

# Report 2 – Evaluation of Location Restrictions

Public Service Company of Oklahoma  
Northeastern Station 3&4  
Bottom Ash Pond

January 2018  
Project No. 35157123



**PUBLIC SERVICE  
COMPANY OF  
OKLAHOMA**<sup>SM</sup>

*A unit of American Electric Power*

**Prepared for:**

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**Terracon**

Environmental



Facilities



Geotechnical



Materials

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## **1.0 Objective**

The purpose of this Location Restriction Evaluation Report (LRER) is to evaluate adequacy and compliance with the location restrictions (LR) with the EPA Coal Combustion Residuals (CCR) regulations (40 CFR 257) and with ODEQ's (Oklahoma Department of Environmental quality) CCR rule OAC 252:517 at the Public Service Company of Oklahoma (PSO) – Northeastern Stations 3 & 4 Bottom Ash Pond (BAP). This evaluation included a review of AEP-provided data associated with previously completed subsurface investigation activities in the vicinity of the BAP as well as publicly available geologic and hydrogeologic data.

## **2.0 Background Information**

### **2.1 Facility Description**

The Northeastern Power Station facility is located at the junction of U.S. Highway 169 and Oklahoma Highway 88 approximately 1 mile south of Oologah, Rogers County, Oklahoma. The facility property consists of approximately 1230 acres located in Sections 3 and 4, Township 22 North, Range 15 East, and Sections 33 and 34, Township 23 North, Range 15 East (I.M.) in Rogers County, Oklahoma. Four (4) electric generating Units are present at the facility. Units 1&2 are gas fired while Units 3&4 are coal fired units. Unit 4 ceased operation in April of 2016. A site location map showing the general location of the BAP is presented in **FIGURE 1 & 2**.

### **2.2 Description of CCR Unit**

#### **2.2.1 Embankment Configuration**

The Bottom Ash Pond was constructed in 1979. The embankment is a 4,200-foot long, cross valley impoundment on an unnamed tributary to Fourmile Creek. The embankment is roughly U-shaped in plan, with the spillway located near its northwest corner, and the cross section of the maximum height is at the location of the original stream bed on the southern portion of the embankment. The emergency spillway crest is at approximately 625 feet amsl. The elevation at the crest of the embankment is approximately 630 feet amsl. The embankment was constructed with clay material at a 2.5:1 slope (**Black & Veatch Consulting Engineers, Embankment Details DWG#85127-E, Revised February 1982**)<sup>1</sup>.

## 2.2.2 Area/Volume

The current Northeastern BAP consists of approximately 71 acres located in the southern portion of the property and has an approximate capacity of 501,793,000 gallons. **(SEE FIGURES 3 and 5)**. The pond is approximately 29.5 feet deep with an embankment height of 630 feet amsl.

## 2.2.3 Construction and Operational History

The BAP was constructed in 1979 on top of limestone bedrock, northwest of the landfill. It is approximately 29.5 feet deep with a berm crest height of 630 amsl. The embankment was constructed with 2.5:1 slopes. There have been no major modifications to the BAP since it was originally constructed.

The BAP is used for the management of bottom ash from the coal combustion operations on site from two coal-fired generation units (Units 3 and 4). Additionally, the BAP receives effluent from the on-site sewage treatment facility, effluent from the wastewater treatment facility, low volume wastewater, plant storm water, contact storm water from the landfill via basin C, coal pile storm water runoff, circulating water as well as condensate polisher water from Units 3 and 4. Discharge from the BAP is monitored at outfall 005 and reported on a DMR.

## 2.2.4 Surface Water Control

The general topographic gradient (from high to low) across the facility is to the south and west. An unnamed tributary to the Verdigris is located just east of the coal storage area. Fourmile Creek, which traverses through a portion of the property approximately 0.5 miles south of the site, is also a main tributary of the Verdigris River **(Well Installation Report, Terracon, May 2011, pg.3)**<sup>2</sup>.

Any discharge from the BAP through the emergency spillway leads to the Verdigris River via unnamed tributary.

## 2.3 Previous Investigations

- § Hemphill Corporation, Site Geological Investigation, 1975.
- § Golder, Bottom Ash Pond Inspection, 2009.
- § Freese and Nichols, Hydrologic Analysis, 2011.
- § Freese and Nichols, Breach Analysis, 2012.
- § AEPSC Civil Engineering, Slope Stability Analysis, April 2012.
- § Well Installation Report, Terracon, May 2011
- § Available data from monitoring wells SP-1 through SP-11.

- § Dewberry & Davis, LLC Fairfax, Virginia, Coal Combustion Residue Impoundment Round 9 - Dam Assessment Report *Northeastern 3 & 4 Station Bottom Ash Basin AEP Public Service Company of Oklahoma* Oologah, Oklahoma, 2011.

## 2.4 Hydrogeologic Setting

Groundwater encountered in bedrock in this region occurs in secondary openings, such as joints, fractures, and solution cavities. Groundwater occurs in most of the geologic units in the region; however, many of the units do not yield significant amounts of water.

Groundwater yields from the Oologah Formation, Labette Formation, and Fort Scott Limestone are small. The average yield of wells in the Pennsylvanian and Mississippian Age rocks is estimated to be 0.5 gallons per minute (Marcher, 1971). A review of the Oklahoma Geological Survey Hydrologic Atlas map titled *Maps Showing Principal Groundwater Resources and Recharge Areas in Oklahoma (Sheet 2 - Bedrock Aquifers and Recharge Areas, 1988)* indicates that the site is not located within a principal bedrock aquifer or recharge area.

The largest yields are found in unconsolidated material along streams and rivers. Alluvium along the lower portion of the Verdigris River can be utilized as a source of water and yields of up to 30 gallons per minute have been reported (Marcher, 1971), (**GW Well Install Report 2011, Terracon**)<sup>2</sup>.

### 2.4.1 Climate

Oologah receives an average of 42 inches of rainfall annually. The average temperature annually ranges from 35°F to 85°F (<http://www.city-data.com/city/Oologah-Oklahoma.html>)<sup>3</sup>.

### 2.4.2 Regional and Local Geologic Setting

#### Soils

According to the USDA Soil Survey of Rogers County, Oklahoma (July, 2007), the two predominant soils in the vicinity of the pond are the Hector-Endshaw complex (Rs) and Claremore silt loam (CmB). The Shidler stony silty clay loam (So) and Verdigris silty clay loam (Vf) are also present near the pond but to a lesser extent. A majority of the soils in the vicinity of the pond have been altered or removed during site development.

The Claremore consists of a reddish brown silty clay loam approximately 19 to 24 inches thick and is underlain by bedrock. The Claremore is well drained with a low to moderately low water capacity.

The Hector-Endshaw consists of a gravelly fine sandy loam approximately 15 to 25 inches thick and is underlain by bedrock. The Hector-Endshaw is well drained with a very low to moderately high water capacity.

