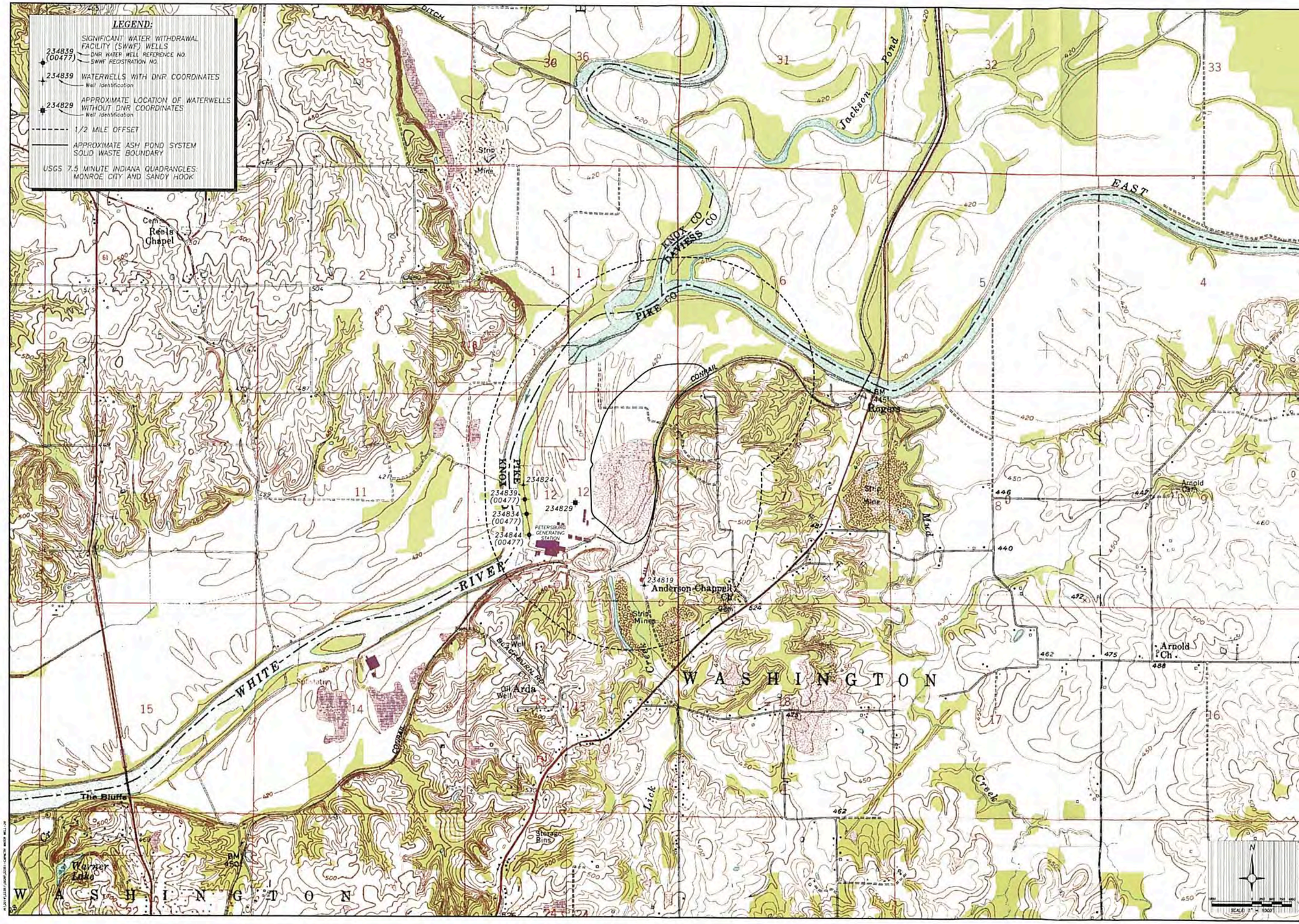
APPENDIX A

IDEM Application Documents for the Proposed Closure of Petersburg Station Ash Pond System

APPENDIX A-1

Preliminary Design Drawings, August 2014, Modified March 2017 (Approved July 2017)



Project Number: 86.22351.0026
Drawing File: SEE LOWER LEFT
Date: 7/14
Scale: AS SHOWN
Rev'd By: | Chd. By: SB/JN | Drn. By: AK/CR

Company Name:
IPL PETERSBURG GENERATING STATION
6925 NORTH STATE ROAD 57
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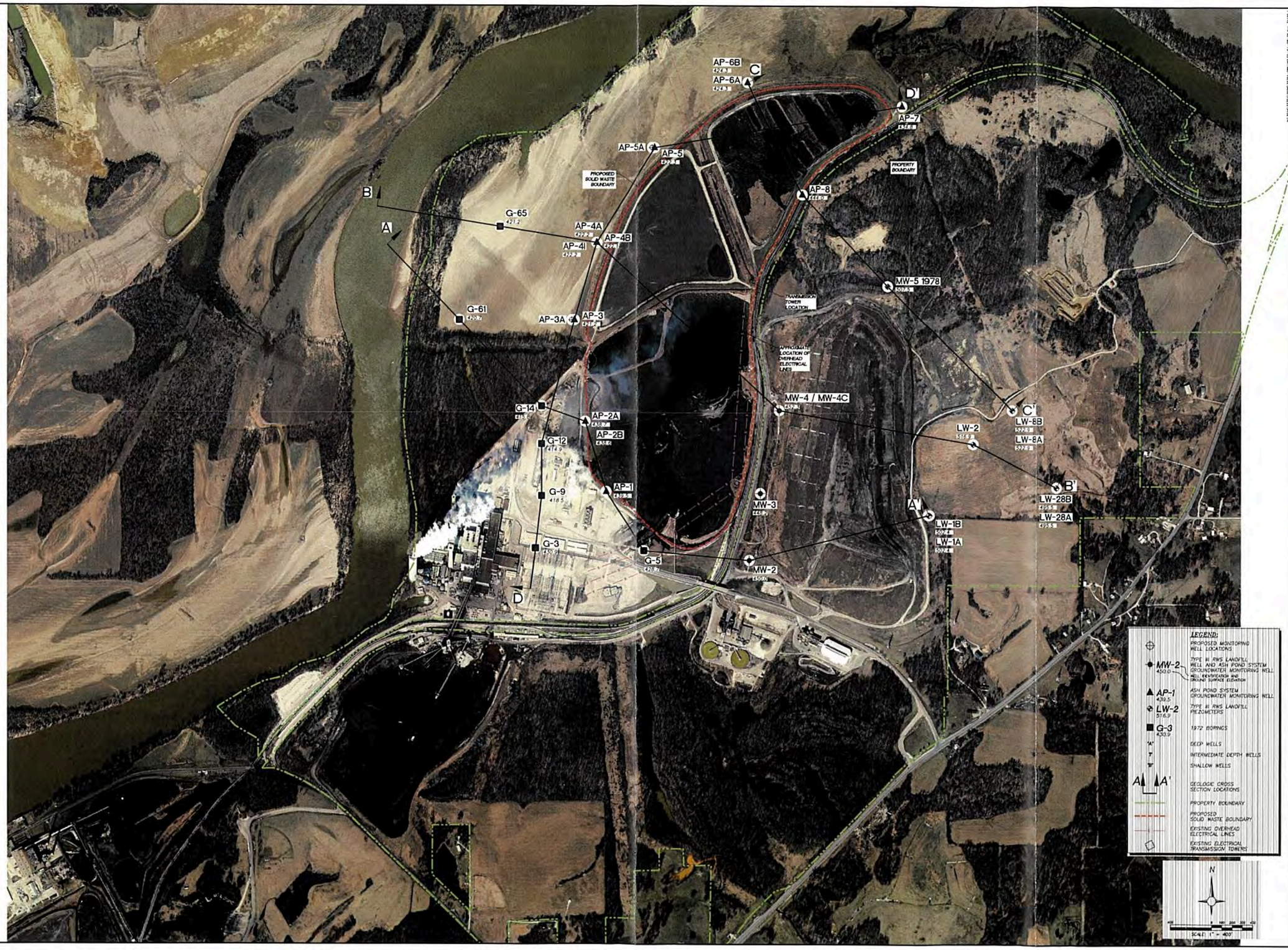
www.cardnoatc.com - www.cardno.com

Drawing Title:
VICINITY MAP/WATERWELLS
PROPOSED CLOSURE OF PETERSBURG STATION ASH POND SYSTEM

Sheet:
1



Revision

Project Number: 66.22351.0026

Drawing File: SEE LOWER LEFT

Date: 7/14

Scale: AS SHOWN

Dwn By: JN/SB

Chk By: CR

Company Name: IPL PETERSBURG GENERATING STATION
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Drawing Title: SITE PLAN
PROPOSED CLOSURE OF PETERSBURG STATION ASH POND SYSTEM

Sheet: 2

AP-6B
AP-6A
D'
AP-7
AP-5A
AP-5
PROPOSED SOLID WASTE BOUNDARY
PROPERTY BOUNDARY
AP-8
B
G-65
A
AP-4A
AP-4B
AP-4I
MW-5 1978
TRANSMISSION TOWER LOCATION
APPROXIMATE LOCATION OF OVERHEAD ELECTRICAL LINES
G-61
AP-3A
AP-3
MW-4 / MW-4C
C
LW-8B
LW-8A
G-14
AP-2A
AP-2B
LW-2
G-12
AP-1
G-9
MW-3
A'
LW-1B
LW-1A
G-3
G-5
N
SCALE: 1" = 200'
LEGEND:
PROPERTY BOUNDARY
PROPOSED SOLID WASTE BOUNDARY
EXISTING OVERHEAD ELECTRICAL LINES
EXISTING ELECTRICAL TRANSMISSION TOWERS
2013 INDIANA LIDAR CONTOURS
PROPOSED MONITORING WELL LOCATIONS
MW-2 450.0
TYPE III RWS LANDFILL WELL AND ASH POND SYSTEM GROUNDWATER MONITORING WELL
WELL IDENTIFICATION AND GROUND SURFACE ELEVATION
AP-1 432.5
ASH POND SYSTEM GROUNDWATER MONITORING WELL
LW-2 516.9
TYPE III RWS LANDFILL PIEZOMETERS
G-3 430.8
1972 BORINGS
'A'
DEEP WELLS
T
INTERMEDIATE DEPTH WELLS
T
SHALLOW WELLS
A A'
GEOLOGIC CROSS SECTION LOCATIONS
Project Number: 86.22351.0024
Drawing File: SEE LOWER LEFT
Date: 7/14
Scale: AS SHOWN
Revised By: DG
Drn By: SP/CR
Company Name: IPL PETERSBURG GENERATING STATION 6925 NORTH STATE ROAD 57 PETERSBURG, INDIANA
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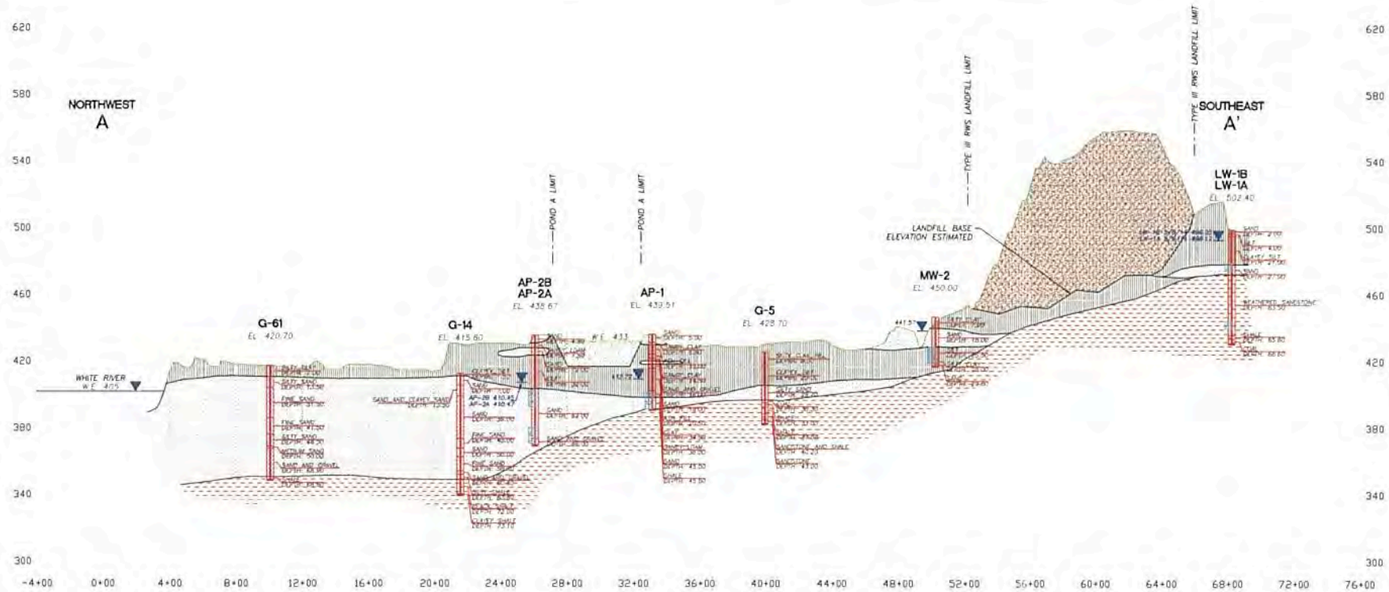
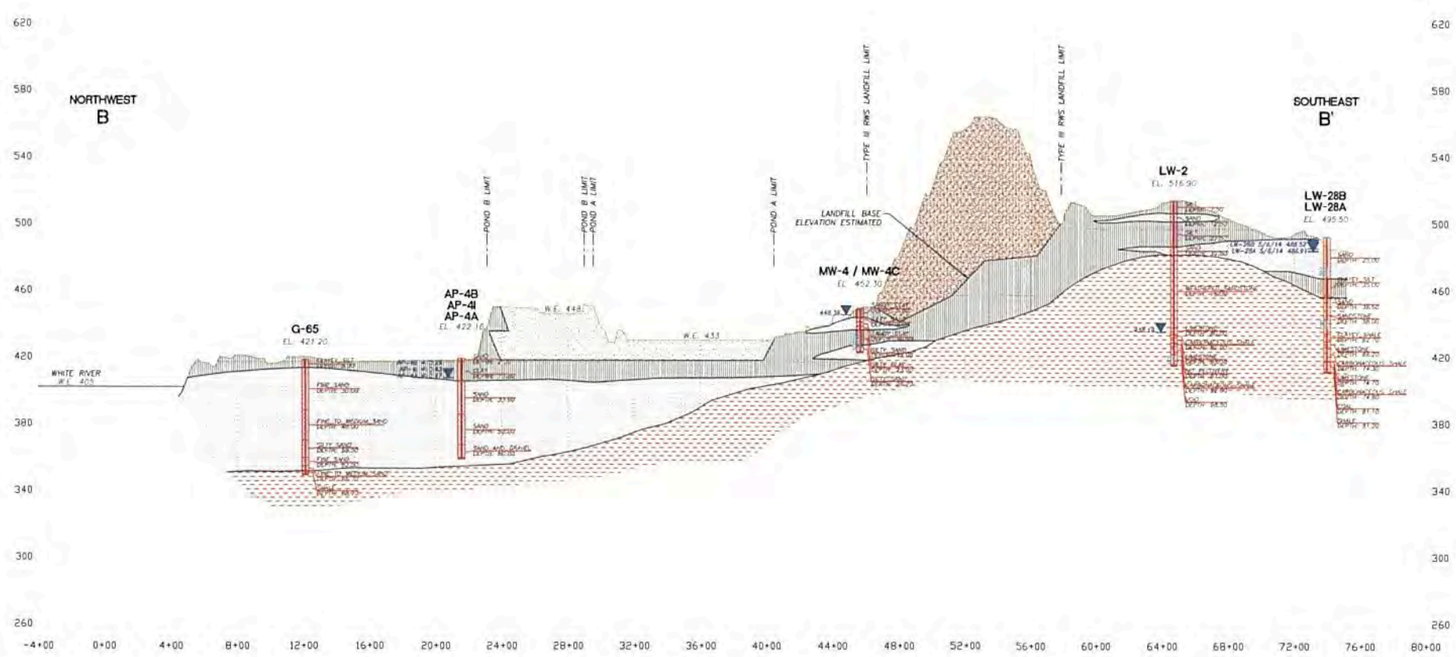
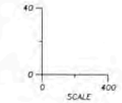
Drawing Title: EXISTING ASH POND SYSTEM CONDITIONS PROPOSED CLOSURE OF PETERSBURG STATION ASH POND SYSTEM
Sheet: 3



CROSS SECTION A-A'

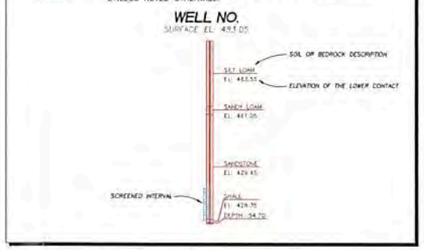


CROSS SECTION B-B'



LEGEND:

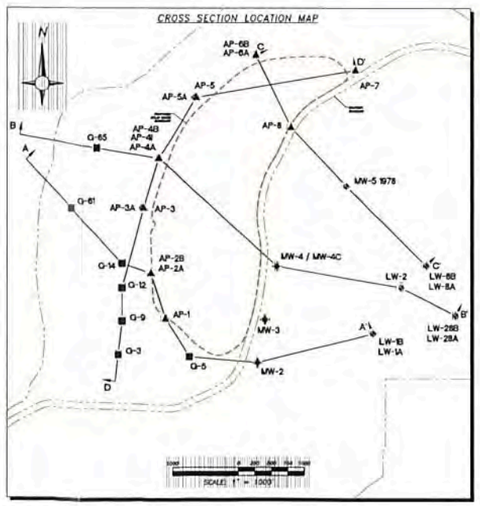
- FINE GRAINED UNCONSOLIDATED DEPOSITS TYPICALLY DESCRIBED AS TOPSOIL, SILT, CLAYEY SILT, LOAM, SANDY LOAM, SILTY LOAM, AND CLAY LOAM
- GRANULAR UNCONSOLIDATED DEPOSITS DESCRIBED GENERALLY AS SAND, SAND AND GRAVEL, SILTY SAND, LOAMY SAND, AND CLAYEY SAND (SEE BORING LOGS FOR DETAILED DESCRIPTIONS)
- TYPE III RWS FILL
- COAL ASH
- SILTSTONE SHALE, SANDSTONE, LIMESTONE BEDROCK AND COAL
- STATIC WATER LEVELS MEASURED JUNE 30 TO JULY 2, 2014 UNLESS NOTED OTHERWISE.



NOTES:

POSTED LITHOLOGIC DESCRIPTIONS ON THE CROSS SECTIONS ARE SUMMARIZED AND CONDENSED FOR CLARITY. SEE BORING LOGS IN THE APPENDICES FOR COMPLETE DESCRIPTIONS.

ASH POND AND TYPE III RWS LANDFILL LIMITS ARE APPROXIMATE.



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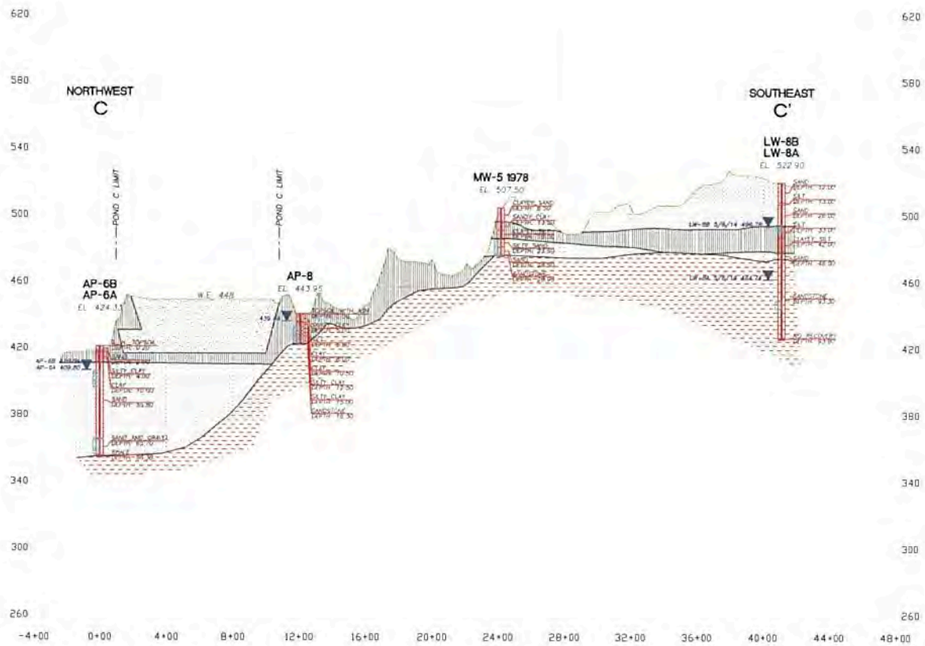
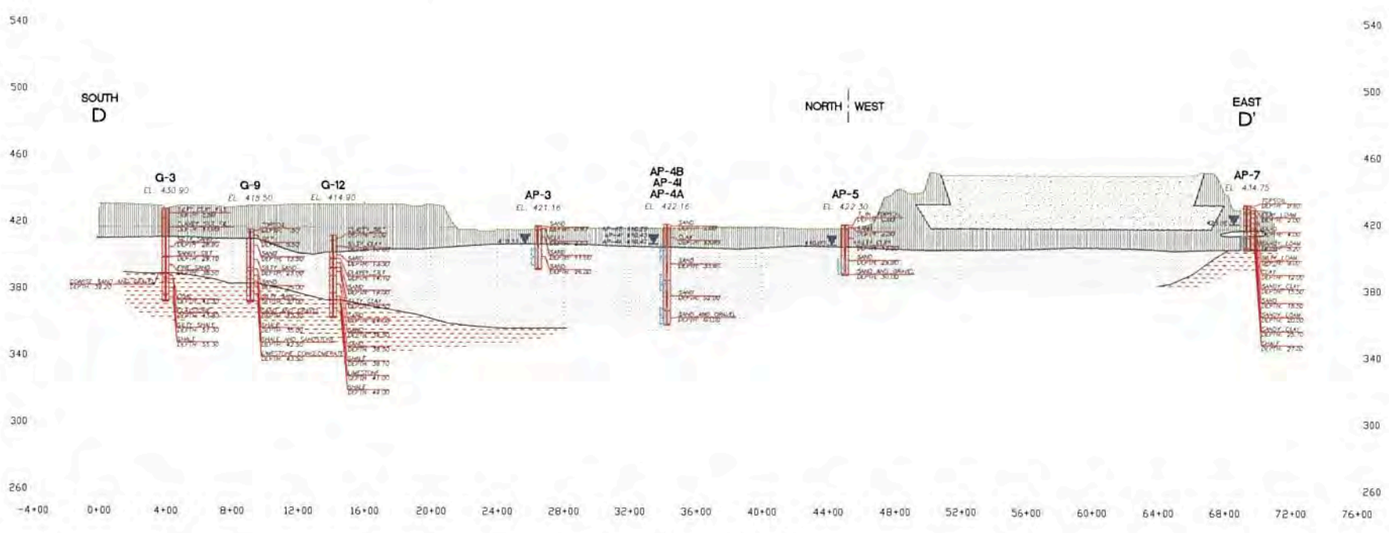
Drawing Title: CROSS SECTIONS A-A' AND B-B'
PROPOSED CLOSURE OF PETERSBURG STATION ASH POND SYSTEM

Sheet: 4

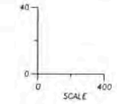
Project Number: 86.22351.0026
Drawing File: SEE LOWER LEFT
Date: 7/14
Scale: AS SHOWN
Ind. By: JN/SB
Dr. By: CR



CROSS SECTION C-C'



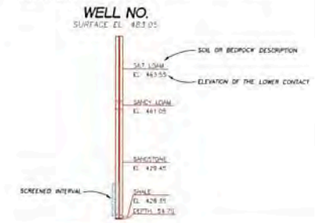
CROSS SECTION D-D'



Horizontal Scale: 1" = 400'
Vertical Scale: 1" = 40'

LEGEND:

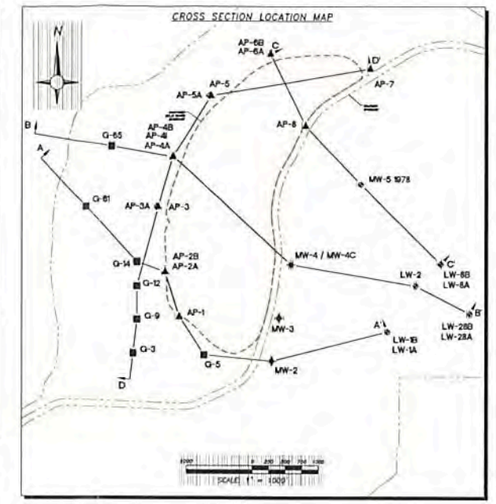
- FINE GRAINED UNCONSOLIDATED DEPOSITS TYPICALLY DESCRIBED AS TOPSOIL, SILT, CLAYEY SILT, LOAM, SANDY LOAM, SILTY LOAM, AND CLAY LOAM
- GRANULAR UNCONSOLIDATED DEPOSITS DESCRIBED GENERALLY AS SAND, SAND AND GRAVEL, SILTY SAND, LOAMY SAND, AND CLAYEY SAND (SEE BORING LOGS FOR DETAILED DESCRIPTIONS)
- TYPE III RWS FILL
- COAL ASH
- SILTSTONE, SHALE, SANDSTONE, LIMESTONE BEDROCK AND COAL
- STATIC WATER LEVELS MEASURED JUNE 30 TO JULY 2, 2014 UNLESS NOTED OTHERWISE.



NOTES:

POSTED LITHOLOGIC DESCRIPTIONS ON THE CROSS SECTIONS ARE SUMMARIZED AND CONDENSED FOR CLARITY. SEE BORING LOGS IN THE APPENDICES FOR COMPLETE DESCRIPTIONS.

ASH POND AND TYPE III RWS LANDFILL LIMITS ARE APPROXIMATE.



Revision:

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Drawing File: SEE LOWER LEFT
Date: 7/14
Scale: AS SHOWN
Rev'd By: JN/SB
Drn. By: CR

Company Name:
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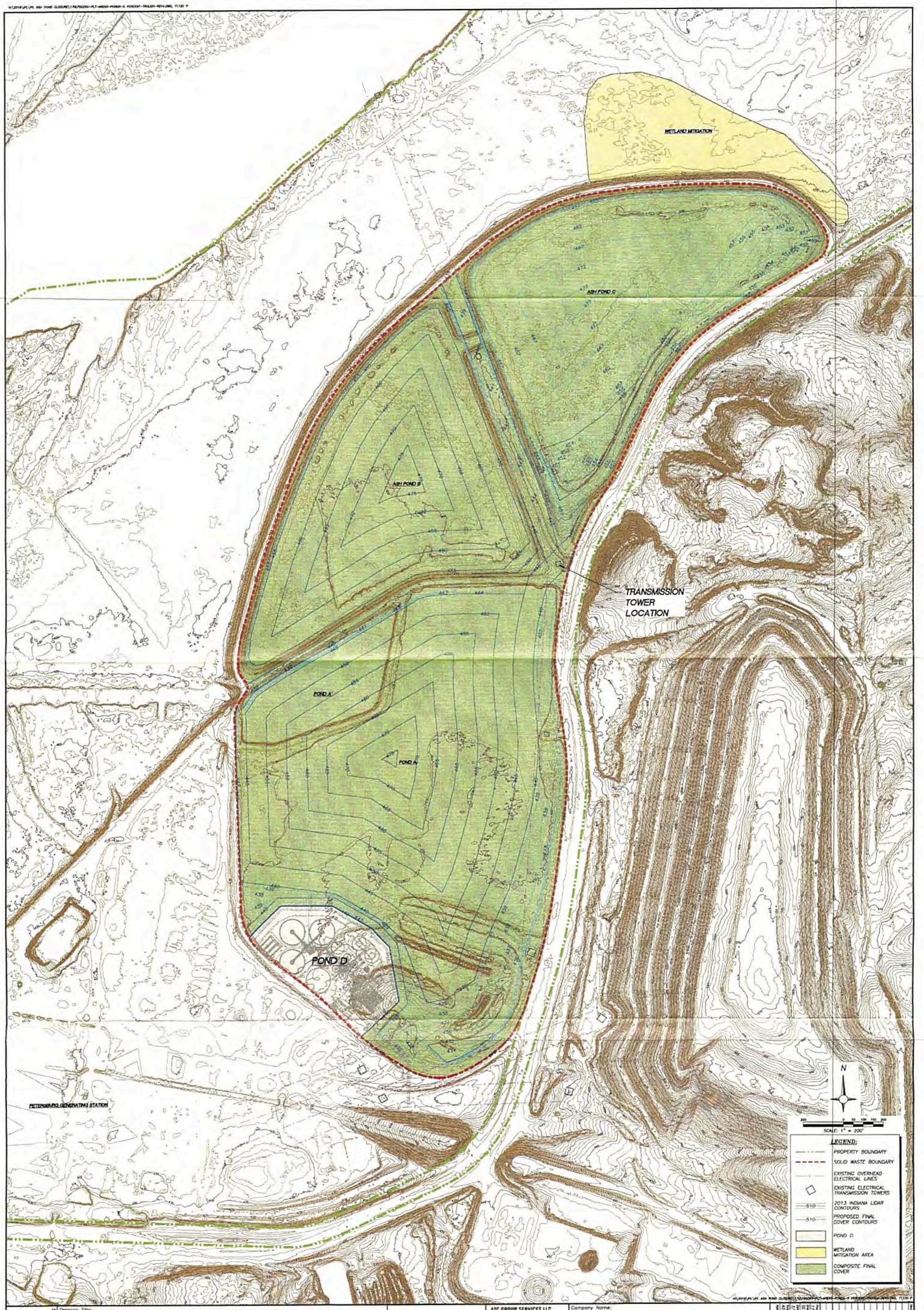
Drawing Title:
CROSS SECTIONS C-C' AND D-D'
PROPOSED CLOSURE OF PETERSBURG STATION ASH POND SYSTEM

Sheet:
5



Sheet: 9

Drawing Title:

PROPOSED FINAL GRADING PLAN
PROPOSED CLOSURE OF PETERSBURG STATION ASH POND SYSTEM

RECEIVED
APR 28 2017
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OFFICE OF LAND QUALITY

ATC

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7988 CENTERPOINT DR.
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INDIANAPOLIS, IN 46256
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Company Name:

IPL PETERSBURG GENERATING STATION
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PETERSBURG, INDIANA

Project Number: 1751000995
Drawing Title: SEE LOWER LEFT
Scale: 1/2"
Date: 3/7/17
Drawn By: DS
Checked By: CL

CROSS-SECTION A1-A1'

CROSS-SECTION A2-A2'

CROSS-SECTION B-B'

CROSS-SECTION C-C'

CROSS-SECTION D-D'

N

SCALE: 1" = 50'

Revisions

Project Number: 86.22351.0024

Drawing File: SEE LOWER LEFT

Date: 7/14

Scale: AS SHOWN

Rev'd By	Chd By	Drn By
	DB	SP

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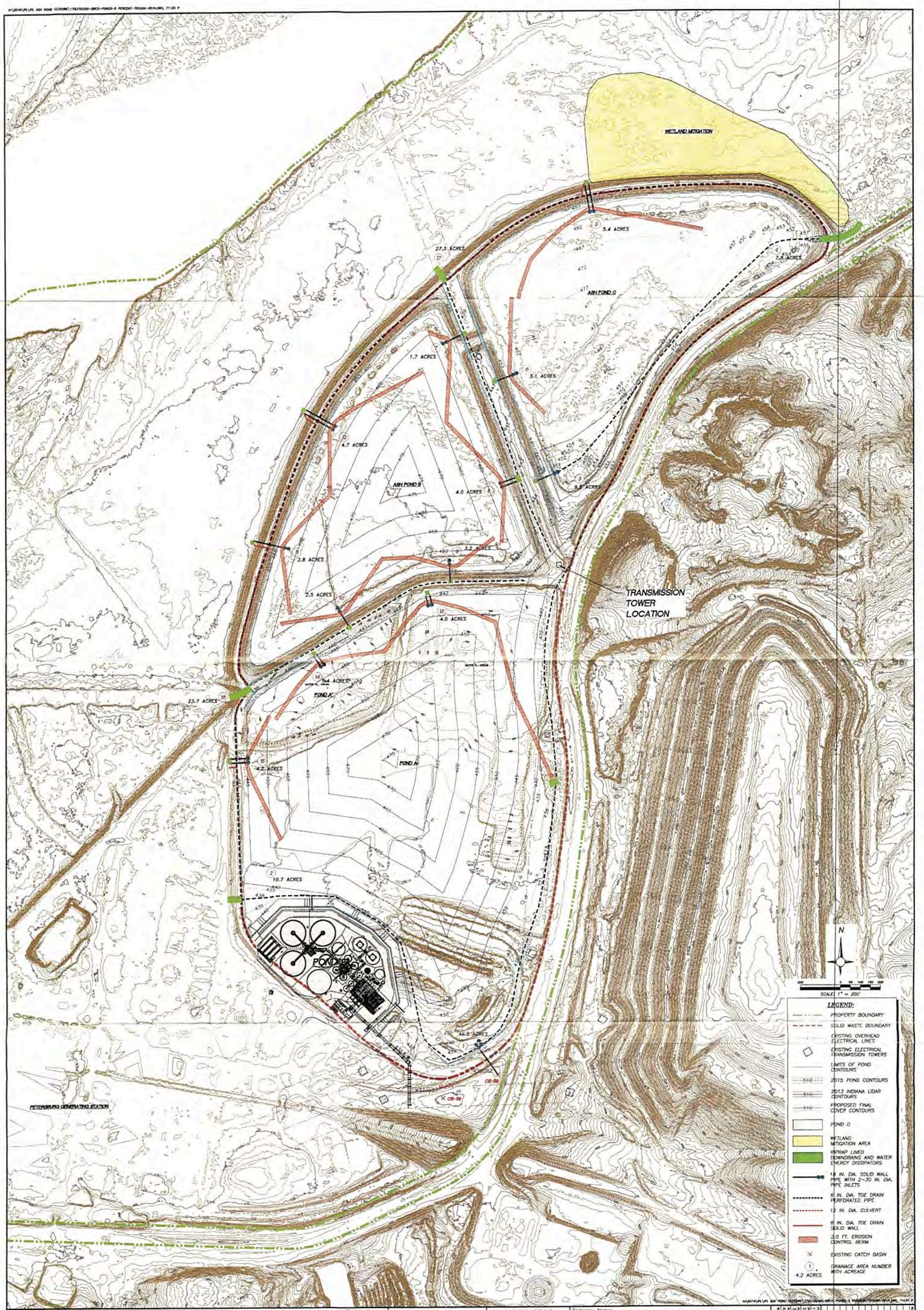
Drawing Title: GENERALIZED CROSS-SECTIONS OF PROPOSED FINAL COVER
PROPOSED CLOSURE OF PETERSBURG STATION ASH POND SYSTEM

Sheet: 7



Sheet: 8

Drawing Title:

LOCATION OF PROPOSED WATER CONTROL SURFACE STRUCTURES
PROPOSED CLOSURE OF PETERSBURG STATION ASH POND SYSTEM

RECEIVED
APR 28 2017
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
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4	3/16/17	JS	SCHEMATIC UPDATE
3	12/16/16	JS	SCHEMATIC UPDATE
2	11/17/16	JS	SCHEMATIC UPDATE
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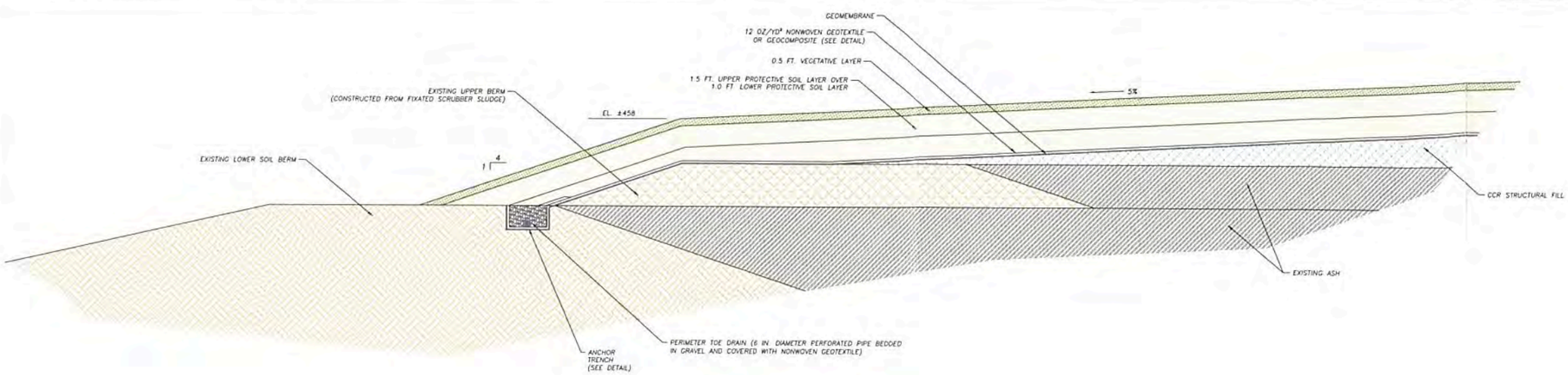
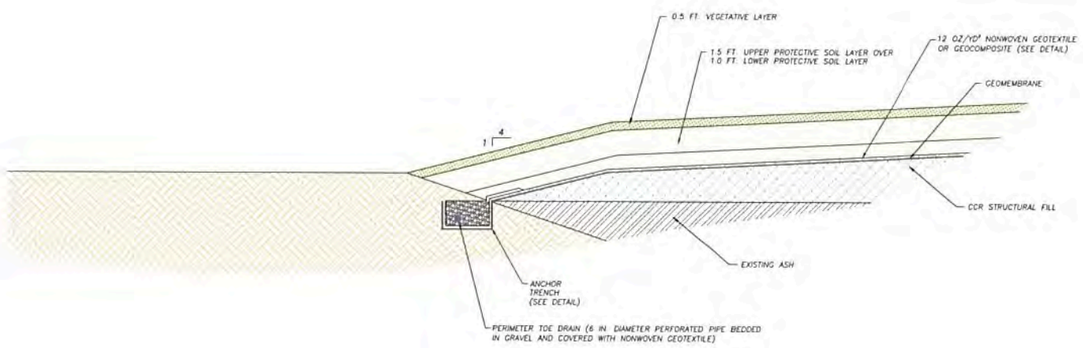
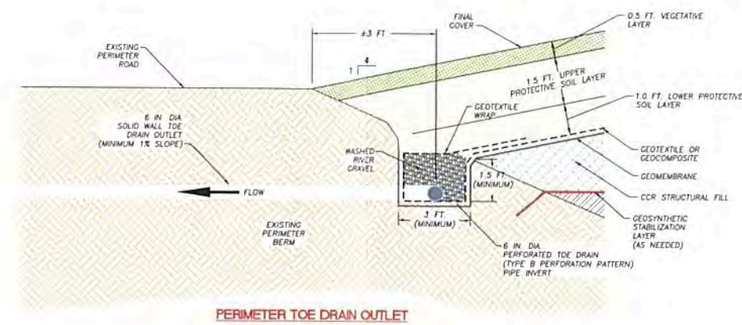


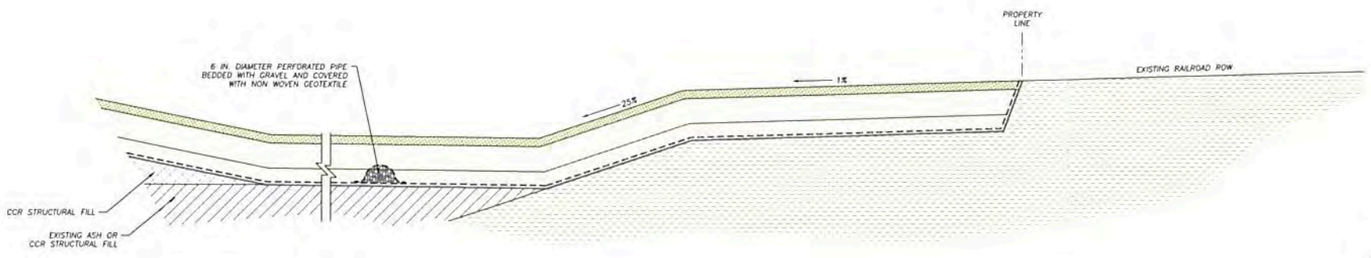
TYPICAL CROSS-SECTON OF FINAL COVER
(ASH PONDS B AND C)
(NOT TO SCALE)



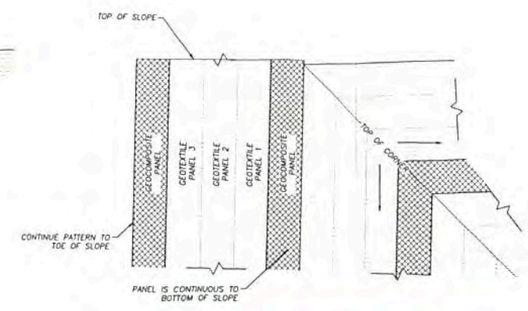
TYPICAL CROSS-SECTON OF FINAL COVER
(ASH POND A)
(NOT TO SCALE)



PERIMETER TOE DRAIN OUTLET
(NOT TO SCALE)



TYPICAL CROSS-SECTON OF FINAL COVER
(ASH POND A - EAST SIDE UNDER TRANSMISSION LINES)
(NOT TO SCALE)



GEOTEXTILE AND GEOCOMPOSITE PANEL LOCATIONS
(NOT TO SCALE)

LEGEND:

- RIPRAP
- WASHED RIVER GRAVEL
- CCR STRUCTURAL FILL
- EXISTING ASH
- EXISTING LOWER BERM
- EXISTING UPPER BERM
- PROTECTIVE SOIL LAYER
- VEGETATIVE LAYER
- EXISTING SOIL

Revision:

Project Number: 170LF00104
Drawing File: SEE LOWER LEFT
Date: 5/17
Scale: AS SHOWN

Rev'd By:	Chk By:	Drn By:
	DS	CL

Company Name: IPL PETERSBURG GENERATING STATION
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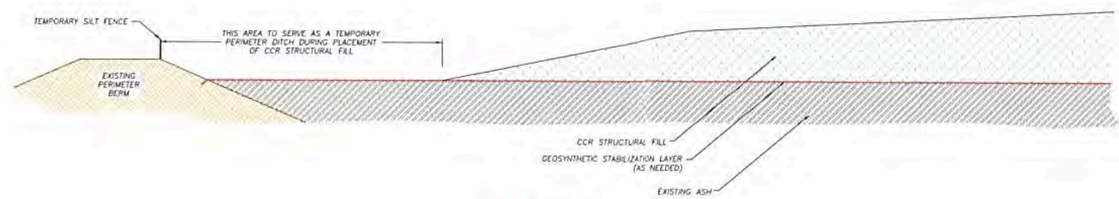
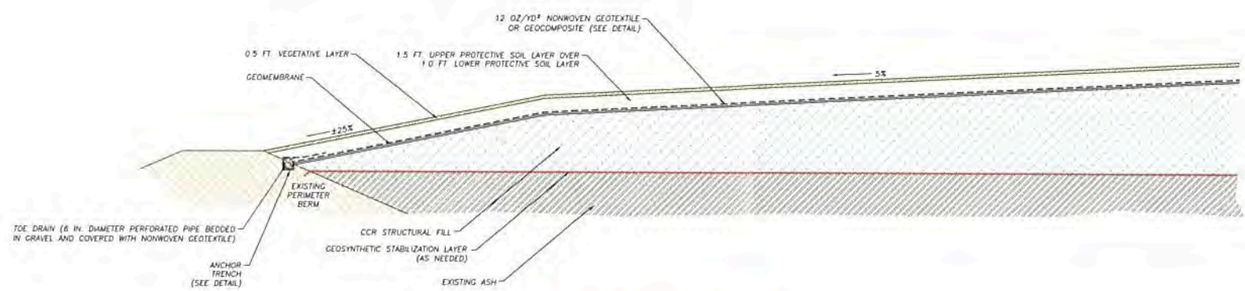
Drawing Title: TYPICAL FINAL COVER DETAILS - 1
PROPOSED CLOSURE OF PETERSBURG STATION ASH POND SYSTEM

Sheet: 9



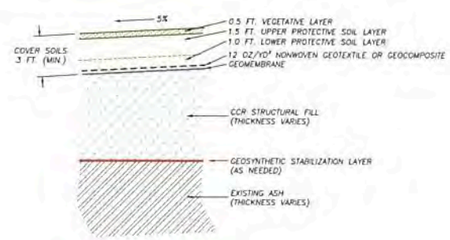
INITIAL CCR FILL

(NOT TO SCALE)



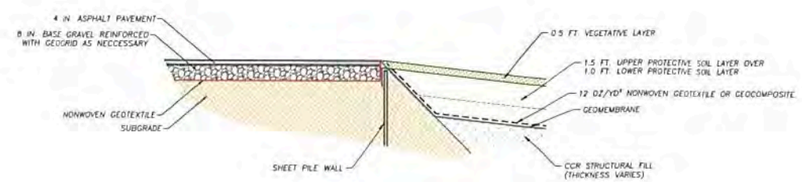
TYPICAL CROSS SECTION OF FINAL COVER

(NOT TO SCALE)



GEOCOMPOSITE FINAL COVER OPTION

(NOT TO SCALE)



ASPHALT PAVEMENT CONNECTION TO GEOCOMPOSITE FINAL COVER OPTION

(NOT TO SCALE)

LEGEND:

- ASPHALT PAVEMENT
- RIPRAP
- WASHED RIVER GRAVEL
- WASHED RIVER GRAVEL
- CCR STRUCTURAL FILL
- EXISTING ASH
- EXISTING LOWER BERM
- EXISTING UPPER BERM
- UPPER AND LOWER PROTECTIVE SOIL LAYERS
- VEGETATIVE LAYER

Revision:

Project Number: 170LF00104
Drawing File: SEE LOWER LEFT
Date: 3/17
Scale: AS SHOWN
Appl'd By: | Chkd By: DS | Drn By: CL

Company Name:
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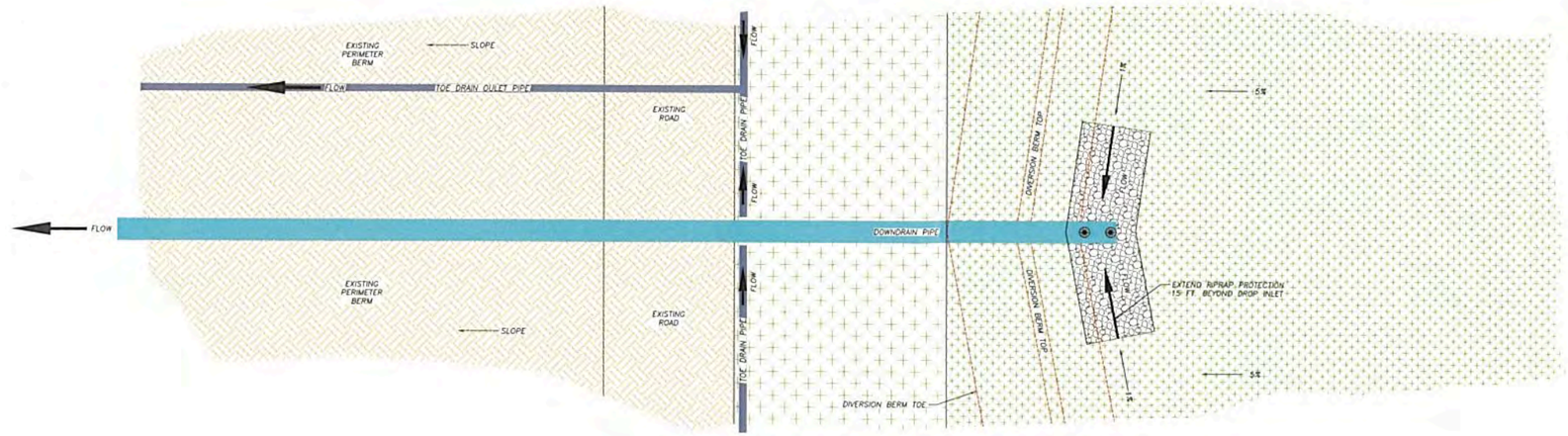
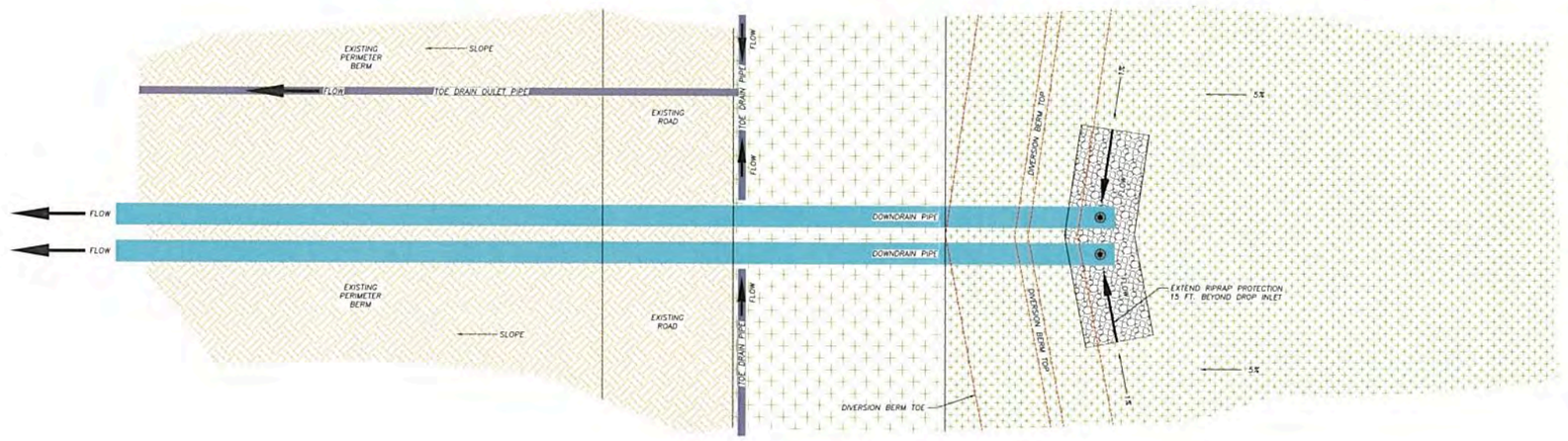
Drawing Title:
TYPICAL FINAL COVER DETAILS - 2
PROPOSED CLOSURE OF PETERSBURG STATION ASH POND SYSTEM

Sheet:
10



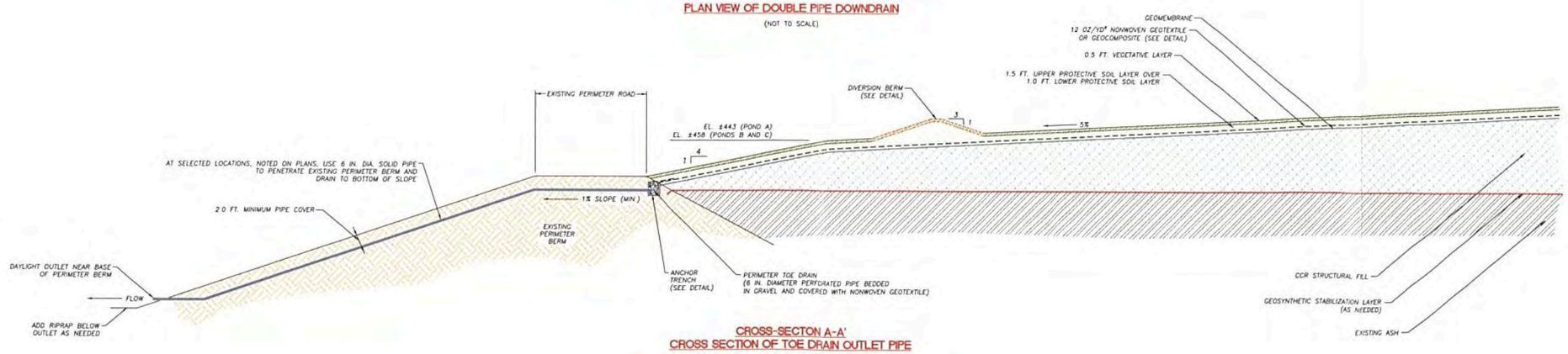
PLAN VIEW OF SINGLE PIPE DOWNDRAIN

(NOT TO SCALE)



PLAN VIEW OF DOUBLE PIPE DOWNDRAIN

(NOT TO SCALE)



CROSS-SECTON A-A'
CROSS SECTION OF TOE DRAIN OUTLET PIPE

(NOT TO SCALE)

LEGEND:

- RIPRAP
- WASHED RIVER GRAVEL
- CCR STRUCTURAL FILL
- EXISTING ASH
- EXISTING LOWER BERM
- EXISTING UPPER BERM
- UPPER AND LOWER PROTECTIVE SOIL LAYERS
- VEGETATIVE LAYER

Revision

Project Number: 170LF00104
Drawing File: SEE LOWER LEFT
Date: 3/17
Scale: AS SHOWN
App'd By: Chk By: ZG Drn By: CL

Company Name: IPL PETERSBURG GENERATING STATION
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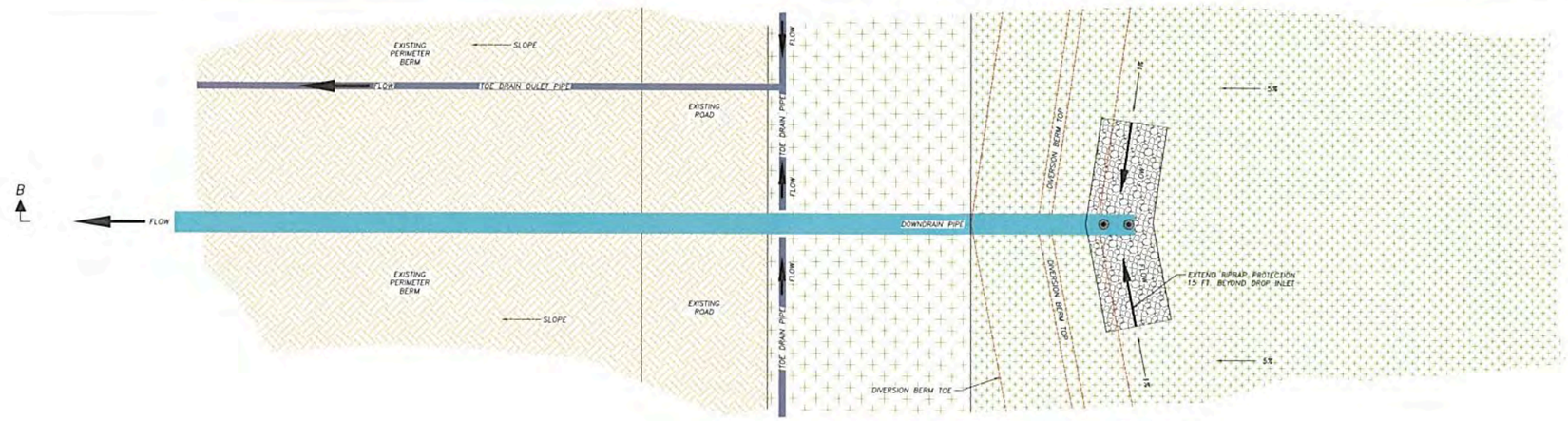
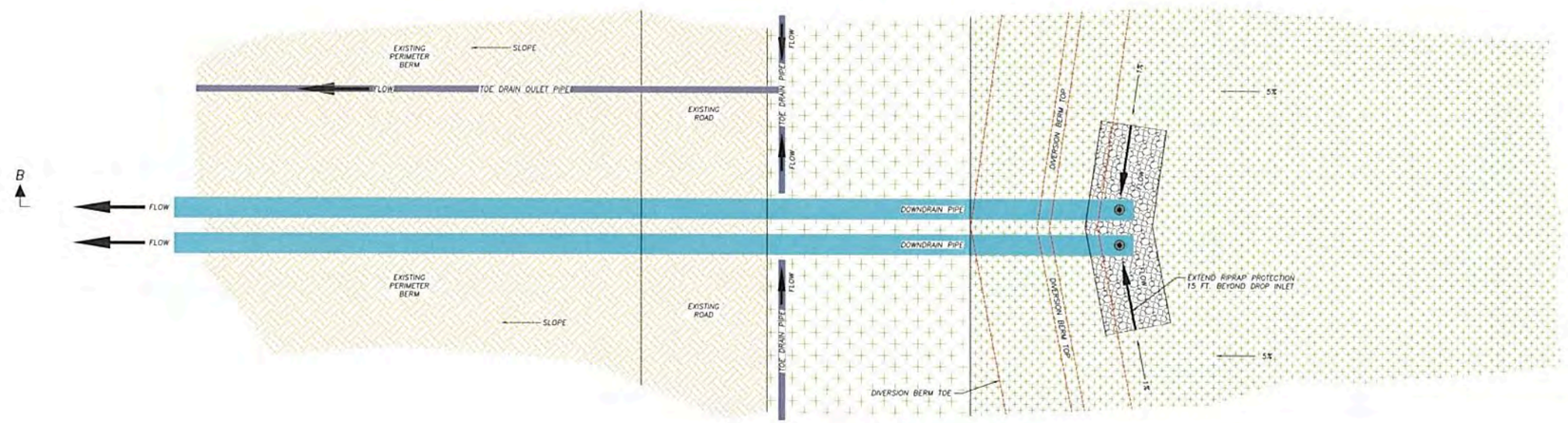
Drawing Title: TYPICAL FINAL COVER DETAILS - 3
PROPOSED CLOSURE OF PETERSBURG STATION ASH POND SYSTEM

Sheet: 11



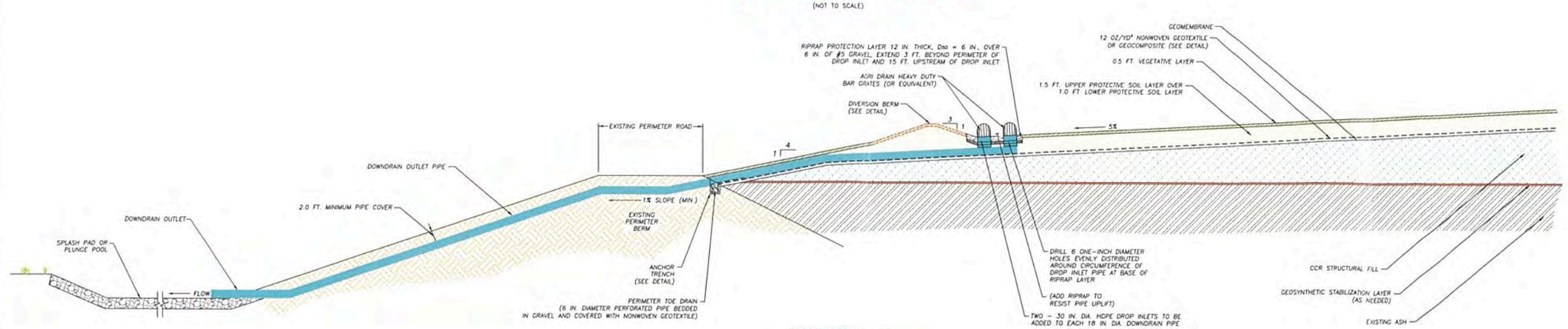
PLAN VIEW OF SINGLE PIPE DOWNDRAIN

(NOT TO SCALE)



PLAN VIEW OF DOUBLE PIPE DOWNDRAIN

(NOT TO SCALE)



CROSS-SECTON B-B'
CROSS SECTION OF DOWNDRAIN

(NOT TO SCALE)

LEGEND:

- RIPRAP
- WASHED RIVER GRAVEL
- CCR STRUCTURAL FILL
- EXISTING ASH
- EXISTING LOWER BERM
- EXISTING UPPER BERM
- UPPER AND LOWER PROTECTIVE SOIL LAYERS
- VEGETATIVE LAYER

Revision:

Project Number: 170LF00104
Drawing File: SEE LOWER LEFT
Date: 3/17
Scale: AS SHOWN
Kyd'd By: DS
Chd By: DS
Drn. By: CL

Company Name:
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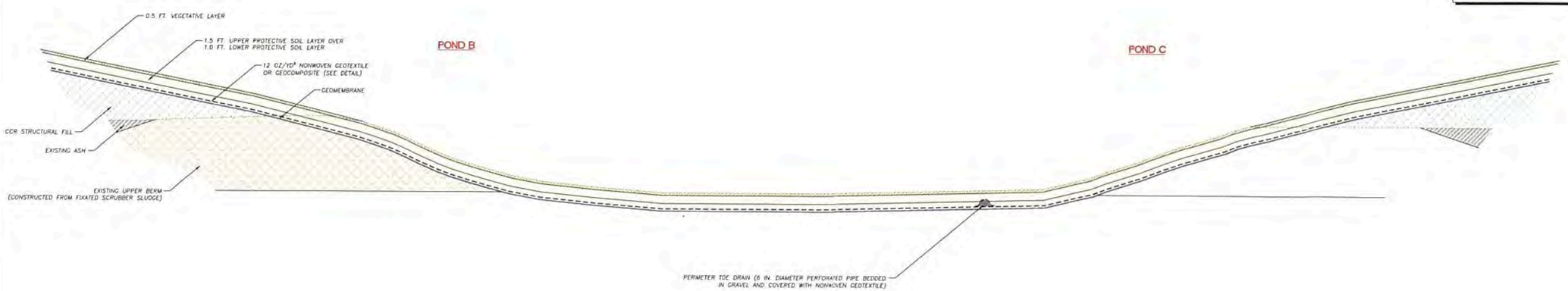
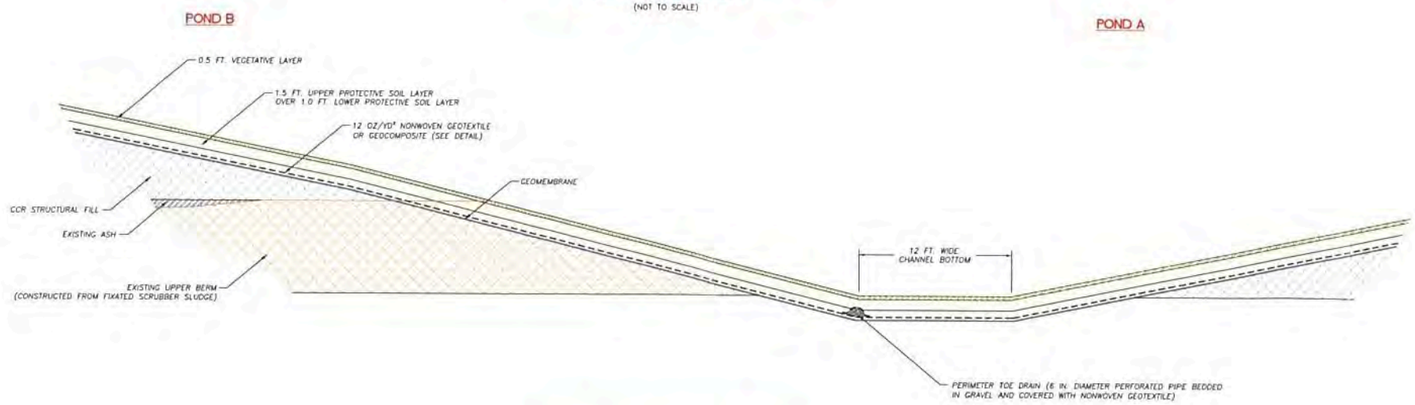
Drawing Title:
TYPICAL FINAL COVER DETAILS - 4
PROPOSED CLOSURE OF PETERSBURG STATION ASH POND SYSTEM

Sheet:
12



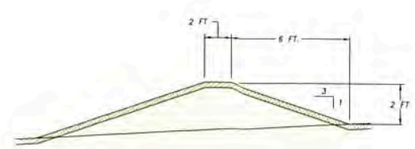
TYPICAL CROSS-SECTON OF FINAL COVER BETWEEN PONDS B AND C

(NOT TO SCALE)



TYPICAL CROSS-SECTON OF FINAL COVER BETWEEN PONDS A AND B

(NOT TO SCALE)



2 FT. DIVERSION BERMS

(NOT TO SCALE)

LEGEND:

- RIPRAP
- WASHED RIVER GRAVEL
- CCR STRUCTURAL FILL
- EXISTING ASH
- EXISTING LOWER BERM
- EXISTING UPPER BERM
- UPPER AND LOWER PROTECTIVE SOIL LAYERS
- VEGETATIVE LAYER

Revision

Project Number: 170LF00104

Drawing File: SEE LOWER LEFT

Date: 3/17

Scale: AS SHOWN

App'd By	Chk By	Drn By
	DS	CL

Company Name:

IPL PETERSBURG GENERATING STATION
6925 NORTH STATE ROAD 57
PETERSBURG, INDIANA

ATC GROUP SERVICES LLC
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Drawing Title:

TYPICAL FINAL COVER DETAILS - 5
PROPOSED CLOSURE OF PETERSBURG STATION ASH POND SYSTEM

Sheet:

13

APPENDIX A-2

Solid Waste Closure and Post-Closure Plans, March 2017 (Approved July 2017)

August 4, 2014

Ms. Jamie Miller
Environmental Manager
Indiana Department of Environmental Management
Solid Waste Permits Section
MC 65-45 IGCN 1101
100 North Senate Ave
Indianapolis, IN 46204-2251

RE: Proposed Closure and Post-Closure Plans Ash Pond System
Indianapolis Power & Light Company - Petersburg Generating Station Petersburg, Indiana

Dear Ms. Miller:

The Indianapolis Power & Light Company (IPL) Petersburg Generating Station hereby submits Proposed Closure and Post-Closure Plans for the Ash Pond System. As described and presented for your review and approval, the facility will conduct in-place closure of Ash Ponds A, A', B and C.

The facility is proposing to close the Ash Pond System in stages. Initially, the southern end of Ash Pond A will be closed by October 2017 to facilitate the construction of a new wastewater treatment plant that is required to comply with an Indiana Department of Environmental Management (IDEM) Agreed Order related to the National Pollutant Discharge Elimination System (NPDES) permit at Petersburg Station. Construction of the final cover in Ash Pond B is planned to begin in 2015 and completed in 2021. The facility intends to complete construction of the final cover over the remainder of Ponds A and C within 5 years after ash is no longer sluiced to the ponds.

Please contact Mr. Erv Leidolf at (812) 354-7224 or Ms. Nysa Hogue at (317) 261-5473 if you have any questions or require additional information. We appreciate your timely review of this submittal.

Sincerely,

Nysa L. Hogue

Nysa L. Hogue

Attachment
cc: Mr. Erv Leidolf, Indianapolis Power & Light Company Petersburg Generating Station
Mr. David Kehres, Indianapolis Power & Light Company Petersburg Generating Station

Cardno ATC

Shaping the Future

PROPOSED CLOSURE AND POST-CLOSURE PLANS

ASH POND SYSTEM
PETERSBURG GENERATING STATION
PETERSBURG, IN 47567-0436

CARDNO ATC PROJECT NO. 86.22351.0026

AUGUST 1, 2014

PREPARED FOR:

INDIANAPOLIS POWER & LIGHT COMPANY
ONE MONUMENT CIRCLE
INDIANAPOLIS, IN 46204-2901
ATTENTION: NYSA HOGUE

Cardno ATC

Shaping the Future

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August 1, 2014

Ms. Nysa Hogue
Senior Environmental Coordinator
Indianapolis Power & Light Company
One Monument Circle
Indianapolis, IN, 46204

Re: **Proposed Closure and Post-Closure Plans**
Ash Pond System
Petersburg Generating Station
Petersburg, IN
Cardno ATC Project No. 86.22351.0026

Dear Ms. Hogue:

In accordance with your request, Cardno ATC (Cardno) prepared the enclosed proposed closure and post-closure plans for the Ash Pond System at the Petersburg Generating Station. The Ash Pond System consists of Ash Ponds A, A', B and C which occupy a total area of approximately 151.7 acres.

This report was prepared based on the Indiana Department of Environmental Management's (IDEM) document entitled "Surface Impoundment Closure Guidance". To help facilitate IDEM's review of the proposed Closure and Post-Closure Plans, the report has been formatted to provide the content of their guidance document in bold italics followed by our response.

We appreciate the opportunity to be of assistance with this project. If you have any questions regarding this letter, please contact our office.

Sincerely,

David L. Stelzer, PhD, P.E.
Senior Project Engineer
for Cardno ATC

John R. Noel, L.P.G.
Senior Project Geologist
for Cardno ATC

Donald L. Bryenton, P.E.
Principal Engineer
for Cardno ATC

Copies: Ms. Jamie Miller, IDEM, (3 Hardcopies, 1 CD)
Nysa Hogue – IPL, (2 Hardcopies, 1 CD)
Erv Leidolf – IPL, (1 Hardcopy)
David Kehres – IPL, (1 Hardcopy)

DONALD LEE BRYENTON
REGISTERED
No
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STATE OF
INDIANA
PROFESSIONAL ENGINEER

LICENSED PROFESSIONAL
JOHN R. NOEL
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INDIANA
GEOLOGIST

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INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OFFICE OF LAND QUALITY

SURFACE IMPOUNDMENT CLOSURE GUIDANCE

The following guidance provides an outline of the information required by this office to approve the closure of a surface impoundment. This guidance is meant to provide general guidelines for obtaining closure approval. Approval for the closure of any specific impoundment must be coordinated through the Permit Branch of the Office of Land Quality (OLQ): for more information contact Solid Waste Permit Section at 317/232-7200.

Pursuant to 329 IAC 10-3-1(9), the operation of surface impoundments is excluded from regulation under the solid waste management regulations of 329 IAC 10. However, this exclusion goes on to state ". . . the final disposal of solid waste in such facilities at the end of their operation is subject to approval by the commissioner . . ." Impoundments which receive only coal ash and either (1) have a water pollution control facility construction permit under 327 IAC 3, or (2) receive less than 100 cubic yards of coal ash per year from generators who produced less than 100 cubic yards of coal ash per year, are exceptions and remain excluded pursuant to 329IAC 10-3-1(8) and (10).

Two basic types of closures for surface impoundments are covered in this guidance: 1) Clean Closure, and 2) Closure In Place. The technical information that needs to be submitted along with a request for closure approval will vary depending on whether a clean closure or in-place closure is planned.

