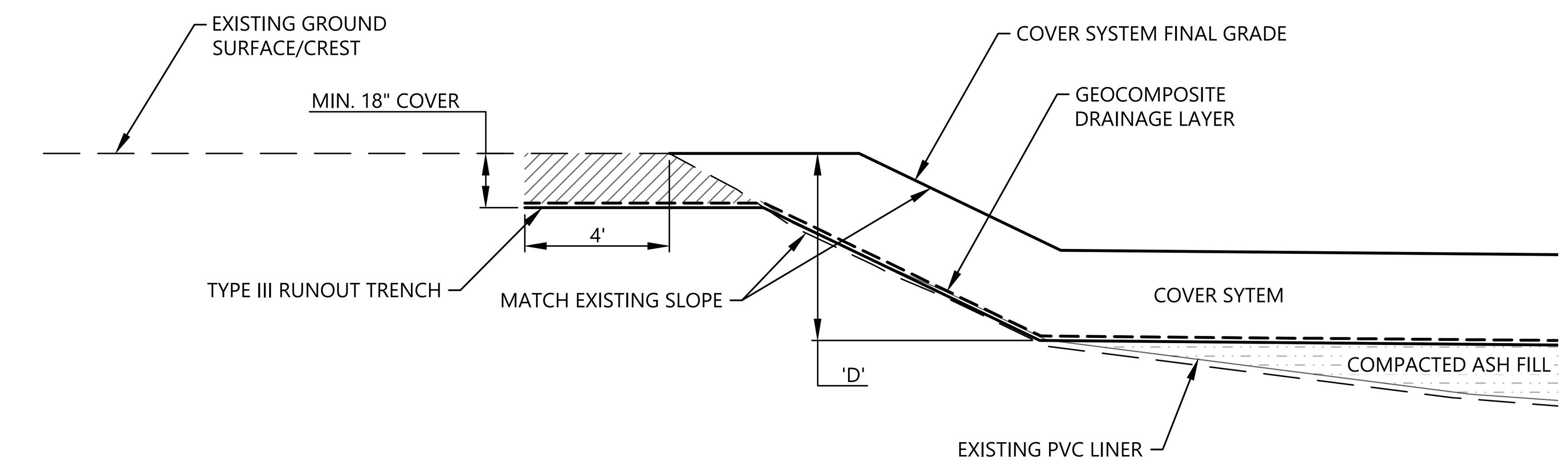
DRAWING NAME
TYPICAL SECTIONS

△ MODIFIED FOR 36" COVER SYSTEM

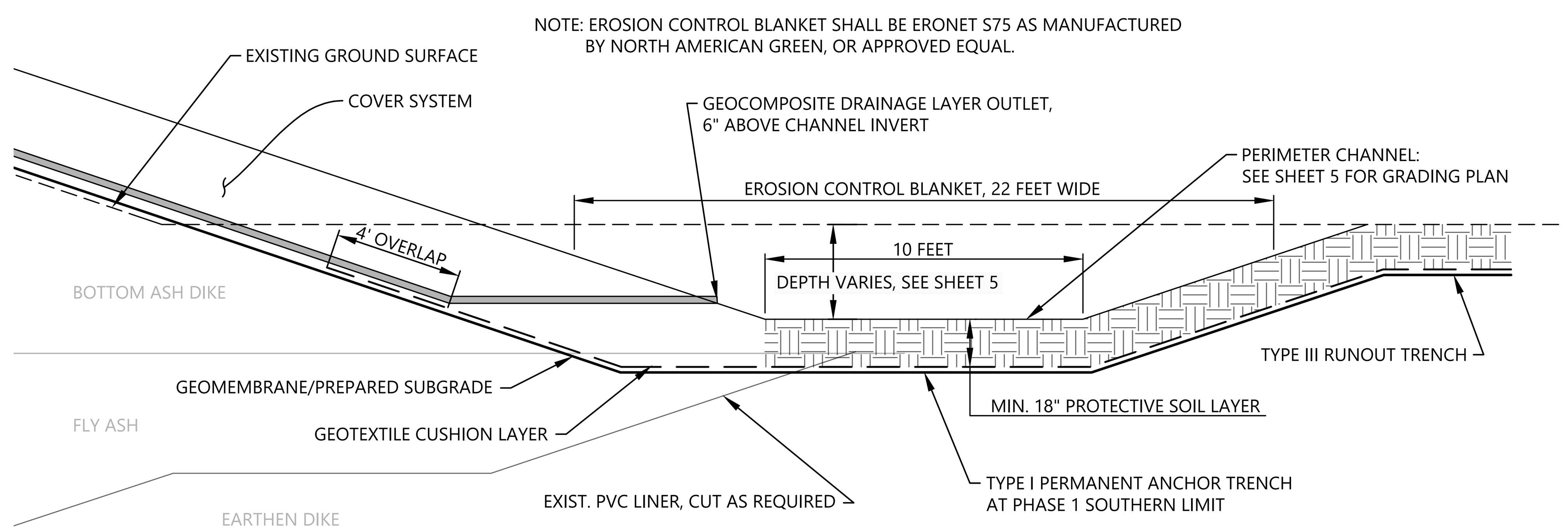


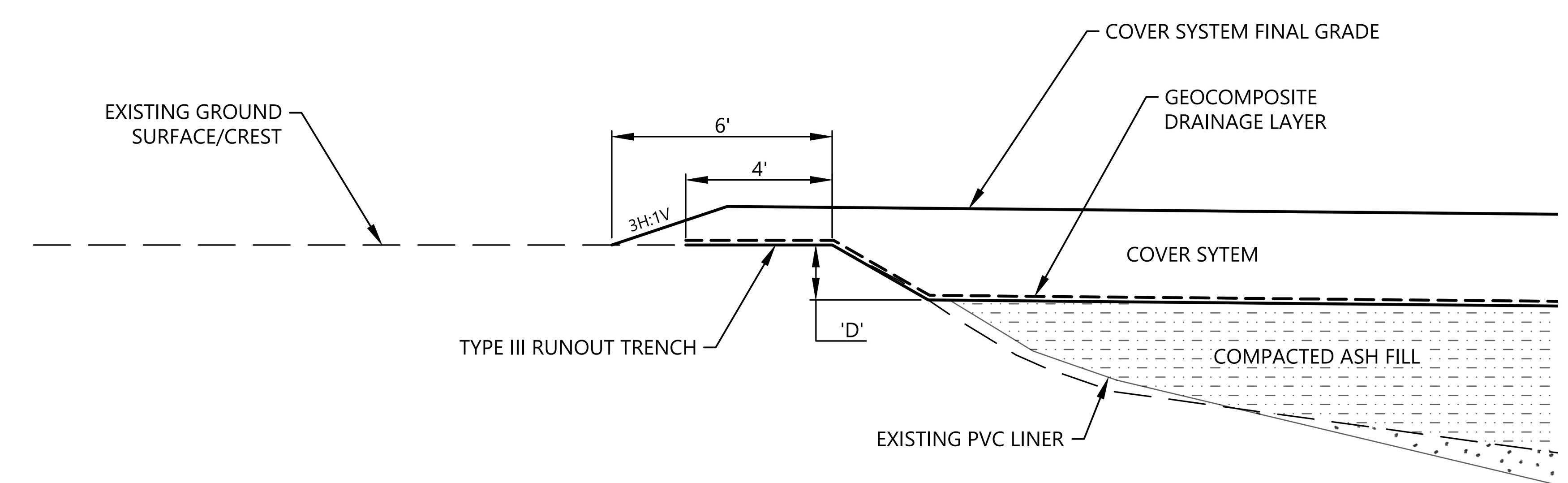
1 COVER SYSTEM TYPICAL SECTION

NOT TO SCALE