The pond is located in an area underlain by the Pennsylvanian Age Oologah Formation, which is the major geologic formation outcropping in this area. Although some Quaternary Age Alluvial deposits (consisting of sand, gravel and clay) are located along the Verdigris River, alluvial deposits were not identified within the boundary of the pond or on PSO property within the reviewed reports. (See **FIGURE 12**)

### **Geology**

The Oologah Formation dips gently to the northwest at 30 to 50 feet per mile (Oakes, 1952) and rests conformably on the Labette Shale. The Oologah Formation consists of marine limestones and shales and is divided into three distinct members: (1) Altamont Limestone (upper), (2) Bandera Shale (middle), and (3) Pawnee Limestone (lower).

The Altamont Limestone is comprised of a carbonate marine limestone deposited on a broad offshore platform. The Altamont consists of light gray to dark gray limestone, moderately fossiliferous, and massive to thin-bedded.

The Bandera Shale was deposited during a major fluctuation in sea level which caused an influx of mud to be deposited on the normally non-turbid offshore platform. The middle shaly zone is typically only a few feet thick in the latitude of this region, but is thicker southward reaching a maximum thickness of 15 to 20 feet. The Bandera consists of gray to black shale, all more or less calcareous in fresh exposures. The Bandera is an aquitard that can produce temporary perched water table conditions within the overlying Altamont under certain conditions.

The Pawnee Limestone is similar to the Altamont in composition and depositional environment. The formation consists of light gray to dark gray limestone, moderately fossiliferous and somewhat cherty with some thin beds of shale. According to the original pond permit (Oklahoma State Department of Health - August 3, 1978), the Oologah Formation within the disposal area is represented by the lower Pawnee Limestone member. The Oologah Limestone rests conformably on the Labette shale.

The Labette Shale was deposited as muds on an offshore bank. The formation consists of clay shale and silty to sandy shale with some thin beds of sandstone and limestone. In this region, the Labette is 180 to 250 feet thick (Oakes, 1952) and rests conformably upon the Pennsylvanian Age Fort Scott Limestone. (**Volume 2 Major Mod 2011 Terracon Project No. 35107130**)<sup>4</sup>

### 2.4.3 Surface Water/Groundwater Interactions

The Verdigris River is approximately 0.5 miles southeast of the BAP. River flow is controlled by the Oologah Dam (Corps of Engineers – U.S. Army) located approximately 1 mile north and east of the site. Fourmile Creek, which empties into the Verdigris River, is located approximately 650 ft to the south of the BAP. Based on groundwater level elevations from the July 2017 sampling event, the groundwater in the area of the BAP flows southwest (**FIGURE 6**). Currently there is not enough data to determine if there is surface to groundwater communication.

### 2.4.4 Water Users

According to the Oklahoma Water Resources Board map, there are no known groundwater wells within a 1 mile of the site. There is a well located approximately 2 miles from the site which has been plugged (**FIGURE 11**).

## 3.0 Required Isolation from Uppermost Aquifer

CCR Rule 40 CFR Part §257.60 and ODEQ 252:517-5-1 require that the base of new and existing CCR surface impoundments be constructed such that the base of the unit is no less than 5 ft above the top of the uppermost aquifer, or that if the base is within 5 ft of the uppermost aquifer, that there will not be hydraulic connection between the base of the unit and the uppermost aquifer.

### 3.1 Aquifer Description and Piezometric Analysis

Both the EPA CCR regulations given in Title 40, CFR Part 257.53 and ODEQ's CCR regulations in 252:517 define an aquifer as *“a geologic formation, group of formations, or portion of a formation capable of yielding useable quantities of groundwater to wells or springs”*, and an uppermost aquifer is defined as *“the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility's property boundary. Upper limit is measured at a point nearest the natural ground surface to which the aquifer rises to during the wet season.”*

Hydrogeological data from soil borings/monitoring wells installed at the BAP show the uppermost aquifer unit to be present in the limestone unit. Well depths range from 31.5 to 75 feet bgs. Groundwater elevations for the BAP CCR monitoring well network are present in **TABLE 1**. The lowest point of the BAP is approximately 599 feet amsl. Cross section maps (**FIGURES 4 & 5**) are based on soil boring logs and illustrate this finding.



### **3.2 Compliance**

Hydrogeological data collected at the site shown on the cross-sections presented on **FIGURE 5**, shows the base of the BAP is located within 5 feet of the uppermost aquifer. Based on this information the BAP does not meet the location restriction for the five foot separation requirements set forth by 40 CFR §257.60 and 252:517-5-1.

### **4.0 Wetlands Impact**

CCR Rule 40 CFR Part §257.61 and ODEQ 252:517-5-2 require that existing and new CCR surface impoundments must not be located in wetlands.

#### **4.1 Review of Local Wetlands**

According to 40 CFR 232 §232.2, *Wetlands* means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. The CCR unit was not identified to be located within any wetland regions according to the National Wetlands Inventory (NWI) (**FIGURE 7**).

#### **4.2 Compliance**

Since there are no wetlands identified by NWI on the CCR site, the site meets the location restriction requirements set by both EPA and ODEQ

### **5.0 Fault Area**

CCR Rule 40 CFR Part §257.62 and ODEQ 252:517-5-3 require that existing and new CCR surface impoundments must not be located within 200 ft of the outermost damage zone of a fault that has had displacement in Holocene time unless the owner or operator demonstrates that the and alternate setback will prevent damage to the structural integrity of the CCR unit.

#### **5.1 Description of Regional Geologic Structural Features and Tectonic History**

Regional geologic publications were reviewed to determine structural features for the Site. A regional fault map is provided on **FIGURE 8**. There are no active faults within the site area.

## 5.2 Compliance

A review of available geologic reports and maps has indicated that the site is not located near any faults with displacement in the Holocene. Therefore, the BAP at this site meets the location restriction for faults.

## 6.0 Seismic Impact Zone

CCR Rule 40 CFR Part §257.63 and ODEQ 252:517-5-4 require that existing and new CCR surface impoundments must not be located within a seismic impact zone unless the owner or operator demonstrates that all structural components of the CCR unit are designed to withstand the maximum horizontal acceleration in lithified earth material for the site.

### 6.1 Seismic Impact Zone – Definition and Regional Information

Both CCR Rule 40 CFR Part 257.53 and ODEQ 525:517 define a seismic impact zone as an area having a 2% or greater probability that the maximum expected horizontal acceleration, expressed as a percentage of the earth's gravitational pull (g), will exceed 0.10 g in 50 years.

