SAFETY FACTOR ASSESSMENT PERIODIC 5-YEAR REVIEW

OAC 252:517-11-4(e)

Bottom Ash Pond

Northeastern 3&4 Power Station
Oologah, Oklahoma

October, 2021

Prepared for: Public Service Company of Oklahoma – Northeastern 3&4 Power Station

Oologah, Oklahoma

Prepared by: American Electric Power Service Corporation

1 Riverside Plaza

Columbus, OH 43215

Document ID: GERS-21-040

SAFETY FACTOR ASSESSMENT
PERIODIC 5-YEAR REVIEW
OAC 252:517-11-4(e)
NORTHEASTERN 3&4 POWER STATION
BOTTOM ASH POND

Document ID: GERS-21-040

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GARY F. ZYCH
No. 28771
OKLAHOMA
9/30/2021

I certify to the best of my knowledge, information, and belief that the information contained in this safety factor assessment meets the requirements of OAC 252:517-11-4(e)

SAFETY FACTOR ASSESSMENT
PERIODIC 5-YEAR REVIEW
NORTHEASTERN 3&4 POWER STATION
BOTTOM ASH POND

Table of CONTENTS

1.0 OBJECTIVE 4

2.0 DESCRIPTION OF THE CCR UNIT 4

3.0 SAFETY FACTOR ASSESSMENT OAC 252:517-11-4(e).......... 4

Attachment A

▪Initial Safety Factor Assessment, October 2016

1.0 OBJECTIVE

This report was prepared by AEP- Geotechnical Engineering Services (GES) section to fulfill requirements of OAC 252:517-11-4(e) for the safety factor assessment of CCR surface impoundments. This is the first periodic 5-year review of the safety factor assessment.

2.0 DESCRIPTION OF THE CCR UNIT

The Northeastern 3&4 Power Station is located near the City of Oologah, Rogers County, Oklahoma. It is owned and operated by Public Service Company of Oklahoma (PSO). The facility operates one surface impoundment for storing CCR called the Bottom Ash Pond.

The embankment is about 4,200 feet long, encompassing about 72 acres with about 34 acres of surface water. The dam crest gradually increases in elevation from about 630 feet-msl at the north berm east of the auxiliary spillway, to about elevation 639 feet-msl at the south berm where it meets the coal storage area on the east side. The embankment was constructed across a first order tributary to Fourmile Creek leaving the site to the south where the embankment is at its highest, 38 feet from the crest to the toe of the dam. A railroad track extends the length of the crest, typically used to remove empty coal cars from the site.

3.0 SAFETY FACTOR ASSESSMENT OAC 252:517-11-4(e)

The periodic 5-year review was conducted to evaluate if any physical changes have been made to the earthen dam and/or operating changes that could impact the loading on the structure. The assumptions, material properties and operating pools defined in the initial assessment were reviewed. The review concluded that there have been no changes to the structure (e.g. materials, geometry, operating condition, etc.) that would impact the stability analyses that were previously conducted. Therefore, the previous report and analyses included in Attachment A are still applicable to the current condition of the facility.

The results indicate that the calculated factors of safety meet or exceed the minimum values defined in Section OAC 252:517-11-4(e)

ATTACHMENT A

PERIODIC SAFETY FACTOR ASSESSMENT

CFR 257.73(e)(1)

Bottom Ash Pond

Northeastern 3&4 Power Station
Oologah, Oklahoma

October, 2016

Prepared for: Public Service Company of Oklahoma – Northeastern 3&4 Power Station

Oologah, Oklahoma

Prepared by: American Electric Power Service Corporation

1 Riverside Plaza

Columbus, OH 43215

Document ID: GERS-16-030

BOTTOM ASH POND AT
NORTHEASTERN 3 & 4 POWER STATION
ROGERS COUNTY, OK

PREPARED BY Leilah Saadi **DATE** 9/9/2016
M. Leilah Saadi, E.I.T.

REVIEWED BY M. A. Ajlouni **DATE** 9/19/2016
Mohammad A. Ajlouni, Ph.D.,P.E.

APPROVED BY Gary F. Zych **DATE** 9/20/2016
Gary F. Zych, P.E.
Manager – AEP Geotechnical Engineering

Gary F. Zych

LICENSED PROFESSIONAL ENGINEER
GARY F. ZYCH
No. 28771
OKLAHOMA

9/20/2016

PROFESSIONAL ENGINEER

SEAL & SIGNATURE

I certify to the best of my knowledge, information, and belief that the information contained in this the safety factor assessment meets the requirements of 40 CFR 257.73(e)

BOTTOM ASH POND
INITIAL SAFETY FACTOR ASSESMENT
NORTHEASTERN 3 & 4 POWER STATION
ROGERS COUNTY, OK

TABLE OF CONTENTS

INTRODUCTION 1

PROJECT INFORMATION 1

PREVIOUS SLOPE STABILITY ANALYSES 2

SLOPE STABILITY ANALYSIS 2

  Railroad Loading Analysis 2

  Soil Parameters 3

  Reservoir Elevations 3

  Seismic Loading 4

SLOPE STABILITY ANALYSIS RESULTS 4

CONCLUSIONS 5

REFERENCES 6

LIST OF FIGURES

Figure 1 – Location Map
Figure 2 – NE Bottom Ash Pond Embankment Model
Figure 3 - Interactive Deaggregations from USGS Geological Hazards Science Center
Figure 4 – “Response of Soil Sites During Earthquakes”
Figure 5 – Slope Stability Analysis – Static Load
Figure 6 - Slope Stability Analysis – Maximum Pool Load
Figure 7- Slope Stability Analysis – Seismic Load

APPENDICIES

Appendix A – Site Characterization Report
Appendix B– Hydrologic Analysis

INTRODUCTION

In April of 2015, the US EPA formally published national regulations for disposal of coal combustion residuals (CCR) from electric facilities. As part of the rule, the owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that aspects of the CCR impoundments are in accordance with the rules. This report provides the documentation needed to fulfill the requirements of 40 CFR § 257.73(e), *Periodic Safety Factor Assessments*. AEPSC (American Electric Power Service Corporation) Civil Engineering has performed a slope stability analysis of the dam impounding the bottom ash pond at the Northeastern 3&4 Power Station.

PROJECT INFORMATION

The Northeastern 3&4 Power Station, shown in Figure 1, is located in Rogers County, near Oologah, Oklahoma. The Bottom Ash Pond, put into service in 1979, is located south-west of the generating plant. See the information listed below for specific details of the bottom ash pond size specifications and location.

<u>GENERAL INFORMATION</u>

Dam or Reservoir:	Bottom Ash Pond at Northeastern 3&4 Power Station
Owner:	Public Service Company of Oklahoma
Type of Dam:	Earth Embankment Structure
Date of Construction:	1979

<u>LOCATION</u>

County:	Rogers County
General Location:	Approximately 22 miles north-northeast of Tulsa, OK
Stream and Basin:	Unnamed tributary to Fourmile Creek; Verdigris River Basin

<u>SIZE</u>

Dam Crest Elevation:	~ 630 feet-MSL (low point near emergency spillway)
Emergency Spillway:	625.0 feet-MSL
Crest Elevation:	628 feet - MLS
Height[1]:	~ 29.5 feet
Surface Area:	~34 acres current open water, 70 acres original design

*Notes: 1. Estimated from construction drawings

PREVIOUS SLOPE STABILITY ANALYSES

Two previous slope stability analyses were conducted on the Northeastern 3&4 Station Bottom Ash Pond embankment. The first report, entitled Final Geotechnical Investigation and Stability Evaluation of Bottom Ash Pond was completed by Standard Testing and Engineering Company in 2010. The second report is titled Bottom Ash Pond At Northeastern 3&4 Power Station, Rogers County OK, dated April 25, 2012, prepared by AEPSCAmerican Electric Power Service Corporation Civil Engineering Department (AEPSC). The analysis within this report supplements and supersedes the previous two reports. Limited data from the previous two analyses were used.

SLOPE STABILITY ANALYSIS

Slope stability analyses were performed to document that the existing conditions fulfill the requirements of 40 CFR § 257.73(e), *Periodic Safety Factor Assessments*. The following factors of safety requirements were evaluated.

1. The calculated static factor of safety under long-term, maximum storage pool loading condition must equal or exceed 1.50
2. The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.
3. The calculated seismic factor of safety must equal or exceed 1.00
4. For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20

Slope stability safety factors were determined using SLOPE/W by Geo-Slope International. The information provided by the soil boring investigation, and original construction drawings were used to create a representative embankment cross section to input into the program. The embankment model incorporated soil/rock layer configurations, reservoir elevations, phreatic surface elevation, material engineering properties, and surcharge loadings. Mohr-Coulomb failure criterion was assumed for the material and limit equilibrium theory to solve for both force and moment. Seismic analysis was performed based on the pseudo-static slope stability approach using modified peak horizontal ground accelerations.

Figure 2 shows the embankment model as drawn in Geo Studio Sloe/W. The modeled configuration for the embankment including the soil layers, the railroad subballast, ballast, the estimated phreatic surface and railroad surcharge load are shown. The geometry displayed within this model was incorporated into both the static and seismic slope stability analyses.

RAILROAD LOADING ANALYSIS

The maximum live load applied by stationary railroad engines at the crest of the dam was incorporated into both the static and seismic analyses. The uniform maximum live load of 20,000 pounds per foot of rail, derived from the alternate live load on four axles in the AREMA Manual for Railway Engineering, 2014, was applied over the 8.5-foot length of railroad tie resulting in uniform surcharge load of 2.353 kips per foot of railroad tie. For this analysis the derived uniform surcharge load was portrayed as a uniform load that is evenly distributed over a distance of 8.5ft and is applied directly to the ballast and subballast layers of material. The ballast and subballast layers were assigned material properties that are typical for the uniformly graded coarse to fine angular gravel and well-graded sand and gravel materials specified in the original construction documents, respectively (internal friction angles of 42 and 38 degrees, respectively, with no cohesion).

SOIL PARAMETERS

Soil parameters used were based on the soil boring investigation report, See Appendix A. In 2010, a previous soil investigation was completed for the previous factor of safety analyses and it was apparent that the soil within the embankment was similar throughout. Therefore it was determined that one soil boring at the most critical section of the dam will provide an accurate representation of the embankment materials. The location of the single soil boring, shown in Figure -1 was selected based on the determination that the selected location is the most critical section of the dam. Laboratory testing was completed on this single soil boring for precise soil parameters for the analysis. The investigation shows clayey soil material until reaching limestone bedrock at a depth of 25ft, where drilling was terminated. The limestone bedrock was treated as an impenetrable material where augering refusal was reached. Table 1 summarizes the soil layers and the soil parameters used.

Table 1 – Material Parameters

Material Layer	Unit Weight (pcf)	Cohesion (psf)	Friction Angle (deg)	Source of Data
Ballast	130	0	42	Construction Drawings
Subballast	130	0	38	Construction Drawings
Fat Clay	130	312	21.6	Soil boring investigation
Fat Clay	126	662	18.1	Soil boring investigation
Limestone Bedrock	IP	IP	IP	N/A

Notes: N/A – Not Applicable, IP- Impenetrable material

RESERVOIR ELEVATIONS

The elevation of the reservoir for the long-term storage pool loading and the surcharge pool loading condition were taken from previous analyses and the Hydrologic Analysis, Appendix B. Information gathered by two piezometers, located at the crest of the dam and at the toe of the dam, allowed the simulation of the phreatic surface within the embankment. The long-term pool elevation of 624 feet-msl was used for the static and seismic stability analysis. The surcharge maximum pool level of 628.2 feet-msl was based on the Design Storm (40% PMF) Peak Stage elevation.

SEISMIC LOADING

The procedure below describes determination of the acceleration coefficient used in the SLOPE/W:

1. The 2%, 50-year statistical analysis was used to obtain the Peak Ground Acceleration at the rock interface (PGA_{rock}). Using the USGS deaggregation tool located at http://geohazards.usgs.gov/deaggint/2008/
   See Figure 3. The PGA_{rock} value for this site was 0.05540g.

2. The PGA_{rock} was adjusted to account for earthquake magnitude amplification through the overlying soils/embankment materials. The adjusted PGA ($PGA_{adjusted}$) was determined from Idriss, (1990), "Response of Soft Soil Sites During Earthquakes,", see Figure 4.
   Based on this figure the the $PGA_{adjusted}$ is 0.13g.

3. The earthquake acceleration “a,” is determined based on the $PGA_{adjusted}$ using this equation:
   a = 0.5* $PGA_{adjusted}$ = 0.5*0.13g
   Therefore, a = 0.065g.

4. The pseudo-static coefficient, “k,” is then input into the SLOPE/W program to model the effects of seismic loading. The pseudo-static coefficient is represented by the following equation:
   $k = \frac{a}{g} = \frac{0.065g}{g} = 0.065$

SLOPE STABILITY ANALYSIS RESULTS

A summary of the resulting factors of safety against failure, along with the corresponding required minimum values for each of the supplemental analyses is presented in the following table. Per each condition there is a correlating Figure produced from SLOPE/W displaying the grid of modeled potential failure arc centers, and the area of potential failure arc tangents, and the final factor of safety.

The fourth CCR Rule requirement called for a calculation of the liquefaction factor of safety of embankment soils that are susceptible to liquefaction. The boring log shows the embankment is constructed of compacted clayey soils that are not susceptible to liquefaction. Therefore, a liquefaction factor of safety analysis was not performed.

Table -2 Summary of Supplemental Stability Analysis Results

Slope Stability Case	Minimum Factor of Safety from Slope Stability Analysis	Required Minimum Factor of Safety (257.73e)	Figure
Long-Term, Maximum Storage Pool Loading	1.618	1.50	Figure-5
Maximum Surcharge Pool Loading	1.618	1.40	Figure-6
Seismic	1.481	1.00	Figure-7
Liquefaction	N/A	1.20	N/A

CONCLUSIONS

Based on the analyses performed, it is the conclusion that the subject impoundment dikes satisfy all minimum slope stability factors of safety values required by the CCR rules.

REFERENCES

Documents reviewed for this evaluation include:

- Slope Stability Analysis Report Bottom Ash Pond at Northeastern 3&4 Power Station Rogers County, OK. Prepared by AEPSC (American Electric Power Service Corporation) Civil Engineering, Geotechnical Engineering Section. Columbus, OH 43215. April 25, 2012.
- Final Geotechnical Investigation and Stability Evaluation of Bottom Ash Pond AEP Northeastern Station Units 3&4 Oologah, Oklahoma Standard Testing Project No 8309-3150Prepared by Standard Testing and Engineering Company Oklahoma City, Oklahoma. March 11,2010.
- Site Characterization Report Northeastern Power Station, Bottom Ash Pond Oolagah, Oklahoma Terracon Project No. 04155186. Prepared by Terracon Consultants, Inc. Tulsa, Oklahoma. January 18, 2016.
- Inspection Report For Bottom Ash Pond at Northestern 3&4 Station, Rogers County, OK. Prepared by Golder Associates Inc. Atlanta GA. September 29, 2015.
- Hydrologic Analysis of Northeaster 3&4 Power Station Bottom Ash Pond American Electric Power Company. Prepared by Freese and Nichols, Inc. Fort Worth Texas. May 2011

FIGURES

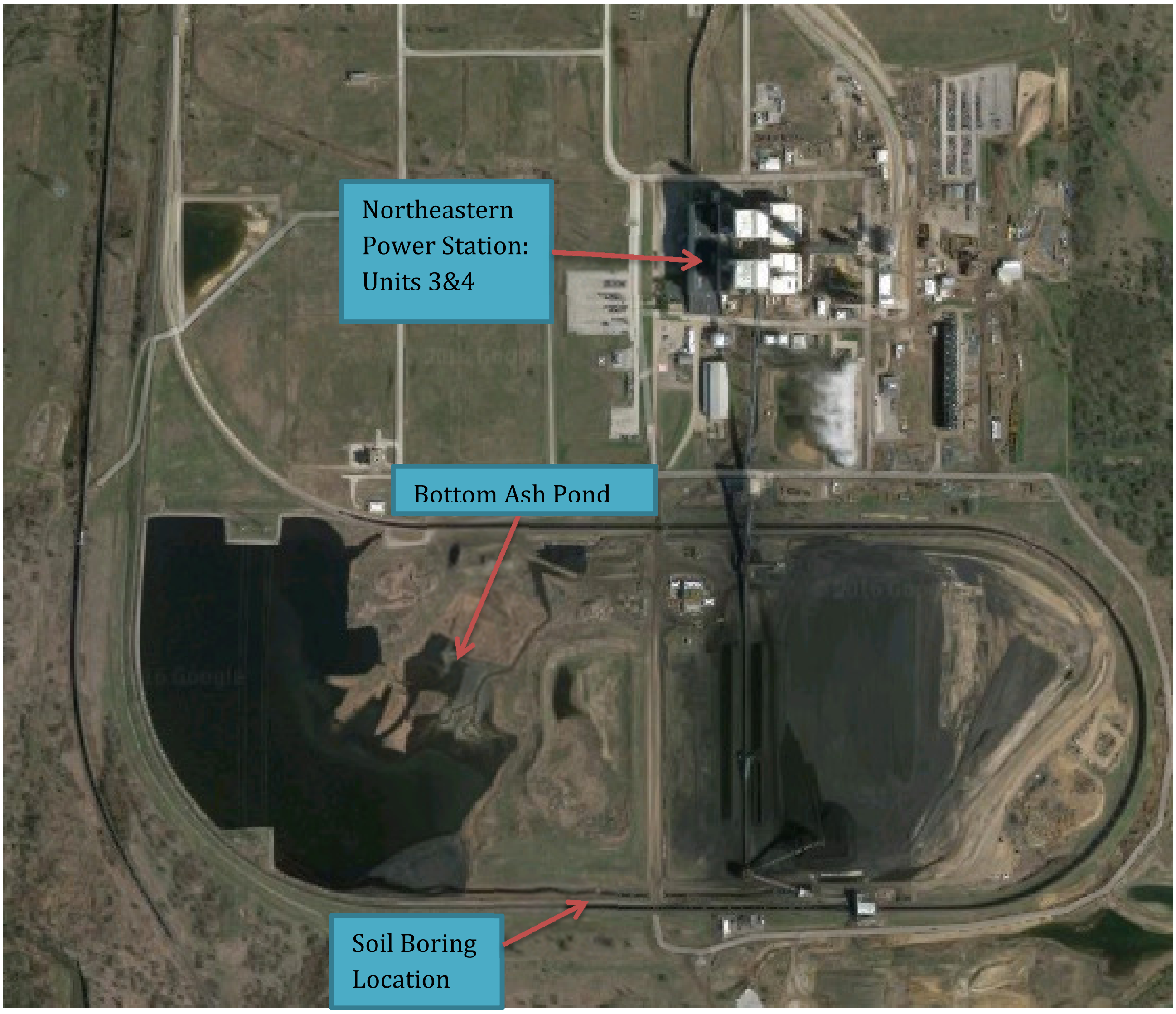


Figure-1 Northeastern Power Station Bottom Ash Pond

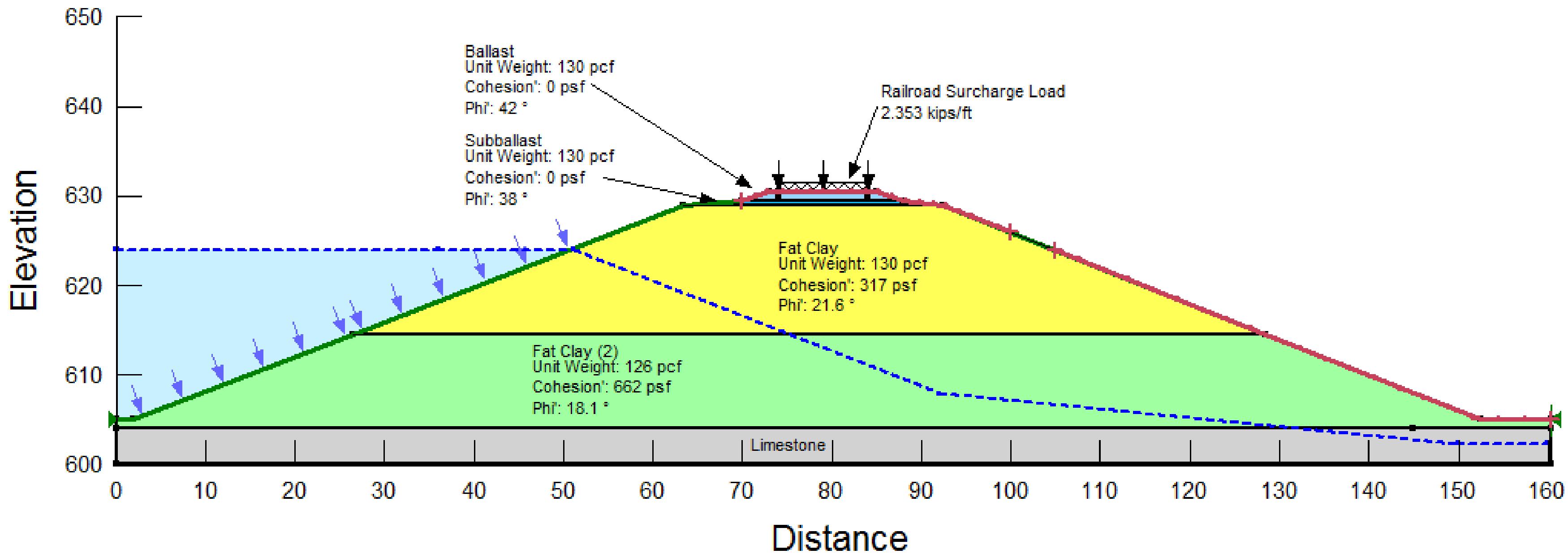


Figure-2 Bottom Ash Pond Embankment Model from SLOPE/W by Geo-Slope International.

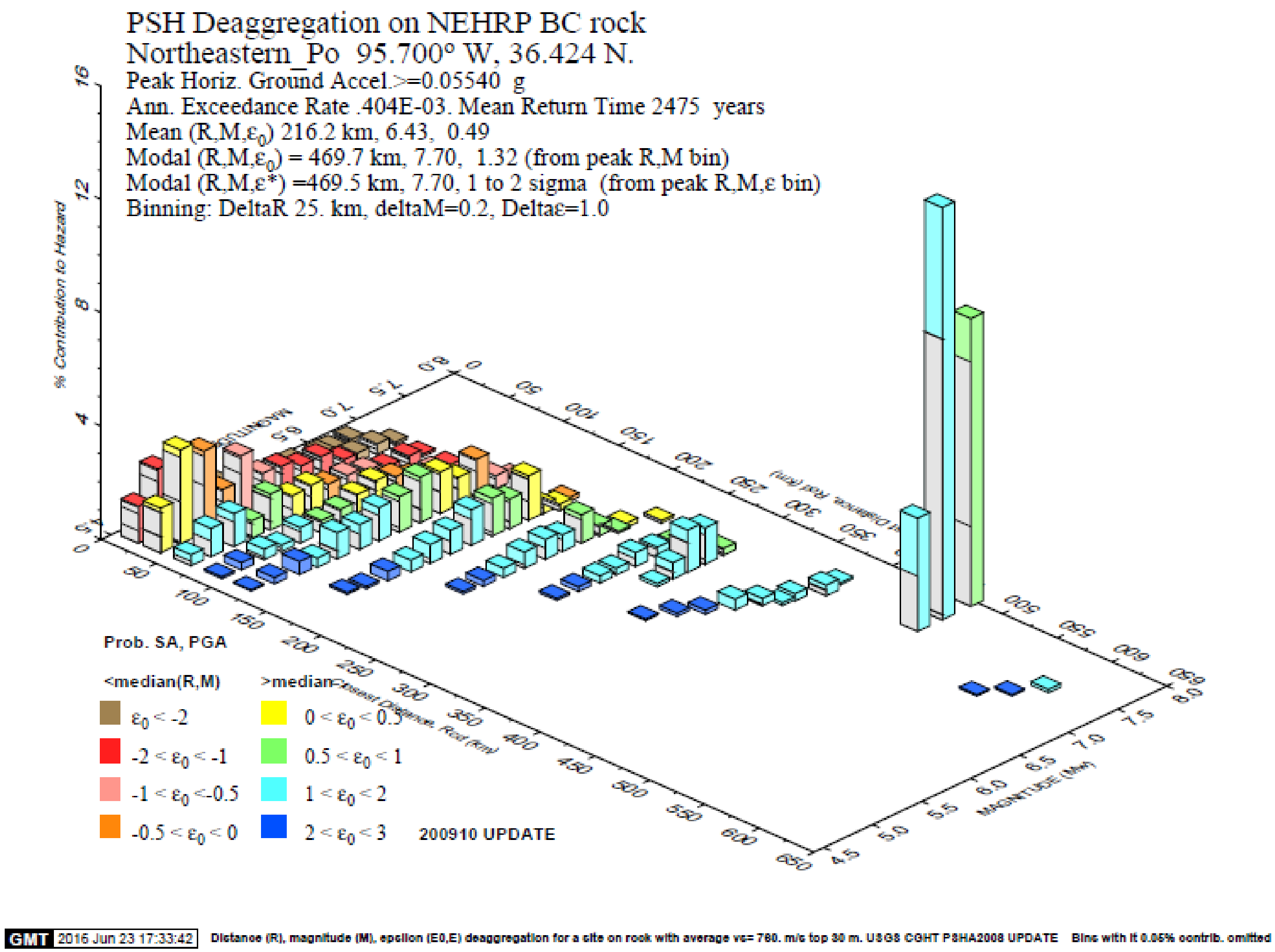


Figure-3 Interactive Deaggregations from USGS Geological Hazards Science Center

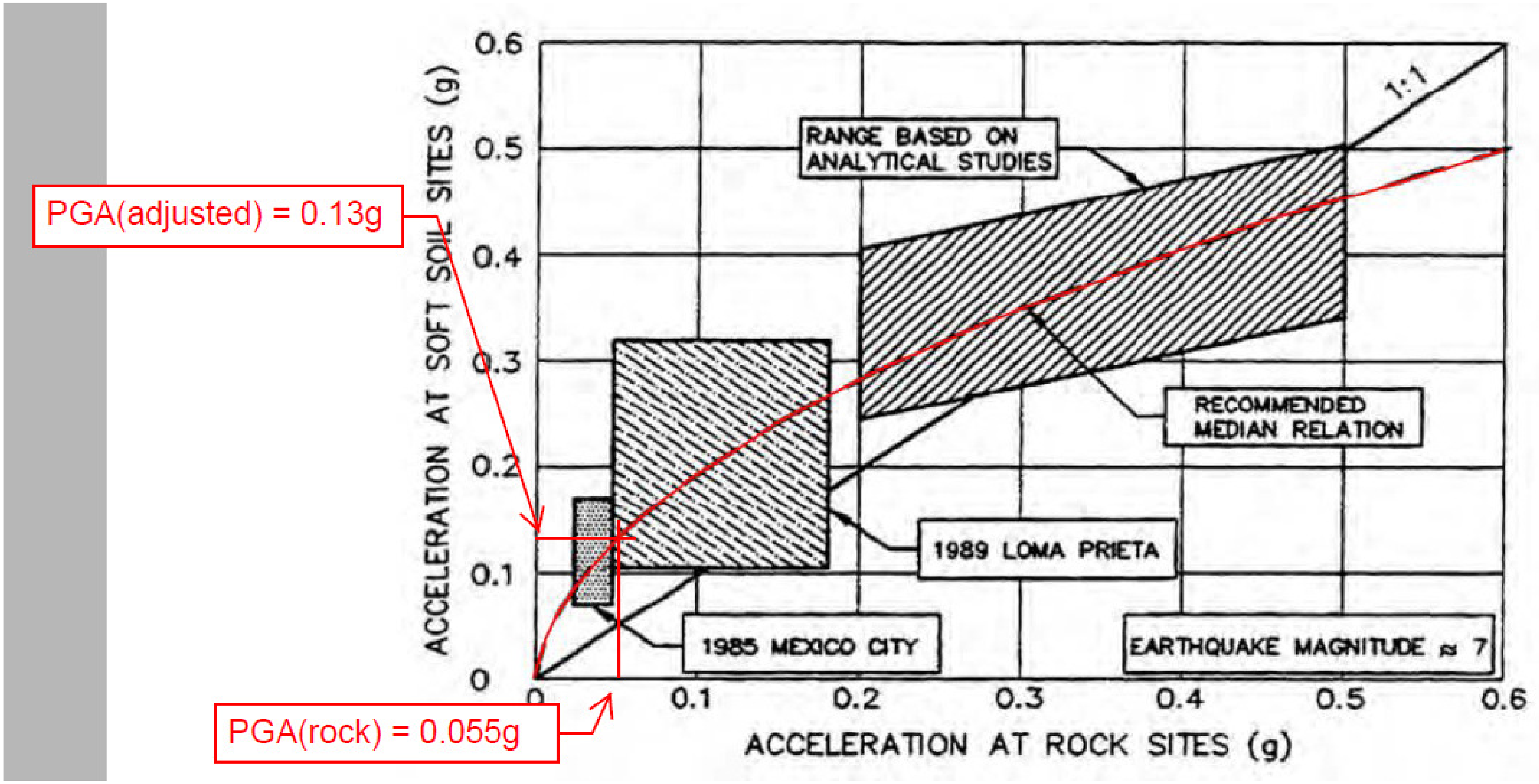


Figure-4 From Idriss, I.M. (1990), "Response of Soft Soil Sites During Earthquakes," Proc. Memorial Symposium to Honor Professor H.B. Seed, Berkeley, California.