DEPTH TO LINER 'D' GREATER THAN 2 FEET





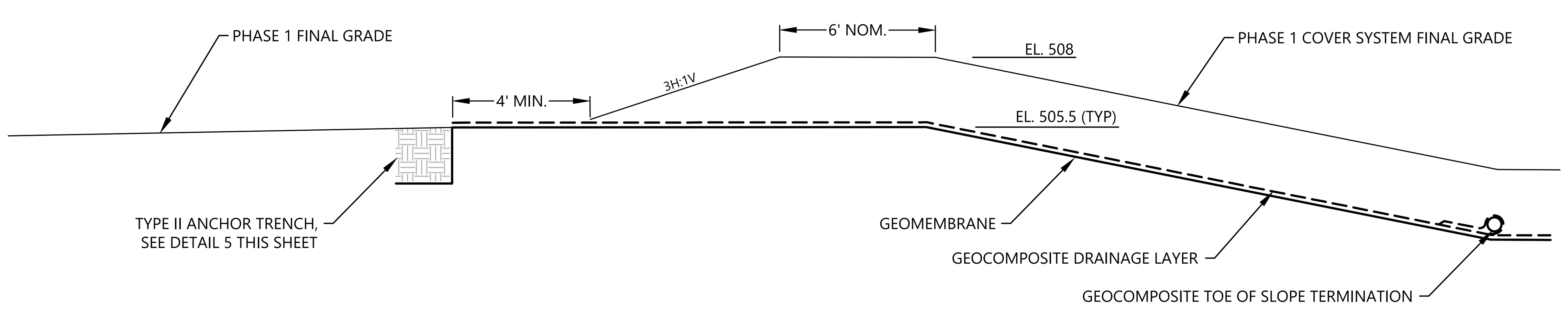
DEPTH TO LINER 'D' LESS THAN 2 FEET

2 LINER TERMINATION AT PERIMETER CHANNEL

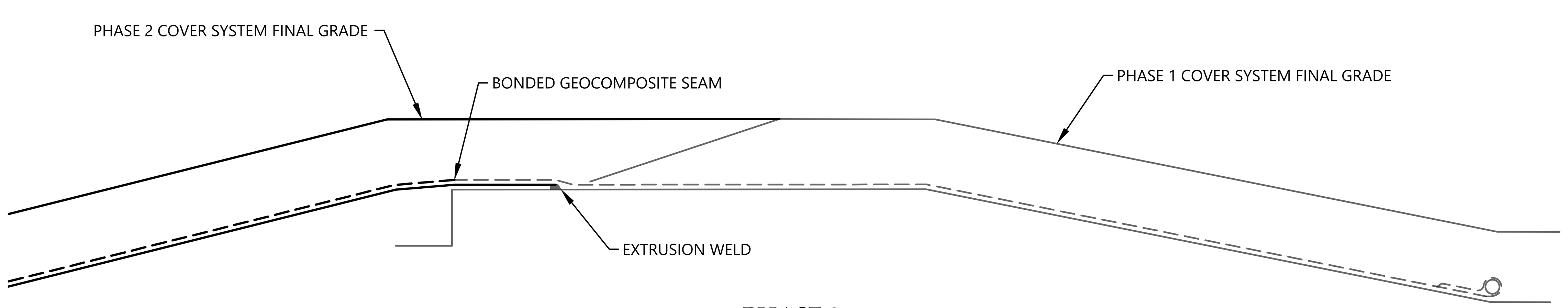
SCALE: 1" = 4'

4 CLEAR WATER POND LINER TERMINATION

SCALE: 1" = 4'