Indianapolis Power & Light Company (IPL) will conduct in-place closure for the disposal areas of the Ash Pond System at the Petersburg Generating Station, which is comprised of Ash Ponds A, A', B and C. These areas are shown on the drawings included in Appendix M. The closure and post closure activities described in this submittal address all three ponds. The Ash Pond System is bordered to the south by the Petersburg Generating Station and to the east by the Indiana Southern Railroad. The solid waste boundary for the Ash Pond System is labelled on the drawings and covers approximately 151.7 acres.

The Ash Pond System will be closed in stages. It is currently anticipated that the southern end of Ash Pond A will be closed by October 2017 to facilitate the construction of a new wastewater treatment plant that is required to comply with an Indiana Department of Environmental Management Agreed Order related to the National Pollutant Discharge Elimination System (NPDES) permit at the Petersburg Generating Station. Construction of the final cover in Ash Pond B is currently planned to begin in 2015 and be completed in 2021. Construction of the remainder of the final cover in Ash Pond A and all of Ash Pond C will begin within 12 months, and be completed within 5 years, after the facility stops sluicing ash into the ponds.

IN-PLACE CLOSURE

This type of closure involves leaving waste residues within the impoundment and developing a plan designed to contain, control, and monitor the impoundment as a land disposal unit in a manner which is protective of public health and the environment. Waste residue characterization and site characterization, including information about both the general area and the impoundment design and construction, is required for in-place closure. The design and monitoring requirements for impoundments which are closed with the waste in place will be based on type of waste disposed of in an impoundment. The general requirements for nonmunicipal solid waste landfill and restricted waste site (RWS) Type I and Type II are found under 329 IAC 10-24 thru 10-31. (Any waste containing significant quantities of VOCs, or SVOCs will generally be required to close under nonmunicipal solid waste requirements.) The general requirements for Type III are found under 329 IAC 10-32 thru 10-38. In addition, if the applicable restricted waste site criteria are not at least as stringent, biosolid impoundments must meet the land disposal requirements of Federal rule 40 CFR 503.

Please be aware that this office may require clean closure if the waste, residue or site characteristics indicate that in-place closure will not be protective to human health and the environment.

The following additional information will be required for staff to review and consider the impoundment as a candidate for this type of closure approval:

1) Waste Characterization: A waste determination must be conducted pursuant to 40 CFR 262.11, and, if impoundments will be closed in the same manner as restricted waste sites, the waste must be classified as specified in 329 IAC 10-9-4. Additional parameters which may need to be evaluated will be determined on a case-by-case basis. The following waste characterization information should be submitted as part of any in-place closure request.

(A) Identification of Physical Parameters: Any physical aspects of the residue that may pose an environmental or technical design problem should also be reported and quantified as necessary and applicable: i.e., low percent solids, high water content, etc.

(B) Identification/Quantification of Chemical Constituents: This evaluation generally involves the quantification of the amount of each chemical present within the residue that potentially poses an environmental concern, giving specific consideration to chemicals such as heavy metals, volatile and semi-volatile organic compounds, salts, polychlorinated biphenyls (PCBs), pesticides, neutral leachate parameters defined under 329 IAC 10-9-4, and other chemicals that may pose a public health or environmental threat. These analyses generally involve determining total amounts for these chemicals, but analyses of representative samples of the residue by Toxicity Characteristic Leaching procedure and neutral leachates may also be required to make regulatory status determinations and appropriate disposal decisions.

If the responsible party is uncertain as to the waste characterization, the Permit Branch of OLQ can arrange for an OLQ chemist to be consulted for guidance. This office may require that additional parameters be analyzed based on the review of the submitted information.

IPL is proposing to close the Ash Pond System meeting all Restricted Waste Type I criteria for in-place closure. 329 IAC 10-9-4 (d) restricted waste site criteria do not require waste characterization of coal combustion CCP when managed using engineered controls equivalent to those required for a Restricted Waste Type I Facility. IPL will not be characterizing the coal ash in the facility's Ash Pond System.

2) <u>Site Characterization</u>: A narrative description of the impoundment must be provided and should include the following items at a minimum:

(A) Impoundment Design: A description of physical design/specifications such as dimensions (length, width, depth), liner construction, etc. of the impoundment. The narrative should include any design documentation that may exist such as drawings, field notes, etc.

The Ash Pond System at the Petersburg Generating Station is constructed along the eastern edge of the White River flood plain. The Ash Pond System consists of Ponds A, A', Pond B, and Pond C. The system is a north-south oriented elongate bermed set of ponds approximately 4,600 ft. long and 1,500 feet wide. Original berms were constructed to a design height of EL 435. The berms surrounding Ponds B and C were later raised to EL 455 in order to increase impoundment capacity. The ponds were constructed with natural soil liners placed at an approximate elevation of EL 420 that corresponds to the pre-development ground surface. The Ash Pond System solid waste boundary is shown on drawings included in Appendix M.

(B) Volume of Waste: The amount of waste or any other residues or material remaining in the impoundment.

Based on information provided by the Petersburg Generating Station, the volume of ash in the Ash Pond System is estimated to be approximately 5.7 million cubic yards.

(C) Discharges to The Impoundment: A detailed description of those Industrial processes, including raw materials used and their characteristics, that generated wastes which were placed in the surface impoundment.

The Ash Pond System has received coal ash, a combination of fly ash and bottom ash that was produced at the Petersburg Generating Station. Although coal ash is the most significant waste stream that is discharged to the pond, other wastewaters from the facility are also discharged to the Ash Pond System. A listing of all of those wastewaters can be provided upon request. Discharge from the Ash Pond System is monitored through NPDES Outfall #001.

(D) Site Description: Area maps indicating the location of the impoundment and all other relevant items. All drinking water wells within ½mile of the impoundment area must be identified, both on and off the facility property. Sites with waste that test as restricted waste Type I or Type II should use the information requested in 329 IAC 10-24-

2 as an outline in preparing the description. Sites with waste that test as restricted waste Type III should use the information requested in 329 IAC 10-32-2.

The IPL Petersburg Generating Station is located in Pike County, Washington Township, Indiana in Township 1N, Range 8W, Section 12. The proposed closure and post-closure plans for the Petersburg Ash Pond System submitted herein cover approximately 151.7 acres. A legal description of the solid waste boundary for the Ash Pond System is included in Appendix I.

A drawing showing portions of the Monroe City and Sandy Hook, Ind. 7½ minute USGS topographic quadrangle maps is provided as Sheet 1 in Appendix M. A second plot plan showing the impoundment superimposed on an aerial photograph is included as Sheet 2. Sheet 3 shows the Ash Pond System with respect to current site topography. The closure limit for the Ash Pond System is shown on the drawings in Appendix M.

Results from investigation and review of the Indiana Department of Natural Resources (IDNR) – Division of Water (DOW) Water Well Records database[1] are summarized on Sheet 1. Water well records that include UTM coordinates are plotted, and the well records are included in Appendix A. Water well records that do not include UTM coordinates are located based on driving direction and administrative information. These records are included in Appendix B.

As shown on Sheet 1, water well records are available from IDNR's DOW well database for three wells associated with registered significant water withdrawal facilities (SWWF) within a ½ mile radius from the perimeter of the Ash Pond System. The three wells are identified by reference numbers and well names in IDNR's well record and significant water withdrawal facility databases. Well record and corresponding source identifiers in the SWWF database are:

Well Record Reference Number	SWWF Source Identification
234834	Well 3
234839	Well 2
234844	Well 4

These three wells were drilled through outwash sand to the contact with bedrock at approximately 65 ft. below ground surface (bgs).

The wells identified by water well records in IDNR's water well database are no longer in service at IPL's Petersburg Generating Station. Water for plant operations is obtained as surface water from the White River. The station is served with potable water provided by the local municipal water utility.

The review of IDNR's water well record database did not identify water wells within a ½ mile zone around the perimeter of the Ash Pond System that are not related to operations at Petersburg Generating Station. Although there are water well records for residential properties east of the plant along State Road 57, these locations are upgradient of the ash pond.

(E) Site Geology: General information on the geology of the site such as:

(1) General direction of ground water flow.

[1] Indiana Department of Natural Resources, Division of Water, http://www.in.gov/dnr/water.

The general direction of groundwater flow in unconsolidated deposits underlying Petersburg's Ash Pond System is expected to be northwest and west toward the White River. Regional flow directions in the area of the Ash Pond System are controlled by recharge to unconsolidated flow zones in topographically elevated upland areas east of the ash ponds and expected discharge to the East Fork and main White River channels located north, northwest, and west of the ash ponds. Regional groundwater flow is locally influenced by infiltration from the ash pond. Additional discussion of groundwater flow directions is included with information summarizing the monitoring well sampling and testing results.

(2) The depth of the water table across the entire site and the permeability of soils associated with the table.

Based on water level measurements collected from June 30 to July 2, 2014, the depth to groundwater ranges from approximately 2.5 to over 28 ft. bgs. Water levels vary depending on the ground surface elevation and location of wells or piezometers with respect to the ash ponds and the White River. Static water levels are summarized in Table 1.

Hydraulic conductivities have been estimated for subsurface soils at the twelve ash pond monitoring wells installed in June 2014. Hydraulic conductivities were estimated by performing slug tests. To run each test, a pressure transducer was lowered into the monitoring well. The transducer was connected to a data logger at ground surface that was used to start and stop the test and record water level recovery after stressing the well. Both rising head and falling head tests were run using a weighted PVC cylinder as a slug.

Estimates of formation hydraulic conductivity were determined using the Bouwer-Rice analytical model[2] for confined aquifers implemented in AQTESOLV®. Well recovery diagrams are included in Appendix C and a summary of estimated hydraulic conductivities is attached in Table 2. In general, hydraulic conductivity values are consistent with the expected values for wells screened in outwash sand. Hydraulic conductivities in wells at locations AP-2, AP-3, AP-4, and AP-5 ranged from 1×10^{-2} to 9×10^{-2} cm/s. At AP-6A, the rising head estimate is 6×10^{-3} cm/s and the falling head hydraulic conductivity is 1.5×10^{-2} cm/s.

Lower hydraulic conductivities were measured at AP-1, AP-7, and AP-8. Each of these wells is screened in finer grained, loamy unconsolidated soils. Well AP-1 is screened in sandy loam, and wells AP-7 and AP-8 are screened in soils described as loam, silty clay, sandy clay, sand, and sandy loam. The hydraulic conductivities from slug tests in AP-1 and AP-7 are on the order of 10^{-4} cm/s and the hydraulic conductivity at AP-8 is on the order of 10^{-3} cm/s.

(3) Delineation of soil strata under the site (i.e., sand, silt, clay, etc.).

General Geologic Setting. The Ash Pond System is located in the Southern Hills and Lowlands physiographic[3] region of southwest Indiana. Within the Southern Hills and Lowlands region, the site is located in the Wabash Lowland subregion. The Wabash Lowland subregion is characterized by rolling hills of low relief forming uplands along and between dominant bedrock drainage channels of the present-day Wabash, Eel, White, and East Fork White rivers. The site is south of the area of Indiana

[2]Bouwer, H. and R.C. Rice, 1976. A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research, vol. 12, no. 3, pp. 423-428.
[3]Gray, H., Physiographic Divisions of Indiana, Indiana Geological Survey Special Report 61, 2000.

affected by the last major Wisconsin glacial ice sheets but lies north and within the part of Indiana affected by earlier Pleistocene continental glacial episodes.

Petersburg's Ash Pond System is located along the eastern edge of the White River flood plain. Topographically elevated hills east of the Ash Pond System reflect the topography of the Quaternary erosional bedrock surface. According to Gray (2000)[3],

> "Near the edge of major river valleys the hills are capped by dune sand that was blown from the valley flats, principally during Wisconsin time. On the upland, areas of pre-Wisconsin till plain are particularly extensive northward, and the entire upland is capped by a layer of loess that in most places is about 6 ft. (2 meters) thick."

This general conceptual geologic context is consistent with boring results at locations east and topographically higher than the Ash Pond System as well as findings in borings around the perimeter of the ponds and at more westerly boring locations in the White River flood plain. Borings associated with upland areas for investigations related to the adjacent Type III RWS landfill typically describe unconsolidated deposits of medium to fine grained sand, sandy silt, silt, and clayey silt over the first 20 or 30 ft. bgs. Deeper borings indicate the presence of Pennsylvanian bedrock. In this area the Springfield (V) coal has been extensively mined. The Springfield coal marks the top of the Pennsylvanian age Petersburg Formation. Bedrock lying above the Springfield coal is assigned to the Dugger formation.

Borings near and west of the Ash Pond System show the presence of thicker Quaternary granular deposits in bedrock valleys. These unconsolidated deposits are generally outwash fine to coarse sand with finer grained silts and clays near the ground surface.

The landscape and subsurface hydrogeology in the area around the Ash Pond System have been modified over the last century. Areas northeast, east, and southeast of the Ash Pond System have been changed by surface and underground coal mining. The area south and southwest of Pond A has been modified by construction of the power plant, and the Ash Pond System itself is a significant topographic and hydrogeologic feature.

1972 Borings. A series of ninety-seven standard penetration test (SPT) and hollow stem auger (HSA) geotechnical borings were drilled in 1972 in order to provide subsurface data for design of generating Unit 3, a new coal handling system, and additional plant upgrades and improvements.[4] While many of these borings were located in areas southwest of IPL's Ash Pond System, various borings investigated areas within the footprint of the Ash Pond System, west of Ponds A and B, and east of Pond A. Borings G-50, G-51, and G-68 through G-71 delineate deposits at locations in Pond A and at locations in the area where Pond B was later constructed. In the area south of the Outfall 001 drainage from the edge of Pond A to the White River, borings G-7 through G-15 show subsurface deposits west of Pond A. Borings G-61 through G-67 were advanced northwest and north of Pond A and provide stratigraphic information west of the boundary of Pond B. The series of borings from GA-6 through GA-16 were drilled east of Pond A in the area later developed with IPL's Type III RWS landfill. Copies of the site plan, cross sections, and boring logs from this drilling program are included in Appendix D.1.

[4]Subsurface Investigation and Recommendations, Indianapolis Power & Light Company Petersburg Unit No. 3, E.D'Appolonia Consulting Engineers, Inc., IPALCO Job No. 29550, G&H Project No. 2264-A, EDCE Project No 72-605, May 1973.

Borings G-50 and G-51 were advanced through ash fill to the contact with underlying clayey silt and silt. This contact is shown at depths of 13.9 ft. and 9 ft. in borings G-50 and G-51, respectively. These depths correspond to approximate elevations of EL 411.8 at G-50 and EL 417.3 at G-51.

Borings G-68 through G-71 investigated the area under Pond B prior to construction. Borings results at these locations suggest that the ground surface elevation was roughly EL 418. The borings show that silty clay, clayey sand, and silty sand occurred to depths of 10 to 20 ft. Below these relatively cohesive soils primarily fine sand grading to medium sand was logged to the contact with bedrock at 55 to 62.8 ft. bgs.

Cross sections on Sheets 4 and 5 include borings G-3, G-5, G-9, G-14, G-61, and G-65 from this report.

1991 Borings. Subsurface information is available from a boring and well installation program initiated in 1991. Results are summarized in Stone & Webster Engineering Corporation's report of Geologic Site Information included in the 1994 permit application[5] for expansion of the Type III Restricted Waste Site (RWS) landfill. This investigation involved advancing eighteen borings and installing eleven monitoring wells. Boring and well locations are east of the ash pond and east of the originally permitted Type III RWS landfill. However, information from these borings has been reviewed to provide an understanding of the geology and hydrogeology east of the White River flood plain and outwash channel. Copies of the boring logs are included in Appendix D.2.

In general the borings described interbedded sand, silty sand, silt, clayey sand, and clayey silt over the first twenty to thirty-five feet bgs. At deeper depths several borings completed as monitoring wells; including LW-1A, LW-2, LW-8A, LW-18, and LW-28; describe fine silty sand, often grey and sometimes recognized as slightly cemented. Cross sections included with the 1994 report label this zone as "very dense silty sand", presumably based on the high blow counts and limited recovery. For the purposes of characterizing the geology for closure of the Ash Pond System, the intervals on these logs described as silty fine sand and exhibiting high resistance to split-spoon penetration are interpreted to represent Pennsylvanian age sandstone bedrock of the Dugger Formation. This interpretation is reflected on the cross sections included on Sheets 4 and 5.

2013 Boring Program. A set of fourteen borings were drilled in 2013 in the area of the proposed wastewater treatment plant shown on Sheet 6. Boring locations and copies of the boring logs are included in Appendix D.3. Borings SPT-01 through SPT-05 and SPT-11 were hydro-excavated to eleven feet and were sampled below eleven feet until auger refusal or retrieval of a bedrock sample. These borings show that most of the unconsolidated overburden consists of silty clay. Approximately six feet of sand or silty sand was logged in the interval above bedrock at SPT-04 and SPT-05.

Borings SPT-06 through SPT-10 and SPT-12 through SPT-14 were drilled through ash deposits at the south end of Pond A. The thickness of ash deposits in these borings ranged from 19.5 to 33.5 ft.. Silty clay typically underlies ash fill until a deeper contact with silty sand or sand. Bedrock elevations are typically EL 395 to EL 400 in these borings, however, the top of bedrock was EL 376.7 and EL 377.5 at borings SPT-12 and SPT-14, respectively.

June 2014 Boring Program. Unconsolidated subsurface deposits were investigated at eight locations around the perimeter of the Ash Pond System to determine soil conditions, groundwater levels, and monitoring well screen depths during a June 2014 drilling program. The locations of these

[5]Landfill Permit Application Major Modification to Operating Permit No. 63-2, Stone & Webster Engineering Corporation, January 1994.

borings are shown on Sheets 2 and 3 and on cross sections included on Sheets 4 and 5. Boring logs are included in Appendix E. Grain size curves and cation exchange capacity laboratory results are attached in Appendix F. Table 3 summarizes grain size analysis results, United States Department of Agriculture (USDA) soil textural designations, and cation exchange capacity test results.

Boring logs at wells AP-3, AP-4, AP-5, and AP-6 show similar results reflecting locations in the White River flood plain. Unconsolidated deposits to depths ranging from 10 to 14 ft. bgs are generally finer grained soils with loam, silt loam, and loamy sand textures. Deeper unconsolidated deposits are sand or loamy sand. Bedrock was encountered in boring AP-6 at 65.7 ft. bgs (EL 356.2).

Borings at AP-1 and AP-2 were drilled along the south and southwest berm of Pond A. Unconsolidated deposits at these locations are relatively more heterogeneous due likely to modification and potential filling related to site development. At boring AP-1, deposits are primarily silty clay loam, loam, and sandy loam. Ash was present in the log from 6.5 to 12 ft. and 18 to 20.5 ft. bgs. Eleven feet of sandy loam, from 34 to 45 ft. bgs, overlies shale bedrock at AP-1. At AP-2, silty clay loam from 12 to 32 ft. bgs overlies fine to coarse grained sand logged to 66 ft. bgs.

Borings at AP-7 and AP-8 show the presence of a relatively thin cover of primarily cohesive soils over bedrock. At both locations the borings show heterogeneous mixtures of loamy soils with limited, relatively thin deposits of silt and sand. Coal fragments were noted in soil samples at both locations and suggest that these deposits may be mine spoil.

Bedrock. Bedrock in the area of Petersburg's Ash Pond System is Pennsylvanian age sandstone, limestone, shale, and coal of the Carbondale Group.[6] Two formations, the Petersburg Formation and the Dugger Formation, underlie unconsolidated outwash, flood plain, and wind-blown deposits. The Petersburg Formation includes the Houchin Creek, Folsomville, and Springfield Coal members. The Springfield Coal is the uppermost coal and stratigraphic top of the Petersburg Formation. The Petersburg Formation ranges from 40 to 120 ft. thick and includes shale, sandstone, and coal deposits. The Dugger Formation overlies the Petersburg and consists of coal, limestone, sandstone, and shale deposits. Sandstone bedrock encountered above the Springfield coal in the area of Petersburg Generating Station is assigned to the Dugger Formation.

(4) If monitoring wells are currently in place, the following information concerning the wells must be provided:

(a) Site map indicating location of wells.

Existing and proposed monitoring wells are listed in Table 4 and are shown on Sheets 2 and 3 in Appendix M. The proposed ash pond monitoring well system includes twelve monitoring wells that were installed in 2014 (wells AP-1, AP-2A, AP-2B, AP-3, AP-4A, AP-4I, AP-4B, AP-5, AP-6A, AP-6B, AP-7, and AP-8). Three wells currently in use as landfill monitoring points will serve also as monitoring points for the Ash Pond System. The facility is proposing to install two additional deep monitoring wells (AP-3A and AP-5A) at locations near existing wells AP-3 and AP-5, respectively. Wells AP-3 and AP-5 will be renamed AP-3B and AP-5B.

(b) Identification of upgradient and downgradient wells.

[6] Shaver, Robert H, et al, 1986, Compendium of Paleozoic Rock-Unit Stratigraphy in Indiana—A Revision, Indiana Geological Survey Bulletin Number 59, Indiana Geological Survey, Bloomington, Indiana

Based on static water levels measured during the sampling event conducted June 30 to July 2, 2014, wells MW-2, MW-3, and MW-4C are upgradient of the Ash Pond System and are upgradient with respect to the twelve new ash pond monitoring wells. Wells at the eight ash pond monitoring locations (AP-1 through AP-8) are considered downgradient monitoring wells. Water elevations are summarized in Table 1 and posted on the potentiometric surface map included as Figure 1.

Groundwater flow gradients and flow directions in the area of Petersburg Station's Ash Pond System are the result of the superimposed hydraulic effects of regional westward flow toward the White River and groundwater mounding associated with recharge from the Ash Pond System. Plant operations and fly ash management require sluicing and water discharge to Ponds A, B, and C. Some amount of infiltration and seepage is expected through the base of these ponds creating radial flow. Qualitatively, larger discharges to groundwater are expected toward the northwest, west, and southwest compared to potential flow toward the east where the topography is elevated and unconsolidated deposits are finer grained and less transmissive. Flow paths and flow gradients are expected to gradually change as portions of the Ash Pond System are closed and generating units are converted to dry ash handling.

(c) The type of stratum and the depth the wells are screened.

Subsurface stratigraphy is discussed in section 2(E)(3) above. Boring information from past subsurface investigations is included in Appendix D. Boring logs from borings advanced in 2014 in the area of the Ash Pond System are included in Appendix E. Screen depths for existing monitoring wells are depicted on cross sections, listed on Table 4, and shown on the monitoring well construction diagrams in Appendix G.

(d) Description of well installations including a bore hole log.

Monitoring wells AP-1, AP-2A, AP-2B, AP-3, AP-4A, AP-4I, AP-4B, AP-5, AP-6A, AP-6B, AP-7, and AP-8 were installed in June 2014. The well borings were drilled with 8 in. outer diameter hollow stem augers and constructed with nominal 2 inch PVC risers and 2 inch, 10 foot PVC well screens. Wells AP-1, AP-2A, and AP-2B were completed at the ground surface with flush-mount well vaults. The remaining wells were constructed with stick-up risers and protective covers set in concrete pads. Protective covers at AP-3, AP-4A, AP-4I, AP-4B, AP-5, AP-6A, AP-6B, and AP-7 are 6 in. diameter steel cylinders fitted with cam-lock well caps designed to provide extra protection against well damage or infiltration related to potential inundation during flooding. These protective covers are designed to be airtight and were not constructed with weep holes. Prior to measuring water levels in these wells the cam-lock caps should be removed to allow water levels to equilibrate. As noted above, well logs and construction diagrams are included in the Appendices.

(e) Any ground water monitoring data that would indicate background water quality.

Groundwater monitoring results from an initial Ash Pond System sampling event are included in Appendix H and summarized in Table 5. The facility plans to collect and analyze groundwater samples from the ash pond well system during a second sampling event planned for September 2014. Results from the September 2014 sampling event along with historical groundwater data from monitoring wells MW-2, MW-3, and MW-4C will be submitted in late September 2014 as an addendum to this Proposed Closure/Post-Closure Plan.

Petersburg Ash Pond System Water Quality

Water quality data collected during the Ash Pond System groundwater monitoring program will be used to support closure and post-closure at Petersburg Generating Station's Ash Pond System. The data provided in this plan and in the Proposed Closure and Post-Closure Plan Addendum are an initial indication of groundwater quality and potential impacts to groundwater related to Ash Pond System operation. Petersburg Generating Station intends to continue collecting groundwater monitoring samples on a quarterly basis for six additional quarters to establish a database representing current site groundwater quality.

Groundwater results for samples collected from June 30 to July 2, 2014 are provided on the laboratory report in Appendix H. The results are summarized in Table 5 and are plotted on the ternary diagram included as Figure 2. The ternary diagram indicates that the cation characteristics of groundwater are similar within the group of the new ash pond wells and with respect to the chemical character of samples from wells MW-2, MW-3, and MW-4C. There is greater variation in chemical character with respect to anions. Two ash pond wells, AP-3 and AP-6B, have relatively low sulfate concentrations (270 and 260 mg/L, respectively) and are primarily calcium carbonate type groundwater. In contrast, sulfate concentrations are higher in other wells. Sulfate is the dominant anion in wells AP-1, AP-2A, AP-4A, AP-4I, AP-6A, and AP-8. Wells MW-2, MW-3, MW-4C, AP-4B, AP-5, and AP-7 are mixtures that exhibit both carbonate alkalinity and sulfate anion characteristics.

Groundwater quality at Petersburg Generating Station may be affected by nineteenth and twentieth century surface and underground coal mining in areas northeast, east, and southeast of the Ash Pond System. Monitoring well AP-8 is located along the east boundary of Pond C near areas of previous mining. The field pH measured at well AP-8, 5.4 su, is notably more acidic than pH values ranging from 6.35 to 8.39 su in the other eleven ash pond wells. This suggests the possibility that this location may be affected by coal mining related acid generation.

Continued groundwater monitoring and characterization of local groundwater quality will be used to evaluate the performance of the closure actions. To obtain sufficient data for assessing anticipated groundwater quality improvements related to Ash Pond System closure actions all of the available data from wells for the Ash Pond System as well as data from potential new wells will be used to establish performance goals and for making statistical comparisons. As noted above, groundwater flow paths and groundwater flow gradients are expected to change as portions of the Ash Pond System are closed, the facility transitions to dry handling of fly ash, and the volume of water discharged to ash impoundment ponds decreases or is ended. It is anticipated that decreasing trends in concentrations of groundwater quality parameters will be observed as closure actions commence.

Assessment Monitoring Plan Overview for the Ash Pond System

For the purposes of determining the effectiveness of Ash Pond System closure at Petersburg Generating Station the following groundwater assessment plan is proposed:

Installation of Two Additional Monitoring Wells. Groundwater quality results from the June 30 to July 2, 2014 sampling event indicate that downward flow to deeper parts of the outwash sand aquifer may be occurring. Concentrations of several parameters are elevated in deep (A) wells compared to shallow (B) wells at the same locations. Sulfate concentrations in wells AP-6A and AP-4A (1100 and 850 mg/L, respectively) are greater than concentrations of 260 mg/L in AP-6B and 380 mg/L at AP-4B. Comparisons for total dissolved solids, chloride, iron, boron, and sodium show similar elevated concentrations in deep wells screened near the contact between unconsolidated sand and bedrock relative to co-located shallow wells.

In order to evaluate groundwater quality in the deep part of the aquifer two additional monitoring wells are proposed. An additional monitoring well (AP-3A) will be drilled to the base of the outwash sand aquifer at location AP-3, and a deep well (AP-5A) will be installed at location AP-5. Each well will be screened over an approximate depth of 55 to 65 ft. bgs. These wells will be installed after approval of the Petersburg Station Proposed Ash Pond System Closure and Post-Closure Plan.

Groundwater Sampling and Analysis Plan. Following approval of the Petersburg Station Proposed Ash Pond System Closure and Post-Closure Plan, a Groundwater Sampling and Analysis Plan (SAP) will be prepared and submitted to IDEM. This plan will be prepared after installation of wells AP-3A and AP-5A.

Groundwater Sampling Schedule. Petersburg's Ash Pond System well network will be sampled quarterly until eight quarters of groundwater results are available. Reports summarizing results from each sampling event will be prepared and submitted to IDEM within 60 days of completing the sampling field work. After eight quarterly groundwater sampling events are completed the sampling frequency will change to semi-annual during the months of May and November. Groundwater monitoring will continue throughout closure and until the end of the post-closure period. The data evaluation during the Ash Pond System closure period will be used to assess potential impact to groundwater quality.

Groundwater Monitoring Proposed Analytical Data Parameters. Table 6 lists proposed parameters, analytical methods, and reporting limits for initial groundwater monitoring of the Ash Pond System well network. Following collection of eight quarters of groundwater monitoring results, the analytical parameter list may be revised if continued monitoring of specified parameters is not beneficial for assessing groundwater quality with respect to Ash Pond System closure.

Data Review and Evaluation during Closure Activities

During the closure period groundwater quality will be assessed with an emphasis on identifying improved or worsened conditions. Various groundwater quality data evaluation tools, including but not limited to, graphical displays, intra-well and inter-well comparisons, parametric and non-parametric statistical tests, major ion geochemistry, and risk assessment may be employed during closure.

Establishing Performance Goals for Post-Closure Monitoring

Performance goals for post-closure monitoring will be established after dewatering, capping and closure of the Ash Pond System is complete. The data from future post-closure semi-annual groundwater monitoring will be used to assess changes in static water levels, potential reduction or elimination of radial flow, changes to constituent concentrations, and potential improvements in groundwater. Performance goals will be based on constituent concentrations from samples collected during the closure period.

Groundwater monitoring data collected from each on-site monitoring well during the initial quarterly monitoring program and potentially during semi-annual events performed following the quarterly program will be used as a benchmark against which any potential post-remedy constituent increasing concentration shifts will be gauged. Performance goals may be determined as intra-well Shewhart control limits or by other appropriate estimates of groundwater quality. These limits will serve as goals for each parameter (constituent) in each well.

- Upon completion of the second semi-annual monitoring event, a well-by-well comparison of post-closure groundwater monitoring results will be performed against the parameter performance goals as applicable. If the goal level is exceeded in a particular well or wells, the facility will collect an additional groundwater sample from the well or wells with the

exceedances within 1 month of receipt of validated analytical results to verify the detected concentration.

- If the exceedance or exceedances of performance goals are verified, monitoring will continue on the semi-annual schedule and the event at the specific monitoring well will be labeled as "goal exceeded". A potential indicator of a departure from closure effectiveness is four successive goal limits exceeded in a single monitoring well over the scheduled monitoring frequency.
- If after at least four sampling events fewer, than four goals in any specific well have been exceeded such that it is determined that no increasing concentration shift exists, or that the increase was temporary due to changing conditions during post-closure, the "goal exceeded" designation shall be removed and the normal monitoring program shall continue.
- If after at least four sampling events it is determined that an increasing concentration shift may exist, the facility will increase the monitoring frequency to quarterly and assess the effectiveness of the closure action. As long as concentrations do not approach 95% of the groundwater monitoring goals presented above, the facility will continue to monitor the shift. If the increasing concentration shift reverses and a pattern of decreasing concentrations is established after two sampling events, the facility will resume the normal monitoring program.
- If the increasing shift continues and is determined to present an unacceptable condition for post-closure of the Ash Pond System, the facility will take action to determine the appropriate steps to take to mitigate the degradation in effectiveness of the closure action.

It should be noted that many factors affect groundwater quality variability including seasonality, prior land use, site construction and development, and infiltration rates. Temporary increases in parameter concentrations could result from construction activities or the change in hydrogeologic conditions due to operational changes at the generating station. Groundwater flow velocities and directions are likely to change during closure of the Ash Pond System. The response of the constituent (parameter) concentrations in on-site groundwater as a result of closure actions, given the hydrogeologic conditions, could take years to evaluate. The actual amount of time to establish if an increasing concentration trend exists is not clear and post-closure construction data will need to be evaluated if potential increasing concentration trends are observed.

(f) Any ground water monitoring data collected after installation and operation of impoundment commenced which may be utilized to determine if there is any current ground water contamination.

Groundwater monitoring associated with the Ash Pond System was not performed prior to installation of wells AP-1 through AP-8.

Based on review of this data and the residue chemistry, more comprehensive and specific geology information may be required. Sites with waste that test as restricted waste Type I or Type II can use the information requested in 329 IAC 10-24-3 and 10-24-4 as an outline in preparing the geology description. Sites with waste that test as restricted waste Type III can use the information requested in 329 IAC 10-32-3.

3) <u>Closure Plan</u>: A detailed proposal for closure design and construction and for post-closure care of the impoundment must be submitted. Sites will close under the applicable requirements for Restricted Waste Sites (RWS), as described in 329 IAC 10-24 thru 10-38, depending on the characteristics of the waste in the impoundments.

Please note, if the residue in the impoundment is determined to be hazardous waste, this guidance is not applicable; for more information consult the Permit Branch for guidance at (317)232-4462.

At a minimum, the proposed closure plan must include details of the following:

(A) Cap Design: A description of the cap including dimension, Slope, and description of materials to be used. Caps at sites that test as restricted waste site Type I or Type II must be designed in accordance with applicable requirements of 329 IAC 10-30-2 or 10-30-3. Sites that test as restricted waste site type III must be designed in accordance with 329 IAC 10-37-2. Sludges from wastewater treatment plants that test as restricted waste site Type III must also comply with the design requirements of 40 CFR 503.

Three final cover systems are proposed for use in the closure of the facility's Ash Pond System as described in the following paragraphs. It is noted that coal combustion residuals (CCRs) (a.k.a., coal combustion products - CCPs) will be used as structural fill in Options 1 and 2 to create a slope across the current surface of the coal ash that is present in the ash ponds. The CCRs that will be utilized will be produced at the Petersburg Generating Station and will consist of any or all of the following materials: fly ash, bottom ash, and gypsum.

Option 1 – This option will consist of a minimum of 0.5 ft. of topsoil and 3 ft. of compacted cover soils on slopes greater than 15% but less than or equal to 25%, and 0.5 ft. of topsoil and 2 ft. of compacted cover soils on slopes less than 15%. These materials will be installed over the surface of the CCR structural fill placed to form the required slope across the surface of the ash pond.

Option 2 – This option will consist of either a 30 mil PVC or a 40 mil LLDPE geomembrane liner installed over the surface of the CCR structural fill placed to form the required slope across the surface of the ash pond. The liner will be overlain with a cushion geotextile or strips of geocomposite drainage material. The geocomposite will be placed at selected intervals to help facilitate removal of surface water that infiltrates through the 2.5 ft. thick protective layer and the 0.5 ft. layer of topsoil.

Option 3 – This option will consist of a minimum of four inches of asphalt pavement placed over a minimum of eight inches of crushed limestone. The crushed limestone will be underlain by a geotextile place on a subgrade of the CCR structural fill materials. The pavement section will only be utilized as final cover within the limits of the proposed wastewater treatment plant on the south side of Ash Pond A.

The approximate limits of the wastewater treatment plant proposed for construction at the south end of Ash Pond A are noted on Sheet 6 in Appendix M. The Option 3 final cover system (i.e., asphalt

pavement) will be utilized to cover any area inside these limits that will not be covered by a structure. Drainage pipes located within the 8 inch crushed limestone base of the pavement section will collect and discharge any water that seeps through the asphalt pavement to an area outside the solid waste boundary of the ash pond. The surface of the pavement section will be sloped to drain to catch basins within the paved area to avoid the ponding of storm water. The closure cost plan includes an estimate of the cost of installing the pavement system, while the post-closure plan includes an estimate of the cost to maintain the paved area during the post-closure period.