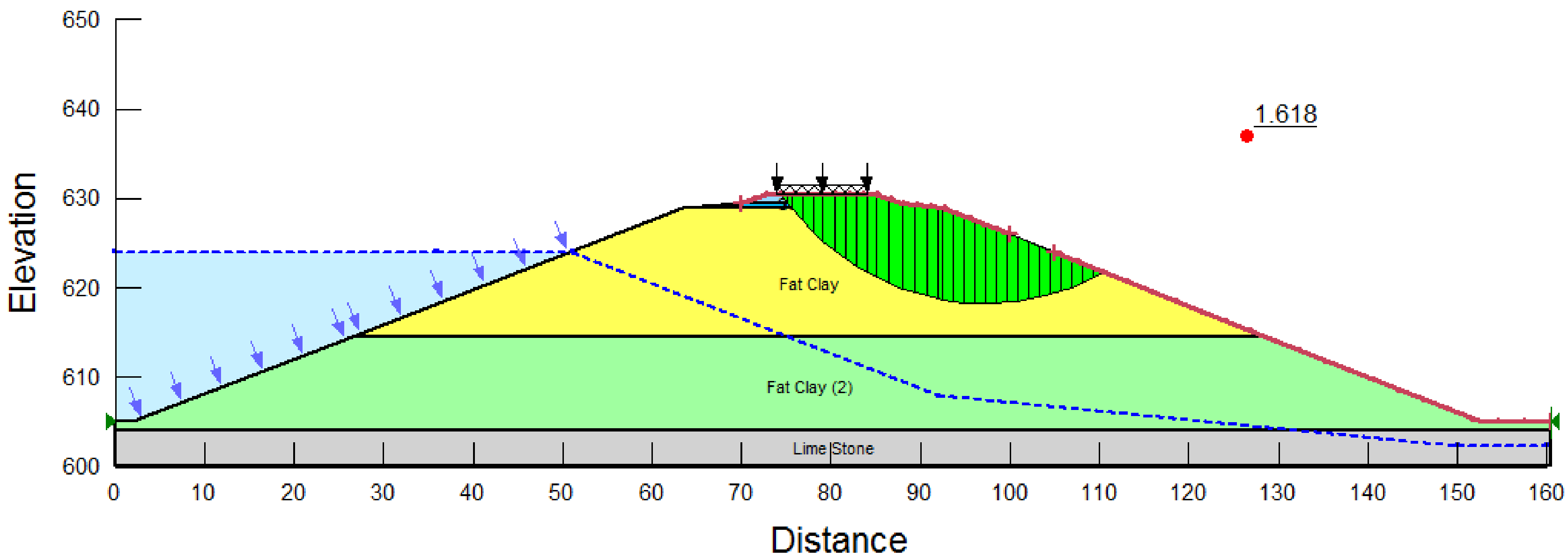


Figure-5 Critical section of dam showing simulated critical failure surface with static load and long-term storage pool loading demonstrating a factor of safety of 1.618.

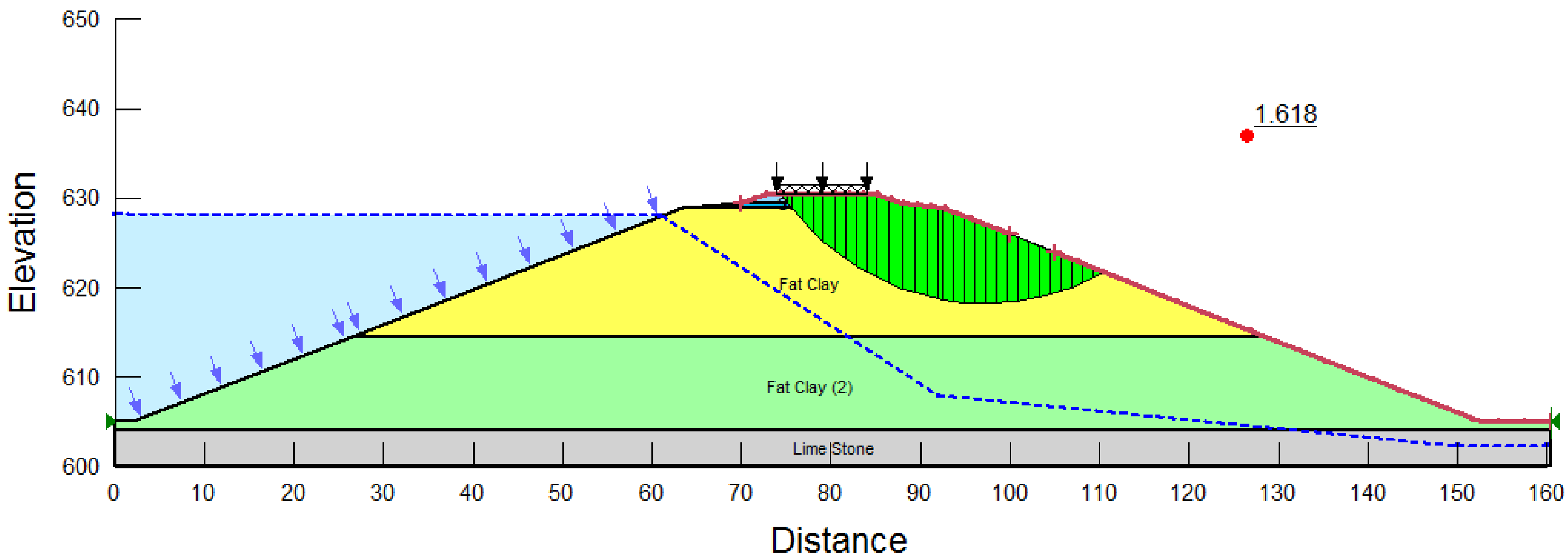


Figure-6 Critical section of dam showing simulated critical failure surface with static load and maximum surcharge pool loading demonstrating a factor of safety of 1.618.

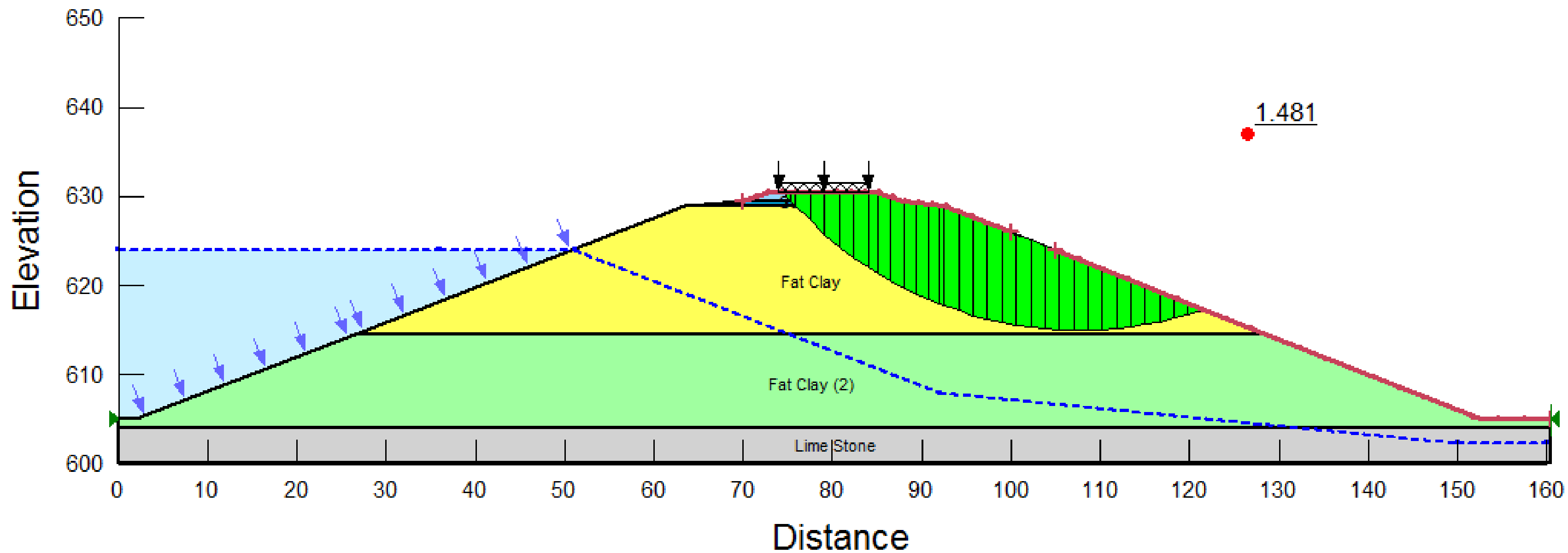


Figure-7 Critical section of dam showing simulated critical failure surface with .065g seismic load and a factor of safety of 1.481.

APPENDICIES

APPENDIX A

Site Characterization Report

Site Characterization Report

Northeastern Power Station, Bottom Ash Pond
Oolagah, Oklahoma
January 18, 2016
Terracon Project No. 04155186

Prepared for:
American Electric Power
Columbus, Ohio

Prepared by:
Terracon Consultants, Inc.
Tulsa, Oklahoma

January 18, 2016

Terracon

American Electric Power (AEP)
1 Riverside Plaza
Columbus, Ohio 43215

Attn: Mr. Mohammed A. Ajlouni, Ph.D., P.E.
Civil/ Geotechnical Engineering
P: (614) 716-2939
E: maajlouni@aep.com

Re: Site Characterization Report
Northeastern Power Station, Bottom Ash Pond
Oolagah, Oklahoma
Terracon Project No. 04155186

Dear Mr. Ajlouni:

Terracon Consultants, Inc. (Terracon) has completed the drilling and testing services for the Northeastern Power Station, Bottom Ash Pond in Oolagah, Oklahoma. Our services were performed in general accordance with Terracon Proposal No. PN4150555 dated September 23, 2015. This report presents a brief description of our services and includes a site location map, boring location plan, a boring log, and laboratory test results.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.
Cert. of Auth. #CA-4531 exp. 6/30/17

Saba M. Gebretsadik
Staff Geotechnical Engineer

REGISTERED PROFESSIONAL ENGINEER
BRADLEY MARK WATTS
16526
OKLAHOMA
1/18/16

Bradley M. Watts, P.E.
Oklahoma No: 16526

SMG:BMW:lo
Enclosures
Addressee (1 via US Mail and 1 via email)

TABLE OF CONTENTS

Page

1.0 BORING LAYOUT 1
2.0 DRILLING 1
3.0 SAMPLING 1
4.0 LABORATORY TESTING 2
5.0 BORING LOG 2

APPENDIX A – FIELD EXPLORATION
Exhibit A-1 Site Location Map
Exhibit A-2 Boring Location Plan
Exhibit A-3 Boring Log

APPENDIX B – LABORATORY TEST RESULTS
Exhibit B-1 Grain Size Distribution Curves
Exhibit B-1 CU Triaxial Compression Tests

APPENDIX C – SUPPORTING DOCUMENTS
Exhibit C-1 General Notes
Exhibit C-2 Unified Soil Classification System
Exhibit C-3 General Notes – Description of Rock Properties

SITE CHARACTERIZATION REPORT
NORTHEASTERN POWER STATION, BOTTOM ASH POND
OOLAGAH, OKLAHOMA

Terracon Project No. 04155186
January 18, 2016

1.0 BORING LAYOUT

The boring location was staked in the field by Terracon's representative in coordination with AEP personnel. The approximate site location and boring location are shown on Exhibits A-1 and A-2, respectively.

2.0 DRILLING

As requested, we drilled one (1) boring, designated B-1, for the project. The boring was drilled to a depth of approximately 25 feet below the existing ground surface. The boring was drilled with an ATV-mounted rotary drill rig using continuous flight solid-stem augers to advance the borehole. The log of the boring is presented in Appendix A.

Terracon observed and recorded groundwater levels while drilling and immediately after boring completion. As shown in the lower left corner of the boring log, groundwater was not encountered in the boring during our field exploration.

The groundwater level observations made during our exploration provide an indication of the groundwater conditions at the time the boring was drilled. Our observation occurred over the short duration of the boring. Due to the relatively low permeability of the clay encountered at this site, a relatively long period of time may be necessary for a groundwater level to develop and stabilize in these materials. Therefore, our groundwater observation does not necessarily mean that the boring terminated above groundwater. Fluctuations in groundwater levels could occur throughout the year depending upon variations in the amount of rainfall, runoff, evaporation, and other hydrological factors not apparent at the time the boring was performed. The possibility of groundwater fluctuations should be considered when developing the design and construction plans for the project intended at this site.

3.0 SAMPLING

Samples were obtained by the split-barrel and thin-walled tube sampling procedures. The split-barrel sampling procedure uses a standard 2-inch, O.D. split-barrel sampling spoon that is driven into the bottom of the boring with a 140-pound drive hammer falling 30 inches. The number of blows required to advance the sampling spoon the last 12 inches, or less, of an 18-inch sampling interval or portion thereof, is recorded as the standard penetration resistance value, N. The N value is used to estimate the in-situ relative density of cohesionless soils, and to a lesser degree of accuracy, the consistency of cohesive soils and hardness of weathered bedrock. The thin-walled sampling procedure uses a standard 3-inch, O.D. tube (Shelby tube) that is hydraulically pushed into the bottom of the boring to recover a relatively undisturbed sample of clayey soils.

The sampling depths, penetration distances, and N values are reported on the boring log. The samples were tagged for identification, sealed to reduce moisture loss and returned to the laboratory for further examination, classification and testing.

4.0 LABORATORY TESTING

Select soil/rock samples obtained from the site were tested for the following engineering properties:

- Water content
- Atterberg limits
- Grain size distribution
- Dry density
- Consolidated Undrained (CU) triaxial compression tests

Our scope of services included performing 3-point CU triaxial compression tests on two Shelby tubes. However, the samples extruded from the Shelby tubes had sufficient length of undisturbed recovery to run only two points. Per direction from AEP, we performed the test on two points per sample.

The laboratory test results are presented on the boring log next to the respective samples in Appendix A. Triaxial compression test reports and grain size distribution reports are provided in Appendix B. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

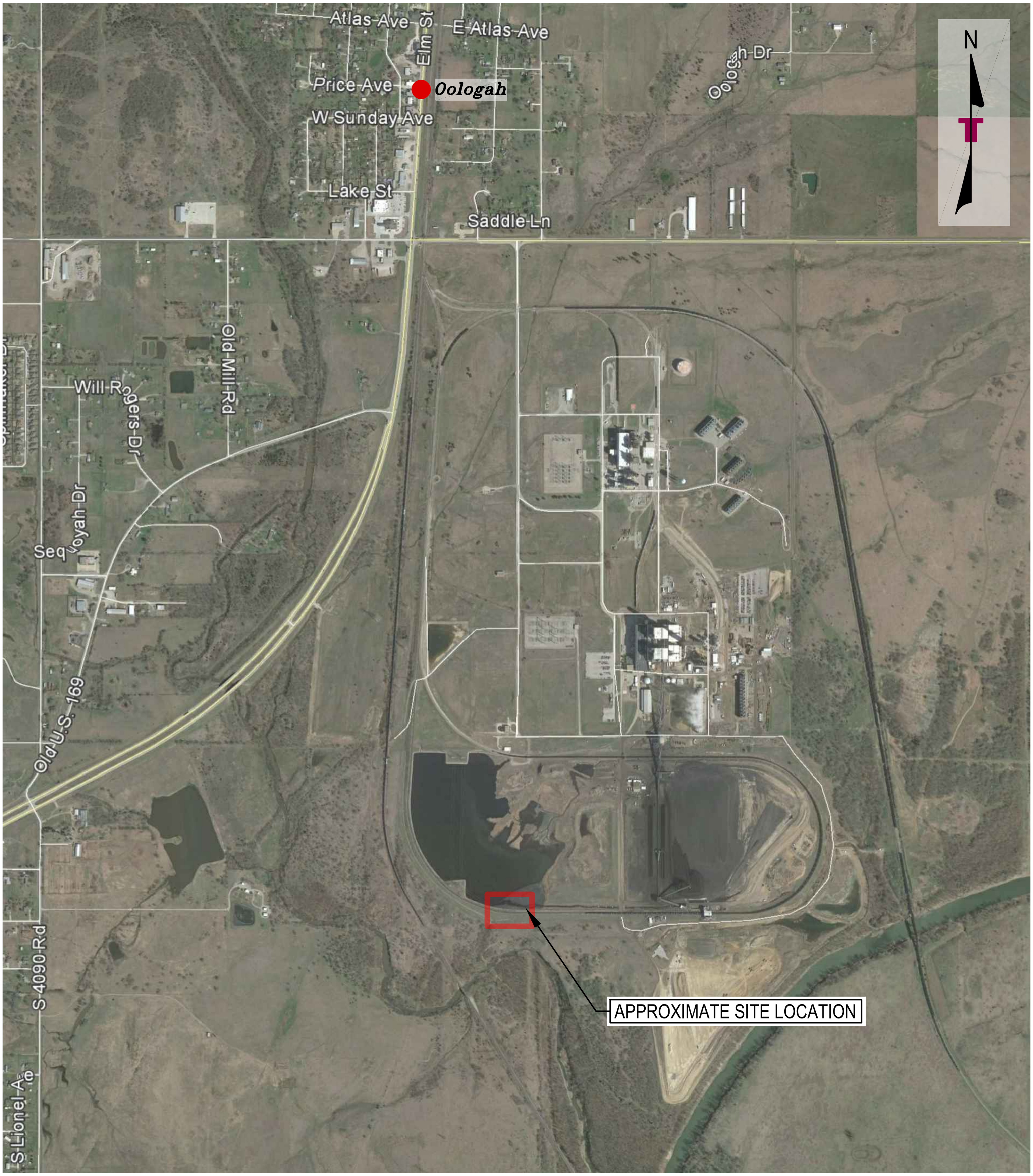
5.0 BORING LOG

A field log of the boring was prepared by a Terracon field geologist. The log included visual classifications of the materials encountered during drilling as well as the field geologist's interpretation of the subsurface conditions between samples. The samples obtained in the field were reviewed and visually classified in our laboratory by a Terracon engineer. The final boring log included with this report represents the engineer's interpretation of the field log and include modifications based on laboratory observation and tests of the samples.

Soil classification was based on the Unified Soil Classification System (USCS) presented in Appendix C. Bedrock materials were classified according to the General Notes and described using commonly accepted geotechnical terminology.

APPENDIX A

FIELD EXPLORATION



1500 0 500 1000 1500

APPROXIMATE SCALE IN FEET

Project Mngr: SMG	Project No. 04155186	Terracon Consulting Engineers and Scientists	SITE LOCATION MAP
Drawn By: JM	Scale: SEE BAR SCALE		GEOTECHNICAL EXPLORATION
Checked By: SMG	File No. 04155186	9522 EAST 47TH PLACE, UNIT D TULSA, OKLAHOMA 74145	NORTHEASTERN POWER STATION, BOTTOM ASH POND
Approved By: BMW	Date: JAN 2016	PH. (918) 250-0461 FAX. (918) 250-4570	OOLAGAH, OKLAHOMA

EXHIBIT NO. A-1

N

LEGEND
BORING LOCATION

400 0 100 200 300 400

APPROXIMATE SCALE IN FEET

DIAGRAM IS FOR GENERAL LOCATION ONLY,
AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Mngr: SMG	Project No. 04155186	Terracon Consulting Engineers and Scientists	BORING LOCATION PLAN
Drawn By: JM	Scale: SEE BAR SCALE		GEOTECHNICAL EXPLORATION
Checked By: SMG	File No. 04155186	9522 EAST 47TH PLACE, UNIT D TULSA, OKLAHOMA 74145	NORTHEASTERN POWER STATION, BOTTOM ASH POND
Approved By: BMW	Date: JAN 2016	PH. (918) 250-0461 FAX. (918) 250-4570	OOLAGAH, OKLAHOMA

EXHIBIT NO.

A-2

BORING LOG NO. B-1

PROJECT: Northeastern Power Station, Bottom Ash Pond

CLIENT: American Electric Power

**SITE: US-169 and OK-88
Oolagah, Oklahoma**

LOCATION See Exhibit A-2

Latitude: 36.41852° Longitude: -95.70573°

DEPTH	
	3" Black gravel and sand
3.5	**FILL - LEAN CLAY**, with gravel and sand, yellowish-brown and brown
8.0	**FILL - FAT CLAY**, with gravel, yellowish-brown and gray
11.0	**FILL - FAT CLAY**, trace gravel and sand, yellowish-brown
16.5	**FILL - SANDY FAT CLAY**, reddish-brown with black
21.5	**FILL - FAT CLAY**, thin roots and trace wet soil, light olive-brown and gray
23.0	**FILL - FAT CLAY**, trace wet soil, olive and gray with reddish-brown
24.5	**FILL - FAT CLAY**, tree bark, reddish-brown
24.9	**LIMESTONE+**
	Boring Terminated at 24.9 Feet

RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
16	2-3-5 N=8	1500 (HP)	13		
6	3-4-4 N=8	1500 (HP)	13		
18	2-4-4 N=8	4000 (HP)	23		
12		4500 (HP)		54-18-36	77
18	1-2-2 N=4	2500 (HP)	22		
18	3-6-4 N=10	4000 (HP)	18		
13	3-2-5 N=7	3500 (HP)	25		
9	2-3-4 N=7	3000 (HP)	27		
18	3-4-6 N=10	6500 (HP)	23		
10		2000 (HP)		55-17-38	65
18	2-3-3 N=6	5500 (HP)	25		
	3-4-6 N=10	5500 (HP)	21		
21		6500 (HP)			
18	3-4-5 N=9	6000 (HP)	27		
18	4-6-8 N=14	5000 (HP)	26		
4	50/4"		22		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic
+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with cement-bentonite grout upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

Consolidated Undrained triaxial compression tests performed on Shelby Tube samples collected at 5 to 6.5' and 15 to 16.5'. See Appendix B for test results.

WATER LEVEL OBSERVATIONS

Not Encountered While Drilling

Not Encountered After Boring

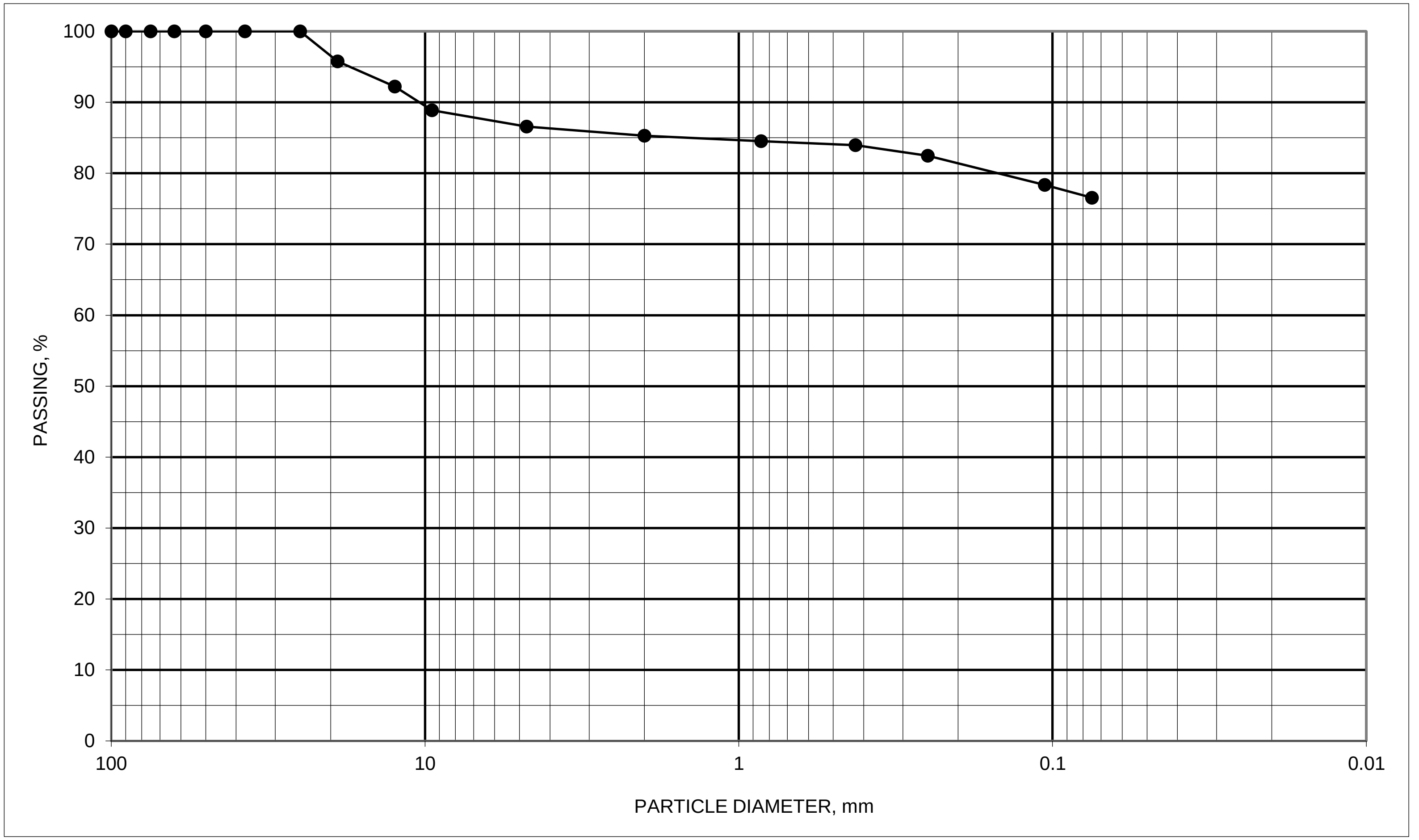
Terracon
9522 East 47th Place, Unit D
Tulsa, Oklahoma

Boring Started: 12/2/2015	Boring Completed: 12/2/2015
Drill Rig: ATV 380	Driller: TJ
Project No.: 04155186	Exhibit: A-3

APPENDIX B

LABORATORY TEST RESULTS

SIEVE SIZE	DIAMETER, mm	PASS, %
4"	100.0	100
3.5"	90.0	100
3"	75.0	100
2.5"	63.0	100
2"	50.0	100
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	96
1/2"	12.5	92
3/8"	9.50	89
#4	4.75	87
#10	2.00	85
#20	0.850	85
#40	0.425	84
#60	0.250	82
#140	0.106	78
#200	0.075	76.6