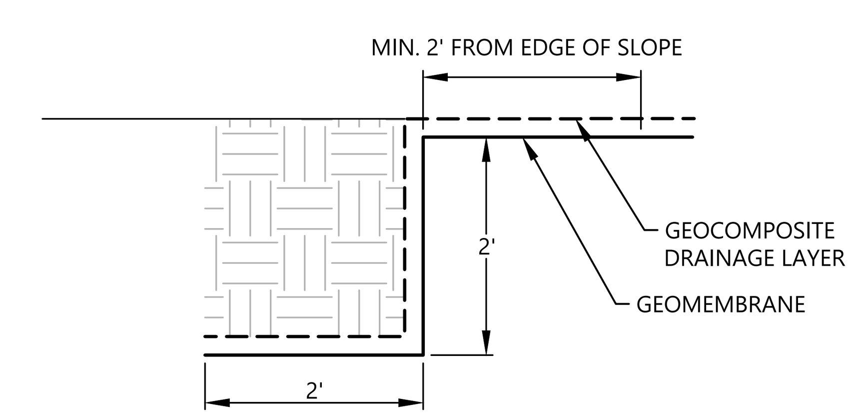
PHASE 1



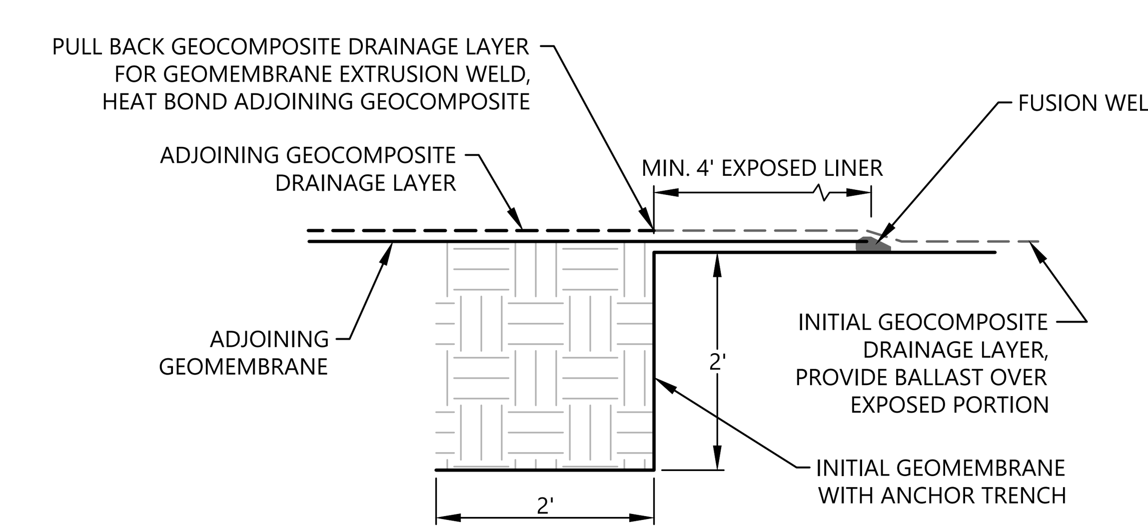
PHASE 2

3 SPLITTER DIKE LINER TERMINATION

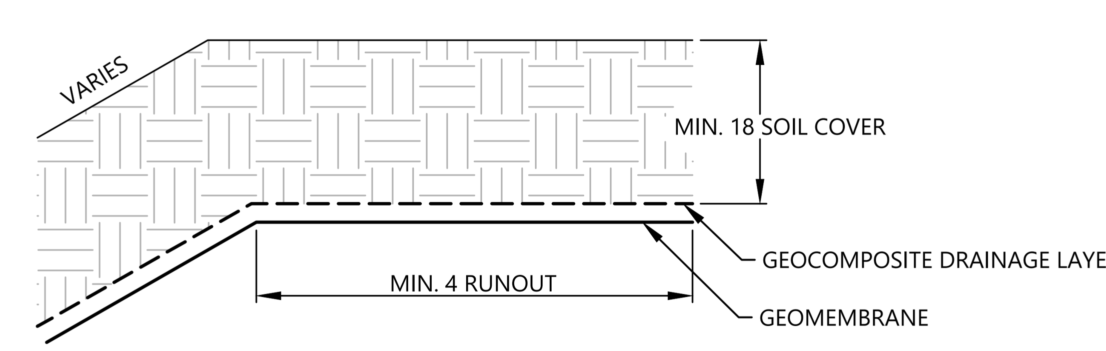
SCALE: 1" = 4'



TYPE I: PERMANENT ANCHOR TRENCH



TYPE II: TEMPORARY ANCHOR TRENCH



TYPE III: RUNOUT TRENCH

5 LINER TERMINATION DETAILS

NOT TO SCALE

0 1" 2" 3"

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TANNERS CREEK DEVELOPMENT, LLC
1650 DES PERES RD., SUITE 303
ST. LOUIS, MO 63131

FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG,DEARBORN COUNTY, IN

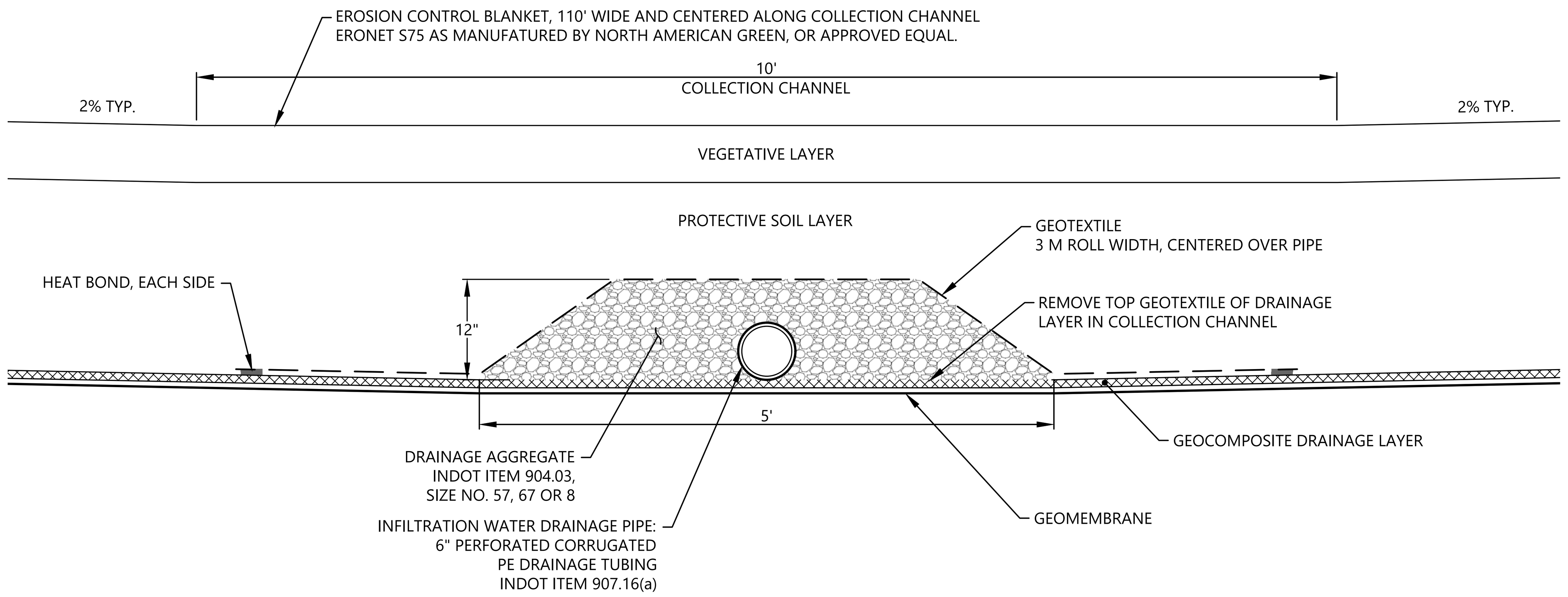
NO.	DATE	DESCRIPTION	BY	CHK	APV
△	06/22/18	MODIFIED DETAILS 1 & 5	PSS	MGR	MTR
△	03/09/18	IDEM RAI NO. 1	DCV	MGR	MTR
△	10/31/17	ISSUED FOR APPROVAL	MTR	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
14