In general, the slope of the final cover around the perimeter of the ash ponds will be sloped at 25% to a thickness of approximately 3 to 4 ft. in order to establish the required thickness of the cover soils. Above this, the final cover will typically be constructed with a minimum slope of 5% in anticipation that the slope of the cover will exceed the 2% percent minimum following consolidation of the sluiced ash materials.

The perimeter slopes on the east side of Ash Pond A, the internal slopes between Ash Ponds A and B, as well as between B and C, and the east side of Ash Pond C will all be sloped at 20%. The increased slopes are used specifically in these areas to help promote surface water runoff away from the existing transmission lines that occupy these areas. It will also be necessary to reduce the slope of the areas immediately beneath the transmission lines to preclude the need to add fill to these areas. Any increase in the existing elevations beneath the transmission lines would result in safety concerns related to the required clearance to the transmission lines. In any areas where the final cover slopes will be less than the required 2%, the final cover will be constructed with a geomembrane as described in Option 2, above. The approximate limits of the areas where the final cover slopes will be less than 2% are highlighted on Sheet 8 in Appendix M.

As noted on Sheet 8 in Appendix M, diversion berms will be added to the final cover to help minimize erosion of the final cover materials. The diversion berms will discharge into pipe downdrains as noted on the drawings in Appendix M. Erosion and surface water control design information is included in Appendix K. The proposed Quality Assurance Manual (QAM) for the construction of the final cover is provided in Appendix L.

The vegetative cover will consist of soils that are classified as ML, ML-CL, CL, CH, SC and SC-SM in accordance with the Unified Soil Classification System. In the event that the Petersburg Station chooses to utilize Option 2 for the cover system, the bottom foot of the protective layer may also include soils that classify as SM, SM-SP or SP.

The Ash Pond System will be closed in stages. It is currently anticipated that the southern end of Ash Pond A will be closed by October 2017 to facilitate the construction of a new wastewater treatment plant that is required to comply with an Agreed Order with the Indiana Department of Environmental Management related to the existing wastewater discharge National Pollutant Discharge Elimination System (NPDES) permit at the Petersburg Generating Station. Construction of the final cover in Ash Pond B is currently planned to begin in 2025 and be completed in 2021. Construction of the remainder of the final cover in Ash Pond A and all of Ash Pond C will begin within 12 months, and be completed within 5 years, after the facility stops sluicing ash into the ponds.

As the water level within each area drops, the surface of the previously sluiced ash will begin to stabilize. It will be necessary to allow the surface of the ash to stabilize before CCR structural fill can be safely placed over the surface of the ash to form the slope of the final cover system. In addition to the dewatering program, geosynthetic materials such as geotextiles and geogrids will be placed on an as-needed basis over the surface of the sluiced ash to provide a working platform for the earthwork operations.

It will also be necessary to uniformly load the surface of the sluiced ash to minimize the potential for instability of the fill slopes. Based on experience on similar projects, it is anticipated that the first lift of the structural fill will be limited to approximately 5 to 10 ft, and that temporary slopes will be maintained at slopes that are less than 20%. Subsequent lifts of structural fill will be applied until the final cover slope is formed as shown on the drawings in Appendix M.

As noted previously in this report, there will be other construction activities associated with the Ash Pond System that will be completed to meet other regulatory requirements. These other activities are outside of the scope of review and approval for this closure and post closure plan but are important to understanding how and why the timelines listed below associated with this closure and post-closure plan were developed. The timeline developed to complete these construction activities associated with the operation of the Ash Pond System and the estimated date of completion are as follows:

Activity	Tentative Completion Schedule
• Phase I – Complete Partial Closure within the Proposed Limits of the Wastewater Treatment Plant	October 1, 2017
• Phase II – Complete Closure within Pond B	December 31, 2021
• Phase III – Complete Closure within the remainder of Ash Pond A and Ash Pond C	Within 5 years of the Cessation of Sluicing of Ash

The time required to complete the construction of the final cover over the Ash Pond System is highly dependent on stability issues related to the placement of the structural fill as well as the supply of CCRs used to create the slope of the final cover. Therefore, it is difficult to establish a definite timeline for the closure activities. It has been assumed that it will take up to two years to place enough structural fill over any portion of the surface of the Ash Pond System to create an area large enough to efficiently install the proposed final cover system. In the event that the structural fill placement is completed ahead of schedule, IPL will proceed with the initiation of the construction of the final cover.

The sedimentation basin (i.e. Ash Pond A') noted at the north end of Ash Pond A will remain in operation throughout the closure activities.

(B) Final Contour Map: A plot plan that indicates the fill boundaries and the proposed final contours of the site at intervals of no more than two (2) feet.

Drawings illustrating the proposed grades at the time of closure are provided in Appendix M. As noted above, the slope of the top of the closed ash pond will range from approximately 1 percent to 20 percent at the time of closure. It is anticipated that the ponded ash will settle under the weight of the structural fill needed to establish the required slopes as well as the final cover itself. Based on settlement calculations made based on consolidation tests performed on ponded ash from other facilities, the final slope of the final cover system (i.e., following settlement) will exceed the 2 percent minimum with the exception of the areas under the transmission lines where a geomembrane will be included in the final cover system.

It is noted that it may be necessary to add surface water ditches to the perimeter of the grading plan prior to the start of construction. The final vertical and horizontal positions of these ditches will be dependent on some of the other construction activities described above. Therefore, details of these ditches will be provided to IDEM prior to the start of construction.

(C) Ground Water Monitoring: Sites that test as restricted waste site type I or Type II must prepare a Ground Water Monitoring and Corrective Action plan in accordance with applicable requirements of 329 IAC 10-29. For wastes which test as Type III, the responsible party must either document the lagoon has a barrier in accordance with 329 IAC 10-34 or it will be necessary to develop a similar program for monitoring ground water downgradient or at the facility boundary to detect any future release from the closed impoundment. Sludge from waste water treatment plants that test as restricted waste site Type III must also comply with the ground water requirements of 40 CFR 503. If monitoring is determined to be necessary, a plan should be submitted to this office which includes:

(1) the number and placement of monitoring wells;

The proposed groundwater monitoring system is described in the preceding sections. Summarizing those sections, seventeen (17) monitoring wells are proposed for groundwater monitoring. Fifteen monitoring wells (AP-1, AP-2A, AP-2B, AP-3, AP-4A, AP-4I, AP-4B, AP-5, AP-6, AP-7, AP-8, MW-2, MW-3, and MW-4C) are existing wells that were either installed in June 2014 or currently serve as part of the landfill monitoring system. Two additional monitoring wells (AP-3A and AP-5A) are proposed and will be installed within six months of approval of this closure plan. Existing and proposed monitoring wells are shown on Sheets 2 and 3 of Appendix M.

(2) the number and frequency of samples;

The proposed groundwater sampling program is described in section 2(E)(4)(e) above.

(3) the chemical parameters to be monitored that should be consistent with those identified with the impoundment characterization;

The proposed monitoring parameters are listed in Table 6. Following collection of eight quarters of groundwater monitoring results, the analytical parameter list may be revised if continued monitoring of specified parameters is not beneficial for assessing groundwater quality with respect to Ash Pond System closure.

(4) sampling protocol; and,

The proposed sampling protocols are outlined in section 2(E)(4)(e) above. A groundwater sampling and analysis plan that describes the sampling protocols, sampling methods, monitoring points, and monitoring parameters will be prepared within 90 days following completion of the monitoring well installations.

(5) how the determination of releases will be made.

Groundwater quality results will be evaluated according to the assessment monitoring program described in section 2(E)(4)(e) above.

(D) Closure Certification: Sites that test as restricted waste site

Type I or Type II must certify closure in accordance with applicable requirements of 329 IAC 10-30-7. Sites that test as restricted waste site Type III must certify closure in accordance with 329 IAC 10-37-7.

IPL will submit a closure certification report at the completion of the closure activities for the Ash Pond System. This report will be prepared to address the requirements of 329 IAC 10-30-7.

(E) Post-Closure Requirements: Sites that test as restricted waste site Type I or Type II must comply with the applicable post-closure requirements of 329 IAC 10-31. Restricted waste site Type III closure must comply with the applicable post-closure requirements of 329 IAC 10-38. Post-closure care will extend for 30 years as specified by 329 IAC 10-31-2(b) or 329 IAC 10-38-2(b). Funding mechanisms to cover the post-closure requirements must be established in accordance with 329 IAC 10-39.

IPL will comply with the applicable post-closure requirements of 329 IAC 10-31.

(F) Responsibilities after Post-Closure: After post-closure is certified as complete, the owner, operator and/or responsible party will still be responsible for the requirements of 329 IAC 10-31-5, 10-31-6 and 10-31-7 or 329 IAC 10-38-5, 10-38-65 and 10-38-7, as applicable.

IPL will comply with the responsibilities outlined above after completion of the post-closure period.

APPENDIX A-3

Quality Assurance Manual for the Installation of Final Cover, March 2017 (Approved July 2017)

QUALITY ASSURANCE MANUAL
INSTALLATION OF FINAL COVER
ASH POND SYSTEM

PETERSBURG GENERATING STATION
PETERSBURG, IN

March 2017

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QUALITY ASSURANCE MANUAL
INSTALLATION OF FINAL COVER
ASH POND SYSTEM
PETERSBURG GENERATING STATION
PETERSBURG, IN

1.0 GENERAL

1.1 SCOPE

This Quality Assurance Manual (QAM) has been prepared to address the construction quality assurance installation activities of the soil and geosynthetic materials used in the final cover by the Petersburg Generating Station (Owner) for the closure of its Ash Pond System which consists of Ash Ponds A, B and C.

Two final cover systems have been proposed to the Indiana Department of Environmental Management for use in the closure of the ash pond system as described in the following paragraphs.

> Option 1 – This option will consist of a minimum of 0.5 ft. of topsoil and 4 ft. of compacted cover soils on slopes greater than 25%, 0.5 ft. of topsoil and 3 ft. of compacted cover soils on slopes greater than 15% but less than or equal to 25% and 0.5 ft. of topsoil and 2 ft. of compacted cover soils on slopes less than 15%.
>
> Option 2 – This option will consist of either a 30 mil PVC, a 60 mil HDPE or a 40 mil LLDPE geomembrane liner installed over the surface of the structural fill placed to form the required slope across the surface of the ash pond. The liner will be overlain with a cushion geotextile and strips of geocomposite drainage material. The geocomposite will be placed at selected intervals to help facilitate removal of surface water that infiltrates through the 2.5 ft. protective layer and 0.5 ft topsoil layer that will be placed over the aforementioned geosynthetics.

The Construction Quality Assurance Plan presented in this document is limited to the Option 2 Final Cover System described above. The Option 1 final cover system will not be utilized at the Ash Pond System until the Indiana Department of Environmental Management (IDEM) has reviewed and approved a Construction Quality Assurance Plan prepared specifically for the Option 1 final cover system.

It is noted that coal combustion products (CCPs) will be used as structural fill to create a slope across the relatively flat surface of the sluiced ash that is present in the Ash Pond System. The CCPs that will be utilized will consist of any or all of the following materials; fly ash, bottom ash, ponded ash, gypsum, and filter cake.

It is anticipated that borrow materials for the vegetative cover layer will come primarily from excavations within property owned by the Petersburg Generating Station.

The management of the construction quality includes both construction quality control (CQC) and construction quality assurance (CQA). CQC involves a planned system of inspections that are used to directly monitor and control the quality of the proposed composite liner system. CQA involves a planned system of activities (inspections, verifications, audits, and evaluations of materials and workmanship) that provides assurance that the composite liner systems were constructed as specified in the design. This document will contain elements of CQC but has been written primarily as the CQA plan or manual.

The overall goals of this CQA Plan are to verify that the materials and installation techniques used meet project specifications. Additionally, the program is intended to: (1) identify and define any problems that may occur during construction, and (2) document that any such problems are corrected before the construction is complete. At completion of the work, the program will culminate in a report that documents the CQA Consultant's assessment whether the work has been performed in compliance with the design intent of the design standards and specifications. The main emphasis of the CQA Plan is careful documentation during the entire quality assurance process, from the delivery of the lining system materials through construction of the lining systems.

This QAM primarily addresses quality assurance and is directed toward the Quality Assurance Consultant. In the context of this manual, quality assurance refers to means and actions employed by the Owner to assure conformity of the lining system production and installation with the project-specific design, contractual and regulatory requirements. Quality control refers only to those actions taken to ensure that materials and workmanship meet the requirements of the project plans and specifications. Quality control is provided by the manufacturers, suppliers, contractors and installers of the various components of the lining system.

1.2 PARTIES

The parties discussed in this section are associated with the ownership, design, supply, manufacture, transportation, installation, and quality assurance of a lining system. The definitions, responsibilities, qualifications, and submittals of these parties are outlined in the following subsections.

1.2.1 Project Manager

1.2.1.1 Definitions - The Project Manager is the official representative of the Owner. In this manual, the term Project Manager shall apply equally to Owner and/or "Construction Coordinator", defined as the individual who coordinates construction and quality assurance activities for the project.

1.2.1.2 Responsibilities - The Project Manager is responsible for coordination of all construction quality assurance activities. The Project Manager is responsible for the implementation of the QAM for the project. If the Project Manager is away from the site, he will designate an alternate to perform his duties in his absence.

The Project Manager shall serve as communications coordinator for the project, initiating the resolution, pre-construction and construction meetings. As communications coordinator, the Project Manager shall serve as a liaison between all parties involved in the project to ensure that communications are maintained. The Project Manager shall also be responsible for proper resolution of all quality assurance issues that arise during construction.

1.2.1.3 Qualifications - The selection of the Project Manager is the direct responsibility of the Owner. Qualifications for this position include familiarity with the following:

1. Sections of this QAM.
2. General earthwork construction techniques.
3. General geosynthetic installation techniques.
4. All applicable regulatory requirements.

1.2.2 Designer

1.2.2.1 Definitions - The Designer is the individual and/or firm who prepares the design, including project plans and specifications for the lining system.

1.2.2.2 Responsibilities - The Designer is responsible for performing the engineering design and preparing the associated project plans and specifications for the lining system. The Designer is responsible for review, generation and approval of all design and/or specification modifications and clarifications. These modifications and clarifications may occur prior to construction and/or during construction. The Designer shall report to the Owner or to the Owner's designated representative.

1.2.2.3 Qualifications - The Designer shall be a qualified engineer, certified or licensed as required by regulation. The Designer shall be familiar with the use of soils and/or geosynthetics including detailed design methods and procedures. In addition, the Designer should be familiar with applicable regulatory requirements.

1.2.3 Manufacturer

1.2.3.1 Definitions - The Manufacturer is the firm that produces any of the various geosynthetic lining system components outlined in this QAM. In the case of a geocomposite, the Manufacturer is the firm that combines the components into the final product.

1.2.3.2 Responsibilities - Each Geosynthetic Manufacturer is responsible for the production of geosynthetic products and for providing quality control documentation for its product, which shall meet all relevant project specifications. Additionally, the Manufacturer is responsible for the condition of the geosynthetic product until accepted by the owner or it's designee upon delivery.

1.2.3.3 Qualifications - Each Manufacturer shall:

1. Be pre-qualified and approved by the Owner.
2. Provide sufficient production capacity and qualified personnel to meet the demands of the project.
3. Have an internal quality control program for its product that meets the project requirements.

1.2.4 Earthwork Contractor

1.2.4.1 Definitions - The Earthwork Contractor is the firm that performs the site earthwork preparation and construction of the soil components of the lining system. The Earthwork Superintendent is the individual responsible for the Earthwork Contractor's field crew.

1.2.4.2 Responsibilities - The Earthwork Contractor is responsible for constructing soil components of the lining systems in conformance with the project plan and specifications. The Earthwork Contractor may also be responsible for locating and transporting the required earth and granular materials, concrete, piping or other components as required by the design plans, specifications or construction drawings. Upon recommendation by the soil QAC, the Owner shall consider accepting the soil components of the lining system. The earthwork Contractor will retain all ownership and responsibility for the soil lining components until acceptance by the Owner. At the Owner's discretion, the lining system may be accepted in sections or at points of substantial completion. The Earthwork Contractor(s) shall report to the Owner or the Owner's designated representative. All or any portion of the Earthwork Contractors(s) task may be completed by the Owner's own internal resources.

1.2.4.3 Qualifications - The Earthwork Contractor shall be:

1. Pre-qualified and approved by the Owner.
2. Able to provide qualified personnel to meet the demands of the project.
3. At a minimum, the Earthwork Contractor shall provide a Superintendent. The Superintendent must be qualified based on previously demonstrated experience,

management ability, and authority.

1.2.5 Geosynthetic Installer

1.2.5.1 Definitions - The Geosynthetic Installer (Installer) is the firm that installs the geosynthetic components of the lining system. The Geosynthetic Superintendent is the individual responsible for the Installer's field crew.

1.2.5.2 Responsibilities - The Geosynthetic Installer is responsible for all aspects of the geosynthetics installation including, on-site storage, field handling, placing, seaming, field testing, temporary restraining and all other aspects of the geosynthetics installation. The Geosynthetic Installer may be affiliated with the Geosynthetic Manufacturer or the Earthwork Contractor.

The installer will retain all ownership and responsibility for the geosynthetic lining components until acceptance by the Owner. Upon recommendation by the geosynthetic QAC, the Owner shall consider accepting the geosynthetic components of the lining system. At the Owner's discretion, the lining system may be accepted in sections or at points of substantial completion.

1.2.5.3 Qualifications - The Installer shall be pre-qualified and approved by the Owner. The Installer shall be able to provide qualified personnel to meet the demands of the project.

1.2.6 Soil Quality Assurance Consultant

1.2.6.1 Definitions - The Soil Quality Assurance Consultant (Soil QAC) is the firm that observes and documents activities related to the quality assurance of the installation of the soil components of the lining system on behalf of the Owner.

The term Soil Quality Assurance Engineer (Soil QAE) refers to the engineer employed by the QAC who is personally in charge of the quality assurance work. The personnel of the Soil QAC also include Soil Quality Assurance Technicians (Soil QA Technicians) who are located at the site for construction observation and documentation, and a Resident Engineer who reviews the work of the technicians and assists the QAE in directing the quality assurance work.

1.2.6.2 Responsibilities - The Soil QAC is responsible for observing and documenting activities related to the quality assurance of the construction of the soil components of the lining system. During implementation of the CQA plan, the Soil CQA Consultant(s) shall be responsible for observing, field testing of soils, collection of test samples to forward to the soils laboratory for testing, and documenting the daily activities associated with construction quality assurance during the construction of the lining system. The Soil CQA Consultant(s) shall report construction activities and progress to the Owner on a regular basis. The Soil CQA Consultant(s) shall immediately report to the Owner or his representative any activities, observations or test results that indicate the construction activities are not in conformance to the project plans and/or specifications.

The Soil QAC is also responsible for issuing a final Quality Assurance Report, sealed by a licensed Professional Engineer.

The QAE or his designee shall monitor all base liner and/or final cover construction activities.

1.2.6.3 Qualifications - The Soil QAC shall be pre-qualified and approved by the Owner.

1.2.7 Geosynthetic Quality Assurance Consultant

1.2.7.1 Definitions - The Geosynthetic Quality Assurance Consultant (Geosynthetic QAC) is the firm that observes and documents activities related to the quality assurance of the production and installation of the geosynthetic components of the lining system on behalf of the Owner.

The term Geosynthetic Quality Assurance Engineer (Geosynthetic QAE) shall be used to designate the engineer working for the Geosynthetic QAC in charge of the quality assurance work. The personnel of the Geosynthetic QAC also include Geosynthetic Quality Assurance Technicians who are located at the site for construction observation and documentation, and a Resident Engineer who reviews the work of the technicians and assists the QAE in directing the quality assurance work.

1.2.7.2 Responsibilities - The Geosynthetic QAC is responsible for observing and documenting activities related to the quality assurance of the production and installation of the geosynthetic components of the lining system. The Geosynthetic QAC is responsible for certification of the final construction as being in general compliance with the project plans and specifications. This CQA plan outlines the minimum inspection requirements to be used by the Geosynthetic QAC to ensure that the project plans and specifications are met. During implementation of the CQA plan, the Geosynthetic QAC shall be responsible for the overall administration of quality assurance procedures and for the control of quality assurance documents. The Geosynthetic QAC shall also be responsible for the oversight and coordination of quality assurance technicians and testing laboratories. The Geosynthetic QAC shall report construction activities and progress to the Owner on a regular basis. The Geosynthetic QAC shall immediately report to the Owner or his representative any activities, observations or test results that indicate the construction activities are not in conformance with the project plans and/or specifications. The Geosynthetic QAC is also responsible for issuing a final Quality Assurance Report, sealed by a licensed Professional Engineer, typically the QAE.

1.2.7.3 Qualifications - The Geosynthetic QAC shall be pre-qualified by the Owner. The Geosynthetic QAC shall be experienced in quality assurance of geosynthetics with emphasis on geomembranes.

1.2.8 Soil Quality Assurance Laboratory

1.2.8.1 Definitions - The Soil Quality Assurance Laboratory (Soil QAL) is the firm that conducts tests on soil samples obtained for the project. The Soil QAL and Geosynthetic QAL may be the same party.

1.2.8.2 Responsibilities - The Soil QAL is responsible for conducting the appropriate laboratory testing as directed by the Soil QAE. Test procedures shall be performed in accordance with the project test methods. The Soil QAL shall be responsible for providing test results. The Geosynthetic QAC may be affiliated with the Soil Quality Assurance Laboratory.

1.2.8.3 Qualifications - The Soil QAL shall be pre-qualified by the Owner and approved by the Project Manager. The Soil QAL shall have properly maintained and periodically calibrated appropriate testing equipment.

1.2.9 Geosynthetic Quality Assurance Laboratory

1.2.9.1 Definitions - The Geosynthetic Quality Assurance Laboratory (Geosynthetic QAL) is the firm that conducts tests on samples of geosynthetics obtained for the project.

1.2.9.2 Responsibilities - The Geosynthetic QAL is responsible for conducting the appropriate laboratory tests on geosynthetic samples as directed by the Geosynthetic QAE. The test procedures shall be done in accordance with the project specifications and/or the latest industry standards. The Geosynthetic QAL shall be responsible for providing test results.

1.2.9.3 Qualifications - The Geosynthetic QAL shall be pre-qualified by the Owner and approved by the Project Manager. The Geosynthetic QAL shall have properly maintained and periodically calibrated appropriate testing equipment. The Geosynthetic QAL shall also ensure the laboratory testing is performed by personnel with experience and/or training in geosynthetic testing fundamentals.

1.2.10 Surveyor

1.2.10.1 Definitions - The Surveyor is the firm that conducts field surveys at the site, including but not limited to, construction stakeout and record documentation purposes. More than one surveyor may be employed by the Project Manager and/or the subcontractors.

1.2.10.2 Responsibilities - The Surveyor is responsible for conducting the appropriate field surveys as directed by the Project Manager or the Earthwork Contractor, depending on specific contractual arrangements. The surveys will be performed in accordance with all applicable design, contractual and regulatory requirements.

The survey requirements generally include, but are not limited to, construction stakeout, constructed grade verification, constructed soil thickness verification, soil and material quantity

verification, material sample and repair locations, and final record documentation surveys. The surveyor may also be responsible for preparing record construction maps and data.

1.2.10.3 Qualifications - The Surveyor shall be pre-qualified by the Owner and approved by the Project Manager. The Surveyor shall have properly maintained and periodically calibrated appropriate survey equipment. The surveyor shall be licensed for practice in the state of Indiana.

1.3 COMMUNICATION

To help ensure a high degree of quality during installation and assure a final product that meets all project specifications, clear, open channels of communication are essential between all parties.

1.3.1 Lines of Communication

The typical lines of communication necessary during a project are illustrated in Exhibit 1-1.

1.3.2 Pre-construction Meeting

A pre-construction meeting shall be held at the site prior to beginning of lining system installation. Typically, the meeting shall be attended by the Project Manager, Designer, Earthwork Contractor, Geosynthetic Installer, Soil/Geosynthetic QAE and the Owner's technical representative.

Specific topics considered for this pre-construction meeting may include safety, communication, project design and specifications, materials, drawings, regulations and review of the project QAM for any problems or additions. The responsibilities of each party should also be reviewed and understood clearly. A recommended agenda for the pre-construction meeting is presented in Exhibit 1-2.

Separate pre-construction meetings may be held for the soil and geosynthetic construction activities.

Exhibit 1-1

LINES OF COMMUNICATION

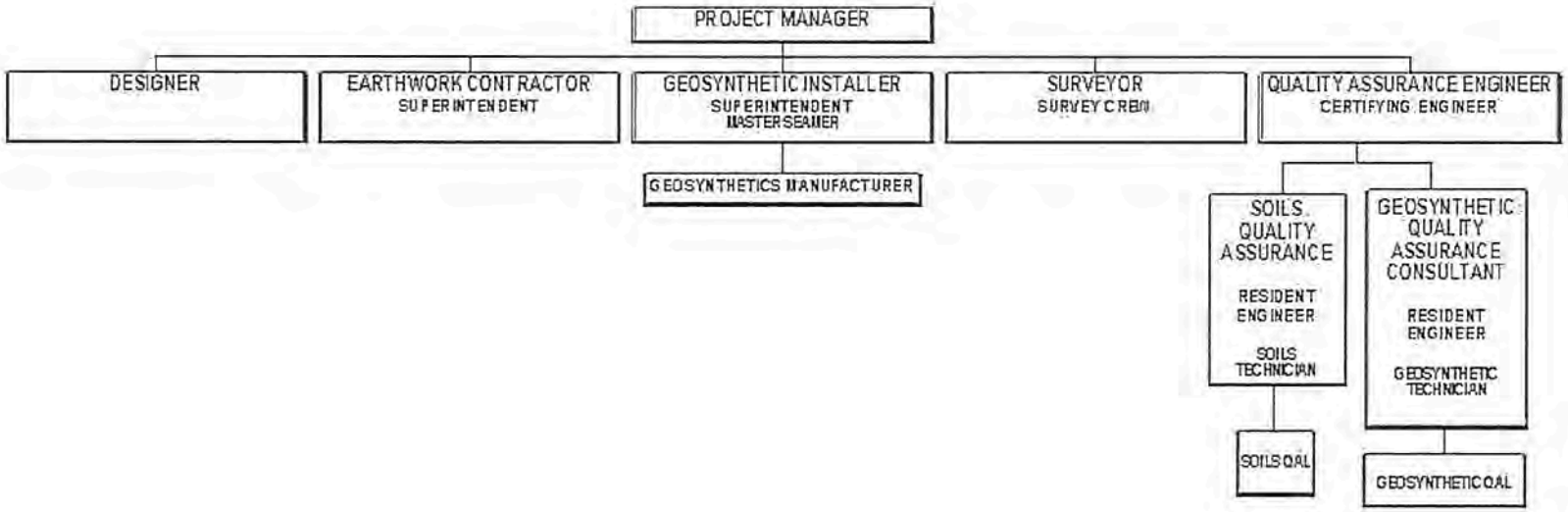


Exhibit 1-2
PRE-CONSTRUCTION MEETING AGENDA
EXAMPLE

(Note: A project specific agenda may be developed based on the requirements of each project. Items listed below are for illustrative purposes only. The actual meeting agenda does not have to be the same as this example agenda; it may differ to suit the specific needs of each meeting. Some items listed below may not be discussed at specific pre-construction meeting, and others may be added. Two separate meetings may be held for the soils and geosynthetics work.)

1. Introduction

   A. Identify Parties and Responsibilities
      1. Project Manager
      2. Designer
      3. Surveyor
      4. Earthwork Contractor
      5. Geosynthetic Installer
      6. Soil/Geosynthetic Quality Assurance Consultant
      7. Soil/Geosynthetic Quality Assurance Laboratory
      8. Owner technical representative
      9. Others

2. Tour Project Site

3. Review Documents

   A. Project Plans
   B. Project Specifications
   C. Geosynthetic Panel Layout
   D. Project Quality Assurance Manual
   E. Health and Safety Plan

4. Define Lines of Communication

   A. Lines of Communication
   B. Reporting Methods
   C. Distribution Methods
   D. Progress Meetings
   E. Procedures for Approving Design Clarifications and Changes During Installation

Exhibit 1-2 (Continued)
PRE-CONSTRUCTION MEETING AGENDA
EXAMPLE

5. Review Site Requirements

    A. Safety Rules
    B. Site Rules
    C. Work Schedule
    D. Storage of Materials
    E. Available Facilities

6. Discuss Construction Issues

    A. Scope of Work
    B. Review Design
        1. Construction Drawings
        2. Specifications
        3. Geosynthetic Panel Layout
    C. Construction Procedures
        1. Proposed Construction Sequencing
        2. Location of Soil Stockpile Areas
        3. Location of Geosynthetic Storage Area
        4. Equipment
    D. Construction Schedule
    E. Procedures for Preparing and Approving Change Orders

7. Construction Quality Assurance Manual

    A. Soils
    B. Geosynthetics
    C. Structural Systems (e.g., risers, piping, etc.)

8. Establish Project Deliverables

    A. Responsibilities
        1. Designer
        2. Installer
        3. Earthwork Contractor
        4. Soil/Geosynthetic Quality Assurance Consultant
        5. Soil/Geosynthetic Quality Assurance Laboratory
        6. Project Manager
    B. Distribution of Deliverables
    C. Approval Procedures

1.3.3 Progress Meetings

Periodic progress meetings may be held between the Soil/Geosynthetic QAE, Earthwork Contractor's/Installer's Superintendent, Geosynthetic Contractor's/Installer's Superintendent, Project Manager and any other concerned parties. These meetings shall discuss current progress, planned activities, issues requiring resolution, and any new business or revisions to the work.

Should a construction problem or deficiency occur or be likely to occur, a deficiency resolution meeting shall be held. This meeting shall be attended by the Owner or Owner's representative, the contractors associated with the problem or deficiency and CQA Consultant. If the problem requires modification(s) to the design, the Design Engineer shall also attend. This meeting may be held in conjunction with the regularly scheduled progress meeting.

The intent of this meeting shall be to identify, isolate and resolve the problem or deficiency to the satisfaction of the project plans and specifications, and all parties. This meeting shall be documented and included in the CQA Consultant's reports to the Owner's Representative.

1.3.4 Authority to Meet with Regulators

The only individuals authorized to discuss the project with the Indiana Department of Environmental Management (IDEM) or other regulators are representatives of the Petersburg Generating Station, Indianapolis Power & Light Company (IPL), AES SBU Services, LLC, or persons designated by the Petersburg Generating Station, AES SBU Services, LLC, or IPL.

2.0 DOCUMENTATION

The Soil/Geosynthetic QAC shall document that all requirements in the lining system of the project have been addressed and satisfied.

2.1 DAILY REPORTS

2.1.1 Soils Reports

The Soil Quality Assurance Technician shall complete a daily report and/or logs on prescribed forms outlining all monitoring activities for that day. The report at a minimum shall consist of field notes, observations, test data sheets, construction problems and solution data sheets.

2.1.2 Geosynthetic Reports

The Geosynthetic Quality Assurance Technician shall complete a daily report and/or logs on

prescribed forms outlining all monitoring activities for that day. The precise areas worked on, panel numbers, seams completed and approved, measures taken to protect unfinished areas overnight and other appropriate data and information shall be identified. Failed seams, defective panel areas, or other geosynthetics requiring remedial action shall be identified with regard to the nature of problem, required repair, and precise location. Repairs completed must also be identified.

2.2 TEST REPORTS

2.2.1 Soils Testing Reports

Records of field and laboratory testing performed on the soil components of the liner system shall be collated by the Soil QAC.

2.2.2 Geosynthetic Testing Reports

The test reports from all sources shall be collated by the Geosynthetic QAC. This includes field tests, Installer's laboratory tests (if performed), and Geosynthetic QAL tests. A summary list of test samples pass/fail results shall be prepared by the Geosynthetic QAC. The summary shall also contain resolution on failed tests clearly documenting complete quality assurance conformance with established procedures.

2.3 RECORD DRAWINGS

2.3.1 Soils Drawings

Record drawings shall be prepared by the Soil QAC or a licensed surveyor (drawings shall be reviewed by the QAC if prepared by a surveyor).

2.3.2 Geosynthetic Drawings

Record drawings shall be prepared by the Geosynthetic QAC or a licensed surveyor (drawings shall be reviewed by the QAC if prepared by a surveyor).

2.4 FINAL QUALITY ASSURANCE REPORT

Upon completion of the work, the Soil/Geosynthetic QAC shall submit a final Quality Assurance Report to the Project Manager, including all applicable quality assurance data and documentation, record drawings, and laboratory test results.

3.0 LINING SYSTEM ACCEPTANCE

3.1 SOIL COMPONENTS ACCEPTANCE

Upon recommendation by the soil QAC, the Project Manager shall consider accepting the soil components of the final cover system. The earthwork Contractor will retain all ownership and responsibility for the soil components of the final cover system until acceptance by the Project Manager. At the Project Manager's discretion, the final cover system may be accepted in sections or at points of substantial completion.

3.2 GEOSYNTHETIC COMPONENTS ACCEPTANCE

Upon recommendation by the geosynthetic QAC, the Project Manager shall consider accepting the geosynthetic components of the final cover system. The installer will retain all ownership and responsibility for the geosynthetic components of the final cover system until acceptance by the Project Manager. At the Project Manager's discretion, the final cover system may be accepted in sections or at points of substantial completion.

4.0 SOIL COVER AND STRUCTURAL FILL

4.1 DESCRIPTION AND APPLICABILITY

The vegetative soil cover layer will consist of soils that are classified as ML, CL-ML, CL, CH, SC and SC-SM in accordance with the Unified Soil Classification System or loam, fine sandy loam, loamy sand, and sandy soils that are typical of the Alvin-Bloomfield complex (as described in the Pike County Soil Survey) and have been approved by IDEM for use as final cover soils for the IPL Petersburg Type III Landfill. The bottom foot of the vegetative layer may also include soils that classify as SM, SP-SM or SP.

4.2 PRE-CONSTRUCTION TESTING

Pre-construction testing of any natural soils Shall be performed as outlined below to ensure the consistency of the properties of the soil obtained from on or off-site borrow sources. These tests shall be performed on or off-site prior to placement of the soil.

At a minimum, the following tests shall be conducted:

1. Particle size (ASTM D1140, D422).
2. Atterberg limits (ASTM D4318).

Unless otherwise specified, all tests performed on natural soils shall be conducted at a frequency of one per 10,000 yd^3 or upon changes in the material type.

The laboratory test results shall be evaluated to confirm that the materials are in accordance with the Project Specifications. Materials not meeting the specifications shall not be acceptable. The CQA Consultant shall verify that required specifications and testing frequencies are met.

4.3 SUBGRADE PREPARATION

The Earthwork Contractor shall be responsible for preparing subgrade soil for placement of overlying materials.

The Soil QAE shall inspect the subgrade for defects prior to placement of the geomembrane liner. If the subgrade is acceptable for placement (as defined by the Project Specifications), the QAE shall complete and certify a subgrade acceptance report and shall notify the Project Manager that placement may proceed. Prior to and during installation of the geomembrane liner, the Soil QAC shall indicate to the Project Manager any locations that are not adequate for the placement. Such defects include, but are not limited to: insufficient grading, presence of ruts, presence of wet areas, areas of inadequate compaction, and unacceptable soil types. No geosynthetic liner material shall be placed upon frozen ground. The Project Manager will direct the Earthwork Contractor to repair any defects to the satisfaction of the Soil QAE before the subgrade will be accepted. Upon completion of satisfactory subgrade repairs, the QAE shall complete and certify a subgrade acceptance report and shall notify the Project Manager that installation of the geomembrane may proceed.