ASTM D1140 / C117 #200 WASH SIEVE AND C136 SIEVE ANALYSIS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
B-1	4	5 TO 6.5	FAT CLAY WITH GRAVEL BROWN & YELLOWISH BROWN	CH		54	18	36

PROJECT NORTHEASTERN POWER STATION, BOTTOM ASH POND

JOB NO. 04155186 DATE 12/28/2015

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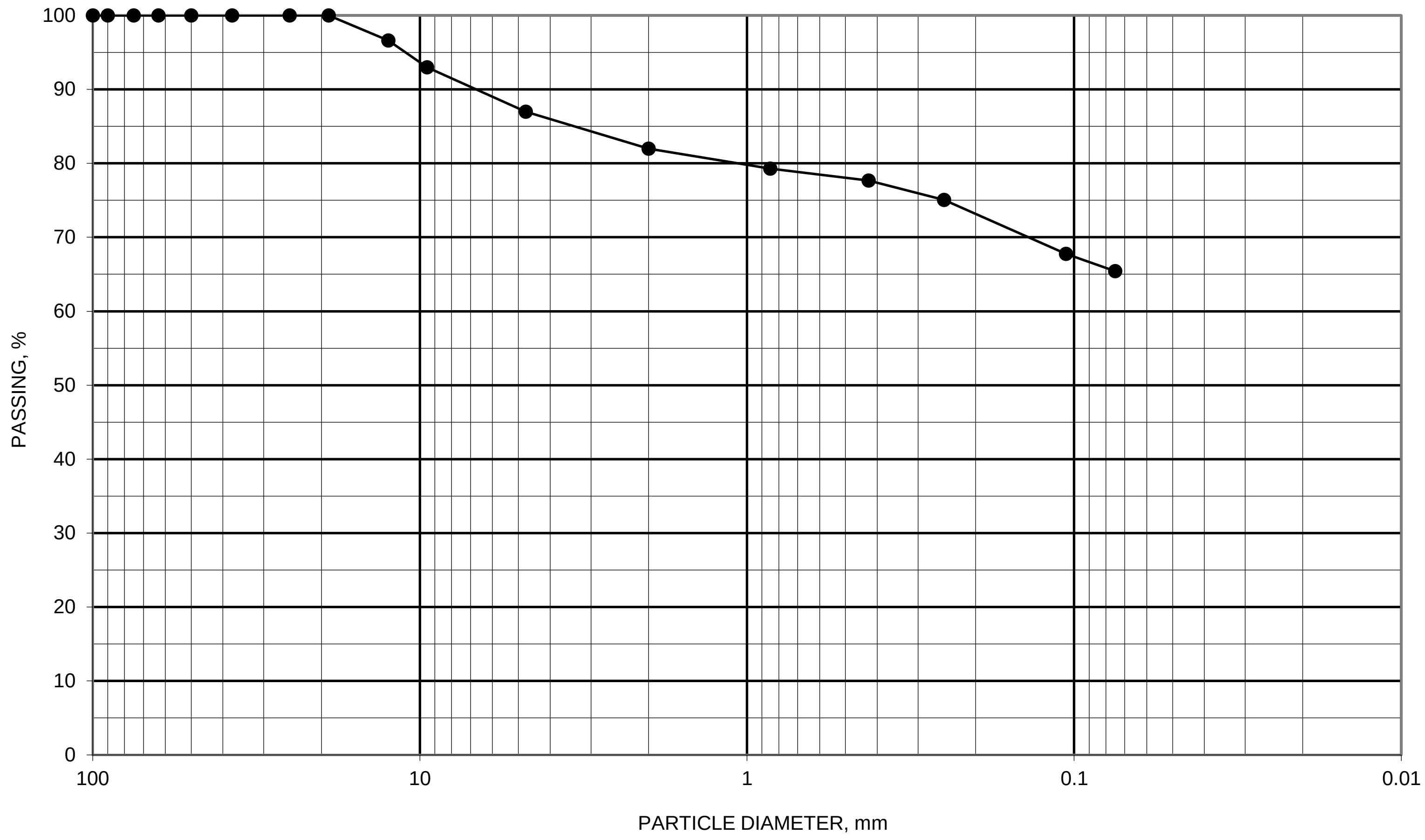
SIEVE SIZE	DIAMETER, mm	PASS, %
4"	100.0	100
3.5"	90.0	100
3"	75.0	100
2.5"	63.0	100
2"	50.0	100
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	97
3/8"	9.50	93
#4	4.75	87
#10	2.00	82
#20	0.850	79
#40	0.425	78
#60	0.250	75
#140	0.106	68
#200	0.075	65.4



ASTM D1140 / C117 #200 WASH SIEVE AND C136 SIEVE ANALYSIS

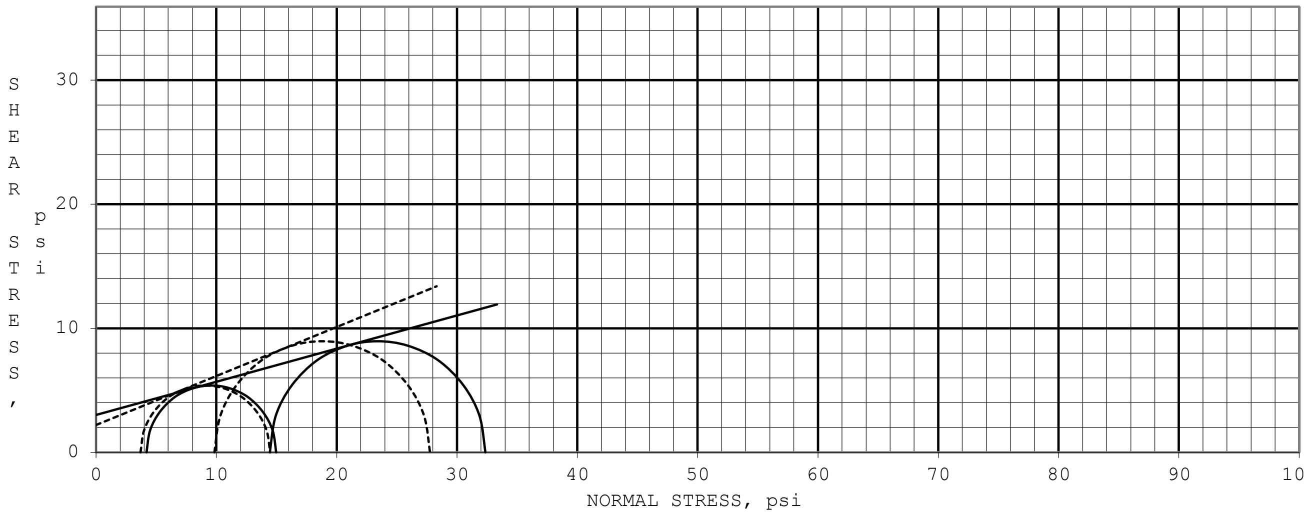
BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
B-1	10	15 TO 16.5	SANDY FAT CLAY BROWN & DARK BROWN	CH		55	17	38

PROJECT NORTHEASTERN POWER STATION, BOTTOM ASH POND

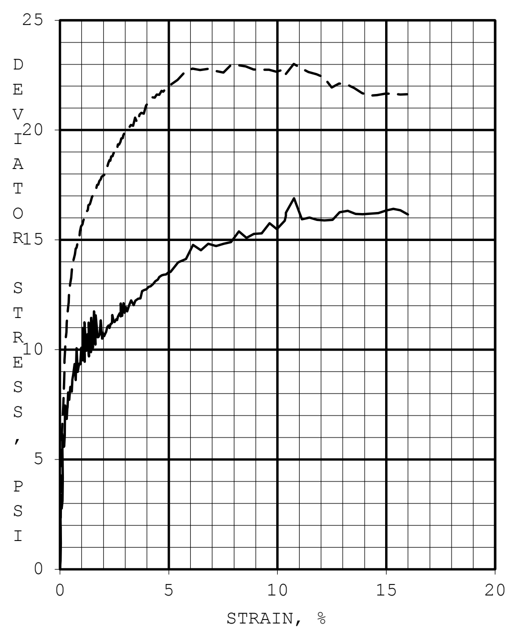
JOB NO. 04155186 DATE 12/28/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\04155186 Lab Data\[04155186 200 Wash Plot B1-4-5.0.xlsx]REPORT

Terracon



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	**21.6**	COHESION, psi	**2.2**
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	**15.0**	COHESION, psi	**3.0**



SPECIMEN ID:		A	B	
INITIAL	WATER CONTENT, %	22.3	21.7	
	DRY DENSITY, pcf	106.4	106.2	
	SATURATION, %	104	101	
	VOID RATIO	0.58	0.58	
BEFORE SHEAR	WATER CONTENT, %	21.4	20.5	
	DRY DENSITY, pcf	106.6	108.2	
	SATURATION (B PARAMETER)	0.95	0.96	
	VOID RATIO	0.58	0.55	
	FINAL BACK PRESSURE, psi	100.0	100.0	
MINOR PRINCIPAL STRESS, psi		4.2	14.4	
EFFECTIVE STRESS PEAK AT % STRAIN		2.0	2.0	
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		10.8	17.9	
TOTAL STRESS PEAK AT % STRAIN		2.0	2.0	
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		10.8	17.9	
ULTIMATE DEVIATOR STRESS (15% STR), psi		16.3	21.7	
TIME TO 50% PRIMARY CONSOLIDATION, min		32.00	73.00	
STRAIN RATE, % / hour		0.25	0.25	
INITIAL DIAMETER, inch		1.365	1.365	
INITIAL HEIGHT, inch		2.811	2.832	
AREA AFTER CONSOLIDATION, inch2		1.456	1.438	

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:

FAT CLAY WITH GRAVEL, BROWN & YELLOWISH BROWN

LL	PL	PI	Gs
54	18	36	2.69 EST.

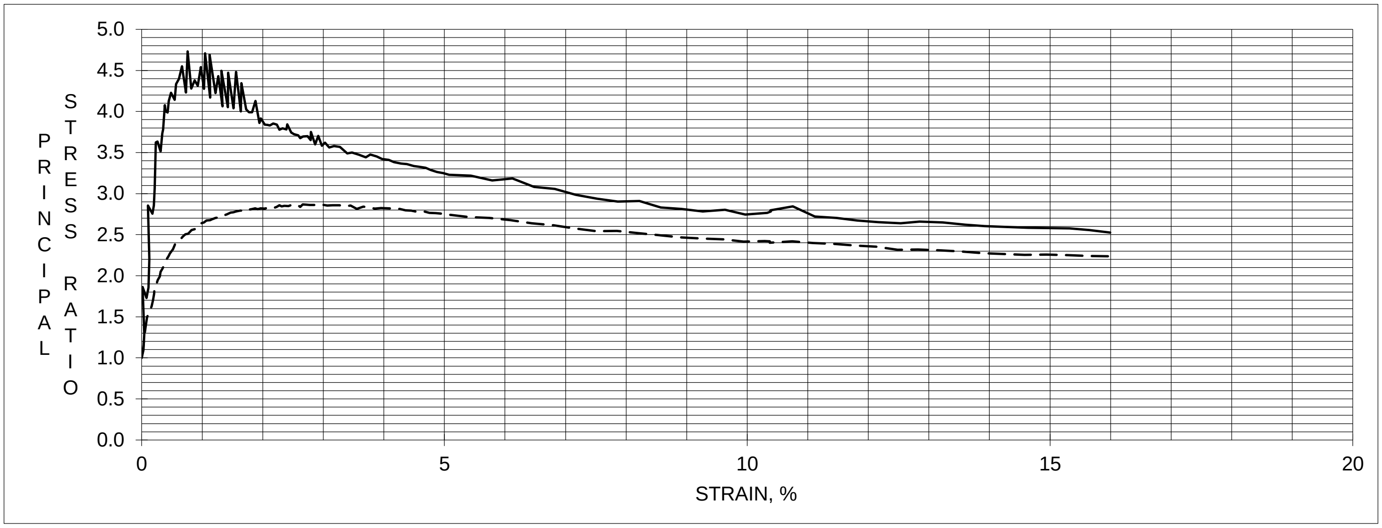
PROJECT NO. 04155186	PROJECT: NORTHEASTERN POWER STATION BOTTOM ASH POND
	BORING #: B-1
LABORATORY: TERRACON - LENEXA	SAMPLE #: 4
DATE: 12/29/2015	DEPTH, feet: 5.0 - 6.5

PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

Terracon

NORTHEASTERN POWER STATION

04155186 B-1 4 5.0 - 6.5



FAILURE SKETCH	FAILURE SKETCH	FAILURE SKETCH
		
SPECIMEN A	SPECIMEN B	SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 2 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 2 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 2 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 2 % STRAIN.

DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

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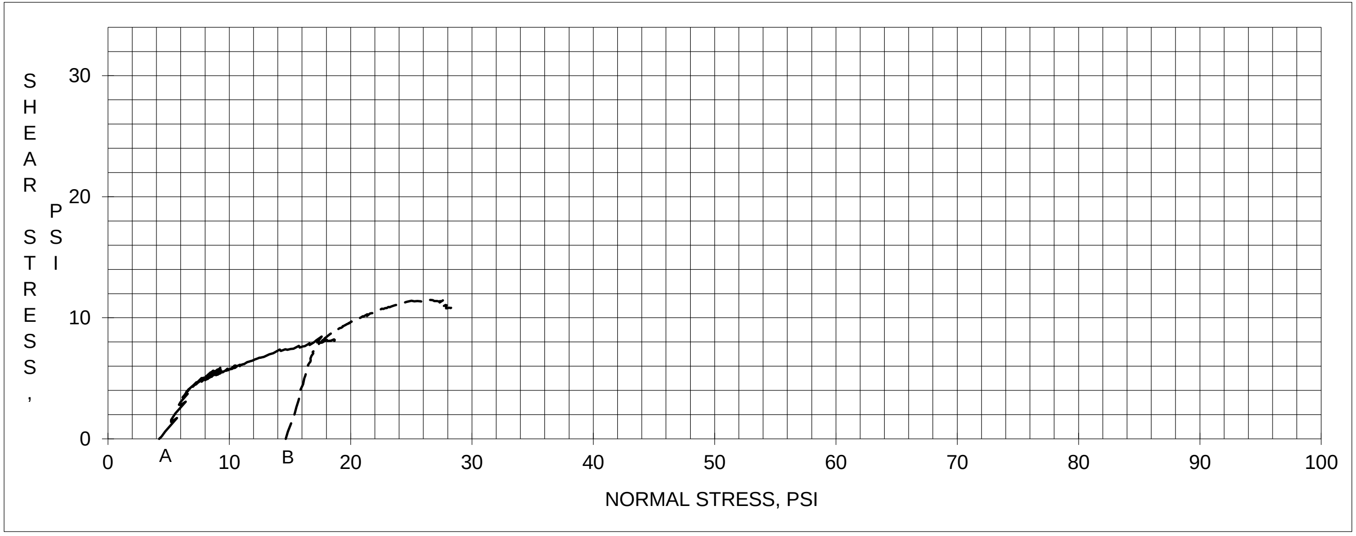
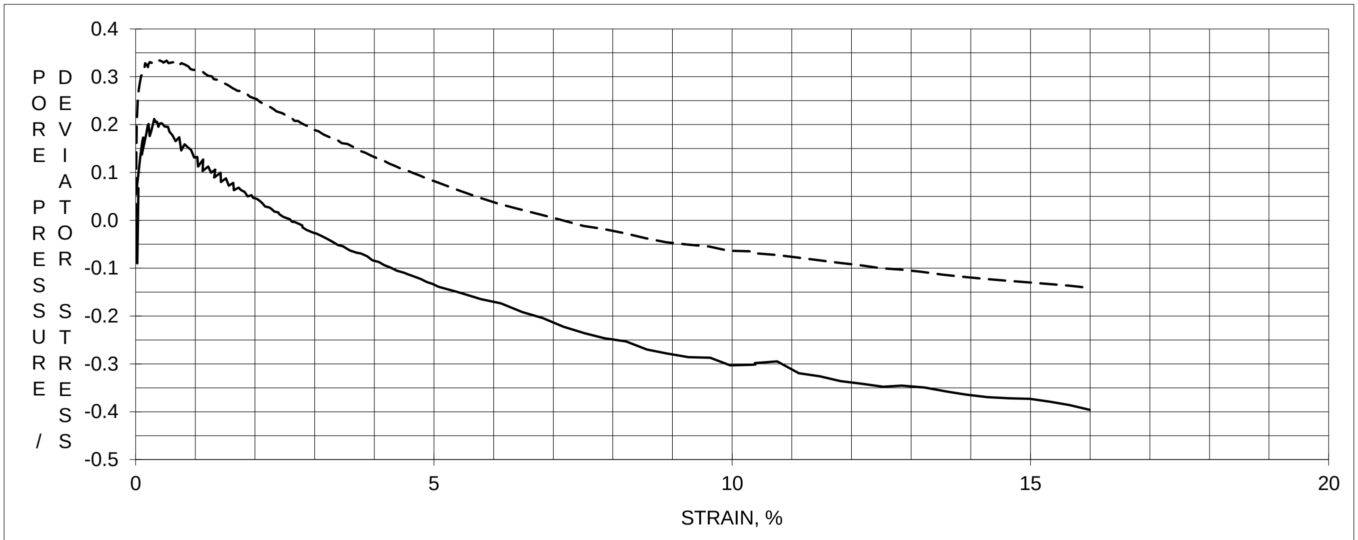
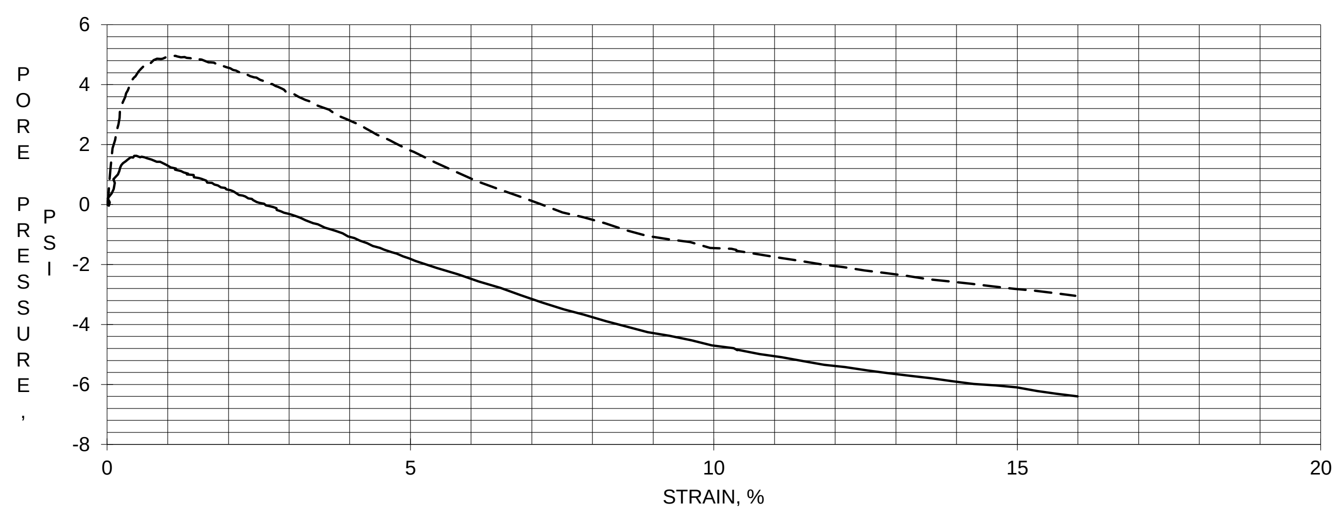
NORTHEASTERN POWER STATION

04155186 B-1 4 5.0 - 6.5







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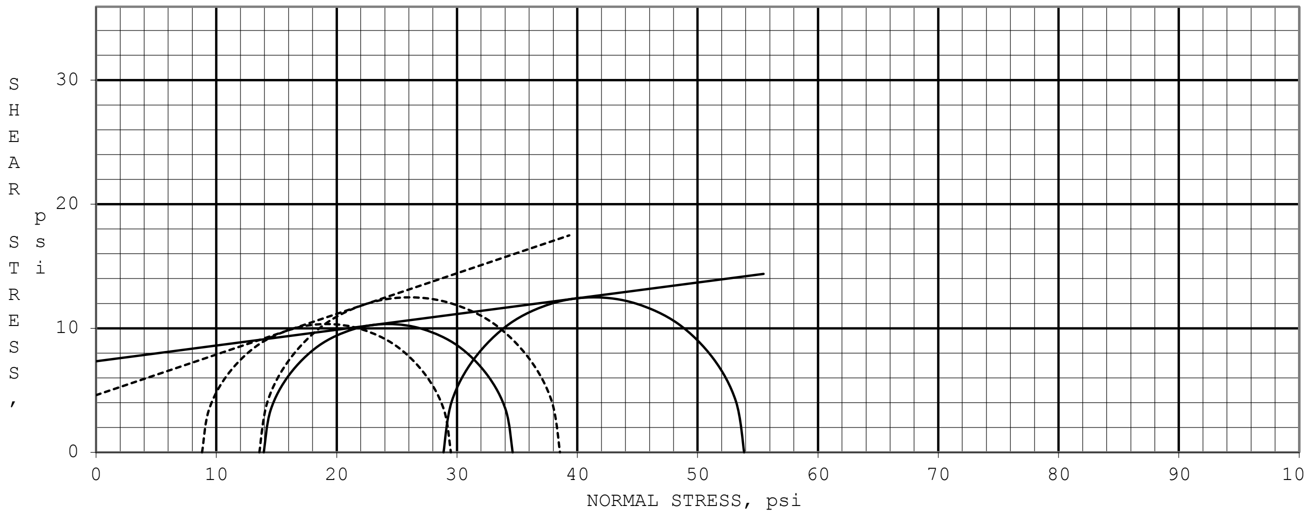
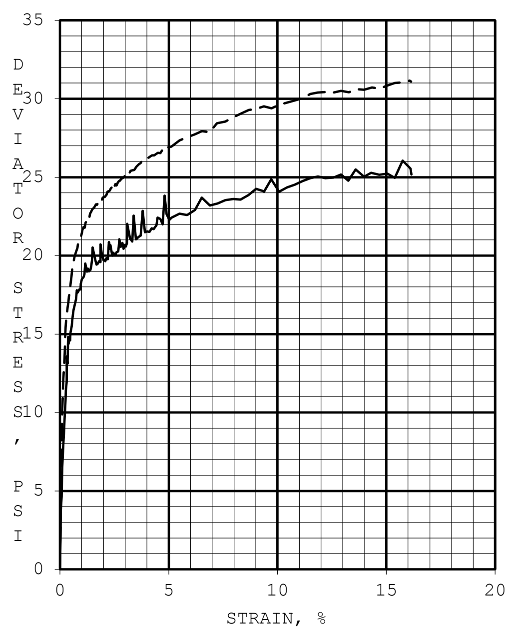


EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	**18.1**	COHESION, psi	**4.6**
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	**7.2**	COHESION, psi	**7.3**



SPECIMEN ID:		A	B	
INITIAL	WATER CONTENT, %	19.3	21.1	
INITIAL	DRY DENSITY, pcf	104.6	106.1	
INITIAL	SATURATION, %	87	98	
INITIAL	VOID RATIO	0.60	0.58	
BEFORE SHEAR	WATER CONTENT, %	21.6	19.9	
BEFORE SHEAR	DRY DENSITY, pcf	106.0	109.0	
BEFORE SHEAR	SATURATION (B PARAMETER)	0.95	0.96	
BEFORE SHEAR	VOID RATIO	0.58	0.53	
BEFORE SHEAR	FINAL BACK PRESSURE, psi	100.2	101.3	
MINOR PRINCIPAL STRESS, psi		13.9	28.9	
EFFECTIVE STRESS PEAK AT % STRAIN		3.0	3.0	
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		20.7	25.0	
TOTAL STRESS PEAK AT % STRAIN		3.0	3.0	
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		20.7	25.0	
ULTIMATE DEVIATOR STRESS (15% STR), psi		25.1	30.8	
TIME TO 50% PRIMARY CONSOLIDATION, min		6.90	7.90	
STRAIN RATE, % / hour		2.16	2.16	
INITIAL DIAMETER, inch		1.374	1.363	
INITIAL HEIGHT, inch		2.825	2.814	
AREA AFTER CONSOLIDATION, inch2		1.469	1.429	

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
SANDY FAT CLAY, BROWN & DARK BROWN

LL 55	PL 17	PI 38	Gs 2.68 EST.

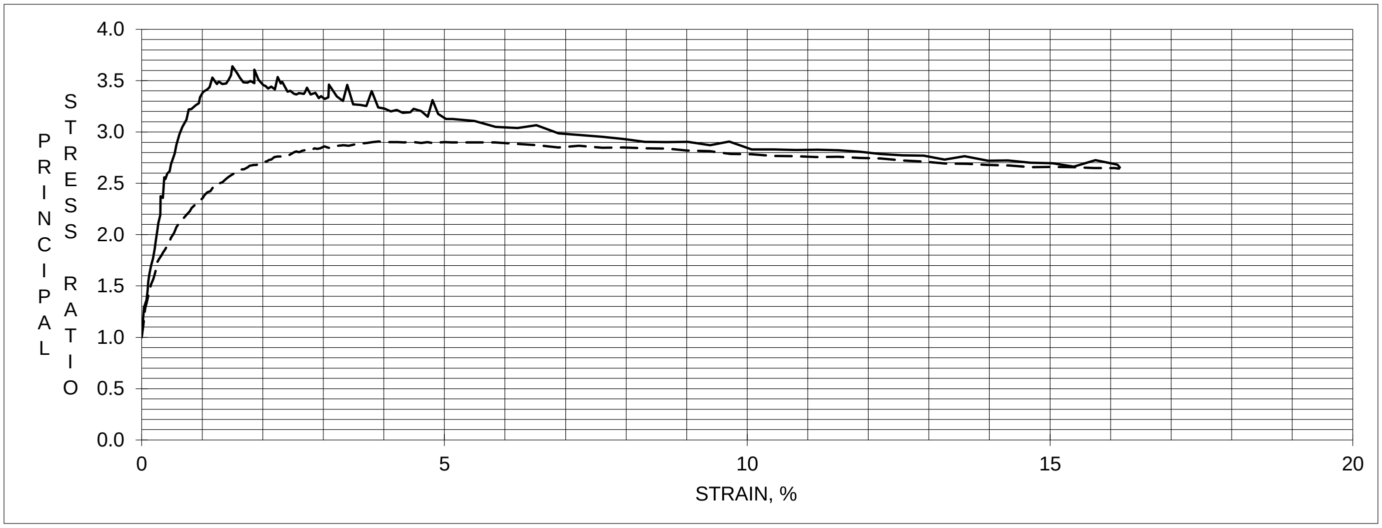
PROJECT NO. 04155186	PROJECT: NORTHEASTERN POWER STATION BOTTOM ASH POND
	BORING #: B-1
LABORATORY: TERRACON - LENEXA	SAMPLE #: 10
DATE: 12/28/2015	DEPTH, feet: 15.0 - 16.5

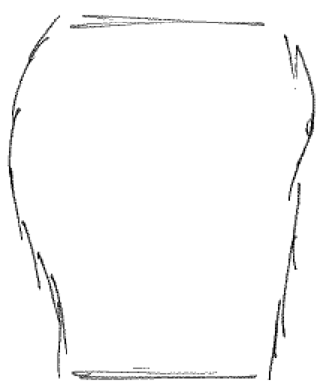
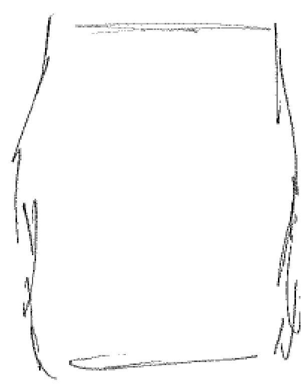
PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

Terracon

NORTHEASTERN POWER STATION

04155186 B-1 10 15.0 - 16.5



FAILURE SKETCH	FAILURE SKETCH	FAILURE SKETCH
		
SPECIMEN A	SPECIMEN B	SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 3 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 3 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 3 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 3 % STRAIN.