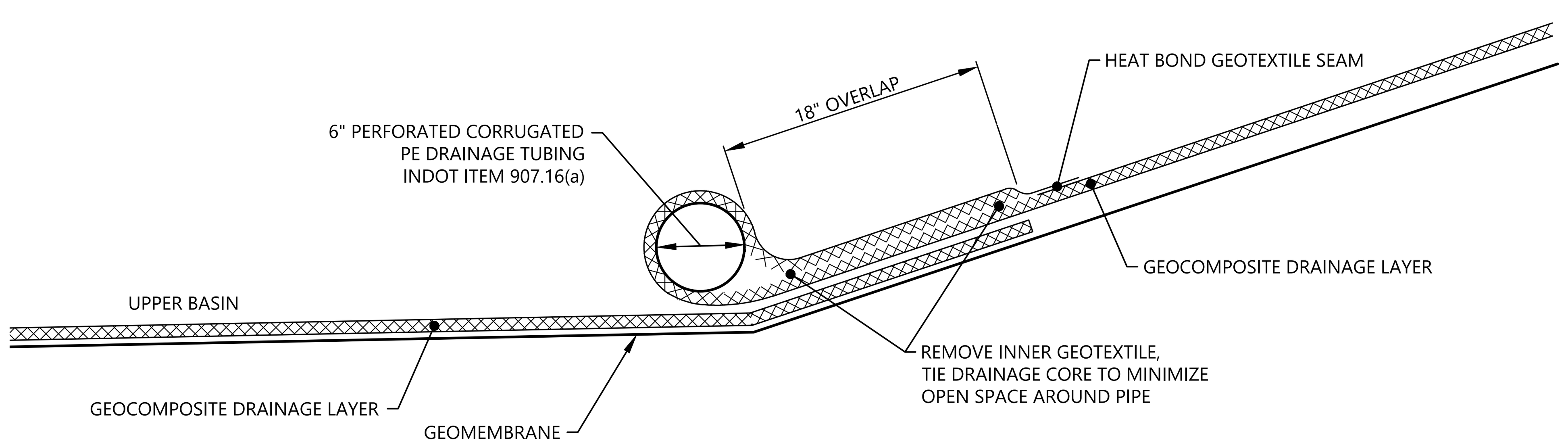
DRAWING NAME
DETAILS

T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\13-16_DETAILS.dwg-14 Details Jun 21, 2018 - 11:50am psimko



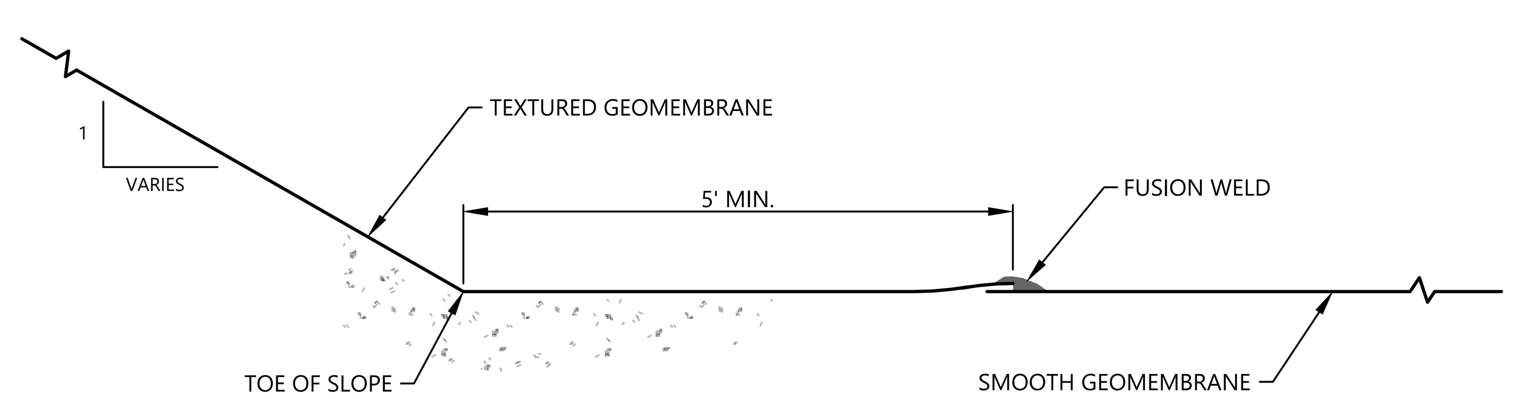
6 COLLECTION CHANNEL

NOT TO SCALE



7 GEOCOMPOSITE OUTLET AT TOE OF SLOPE

NOT TO SCALE



8 SMOOTH TO TEXTURED LINER TRANSITION

NOT TO SCALE

0 1" 2" 3"

T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\13-16_DETAILS.dwg-15 Details Jun 21, 2018 - 11:56am psimko