4.4 CONSTRUCTION OBSERVATION

Observation of the structural fill placement shall be coordinated with construction testing.

4.5 CONSTRUCTION TESTING

All construction quality assurance testing shall be conducted in accordance with the Project Specifications.

4.5.1 Field Testing

No field moisture/density testing will be required on soils placed in the final cover.

The completed thickness of the final cover shall be measured by surveying the elevations of the top of the subgrade and the top of the final cover on a 200 ft. x 200 ft. field grid. The Surveyor shall verify that the lines and grades of the subgrade are at or within the acceptable tolerances of the design elevations and slopes specified in the approved construction drawings. The surveyed subgrade elevation will be subtracted from the surveyed final cover elevation to determine the final cover thickness.

4.6 DEFECTS AND REPAIRS

4.6.1 Identification

At locations where the testing indicates the requirements of the Project Specifications are not met, the Soil QAC shall determine the extent and the nature of the defect and recommend corrective actions to the Project Manager.

4.6.2 Notification

After determining the extent and nature of any defect, the Soil QAC shall promptly notify the Earthwork Contractor and the Project Manager.

4.6.3 Repairs and Retesting

The Earthwork Contractor shall correct all deficiencies in accordance with the project specifications.

5.0 PVC GEOMEMBRANES

5.1 DESCRIPTION AND APPLICABILITY

This Section applies to the use of PVC geomembranes in the event that they are included in the final cover system.

To assure the quality of the finished raw material, the quality of each of the raw materials must be checked by the PVC geomembrane manufacturer. Only virgin, first grade raw materials are acceptable. The basic raw materials used in PVC geomembranes are PVC resin, plasticizer and stabilizer. Raw materials are checked by manufacturers for the following:

PVC Resin	Plasticizer	Stabilizer
• Relative viscosity (Molecular weight) • Fisheye count • Plasticizer drying time • Contamination • Color • Particle size • Bulk density • Percent volatiles • Residual vinylchloride monomer • Particle size distribution	• Refractive index • Viscosity • Specific gravity • Percent moisture • Ester content • Acid number • Color	• Refractive index • Stability • Plate out • Specific gravity • Color • Metal analysis

In addition to meeting the minimum project specifications, each panel must conform to the specifications outlined in the most current version of the PVC Geomembrane Institute Specifications for PVC geomembranes.

5.2 MANUFACTURING PLANT INSPECTION

The Project Manager, or his designated representative, may visit the manufacturing plant for a project-specific inspection if deemed necessary.

5.3 QUALITY CONTROL DOCUMENTATION

5.3.1 PVC Raw Materials

The PVC Manufacturer will provide the Owner or Geosynthetic QAC with the following information for the PVC geomembrane to be used:

1. Written certification accompanying all material shipments stating that their product meets all manufacturing specifications and passes all QA/QC requirements as identified by the manufacturer. The Manufacturer shall also provide Quality Control documentation and results of testing that the material specified in this section shall meet or exceed the requirements of the specifications and CQA Plan.
2. The origin (PVC Resin and Plasticizer Supplier's name, identification brand name, number) and production date of the PVC resin and plasticizer;
3. A copy of the quality control certificate issued by the PVC Resin and Plasticizer Supplier;
4. Summary reports of the test results, including the test frequency used by the Manufacturer to verify the quality of each resin and plasticizer batch used to manufacture the PVC geomembrane panels.

All quality control tests shall be performed in accordance with the test methods and frequencies as set forth in the project specifications and this QAM. Based on the data supplied by the Manufacturer, the Geosynthetics QAC will notify the Owner of any deviation from the project specifications or CQA Plan. If the results contained in the manufacturer's certifications do not meet or exceed the values contained in the project specifications, the material shall be considered out-of-specification and rejected.

5.3.2 PVC Geomembrane Panels

The Manufacturer will provide the Owner or Geosynthetic QAC with written certification accompanying all material shipments stating that their product meets all manufacturing specifications and passes all QA/QC requirements as identified by the manufacturer for the PVC geomembrane produced, and that the PVC geomembrane supplied under this plan will meet the specifications of ASTM D7176 and the project specifications.

The Manufacturer will provide the Owner or Geosynthetic QAC with quality control certification documentation for all the PVC geomembrane prior to the material being shipped to the site. A responsible party employed by the Manufacturer shall sign the quality control certification documentation. The quality control certification documentation shall include:

1. Roll and panel number and identification, and;

2. Sampling procedures and testing frequency of quality control tests in accordance with ASTM D7176 and the specifications.

Test results shall meet the minimum project specifications.

The Geosynthetic QAC will:

1. Ensure conformance test samples were obtained at the place of manufacture prior to the rolls/panels being delivered to the site; if required by the Owner;
2. Review the quality control certificates, test methods used, and the measured roll/panel properties for conformance to the specifications; and,
3. Verify that the quality control certificates have been provided for all rolls/panels.

5.3.3 PVC Factory Seaming

PVC geomembrane is manufactured into approximately six to eight foot wide sheets. The sheets are then factory seamed together by the PVC Geomembrane Manufacturer or Fabricator to minimize field seaming. The Geomembrane Manufacturer and/or Fabricator shall inspect the factory fabricated seams for the following requirements:

1. The weld shall be accomplished by chemical fusion, dielectric, or hot wedge weld.
2. The seamed surfaces shall be cleaned of all dust, dirt, or foreign debris before seaming.
3. All factory seams must extend to the end of the sheet. The seams shall not have any loose edges.
4. Each panel fabricated must be logged by panel number, size, date fabricated, material lot number, roll numbers and fabrications.
5. All factory seams must be visually inspected by the PVC Geomembrane Fabricator before the panels are shipped to the site.

Any changes in the layout of factory seams should be approved by the CQA Manager. Personnel performing the factory seaming shall meet the same requirements as those performing the field seaming. The factory seam shall be of equal or better quality than that described in Section 5.7.

Factory seams shall be 100% inspected using recommended industry standard techniques before the PVC geomembrane is shipped from the fabrication plant. Rejected seams shall be fully documented and repaired. The Geosynthetic QAC shall review the Manufacturer's quality control documentation to ensure that proper seaming procedures were followed and the resulting seams are of the specified quality. After PVC geomembrane shipment, the Geosynthetic QAC shall visually observe the factory seams on a procedural basis during the construction process to ensure that the seams overlap as specified and that the proper seaming procedure was used.

The Geomembrane Manufacturer/Fabricator shall provide certification based on destructive seam tests performed in the Manufacturers/Fabricators laboratory that the factory seaming performed for each panel or every 3,000 feet length of factory seam, whichever is more frequent, meets the minimum project specifications (e.g., Non Reinforced PVC (Polyvinyl Chloride) Geomembrane Seams as outlined, ASTM D7408). The Manufacturer/Fabricator shall also provide Quality Control documentation and results of testing that the material specified in this section shall meet or exceed the requirements of the Specifications.

5.3.4 Acceptance Criteria

Acceptable criteria for tests to be performed on PVC geomembrane are included in the project specifications. Retesting of PVC geomembrane because of failure to meet any of the project specifications can only be authorized by the Owner or the Geosynthetic QAC.

For those tests where results are reported for both machine and cross direction, each result will be compared to the listed specification to determine acceptance. The following procedure will be used for interpreting results:

1. If the value meets the stated specification, then the panel and the lot will be accepted for use in the liners for the job site.
2. If the result does not meet the minimum project specifications, then the panel and the lot may be retested on samples either from the original panel sample or from another sample collected by the CQA Consultant and forwarded to the Manufacturer. Two additional tests must be performed for the failed test procedure. If both of the retests are acceptable, then the panel and lot will be considered acceptable. If either of the two additional tests fail, then both the panel and lot are unsuitable and shall be rejected.

5.4 CONFORMANCE TESTING

Since the Manufacturer and the Fabricator are both required to control and meet the minimum specifications and testing frequencies as set forth in the project specifications and the latest ASTM Standards, conventional "Conformance Testing", in accordance with IDEM State Regulations, is not required. However, following the review of the required certification documentation and the test results as performed by the Manufacturer or Fabricator, at the recommendation of the Geosynthetic QAC the Owner reserves the right to assign additional "Conformance Testing" by an independent QAL to assure the geomembrane material meets the minimum project specifications.

5.4.1 Sampling Procedures

Prior to the panel fabrication or the installation, the Geosynthetic QAC may assign the appropriate conformance tests at the appropriate frequencies as applicable to the project. An independent third party shall perform in-plant sampling and conformance testing for the

Geosynthetic QAC prior to delivery of the geomembrane to the project site, the Geosynthetic QAC shall ensure that conformance test samples are obtained and tested. The Geosynthetic QAC shall review and approve the conformance test results prior to the material being shipped to the site.

5.4.2 Conformance Tests

At a minimum, the following conformance tests may be conducted:

1. Thickness (ASTM D5199).
2. Tensile Properties (ASTM D882).
3. Tear Strength (ASTM D1004).
3. Low Temperature Impact (ASTM D1790).
4. Dimensional Stability (ASTM D1204).
5. Specific Gravity (ASTM D792).
6. Hydrostatic Resistance (ASTM D751).
7. Volatile Loss (ASTM D1203).
8. Seam Strength (ASTM D7408).

Conformance testing may be performed at a minimum frequency of one test per 100,000 ft^2 of geomembrane unless otherwise specified.

5.4.3 Test Results

All conformance test results shall be reviewed and accepted or rejected by the Geosynthetic QAE prior to the deployment of the geomembrane. If the results of the conformance tests performed on the geomembrane do not meet or exceed the minimum values contained in the project specifications, the material shall be considered out-of-specification and rejected.

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the Manufacturer present during the testing. Alternatively, the Manufacturer may have the sample retested at two different, Owner-approved Geosynthetic QAL's. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted.

If a test result is in nonconformance, all material represented by the failing test should be considered out-of-specification and rejected. Alternatively, at the option of, and at no cost to, the Project Manager, an additional full suite of conformance tests may be performed to "bracket" the portion of the geomembrane not meeting the project specifications. This procedure is valid only when the nearest numbered rolls on each side of the non-conforming roll can be sampled and the extent of the non-conformance can be established. To isolate the out-of-specification material,

additional samples must be taken from rolls that have roll numbers immediately prior to and following the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot represented by the non-conforming roll shall be rejected or at the discretion of the Project Manager, the procedure may be repeated with two additional tests that bracket a greater number of rolls within the lot. The use of these procedures noted above for dealing with failed test results is subject to the approval of the Project Manager.

5.4.4 Transportation, Handling, and Storage

Transportation of the PVC geomembrane is the responsibility of the Manufacturer, the Installer, or other party as decided by the Owner. All handling on-site after unloading is the responsibility of the Installer. The CQA Monitor will observe the following with regard to the geomembrane:

1. Each factory fabricated PVC panel is labeled with an identification number and a batch (lot) number.
2. Geomembrane delivered to the site is free from defects and/or damage.
3. The geomembrane must have no striations, roughness, or bubbles on the surface.
4. The geomembrane must be free of holes, blisters, undispersed raw materials, or any other sign of contamination by foreign matter.
5. The adequacy of on-site handling of equipment to minimize risk of damage to both the geomembrane and underlying geosynthetic or subgrade materials.
6. The careful handling of the geomembrane by the Installer's personnel.

The CQA Monitor will indicate/report to the Owner any geomembrane or portions thereof, which in the opinion of the CQA Monitor should be rejected and removed from the site because of visually obvious flaws; or panels that include flaws, which may be not repairable.

The owner shall allocate sufficient space to store the geomembrane upon its arrival. The panels must be stored in their original unopened containers in a dry area protected from damage. Pallets shall be stored on a prepared level surface as close to the work area as possible. The pallets shall not be stacked.

The geomembrane shall be stored so as to be protected from puncture, dirt grease, water, moisture, mud, mechanical abrasions, excessive heat, extreme cold or other damage.

If the geomembrane will be installed at ambient temperatures below 60° F, provisions must be made to store the geomembrane in a heated area to maintain the material sheet temperature above 60° F.

5.5 SUBGRADE PREPARATION

5.5.1 Surface Preparation

The Earthwork Contractor shall be responsible for preparing and maintaining the underlying soil prior to and until the completion of the geomembrane installation.

Before the geomembrane installation begins, the Geosynthetic QAC shall verify that:

1. A licensed land surveyor has verified all lines, thicknesses and grades.
2. The underlying soil surface to be lined has been rolled, compacted, or hand-worked so as to be free of irregularities, protrusions, loose soil, and abrupt changes in grade.
3. The surface of the underlying soil has been prepared by the Earthwork Contractor by removing sharp stones, stones over 1.25cm (0.5 inches) in diameter, sticks and other debris that may be damaging to the geomembrane.
4. There is no area of standing water, excessively softened by high water content, mud, or snow.
5. There is no area where the underlying soil surface contains desiccation cracks that may damage the geomembrane.
6. The surface of the underlying soil is free from organic material.

The Installer shall certify that the surface on which the geomembrane will be installed is acceptable prior to and during installation. The Soil QAE must approve any deviation from the above requirements.

In situations where the geomembrane is to be installed at or below the current or possible groundwater elevation, the Owner is responsible for providing an adequate underdrain or dewatering system. It is the responsibility of the Designer to determine if the system is appropriate to suppress the groundwater for the duration of the project.

5.5.2 Anchor Trench

The Geosynthetic QAC shall verify:

1. The anchor trench has been constructed according to the project plans and specifications.
2. If the anchor trench is excavated in a clay material susceptible to desiccation, the amount of trench open at any time is minimized.
3. Rounded corners are provided in the trench so as to avoid sharp bends in the geomembrane.
4. Excessive amounts of loose soil are not allowed to underlie the geomembrane in the anchor trench.
5. The anchor trench is adequately drained to prevent ponding or softening of the adjacent soils while the trench is open.

6. The anchor trench is backfilled and compacted.

Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetic components.

5.6 GEOMEMBRANE DEPLOYMENT

5.6.1 Panel Identification

A panel is the unit area of geomembrane that is seamed in the field. The unit area can consist of a factory fabricated PVC panel or a portion of the fabricated panel cut in the field.

Prior to or during the preconstruction meeting, the Geomembrane Installer will provide the Owner and CQA Consultant with a drawing of the cell to be lined showing the orientation of the geomembrane panels. The Geosynthetic QAC will review the panel layout and document that it is consistent with the accepted state of practice.

Each panel will be given an "identification code" (number or letter-number) consistent with the layout plan. This identification code will be agreed upon by the Geomembrane Installer and the CQA Monitor. This identification code shall be simple and logical (note that roll numbers established in the manufacturing plant may be cumbersome and are unrelated to location in the field).

5.6.2 Panel Placement

On-site handling of the geomembrane shall be the responsibility of the installer. Appropriate handling equipment shall be used when loading or moving the pallets.

Pallet placement for deployment shall be performed by the installer. Placement of each pallet should be marked with survey flags, according to the project drawings. Pallet placement should be done only after the project area has been surveyed and inspected to assure conformance with the design and the installer and geosynthetic QAC have accepted the subgrade.

Any damage to the geomembrane occurring during placement shall be documented. If the damaged geomembrane cannot be satisfactorily repaired to comply with the project specifications, it will be removed from the work area and replaced with acceptable geomembrane material.

During the unfolding of the geomembrane, the Geosynthetic QAC will visually inspect each sheet. Damaged or suspect areas will be marked for testing and/or repair.

The number of panels to be deployed in any day shall be limited to the number of panels that can

be seamed that day. The geomembrane shall be placed over the prepared subgrade in such a manner as to assure minimal handling. The geomembrane shall be installed in a relaxed manner and shall be free of tension and stress. Stretching the geomembrane shall not be allowed.

The panels may be repositioned after deployment to meet the minimum overlap requirements, however, deployment and repositioning measures shall not involve dragging or elongating the geomembrane panels. When possible, the seam overlap should be in the predominant wind direction to reduce wind lift possibilities. However, the final seam overlap shall be in the down gradient direction.

Sandbags or other approved ballast shall be used to prevent bridging or material movement in areas such as toe of slope or near sumps. Ballast shall not be used to force the geomembrane in contact with the subgrade. Special care shall be taken to prevent tensile stress in the geomembrane and geomembrane seams in all corners and grade changes.

5.6.3 Installation:

The CQA Monitor will document that panel installation is consistent with regard to locations indicated in the Geomembrane Installer's layout plan, as approved or modified at the preconstruction meeting.

1. Only those panels that can be reasonably expected to be anchored or seamed together in one day are to be deployed. Panels may be installed using any of the following schedules:
2. All panels placed prior to field seaming;
3. Panels placed one at a time and each panel seamed immediately after its placement;
4. Any combination of the above.
5. The CQA Monitor will record the panel identification, location, and date of installation of each geomembrane panel.
6. In general vehicles shall not be allowed to drive on deployed geomembrane.. Any necessary vehicular traffic on the geomembrane shall be kept to a minimum. Only lightweight, rubber tired equipment such as a 4-wheel all terrain (ATV) may be allowed on deployed geomembrane or overlying geosynthetics only at the discretion of the QAC. In the event that lightweight rubber-tired equipment is allowed on the geomembrane, no sudden stops, starts, or turns will be allowed.

If a decision is reached to place multiple panels prior to field seaming, care should be taken to facilitate drainage in the event of precipitation so water is not accumulated under the liner. Scheduling installation decisions must be made during placement in accordance with varying weather conditions. The CQA Monitor will evaluate changes in the schedule proposed by the Installer and will advise the Owner and the Geosynthetic QAC. All parties shall agree upon acceptability of the proposed changes. The CQA Monitor shall also observe that the condition of the supporting soil has not changed detrimentally during installation.

5.6.4 Deployment Weather Conditions

Geomembrane deployment may proceed when ambient temperature and material sheet temperature are between 40°F and 105°F. Sheet temperature will be measured on the geomembrane surface by an infrared thermometer or surface contact thermometer.

Geomembrane deployment at ambient temperatures below 40°F will not be permitted without the approval of the Owner and the Geosynthetic QAC. Deployment of geomembrane at temperatures below 40°F must be done in accordance with a cold weather seaming plan that has been approved by the Geosynthetic QAC.

Geomembrane deployment shall not be done during any precipitation, in the presence of excess moisture, (e.g., snow, fog, rain, dew, mud) or in the presence of excess winds, or upon frozen subgrade, as determined by the Geosynthetic QAC.

5.7 FIELD SEAMING

5.7.1 Seam Layout

In general, seams should be oriented parallel to the line of maximum slope, thus, oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams shall be minimized. No horizontal seam should be less than 5 ft. (1.5 m) from the toe or crest of the slope, or areas of potential stress concentrations, unless otherwise authorized by the Project Manager.

The CQA Monitor shall use a seam numbering system compatible with the panel layout numbering system.

5.7.2 Accepted Seaming Methods

Approved processes for field production seaming for PVC geomembrane is dual track hot air or hot wedge fusion welding. Single track fusion seaming and chemical adhesive seaming of PVC may only be performed on repairs (e.g., capping, repairs) and short seam sections that are impractical to be dual track fusion welded.

5.7.2.1 Fusion Process

The Geosynthetic QAC shall log ambient temperature at appropriate intervals and report any noncompliance to the Project Manager. Seaming apparatus temperatures shall be logged for each trial weld.

The Geosynthetic QAC shall also verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatus.
2. Equipment used for seaming is not likely to damage the geomembrane.
3. A movable protective layer is used as required by the Installer directly below each overlap of geomembrane that is to be seamed to prevent buildup of moisture between the sheets and to prevent debris from collecting around the pressure rollers.
4. In general, the geomembrane panels are aligned to have an overlap of 4 to 6 inches for fusion welding. In any event, the final overlap shall be sufficient to allow destructive testing to be performed on the seam.
5. No solvent or adhesive is used except for repairing of short seam sections that are impractical to be fusion welded.
6. The geomembrane is protected from damage in heavy traffic areas.

5.7.3 Seam Preparation

The Geosynthetic QAC shall periodically verify that prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris or foreign material of any kind. The Geosynthetic Installer must ensure that the seaming operation is performed in a way that does not damage the geomembrane. The Geosynthetic Installer shall also verify that seams are aligned with the fewest possible number of wrinkles and "fishmouths".

5.7.4 Trial Seams

Trial seams shall be made on fragment pieces of geomembrane liner to verify that conditions are adequate for production seaming. Such trial seams shall be made at the beginning of each seaming period, and at an average of least once each four hours, for each production seaming apparatus (and combination of welder and seaming apparatus) used that day or significant changes in temperature. Trial seams shall be made under the same conditions as production seams.

Trial seam testing shall include testing three (3) samples for peel strength and three (3) sample for bonded shear strength. The specimens shall be tested in peel and in shear using a field tensiometer. The tensiometer shall be capable of maintaining a constant jaw separation rate of two to twenty inches per minute. All trial seam samples must meet the minimum strength values contained in the project specifications.

Definition of Pass/Fail Criteria for PVC

Peel - A passing trial seam test produced by fusion welding will be achieved in peel when strength equal to or greater than the minimum project specification values is achieved.

Shear - A passing trial seam test produced by fusion welding will be achieved in shear when strength equal to or greater than minimum project specification values is achieved.

If a specimen fails to meet or exceed the minimum strength requirements, the entire trial seam operation shall be repeated. If the additional specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved.

5.7.5 Seaming Weather Conditions

The typical weather conditions required for seaming are as follows:

1. No seaming shall be attempted above 105° F ambient air temperature or below 40° F ambient air temperature, without approval from the Geosynthetic QAC. Ambient temperature shall be measured approximately between 12 inches above the liner to waist high (approx. 3 ft.).
2. In all cases, the geomembrane shall be dry and protected from wind damage.
3. The CQA Monitor will observe that the seaming techniques appropriate for the prevailing weather conditions are employed and will advise the Owner of deviations. The final decision as to whether or not seaming may be performed shall be made by agreement between the Geosynthetic QAC and the Owner and in accordance with the project specifications and State requirements.
4. Seaming shall not be performed during any precipitation event unless the Installer erects satisfactory shelter to protect the geomembrane areas for seaming from water and/or moisture.
5. Seaming shall not be performed in areas where ponded water has collected below the surface of the geomembrane.

If the Installer wishes to use methods which may allow seaming at ambient temperatures below 40°F or above 105°F, the Installer will demonstrate and certify that the methods and techniques used to perform the seaming produce seams are entirely equivalent to seams produced at temperatures above 40°F and below 105°F, and that the overall quality of the geomembrane is not adversely affected.

The CQA Monitor will document the following items:

1. Ambient temperature at which seaming is performed.
2. Any precipitation events occurring at the site.

The Geosynthetic QAC shall inform the Owner if any of the weather condition requirements are not being fulfilled or inadequate seaming is apparent due to the weather conditions. The Owner or Geosynthetic QAC will stop or postpone the geomembrane seaming when conditions are unacceptable.

5.8 NONDESTRUCTIVE SEAM AND DEFECT REPAIR TESTING

The Geomembrane Installer will nondestructively test all field production seams over their full length for continuity. Continuity testing shall be performed using seam pressure tests for dual track fusion welded seams in accordance with ASTM D7177. Air lance testing shall be performed for chemical repairs (i.e., patches) and short lengths of seams that are deemed impractical by the QAC to be air pressure tested and single track welded seams as approved by the QAC and Owner. Continuity testing will be done as the seaming work progresses. Vacuum box testing shall not be performed on PVC geomembrane.

Seam Pressure Test Procedure:

1. The seam pressure test, in accordance with ASTM D7177, is designed to detect leaks in dual track thermally welded seams where an air chamber exists between the seams and to provide an indication of physical peel strength over 100 % of the seam being tested. After the seam has been fabricated for a given length, both ends of the air chamber are sealed. A needle attached to a pressure gauge/air valve assembly is inserted into the air chamber and air pressure is applied. The geomembrane sheet temperature and the gauge are monitored for drop in air pressure over time in accordance with the procedures outlined in ASTM D7177.

2. If failure occurs (i.e., pressure reduction over the scheduled time period is greater than the maximum allowable), the end seals will be checked and the seam retested. If failure recurs, the affected seam length will be visually observed to attempt to locate leaks. If leak areas are located, these areas will be patched and pressure tested on both sides of the patched area. The patched area will be air lance tested. This procedure will be repeated until 100 % of the seam being tested has passed minimum project specifications.

Air Lance Test Procedure:

The air lance testing equipment shall consist of an air lance that must be capable of supplying a minimum of 50 psi through a 3/16 diameter nozzle. The following procedures shall be followed:

1. Direct the air stream at the upper edge of the seam no more than 2 inches from the seam edge.
2. Any voids noted in the seam shall be marked, repaired and retested with the air lance.

All seams must be constructed in a fashion that allows non-destructive testing. Any patches, seams around liner penetrations, or seams near sharp corners must be capped or patched with geomembrane of sufficient size to allow non-destructive testing of all seams, patches or repairs.

The seam number, date of observation, name of tester, and outcome of the test or observation for all non-destructive testing will be recorded by the CQA Monitor.

5.9 DESTRUCTIVE SEAM TESTING

5.9.1 Locations and Frequency

Destructive testing will not be performed on dual track thermally-bonded seams that have been 100 % air pressure tested in accordance with ASTM D7177. However, at the discretion of the geosynthetic QA Monitor, full destructive samples may be obtained and destructively tested from any production seam as outlined in this section to verify the seaming quality.

In the event that an alternative field production seaming method to dual track fusion welding (e.g., single track) has been approved by the QAC and the Owner and is utilized, destructive testing protocol will be performed as outlined in this section.

The CQA Monitor will select the locations where seam samples are to be cut for laboratory testing. The sampling should be established as follows:

1. A minimum frequency of one test location per 500 feet of field seam length per welding machine and machine/welder combination is required. These frequencies are to be determined as an average taken throughout the entire geomembrane installation.
2. Additional test locations may be selected during seaming at the discretion of the CQA Monitor. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of inadequate welding.

5.9.2 Sampling Procedures

The Geomembrane Installer will not be informed in advance of the locations where the seam samples will be taken. Samples will be cut by the Geomembrane Installer as the seaming progresses in order to have laboratory test results before completion of liner installation.

The CQA Monitor will:

1. Observe sample cutting;
2. Assign a number to each sample and mark it accordingly;
3. Record the sample location on a layout drawing; and,

Holes in the geomembrane resulting from destructive seam sampling will be immediately repaired by the Geomembrane Installer in accordance with repair procedures described in

Section 5.10. The continuity of the new seams in the repaired area will be tested according to Section 5.8.

5.9.3 Size of Samples

The samples will be a minimum of 12 inches wide by approximately 36 inches long with the seam centered lengthwise. The sample will be cut into two parts and distributed as follows:

1. One portion for CQA Consultant for laboratory testing, 12 in. x 18 in.
2. One portion to the Owner for archive storage, 12 in. x 18. in.
3. Samples will be cut by the Geomembrane Installer at the locations designated by, and under the observation of, the CQA Monitor as the seaming progresses in order to obtain laboratory test results prior to completion of liner installation.

An additional sample may be obtained for the Installer if desired. The CQA Monitor will witness field tests and mark samples with their number. The CQA Monitor will also log the date, name of seamer, number of seaming unit, and pass or fail description of the test result.

5.9.4 Testing Requirements

Laboratory testing of seams will commence as soon as possible after the destructive seam samples are obtained. A minimum of five specimens should be tested each for shear and peel, for a total of ten destructive tests per destructive sample. The shear and peel testing of the seams should be conducted according to ASTM D7408.

5.9.5 Definition of Pass/Fail Criteria for PVC

Peel - A passing seam produced by fusion welding will be achieved in peel when strength equal to or greater than the minimum project specification values is achieved.

Shear - A passing seam produced by fusion welding will be achieved in shear when strength equal to or greater than minimum project specification values is achieved.

5.9.6 Procedures for Destructive Test Failure

The following procedures will apply whenever a sample fails a destructive test. The Geomembrane Installer has two options:

1. The Geomembrane Installer can cap strip the seam between any two passing destructive test locations. Cap-stripping involves applying a strip of geomembrane, a minimum distance of six inches on all sides of the defective seams, and seaming it to the sheet material.

2. The Geomembrane Installer can retrace the welding path to an intermediate location on both sides of the failed test location (10 ft. minimum from the location of the failed test) and take a 1 in wide die for an additional field test at each location. If these additional samples pass the test, then full specimens shall be obtained and laboratory tested. If these samples pass, then the seam is repaired between these locations. If either of these samples fail, then the process is repeated to establish the zone in which the seam should be repaired.

In any case, all acceptable reconstructed seams must be bound by two passing test locations, (i.e., the above procedure should be followed in both directions from the original failed location), and, where applicable, one test must be taken within the reconstructed area if the failed seam length exceeds 150 lineal feet.

The CQA Monitor will observe and note actions taken in conjunction with destructive test failures.

5.10 REPAIR PROCEDURES

Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test shall be repaired. Repair procedures should be agreed upon between the Owner, the Geomembrane Installer, and the Geosynthetic QAC. Unless otherwise agreed, the repair procedures will be as follows:

1. Defective seams will be repaired by reconstruction or capping.
2. Tears or holes will be repaired by patching.
3. Pinholes will be repaired by patching.
4. Blisters, larger holes, undispersed raw materials, and contamination by foreign matter will be repaired by patching.

Patches shall be round or oval in shape, made of the same material as the geomembrane, and extend a minimum of six inches beyond all edges of the defect. Patches will be applied using the approved method as required in the specifications. No patches shall have a radius of less than 3 inches

All repairs, either patches or seams, made in repairing defects will be subjected to the nondestructive test procedures as outlined in Section 5.8.

5.10.1 Seam Reconstruction Procedures

Unacceptable seam sections that need repair shall be reconstructed by either removing the defective portion of seam, repositioning the panels and re-seaming or cap stripping with the same geomembrane material. Cap stripping shall consist of applying a strip of geomembrane a minimum distance of six inches on all sides of the defective portion of seam, and welding it to the sheet material using chemical adhesion. In general, seam reconstruction using chemical

adhesion shall be performed only on short sections of seams where it is impractical to reposition panels and/or use fusion welding for the reconstruction. Regardless, the method of seam reconstruction to be performed must be approved by the geosynthetic CQA Monitor.

Each repair will be nondestructively tested using the methods described in Section 5.8, as appropriate. Repairs, which pass the non-destructive test, will be taken as an indication of an adequate repair. Repairs, which fail, will be redone and retested until a passing test is achieved. The CQA Monitor will observe all non-destructive testing of repairs.

5.11 GEOMEMBRANE PROTECTION

The quality assurance procedures indicated in this Section are intended only to assure that the installation of adjacent materials does not damage the geomembrane.

5.11.1 Vegetative Layer

The Geosynthetic QAE shall verify that these project specifications are consistent with geosynthetic state-of-practice such as:

1. Placement of vegetative layer materials on PVC geomembrane shall be limited to ambient temperatures ranging between 40°F (0°C) and 105°F (41°C) unless otherwise specified.
2. Equipment used for placing vegetative material shall not be driven directly on the geomembrane.
3. A minimum thickness of 1 ft. of vegetative material is specified between a low ground pressure dozer (maximum contact pressure of 8 lb/sq inch) and the geomembrane.
4. In any areas traversed by heavy construction, any vehicles other than low ground pressure vehicles approved by the Project Manager, the vegetative layer material shall have a minimum thickness of 3 ft. This requirement may be waived if provisions are made to protect the geomembrane through an engineered design. Drivers shall proceed with caution when on the overlying drainage material and prevent spinning of tires, sharp turns and quick starts or stops.

The Geosynthetic QAC shall observe the vegetative layer thickness or review vegetative layer thickness data provided by the project surveyor and verify that the required thickness is present. The Geosynthetic QAC must also verify that final thickness is consistent with the design and verify that placement of the vegetative layer is done in such a manner that geomembrane damage is unlikely.

6.0 POLYETHYLENE GEOMEMBRANES

6.1 DESCRIPTION AND APPLICABILITY

Geomembranes are low permeability geosynthetic barriers used in lining systems. This Section is particularly applicable to smooth and textured polyethylene geomembranes including high-density (HDPE, 60-mil) and linear low-density (LLDPE, 40-mil).

6.2 MANUFACTURING PLANT INSPECTION

The Project Manager, or his designated representative, may visit the manufacturing plant for a project-specific inspection if deemed necessary.

6.3 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geomembrane, the Manufacturer or Installer shall provide the Project Manager with the following information:

1. The origin (supplier's name and production plant) and identification (brand name and number) of the resin used to manufacture the geomembrane.
2. Copies of dated quality control certificates issued by the resin supplier.
3. Results of tests conducted by the Manufacturer to verify that the resin used to manufacture the geomembrane meets the project specifications.
4. A statement indicating that the amount of reclaimed polymer added to the resin during manufacturing was done with appropriate cleanliness.
5. A specification for the geomembrane that includes all properties contained in the project specifications measured using the appropriate test methods.
6. Quality control certificates, signed by a responsible party employed by the Manufacturer. Each quality control certificate shall include roll identification numbers, testing procedures, and results of quality control tests. The test types and frequencies shall meet the requirements of the Geosynthetic Institute's GRI GM13 and GRI GM17. At a minimum, results shall be given for:

    a. Density (ASTM D1505).
    b. Carbon black content (ASTM D1603).
    c. Carbon black dispersion (ASTM D5596).
    d. Thickness (ASTM D5199 for smooth geomembrane and D5994 for textured).
    e. Tensile properties (ASTM D6693 - tensile strength at break and yield, elongation at break and yield).
    f. Puncture resistance (ASTM D4833).
    g. Melt flow index (ASTM D1238).

h. 2% modulus – secant (ASTM D5323 for LLDPE).
i. Axi-symetric break resistance (ASTM D5617 for LLDPE).
j. Stress Crack Resistance (ASTM D 5397 for HDPE).
k. Oxidative induction time (OIT) (ASTM D5885/D3895).
l. UV resistance (ASTM D7238).
m. Tear resistance (ASTM D1004).
n. Asperity Height for textured (ASTM D7466).

All quality control testing shall be performed in accordance the appropriate industry standard test method. Tensile properties, density, tear resistance, puncture resistance, carbon black content and carbon black dispersion shall be performed at a frequency of not less than one test per 50,000 ft^2 of material produced. 2% modulus, axi-symetric break resistance, oven aging and UV resistance results shall be reported once for each formulation. Oxidative induction time shall be performed for each 200,000 lbs of material produced.

~~7. Results of environmental stress crack resistance tests (ASTM D1693). At a minimum, tests shall be performed once every resin batch.~~

If the results contained in the manufacturer's certifications do not meet or exceed the values contained in the project specifications, the material shall be considered out-of-specification and rejected.

The Manufacturer shall identify all rolls of geomembranes with the following:

1. Manufacturer's name
2. Product identification
3. Thickness
4. Roll number
5. Roll dimensions

6.4 CONFORMANCE TESTING

6.4.1 Sampling Procedures

An independent third party may perform in-plant sampling and conformance testing for the Geosynthetic QAC or upon delivery of the rolls of the geomembrane to the project site, the Geosynthetic QAC shall ensure that conformance test samples are obtained.

At a minimum, samples shall be taken at a rate of one per resin batch and not less than one per 50,000 ft^2 of geomembrane. These samples shall be forwarded to the Geosynthetic QAL for testing.

6.4.2 Conformance Tests

The following conformance tests shall be conducted:

1. Thickness (ASTM D5199 for smooth geomembrane and D5994 for textured).
2. Tensile properties (ASTM D638).
3. Carbon black content (ASTM D4218).
4. Carbon black dispersion (ASTM D5596).
5. Density (ASTM D1505).
6. Puncture Resistance (ASTM D4833).
7. Tear resistance (ASTM D1004).
8. Asperity Height for textured (ASTM D7466).