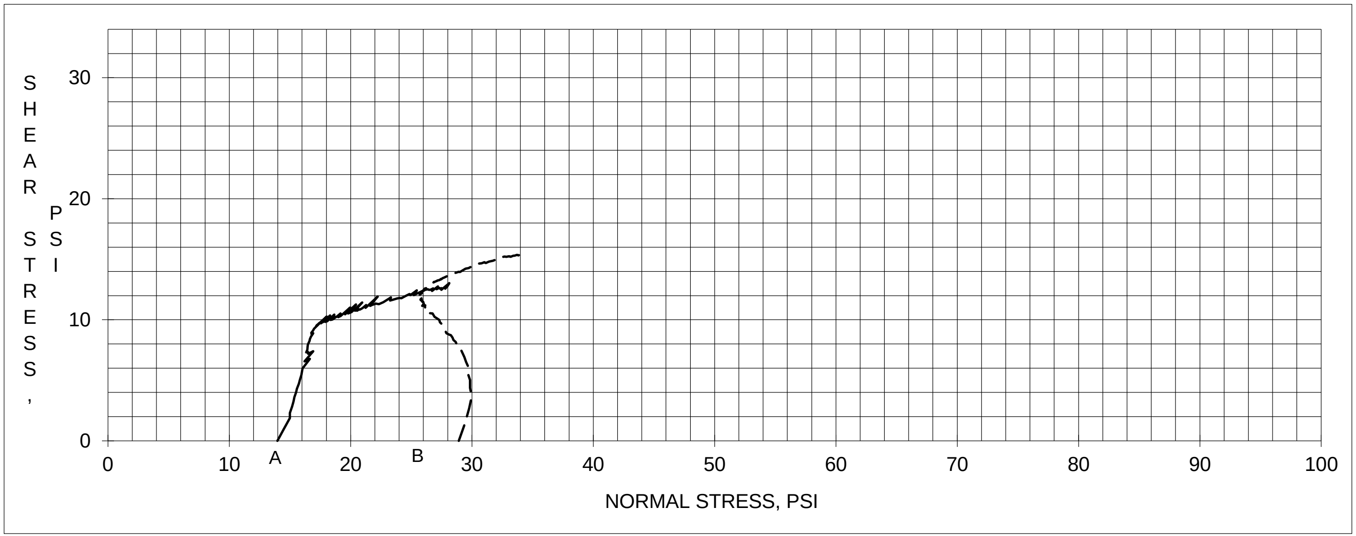
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

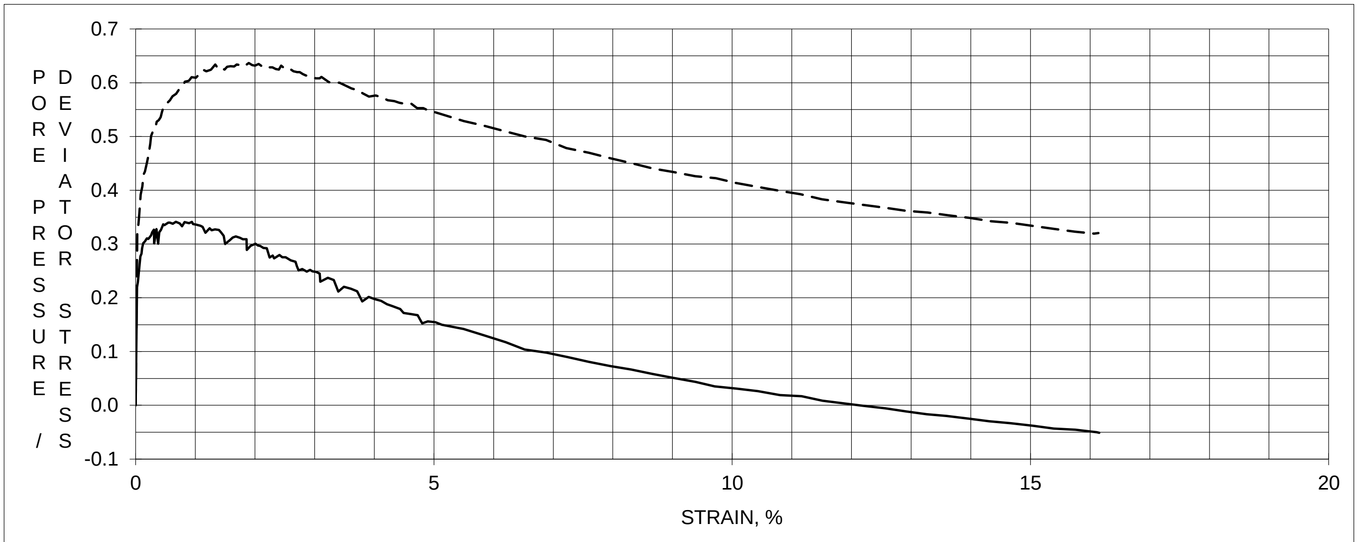
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

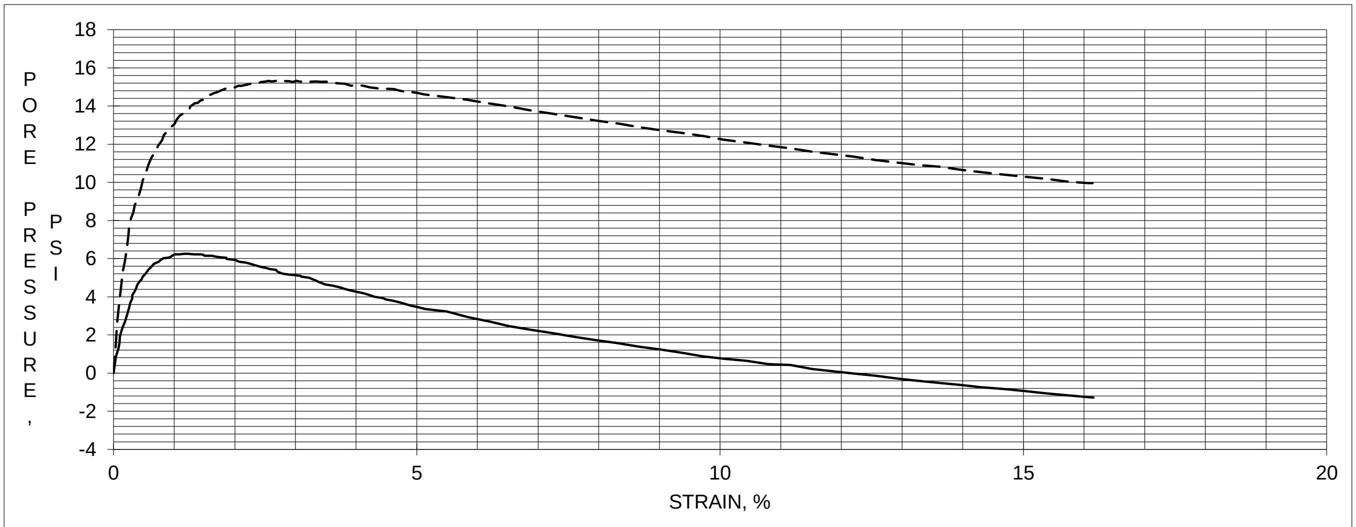
Terracon

NORTHEASTERN POWER STATION

04155186 B-1 10 15.0 - 16.5







APPENDIX C

SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Auger	Split Spoon
Shelby Tube	Macro Core
Ring Sampler	Rock Core
Grab Sample	No Recovery

WATER LEVEL

- Water Initially Encountered
- Water Level After a Specified Period of Time
- Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, psf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

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UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G, H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines Classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	$PI > 7$ and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			$PI < 4$ or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay
[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains $\geq$ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains $\geq$ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains $\geq$ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains $\geq$ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] $PI \geq 4$ and plots on or above "A" line.
[O] $PI < 4$ or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.

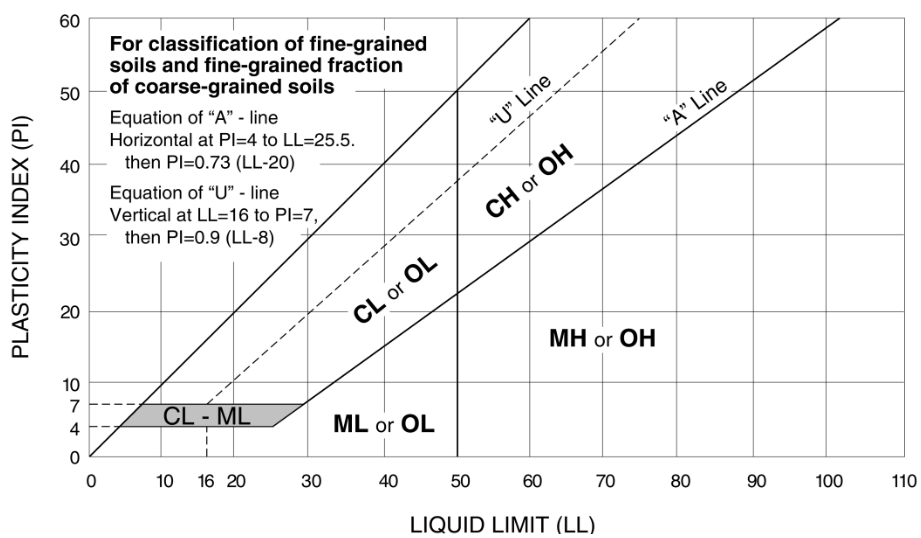

Exhibit C-2

GENERAL NOTES

Sedimentary Rock Classification

DESCRIPTIVE ROCK CLASSIFICATION:

Sedimentary rocks are composed of cemented clay, silt and sand sized particles. The most common minerals are clay, quartz and calcite. Rock composed primarily of calcite is called limestone; rock of sand size grains is called sandstone, and rock of clay and silt size grains is called mudstone or claystone, siltstone, or shale. Modifiers such as shaly, sandy, dolomitic, calcareous, carbonaceous, etc. are used to describe various constituents. Examples: sandy shale; calcareous sandstone.

LIMESTONE	Light to dark colored, crystalline to fine-grained texture, composed of $CaCo_3$, reacts readily with HCl.
DOLOMITE	Light to dark colored, crystalline to fine-grained texture, composed of $CaMg(CO_3)_2$, harder than limestone, reacts with HCl when powdered.
CHERT	Light to dark colored, very fine-grained texture, composed of micro-crystalline quartz ($Si0_2$), brittle, breaks into angular fragments, will scratch glass.
SHALE	Very fine-grained texture, composed of consolidated silt or clay, bedded in thin layers. The unlaminated equivalent is frequently referred to as siltstone, claystone or mudstone.
SANDSTONE	Usually light colored, coarse to fine texture, composed of cemented sand size grains of quartz, feldspar, etc. Cement usually is silica but may be such minerals as calcite, iron-oxide, or some other carbonate.
CONGLOMERATE	Rounded rock fragments of variable mineralogy varying in size from near sand to boulder size but usually pebble to cobble size (½ inch to 6 inches). Cemented together with various cementing agents. Breccia is similar but composed of angular, fractured rock particles cemented together.

PHYSICAL PROPERTIES:

DEGREE OF WEATHERING

Slight	Slight decomposition of parent material on joints. May be color change.
Moderate	Some decomposition and color change throughout.
High	Rock highly decomposed, may be extremely broken.

HARDNESS AND DEGREE OF CEMENTATION

Limestone and Dolomite:

Hard	Difficult to scratch with knife.
Moderately Hard	Can be scratched easily with knife, cannot be scratched with fingernail.
Soft	Can be scratched with fingernail.

Shale, Siltstone and Claystone

Hard	Can be scratched easily with knife, cannot be scratched with fingernail.
Moderately Hard	Can be scratched with fingernail.
Soft	Can be easily dented but not molded with fingers.

Sandstone and Conglomerate

Well Cemented	Capable of scratching a knife blade.
Cemented	Can be scratched with knife.
Poorly Cemented	Can be broken apart easily with fingers.

BEDDING AND JOINT CHARACTERISTICS

Bed Thickness	Joint Spacing	Dimensions
Very Thick	Very Wide	>10′
Thick	Wide	3′ - 10′
Medium	Moderately Close	1′ - 3′
Thin	Close	2″ - 1′
Very Thin	Very Close	.4″ - 2″
Laminated	—	.1″ - .4″

Bedding Plane	A plane dividing sedimentary rocks of the same or different lithology.
Joint	Fracture in rock, generally more or less vertical or transverse to bedding, along which no appreciable movement has occurred.
Seam	Generally applies to bedding plane with an unspecified degree of weathering.

SOLUTION AND VOID CONDITIONS

Solid	Contains no voids.
Vuggy (Pitted)	Rock having small solution pits or cavities up to ½ inch diameter, frequently with a mineral lining.
Porous	Containing numerous voids, pores, or other openings, which may or may not interconnect.
Cavernous	Containing cavities or caverns, sometimes quite large.

Terracon

APPENDIX B

Hydrologic Analysis

Innovative approaches
Practical results
Outstanding service

`

Hydrologic Analysis of Northeastern 3 &4 Power Station Bottom Ash Pond

American Electric Power Company

Prepared by:

FREESE AND NICHOLS, INC.
4055 International Plaza, Suite 200
Fort Worth, Texas 76109
817-735-7300

AEP11201

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

Hydrologic Analysis of Northeastern 3 &4 Power Station Bottom Ash Pond

American Electric Power Company

REGISTERED PROFESSIONAL ENGINEER
JOHN LEE RUTLEDGE
16255
OKLAHOMA

5-16-11

Prepared by:

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4055 International Plaza, Suite 200
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817-735-7300

AEP11201

TABLE OF CONTENTS

1.0 Introduction 1
2.0 Hydrologic Model Development 3
2.1 Basin Delineation & Connectivity 3
2.2 Hydrologic Parameters 5
2.3 Elevation-Storage Data 8
2.4 Discharge Rating Curves 8
2.5 Frequency Model Results 10
2.6 PMF Model Results 12
3.0 Summary and Conclusions 14

LIST OF TABLES

Table 1 – Curve Number Calculation Matrix 5
Table 2 – Basin Parameters 5
Table 3 – Elevation-Storage Data 8
Table 4 – Discharge Rating Curve 9
Table 5 – Frequency Precipitation Depths 11
Table 6 – Frequency Model Results 11
Table 7 – HMR-52 Point Rainfall Depths 12
Table 8 –PMF Model Results 13
Table 9 – Pertinent Dam Information 14
Table 10 – Summary of Results 14

LIST OF FIGURES

Figure 1 – Location Map 2
Figure 2 – Drainage Basin Map 4
Figure 3 – Hydrologic Soil Classifications 6
Figure 4 – Land Cover Data 7
Figure 5 – Bottom Ash Pond Spillway 10
Figure 6 – Downstream Basin with Culverts 10
Figure 7 – PMP Rainfall Hyetograph 13

APPENDICES

Appendix A – References
Appendix B – Discharge Rating Curve Calculations and Hydrologic Parameters
Appendix C – Pertinent Drawings

1.0 INTRODUCTION

In April of 2011, Freese and Nichols, Inc., (FNI) was retained by American Electric Power (AEP) to perform various hydrologic and hydraulic calculations to determine the hydraulic adequacy of the Bottom Ash Pond for the Northeastern 3 & 4 Power Station located near Oologah, Oklahoma. This report summarizes the results of the analysis for the 10-year, 100-year, and 40% PMF events.

The Ash Pond is situated immediately southwest of the Power Plant and west of Oologah Dam. The general location of the power plant and associated reservoirs is shown in Figure 1.

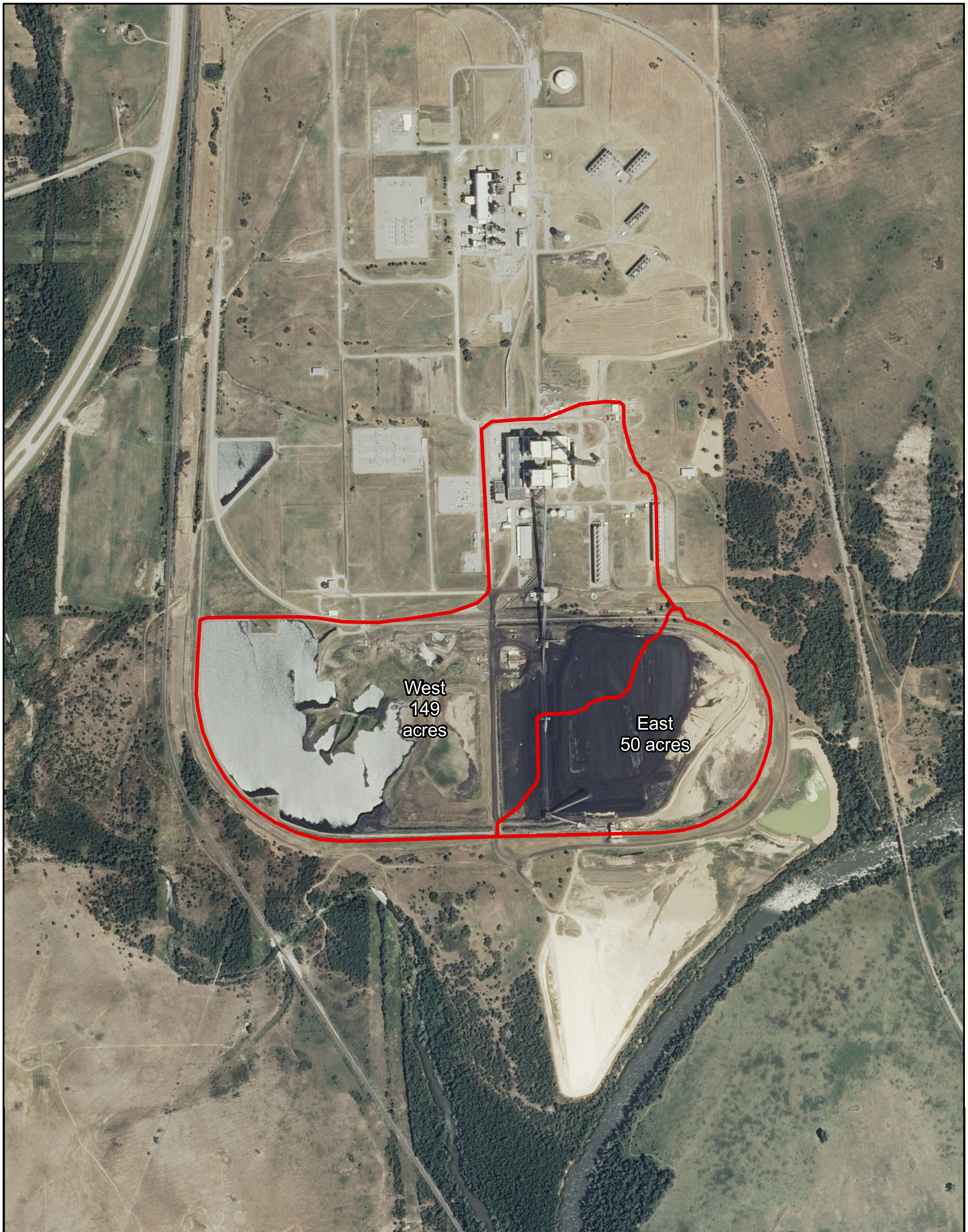
FN PROJECT NO. AEP11201	FREESE AND NICHOLS 4055 International Plaza, Suite 200 Fort Worth, TX 76109-4895 817-735-7300	0 0.5 1 2 Miles	N	FIGURE 1
FILE NAME H:\WR_DESIGN\FIGURES\Figure1_LocationMap.mxd		NORTHEASTERN 3 & 4 ASH POND		
DATUM & COORDINATE SYSTEM NAD83 STATE PLANE OKLAHOMA NORTH (FT)		LOCATION MAP		
DATE CREATED APRIL 2011				
PREPARED BY JPM				

2.0 HYDROLOGIC MODEL DEVELOPMENT

2.1 BASIN DELINEATION & CONNECTIVITY

The hydrologic model for the Northeastern 3 & 4 Power Station Bottom Ash Pond was created in HEC-HMS[1] and consisted of two total drainage basins, as shown in Figure 2. The total drainage area modeled is approximately 0.31 square miles, or 199 acres. One basin represents the area that includes most of the power plant facilities and the Bottom Ash Pond itself, while the other represents the area that includes the coal pile and the area east of the coal pile, which is connected to the Bottom Ash Pond via a small channel. The basins were delineated from one-foot contours generated from a March 2010 survey[2] of the area and supplemented with the National Elevation Dataset (NED) 10-meter resolution Digital Elevation Model (DEM).

The Northeastern 3 & 4 Power Station Bottom Ash Pond is connected to multiple segments of the overall plant system and has several inflows and outflows that are assumed to be constant. Stormwater from a retention basin at the fly ash landfill, known as Basin C, is pumped to the bottom ash pond at a maximum rate of 4,000 gpm or 8.91 cfs. Inflow from pumping operations at Basin C, as well as from drains at Units 1, 2, 3, and 4, contribute a combined 6.3 MGD, or 9.75 cfs. The on-site wastewater treatment facility has capacity to pump approximately 1000 gpm, or 2.23 cfs. This capacity is used to regulate the normal pool elevation. Additionally, during emergency or high flood situations, flow may be diverted to the plant's cooling towers at a rate of 2.0 MGD, or 3.09 cfs.



FN PROJECT NO. AEP10431 FILE NAME H:\WR_DESIGN\FIGURES\Figure2_Basins.mxd DATUM & COORDINATE SYSTEM NAD83 STATE PLANE OKLAHOMA NORTH (FT) DATE CREATED APRIL 2011 PREPARED BY JPM	FREESE AND NICHOLS 4055 International Plaza, Suite 200 Fort Worth, TX 76109-4895 817-735-7300	0 500 1,000 2,000 Feet NORTHEASTERN 3&4 ASH POND DRAINAGE BASIN MAP	N	FIGURE 2

2.2 HYDROLOGIC PARAMETERS

The HEC-HMS model incorporates the NRCS Curve Number and Unit Hydrograph methods for each basin. In this model, the curve numbers were based on hydrologic soil classifications and land cover. The instantaneous runoff effect of open water surfaces was accounted for in the development of the curve numbers. The soils dataset was obtained from the NRCS Soil Survey Geographic Database[3] (SSURGO), and land use classification was determined from National Agriculture Imagery Program[4] (NAIP) 2010 aerial imagery of the site. Spatial information about soil types and land use classifications is presented in Figures 3 and 4, respectively. Table 1 provides the matrix used in determining the curve number for each basin. All soils in the basin are in Hydrologic Soil Group D. The curve numbers shown in Table 1 represent only these soils and are for Antecedent Moisture Condition (AMC) II. These values were incorporated in the model for the frequency storm events, such as the 10-year storm event. For the PMP events, a higher curve number with AMC III was used to simulate a worst-case scenario with the ground fully saturated.

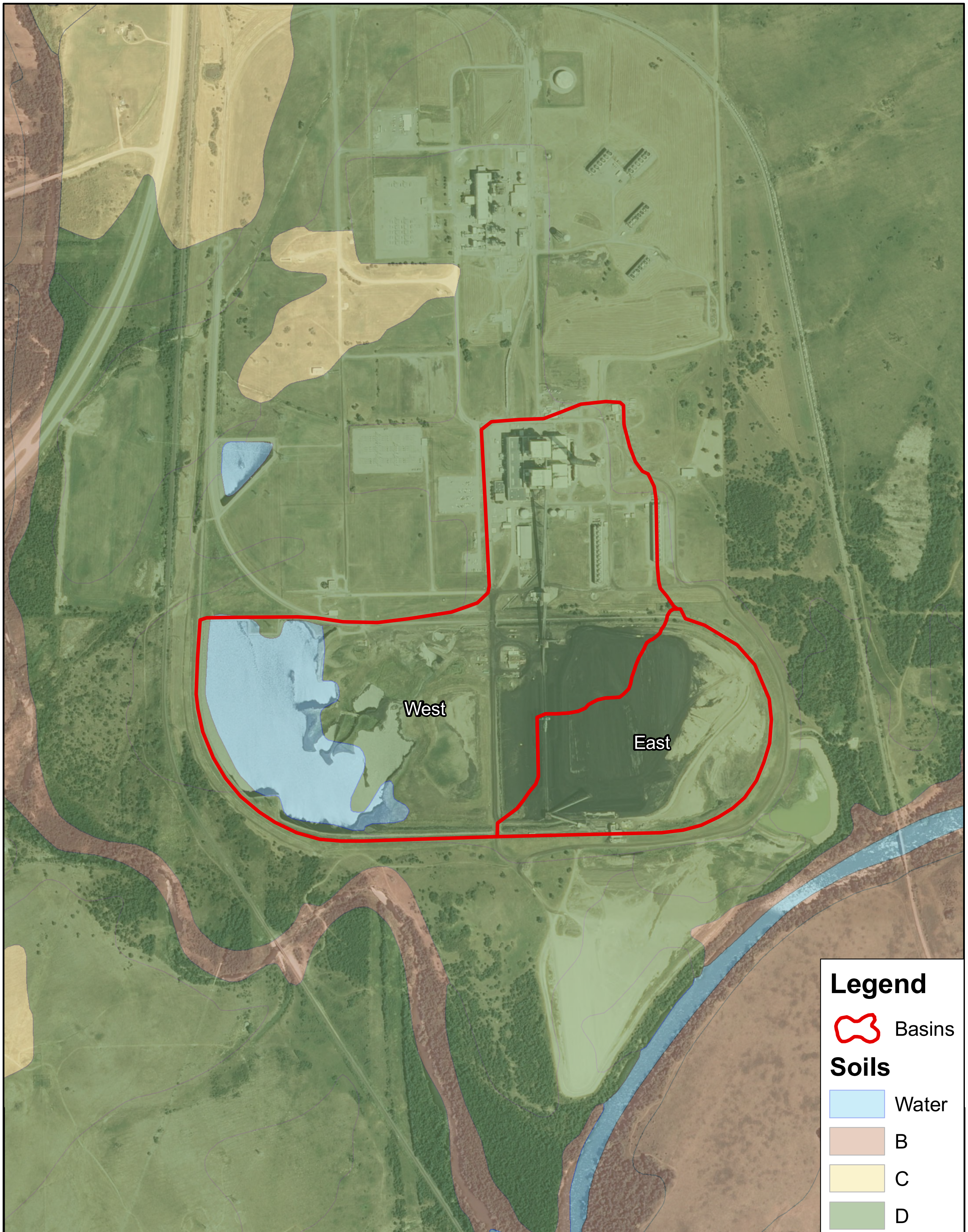
Table 1 – Curve Number Calculation Matrix

Land Use Classification	Curve Number (AMC II)
Water	100
Open Space	89
Industrial	93
Coal Pile	94

The only input into HEC-HMS for the NRCS Dimensionless Unit Hydrograph is a lag time, which is calculated based on basin conditions, such as hydraulic length and average slope, according to the NRCS TR-55 Method. Table 2 provides a summary of the hydrologic parameters for each basin.