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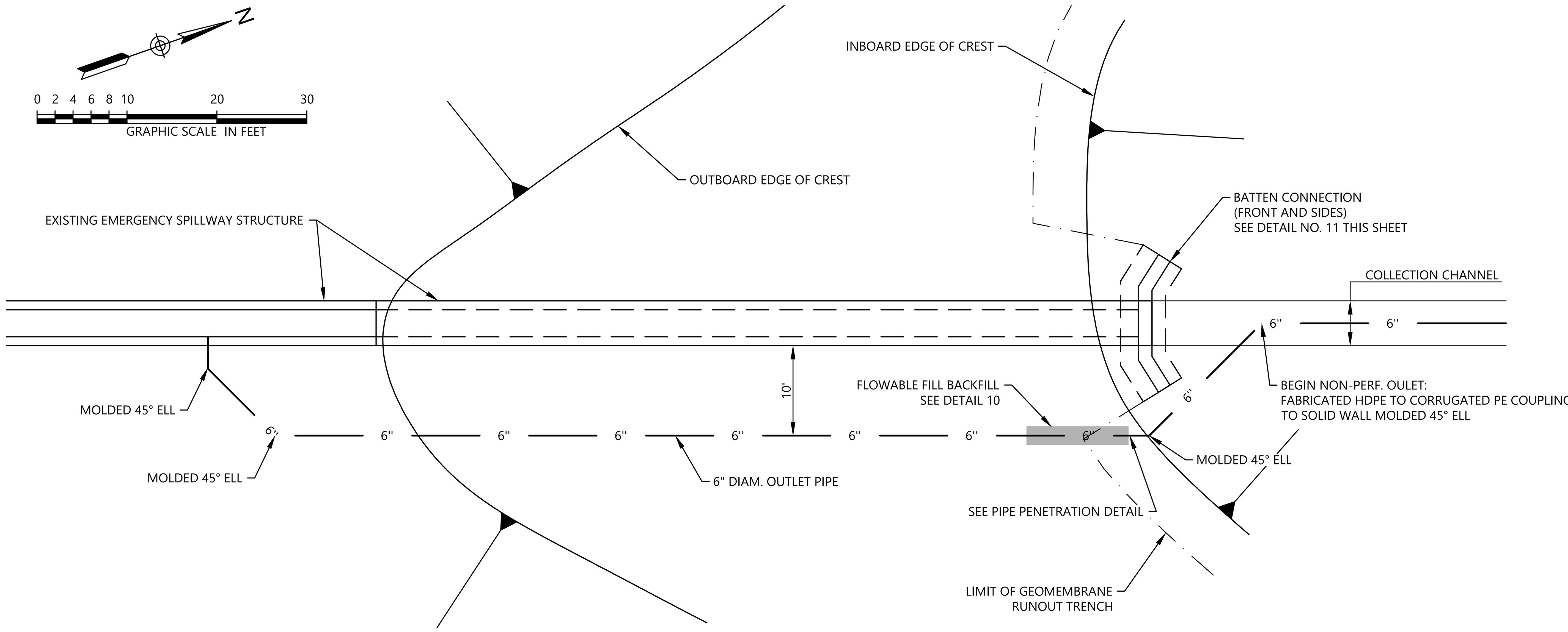
FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG,DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
2	06/22/18	MODIFIED DETAIL 7	PSS	MGR	MTR
1	10/31/17	ISSUED FOR APPROVAL	MTR	MGR	MTR

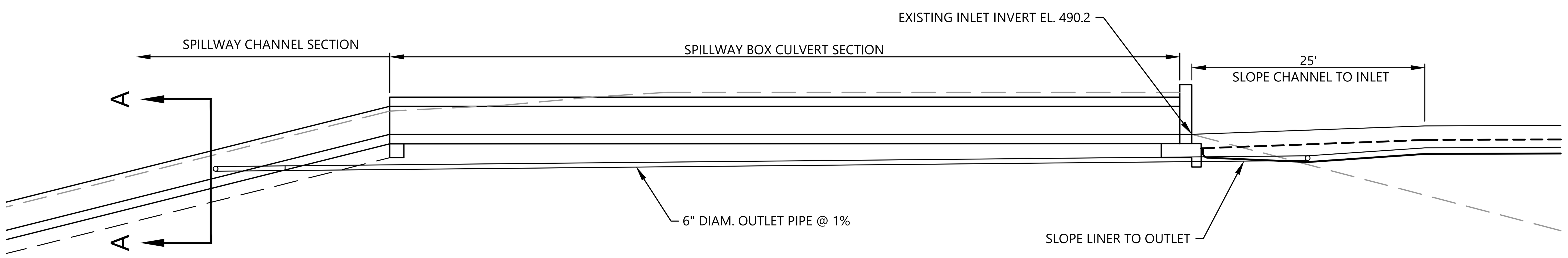
PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
15