Conformance testing shall be performed at a frequency of one test per 50,000 ft^2 of geomembrane, except for thickness (which shall be performed in the field at a frequency of five per roll of geomembrane) and except for density, puncture resistance and tear resistance (which shall be performed at a frequency of one test per 250,000 ft^2). The thickness tests shall be performed at either the leading edge or the trailing edge of the roll at locations distributed across the width of the roll. Additional thickness tests will be taken across the width of cut or partial rolls, at the discretion of the geomembrane QAC.

6.4.3 Test Results

All conformance test results shall be reviewed and accepted or rejected by the Geosynthetic QAE prior to the deployment of the geomembrane. If the results of the conformance tests performed on the geomembrane do not meet or exceed the minimum values contained in the project specifications, the material shall be considered out-of-specification and rejected.

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the Manufacturer present during the testing. Alternatively, the Manufacturer may have the sample retested at two different, Owner-approved Geosynthetic QAL's. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted.

If a test result is in nonconformance, all material from the resin batch represented by the failing test should be considered out-of-specification and rejected. Alternatively, at the option of the Project Manager, additional conformance test samples may be taken to "bracket" the portion of the resin batch not meeting the project specification. This procedure is valid only when all rolls in the resin batch are consecutively produced and numbered from one manufacturing line. To isolate the out-of-specification material, additional samples must be taken from rolls that have roll numbers immediately prior to and following the roll that was sampled and failed. If both

additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire resin batch shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the resin batch. The use of the above noted procedures for dealing with failed test results is subject to the approval of the Project Manager.

6.5 SUBGRADE PREPARATION

6.5.1 Surface Preparation

The Earthwork Contractor shall be responsible for preparing and maintaining the underlying soil prior to and until the completion of the geomembrane installation.

Before the geomembrane installation begins, the Geosynthetic QAC shall verify that:

1. A licensed land surveyor has verified all lines, thicknesses and grades.
2. The underlying soil surface to be lined has been rolled, compacted, or hand-worked so as to be free of irregularities, protrusions, loose soil, and abrupt changes in grade.
3. The surface of the underlying soil has been prepared by the Earthwork Contractor by removing sharp stones, stones over 1.25cm (0.5 inches) in diameter, sticks and other debris that may be damaging to the geomembrane.
4. There is no area of standing water, excessively softened by high water content, mud, or snow.
5. There is no area where the underlying soil surface contains desiccation cracks that may damage the geomembrane.
6. The surface of the underlying soil is free from organic material.

The Installer shall certify that the surface on which the geomembrane will be installed is acceptable prior to and during installation. The Soil QAE must approve any deviation from the above requirements.

In situations where the geomembrane is to be installed at or below the current or possible groundwater elevation, the Owner is responsible for providing an adequate underdrain or dewatering system. It is the responsibility of the Designer to determine if the system is appropriate to suppress the groundwater for the duration of the project.

6.5.2 Anchor Trench

The Geosynthetic QAC shall verify:

1. The anchor trench has been constructed according to the project plans and specifications.

2. If the anchor trench is excavated in a clay material susceptible to desiccation, the amount of trench open at any time is minimized.
3. Rounded corners are provided in the trench so as to avoid sharp bends in the geomembrane.
4. Excessive amounts of loose soil are not allowed to underlie the geomembrane in the anchor trench.
5. The anchor trench is adequately drained to prevent ponding or softening of the adjacent soils while the trench is open.
6. The anchor trench is backfilled and compacted.

Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetic components.

6.6 GEOMEMBRANE DEPLOYMENT

6.6.1 Panel Nomenclature

A field panel is defined as a unit of geomembrane that is to be seamed in the field. The Geosynthetic QAC shall be responsible to ensure that each field panel is given an identification code (number or letter-number) consistent with the layout plan.

6.6.2 Deployment Weather Conditions

Geomembrane deployment shall not be undertaken if weather conditions will preclude material seaming following deployment. This Section applies particularly to HDPE and LLDPE geomembranes.

The normal required weather conditions for seaming are as follows:

1. Ambient temperature between 32°F (0°C) and 120°F (49°C).
2. Dry conditions (no precipitation or other excessive moisture)
3. No excessive winds (not more than 20 mph or as approved by the QAE or Project Manager).
4. Geomembrane sheet temperature between 32° (0°C) and 158°F (70°C).

The Geosynthetic QAC shall inform the Project Manager of any weather-related problems that may not allow geomembrane placement to proceed. The Project Manager will determine if the installation is to be stopped or special procedures are to be used.

6.6.3 Method of Deployment

The Geosynthetic QAC shall ensure that the storage conditions and handling procedures meet the

Manufacturer's recommendations. This includes recommendations for wrapping and sheltering requirements, and storage of the geomembrane to prevent damage from accidental puncture or cutting.

The Geosynthetic QAC shall verify the following:

1. The geosynthetic QAC shall ensure that the equipment used to handle the geomembrane has the capacity to safely lift the geomembrane and will not damage the material during lifting and handling. During handling, the Geosynthetic QAC shall procedurally observe that the Installer's personnel handle the geomembrane with care.
2. The prepared surface underlying the geomembrane is acceptable prior to and during geomembrane installation.
3. Geosynthetic or soil elements immediately underlying the geomembrane are clean and free of debris.
4. Personnel do not smoke or wear damaging shoes while working on the geomembrane, or engage in other activities that could damage the geomembrane.
5. Before deployment begins on a given day, installers have the correct equipment to deploy the geomembrane, including pliers with grippers to avoid cutting handholes in the geomembrane when deploying.
6. Before deployment begins on a given day, adequate temporary loading and/or anchoring materials are available in the area where geomembrane is to be installed that day. Materials used shall not damage the geomembrane, such as sand bags or tires.
7. The method used to place the panels minimizes wrinkles especially differential wrinkles between adjacent panels.
8. The geomembrane is loaded sufficiently with anchoring materials as it is being deployed to prevent uplift by wind. In case of high winds, continuous loading is recommended along edges of panels to minimize risk of wind flow under the panels.
9. If the geomembrane is moved by wind and becomes folded, no equipment drives on the folded portions of the geomembrane. If the folded geomembrane is to be redeployed, the Geosynthetic QAC shall verify that the geomembrane still meets the project specifications.
10. The method used to unroll and deploy the panels does not cause excessive scratches or crimps in the geomembrane and does not damage the supporting soil.
11. Sufficient slack exists in the geomembrane to prevent trampolining (lifting of the geomembrane off of the subgrade) and tensile stresses in the geomembrane due to thermal contraction.
12. Direct contact with the geomembrane is minimized, and the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected.

6.6.4 Damage and Defects

Upon delivery to the site, the Geosynthetic QAC shall conduct a surface observation of all rolls for defects, lack of uniformity, damage, imperfections, tears, punctures, blisters and excessive folding. This examination shall be conducted without unrolling rolls unless defects or damages

are found or suspected.

The Geosynthetic QAC shall examine each panel, after placement for damage and/or defects. The Geosynthetic QAC shall advise the Project Manager which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels, or portions of damaged panels, which have been rejected shall be marked and their removal from the work area recorded by the Geosynthetic QAC.

6.6.5 Writing on the Liner

To avoid confusion, the Installer and the Geosynthetic QAC shall each use different colored markers that are readily visible for writing on the geomembrane. The markers used must be semi-permanent and compatible with the geomembrane.

6.7 FIELD SEAMING

6.7.1 Seam Layout

In general, seams should be oriented parallel to the line of maximum slope, thus, oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. Adjacent roll end or "butt seams" on slopes shall be staggered a minimum of 5 ft. No horizontal seam should be less than 5 ft. (1.5 m) from the toe or crest of the slope, or areas of potential stress concentrations, unless otherwise authorized by the Project Manager.

6.7.2 Accepted Seaming Methods

Approved processes for field seaming are dual track fusion welding and extrusion welding. Proposed alternate processes shall be documented and submitted by the Installer to the Project Manager for approval.

6.7.2.1 Fusion Process –

The Geosynthetic QAC shall log ambient temperature at appropriate intervals and report any noncompliance to the Project Manager. Seaming apparatus temperatures shall be logged for each trial weld.

The Geosynthetic QAC shall also verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatus.
2. Equipment used for seaming is not likely to damage the geomembrane.
3. A movable protective layer is used as required by the Installer directly below each overlap of

geomembrane that is to be seamed to prevent buildup of moisture between the sheets and to prevent debris from collecting around the pressure rollers.

4. In general, the geomembrane panels are aligned to have an overlap of 4 to 6 inches for fusion welding. In any event, the final overlap shall be sufficient to allow destructive testing to be performed on the seam.
5. No solvent or adhesive is used.
6. The geomembrane is protected from damage in heavy traffic areas.

6.7.2.2 Extrusion Process –

The Geosynthetic QAC shall log ambient temperature at appropriate intervals and report any noncompliance to the Project Manager. Seaming apparatus temperatures shall be logged for each trial weld.

The Geosynthetic QAC shall verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatus.
2. Equipment used for seaming is not likely to damage the geomembrane.
3. Prior to beginning a seam, the extruder is purged until all heat-degraded extrudate has been removed from the barrel.
4. Clean and dry welding rods or extrudate pellets are used.
5. Grinding is completed no more than one hour prior to seaming.
6. The geomembrane is protected from damage in heavy traffic area.
7. Exposed grinding marks adjacent to an extrusion weld shall be minimized. In no instance shall exposed grinding marks extend beyond the finished seamed area.
8. In general, the geomembrane panels are aligned to have a nominal overlap of at least 3 inches for extrusion welding. In any event, the final overlap shall be sufficient to allow destructive testing to be performed on the seam.
9. No solvent or adhesive is used.
10. The procedure used to temporarily bond adjacent panels together does not damage the geomembrane; in particular, the temperature of hot air at the nozzle of any temporary welding apparatus is controlled such that the geomembrane is not damaged.

6.7.3 Seam Preparation

The Geosynthetic QAC shall periodically verify that prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris or foreign material of any kind. If seam overlap grinding is required, the Geosynthetic QAC must ensure that the process is completed according to the Manufacturer's instructions within one hour of the seaming operation, and in a way that does not damage the geomembrane. The Geosynthetic QAC shall also verify that seams are aligned with the fewest possible number of wrinkles and "fishmouths".

6.7.4 Trial Seams

Trial seams shall be made on fragment pieces of geomembrane liner to verify that conditions are adequate for production seaming. Such trial seams shall be made at the beginning of each seaming period, and at an average of least once each four hours of continuous seaming operation, for each production seaming apparatus (and combination of welder and seaming apparatus) used that day or significant changes in temperature. Trial seams shall be made under the same conditions as production seams.

Trial seam testing shall include testing three (3) samples for peel strength and three (3) samples for shear strength. The specimens shall be tested in peel and in shear using a field tensiometer. The tensiometer shall be capable of maintaining a constant jaw separation rate of two inches per minute. All trial seam samples must meet the minimum strength values contained in the project specifications and the failure mode must be a film tear bond (FTB). If a specimen fails to meet or exceed the minimum strength requirements or is a non-film tear bond failure, the entire trial seam operation shall be repeated. If the additional specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved.

6.7.5 General Seaming Procedures

During general seaming, the Geosynthetic QAC shall ensure the following:

1. Fishmouths or wrinkles shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 inches beyond the cut in all directions.
2. If seaming operations are carried out at night, adequate illumination shall be provided.
3. Seaming shall extend to the outside edge of panels placed in the anchor trench.
4. All cross seam tees should be extrusion welded to a minimum distance of 4 inches on each side of the tee.
5. A firm substrate may be required to be provided by using a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support.

6.7.6 Seaming Weather Conditions

6.7.6.1 Cold Weather Conditions

To ensure a quality installation, if seaming is conducted when the ambient temperature or the geomembrane sheet temperature is below 32°F (0°C), the following conditions shall be met:

1. Geomembrane surface temperatures may be determined by the Geosynthetic QAC at

intervals of at least once per 100 feet of seam length to determine if preheating is required. For extrusion welding, preheating may be required if the surface temperature of the geomembrane is below 32°F.

2. For fusion welding, preheating may be waived by the Project Manager based on a recommendation from the Geosynthetic QAE, if the Installer demonstrates to the Geosynthetic QAE's satisfaction that welds of equivalent quality may be obtained without preheating at the expected temperature of installation.
3. If preheating is required, the Geosynthetic QAC shall periodically observe areas of geomembrane that have been preheated prior to seaming, to ensure that they have not been overheated.
4. Care shall be taken to confirm that the surface temperatures are not lowered below the minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for the seam area.
5. All preheating devices shall be approved prior to use by the Project Manager.
6. Additional destructive tests may be taken at intervals less than 400 feet (extrusion) and 500 feet (fusion) of seam length, at the discretion of the Geosynthetic QAE.
7. Sheet grinding may be performed before preheating, if applicable.
8. Trial seaming shall be conducted under the same ambient temperature and preheating conditions as the production seams. Under cold weather conditions, new trial seams shall be conducted if the ambient temperature fluctuates by more than 10°F higher or lower the initial trial seam test conditions. Such new trial seams shall be conducted upon completion of seams in progress during temperature drop.

6.7.6.2 Warm Weather Conditions

At ambient temperatures above 120°F or geomembrane sheet temperatures above 158°F, no seaming of the geomembrane shall be permitted unless the Installer can demonstrate to the satisfaction of the Project Manager that geomembrane seam quality is not compromised.

6.8 NONDESTRUCTIVE SEAM TESTING

6.8.1 Concept

The Installer shall nondestructively test all field seams over their full length using an air pressure test (for dual track fusion seams only), a vacuum test or other approved method. Any seams that cannot be nondestructively tested shall be overlain with geomembrane material of identical type. At locations where it is not physically possible to overlay the untested seam/repair with geomembrane material of identical type, an additional extrusion weld "double bead" shall be applied and the area visually inspected by the Geosynthetic QAC to verify the application of the double bead. The application of a "double bead" must be approved by the Geosynthetic QAC.

6.8.2 Air Pressure Testing

Air pressure testing is applicable to dual track fusion welding which produces a double seam with an enclosed space.

1. The equipment for air pressure testing shall consist of the following:

   a. An air pump (manual or motor driven), equipped with pressure gauge and capable of generating and sustaining a pressure range as required by the project specifications and mounted on a cushion to protect the geomembrane.
   b. A rubber hose with fittings and connections.
   c. A sharp hollow needle, or other pressure feed device, approved by Project Manager.

2. The following procedures shall be followed:

   a. Seal both ends of the seam to be tested.
   b. Insert needle or other approved pressure feed device into the air channel created by the fusion weld.
   c. Pressurize the air channel within a pressure range in accordance with the project specifications. Close valve, allow 2 minutes for pressure to stabilize, and sustain pressure for the dwell time as required by the project specifications.
   d. If loss of pressure exceeds the maximum permissible pressure differential within the specified dwell time as required by the project specifications, or does not stabilize, locate faulty area and repair.
   e. Cut opposite end of tested seam area once testing is completed to verify continuity of the air channel. If air does not escape, locate blockage and retest unpressurized area. Seam the cut end of the air channel.
   f. Remove needle or other approved pressure feed device and seal the hole in the geomembrane.

6.8.3 Vacuum Testing

Vacuum testing is applicable to extrusion welding.

1. The equipment shall consist of the following:

   a. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, a porthole or valve assembly, and a vacuum gauge.
   b. A pump assembly equipped with a pressure controller and pipe connections.
   c. A rubber pressure/vacuum hose with fittings and connections.
   d. A soapy solution. (Geosynthetic QAC shall ensure solution makes bubbles when air is passed through.)

e. A bucket and wide paint brush, or other means of applying the soapy solution.

2. The following procedures shall be followed:

   a. Wet a strip of geomembrane approximately 12 in x 48 in with the soapy solution.
   b. Place the box over the wetted area.
   c. Close the bleed valve and open the vacuum valve.
   d. Ensure that a leak-tight seal is created.
   e. Energize the vacuum pump and reduce the applied pressure to approximately 5 psi gauge.
   f. For a minimum of 10 seconds, apply vacuum with the box placed and maintaining a seal, examine the geomembrane through the viewing window for the presence of soap bubbles.
   g. If no bubble appears after 10 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in overlap, and repeat the process.
   h. All areas where soap bubbles appear shall be marked and repaired.

6.8.4 Test Failure Procedures

The Installer shall complete any required repairs.

6.9 DESTRUCTIVE SEAM TESTING

6.9.1 Concept

The purpose of destructive tests is to evaluate seam strength. Destructive seam tests shall be performed at selected locations. Seam strength testing shall be done as the seaming work progresses, not at the completion of all field seaming.

6.9.2 Location and Frequency

The Geosynthetic QAC shall select where seam samples will be cut out for testing. The frequency and locations shall be established as follows:

1. A minimum frequency of one test location per 500 ft. of fusion seam length and one test location per 400 ft. of extrusion seam length performed by each welding machine. These frequencies are to be determined as an average taken throughout the entire facility. Additionally, a minimum of one test for each welding machine and machine/welder combination is required.
2. Test locations shall be determined during seaming at the Geosynthetic QAC's discretion. Special consideration shall be given to locations where the potential for imperfect welding, such as overheating, contamination, offset welds exists.

3. In general, no destructive seam testing shall be performed on seam repair welds or patch repair welds. However, reconstructed seam lengths or repairs that have been repaired by "capping" or overlaying the original seam with identical geomembrane material requiring over 150 linear feet of welding shall require destructive test sampling.

The Installer shall not be informed in advance of the locations where the seam samples will be taken.

6.9.3 Sampling Procedures

Samples shall be cut by the Installer at locations chosen by the Geosynthetic QAC as the seaming progresses so that test results are available before the geomembrane is covered by another material. One sample shall be taken at each location for immediate use in destructive testing by the Geosynthetic QAC. The Geosynthetic QAC shall:

1. Observe sample cutting.
2. Assign a number to each sample, and mark it accordingly.
3. Record sample location on layout drawing.

All holes in the geomembrane resulting from destructive seam sampling shall be repaired immediately following receipt of successful test results. The continuity of the new seams in the repaired area shall be tested.

6.9.4 Destructive Testing

Destructive test samples shall be tested on-site by the Geosynthetic QAC or shall be packaged and shipped to the QAL, if necessary, under the responsibility of the Geosynthetic QAC in a manner that will not damage the test sample.

Testing shall include seam shear strength and peel adhesion (ASTM D6392). At least 5 specimens shall be tested, each in both shear and peel. Specimens shall be selected alternately by test from the samples (i.e., peel, shear, peel, shear). A passing test must meet the minimum acceptable project specification values in at least 4 of the 5 specimens tested for each method. Additionally, a "non-film tear bond" or non-FTB shall be recorded as a failing test result.

6.9.5 Destructive Test Failure

When a sample fails a destructive test, whether that test is conducted by the Geosynthetic QAL or by field tensiometer, the Installer has two options:

1. The Installer can repair the seam between any two passing destructive test locations.
2. The Installer can trace the welding path to an intermediate location 10 ft. minimum from the

point of the failed test in each direction and take a sample with a 1 in wide die for an additional field test at each location. If these additional samples pass the test, then full samples are taken. If these samples pass the tests, then the seam is repaired between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be repaired.

All acceptable repaired seams shall be bound by two locations from which samples passing destructive tests have been taken. Reconstructed seam lengths or repairs that have been repaired by "capping" or overlaying the failed seam/repair with identical geomembrane material requiring over 150 linear feet of welding must also pass destructive testing. No destructive tests shall be attempted on extruded repairs of "zipped" fusion welds. Any seams that have been reconstructed in this manner shall, however, pass subsequent non-destructive testing (e.g., vacuum test).

6.10 DEFECTS AND REPAIRS

6.10.1 Identification

All seams and non-seam areas of the geomembrane shall be examined by the Geosynthetic QAC for defects, holes, blisters, undispersed raw materials, large wrinkles and any sign of contamination by foreign matter.

6.10.2 Evaluation

Each suspect location both in seam and non-seam areas shall be nondestructively tested. Each location that fails the nondestructive testing shall be marked by the Geosynthetic QAC and repaired by the Installer. Work shall not proceed with any materials that will cover locations that have been repaired until successful nondestructive tests are obtained.

When seaming of the geomembrane is completed, and prior to placing overlying materials, the Geosynthetic QAC shall indicate to the Project Manager any large wrinkles that should be cut and repaired by the Installer. The number of wrinkles to be repaired should be kept to an absolute minimum. Therefore, wrinkles should be located/repaired during the coldest part of the installation period, while keeping in mind the forecasted weather to which the uncovered geomembrane may be exposed. Wrinkles are considered to be large when the geomembrane can be folded over on to itself, which is generally a wrinkle that extends about 12 inches from the subgrade. Seams produced while repairing wrinkles shall be nondestructively tested.

6.10.3 Repair Procedures

Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to

the appropriate repair procedure shall be agreed upon between the Project Manager, Installer, Designer, and Geosynthetic QAC.

1. The repair procedures available include:

   a. Patching, used to repair holes, tears, undispersed raw materials, and contamination by foreign matter.
   b. Spot-welding used to repair pinholes, or other minor, localized flaws.
   c. Capping, used to repair large lengths of failed seams.
   d. Extrusion welding the flap, used to repair areas of inadequate fusion seams which have an exposed edge and sufficient underlying overlap. Repairs of this type shall be approved by the Geosynthetic QAC.
   e. Removing bad seam and relocating the panel or replacing with a strip of new material welded into place.

2. For any repair method, the following provisions shall be satisfied:

   a. Surfaces of the geomembrane that are to be repaired using extrusion methods shall be ground no more than one hour prior to the repair.
   b. All surfaces shall be clean and dry at the time of the repair.
   c. All seaming equipment used in repairing procedures shall meet the requirements of the project specifications.
   d. Patches or caps shall extend at least 6 inches (150 mm) beyond the edge of the defect, and all corners of patches shall be rounded with a radius of approximately 3 inches (75 mm) or greater.

6.10.4 Repair Verification

The Geosynthetic QAC shall observe all nondestructive testing of repairs and shall record the number of each repair, date and test outcome. Each repair shall be nondestructively tested as appropriate. Repairs that pass the nondestructive test shall be taken as an indication of an adequate repair. Failed tests require that the repair shall be redone and retested until a passing test result is achieved. Repairs that have been completed by "capping" or overlaying the defective area with identical geomembrane material requiring over 150 linear feet of welding shall require destructive test sampling. No destructive testing shall be attempted on extruded repairs of "zipped" fusion welds.

6.11 GEOMEMBRANE PROTECTION

The quality assurance procedures indicated in this Section are intended only to assure that the installation of adjacent materials does not damage the geomembrane.

6.11.1 Vegetative Layer

The Geosynthetic QAE shall verify that these project specifications are consistent with geosynthetic state-of-practice such as:

1. Placement of vegetative layer materials on the geomembrane shall be limited to ambient temperatures ranging between 32°F (0°C) and 120°F (41°C) unless otherwise specified.
2. Equipment used for placing vegetative material shall not be driven directly on the geomembrane.
3. A minimum thickness of 1 ft. of vegetative material is specified between a low ground pressure dozer (maximum contact pressure of 8 lb/sq inch) and the geomembrane.
4. In any areas traversed by heavy construction, any vehicles other than low ground pressure vehicles approved by the Project Manager, the vegetative layer material shall have a minimum thickness of 3 ft. This requirement may be waived if provisions are made to protect the geomembrane through an engineered design. Drivers shall proceed with caution when on the overlying drainage material and prevent spinning of tires, sharp turns and quick starts or stops.

The Geosynthetic QAC shall observe the vegetative layer thickness or review vegetative layer thickness data provided by the project surveyor and verify that the required thickness is present. The Geosynthetic QAC must also verify that final thickness is consistent with the design and verify that placement of the vegetative layer is done in such a manner that geomembrane damage is unlikely.

7.0 GEOTEXTILES

7.1 DEFINITION AND APPLICABILITY

In the event that Option 2 is selected as the final cover system, a cushion geotextile will be utilized to help protect the geomembrane during installation of the vegetative soils. This Section is applicable to non-woven geotextiles made of polypropylene.

7.2 MANUFACTURING PLANT INSPECTION

The Project Manager, or his designated representative, may visit the manufacturing plant for a project-specific inspection if deemed necessary.

7.3 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geotextile, the Manufacturer or Installer shall provide the Project Manager or the Quality Assurance Engineer with the following information:

1. Reports on quality control tests conducted by the Manufacturer to verify that the geotextile manufactured for the project meets the project specifications.
2. Provide written confirmation for the geotextile that includes all properties, measured using the appropriate test methods, contained in the project specifications for geotextiles.
3. Quality control certificates, presented by the Manufacturer. The quality control certificates shall include roll identification numbers, testing procedures and results of quality control tests.

At a minimum, results shall be given for:

1. Mass per unit area (ASTM D5261).
2. Grab strength (ASTM D4632).
3. Trapezoidal tear strength (ASTM D4533).
4 Puncture strength (ASTM D4833).
5. Permittivity (ASTM D4491).
6. Apparent Opening Size (ASTM D4451).
7. UV Resistance
~~4. Burst strength (ASTM D3786).~~

These quality control tests shall be performed in accordance with the test methods for at least once per lot for UV Resistance and every 100,000 ft^2 of geotextile produced for all other tests. If the results contained in the manufacturer's certifications do not meet or exceed the minimum values contained in the project specifications, the material shall be considered out-of-specification and shall be rejected.

The Manufacturer shall identify all rolls of geotextiles with the following:

1. Manufacturer's name
2. Product identification
3. Roll number
4. Roll dimensions

7.4 CONFORMANCE TESTING

Conformance testing is not required for geotextile materials.

7.5 GEOTEXTILE DEPLOYMENT

During shipment and storage, the geotextile shall be protected from ultraviolet light exposure, moisture, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

The Geosynthetic QAC shall observe the materials once delivered to the site. Any apparently damaged or improperly wrapped rolls shall be reported to the Project Manager.

The Installer shall ensure that geotextiles are not damaged during handling. The geotextile shall be deployed as described below:

1. On slopes, the geotextiles shall be securely anchored and then rolled down the slope in such a manner as to continually keep the geotextile sheet in tension.
2. In the presence of wind, all geotextiles shall be weighted with sandbags or the equivalent. Such sand bags shall be installed during deployment and shall remain until replaced with cover material.
3. Geotextiles shall be cut using a geotextile cutter (hook blade) only. If in place, special care shall be taken to protect other materials from damage that could be caused by the cutting of the geotextiles.
4. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geotextile.
5. During placement of geotextiles, care shall be taken not to entrap, in or beneath the geotextile, stones or other material that could damage the geomembrane, cause clogging of drains or filters, or hamper subsequent seaming.
6. A visual examination of the geotextile shall be carried out over the entire surface, either during or after installation, to ensure that no potentially harmful foreign objects are present.

The Geosynthetic QAC shall note any observed noncompliance and report it to the Project Manager.

7.6 SEAMING PROCEDURES

Geotextiles shall be overlapped a minimum of 3 inches prior to seaming. In general, no horizontal seams shall be allowed on side slopes (seams along, not across, the slope) except as part of a patch. When horizontal seams on slopes are necessary, adjacent seams shall be staggered a minimum of 5 ft. horizontally.

All geotextiles shall be continuously sewn. Spot sewing is not allowed. Sewing shall be done using polymeric thread with chemical and ultraviolet light resistance properties. The color of the sewing thread shall contrast the background color of the geotextile. Sewing shall be done using machinery and stitch types approved by the Project Manager and the Geosynthetic QAE.

7.7 DEFECTS AND REPAIRS

7.7.1 Identification

If a defect is identified in the geotextile, the Geosynthetic QAC shall determine the extent and nature of the defect.

7.7.2 Notification

After determining the extent and nature of the defect, the Geosynthetic QAC shall promptly notify the Installer and Project Manager.

7.7.3 Repair Procedures

The Geosynthetic QAC or designated representative shall observe any repairs to the cushion layer geotextile and report any noncompliance with the above requirements to the Project Manager.

Any holes or tears in the geotextile shall be repaired using the following procedure: A patch made from the same geotextile shall be thermally bonded or sewn into place with a minimum of 12-inch overlap in all directions. Care shall be taken to remove any soil or other material that may have penetrated the torn geotextile.

The final decision as to the appropriate repair shall be agreed upon between the Project Manager, Installer, and Geosynthetic QAE.

7.8 GEOTEXTILE PROTECTION

All vegetative layer materials located on top of a geotextile shall be deployed in such a manner as to ensure:

1. The geotextile and underlying lining materials are not damaged.
2. Minimal slippage of the geotextile on underlying layers occurs.
3. No excess tensile stresses occur in the geotextile.

8.0 GEOTEXTILE/GEONET COMPOSITE

8.1 DEFINITION AND APPLICABILITY

Geotextile/geonet composites are geocomposites used as a filter and drainage media at select locations over the geomembranes used in the final cover. This Section is applicable to drainage geocomposites made of polypropylene non-woven geotextiles and high-density polyethylene (HDPE) geonet. The geotextiles may be bonded to one side or both sides of the geonet. This Section is not applicable to geocomposites made with other material or components.

8.2 MANUFACTURING PLANT INSPECTION

The Project Manager, or his designated representative, may visit the manufacturing plant for a project-specific inspection if deemed necessary.

8.3 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geocomposite, the geocomposite Manufacturer or Installer shall provide the Project Manager with the following information:

1. Reports on quality control tests conducted by the Manufacturer to verify that the geocomposite manufactured for the project meets the project specifications.
2. Provide written confirmation for the geocomposite that includes all properties, measured using the appropriate test methods, contained in the project specifications for geocomposites.
3. Quality control certificates for the geocomposite, signed by a responsible party employed by the Manufacturer. The quality control certificates shall include roll identification numbers, testing procedures and results of quality control tests.

At a minimum, results shall be given for the following properties at the frequencies listed:

Geonet:

a. Density (ASTM D1505) (50,000 ft^2).
b. Thickness (ASTM D5I99) (50,000 ft^2).
c. Carbon black content (ASTM D4218) (50,000 ft^2).
~~d. Tensile strength (ASTM D5035) (50,000 ft^2).~~
~~e. Melt flow index (ASTM D1238) (once per resin lot).~~

Geotextile:

a. Mass per unit area (ASTM D5261) (100,000 ft^2).
b. Grab strength (ASTM D4632) (100,000 ft^2).
c. Permittivity (ASTM D4491) (500,000 ft^2).
d. AOS (ASTM D4751) (500,000 ft^2).
e. Trapezoidal tear strength (ASTM D4533) (100,000 ft^2)
f. Puncture strength (ASTM D4833) (100,000 ft^2).
g. UV Resistance (500,000 ft^2).

Geocomposite:

a. Thickness (ASTM D5199) (100,000 ft^2).
b. Hydraulic transmissivity (ASTM D4716) (500,000 ft^2 ~~once per project~~).
c. Ply adhesion (ASTM D7005) (100,000 ft^2).
~~d. Tensile strength (ASTM D4632) (50,000 ft^2).~~

Quality control tests shall be performed in accordance with the appropriate test methods. If the results contained in the manufacturer's certifications do not meet or exceed the minimum values contained in the project specifications, the material shall be considered out-of-specification and shall be rejected.

The Manufacturer shall identify all rolls of geocomposite with the following:

1. Manufacturer's name
2. Product identification
3. Roll number
4. Roll dimensions

8.4 CONFORMANCE TESTING

8.4.1 Sampling Procedures

An independent third party may perform in-plant sampling and conformance testing for the Geosynthetic QAC or upon delivery of the rolls of the geotextiles to the project site, the Geosynthetic QAC shall ensure that conformance test samples are obtained.

8.4.2 Conformance Tests

The following conformance tests shall be conducted:

Geonet:

a. Density (ASTM D1505) (250,000 ft^2).

b. Thickness (ASTM D5I99) (250,000 ft^2).
c. Carbon black content (ASTM D4218) (250,000 ft^2).

Geocomposite:

a. Hydraulic transmissivity (ASTM D4716) (500,000 ft^2).
b. Ply adhesion (ASTM D7005) (500,000 ft^2).

~~1. Mass per unit area (ASTM D5261).~~
~~2. Grab strength (ASTM D4632).~~
~~3. Puncture strength (ASTM D4833).~~

~~Conformance testing shall be performed at a frequency of one test per 250,000 ft^2 geotextile produced.~~

8.4.3 Test Results

All conformance test results shall be reviewed and accepted or rejected by the Geosynthetic QAE prior to the deployment of the geotextile. If the results of the conformance tests performed on the geotextile do not meet or exceed the minimum values contained in the project specifications, the material shall be considered out-of-specification and rejected.

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the Manufacturer present during the testing. Alternatively, the Manufacturer may have the sample retested at two different, Owner-approved Geosynthetic QAL's. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted.

If a test result is in nonconformance, all material from the resin batch represented by the failing test should be considered out-of-specification and rejected. Alternatively, at the option of the Project Manager, additional conformance test samples may be taken to "bracket" the portion of the resin batch not meeting the project specification. This procedure is valid only when all rolls in the resin batch are consecutively produced and numbered from one manufacturing line. To isolate the out-of-specification material, additional samples must be taken from rolls that have roll numbers immediately prior to and following the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire resin batch shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the resin batch. The use of the above noted procedures for dealing with failed test results is subject to the approval of the Project Manager.

8.5 GEOCOMPOSITE DEPLOYMENT

During shipment and storage, the geocomposite shall be protected from ultraviolet light exposure, moisture, mud, dirt, dust, puncture, cutting, or any other damaging conditions.

The Installer shall handle all geocomposite in such a manner as to ensure they are not damaged, and the following shall be complied with:

1. On slopes, the geocomposite shall be securely anchored and then rolled down the slope in such a manner as to continually keep the geocomposite sheet in tension. If necessary, the geocomposite shall be positioned by hand after being unrolled to minimize wrinkles.
2. In the presence of wind, all geocomposites shall be weighted with sandbags or the equivalent. Sandbags shall be installed during deployment and shall remain until replaced with cover material.
3. Unless otherwise specified, single-sided geocomposite shall not be welded to the geomembrane.
4. Geocomposites shall be cut using a hook blade or other tool approved by the Project Manager. If in place, special care shall be taken to protect underlying geosynthetics from damage that could be caused by the cutting of the geocomposite. Care shall be taken not to leave the tools in the geocomposite.
5. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.
6. During placement of geocomposite, care shall be taken not to entrap in or beneath the geocomposite, stones, or dirt that could damage the geomembrane, cause clogging of drains or filters, or hamper subsequent seaming. If dirt or excess dust is entrapped in the geonet of single-sided geocomposite, it should be washed clean prior to placement of the next material on top of it. In this regard, care shall be taken with the handling of sandbags, to prevent puncturing the sandbag.
7. A visual examination of the geotextile component of the geocomposite shall be carried out over the entire surface, after installation, to ensure that no potentially harmful foreign objects are present.

8.6 SEAMING PROCEDURES

In general, no horizontal seams shall be allowed on side slopes thus seams shall be along, not across, the slope, except as part of a patch. If horizontal seams are required, offset adjacent horizontal seams a minimum of 10 ft.

At a minimum, the following requirements shall be met:

1. Adjacent geocomposite shall be overlapped so that the geonet overlaps by at least 4 inches and geotextile overlap by at least 3 inches.
2. If two-sided geocomposite is used, seam the top geotextile together.