### 6.2 Compliance

**FIGURE 9** presents the seismic hazard map for the Oklahoma area as published by the USGS. As shown on **FIGURE 9**, the site falls within the zone having a maximum horizontal acceleration of 0.04 g. Additionally, the CCR unit is outside of area where suspected nontectonic earthquakes have been detected. Also noted are the factors of safety which are well above the minimum of 1.5 and 1.0, for static and seismic conditions respectively, noted in Section 785:25-3-11 of the Oklahoma Administrative Code for use by engineers assessing the condition of existing dams. As such, it is concluded that the BAP dam at the Northeastern 3 & 4 power station is stable under both static and the generally accepted seismic loading conditions. Therefore, based on Figure 9, the BAP is not located within the Seismic Impact zone.

## 7.0 Unstable Areas

CCR Rule 40 CFR Part §257.64 and ODEQ 252:517-5-5 require that existing and new CCR surface impoundments must not be located within an unstable area unless the owner or operator demonstrates that the design of the unit will ensure the integrity of the structural components of the unit.

## **7.1 Unstable Areas – Definition and Review of Local Conditions**

Both CCR Rule 40 CFR §257.53 and ODEQ 252:517 define an unstable area as location that is susceptible to natural or human induced events or forces capable of impairing the integrity, including structural components of some or all of the CCR unit that are responsible for preventing releases from such unit. Unstable areas can include poor foundation conditions, areas susceptible to mass movements, and karst terrains.

Applicability – Owners or operators of existing or new CCR surface impoundments or any lateral expansion of a CCR unit must not be located in an unstable area. The owner or operator must consider the following factors, at a minimum, when determining whether an area is unstable: (1) On-site or local soil conditions that may result in significant differential settling; (2) On-site or local geologic or geomorphologic features; and (3) On-site or local human-made features or events (both surface and subsurface). The following sections analyze each of these factors as they relate to the surface impoundment.

### **7.1.1 – On-Site and Local Soil Conditions**

The site geology, soil conditions and geomorphology features at the Northeastern Stations 3&4 do not meet the criteria for unstable conditions. Unstable conditions are usually associated with geological conditions such as Karst features. Characteristic physiographic features associated with Karst terrain such as sinkholes, sinking streams, caves, large springs, and blind valleys are not present on the site. **Section 2.4.2** of this document describes the local and regional soil properties. **FIGURE 10** is a soil map of the CCR unit.

### **7.1.2 – On-Site or Local Geologic or Geomorphic Features**

A wide range of hydrogeologic and geotechnical studies were conducted in support of the existing surface impoundment at the Facility. Based on the site specific studies, as well as published local and regional geologic and geomorphic information, there are no known on-site or adjacent geologic or geomorphic features which could adversely affect the stability of the surface impoundment.

### **7.1.3 – On-Site or Local Human-Made Features or Events Affecting Stability**

Based on the site specific observations, as well as, published local and regional information, there are no known on-site or local human-made features or events which could adversely affect the stability of the surface impoundment.

## 7.2 Compliance with Unstable Areas Restriction

Based on our site visit and review of available information, the BAP is not located within unstable areas. Therefore, the BAP meets the location restriction requirements for unstable areas.


## 8.0 Summary and Qualified PE Certification

Based on the information available for the site, as well as the evaluations discussed within this report, the Northeastern Power Station 3&4 BAP meets the CCR surface impoundment location restrictions with the exception of the groundwater separation requirement in 40 CFR Part 257.60 and 252:517-5-1.

### 8.1 Limitations

The findings and conclusions resulting from this investigation are based upon information derived from the on-site activities and other services performed under the scope of work as described in this report; such information is subject to change over time if additional information is obtained. Please note that Terracon does not warrant the work of laboratories, regulatory agencies or other third parties supplying information used in the preparation of the report.

### 8.2 PE Certification

Name: <i>F. Owen Carpenter</i>	Date: <i>1-24-2018</i>	 <p>Stamp</p>
Company: <i>Terracon</i>	Expiration Date: <i>31-OCT-2019</i>	

## Report 2 –Evaluation of Location Restrictions

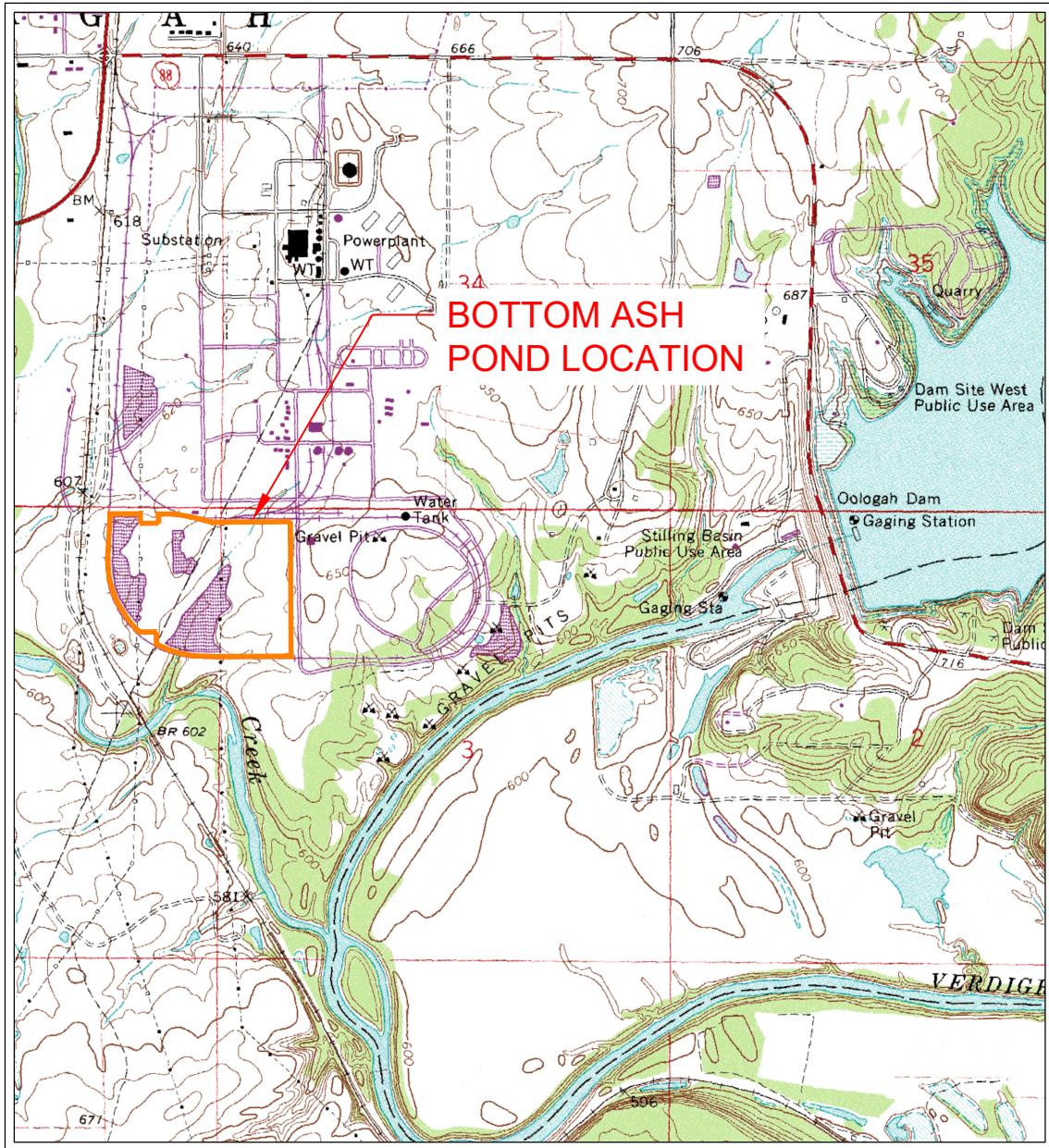
Northeastern Station 3 & 4 ■ Bottom Ash Pond