Table 2 – Basin Parameters

Basin	Area (mi^2)	Lag Time (min)	Curve Number (AMC II)	Curve Number (AMC III)
West	0.246	14.75	94.1	97.4
East	0.078	11.99	92.7	96.7



FN PROJECT NO. AEP11201		FIGURE
FILE NAME H:\WR_DESIGN\FIGURES\Figure3_Soils.mxd	NORTHEASTERN 3&4 ASH POND	3
DATUM & COORDINATE SYSTEM NAD83 STATE PLANE OKLAHOMA NORTH (FT)	HYDROLOGIC SOIL CLASSIFICATIONS	
DATE CREATED APRIL 2011		
PREPARED BY JPM		

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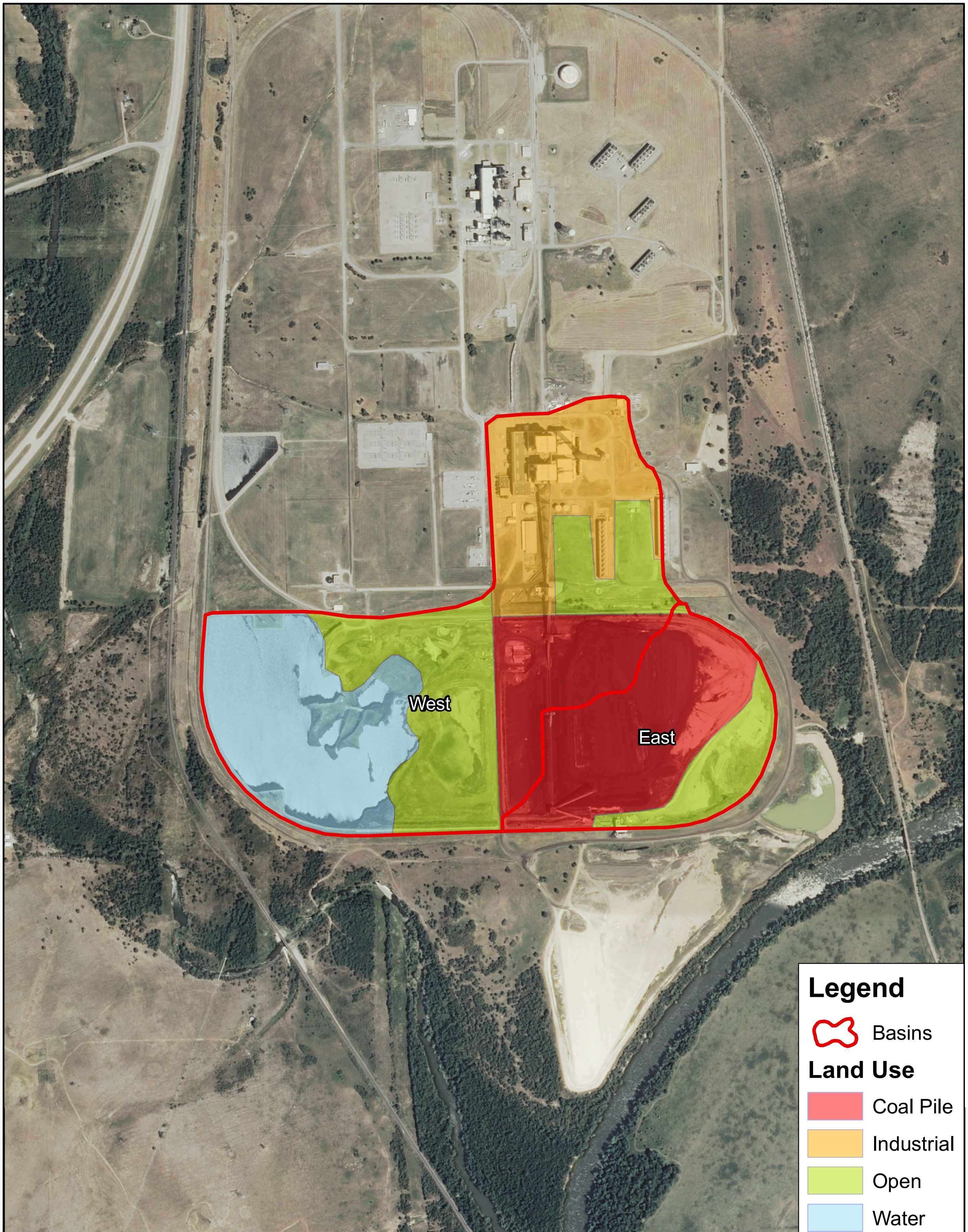


FN PROJECT NO. AEP11201	FREESE AND NICHOLS 4055 International Plaza, Suite 200 Fort Worth, TX 76109-4895 817-735-7300	0 500 1,000 2,000 Feet	N	FIGURE 4
FILE NAME H:\WR_DESIGN\FIGURES\Figure4_LandCover.mxd		NORTHEASTERN 3&4 ASH POND		
DATUM & COORDINATE SYSTEM NAD83 STATE PLANE OKLAHOMA NORTH (FT)		LAND COVER DATA		
DATE CREATED APRIL 2011				
PREPARED BY JPM				

2.3 ELEVATION-STORAGE DATA

Elevation-storage data for the reservoir was approximated with the NED 10-meter DEM to calculate the available storage up to the nominal top of dam elevation of 630.0 ft-msl. This data is considered an approximation based on the best available information because the general topography of the reservoir has changed, and continues to change, with both sedimentation and excavation and grading of the bottom ash material. The elevation-storage relationship was used in the hydrologic model for routing both the frequency storm events and the PMF and is shown in Table 3 below.

Table 3 – Elevation-Storage Data

Elevation (ft-msl)	Storage (acre-ft)
600.0	0
620.0	72
621.0	93
622.0	117
623.0	147
624.0	183
625.0	223
626.0	266
627.0	311
628.0	360
629.0	412
630.0	469

2.4 DISCHARGE RATING CURVES

The dam has a single spillway structure located on the northwest corner of the embankment. Information regarding the dimensions and elevations of the spillway was taken from a combination of original construction drawings and detailed descriptions from AEP personnel. The principal spillway for the Bottom Ash Pond consists of a broad-crested weir with a total length of 24 feet and crest elevation of 625.0 ft-msl. There is also a 1-foot square notch with crest elevation of 624.0 ft-msl; however, this notch has been filled with concrete and no longer contributes to the discharge capacity of the spillway. A 10-foot section of the spillway is covered by a concrete lid. The spillway discharges down a chute with a slope of 2.5:1 and into a stilling basin with chute blocks. Immediately downstream of the stilling basin is a small depressed area contained by the railroad embankment. Two 48-inch HDPE culverts run under the railroad embankment. The original culverts were 60-inch corrugated metal pipe (CMP) culverts, but HDPE slip-liners were recently installed. The overall spillway system, including these downstream culverts, was modeled with a steady-state HEC-RAS[5] model. The HEC-RAS model accounts for submergence of the tailwater from the downstream culverts, which will significantly restrict flow through the spillway. The discharge rating curve for the spillway is shown in Table 4. A photograph of the spillway is shown in Figure 5, along with a photograph of the downstream stilling basin and culverts in Figure 6. Detailed calculations for the discharge rating curve are included in Appendix B.

Table 4 – Discharge Rating Curve

Elevation (ft-msl)	Total Discharge (cfs)
625.0	0
625.5	25
626.0	71
626.5	131
627.0	199
627.5	279
628.0	367
628.5	462
629.0	507
629.5	518
630.0	529

Figure 5 – Bottom Ash Pond Spillway

Figure 6 – Downstream Basin with Culverts

2.5 FREQUENCY MODEL RESULTS

The 10-year frequency – or 10% annual chance – storm event was analyzed for the Northeastern 3 & 4 Power Station Ash Pond. The hydrologic model described in the preceding sections was implemented in analyzing this event. Curve numbers were set to Antecedent Moisture Condition II, and initial abstractions were calculated automatically by HEC-HMS. These assumptions represent normal conditions, as would be expected prior to a storm event of this nature. The precipitation data was obtained from the National Oceanic and Atmospheric Administration's Technical Memorandum NWS HYDRO-35[6] and Technical Paper 40.[7] These values are presented in Table 5. Each storm event was assumed to have a duration of 24 hours.

Table 5 – Frequency Precipitation Depths

Frequency (yrs)	Precipitation (in)							
	5 min	15 min	60 min	2 hr	3 hr	6 hr	12 hr	24hr
1	0.39	0.81	1.50	1.77	1.96	2.27	2.76	3.22
5	0.56	1.19	2.34	2.88	3.17	3.76	4.52	5.17
10	0.62	1.32	2.72	3.26	3.67	4.39	5.22	6.09
25	0.71	1.52	3.17	3.81	4.25	5.12	6.10	7.08
50	0.79	1.68	3.56	4.20	4.77	5.71	6.84	7.92
100	0.86	1.84	4.04	4.71	5.35	6.41	7.63	8.85

These precipitation depths serve as input data into the hydrologic model, and were routed through the model as described previously. Normal engineering assumptions would assume that flood routings were started at the lowest spillway crest elevation. However, the power plant operation policy calls for the normal pool of the reservoir to be maintained at elevation 623.0 ft-msl. This water level is regulated with pumping to the on-site wastewater treatment facility, and, in emergency situations, flow may be diverted to the plant's cooling towers. For comparison, the 10-year storm event was computed with initial elevations at both the normal pool and spillway crest. The results of the 10-year storm are shown in Table 6.

Table 6 – 10-Year Frequency Model Results

Initial Elevation (ft-msl)	Peak Elevation (ft-msl)	Peak Inflow (cfs)	Peak Outflow (cfs)
623.0	625.28	798	14
625.0	626.28	798	104

2.6 PMF MODEL RESULTS

The Probable Maximum Flood (PMF) is defined as the greatest flood to be expected, and the Probable Maximum Precipitation (PMP) is theoretically the greatest depth of rainfall for a given duration that is physically possible over a given size storm area at a particular geographic location. Generally, the rainfall depth is calculated for the ten square miles of the watershed which receive the highest intensity rainfall.

Hydrometeorological Report No. 52 (HMR-52),[8] developed by the U.S. Army Corps of Engineers, was used to determine the rainfall for each basin. PMP estimates were taken from Hydrometeorological Report No. 51[9] and distributed according to HMR-52 to obtain average rainfall depths over the various drainage areas.

HMR-52 calculates rainfall depths for storm durations ranging from five minutes to seventy-two hours. Table 7 lists the point rainfall depths calculated by HMR-52 for storm durations from one hour to 72 hours. Because the total drainage area is less than ten square miles, the same rainfall depths were applied to both basins.HMR-52 also produces a 72-hour, critically stacked temporal distribution by arranging the incremental rainfall depths to produce the rainfall hyetograph shown in Figure 7.

Table 7 – HMR-52 Point Rainfall Depths

Storm Duration (hr)	Depth (in)
1	15.58
2	19.55
3	22.66
6	28.56
12	34.52
24	39.21
48	43.47
72	45.87

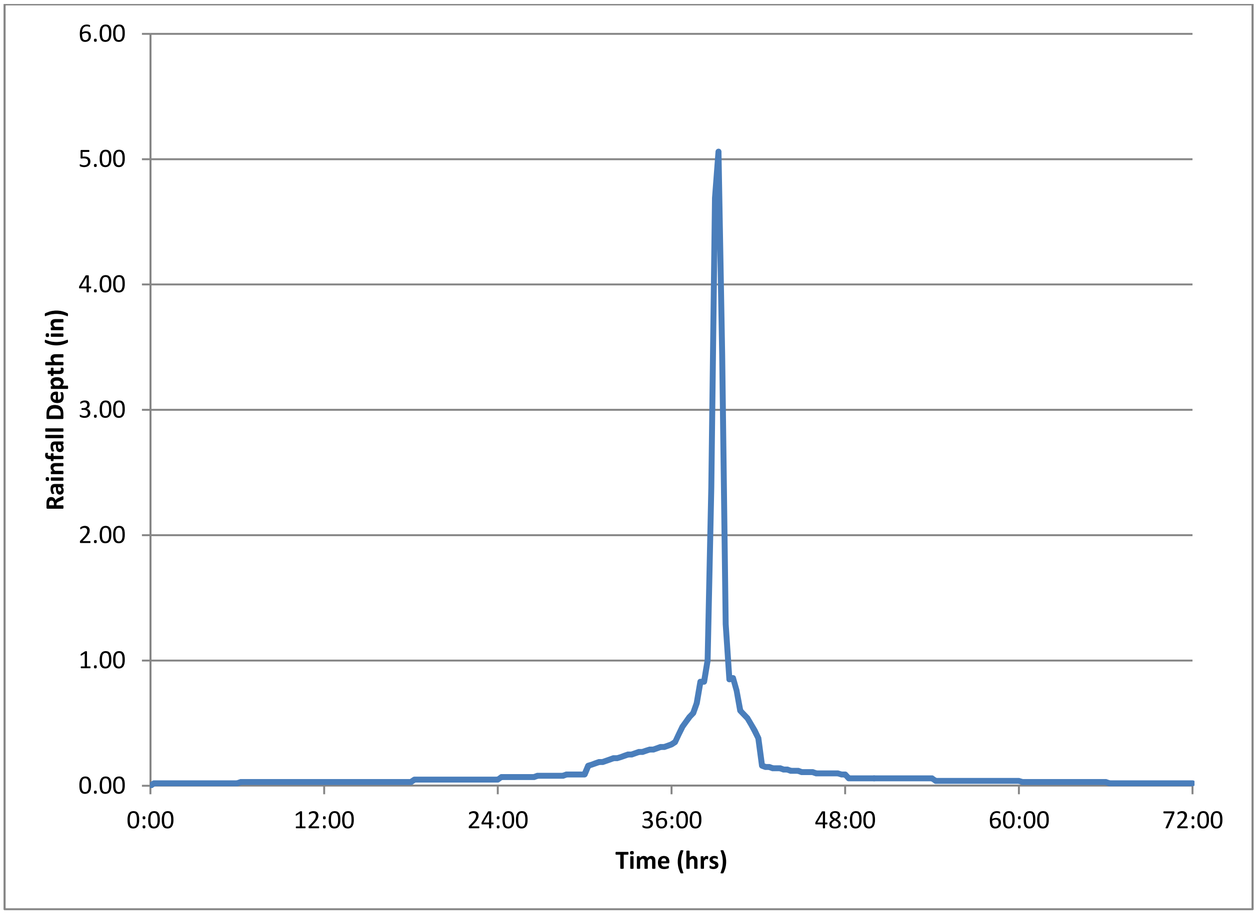


Figure 7 – PMP Rainfall Hyetograph

The PMF was modeled, as described previously, with flood routing started at both elevation 623.0 ft-msl and elevation 625.0 ft-msl. According to the Oklahoma Water Resources Board (OWRB) [10] regulations, the Bottom Ash Pond dam is classified as a small-size dam. The hazard classification may be either low or significant depending on the effects of a dam breach on a railroad bridge downstream. For this analysis, the hazard classification was assumed to be significant. This assumption will be evaluated upon completion of the breach analysis. A dam with a hazard classification of significant is required to pass 40% of the PMF to be in compliance with the OWRB regulations. Table 8 contains the results of these PMF model runs.

Table 8 – 0.4 PMF Model Results

Initial Elevation (ft-msl)	Peak Elevation (ft-msl)	Peak Inflow (cfs)	Peak Outflow (cfs)
623.0	627.87	1,490	344
625.0	628.15	1,490	396

3.0 SUMMARY AND CONCLUSIONS

Based on the results of the hydrologic analysis, the Bottom Ash Pond Dam is hydraulically adequate for the 40% PMF event. Table 9 lists the pertinent elevation data for the dam, including the top of dam elevation and spillway crest elevation. Comparing these elevations to the maximum water surface elevations shown in Table 10 indicates that the dam would safely contain all flood events up to, and including, the 40% PMF. Additionally, while the normal pool elevation is maintained at elevation 623.0 ft-msl by pumping operations, the spillway is engaged during the 10-year storm event.

Table 9 – Pertinent Dam Information

Top of Dam (ft-msl)	Spillway Crest (ft-msl)	Operating Level (ft-msl)
630.0	625.0	623.0

Table 10 – Summary of Results

Initial Elevation (ft-msl)	10-year	0.4 PMF
623.0	625.28	627.87
625.0	626.28	628.15

It should be noted that these results reflect the best understanding of existing conditions and could be significantly affected by major changes to the reservoir. The assumptions in this analysis represent average reservoir conditions. In its current condition, the Bottom Ash Pond associated with the Northeastern 3 & 4 Power Station is deemed to be hydraulically adequate for any storm event up to, and including, the 40% PMF. Pertinent drawings for existing conditions are included in Appendix C.

Appendix A
References

References

1. U.S. Army Corps of Engineers, Hydrologic Engineering Center: *Hydrologic Modeling System HEC-HMS - User's Manual Version 3.5*, Davis, California, August 2010.

2. Henderson Aerial Survey, Inc. *Northeastern Plant*. [computer map]. 1"=50'. Grove City, Ohio, March 31, 2010.

3. "Soil Data Mart." *NRCS Soil Survey Geographic (SSURGO) Database*. <http://soildatamart.nrcs.usda.gov>.

4. U.S. Department of Agriculture, Aerial Photography Field Office: *National Agriculture Imagery Program*, Salt Lake City, UT, 2010. <http://gis.apfo.usda.gov/arcgis/services>.

5. U.S. Army Corps of Engineers, Hydrologic Engineering Center: *River Analysis System - User's Manual Version 4.1*, Davis, California, January 2010.

6. U.S. Department of Commerce, National Oceanic and Atmospheric Administration: *Technical Memorandum NWS HYDRO-35, Five- to 60-Minute Precipitation Frequency for the Eastern and Central United States*, Silver Spring, MD, June 1977.

7. U.S. Department of Commerce, Weather Bureau: *Technical Paper No. 40, Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years*, Washington, D.C., May 1961.

8. U.S. Department of Commerce, National Oceanic and Atmospheric Administration and U.S. Department of the Army, Corps of Engineers: *Hydrometeorological Report No. 52, Application of Probable Maximum Precipitation Estimates, United States East of the 105th Meridian*, Washington, D.C., 1982.

9. U.S. Department of Commerce, National Oceanic and Atmospheric Administration and U.S. Department of the Army, Corps of Engineers: *Hydrometeorological Report No. 51, Probable Maximum Precipitation Estimates, United States East of the 105th Meridian*, Washington, D.C., 1978.

10. Oklahoma Water Resources Board, Dam Safety Program: *Hazard Potential Classification: Guidelines for Dams in Oklahoma*. January 2011.

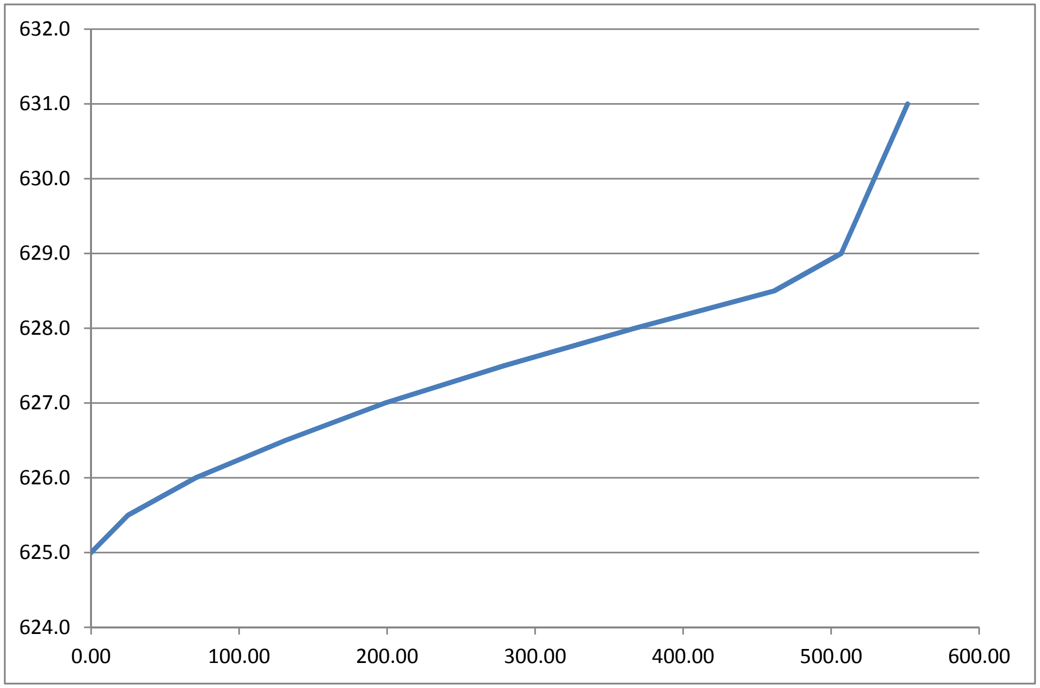
Appendix B
Discharge Rating Curve Calculations and Hydrologic Parameters

Discharge Rating Curve
Overflow Structure

Elevation [ft-msl]	Discharge [cfs]
625.0	0.00
625.5	24.86
626.0	70.65
626.5	131.08
627.0	198.65
627.5	279.03
628.0	367.27
628.5	461.54
629.0	506.74
629.5	517.98
630.0	529.21
630.5	540.45
631.0	551.69
631.5	562.92

RAS Results	
Elevation [ft-msl]	Discharge [cfs]
625	0
625.07	1
625.2	10
625.44	20
625.81	50
626.27	100
627.01	200
627.63	300
628.18	400
628.7	500
633.15	600
640.02	700

**Accounts for Discharge in DS Culverts*

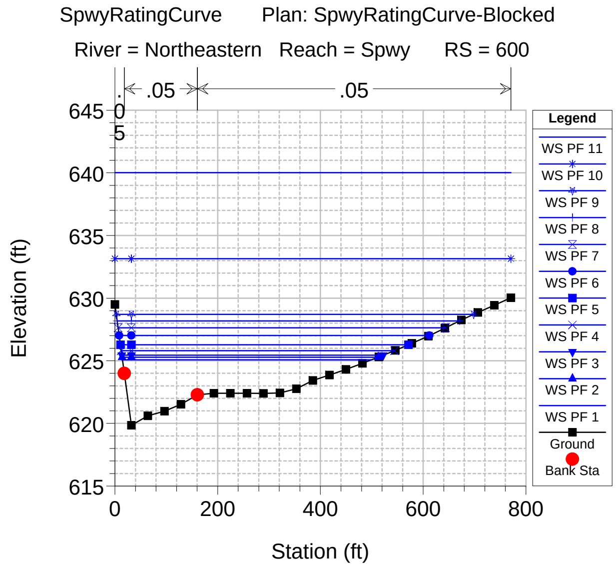


HEC-RAS Plan: SPRC_BL   River: Northeastern   Reach: Spwy

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Spwy	600	PF 1	1.00	619.86	625.07		625.07	0.000000	0.00	1231.66	484.24	0.00
Spwy	600	PF 2	10.00	619.86	625.28		625.28	0.000000	0.01	1336.14	498.46	0.00
Spwy	600	PF 3	20.00	619.86	625.44		625.44	0.000000	0.02	1416.77	508.75	0.00
Spwy	600	PF 4	50.00	619.86	625.81		625.81	0.000000	0.04	1606.45	532.03	0.00
Spwy	600	PF 5	100.00	619.86	626.27		626.27	0.000001	0.07	1859.02	560.46	0.01
Spwy	600	PF 6	200.00	619.86	627.01		627.01	0.000001	0.11	2290.88	603.90	0.01
Spwy	600	PF 7	300.00	619.86	627.63		627.63	0.000002	0.14	2674.13	637.24	0.01
Spwy	600	PF 8	400.00	619.86	628.18		628.19	0.000002	0.17	3035.76	666.36	0.01
Spwy	600	PF 9	500.00	619.86	628.70		628.70	0.000003	0.19	3386.70	695.48	0.01
Spwy	600	PF 10	600.00	619.86	633.15		633.15	0.000000	0.11	6765.67	770.65	0.01
Spwy	600	PF 11	700.00	619.86	640.02		640.02	0.000000	0.07	12057.71	770.65	0.00
Spwy	185	PF 1	1.00	621.00	625.07		625.07	0.000000	0.01	171.72	52.36	0.00
Spwy	185	PF 2	10.00	621.00	625.28		625.28	0.000001	0.06	182.96	53.42	0.01
Spwy	185	PF 3	20.00	621.00	625.44		625.44	0.000002	0.12	191.57	54.22	0.01
Spwy	185	PF 4	50.00	621.00	625.81		625.81	0.000010	0.27	211.60	56.04	0.02
Spwy	185	PF 5	100.00	621.00	626.27		626.27	0.000028	0.48	237.89	58.33	0.04
Spwy	185	PF 6	200.00	621.00	627.00		627.01	0.000069	0.81	282.07	62.01	0.06
Spwy	185	PF 7	300.00	621.00	627.61		627.63	0.000107	1.08	320.80	65.05	0.07
Spwy	185	PF 8	400.00	621.00	628.16		628.18	0.000140	1.31	357.11	67.79	0.09
Spwy	185	PF 9	500.00	621.00	628.67		628.69	0.000169	1.50	392.17	70.33	0.10
Spwy	185	PF 10	600.00	621.00	633.13		633.15	0.000039	0.98	731.89	77.00	0.05
Spwy	185	PF 11	700.00	621.00	640.01		640.01	0.000011	0.69	1261.22	77.00	0.03
Spwy	175	PF 1	1.00	625.00	625.07		625.07	0.000792	0.46	2.17	32.00	0.31
Spwy	175	PF 2	10.00	625.00	625.26		625.28	0.000917	1.21	8.29	32.00	0.42
Spwy	175	PF 3	20.00	625.00	625.40		625.44	0.000852	1.55	12.89	32.00	0.43
Spwy	175	PF 4	50.00	625.00	625.73		625.80	0.000755	2.14	23.35	32.00	0.44
Spwy	175	PF 5	100.00	625.00	626.14		626.26	0.000694	2.74	36.58	32.71	0.45
Spwy	175	PF 6	200.00	625.00	626.81		626.99	0.000597	3.45	59.45	36.03	0.45
Spwy	175	PF 7	300.00	625.00	627.36		627.60	0.000544	3.94	80.27	38.82	0.45
Spwy	175	PF 8	400.00	625.00	627.87		628.15	0.000502	4.30	100.48	41.34	0.45
Spwy	175	PF 9	500.00	625.00	628.34		628.66	0.000466	4.59	120.62	43.71	0.44
Spwy	175	PF 10	600.00	625.00	633.07		633.14	0.000032	2.17	359.78	52.00	0.13
Spwy	175	PF 11	700.00	625.00	639.99		640.01	0.000005	1.35	719.30	52.00	0.06
Spwy	170	PF 1	1.00	625.00	625.03	625.03	625.06	0.020524	1.35	0.74	25.00	1.39
Spwy	170	PF 2	10.00	625.00	625.22		625.27	0.002461	1.79	5.59	25.00	0.67
Spwy	170	PF 3	20.00	625.00	625.35		625.43	0.002331	2.31	8.64	25.00	0.69
Spwy	170	PF 4	50.00	625.00	625.63		625.79	0.002041	3.18	15.73	25.00	0.71
Spwy	170	PF 5	100.00	625.00	625.98		626.24	0.001952	4.10	24.41	25.00	0.73
Spwy	170	PF 6	200.00	625.00	626.54		626.96	0.001790	5.18	38.60	25.00	0.73
Spwy	170	PF 7	300.00	625.00	627.02		627.57	0.001730	5.95	50.41	25.00	0.74
Spwy	170	PF 8	400.00	625.00	627.44		628.11	0.001686	6.55	61.06	25.00	0.74
Spwy	170	PF 9	500.00	625.00	627.85		628.61	0.001636	7.02	71.21	25.00	0.73
Spwy	170	PF 10	600.00	625.00	633.00		633.13	0.000090	2.95	220.04	30.00	0.18
Spwy	170	PF 11	700.00	625.00	639.96		640.01	0.000019	1.83	428.79	30.00	0.08
Spwy	166	PF 1	1.00	624.00	624.62	624.32	624.66	0.001489	1.62	0.62	1.00	0.36
Spwy	166	PF 2	10.00	624.00	625.22	625.13	625.26	0.001714	1.58	6.35	24.00	0.54
Spwy	166	PF 3	20.00	624.00	625.34	625.24	625.42	0.001992	2.16	9.25	24.00	0.61
Spwy	166	PF 4	50.00	624.00	625.62	625.47	625.78	0.002088	3.13	16.00	24.00	0.67
Spwy	166	PF 5	100.00	624.00	625.95	625.77	626.23	0.002305	4.19	23.87	24.00	0.74
Spwy	166	PF 6	200.00	624.00	626.48	626.25	626.95	0.002386	5.47	36.57	24.00	0.78
Spwy	166	PF 7	300.00	624.00	626.92	626.65	627.55	0.002464	6.39	46.98	24.00	0.80
Spwy	166	PF 8	400.00	624.00	627.31	627.01	628.09	0.002509	7.10	56.34	24.00	0.82
Spwy	166	PF 9	500.00	624.00	627.67	627.34	628.59	0.002546	7.70	64.96	24.00	0.82
Spwy	166	PF 10	600.00	624.00	632.99	627.64	633.13	0.000235	3.08	209.47	30.00	0.18
Spwy	166	PF 11	700.00	624.00	639.96	627.94	640.01	0.000041	1.86	418.55	30.00	0.08
Spwy	154	PF 1	1.00	624.00	624.60	624.32	624.64	0.001636	1.68	0.60	1.00	0.38
Spwy	154	PF 2	10.00	624.00	625.17	625.13	625.23	0.003413	1.94	5.15	24.00	0.74
Spwy	154	PF 3	20.00	624.00	625.27	625.24	625.38	0.003801	2.63	7.59	24.00	0.82
Spwy	154	PF 4	50.00	624.00	625.48	625.47	625.73	0.004764	4.03	12.41	24.00	0.99
Spwy	154	PF 5	100.00	624.00	625.77	625.77	626.18	0.004351	5.11	19.58	24.00	1.00
Spwy	154	PF 6	200.00	624.00	626.25	626.25	626.90	0.004034	6.46	30.95	24.00	1.00
Spwy	154	PF 7	300.00	624.00	626.65	626.65	627.50	0.003873	7.39	40.61	24.00	1.00
Spwy	154	PF 8	400.00	624.00	627.01	627.01	628.03	0.003766	8.11	49.34	24.00	1.00
Spwy	154	PF 9	500.00	624.00	627.34	627.34	628.53	0.003732	8.73	57.26	24.00	1.00
Spwy	154	PF 10	600.00	624.00	632.99	627.64	633.13	0.000236	3.08	209.38	30.00	0.18
Spwy	154	PF 11	700.00	624.00	639.96	627.94	640.01	0.000041	1.86	418.53	30.00	0.08
Spwy	152	PF 1	1.00	624.00	624.59		624.64	0.001663	1.69	0.59	1.00	0.39
Spwy	152	PF 2	10.00	624.00	625.15	625.12	625.22	0.004604	2.10	4.76	25.00	0.85
Spwy	152	PF 3	20.00	624.00	625.24	625.23	625.37	0.004957	2.82	7.08	25.00	0.94
Spwy	152	PF 4	50.00	624.00	625.47	625.46	625.71	0.004456	3.92	12.75	25.00	0.97
Spwy	152	PF 5	100.00	624.00	625.78	625.74	626.15	0.003840	4.90	20.39	25.00	0.96
Spwy	152	PF 6	200.00	624.00	626.23	626.22	626.85	0.003684	6.31	31.68	25.00	0.99