3. The geonet overlaps shall be tied with plastic fasteners. Tying devices shall be white or yellow for easy inspection. Metallic devices are not allowed.
4. Tying shall be every 5 ft. along the slope. Every 6 inches in the anchor trench, and every 6 inches along end-to-end seams on the base of the landfill.
5. In the corners of the side slopes where overlaps between perpendicular strips are required, an extra layer shall be unrolled along the slope, on top of the previously installed geocomposite, from top to bottom of the slope.
6. When more than one layer of geocomposite is installed, joints shall be staggered.
7. Once geonet is tied, the geotextile of the geocomposite shall be seamed. All geotextiles shall be continuously sewn. Spot sewing is not allowed. The Installer shall pay particular attention to seams to ensure that no earth cover material could be inadvertently inserted beneath the geotextile if applicable.
8. Sewing shall be done using polymeric thread with chemical and ultraviolet light resistance properties equal to or exceeding those of the geotextile. Sewing shall be done using machinery and stitch types approved by the Project Manager and the Geosynthetic QAE.

8.7 DEFECTS AND REPAIRS

8.7.1 Identification

If a defect is identified in the geotextile/geonet composite, the Geosynthetic QAC shall determine the extent and nature of the defect.

8.7.2 Notification

After determining the extent and nature of the defect, the Geosynthetic QAC shall promptly notify the Installer and Project Manager.

8.7.3 Repair Procedures

The final decision as to the appropriate repair shall be agreed upon by the Project Manager. Prior to acceptance of the geocomposite, the Installer shall locate and repair all damaged areas as directed by the Geosynthetic QAC.

If in the Geosynthetic QAC's judgment, the defect is determined to be small, typically smaller than 3 feet by 3 feet, the geocomposite shall be repaired as follows:

1. If the geonet is judged to be undamaged but the geotextile is damaged, a patch of geotextile shall be placed. The geotextile patch shall be thermally bonded in place with a minimum of a 12 inch overlap in all directions.
2. If the geonet is judged to be damaged, the damaged geonet shall be removed. A section of

geonet shall be cut to extend at least 1 ft. beyond the edge of the hole or tear to replace the removed section. The geonet shall be tied to the existing geonet using white plastic fasteners placed at least every 6 inches. A geotextile patch shall be placed over the repaired geonet section. The geotextile patch shall be thermally bonded in place with a minimum of a 12 inch overlap in all directions.

If in the Geosynthetic QAC's judgment, the defect is determined to be large, typically larger than 3 by 3 feet, the required section of geocomposite shall be replaced.

8.8 GEOCOMPOSITE PROTECTION

All soil materials located on top of the geocomposite shall be deployed in such a manner as to ensure:

1. The geocomposite and underlying lining materials are not damaged.
2. Minimal slippage of the geocomposite on underlying layers occurs.
3. No excess tensile stresses occur in the geocomposite.

APPENDIX A-4

Ash Pond Closure Slope Stability Analyses, by CARDNO ATC Associates, Inc., July 2014"

Table 1

Strength Parameters for Coal Combustion Products

be useful to geotechnical engineers for conceptual design and for evaluating specific test results to determine if those results are representative or may be suspect. However, actual properties of a particular fly ash may vary considerably from these typical values due to changes in fuel, combustion processes and equipment, contamination with other materials, segregation in handling or other factors. Therefore for actual design purposes there is no substitute for data on the actual fly ash being used.

TABLE 2. - Summary of Results for Class F Fly Ash

Property (1)	Mean Value (2)	Standard Deviation (3)	Coefficient of Variation	Comments (5)
Specific Gravity	2.4	0.15	6.0%	
Coefficient of Uniformity	5.49	3.6	60.8%	Also See Table 1
Maximum Dry Density in pounds per cubic foot	83.4	13.0	15.6%	Also See Figure 6
Optimum Moisture Content - %	25.3	10.2	40.1%	Also See Figure 6
Maximum Wet Density in pounds per cubic foot	103.4	10.1	9.7%	
Log (10) of Permeability	-4.88	0.46	9.5%	Mean Value Equals 1.32×10^{-5} cm/sec
Effective Friction Angle in degrees	34.0	3.3	9.8%	
Compression Index	0.13	0.088	67.1%	

Table 2

Average Soil Properties

~~TABLE 8.~~ *Average properties of soils*

Soil classification group	Proctor compaction		Void ratio, e	Permeability, k, feet per year	Compressibility		Shearing strength		
	Maximum dry density in pounds per cubic foot	Optimum water content, percent			@ 20 p.s.i., percent	@ 50 p.s.i., percent	C, p.s.i.	C_{ef}, p.s.i.	tan ϕ
GW	>110	<13.3	(*)	27,000± 18,000	<1.4	(*)	(*)	(*)	>0.79
GP	>110	<12.4	(*)	64,000± 34,000	<0.6	(*)	(*)	(*)	>0.74
GM	>114	<14.6	(*)	>0.3	<1.2	<3.0	(*)	(*)	>0.67
GC	>115	<14.7	(*)	>0.3	<1.2	<2.4	(*)	(*)	>0.60
SW	119±5	13.3±2.5	0.37±*	(*)	1.4±*	(*)	5.7±0.6	(*)	0.79±0.02
SP	110±2	12.4±1.0	0.50±0.03	>15.0	0.8±0.3	(*)	3.3±0.9	(*)	0.74±0.02
SM	114±1	14.6±0.4	0.48±0.03	7.5±4.8	1.2±0.1	3.0±0.4	7.4±0.9	2.9±1.0	0.67±0.02
SM-SC	119±1	12.8±0.5	0.41±0.02	0.8±0.6	1.4±0.3	2.9±1.0	7.3±3.1	2.1±0.8	0.66±0.07
SC	116±1	14.7±0.4	0.48±0.01	0.3±0.2	1.2±0.2	2.4±0.5	10.9±2.2	1.6±0.9	0.60±0.07
ML	103±1	19.2±0.7	0.63±0.02	0.59±0.23	1.5±0.2	2.0±0.3	9.7±1.5	1.3±*	0.62±0.04
ML-CL	109±2	18.8±0.7	0.54±0.03	0.13±0.07	1.0±0.2	2.2±0.0	9.2±2.4	3.2±*	0.62±0.06
CL	108±1	17.3±0.3	0.50±0.01	0.08±0.03	1.4±0.2	2.0±0.4	12.0±1.5	1.9±0.3	0.54±0.04
OL	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
MH	82±4	30.3±3.2	1.15±0.12	0.10±0.10	2.0±1.2	3.8±0.8	10.5±4.3	2.9±1.3	0.47±0.05
CH	94±2	26.5±1.2	0.80±0.04	0.05±0.03	2.0±1.3	3.9±1.5	14.9±4.9	1.0±0.80	0.35±0.09
OH	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)

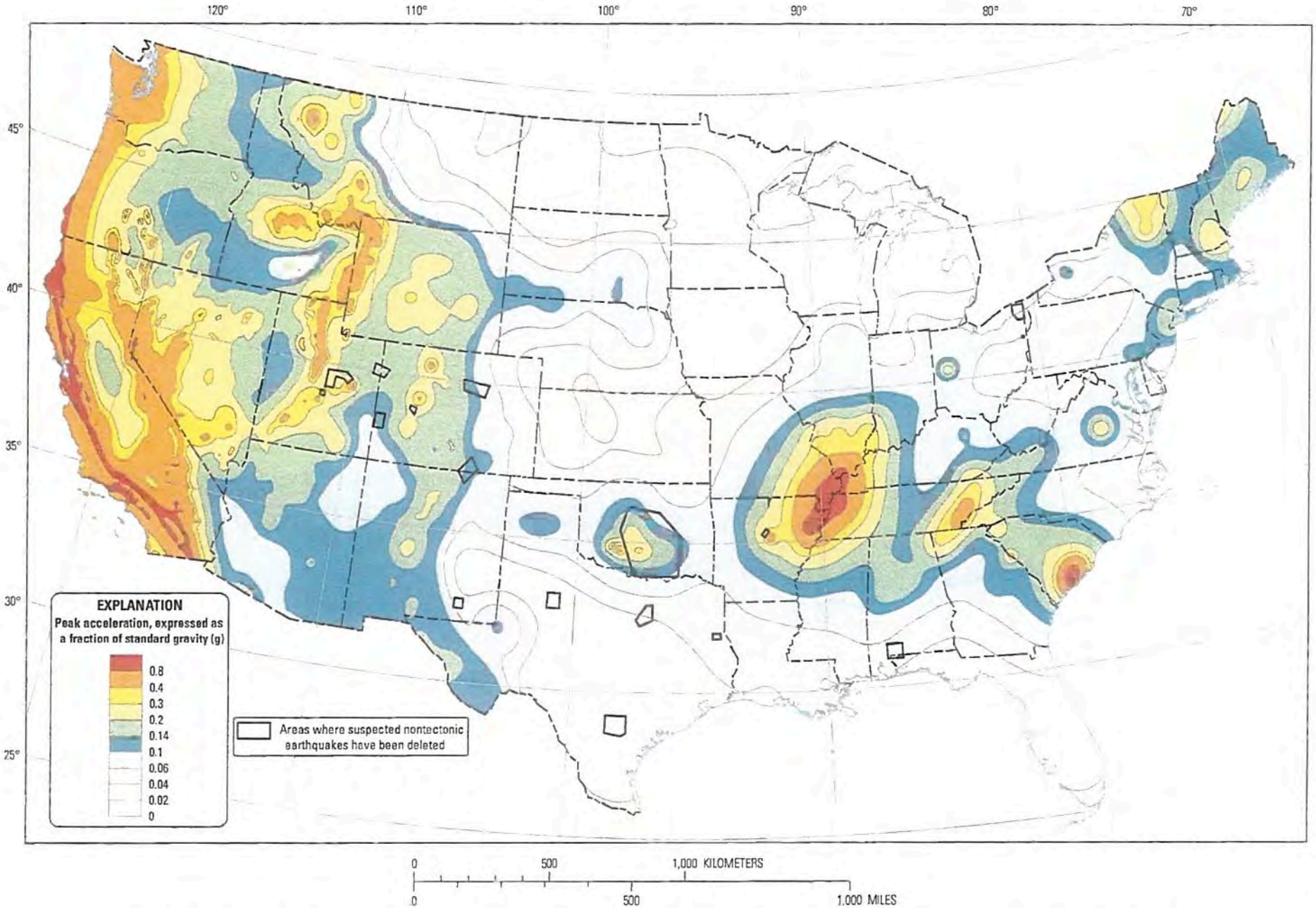
The ± entry indicates 90 percent confidence limits of the average value. * Denotes insufficient data, > is greater than, < is less than.

For CL soils $\phi = 26.6$ to 30.1 ; use $\phi = 28$ or less
$C = 230$ psf to 320 psf : use $C = 100$ psf or less

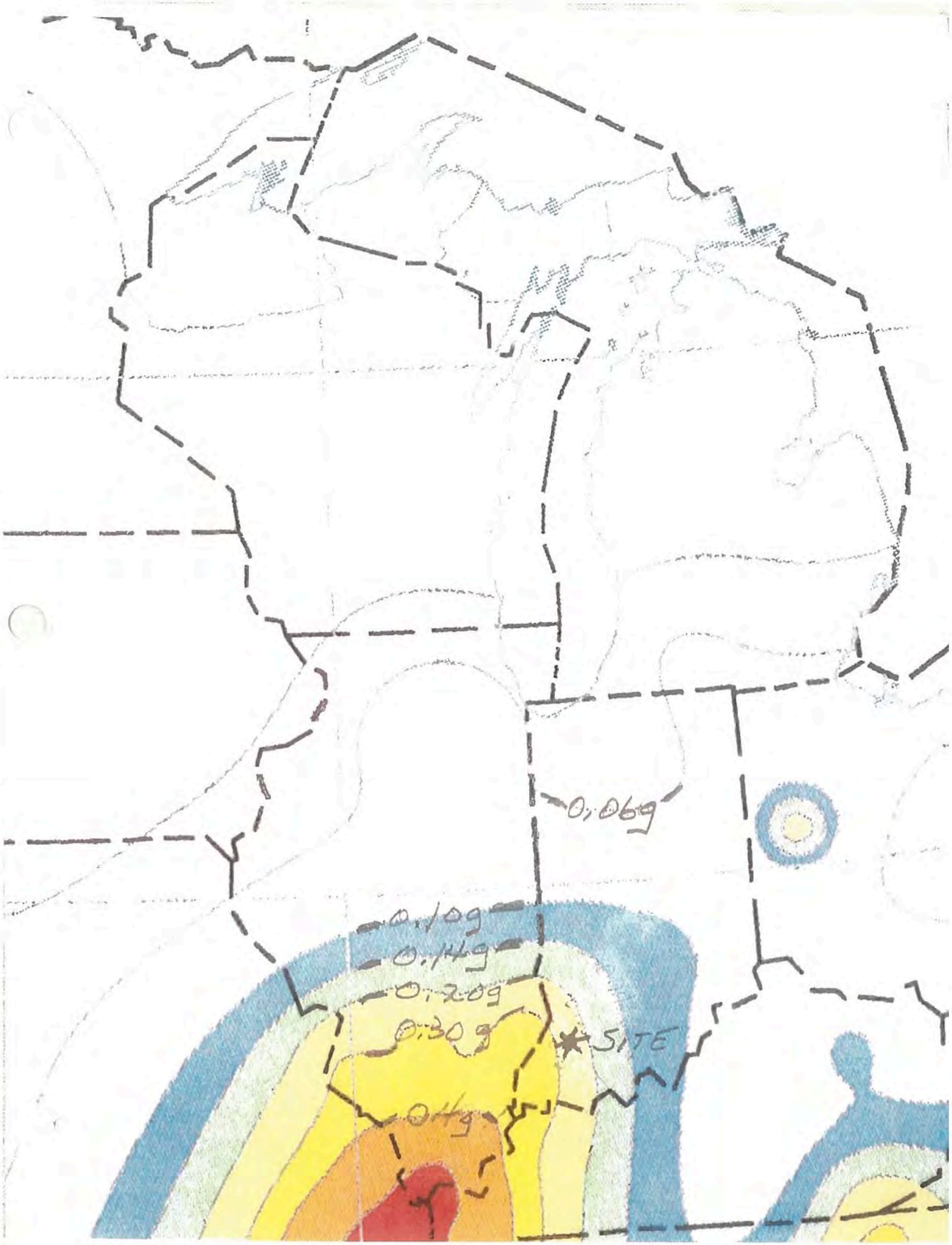
From United States Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, pg. 137.

Figure 1

USGS Earthquake Hazards Program
Peak Horizontal Acceleration with 2% Probability of Exceedance in 50 years



Two-percent probability of exceedance in 50 years map of peak ground acceleration


0.06g
0.10g
0.14g
0.20g
0.30g
SITE
0.4g

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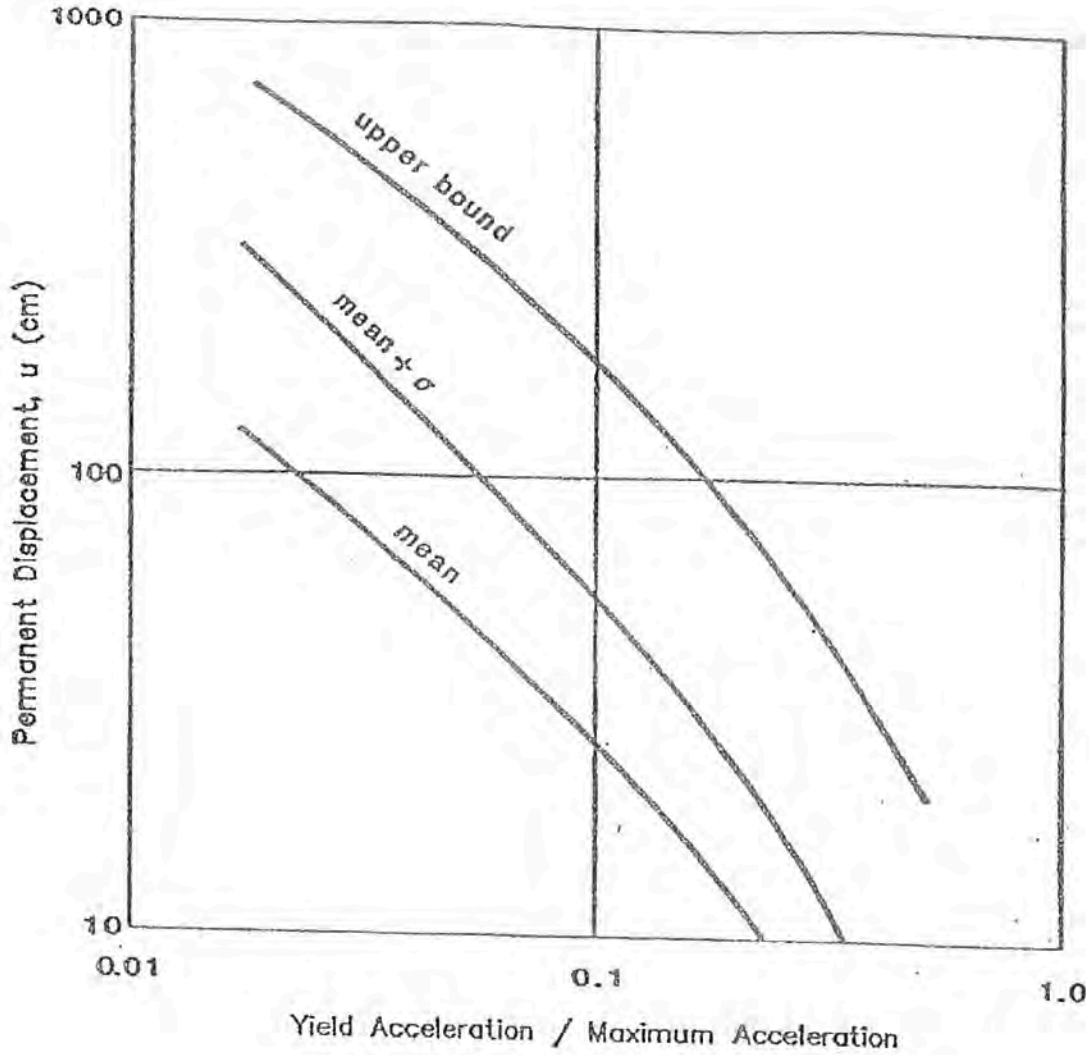
PROJECT	IPL Petersburg AshPond Closures	PROJECT NO.	
	Slope Stability Analyses	PAGE	OF

MADE BY	DS	DATE	11/09	CHECKED BY	DB	DATE	11/09

Figure 2

Permanent Displacement Chart



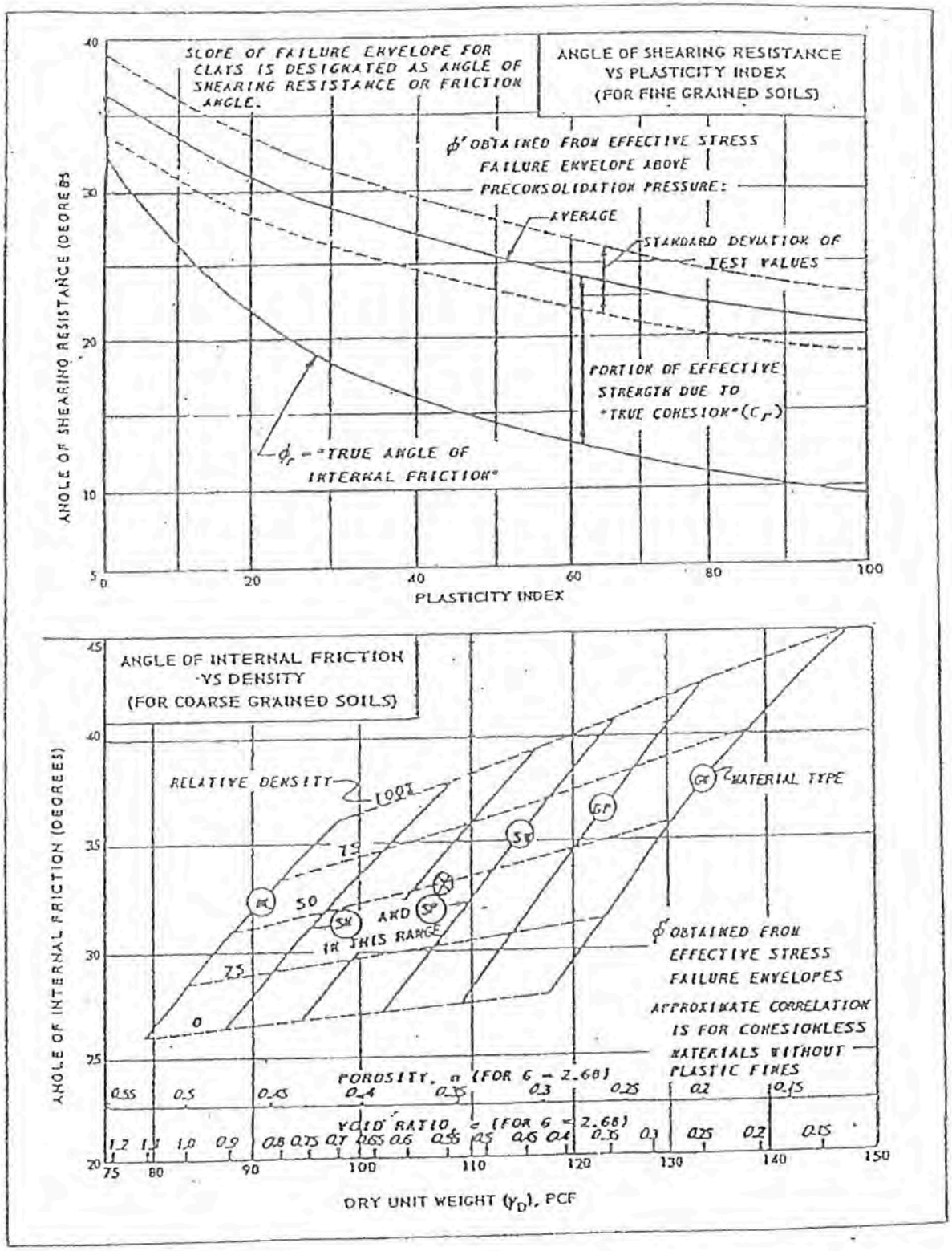
~~Figure 6.5~~ Hynes and Franklin Permanent Seismic Displacement Chart (Hynes and Franklin, 1984).

Figure 3

Unit Weight for Coal Combustion Products

Figure 3

Correlation of Strength Characteristics (for soils)



~~FIGURE 3-7~~

Correlations of Strength Characteristics

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	Slope Stability Analyses	PAGE	OF

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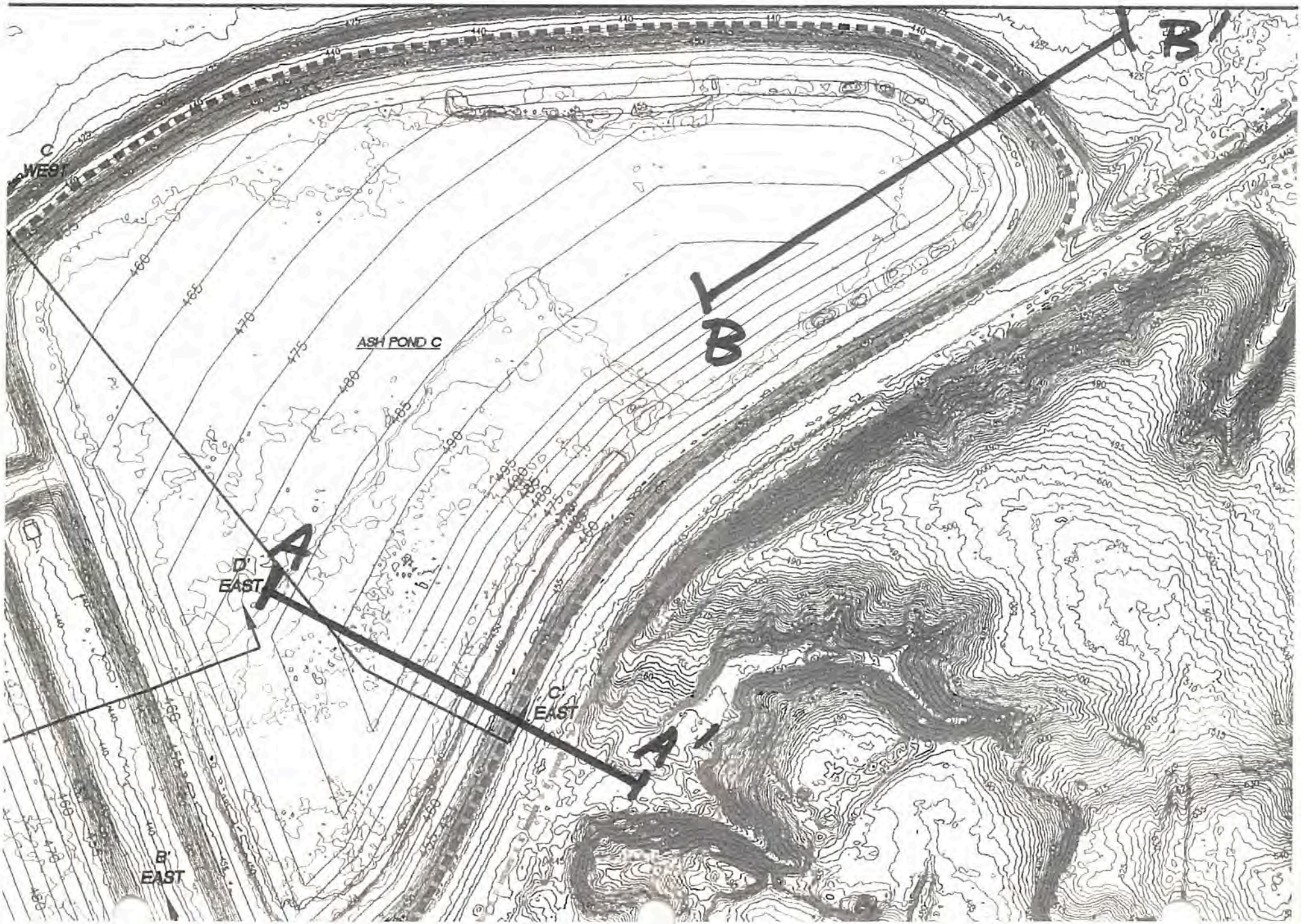
Figure 5

Plan View of Final Cover Elevations With Cross Section Locations


ASH POND C
C
WEST
D'
EAST
C'
EAST
B'
EAST
A
A'
B
B'

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Outputs from STABL Models of Circular-Shaped Failures

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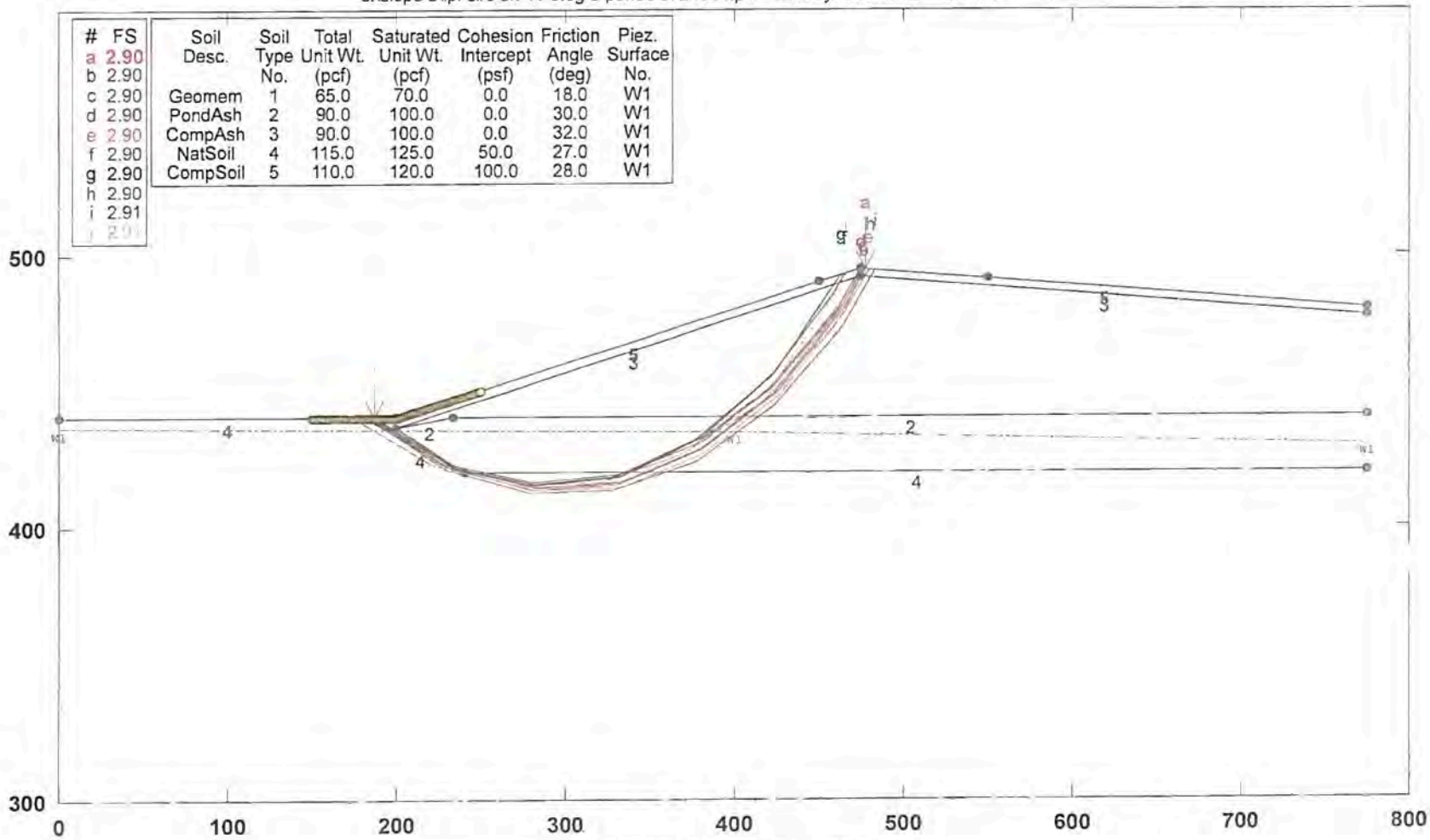
Cross Section A-A'

IPL Ash Pond C - E.Side - Max. 20% Slope- Earthquake Loading Analysis - Circular

c:\slope b\ipl circ 5h-1v 0.0g e pondc 0724514.pl2 Run By: Username 7/24/2014 10:20AM

#	FS
a	2.90
b	2.90
c	2.90
d	2.90
e	2.90
f	2.90
g	2.90
h	2.90
i	2.91
j	2.91

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Geomem	1	65.0	70.0	0.0	18.0	W1
PondAsh	2	90.0	100.0	0.0	30.0	W1
CompAsh	3	90.0	100.0	0.0	32.0	W1
NatSoil	4	115.0	125.0	50.0	27.0	W1
CompSoil	5	110.0	120.0	100.0	28.0	W1



STABL6H FSmin=2.90

Safety Factors Are Calculated By The Modified Bishop Method

STED

** STABL6H **
by
Purdue University
--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer's Method of Slices

Run Date: 7/24/2014
Time of Run: 10:20AM
Run By: Username
Input Data Filename: C:ipl circ 5h-1v 0.0g e pondc 0724514.in
Output Filename: C:ipl circ 5h-1v 0.0g e pondc 0724514.OUT
Plotted Output Filename: C:ipl circ 5h-1v 0.0g e pondc 0724514.PLT
PROBLEM DESCRIPTION IPL Ash Pond C - E.Side - Max. 20% Slope
- Earthquake Loading Analysis - Circular

BOUNDARY COORDINATES
Note: User origin value specified.
Add 0.00 to X-values and 300.00 to Y-values listed.