Project No. 35157123 ■ January 2018

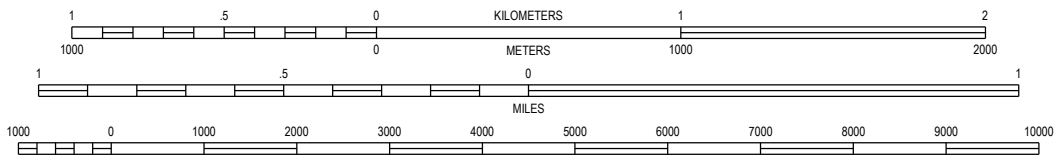


### Bibliography

- 1 Black & Veatch Consulting Engineers, Embankment Details DWG#85127-E, Revised February 1982.
- 2 Well Installation Report, Terracon, May 2011, pg.3
- 3 <http://www.city-data.com/city/Oologah-Oklahoma.html>
- 4 Volume 2 Major Mod 2011 Terracon Project No. 35107130




SCALE 1:24 000



CONTOUR INTERVAL 10 FEET  
NATIONAL GEODETIC VERTICAL DATUM OF 1929

OOLOGAH, OKLAHOMA  
QUADRANGLE  
1970 (PHOTO REVISED 1980)  
7.5 MINUTE SERIES (TOPOGRAPHIC)



Project Mngr: DCM	Project No. 216-003-35157123	 Consulting Engineers and Scientists 25809 I-30 SOUTH BRYANT, AR 72022 PH. (501) 847-9292 FAX. (501) 847-9210	7.5 MINUTE SERIES (TOPOGRAPHIC)	FIG. No.
Drawn By: TLB	Scale: AS SHOWN		EVALUATION OF LOCATION RESTRICTIONS	1
Checked By: TLB	File No. 009A		PUBLIC SERVICE COMPANY OF OKLAHOMA	
Approved By: DCM	Date: 01/18/2018		NORTHEASTERN STATIONS 3 & 4	
			OOLOGAH OKLAHOMA	



REV.	DATE	BY	DESCRIPTION

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 BRYANT, AR 72022  
 FAX. (501) 847-9210

**PLANT AND CCR UNIT LOCATION MAP**  
 EVALUATION OF LOCATION RESTRICTIONS  
 PUBLIC SERVICE COMPANY OF OKLAHOMA  
 NORTHEASTERN STATIONS 3 & 4  
 OOLOGAH  
 OKLAHOMA

**FIGURE 2**

DESIGNED BY:	TLB
DRAWN BY:	TLB
APPROV. BY:	DCM
SCALE:	SEE BARSCALE
DATE:	01/18/2018
JOB NO.	216-003-35157123
ACAD NO.	009
SHEET NO.:	2 OF 12

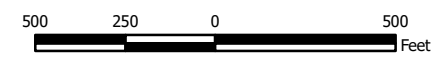


**Monitoring Well Network**

- ◆ Downgradient Sampling Location
- ◆ Upgradient Sampling Location
- Bottom Ash Pond

**Notes**

- Monitoring well coordinates provided by AEP.
- Site features based on information available in Groundwater Monitoring Network for CCR Compliance reports (Terracon, 2016).