DRAWING NAME
DETAILS



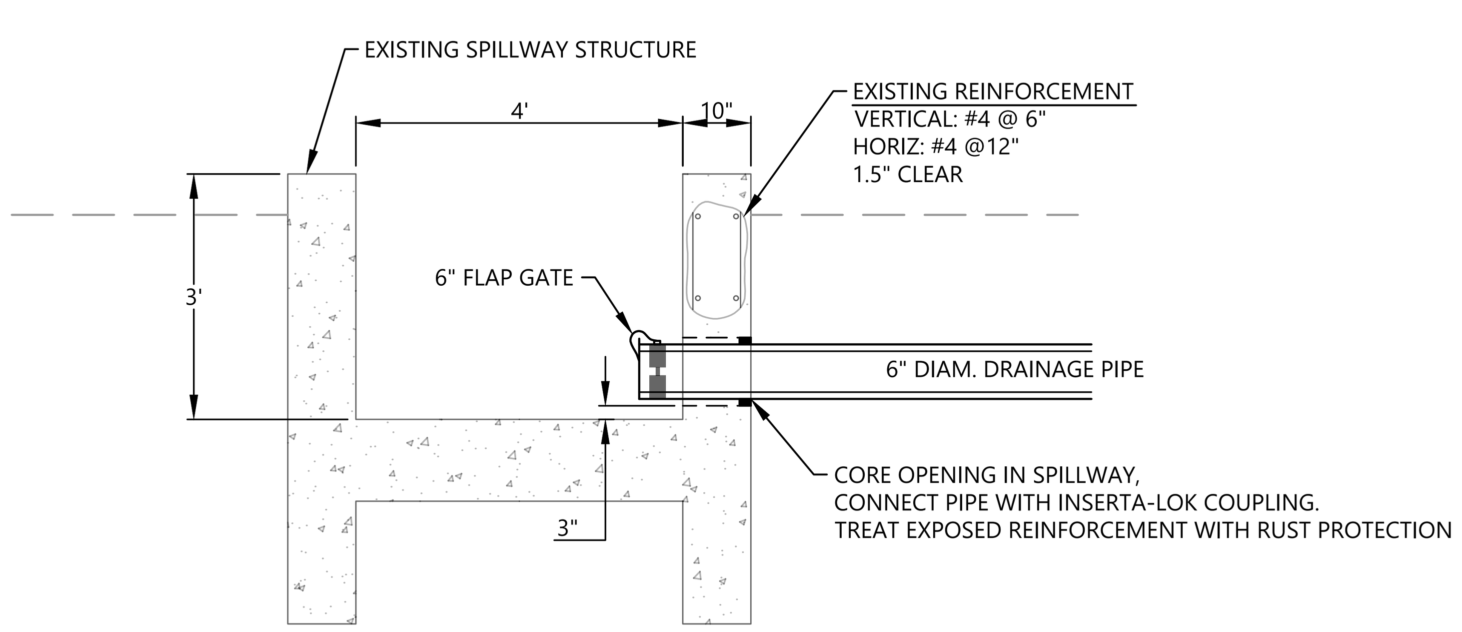
PLAN



PROFILE

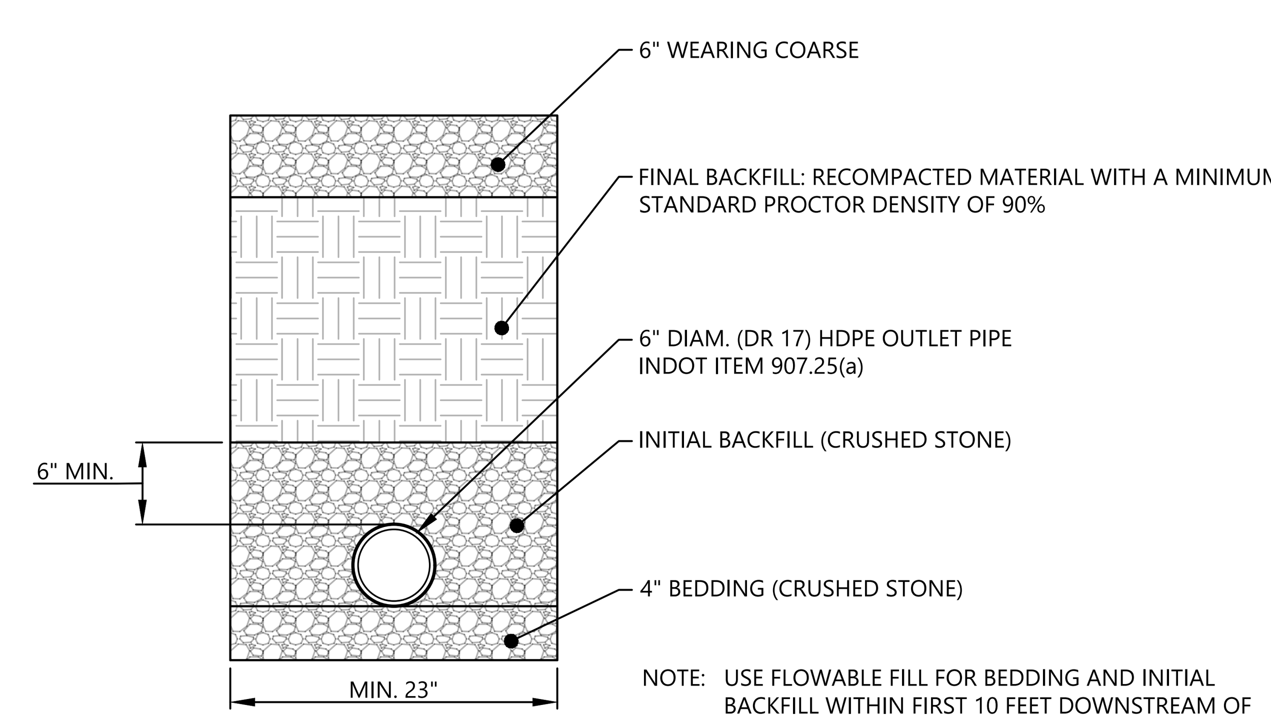
CLEAR WATER POND COLLECTION CHANNEL OUTLET

SCALE: 1" = 10'



SECTION A-A

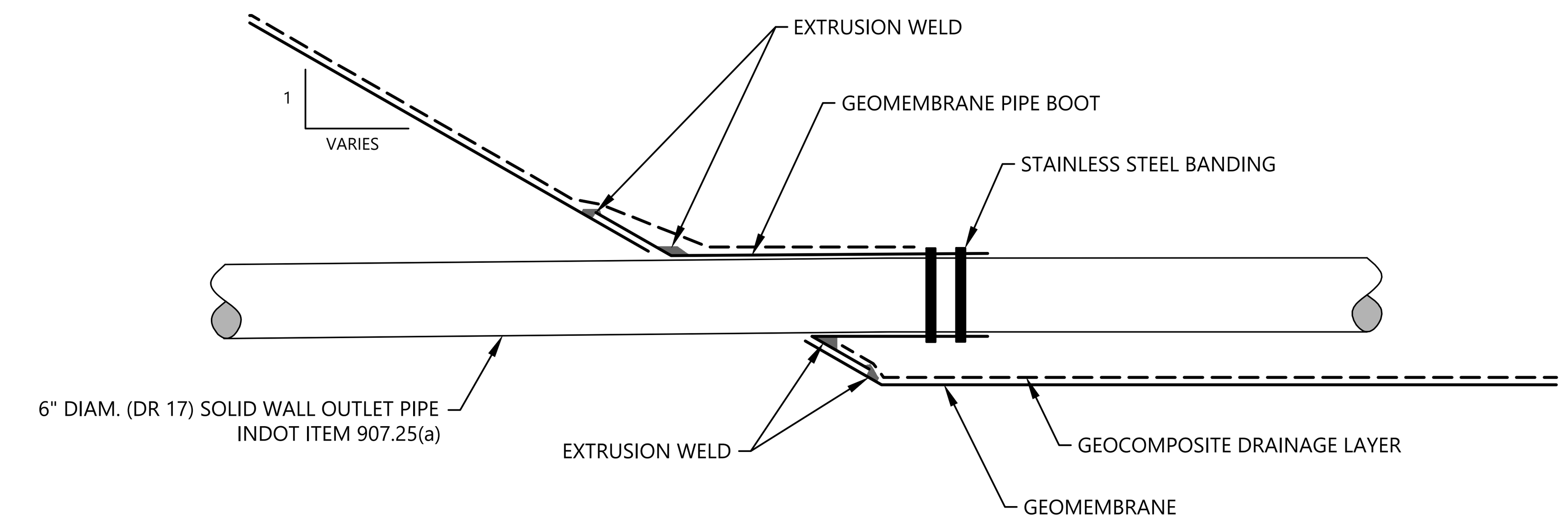
SCALE: 1" = 2'