HEC-RAS Plan: SPRC_BL River: Northeastern Reach: Spwy (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Spwy	152	PF 7	300.00	624.00	626.63	626.60	627.43	0.003411	7.18	41.81	25.00	0.98
Spwy	152	PF 8	400.00	624.00	626.98	626.94	627.95	0.003332	7.92	50.49	25.00	0.98
Spwy	152	PF 9	500.00	624.00	627.29	627.26	628.43	0.003299	8.57	58.36	25.00	0.99
Spwy	152	PF 10	600.00	624.00	632.99		633.13	0.000095	2.94	220.82	30.00	0.18
Spwy	152	PF 11	700.00	624.00	639.96		640.01	0.000020	1.82	429.76	30.00	0.08
Spwy	151	PF 1	1.00	624.00	624.59		624.63	0.001680	1.70	0.59	1.00	0.39
Spwy	151	PF 2	10.00	624.00	625.12	625.12	625.22	0.007571	2.44	4.10	25.00	1.06
Spwy	151	PF 3	20.00	624.00	625.23	625.23	625.37	0.006126	3.01	6.64	25.00	1.03
Spwy	151	PF 4	50.00	624.00	625.46	625.46	625.71	0.004890	4.03	12.40	25.00	1.01
Spwy	151	PF 5	100.00	624.00	625.74	625.74	626.15	0.004453	5.13	19.48	25.00	1.02
Spwy	151	PF 6	200.00	624.00	626.22	626.22	626.85	0.003789	6.37	31.41	25.00	1.00
Spwy	151	PF 7	300.00	624.00	626.59	626.59	627.43	0.003686	7.35	40.80	25.00	1.01
Spwy	151	PF 8	400.00	624.00	626.94	626.94	627.95	0.003540	8.08	49.53	25.00	1.01
Spwy	151	PF 9	500.00	624.00	627.26	627.26	628.43	0.003449	8.69	57.54	25.00	1.01
Spwy	151	PF 10	600.00	624.00	632.99		633.12	0.000117	2.99	200.65	25.00	0.19
Spwy	151	PF 11	700.00	624.00	639.95		640.01	0.000029	1.87	374.86	25.00	0.08
Spwy	114	PF 1	1.00	610.00	610.08		610.08	0.000854	0.52	1.92	25.00	0.33
Spwy	114	PF 2	10.00	610.00	610.22		610.27	0.002417	1.78	5.62	25.00	0.66
Spwy	114	PF 3	20.00	610.00	610.34		610.43	0.002505	2.36	8.46	25.00	0.72
Spwy	114	PF 4	50.00	610.00	610.59	610.49	610.77	0.002574	3.41	14.65	25.00	0.79
Spwy	114	PF 5	100.00	610.00	611.22		611.39	0.000952	3.28	30.49	25.00	0.52
Spwy	114	PF 6	200.00	610.00	613.17		613.27	0.000189	2.52	79.22	25.00	0.25
Spwy	114	PF 7	300.00	610.00	616.21		616.27	0.000057	1.93	155.31	25.00	0.14
Spwy	114	PF 8	400.00	610.00	620.63		620.67	0.000022	1.51	265.76	25.00	0.08
Spwy	114	PF 9	500.00	610.00	626.30		626.33	0.000011	1.23	407.61	25.00	0.05
Spwy	114	PF 10	600.00	610.00	633.07		633.09	0.000007	1.04	576.75	25.00	0.04
Spwy	114	PF 11	700.00	610.00	639.98		640.00	0.000005	0.93	749.56	25.00	0.03
Spwy	109	PF 1	1.00	610.00	610.07	610.03	610.08	0.001103	0.56	1.78	25.00	0.37
Spwy	109	PF 2	10.00	610.00	610.17	610.17	610.26	0.005799	2.32	4.32	25.00	0.98
Spwy	109	PF 3	20.00	610.00	610.27	610.27	610.41	0.005192	2.95	6.78	25.00	1.00
Spwy	109	PF 4	50.00	610.00	610.49	610.49	610.75	0.004480	4.04	12.37	25.00	1.01
Spwy	109	PF 5	100.00	610.00	611.21		611.38	0.000967	3.29	30.35	25.00	0.53
Spwy	109	PF 6	200.00	610.00	613.17		613.27	0.000189	2.53	79.19	25.00	0.25
Spwy	109	PF 7	300.00	610.00	616.21		616.27	0.000057	1.93	155.31	25.00	0.14
Spwy	109	PF 8	400.00	610.00	620.63		620.67	0.000022	1.51	265.76	25.00	0.08
Spwy	109	PF 9	500.00	610.00	626.30		626.33	0.000011	1.23	407.60	25.00	0.05
Spwy	109	PF 10	600.00	610.00	633.07		633.09	0.000007	1.04	576.75	25.00	0.04
Spwy	109	PF 11	700.00	610.00	639.98		640.00	0.000005	0.93	749.56	25.00	0.03
Spwy	100	PF 1	1.00	610.00	610.03	610.03	610.04	0.014233	1.03	0.97	38.00	1.13
Spwy	100	PF 2	10.00	610.00	610.13	610.13	610.19	0.006803	2.06	4.85	38.00	1.02
Spwy	100	PF 3	20.00	610.00	610.21	610.21	610.31	0.005602	2.56	7.80	38.00	1.00
Spwy	100	PF 4	50.00	610.00	610.38	610.38	610.57	0.004696	3.49	14.31	38.00	1.00
Spwy	100	PF 5	100.00	610.00	611.28	610.60	611.35	0.000330	2.05	48.89	39.41	0.32
Spwy	100	PF 6	200.00	610.00	613.21	610.95	613.25	0.000060	1.62	134.10	49.04	0.16
Spwy	100	PF 7	300.00	610.00	616.24	611.24	616.26	0.000014	1.21	293.06	53.00	0.09
Spwy	100	PF 8	400.00	610.00	620.65	611.51	620.66	0.000004	0.94	526.73	53.00	0.05
Spwy	100	PF 9	500.00	610.00	626.31	611.75	626.32	0.000002	0.77	827.16	53.00	0.03
Spwy	100	PF 10	600.00	610.00	633.08	611.98	633.08	0.000001	0.66	1185.60	53.00	0.02
Spwy	100	PF 11	700.00	610.00	639.99	612.19	639.99	0.000000	0.59	1551.88	53.00	0.02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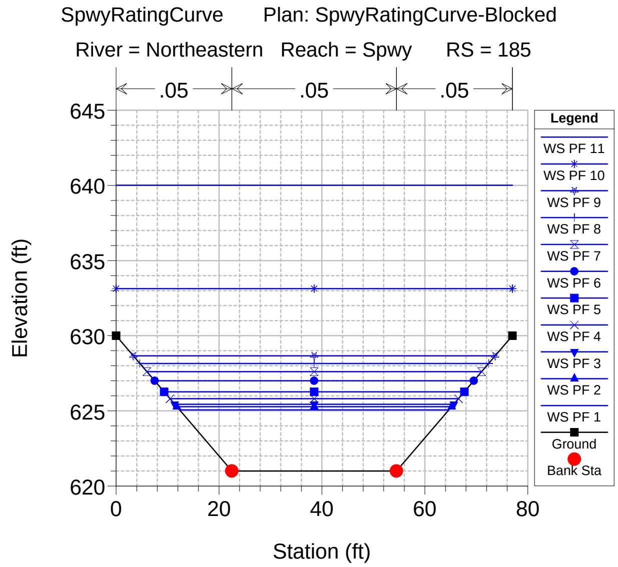
River = Northeastern Reach = Spwy RS = 600
.05
.05
Elevation (ft)
Station (ft)
Legend
WS PF 11
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta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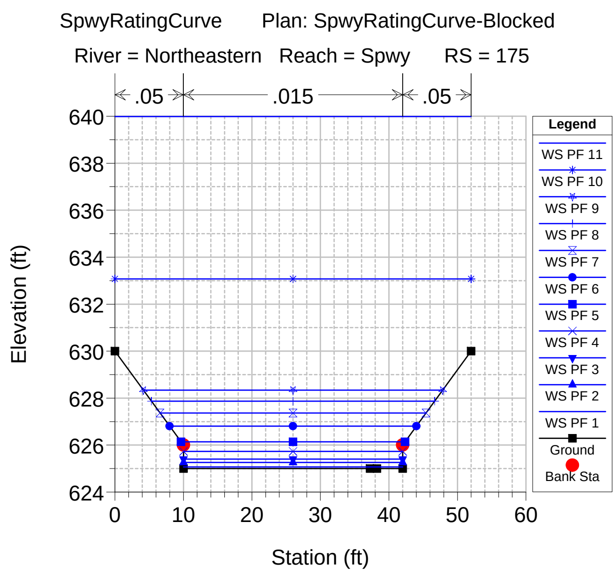
River = Northeastern Reach = Spwy RS = 185
.05
.05
.05
Elevation (ft)
Station (ft)
Legend
WS PF 11
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta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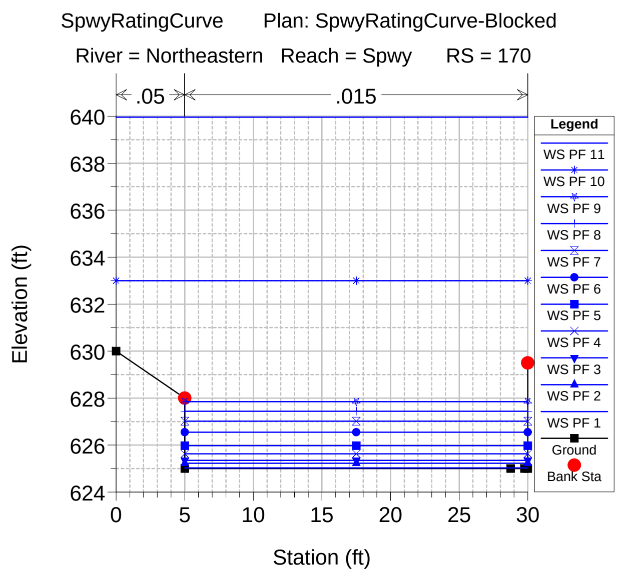
River = Northeastern Reach = Spwy RS = 175
.05
.015
.05
Elevation (ft)
Station (ft)
Legend
WS PF 11
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta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.015
Elevation (ft)
Station (ft)
Legend
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WS PF 10
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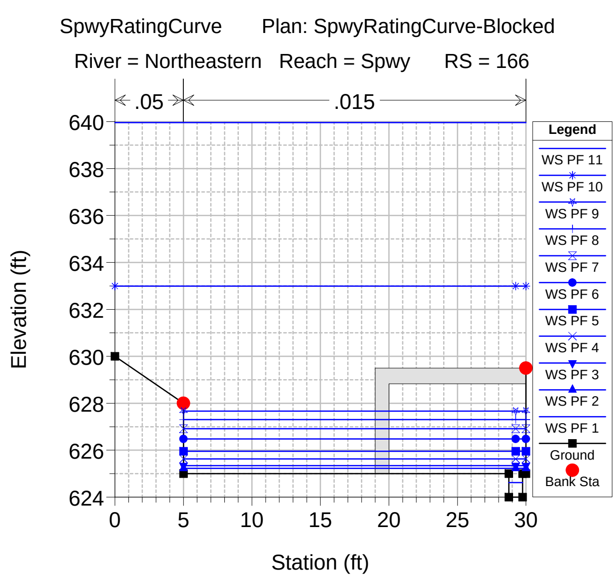
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta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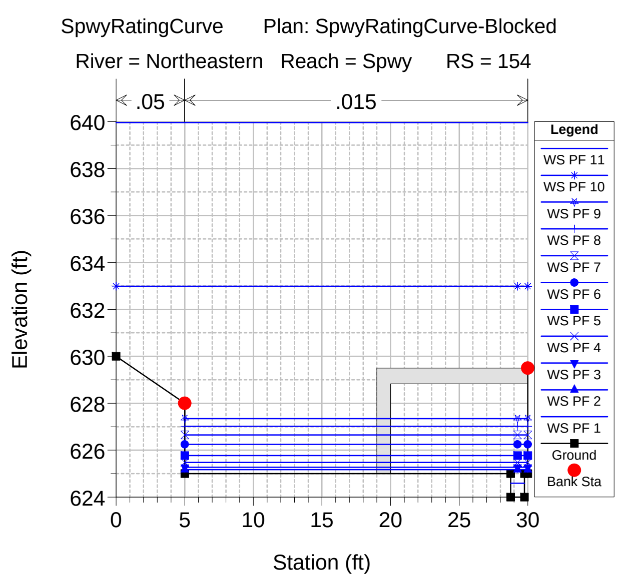
River = Northeastern Reach = Spwy RS = 166
.05
.015
Elevation (ft)
Station (ft)
Legend
WS PF 11
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta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River = Northeastern Reach = Spwy RS = 154
.05
.015
Elevation (ft)
Station (ft)
Legend
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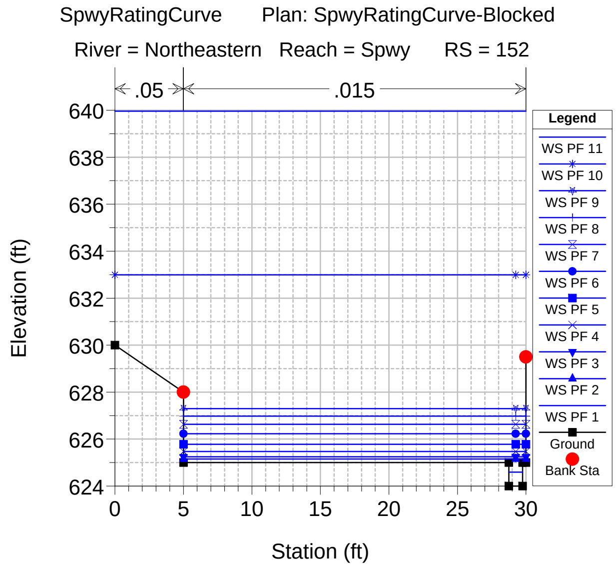
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta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River = Northeastern Reach = Spwy RS = 152
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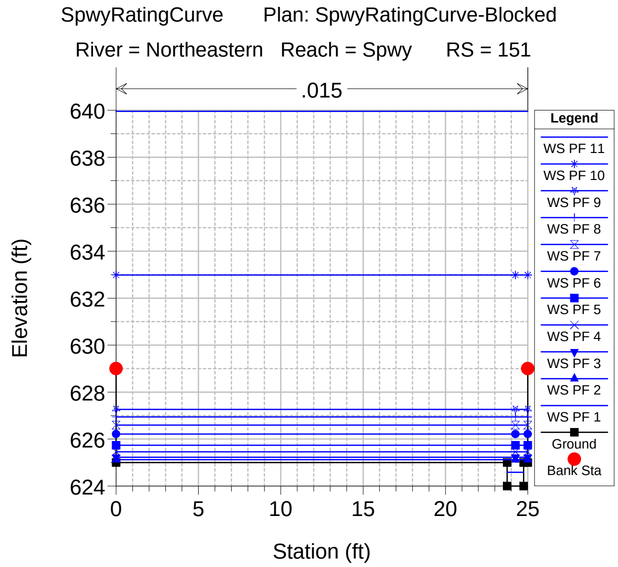
.015
Elevation (ft)
Station (ft)
Legend
WS PF 11
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta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Elevation (ft)
Station (ft)
Legend
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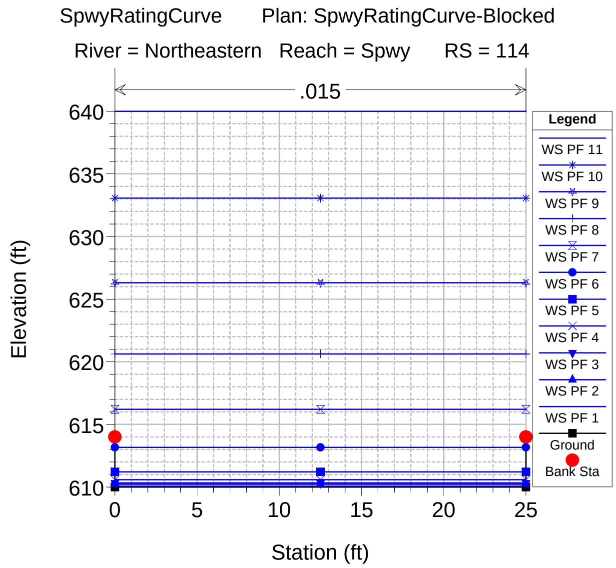
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta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Elevation (ft)
Station (ft)
Legend
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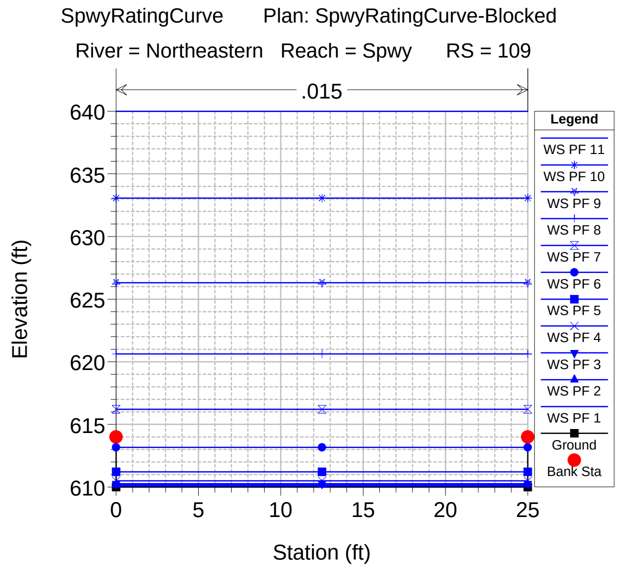
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta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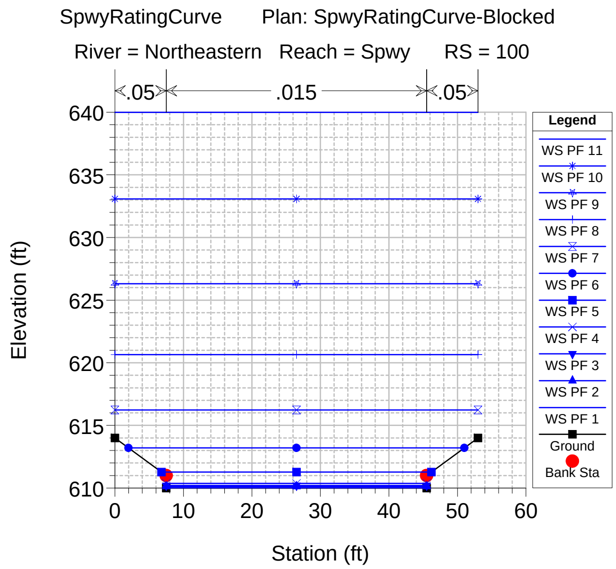
River = Northeastern Reach = Spwy RS = 109
.015
Elevation (ft)
Station (ft)
Legend
WS PF 11
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta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River = Northeastern Reach = Spwy RS = 100
.05
.015
.05
Elevation (ft)
Station (ft)
Legend
WS PF 11
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta

BASIN LAG TIME CALCULATION (Existing)

USING NRCS TR55 METHOD TO COMPUTE TIME OF CONCENTRATION

Existing Conditions

Project Data:		Comments:
PROJECT	Northeastern Station	
LOCATION	Oologah, OK	
DATE	Apr-11	
BASIN COND.		
BY:	JPM	
WSHED NAME	West	

SHEET FLOW: (100' MAX)

Land Use Undeveloped	n value	% Land use	Inc n
Conc.,gravel,asphalt,bare soil	0.015	0	0
Grass Short Prairie	0.15	0	0
Maintained Grass	0.03	0	0
Woods Light Underbrush	0.4	0	0
Woods Dense underbrush	0.8	0	0

based on information for imperviousness from Corps of Engineers

Land Use	% Conc	% Grass	n value	% Land Use	Inc n
Low D. Residential (1+ Acres)	25	75	0.21375	0	0
Med. D. Residential (1/3 Acres)	41	59	0.17135	0	0
High D. Residential (1/4 Acres)	47	53	0.15545	0	0
Multifamily	70	30	0.0945	0	0
Mobile Home Parks	20	80	0.227	0	0
C.B.D.	95	5	0.02825	0	0
Strip Commercial	90	10	0.0415	0	0
Shopping Center	95	5	0.02825	0	0
Instutional-Schools	40	60	0.174	0	0
Industrial	90	10	0.0415	100	0.0415
Highway ROW	35	65	0.18725	0	0
Public Utilities	60	40	0.121	0	0
Vacant urban land and	6	84	0.2361	0	0
Parks	0	0	0	0	
Other	0	0	0	0	0
		TOTAL		100	0.0415

LENGTH	100	**FT.**	**MAX 100'**
2 YR. 24 HOUR PRECIP	4.02	**IN.**	
SLOPE	0.01	**FT/FT**	

$$T_1 = 0.007 \times \frac{(n \times L)^{0.8}}{R^{0.5} \times S^{0.4}}$$

SHALLOW CONCENTRATED FLOW

1=PAVED 2=UNPAVED	2	
LENGTH	1010.04	**FT**
SLOPE	0.0050	**FT/FT**
COMPUTED VELOCITY FROM FIGURE 3.1=	1.131	

$$T_2 = \frac{L}{60 \times V}$$

CHANNEL FLOW

			TOPWIDTH	40
XSECT AREA=	125.000	**SQ FT**	**BOTTOM**	10
			DEPTH	5
WETTED PERIMETER	41.623	**FT**		
SLOPE	0.0063	**FT/FT**		
MANNINGS N	0.04			
COMPUTED VELOCITY	6.159	**FT/S**		
LENGTH	2060.49	**FT**		

$$V = \frac{1.49 \times \left(\frac{a}{p_w}\right)^{\frac{2}{3}} \times s^{\frac{1}{2}}}{n}$$

$$T_6 = \frac{L}{60 \times V}$$

	Conditions	Adjusted	NRCS Method	Selected
WATERSHED NUMBER	**West**	**Tc (Min)**	**Tc (Min)**	**Tc (Min)**
SHEET FLOW	**Max 30 Min**	30.0	4.13	4.13
SHALLOW CONCENTRATED FLOW			14.88	14.88
CHANNEL FLOW			5.58	5.58
TOTAL			24.59	24.59
			Lag (Hrs) =	**0.25**

$$T_c = T_1 + T_2 + T_3 + T_4 + T_5 + T_6$$

Lag (min) = 14.75

BASIN LAG TIME CALCULATION (Existing)

USING NRCS TR55 METHOD TO COMPUTE TIME OF CONCENTRATION

Existing Conditions

Project Data:		Comments:
PROJECT	Northeastern Station	
LOCATION	Oologah, OK	
DATE	Apr-11	
BASIN COND.		
BY:	JPM	
WSHED NAME	East	

SHEET FLOW: (100' MAX)

Land Use Undeveloped	n value	% Land use	Inc n
Conc.,gravel,asphalt,bare soil	0.015	0	0
Grass Short Prairie	0.15	100	0.15
Maintained Grass	0.03	0	0
Woods Light Underbrush	0.4	0	0
Woods Dense underbrush	0.8	0	0

based on information for imperviousness from Corps of Engineers

Land Use	% Conc	% Grass	n value	% Land Use	Inc n
Low D. Residential (1+ Acres)	25	75	0.21375	0	0
Med. D. Residential (1/3 Acres)	41	59	0.17135	0	0
High D. Residential (1/4 Acres)	47	53	0.15545	0	0
Multifamily	70	30	0.0945	0	0
Mobile Home Parks	20	80	0.227	0	0
C.B.D.	95	5	0.02825	0	0
Strip Commercial	90	10	0.0415	0	0
Shopping Center	95	5	0.02825	0	0
Instutional-Schools	40	60	0.174	0	0
Industrial	90	10	0.0415	0	0
Highway ROW	35	65	0.18725	0	0
Public Utilities	60	40	0.121	0	0
Vacant urban land and	6	84	0.2361	0	0
Parks	0	0	0	0	
Other	0	0	0	0	0
		TOTAL		100	0.15