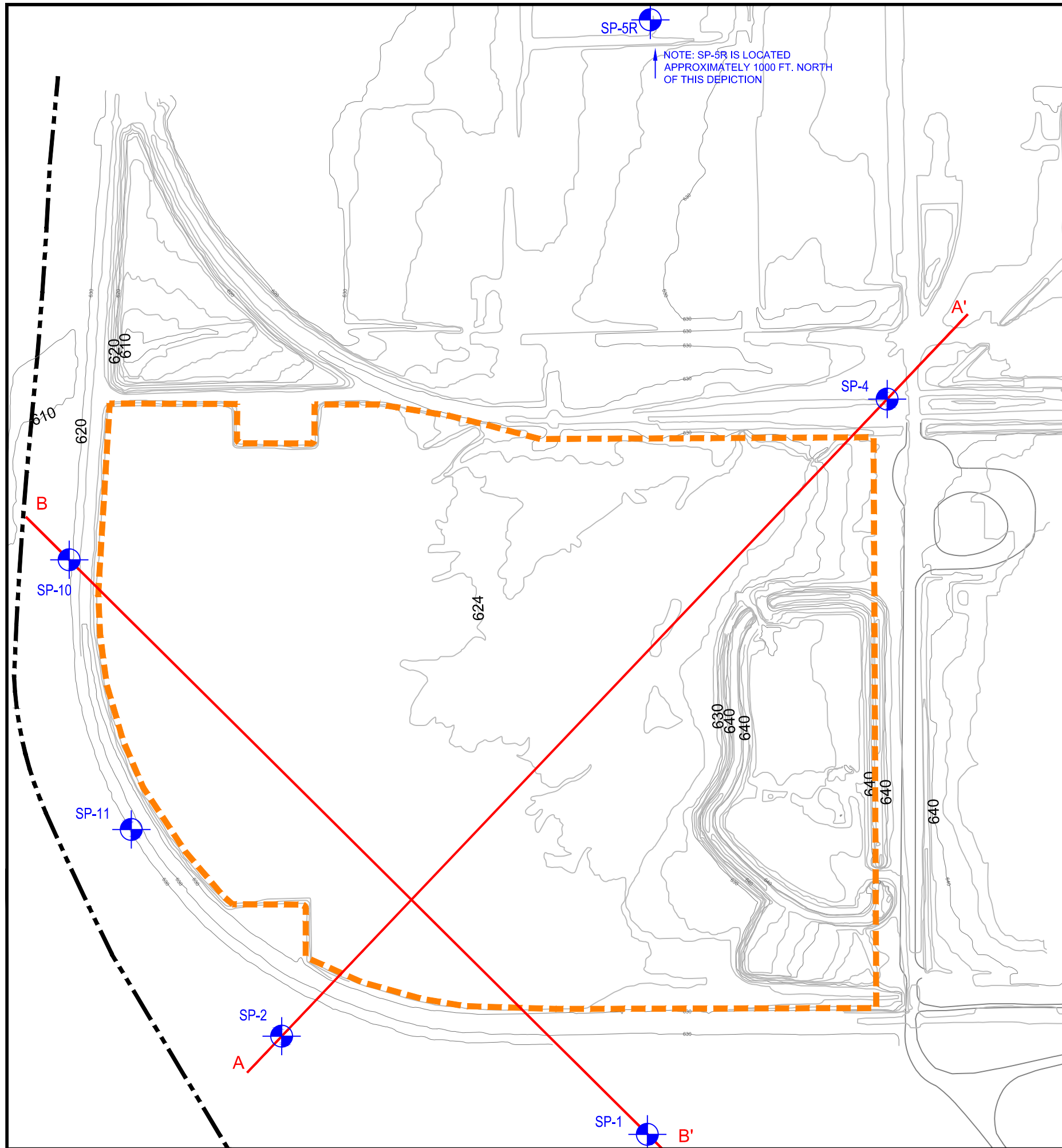


**Site Layout  
Bottom Ash Pond**

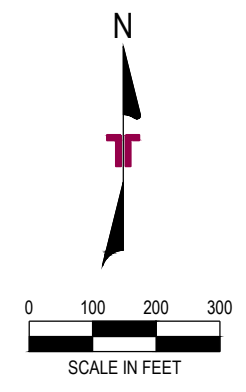
AEP Northeastern Power Plant  
Oologah, Oklahoma

consultants		<b>Figure 3</b>
Columbus, Ohio	2018/01/18	





SP-5R  
 NOTE: SP-5R IS LOCATED APPROXIMATELY 1000 FT. NORTH OF THIS DEPICTION



NOTE:  
 CROSS SECTIONAL INFORMATION DEPICTED IN THESE CROSS SECTIONS WAS TAKEN FROM THE FOLLOWING SOURCES:

TOPOGRAPHIC INFORMATION:  
 SURVEY PROVIDED BY AEP, TITLED "P.S.O. OOLOGAH PLANT TOPOGRAPHIC SURVEY" AND DATED FEBRUARY 1992.

BOTTOM GRADING INFORMATION:  
 SLOPE STABILITY ANALYSIS PERFORMED BY AMERICAN ELECTRIC POWER CORPORATION - ENGINEERING DEPARTMENT, AND DATED APRIL 25, 2012.

UPPERMOST AQUIFER:  
 DATA FROM SAMPLING EVENTS PERFORMED BY AMERICAN ELECTRIC POWER, DATING FROM APRIL 20, 2011 THROUGH JULY 12, 2017.

MONITORING NETWORK:  
 WELLS SHOWN ARE THE APPROVED CCR MONITORING WELL NETWORK.

**LEGEND:**

- BOTTOM ASH POND LOCATION
- CROSS SECTION LOCATION
- EXISTING MONITORING WELL

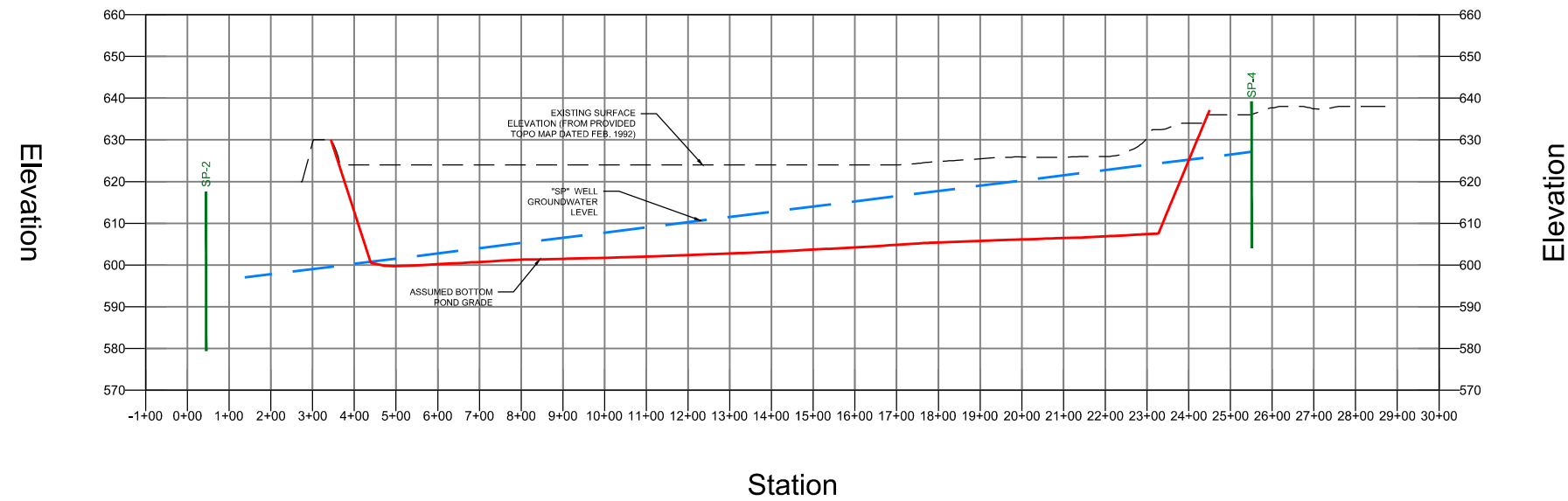
<b>FIGURE 4</b>	
DESIGNED BY: TLB	APPVD. BY: DCM
DRAWN BY: TLB	SCALE: SEE BARSCALE
DATE: 01/18/2018	JOB NO: 216-003-35157123
ACAD. NO: 011	SHEET NO.: 4 OF 12

**CROSS SECTION LOCATIONS MAP**  
 EVALUATION OF LOCATION RESTRICTIONS  
 PUBLIC SERVICE COMPANY OF OKLAHOMA  
 NORTHEASTERN STATIONS 3 & 4  
 OKLAHOMA  
 OOLOGAH