10

TRENCH INSTALLATION DOWNSTREAM OF LINER PENETRATION

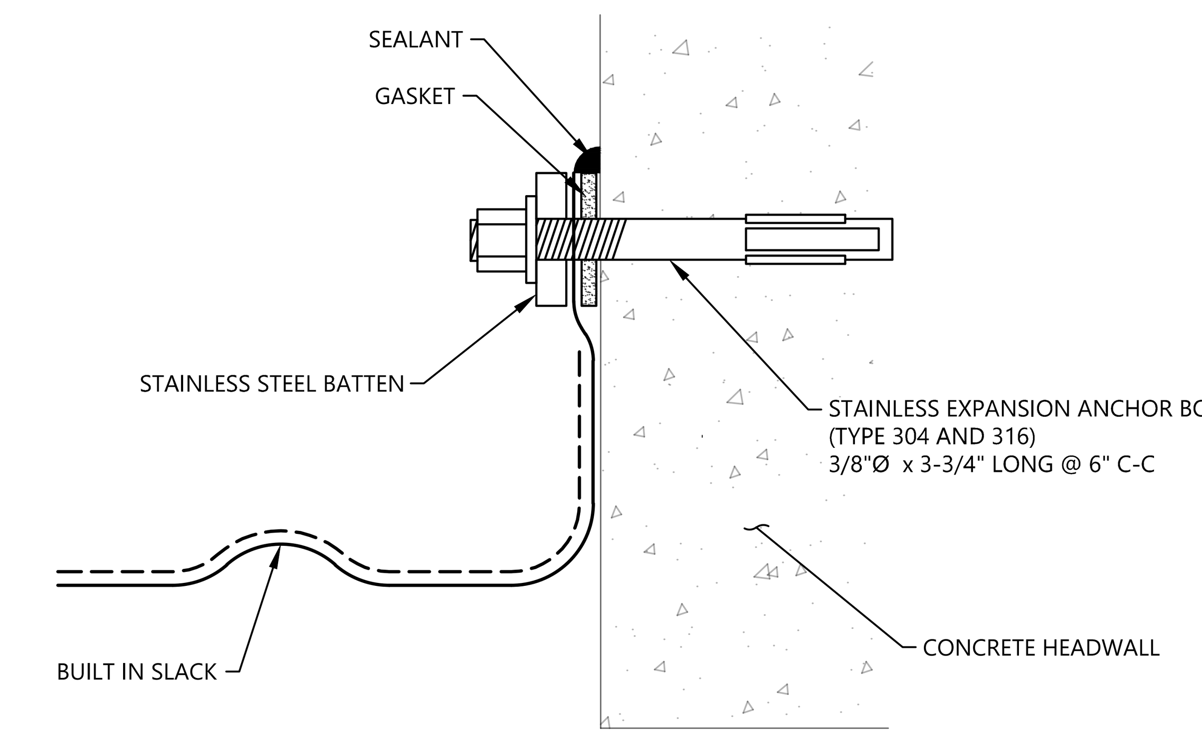
NOT TO SCALE



11

PIPE PENETRATION

NOT TO SCALE



12

STEEL BATTEN WITH CONCRETE ANCHOR

NOT TO SCALE

0 1" 2" 3"

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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG,DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
△	10/31/17	ISSUED FOR APPROVAL	MTR	MGR	MTR

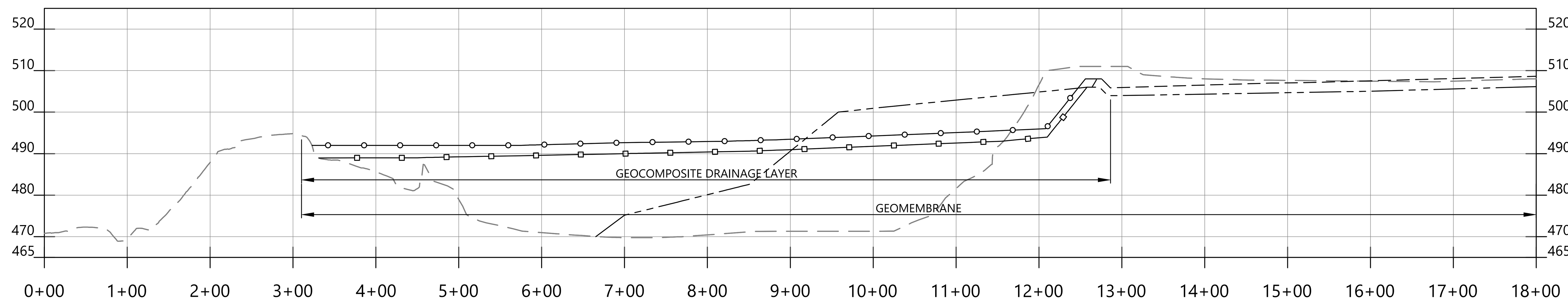
PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
16