LENGTH	100	FT.	MAX 100'
2 YR. 24 HOUR PRECIP	4.02	IN.	
SLOPE	0.2	FT/FT	

$$T_1 = 0.007 \times \frac{(n \times L)^{0.8}}{R^{0.5} \times S^{0.4}}$$

CHANNEL FLOW -- 1

			TOPWIDTH	30
XSECT AREA=	60.000	SQ FT	BOTTOM	10
			DEPTH	3
WETTED PERIMETER	30.881	FT		
SLOPE	0.0018	FT/FT		
MANNINGS N	0.04			
COMPUTED VELOCITY	2.478	FT/S		
LENGTH	1643.35	FT		

$$V = \frac{1.49 \times \left(\frac{a}{p_w}\right)^{\frac{2}{3}} \times s^{\frac{1}{2}}}{n}$$

$$T_6 = \frac{L}{60 \times V}$$

CHANNEL FLOW -- 2

			TOPWIDTH	40
XSECT AREA=	137.500	SQ FT	BOTTOM	15
			DEPTH	5
WETTED PERIMETER	41.926	FT		
SLOPE	0.0052	FT/FT		
MANNINGS N	0.04			
COMPUTED VELOCITY	5.912	FT/S		
LENGTH	1934.24	FT		

$$V = \frac{1.49 \times \left(\frac{a}{p_w}\right)^{\frac{2}{3}} \times s^{\frac{1}{2}}}{n}$$

$$T_6 = \frac{L}{60 \times V}$$

	Conditions	Adjusted Tc (Min)	NRCS Method Tc (Min)	Selected Tc (Min)
WATERSHED NUMBER	East			
SHEET FLOW	Max 30 Min	30.0	3.48	3.48
CHANNEL FLOW -- 1			11.05	11.05
CHANNEL FLOW -- 2			5.45	5.45
TOTAL			19.98	19.98
			Lag (Hrs) =	**0.20**

$$T_c = T_1 + T_2 + T_3 + T_4 + T_5 + T_6$$

Lag (min) = 11.99

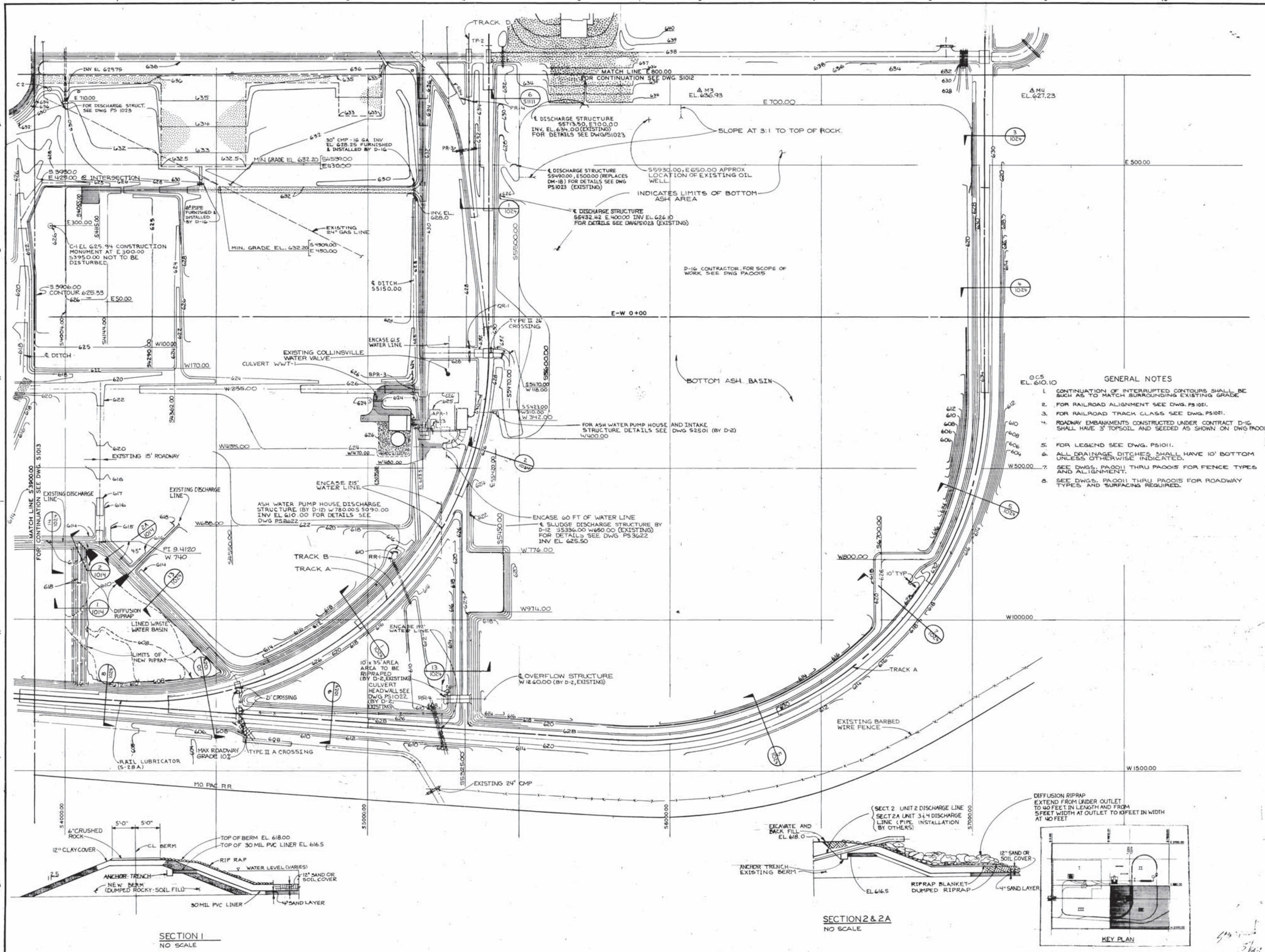
Curve Number

Basin	Land Use	CN	Area (ac)	Inc. CN	
West	Water	100	46.86	31.40	
West	Open Space - Poor	89	46.38	27.66	
West	Industrial	93	32.50	20.25	
West	Coal Pile	94	23.51	14.80	
					AMC III
		Total	**149.25**	**94.11**	**97.35**

Basin	Land Use	CN	Area (ac)	Inc. CN	
East	Open Space - Poor	89	12.68	22.63	
East	Coal Pile	94	37.19	70.10	
					AMC III
		Total	**49.87**	**92.73**	**96.70**

** All soils are Hydrologic Soil Group D*

Appendix C
Pertinent Drawings



SECTION 1
NO SCALE

SECTION 2 & 2A
NO SCALE

GENERAL NOTES

1. CONTINUATION OF INTERRUPTED CONTOURS SHALL BE SUCH AS TO MATCH SURROUNDING EXISTING GRADE.
2. FOR RAILROAD ALIGNMENT SEE DWG. PS1021.
3. FOR RAILROAD TRACK CLASS SEE DWG. PS1021.
4. ROADWAY EMBANKMENTS CONSTRUCTED UNDER CONTRACT D-16 SHALL HAVE 3" TOPSOIL AND SEEDED AS SHOWN ON DWG PA0015.
5. FOR LEGEND SEE DWG. PS1011.
6. ALL DRAINAGE DITCHES SHALL HAVE 10' BOTTOM UNLESS OTHERWISE INDICATED.
7. SEE DWGS. PA0011 THRU PA0015 FOR FENCE TYPES AND ALIGNMENT.
8. SEE DWGS. PA0011 THRU PA0015 FOR ROADWAY TYPES AND SURFACING REQUIRED.

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
1-13-83	CONFORMED TO CONSTRUCTION RECORDS	21	JR		
6-15-82	ISSUED FOR CONSTRUCTION, SPEC D-16	20	SB		
5-21-82	ISSUED FOR ADDENDUM 1, SPEC D-16	19	SB	DE	
5-6-82	ISSUED FOR BIDS, SPEC D-16	18	SB		
8-14-80	ISSUED FOR BIDS; 1	17	TW		DE
11-3-78	ADDED ROADWAY & CULVERT	16	JR	JG	
10-5-78	REVISED AS CIRCLED	15	JR		
9-22-78	ISSUED FOR BIDS, SPEC D-12	14	JR		
11-12-76	REVISED AS CIRCLED	13	JM		
10-8-76	REVISED AS CIRCLED	12	JM		
8-11-76	REVISED AS CIRCLED	11	ES		
5-14-76	REVISED AS CIRCLED	10	BM		
3-12-76	REVISED AS CIRCLED	9	CB		

SCALE: 1"=100'

DEPT HEAD CLM
CHECKED TD
DRAWN KDJ

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF OKLAHOMA

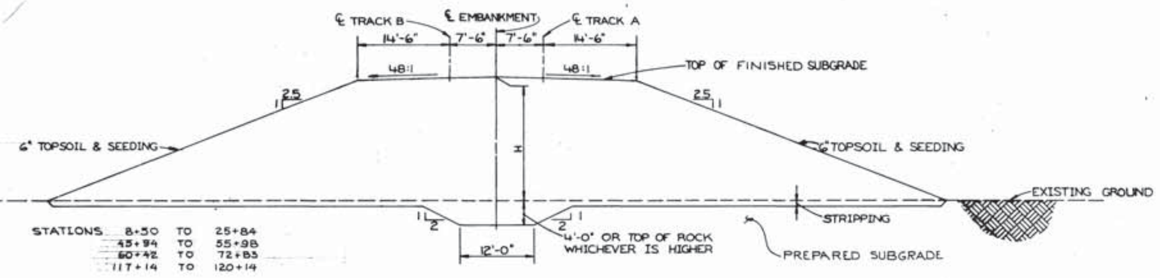
SIGNED ________
DATE 2/29/75 REG. NO. 8592

BLACK & VEATCH
CONSULTING ENGINEERS
PROJECT 6571/6572

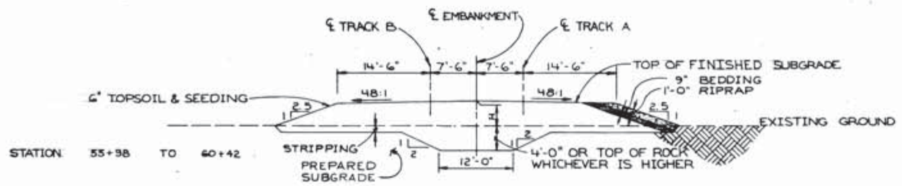
PUBLIC SERVICE COMPANY OF OKLAHOMA
NORTHEASTERN STATION—UNITS 3 & 4

SITE GRADING
PLANT SITE AREA IV

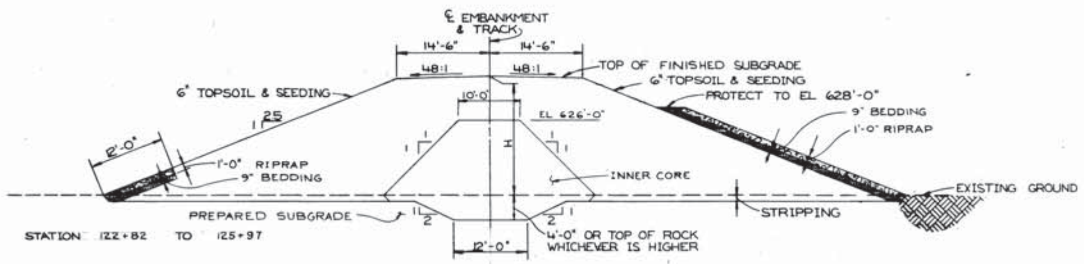
B&V DWG NO. PS1014
REV NO. 21
PSO DWG NO. 85127-E
SHT. 1014



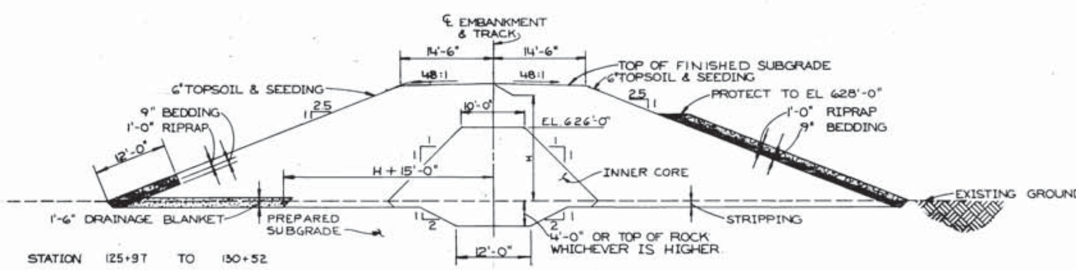
TYPICAL SECTION 1



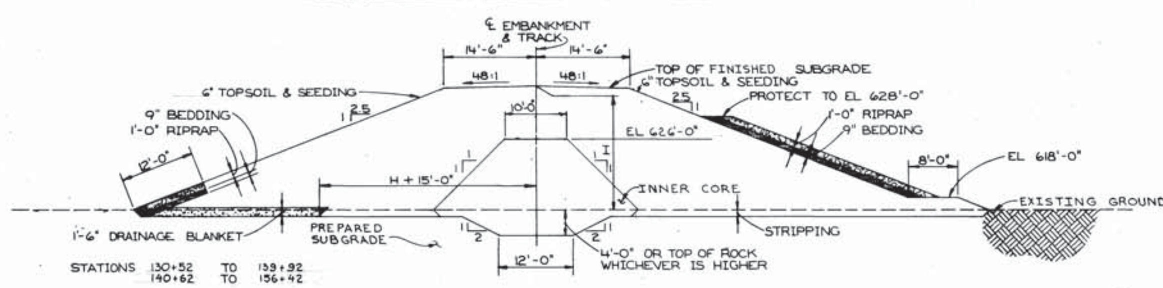
TYPICAL SECTION 2



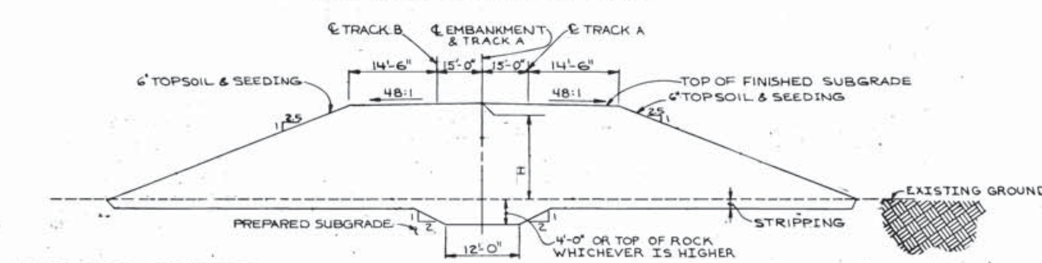
IMPERVIOUS ENBANKMENT SECTION 3



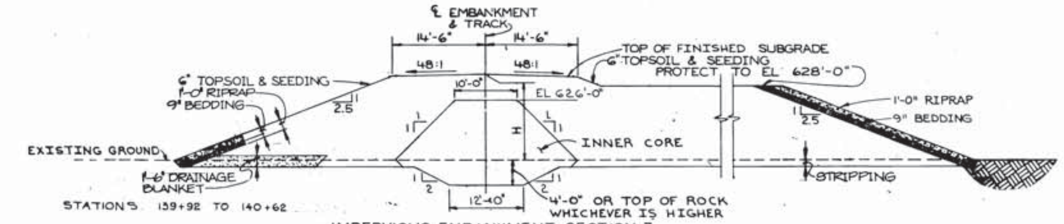
IMPERVIOUS ENBANKMENT SECTION 4



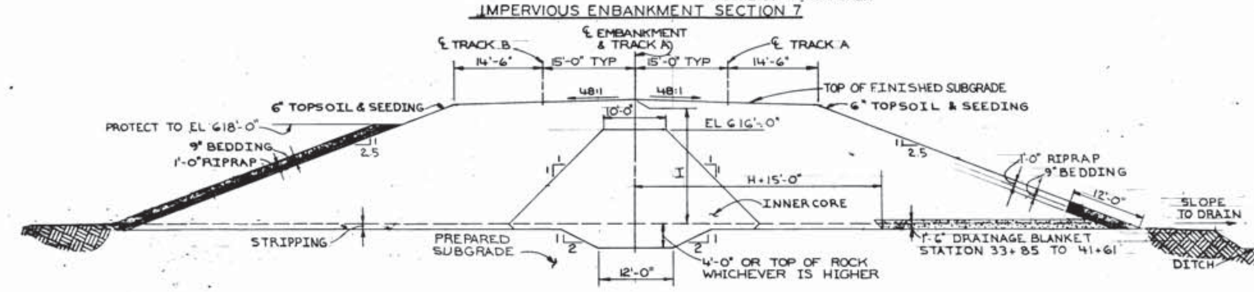
IMPERVIOUS ENBANKMENT SECTION 5



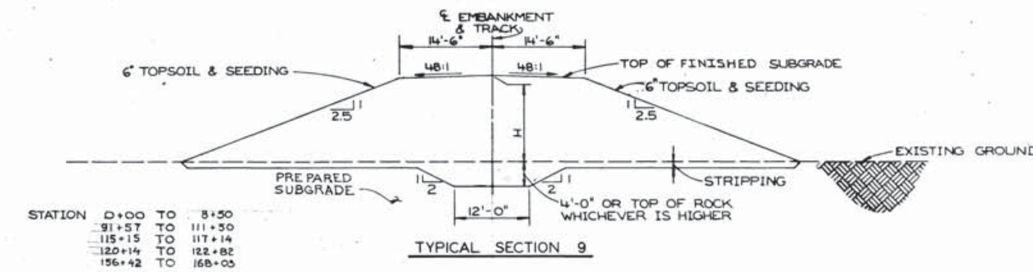
IMPERVIOUS ENBANKMENT SECTION 6



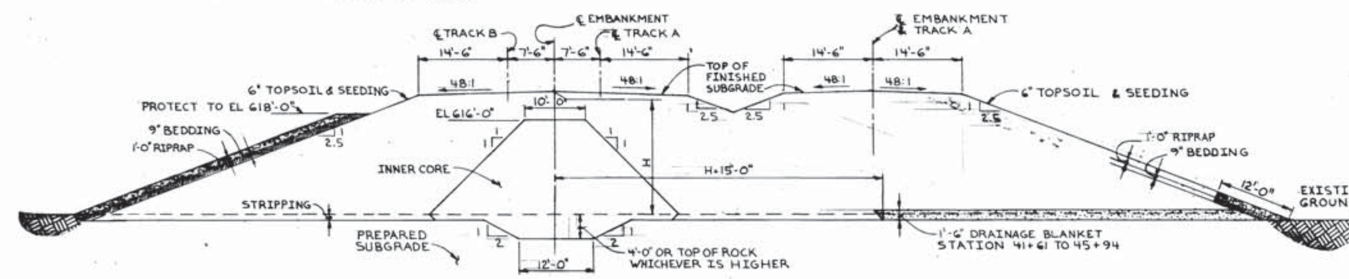
IMPERVIOUS ENBANKMENT SECTION 7



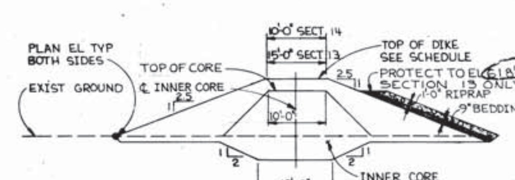
IMPERVIOUS ENBANKMENT SECTION 8



TYPICAL SECTION 9



IMPERVIOUS ENBANKMENT SECTION 10



IMPERVIOUS ENBANKMENT SECTION 13 & 14

SECTION 13 & 14 SCHEDULE	WASTE WATER POND	BOTTOM ASH POND
TOP DIKE	EL 618.0	EL 629.0
TOP CORE	EL 616.0	EL 626.0

GENERAL NOTES

1. EACH SECTION IS FACING TOWARD INCREASING STATION NUMBER.
2. FINISHED AND PREPARED SUBGRADE SHALL BE CONSTRUCTED AS REQUIRED BY SPECIFICATION D-2.

scanned 5/99

NO.	DATE	REVISIONS AND RECORD OF ISSUE	BY	CK	APP
▲	2-12-82	CONFORMED TO CONSTRUCTION RECORDS			
	6-1-76	REVISED EMBANKMENT SECTION 7			
	3-12-76	GENERAL REVISIONS			
	1-16-76	GENERAL REVISIONS			
	9-29-75	GENERAL REVISIONS			
8	8-29-75	REV & ISSUED FOR CONTRACT & CONST SPEC D-2	JR		
7	7-17-75	REVISED & ISSUED FOR ADDENDUM 1-SPEC D-2	FH		
6	6-13-75	REVISED & ISSUED FOR BIDS, SPEC D-2	TD		
5	5-8-75	ISSUED FOR PSO REVIEW	CB		
4			JR		
3			WH	TD	
2			TD		
1			TD		
0			TD		

SCALE: 1" = 10'

DEPT HEAD CLM — CHECKED — DRAWN SJR

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF OKLAHOMA.

DATE 8/29/75 REG. NO. 8592

BLACK & VEATCH CONSULTING ENGINEERS

PROJECT 6571/6572

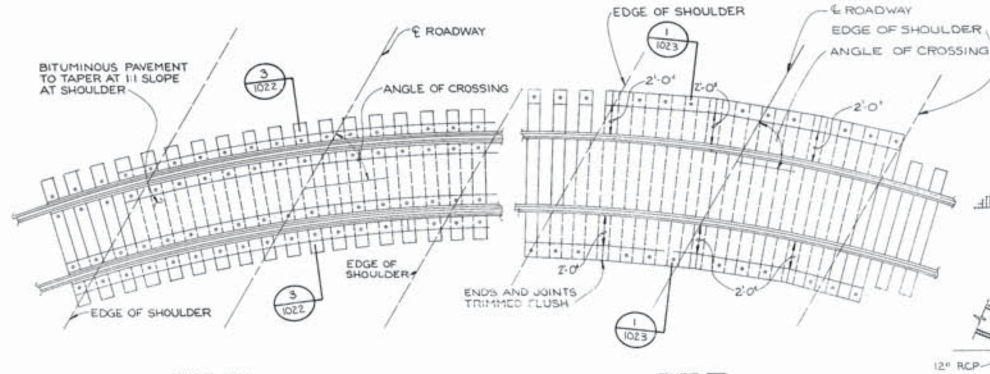
PUBLIC SERVICE COMPANY OF OKLAHOMA
NORTHEASTERN STATION–UNITS 3 & 4

EMBANKMENT DETAILS

B&V DWG NO. PS1024

REV NO. 8 — PSO DWG NO. 85127-E

SHT. 1024

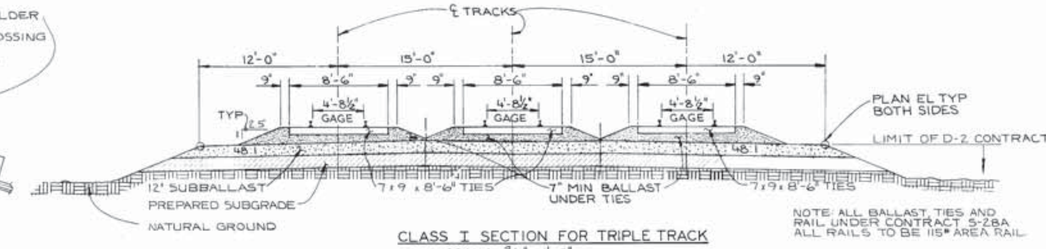


TYPE II A
CURVES 12°30' OR LESS

CURVED TRACK
NO SCALE

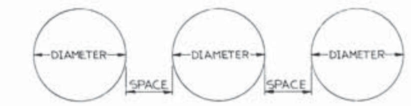
TYPE III
CURVES GREATER THAN 12°30'

TYPICAL RAILROAD CROSSINGS



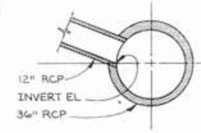
CLASS I SECTION FOR TRIPLE TRACK
SCALE: 3/16" = 1'-0"

NOTE: ALL BALLAST, TIES AND RAIL UNDER CONTRACT S-28A. ALL RAILS TO BE 115# AREA RAIL.

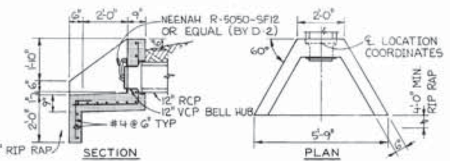


DIAMETER	SPACE
UP TO 24"	12"
24" TO 72"	1/2 DIA. OF PIPE
72" AND OVER	36"

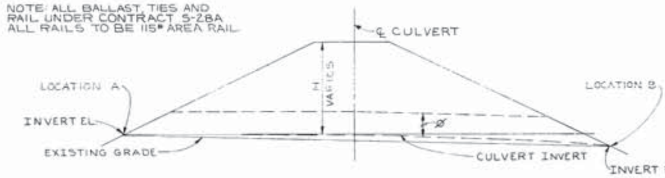
TYPICAL CULVERT SPACING
NO SCALE



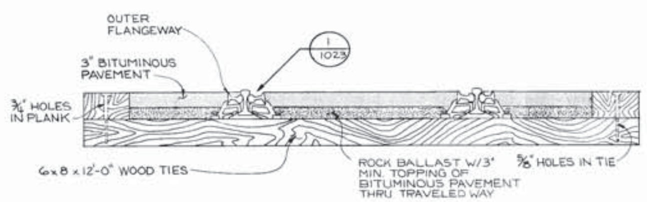
STORM SEWER "Y" CONNECTION
SCALE: 3/8" = 1'-0"



ASH WATER PUMPHOUSE DISCHARGE STRUCTURE
SCALE: 3/8" = 1'-0"
SEE DWG PS1014

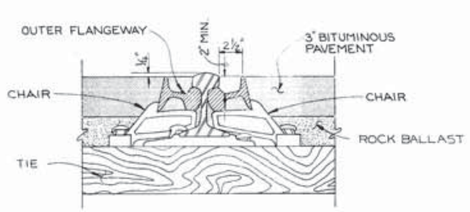


TYPICAL DRAINAGE CULVERT SECTION
NO SCALE

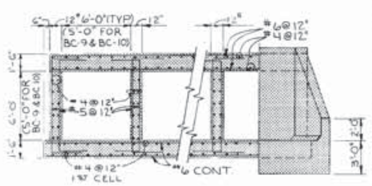


SECTION 1
NO SCALE
SEE THIS DWG

NOTES:
1. 6"x8 3/8"x11'-0" PLANKS.
2. 3/8"x10" WASHER HEAD TIMBER DRIVE SPIKE.
3. SEE RAILROAD CROSSING NOTES DWG. PS1022.



DETAIL 1
NO SCALE
SEE THIS DWG



TYPICAL BOX CULVERT SECTION
W/WINGWALL AND APRON
SCALE: 3/16" = 1'-0"

BOX CULVERT NOTES
1. FOR WINGWALL AND APRON DETAILS SEE THIS SHEET.
2. CONCRETE SHALL HAVE MIN. 28-DAY COMPRESSIVE STRENGTH OF 3000 PSI.
3. STEEL REINFORCEMENT SHALL CONSIST OF DEFORMED BARS, GRADE 40.
4. CONSTRUCTION SHALL CONFORM TO AREA MANUAL, CHAPTER 8.
5. BC-2 TO HAVE 3" CROWN W/FLOAT FINISH.