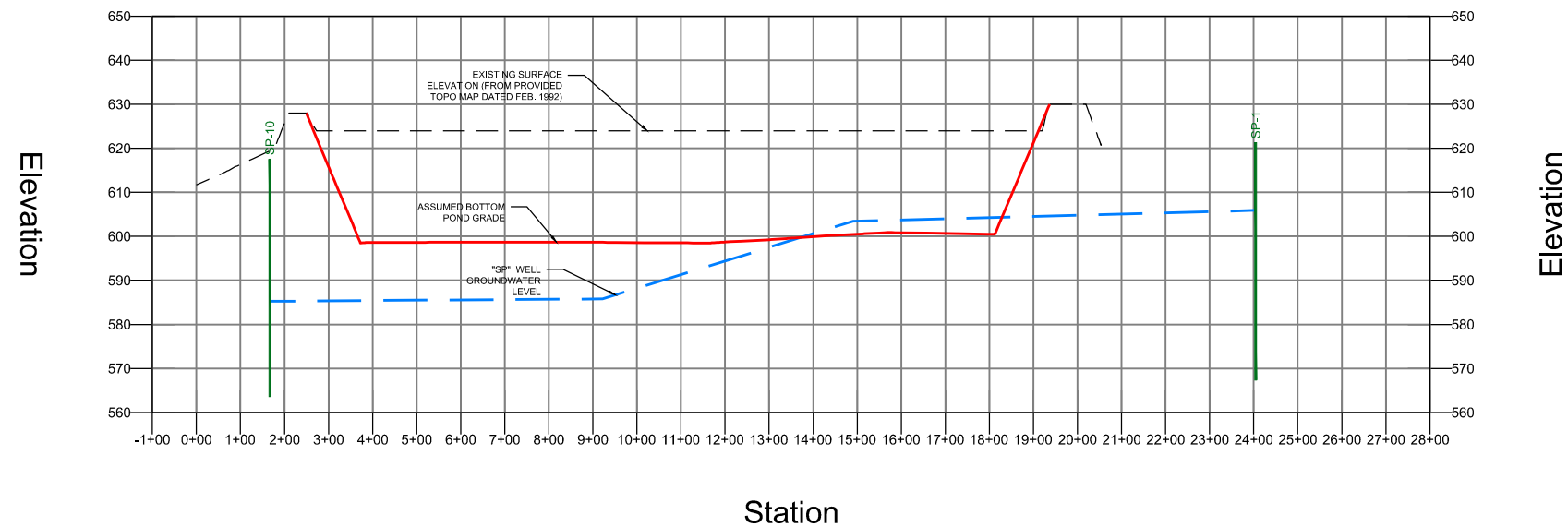
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 FAX. (501) 847-9210

REV.	DATE	BY	DESCRIPTION

### ALIGNMENT - POND A-A'



### ALIGNMENT - POND B-B'



**NOTE:**  
 CROSS SECTIONAL INFORMATION  
 DEPICTED IN THESE CROSS SECTIONS  
 WAS TAKEN FROM THE FOLLOWING  
 SOURCES:

**TOPOGRAPHIC INFORMATION:**  
 SURVEY PROVIDED BY AEP, TITLED "P.S.O.  
 OOLOGAH PLANT TOPOGRAPHIC SURVEY"  
 AND DATED FEBRUARY 1992.

**BOTTOM GRADING INFORMATION:**  
 SLOPE STABILITY ANALYSIS PERFORMED  
 BY AMERICAN ELECTRIC POWER  
 CORPORATION - ENGINEERING  
 DEPARTMENT, AND DATED APRIL 25, 2012.

**UPPERMOST AQUIFER:**  
 DATA FROM SAMPLING EVENTS  
 PERFORMED BY AMERICAN ELECTRIC  
 POWER, DATING FROM APRIL 20, 2011  
 THROUGH JULY 12, 2017.

**MONITORING NETWORK:**  
 THE APPROVED CCR MONITORING WELL  
 NETWORK IS SHOWN ON FIGURE 4.

<b>FIGURE 5</b>	
DESIGNED BY: TLB	
DRAWN BY: TLB	
APPROVED BY: DOM	
SCALE: 1"=400'	
DATE: 01/18/2018	
JOB NO: 216-003-35157123	
ACAD NO: 012	
SHEET NO: 5	OF 12

**CROSS SECTIONS**  
 EVALUATION OF LOCATION RESTRICTIONS  
 PUBLIC SERVICE COMPANY OF OKLAHOMA  
 NORTHEASTERN STATIONS 3 & 4  
 OOLOGAH  
 OKLAHOMA

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REV.	DATE	BY	DESCRIPTION





### Wetlands

- Freshwater Emergent
- Freshwater Forested/Shrub
- Estuarine and Marine Deepwater
- Estuarine and Marine
- Freshwater Pond
- Lake
- Riverine
- Other

**NOTE:**  
 INFORMATION DEPICTED ON THIS  
 FIGURE WAS OBTAINED FROM THE  
 NATIONAL WETLANDS INVENTORY  
 LOCATED ON THE U.S. FISH &  
 WILDLIFE SERVICE WEBSITE.

REV.	DATE	BY	DESCRIPTION

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**NEARBY WETLANDS MAP**  
 EVALUATION OF LOCATION RESTRICTIONS  
 PUBLIC SERVICE COMPANY OF OKLAHOMA  
 NORTHEASTERN STATIONS 3 & 4  
 OKLOGAH  
 OKLAHOMA

<b>FIGURE 7</b>	
DESIGNED BY: TLB	DRAWN BY: TLB
APPROVED BY: DCM	SCALE: SEE BARSCALE
DATE: 01/18/2018	JOB NO. 216-003-35157123
ACAD. NO. 014	SHEET NO. 7 OF 12