3 Top Boundaries
9 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	140.00	200.00	140.00	4
2	200.00	140.00	475.00	195.00	5
3	475.00	195.00	775.00	180.00	5
4	200.00	137.00	475.00	192.00	3
5	475.00	192.00	775.00	177.00	3
6	200.00	137.00	233.00	140.00	2
7	233.00	140.00	775.00	140.00	2
8	200.00	136.90	240.00	120.00	4
9	240.00	120.00	775.00	120.00	4

ISOTROPIC SOIL PARAMETERS
5 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	65.0	70.0	0.0	18.0	0.00	0.0	1
2	90.0	100.0	0.0	30.0	0.00	0.0	1
3	90.0	100.0	0.0	32.0	0.00	0.0	1
4	115.0	125.0	50.0	27.0	0.00	0.0	1
5	110.0	120.0	100.0	28.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED
Unit Weight of Water = 62.40
Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	137.00
2	400.00	135.00
3	775.00	130.00

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.
10000 Trial Surfaces Have Been Generated.
100 Surfaces Initiate From Each Of100 Points Equally Spaced
Along The Ground Surface Between X = 150.00 ft.
and X = 250.00 ft.
Each Surface Terminates Between X = 450.00 ft.
and X = 550.00 ft.
Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.
50.00 ft. Line Segments Define Each Trial Failure Surface.
Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.
* * Safety Factors Are Calculated By The Modified Bishop Method * *
Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

```
    1        187.37       140.00
    2        234.02       121.98
    3        283.36       113.89
    4        333.31       116.07
    5        381.76       128.43
    6        426.65       150.44
    7        466.09       181.17
    8        477.69       194.87
Circle Center At X =  297.8 ; Y =  356.5  and Radius,  243.0
      ***     2.895    ***
Failure Surface Specified By  8 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        184.34       140.00
    2        231.49       123.35
    3        280.97       116.16
    4        330.91       118.69
    5        379.40       130.86
    6        424.62       152.20
    7        464.85       181.89
    8        476.73       194.91
Circle Center At X =  293.0 ; Y =  372.6  and Radius,  256.7
      ***     2.896    ***
Failure Surface Specified By  8 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        184.34       140.00
    2        230.86       121.65
    3        280.15       113.28
    4        330.11       115.23
    5        378.60       127.43
    6        423.54       149.36
    7        463.00       180.06
    8        475.61       194.97
Circle Center At X =  295.7 ; Y =  354.3  and Radius,  241.5
      ***     2.897    ***
Failure Surface Specified By  8 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        181.31       140.00
    2        228.34       123.01
    3        277.77       115.53
    4        327.72       117.84
    5        376.25       129.86
    6        421.50       151.13
    7        461.73       180.83
    8        474.54       194.91
Circle Center At X =  291.0 ; Y =  370.0  and Radius,  254.8
      ***     2.897    ***
Failure Surface Specified By  8 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        187.37       140.00
    2        233.82       121.48
    3        283.08       112.94
    4        333.05       114.75
    5        381.57       126.82
    6        426.56       148.64
    7        466.09       179.26
    8        479.26       194.79
Circle Center At X =  299.4 ; Y =  353.5  and Radius,  241.1
      ***     2.898    ***
Failure Surface Specified By  8 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        182.32       140.00
    2        229.16       122.50
```

```
    3        278.61       115.12
    4        328.52       118.17
    5        376.71       131.52
    6        421.06       154.60
    7        459.66       186.38
    8        464.92       192.98
Circle Center At X =  289.0 ; Y =  354.2  and Radius,  239.4
     ***     2.901    ***
Failure Surface Specified By  8 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        186.36       140.00
    2        233.08       122.17
    3        282.54       114.88
    4        332.41       118.48
    5        380.32       132.80
    6        423.98       157.16
    7        461.33       190.41
    8        462.90       192.58
Circle Center At X =  291.0 ; Y =  344.1  and Radius,  229.4
     ***     2.902    ***
Failure Surface Specified By  8 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        174.24       140.00
    2        221.33       123.17
    3        270.69       115.22
    4        320.68       116.40
    5        369.61       126.68
    6        415.84       145.72
    7        457.83       172.87
    8        480.92       194.70
Circle Center At X =  289.3 ; Y =  387.5  and Radius,  272.9
     ***     2.904    ***
Failure Surface Specified By  8 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        183.33       140.00
    2        229.71       121.32
    3        278.89       112.27
    4        328.88       113.23
    5        377.67       124.16
    6        423.30       144.61
    7        463.92       173.76
    8        483.22       194.59
Circle Center At X =  299.1 ; Y =  360.5  and Radius,  249.1
     ***     2.905    ***
Failure Surface Specified By  8 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        186.36       140.00
    2        232.68       121.17
    3        282.01       112.98
    4        331.93       115.82
    5        380.00       129.56
    6        423.88       153.53
    7        461.43       186.55
    8        466.31       193.26
Circle Center At X =  294.2 ; Y =  338.9  and Radius,  226.2
     ***     2.905    ***
```

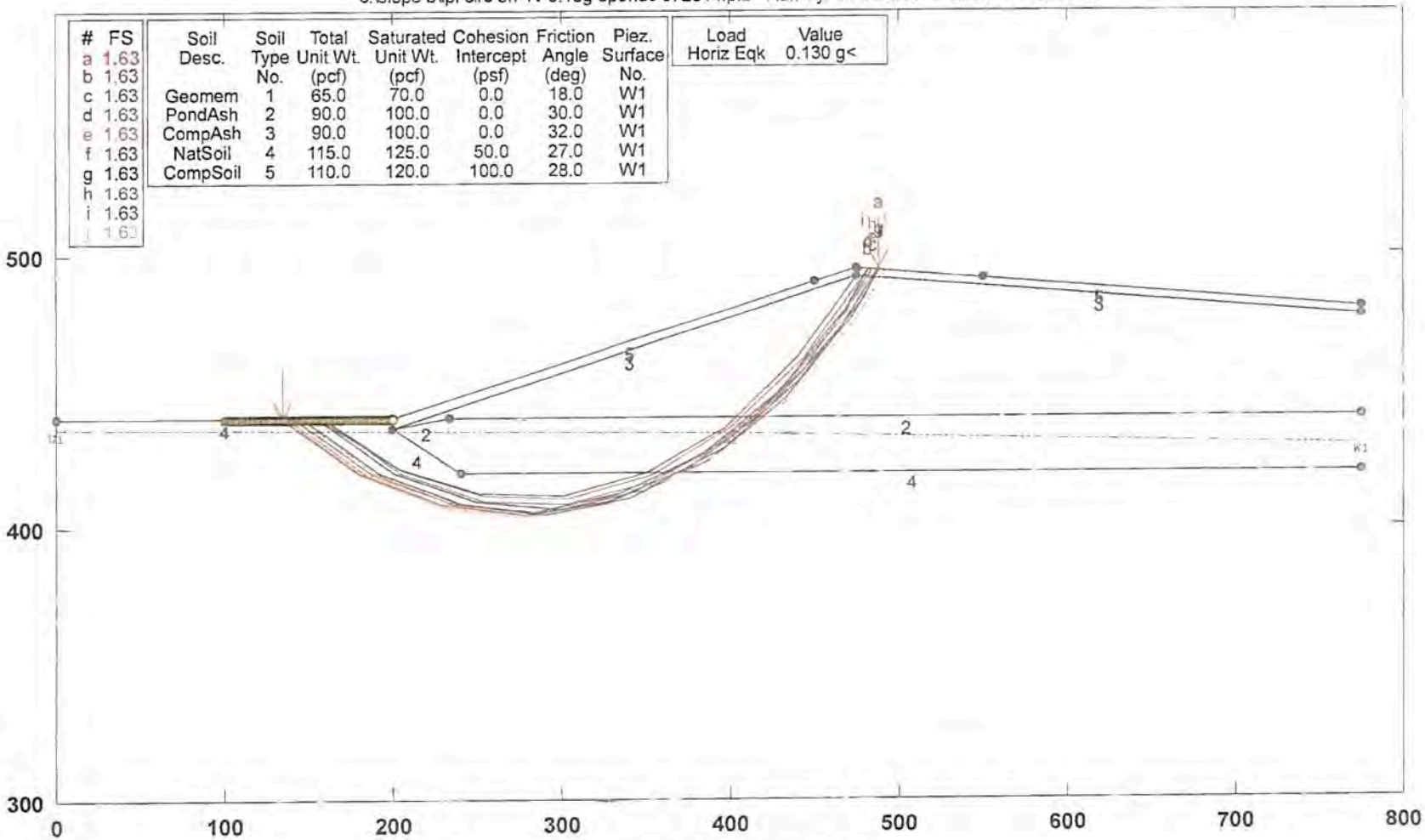
IPL Ash Pond C - E.Side - Max. 20% SlopeEarthquake Loading Analysis - Circular

c:\slope b\ipl circ 5h-1v 0.13g epondc 072314.pl2 Run By: Username 7/24/2014 10:17AM

#	FS
a	1.63
b	1.63
c	1.63
d	1.63
e	1.63
f	1.63
g	1.63
h	1.63
i	1.63
j	1.63

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Geomem	1	65.0	70.0	0.0	18.0	W1
PondAsh	2	90.0	100.0	0.0	30.0	W1
CompAsh	3	90.0	100.0	0.0	32.0	W1
NatSoil	4	115.0	125.0	50.0	27.0	W1
CompSoil	5	110.0	120.0	100.0	28.0	W1

Load	Value
Horiz Eqk	0.130 g<



STABL6H FSmin=1.63

Safety Factors Are Calculated By The Modified Bishop Method

STED

** STABL6H **
by
Purdue University
--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer's Method of Slices

Run Date: 7/24/2014
Time of Run: 10:17AM
Run By: Username
Input Data Filename: C:ipl circ 5h-1v 0.13g epondc 072314.in
Output Filename: C:ipl circ 5h-1v 0.13g epondc 072314.OUT
Plotted Output Filename: C:ipl circ 5h-1v 0.13g epondc 072314.PLT
PROBLEM DESCRIPTION IPL Ash Pond C - E.Side - Max. 20% Slope
Earthquake Loading Analysis - Circular

BOUNDARY COORDINATES
Note: User origin value specified.
Add 0.00 to X-values and 300.00 to Y-values listed.

3 Top Boundaries
9 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	140.00	200.00	140.00	4
2	200.00	140.00	475.00	195.00	5
3	475.00	195.00	775.00	180.00	5
4	200.00	137.00	475.00	192.00	3
5	475.00	192.00	775.00	177.00	3
6	200.00	137.00	233.00	140.00	2
7	233.00	140.00	775.00	140.00	2
8	200.00	136.90	240.00	120.00	4
9	240.00	120.00	775.00	120.00	4

ISOTROPIC SOIL PARAMETERS
5 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	65.0	70.0	0.0	18.0	0.00	0.0	1
2	90.0	100.0	0.0	30.0	0.00	0.0	1
3	90.0	100.0	0.0	32.0	0.00	0.0	1
4	115.0	125.0	50.0	27.0	0.00	0.0	1
5	110.0	120.0	100.0	28.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED
Unit Weight of Water = 62.40
Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	137.00
2	400.00	135.00
3	775.00	130.00

A Horizontal Earthquake Loading Coefficient
Of0.130 Has Been Assigned
A Vertical Earthquake Loading Coefficient
Of0.000 Has Been Assigned
Cavitation Pressure = 0.0 psf
A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.
10000 Trial Surfaces Have Been Generated.
100 Surfaces Initiate From Each Of100 Points Equally Spaced
Along The Ground Surface Between X = 100.00 ft.
and X = 200.00 ft.
Each Surface Terminates Between X = 450.00 ft.
and X = 550.00 ft.
Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.
50.00 ft. Line Segments Define Each Trial Failure Surface.
Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical

First.
* * Safety Factors Are Calculated By The Modified Bishop Method * *
Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	134.34	140.00
2	180.32	120.35
3	228.91	108.56
4	278.78	104.96
5	328.56	109.64
6	376.88	122.49
7	422.42	143.13
8	463.92	171.02
9	488.57	194.32

Circle Center At X = 275.5 ; Y = 406.6 and Radius, 301.7
*** 1.629 ***
Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	158.59	140.00
2	205.03	121.48
3	254.06	111.67
4	304.05	110.89
5	353.36	119.16
6	400.37	136.21
7	443.51	161.47
8	481.38	194.13
9	481.80	194.66

Circle Center At X = 283.4 ; Y = 385.5 and Radius, 275.4
*** 1.629 ***
Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	158.59	140.00
2	204.63	120.51
3	253.48	109.82
4	303.45	108.30
5	352.86	116.00
6	400.00	132.66
7	443.28	157.70
8	481.21	190.27
9	484.62	194.52

Circle Center At X = 286.7 ; Y = 378.5 and Radius, 270.7
*** 1.629 ***
Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	141.41	140.00
2	187.33	120.20
3	235.99	108.72
4	285.91	105.92
5	335.56	111.89
6	383.39	126.44
7	427.95	149.12
8	467.86	179.24
9	482.17	194.64

Circle Center At X = 276.8 ; Y = 390.9 and Radius, 285.1
*** 1.629 ***
Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	133.33	140.00
2	179.04	119.73
3	227.54	107.56
4	277.40	103.84
5	327.16	108.69
6	375.37	121.97

7	420.60	143.27
8	461.54	171.98
9	484.19	194.54

Circle Center At X = 274.1 ; Y = 395.7 and Radius, 291.9
*** 1.629 ***
Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	146.47	140.00
2	192.24	119.88
3	240.82	108.06
4	290.72	104.90
5	340.40	110.51
6	388.35	124.71
7	433.07	147.06
8	473.21	176.87
9	489.62	194.27

Circle Center At X = 283.7 ; Y = 390.0 and Radius, 285.2
*** 1.629 ***
Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	154.55	140.00
2	200.52	120.35
3	249.27	109.24
4	299.22	107.03
5	348.76	113.80
6	396.29	129.32
7	440.28	153.09
8	479.30	184.35
9	487.99	194.35

Circle Center At X = 286.5 ; Y = 385.1 and Radius, 278.3
*** 1.629 ***
Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	137.37	140.00
2	183.42	120.51
3	232.09	109.07
4	282.00	106.01
5	331.71	111.41
6	379.79	125.12
7	424.87	146.75
8	465.65	175.68
9	484.46	194.53

Circle Center At X = 275.1 ; Y = 401.2 and Radius, 295.3
*** 1.629 ***
Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	155.56	140.00
2	202.07	121.65
3	251.13	112.00
4	301.12	111.37
5	350.41	119.76
6	397.38	136.92
7	440.48	162.27
8	478.13	194.84

Circle Center At X = 279.6 ; Y = 386.4 and Radius, 275.9
*** 1.630 ***
Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	144.44	140.00
2	190.35	120.19
3	238.96	108.47
4	288.85	105.19

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    5        338.57      110.45
    6        386.68      124.09
    7        431.76      145.71
    8        472.51      174.69
    9        491.83      194.16
Circle Center At X =  283.0 ; Y =  398.0  and Radius,  292.9
     ***     1.630   ***
```

Cardno ATC Associates Inc.

PROJECT **IPL Petersburg AshPond Closures** PROJECT NO.

Slope Stability Analyses PAGE OF

MADE BY **DS** DATE **7/14** CHECKED BY **DB** DATE

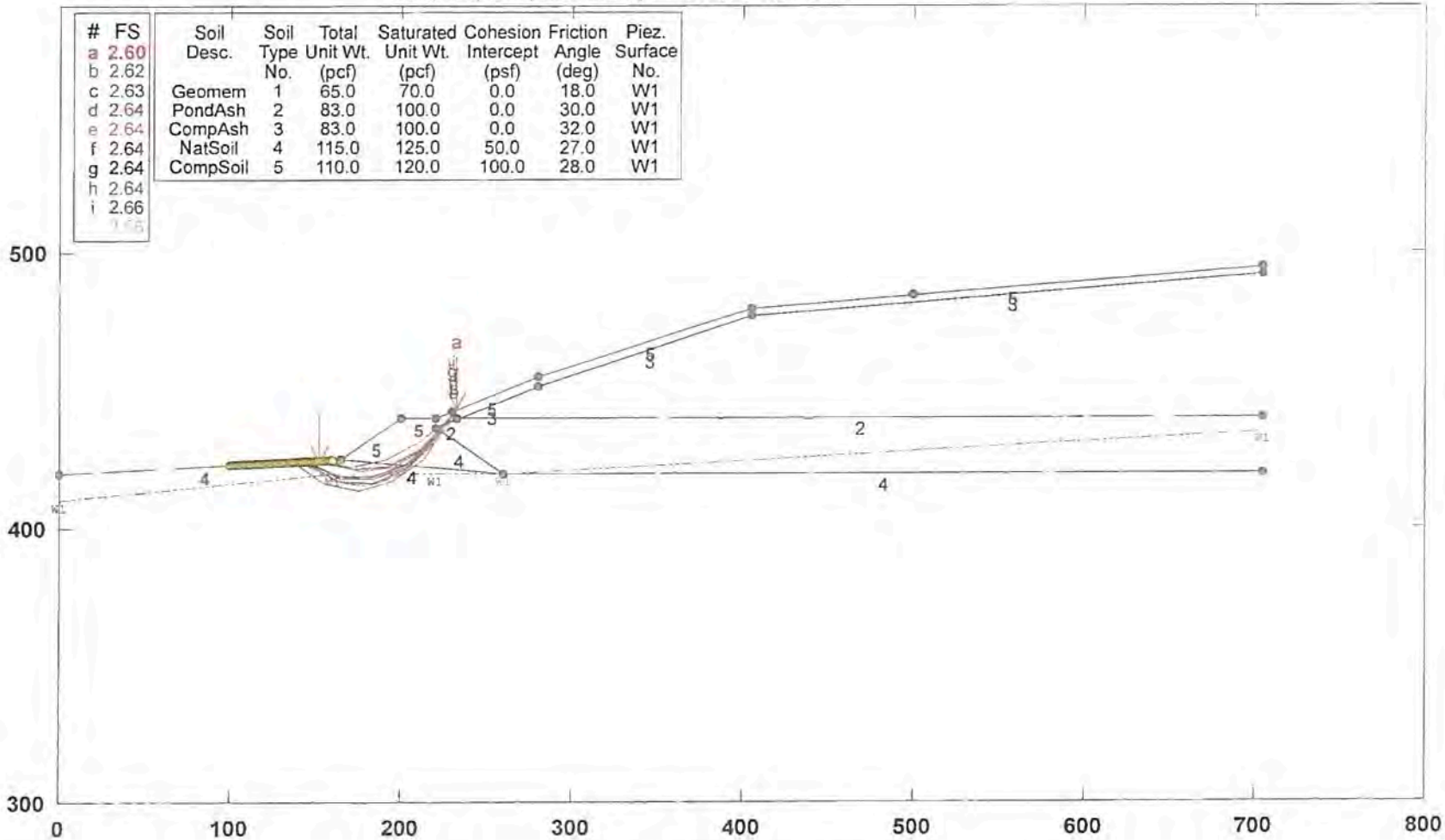
Cross Section B-B'

IPL Ash Pond C - Max.Slope Above Berm -Static Load Analysis - Circular

c:\slope b\ipl circ pondc eq0.0g 072414.pl2 Run By: Username 7/24/2014 09:24AM

#	FS
a	2.60
b	2.62
c	2.63
d	2.64
e	2.64
f	2.64
g	2.64
h	2.64
i	2.66

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Geomem	1	65.0	70.0	0.0	18.0	W1
PondAsh	2	83.0	100.0	0.0	30.0	W1
CompAsh	3	83.0	100.0	0.0	32.0	W1
NatSoil	4	115.0	125.0	50.0	27.0	W1
CompSoil	5	110.0	120.0	100.0	28.0	W1



STABL6H FSmin=2.60

Safety Factors Are Calculated By The Modified Bishop Method

STED

** STABL6H **
by
Purdue University
--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer's Method of Slices

Run Date: 7/24/2014
Time of Run: 09:24AM
Run By: Username
Input Data Filename: C:ipl circ pondc eq0.0g 072414.in
Output Filename: C:ipl circ pondc eq0.0g 072414.OUT
Plotted Output Filename: C:ipl circ pondc eq0.0g 072414.PLT
PROBLEM DESCRIPTION IPL Ash Pond C - Max.Slope Above Berm - Static Load Analysis - Circular

BOUNDARY COORDINATES
Note: User origin value specified.
Add 0.00 to X-values and 300.00 to Y-values listed.

6 Top Boundaries
14 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	120.00	165.00	125.00	4
2	165.00	125.00	200.00	140.00	5
3	200.00	140.00	220.00	140.10	5
4	220.00	140.10	280.00	155.00	5
5	280.00	155.00	405.00	180.00	5
6	405.00	180.00	705.00	195.00	5
7	220.00	137.00	280.00	152.00	3
8	280.00	152.00	405.00	177.00	3
9	405.00	177.00	705.00	192.00	3
10	220.00	137.00	233.00	140.00	2
11	233.00	140.00	705.00	140.00	2
12	220.00	136.90	260.00	120.00	4
13	260.00	120.00	705.00	120.00	4
14	165.00	125.00	260.00	120.00	4

ISOTROPIC SOIL PARAMETERS
5 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	65.0	70.0	0.0	18.0	0.00	0.0	1
2	83.0	100.0	0.0	30.0	0.00	0.0	1
3	83.0	100.0	0.0	32.0	0.00	0.0	1
4	115.0	125.0	50.0	27.0	0.00	0.0	1
5	110.0	120.0	100.0	28.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED
Unit Weight of Water = 62.40
Piezometric Surface No. 1 Specified by 5 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	110.00
2	160.00	120.00
3	220.00	120.00
4	260.00	120.00
5	705.00	135.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.
2500 Trial Surfaces Have Been Generated.
50 Surfaces Initiate From Each Of 50 Points Equally Spaced
Along The Ground Surface Between X = 100.00 ft.
and X = 160.00 ft.
Each Surface Terminates Between X = 230.00 ft.
and X = 500.00 ft.
Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00 ft.
20.00 ft. Line Segments Define Each Trial Failure Surface.

```
Following Are Displayed The Ten Most Critical Of The Trial
     Failure Surfaces Examined.  They Are Ordered - Most Critical
     First.
     * * Safety Factors Are Calculated By The Modified Bishop Method * *
     Failure Surface Specified By  6 Coordinate Points
       Point       X-Surf       Y-Surf
        No.         (ft)         (ft)
         1         152.65       124.63
         2         172.40       121.42
         3         192.34       122.88
         4         211.41       128.91
         5         228.57       139.19
         6         232.74       143.26
     Circle Center At X =  176.2 ; Y =  207.2  and Radius,   85.8
          ***      2.600    ***
     Failure Surface Specified By  6 Coordinate Points
       Point       X-Surf       Y-Surf
        No.         (ft)         (ft)
         1         156.33       124.74
         2         175.96       120.93
         3         195.88       122.68
         4         214.55       129.85
         5         230.52       141.89
         6         231.28       142.90
     Circle Center At X =  179.7 ; Y =  192.7  and Radius,   71.8
          ***      2.620    ***
     Failure Surface Specified By  6 Coordinate Points
       Point       X-Surf       Y-Surf
        No.         (ft)         (ft)
         1         151.43       124.59
         2         171.35       122.85
         3         191.24       124.99
         4         210.34       130.91
         5         227.94       140.41
         6         230.83       142.79
     Circle Center At X =  170.3 ; Y =  226.1  and Radius,  103.3
          ***      2.633    ***
     Failure Surface Specified By  6 Coordinate Points
       Point       X-Surf       Y-Surf
        No.         (ft)         (ft)
         1         145.31       124.40
         2         164.37       118.34
         3         184.36       117.75
         4         203.74       122.67
         5         221.03       132.72
         6         230.69       142.75
     Circle Center At X =  176.5 ; Y =  189.5  and Radius,   72.1
          ***      2.635    ***
     Failure Surface Specified By  6 Coordinate Points
       Point       X-Surf       Y-Surf
        No.         (ft)         (ft)
         1         145.31       124.40
         2         164.48       118.72
         3         184.48       118.32
         4         203.87       123.23
         5         221.26       133.10
         6         231.03       142.84
     Circle Center At X =  176.0 ; Y =  192.7  and Radius,   74.9
          ***      2.635    ***
     Failure Surface Specified By  6 Coordinate Points
       Point       X-Surf       Y-Surf
        No.         (ft)         (ft)
         1         144.08       124.37
         2         163.37       119.07
         3         183.37       118.76
         4         202.81       123.45
         5         220.47       132.83
```

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    6        231.56       142.97
Circle Center At X =  174.6 ; Y =  197.8  and Radius,   79.5
     ***     2.642   ***
Failure Surface Specified By  6 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        144.08       124.37
    2        162.90       117.58
    3        182.87       116.49
    4        202.31       121.18
    5        219.58       131.26
    6        230.19       142.63
Circle Center At X =  176.6 ; Y =  185.1  and Radius,   68.9
     ***     2.643   ***
Failure Surface Specified By  6 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        141.63       124.29
    2        160.32       117.16
    3        180.26       115.64
    4        199.81       119.88
    5        217.34       129.50
    6        230.35       142.67
Circle Center At X =  175.5 ; Y =  184.9  and Radius,   69.5
     ***     2.644   ***
Failure Surface Specified By  7 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        136.74       124.14
    2        155.21       116.47
    3        175.06       114.10
    4        194.82       117.19
    5        213.00       125.53
    6        228.24       138.49
    7        231.18       142.88
Circle Center At X =  173.7 ; Y =  187.1  and Radius,   73.1
     ***     2.658   ***
Failure Surface Specified By  5 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        158.78       124.81
    2        178.62       122.33
    3        198.46       124.85
    4        217.05       132.22
    5        232.00       143.08
Circle Center At X =  178.5 ; Y =  202.2  and Radius,   79.9
     ***     2.659   ***
```

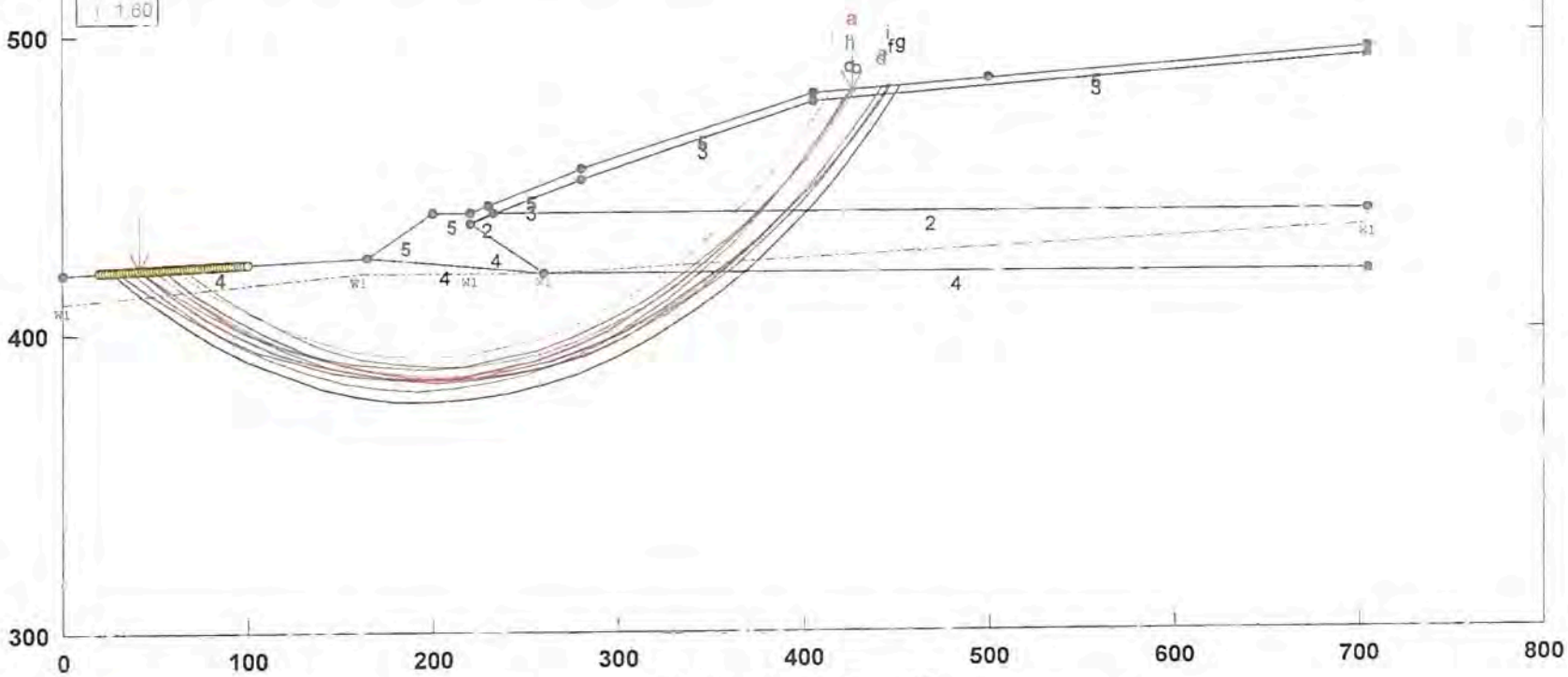
IPL Ash Pond C - Max.Slope Above Berm -Earthquake Load Analysis - Circular

c:\slope b\ipl circ pondc eq0.13g 072414.pl2 Run By: Username 7/24/2014 10:31AM

#	FS
a	1.60
b	1.60
c	1.60
d	1.60
e	1.60
f	1.60
g	1.60
h	1.60
i	1.60
j	1.60

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Geomem	1	65.0	70.0	0.0	18.0	W1
PondAsh	2	83.0	100.0	0.0	30.0	W1
CompAsh	3	83.0	100.0	0.0	32.0	W1
NatSoil	4	115.0	125.0	50.0	27.0	W1
CompSoil	5	110.0	120.0	100.0	28.0	W1

Load	Value
Horiz Eqk	0.130 g<



STABL6H FSmin=1.60

Safety Factors Are Calculated By The Modified Bishop Method

STED

** STABL6H **
by
Purdue University
--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer's Method of Slices

Run Date: 7/24/2014
Time of Run: 10:31AM
Run By: Username
Input Data Filename: C:ipl circ pondc eq0.13g 072414.in
Output Filename: C:ipl circ pondc eq0.13g 072414.OUT
Plotted Output Filename: C:ipl circ pondc eq0.13g 072414.PLT
PROBLEM DESCRIPTION IPL Ash Pond C - Max.Slope Above Berm - Earthquake Load Analysis - Circular

BOUNDARY COORDINATES
Note: User origin value specified.
Add 0.00 to X-values and 300.00 to Y-values listed.

6 Top Boundaries
14 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	120.00	165.00	125.00	4
2	165.00	125.00	200.00	140.00	5
3	200.00	140.00	220.00	140.10	5
4	220.00	140.10	280.00	155.00	5
5	280.00	155.00	405.00	180.00	5
6	405.00	180.00	705.00	195.00	5
7	220.00	137.00	280.00	152.00	3
8	280.00	152.00	405.00	177.00	3
9	405.00	177.00	705.00	192.00	3
10	220.00	137.00	233.00	140.00	2
11	233.00	140.00	705.00	140.00	2
12	220.00	136.90	260.00	120.00	4
13	260.00	120.00	705.00	120.00	4
14	165.00	125.00	260.00	120.00	4

ISOTROPIC SOIL PARAMETERS
5 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	65.0	70.0	0.0	18.0	0.00	0.0	1
2	83.0	100.0	0.0	30.0	0.00	0.0	1
3	83.0	100.0	0.0	32.0	0.00	0.0	1
4	115.0	125.0	50.0	27.0	0.00	0.0	1
5	110.0	120.0	100.0	28.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED
Unit Weight of Water = 62.40
Piezometric Surface No. 1 Specified by 5 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	110.00
2	160.00	120.00
3	220.00	120.00
4	260.00	120.00
5	705.00	135.00

A Horizontal Earthquake Loading Coefficient
Of0.130 Has Been Assigned
A Vertical Earthquake Loading Coefficient
Of0.000 Has Been Assigned
Cavitation Pressure = 0.0 psf
A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.
2500 Trial Surfaces Have Been Generated.
50 Surfaces Initiate From Each Of 50 Points Equally Spaced
Along The Ground Surface Between X = 20.00 ft.
and X = 100.00 ft.

Each Surface Terminates Between X = 230.00 ft.
and X = 500.00 ft.
Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.
20.00 ft. Line Segments Define Each Trial Failure Surface.
Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.
* * Safety Factors Are Calculated By The Modified Bishop Method * *
Failure Surface Specified By 22 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	41.22	121.25
2	59.32	112.72
3	77.89	105.29
4	96.87	98.99
5	116.19	93.84
6	135.79	89.85
7	155.59	87.04
8	175.53	85.43
9	195.52	85.01
10	215.51	85.79
11	235.41	87.77
12	255.16	90.93
13	274.68	95.27
14	293.91	100.77
15	312.77	107.42
16	331.21	115.18
17	349.14	124.03
18	366.51	133.94
19	383.26	144.88
20	399.32	156.79
21	414.64	169.65
22	426.72	181.09

Circle Center At X = 192.5 ; Y = 418.8 and Radius, 333.8
*** 1.595 ***
Failure Surface Specified By 22 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	41.22	121.25
2	59.60	113.34
3	78.38	106.49
4	97.53	100.70
5	116.97	96.01
6	136.65	92.42
7	156.49	89.95
8	176.45	88.60
9	196.45	88.38
10	216.43	89.28
11	236.32	91.32
12	256.07	94.47
13	275.61	98.73
14	294.88	104.09
15	313.82	110.53
16	332.36	118.03
17	350.45	126.56
18	368.03	136.10
19	385.04	146.61
20	401.43	158.07
21	417.15	170.44
22	429.37	181.22

Circle Center At X = 190.4 ; Y = 442.6 and Radius, 354.2
*** 1.597 ***
Failure Surface Specified By 23 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	37.96	121.15

2	55.76	112.04
3	74.10	104.06
4	92.90	97.24
5	112.09	91.60
6	131.60	87.18
7	151.34	83.98
8	171.24	82.02
9	191.23	81.30
10	211.22	81.83
11	231.14	83.61
12	250.92	86.63
13	270.46	90.88
14	289.70	96.33
15	308.56	102.98
16	326.97	110.79
17	344.86	119.74
18	362.16	129.78
19	378.79	140.89
20	394.70	153.01
21	409.82	166.10
22	424.10	180.11
23	424.90	180.99

Circle Center At X = 192.7 ; Y = 401.6 and Radius, 320.3
*** 1.598 ***
Failure Surface Specified By 23 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	49.39	121.50
2	67.42	112.85
3	85.93	105.28
4	104.86	98.82
5	124.14	93.49
6	143.70	89.31
7	163.47	86.30
8	183.38	84.46
9	203.37	83.80
10	223.37	84.33
11	243.29	86.04
12	263.09	88.92
13	282.67	92.97
14	301.98	98.17
15	320.95	104.51
16	339.52	111.95
17	357.60	120.48
18	375.16	130.07
19	392.11	140.68
20	408.41	152.27
21	423.99	164.81
22	438.81	178.24
23	442.36	181.87

Circle Center At X = 204.5 ; Y = 421.7 and Radius, 337.9
*** 1.598 ***
Failure Surface Specified By 23 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	49.39	121.50
2	67.56	113.15
3	86.19	105.86
4	105.20	99.66
5	124.54	94.56
6	144.14	90.58
7	163.94	87.73
8	183.86	86.03
9	203.86	85.48
10	223.85	86.08
11	243.77	87.83
12	263.56	90.72

13	283.15	94.75
14	302.48	99.89
15	321.48	106.14
16	340.08	113.48
17	358.24	121.87
18	375.88	131.29
19	392.95	141.71
20	409.39	153.10
21	425.15	165.41
22	440.18	178.61
23	443.54	181.93

Circle Center At X = 203.4 ; Y = 432.9 and Radius, 347.5

*** 1.598 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	29.80	120.90
2	48.11	112.87
3	66.82	105.80
4	85.87	99.72
5	105.22	94.64
6	124.80	90.57
7	144.57	87.54
8	164.47	85.54
9	184.45	84.58
10	204.45	84.67
11	224.41	85.80
12	244.29	87.98
13	264.04	91.18
14	283.58	95.42
15	302.88	100.67
16	321.88	106.92
17	340.53	114.15
18	358.77	122.35
19	376.56	131.48
20	393.85	141.54
21	410.59	152.48
22	426.74	164.29
23	442.24	176.91
24	448.03	182.15

Circle Center At X = 192.8 ; Y = 467.4 and Radius, 382.9

*** 1.598 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	26.53	120.80
2	44.39	111.80
3	62.72	103.80
4	81.46	96.82
5	100.56	90.89
6	119.96	86.03
7	139.60	82.24
8	159.42	79.54
9	179.35	77.94
10	199.35	77.44
11	219.34	78.05
12	239.27	79.76
13	259.07	82.57
14	278.68	86.47
15	298.06	91.45
16	317.12	97.48
17	335.83	104.57
18	354.11	112.67
19	371.92	121.77
20	389.20	131.84
21	405.90	142.85
22	421.96	154.76

23	437.34	167.55
24	451.99	181.16
25	453.20	182.41

Circle Center At X = 198.3 ; Y = 439.5 and Radius, 362.0
*** 1.599 ***
Failure Surface Specified By 21 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	65.71	121.99
2	83.86	113.59
3	102.51	106.36
4	121.59	100.36
5	141.01	95.59
6	160.70	92.08
7	180.58	89.85
8	200.56	88.90
9	220.55	89.24
10	240.49	90.86
11	260.28	93.76
12	279.84	97.93
13	299.09	103.35
14	317.95	110.00
15	336.35	117.84
16	354.20	126.86
17	371.44	137.00
18	387.99	148.23
19	403.78	160.50
20	418.75	173.77
21	425.97	181.05

Circle Center At X = 205.3 ; Y = 399.6 and Radius, 310.7
*** 1.600 ***
Failure Surface Specified By 23 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	54.29	121.65
2	72.38	113.11
3	90.94	105.66
4	109.90	99.31
5	129.21	94.09
6	148.79	90.01
7	168.57	87.09
8	188.50	85.34
9	208.49	84.77
10	228.48	85.37
11	248.40	87.14
12	268.18	90.08
13	287.76	94.19
14	307.06	99.43
15	326.01	105.80
16	344.57	113.28
17	362.64	121.83
18	380.19	131.43
19	397.14	142.05
20	413.44	153.64
21	429.02	166.17
22	443.84	179.60
23	446.26	182.06

Circle Center At X = 208.3 ; Y = 424.7 and Radius, 340.0
*** 1.600 ***
Failure Surface Specified By 21 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	60.82	121.84
2	79.22	114.00
3	98.07	107.33
4	117.30	101.85
5	136.84	97.58

6	156.61	94.55
7	176.53	92.75
8	196.52	92.20
9	216.51	92.91
10	236.42	94.86
11	256.16	98.06
12	275.66	102.48
13	294.85	108.11
14	313.65	114.93
15	331.99	122.92
16	349.79	132.03
17	366.99	142.25
18	383.52	153.51
19	399.30	165.79
20	414.29	179.03
21	415.80	180.54

Circle Center At X = 195.3 ; Y = 411.9 and Radius, 319.7

*** 1.600 ***