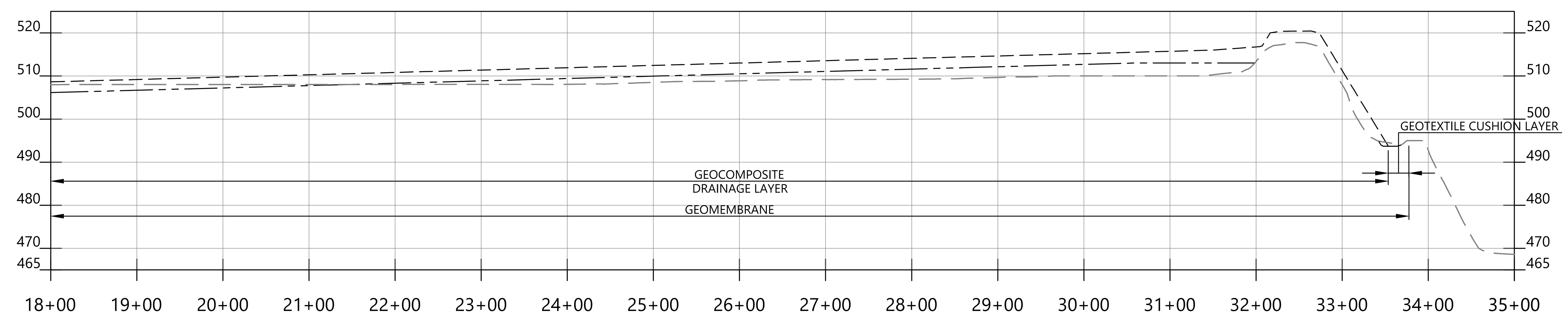
DRAWING NAME
DETAILS

T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\13-16_DETAILS.dwg-16 Details Jun 21, 2018 - 11:58am psimko

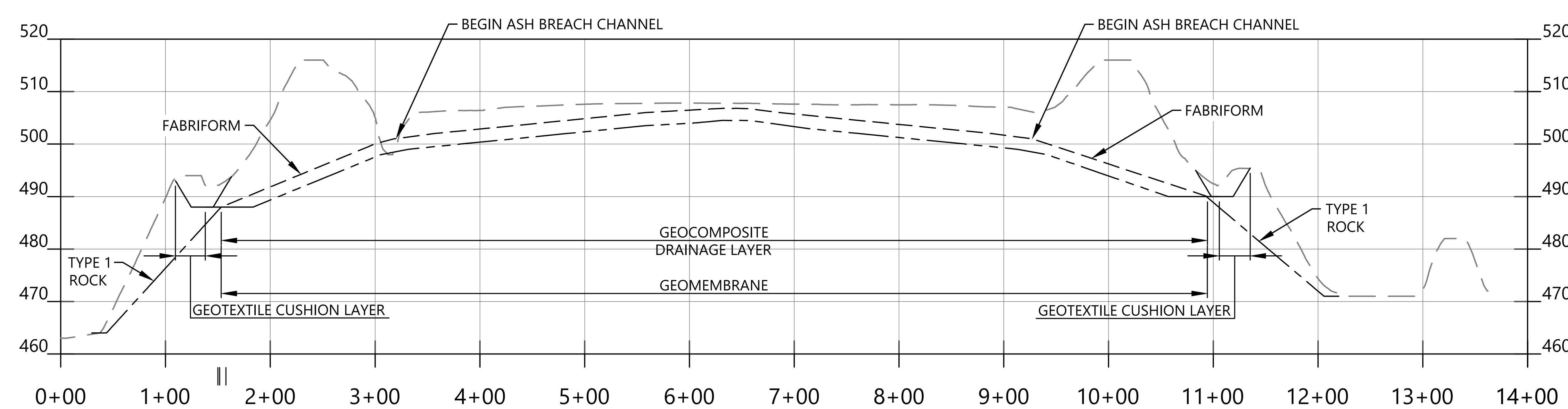
⚠ ADDED LIMITS OF GEOSYNTHETIC LAYERS



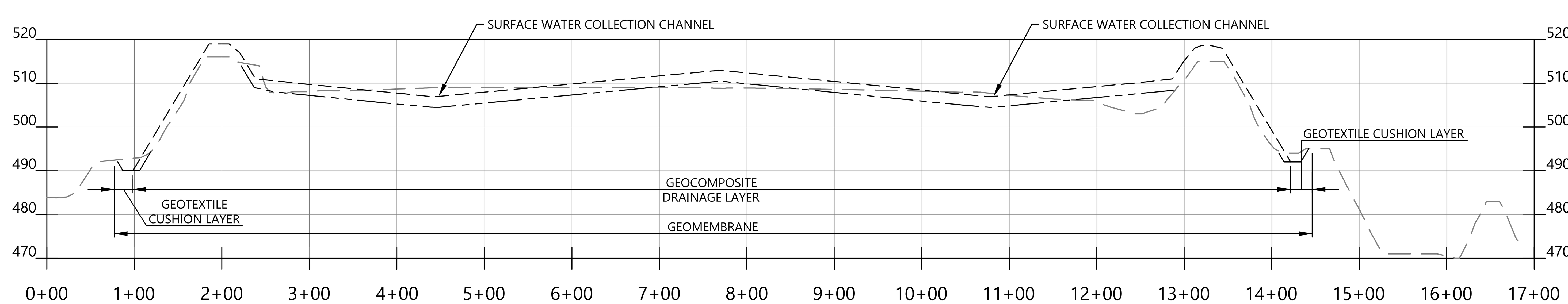
A-A PROFILE
SCALE H:1"=100'; V:1"=20'



A-A PROFILE (CONT'D)
SCALE H:1"=100'; V:1"=20'



B-B PROFILE
SCALE H:1"=100'; V:1"=20'



C-C PROFILE
SCALE H:1"=100'; V:1"=20'

LEGEND

- EXISTING GROUND SURFACE
- INITIAL STORMWATER CONTROLS
- LOWER DIKE BREACH
- PHASE 1 TOP OF ASH
- PHASE 1 FINAL COVER
- PHASE 2 TOP OF ASH
- PHASE 2 FINAL COVER

0 20 40 60 80 100 200 300
GRAPHIC SCALE

T:\Resources\Energy\Pwr Plant Project Data\Multi-Project Docs_TCS\CADD\7217-17-007A FA Pond Closure\DWG\CONSTRUCTION\17_SECTIONS.dwg-Cross Sections Jun 21, 2018 - 12:16pm psimko

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FLY ASH POND CLOSURE
TANNERS CREEK PLANT
LAWRENCEBURG,DEARBORN COUNTY, IN

NO.	DATE	DESCRIPTION	BY	CHK	APV
⚠	06/22/18	UPDATED GEOSYNTHETIC LIMITS	PSS	MGR	MTR
⚠	03/09/18	IDEM RAI NO. 1	DCV	MGR	MTR
⚠	10/31/17	ISSUED FOR APPROVAL	MRM	MGR	MTR

PROJECT NUMBER
7217-17-007A

DRAWING NUMBER
17

DRAWING NAME
CROSS SECTIONS