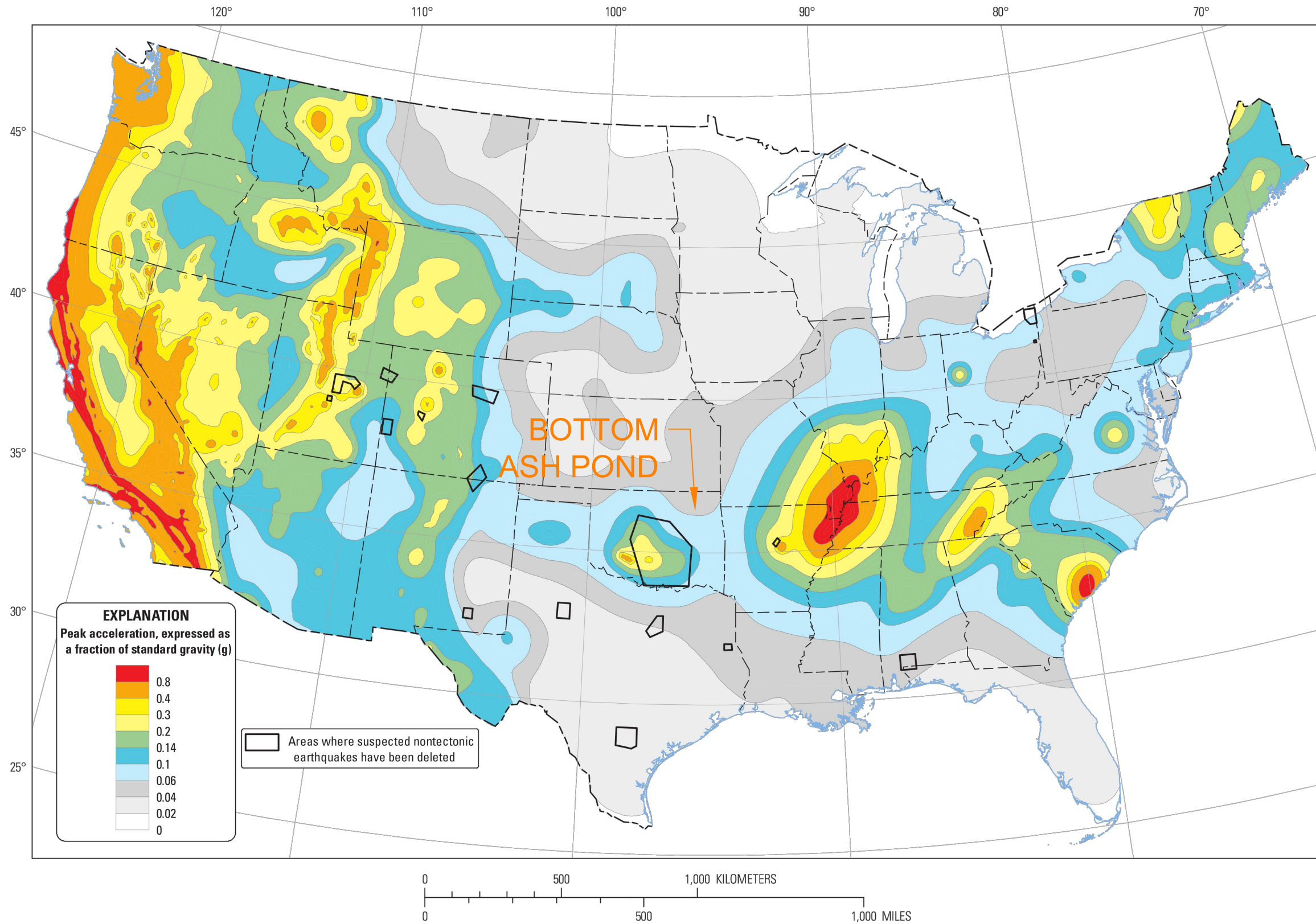
REV.	DATE	BY	DESCRIPTION

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**NEARBY FAULT LOCATIONS**  
 EVALUATION OF LOCATION RESTRICTIONS  
 PUBLIC SERVICE COMPANY OF OKLAHOMA  
 NORTHEASTERN STATIONS 3 & 4  
 OKLOGAH OKLAHOMA

**FIGURE 8**

DESIGNED BY:	TLB
DRAWN BY:	TLB
APP'D BY:	DCM
SCALE:	SEE BARSCALE
DATE:	01/18/2018
JOB NO.	216-003-35157123
ACAD NO.	015
SHEET NO.:	8 OF 12



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



REV.	DATE	BY	DESCRIPTION

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**NEARBY SEISMIC IMPACT ZONES**  
EVALUATION OF LOCATION RESTRICTIONS  
PUBLIC SERVICE COMPANY OF OKLAHOMA  
NORTHEASTERN STATIONS 3 & 4  
OOLOGAH  
OKLAHOMA

**FIGURE 9**

DESIGNED BY:	TLB
DRAWN BY:	TLB
APPROV. BY:	DCM
SCALE:	SEE BARSCALE
DATE:	01/18/2018
JOB NO.	216-003-35157123
ACAD. NO.	016
SHEET NO.:	9 OF 12



BOTTOM ASH POND UNIT

Map Unit Symbol	Map Unit Name
CmB	Claremore silt loam, 0 to 3 percent slopes
Rs	Hector-Endsaw complex, 20 to 35 percent slopes
So	Shidler stony silty clay loam, 3 to 20 percent slopes
URB	Urban land
Vd	Verdigris silt loam, 0 to 1 percent slopes, occasionally flooded
Ve	Verdigris clay loam, 0 to 1 percent slopes, occasionally flooded
Vf	Verdigris silty clay loam, 0 to 2 percent slopes, frequently flooded
W	Water
WagB	Wagstaff silty clay loam, 1 to 3 percent slopes
WsA	Woodson and Apperson soils, 0 to 1 percent slopes