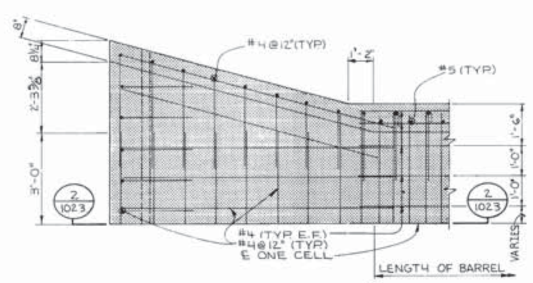
DRAINAGE CULVERT LIST													
FURNISH	INSTALL	CULVERT NO.	CENTERLINE LOCATION		Ø DIAM.	NO. OF UNITS	NOTES	SIZE			END TYPE	INVERT ELEV.	
			SOUTH	E-W				GAGE	CORR. SIZE	LGTH.		LOCATION A	LOCATION B
D-2	D-2	ER-1	315.00	E 1180.95	42	2		16	3x1	60	2	643.20	642.30
D-2	D-2	ER-2	922.00	E 1165.00	24	2		18	STD	48	1	636.70	636.50
D-2	D-2	ER-3	971.00	E 1140.00	12	1		18	STD	46	1	637.70	637.00
D-2	D-2	ER-4	962.00	E 1231.00	24	2		18	STD	28	1	637.00	636.80
D-2	D-2	AC-1	3159.00	E 1250.00	48	3		16	3x1	56	2	634.80	634.00
D-2	D-2	TR-1	3310.00	E 1107.00	48	3		16	3x1	52	3	633.80	633.00
D-2	D-2	PR-1	3302.00	E 1060.00	48	3		16	3x1	55	2	632.80	632.00
D-2	D-2	PR-2	5093.00	E 934.00	18	1		18	STD	64	1	633.50	633.00
D-2	D-2	CTR-1	4562.00	E 1772.00	24	1		18	STD	57	1	639.00	638.50
D-2	D-2	MR-1	5033.00	E 862.00	24	1		18	STD	75	1	631.50	631.00
D-2	D-2	MR-2	6972.00	E 862.00	36	4	ASB BONDED	16	3x1	78	1	627.00	626.00
D-2	D-2	MAR-1	3300.00	E 649.00	48	3		16	3x1	76	2	628.50	628.00
D-2	D-2	CPR-1	3366.00	E 36.00	36	3		16	3x1	48	3	625.00	624.50
D-2	D-2	BPR-1	2800.00	W 235.00	36	1		16	3x1	50	3	619.70	619.20
D-2	D-2	BPR-2	3870.00	W 235.00	42	6	RELOCATED FROM EXIST			60	3	616.40	615.40
D-2	D-2	BPR-3	5150.00	W 235.00	42	1	RELOCATED FROM EXIST			54	3	623.00	622.40
D-2	D-2	BPR-4	5118.75	W 288.00	12	1		18	STD	46	3	623.50	623.00
D-2	D-2	QR-1	5040.00	W 118.00	24	1		18	STD	54	3	627.00	626.40
D-2	D-2	TP-1	5264.00	E 1080.00	12	1		18	STD	76	3	633.20	632.80
D-2	D-2	TP-2	5435.00	E 862.00	12	1		18	STD	76	3	631.80	631.30
D-2	D-2	RR-1	5110.00	W 871.00	60	1		14	3x1	146	2	610.00	608.5
D-2	D-2	PR-3	5335.00	E 553.00	18	1		16	STD	55	3	631.00	630.50
D-2	D-2	PR-4	5332.00	E 702.00	18	1		18	STD	50	3	633.00	632.70
D-2	D-2	RR-4	5231.00	W 1355.00	60	2		14	3x1	140	2	607.90	606.40
D-2	D-2	RR-5	1015.00	W 1047.00	24	2		16	STD	65	3	623.00	622.70
D-2	D-2	LR-1	6911.00	E 2875.00	36	2		16	3x1	60	1	607.80	607.30
D-2	D-2	RR-3	6815.00	E 2730.00	36	1		14	3x1	155	1	612.00	610.00
D-2	D-2	PR-5	700.00	W 765.00	18	1		16	STD	40	1	626.00	625.70
D-2	D-2	APR-1	5180.00	W 268.00	24	1		18	STD	75	1	622.80	622.00
D-2	D-2	MR-3	5535.00	E 894.00	18	1		16	STD	48	1	635.00	634.20
D-2	D-2	MR-4	6925.00	E 885.00	18	2	ASB BONDED	18	STD	62	1	633.00	632.00
D-2	D-2	MR-5	7215.00	E 885.00	12	1		18	STD	75	3	631.00	630.00
D-12	D-12	WWT-2	5152.25	W 347.75	50x31	1	METAL ARCH	12	3x1	44	3	622.20	622.00
D-4	D-4	BC-6	5335.00	E 940.00	6'x2'-9"	1	FOR DETAILS SEE			50'		632.50	631.30
D-4	D-4	BC-5	5180.00	E 1084.37	6'x2'-9"	1	DWG PS1043			75'		633.44	633.22
D-2	D-2	BC-1	700.80	W 60.00	6'-6'	4	FOR BC DETAILS SEE			60'		625.90	625.40
D-2	D-2	BC-2	1340.00	W 235.00	6'-6'	4	THIS DWG			60'		619.90	619.40
D-2	D-2	BC-3	2985.00	W [illegible]	6'-6'	5	SEE THIS DWG			100'		609.00	608.00
D-4	D-4	BC-4	4524.00	E 1287.00	6'x2'-9"	1	SEE DWG PS1043			46'			

FOR CONTINUATION OF CULVERT LIST SEE DWG PS1043

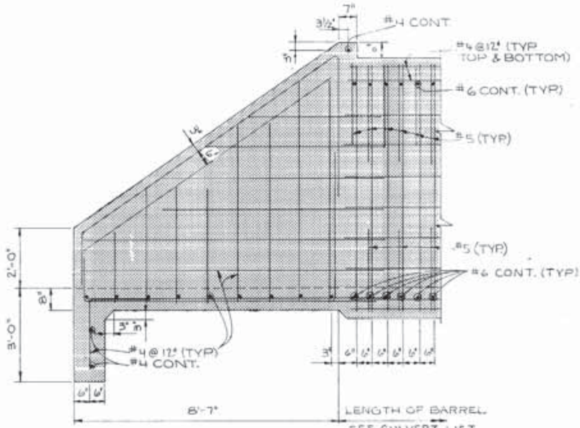
LEGEND
ER - ENTRANCE ROAD
AC - ACCESS ROAD
TR - TEMPORARY RR
PR - PLANT RR
CTR - COOLING TOWER ROAD
MR - MAINTENANCE ROAD
MAR - MAIN ACCESS ROAD
CPR - CONSTR PARKING RD
BPR - BATCH PLANT ROAD
QR - QUARRY ROAD
TP - TEMPORARY CULVERT
RR - COAL RAILROAD
LR - LOOP ROAD
BC - BOX CULVERT
APR - ASH PUMP ROAD

STD CORRUGATION 2 2/3" x 1/2"
END TYPES:
1 = BEVELED
2 = FLARED
3 = SQUARE

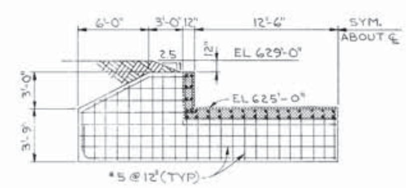
NOTE:
END SECTIONS INCLUDED IN PIPE LENGTH



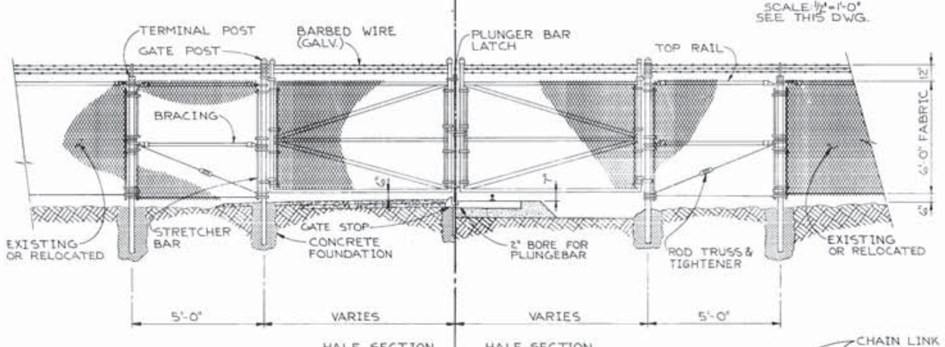
BOX CULVERT
WINGWALL & APRON PLAN
SCALE: 1/2" = 1'-0"



SECTION 2
SCALE: 1/2" = 1'-0"
SEE THIS DWG.

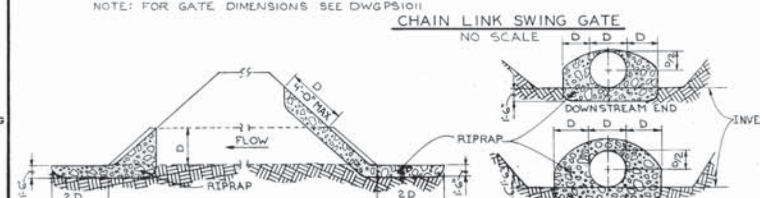


HALF SECTION
ANTI-SEEP COLLAR
SCALE: 3/16" = 1'-0"

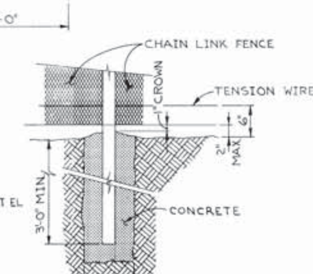


NOTE: FOR GATE DIMENSIONS SEE DWG PS1011

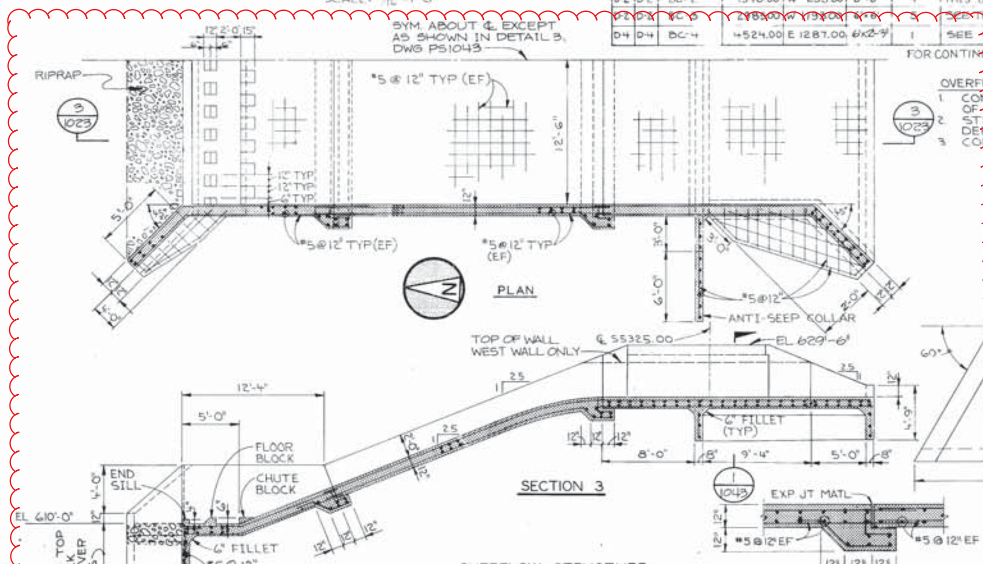
CHAIN LINK SWING GATE
NO SCALE



DRAINAGE CULVERT RIPRAP
ELEVATION & SECTION
NO SCALE



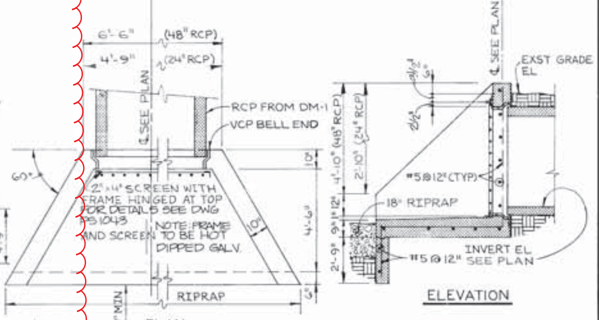
TYPICAL FENCE POST FOUNDATION
NO SCALE



OVERFLOW STRUCTURE
NO SCALE
BY SPEC D-2

OVERFLOW STRUCTURE NOTES
1. CONCRETE SHALL HAVE MIN. 28 DAY STRENGTH OF 3000 PSI.
2. STEEL REINFORCEMENT SHALL CONSIST OF DEFORMED BARS, GRADE 40.
3. CONSTRUCTION SHALL CONFORM TO ACI 318-71.

TYPICAL OVERFLOW STRUCTURE
JOINT DETAIL
NO SCALE



DISCHARGE STRUCTURE
SCALE: 3/8" = 1'-0"

DATE	REVISION	NO.	BY	CK	APP	DATE	REVISION	NO.	BY	CK	APP
11-3-78	ADDED CULVERT WWT-1 & REVISED LOCATION BC-5	13	JR	JG		3-12-76	REVISED AS CIRCLED	8			
6-15-76	REVISED MR-4 INVERT ELEV.	12	JM	TD		1-16-76	GENERAL REVISIONS	7	CB		
5-14-76	REVISED AS CIRCLED	11	GH			11-4-75	GENERAL REVISIONS	6	CB		
4-27-76	REVISED AS CIRCLED	10	TD			9-29-75	GENERAL REVISIONS	5	CB		
3-31-76	REVISED OVERFLOW STRUCTURE	9	PH	LR		8-29-75	REV & ISSUED FOR CONTRACT & CONST-SPEC D2	4			
2-12-82	CONFORMED TO CONSTRUCTION RECORDS	14									

DATE — REVISIONS AND RECORD OF ISSUE — NO. BY CK APP

SCALE: AS NOTED

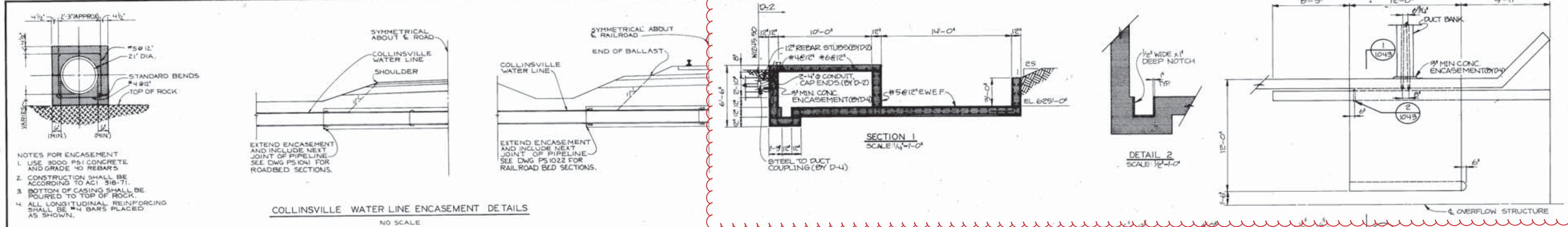
DEPT HEAD CLM
DES ENGR
CHECKED
DRAWN SJR

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF OKLAHOMA
SIGNED
DATE REG. NO.

BLACK & VEATCH
CONSULTING ENGINEERS
PROJECT 6571/6572

PUBLIC SERVICE COMPANY OF OKLAHOMA
NORTHEASTERN STATION–UNITS 3 & 4
MISCELLANEOUS RAILROAD AND SITE GRADING DETAILS

B&V DWG NO. PS1023
FSO DWG NO. 85127-E
SHT. 1023



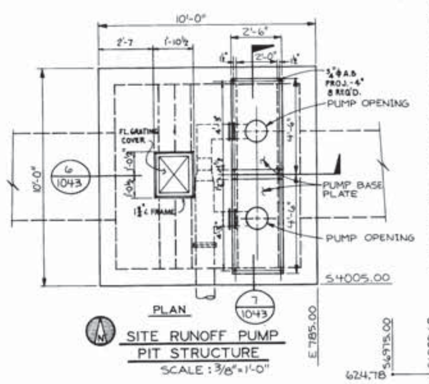
COLLINSVILLE WATER LINE ENCASEMENT DETAILS
NO SCALE

NOTES FOR ENCASEMENT
1. USE 3000 PSI CONCRETE AND GRADE 40 REBARS.
2. CONSTRUCTION SHALL BE ACCORDING TO ACI 318-71.
3. BOTTOM OF CASING SHALL BE POURED TO TOP OF ROCK.
4. ALL LONGITUDINAL REINFORCING SHALL BE #4 BARS PLACED AS SHOWN.

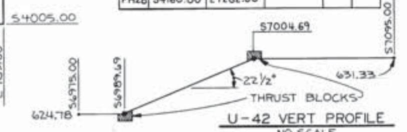
SECTION 1 SCALE 1/4"=1'-0"
DETAIL 2 SCALE 1/2"=1'-0"
DETAIL 3 SCALE 1/4"=1'-0"

HOSE HOUSE LIST					
NO.	CORNER LOCATION SOUTH	CORNER LOCATION E. OR W.	ELEVATION	FURNISH	INSTALL
1					
2	3919.00	E 1066.00			D-6
3	3919.00	E 1488.00			D-6
4	4472.00	E 888.00			D-6
5	4504.00	E 1532.00			D-6
6	4805.00	E 1609.00			D-6
7	4805.00	E 1732.50			D-6
8	5530.00	E 1282.00			D-6
9	5200.00	E 1091.00			D-6
10	6165 .00	E 1198.50			D-6
11	6598.00	E 1210.00			D-6
12	6973.00	E 1673.00			D-6
13	4650.00	E 2067.50			D-6
14	4650.00	E 2191.00			D-6

YARD & FIRE HYDRANT LIST					
NO.	CENTERLINE LOCATION SOUTH	CENTERLINE LOCATION E. OR W.	ELEVATION	FURNISH	INSTALL
FH 1	4542.00	E 1083.00	633.58	B/M B-30A	D-4
FH 2	4475.00	E 886.00	631.50		D-4
FH 3	NOT USED				
FH 4	4075.00	E 886.00	629.50		D-4
FH 5	3909.00	E 1066.00	637.58		D-4
FH 6	3909.00	E 1250.00	637.58		D-4
FH 7	3909.00	E 1660.00	637.58		D-4
FH 8	3980.00	E 1492.00	636.00		D-4
FH 9	4170.00	E 1463.50	637.50		D-4
FH 10	4420.00	E 1492.00	637.50		D-4
FH 11	4502.00	E 1262.50	636.50		D-4
FH 12	4790.00	E 1615.00	638.58		D-4
FH 13	4790.00	E 1735.00	639.58		D-4
FH 14	5040.00	E 1615.00	639.58		D-4
FH 15	5040.00	E 1735.00	639.58		D-4
FH 16	5200.00	E 1106.00	637.50		D-4
FH 17	5550.00	E 1083.00	639.50		D-4
FH 18	5527.00	E 1279.50	644.50		D-4
FH 19	5880.00	E 1207.00	641.50		D-4
FH 20	6170.00	E 1077.00	641.50		D-4
FH 21	6583.00	E 1210.00	641.50		D-4
FH 22	6857.75	E 1170.00	637.75		D-4
FH 23	6956.00	E 1665.00	637.75		D-4
FH 24	4635.00	E 2185.00	638.58		D-4
FH 25	4635.00	E 2065.00	638.58		D-4
FH 26	4885.00	E 2185.00	638.58		D-4
FH 27	4885.00	E 2065.00	638.58		D-4
YH 1	4695.50	E 1645.00		D-4	D-4
YH 2	4605.00	E 1895.00		D-4	D-4
YH 3	4540.50	E 2154.00		D-4	D-4
FH 28	54160.00	E 1282.00			

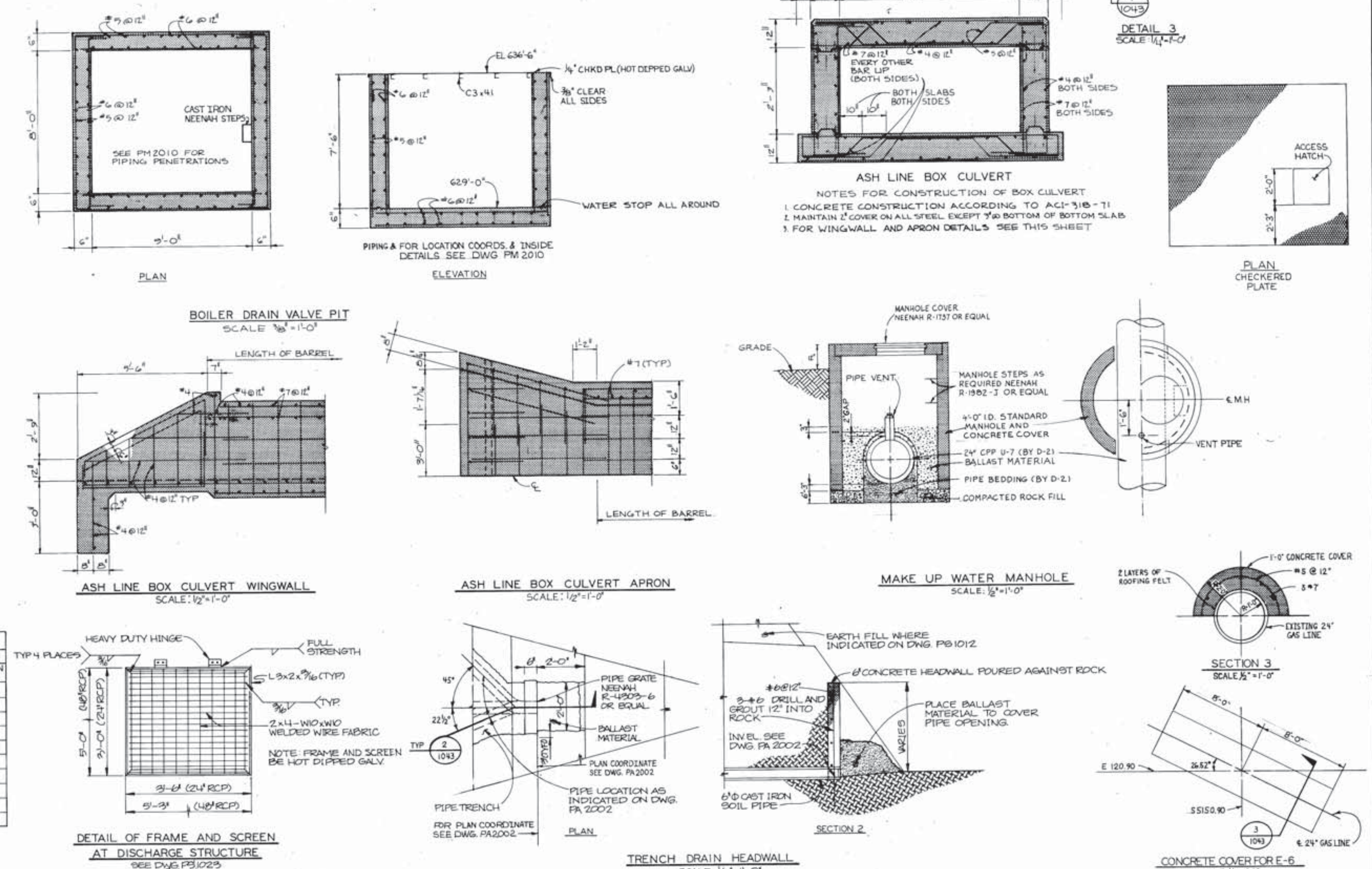


SITE RUNOFF PUMP PIT STRUCTURE
SCALE: 3/8"=1'-0"

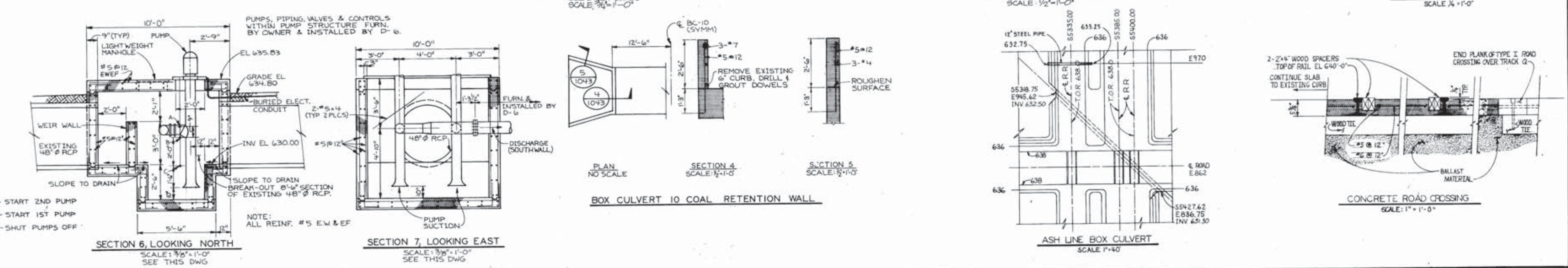


U-42 VERT PROFILE
NO SCALE

DRAINAGE CULVERT LIST (CONT. FROM DWG. PS1023)														
FURNISH	INSTALL	CULVERT NO.	CENTERLINE LOCATION SOUTH	CENTERLINE LOCATION E-W	Ø DIAM.	NO. OF UNIT	NOTES	SIZE GAGE	SIZE CORR. SIZE	SIZE LGTH	END TYPE	INVERT ELEV. LOCATION A	INVERT ELEV. LOCATION B
D-4	D-4	CTR-2	4524.00	E 2028	24"	1		18	STD	70'	1	639.50	639.00
D-4	D-4	CTR-3	4775.00	E 1772.00	12"	1		18	STD	55'	1	641.50	641.00
D-4	D-4	CTR-4	4576.00	E 1630.00	24"	1		18	STD	65'	1	638.00	637.50
D-4	D-4	BC-9	6920.00	E 1545.00	5'x5'	2	FOR BC DETAILS SEE			35'		629.60	629.50
D-4	D-4	BC-10	6905.00	E 1772.00	5'x5'	2	DWG. PS1023			25'		629.80	629.70
D-4	D-4	TR-2	3659.00	E 1210.00	12"	1		16	STD	91'	3	637.10	636.90
D-4	D-4	TR-5	4780.00	E 1200.00	12"	1		16	STD	80	3	636.20	635.80
		PR6-6	5335.0	970.	12	1				-		633.25	632.75
		PR7-7	5300.0	810	12	1				-		634.0	633.5



BOILER DRAIN VALVE PIT SCALE 3/8"=1'-0"
ASH LINE BOX CULVERT
NOTES FOR CONSTRUCTION OF BOX CULVERT
1. CONCRETE CONSTRUCTION ACCORDING TO ACI-318-71
2. MAINTAIN 2" COVER ON ALL STEEL EXCEPT 1" BOTTOM OF BOTTOM SLAB
3. FOR WINGWALL AND APRON DETAILS SEE THIS SHEET
ASH LINE BOX CULVERT WINGWALL SCALE: 1/2"=1'-0"
ASH LINE BOX CULVERT APRON SCALE: 1/2"=1'-0"
MAKE UP WATER MANHOLE SCALE: 1/2"=1'-0"
DETAIL OF FRAME AND SCREEN AT DISCHARGE STRUCTURE SEE DWG PS1023 SCALE 3/4"=1'-0"
TRENCH DRAIN HEADWALL SCALE 1/2"=1'-0"
CONCRETE COVER FOR E-6 SCALE 1/4"=1'-0"



SECTION 6, LOOKING NORTH SCALE: 3/8"=1'-0" SEE THIS DWG
SECTION 7, LOOKING EAST SCALE: 3/8"=1'-0" SEE THIS DWG
BOX CULVERT 10 COAL RETENTION WALL
ASH LINE BOX CULVERT SCALE 1"=40'
CONCRETE ROAD CROSSING SCALE: 1"=1'-0"

2-12-82	CONFORMED TO CONSTRUCTION RECORDS	13				10-8-76	REVISED AS CIRCLED	8	JM			4-5-76	REVISED AS CIRCLED	3	ES
4-14-80	REVISED STORM WATER PUMP PIT	12	CWS			6-25-76	REVISED AS CIRCLED	7	JM			3-31-76	REVISED OVERFLOW STRUCTURE	2	FH
3-6-80	ADDED STORM WATER PUMP PIT.	11	CWS			6-1-76	REVISED AS CIRCLED	6	FH			3-12-76	REVISED AS CIRCLED	1	DD
1-21-77	REVISED AS CIRCLED	10	RS			5-14-76	REVISED AS CIRCLED	5	FH			1-16-76	ISSUED FOR CONSTRUCTION	0	
11-12-76	REVISED AS CIRCLED	9	JM			4-27-76	REVISED AS CIRCLED	4	CB			DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY

SCALE: AS NOTED

BLACK & VEATCH CONSULTING ENGINEERS
PROJECT 6571/6572

PUBLIC SERVICE COMPANY OF OKLAHOMA
NORTHEASTERN STATION-UNITS 3 & 4
MISCELLANEOUS SECTIONS AND DETAILS

PS1043
REV. 13
85127-E
SHT. 1043