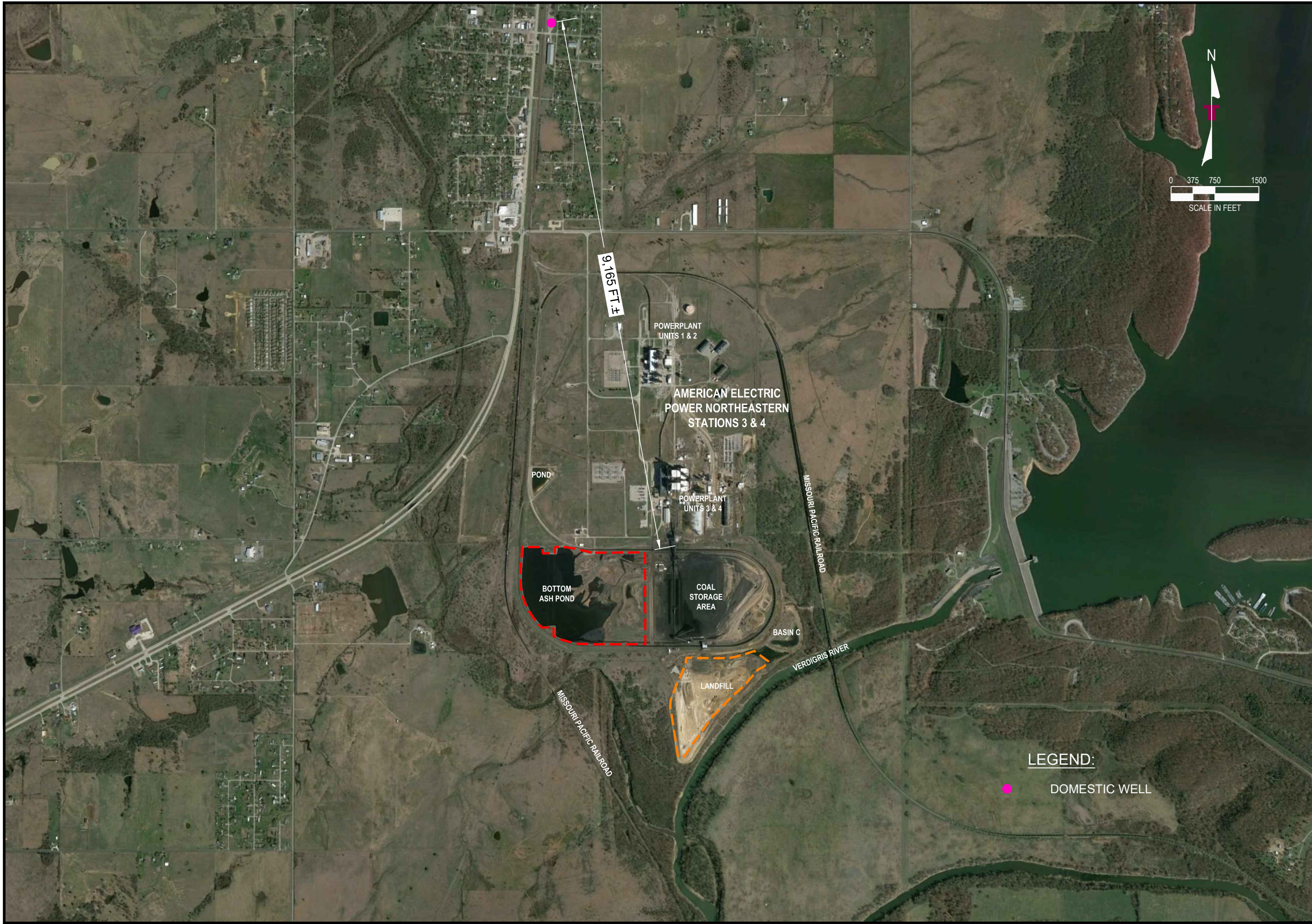
REV.	DATE	BY	DESCRIPTION

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**NEARBY UNSTABLE AREAS**  
 EVALUATION OF LOCATION RESTRICTIONS  
 PUBLIC SERVICE COMPANY OF OKLAHOMA  
 NORTHEASTERN STATIONS 3 & 4  
 OOLOGAH  
 OKLAHOMA

**FIGURE 10**

DESIGNED BY:	TLB
DRAWN BY:	TLB
APPROVED BY:	DCM
SCALE:	SEE BARSCALE
DATE:	01/18/2018
JOB NO.	216-003-35157123
ACAD. NO.	017
SHEET NO.:	10 OF 12



REV.	DATE	BY	DESCRIPTION

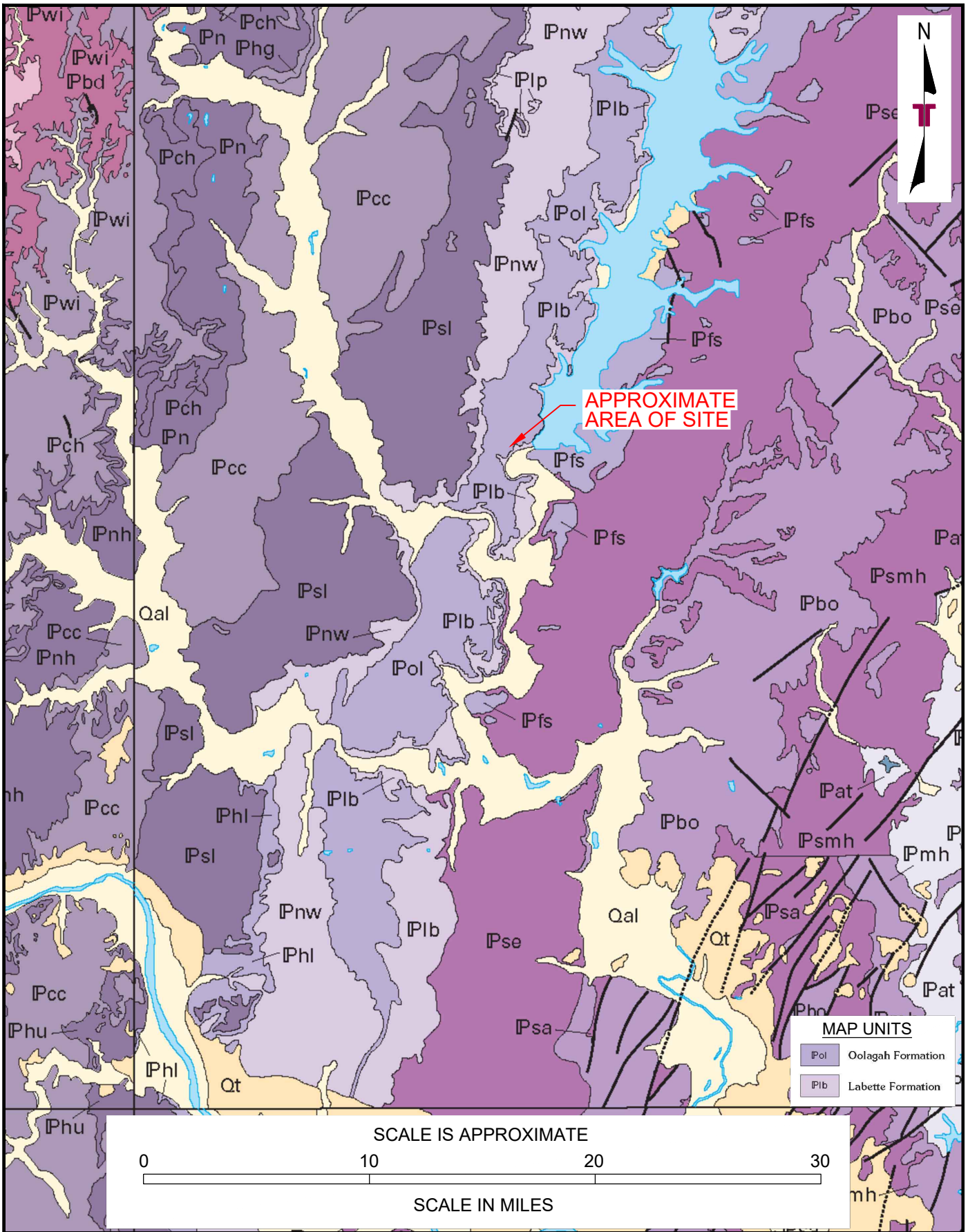
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NEAREST WATER WELL FROM CCR UNIT LOCATION MAP  
 EVALUATION OF LOCATION RESTRICTIONS  
 PUBLIC SERVICE COMPANY OF OKLAHOMA  
 NORTHEASTERN STATIONS 3 & 4  
 OOLOGAH  
 OKLAHOMA

**FIGURE 11**

DESIGNED BY:	TLB
DRAWN BY:	TLB
APPROV. BY:	DCM
SCALE:	SEE BARS/SCALE
DATE:	01/18/2018
JOB NO.	216-003-35157123
ACAD. NO.	019
SHEET NO.:	11 OF 12





Project Mng:	FOC
Drawn By:	TLB
Checked By:	DCM
Approved By:	FOC

Project No.	216-003-35157123
Scale:	AS SHOWN
File No.	020
Date:	01/18/2018

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**REGIONAL GEOLOGIC MAP**  
 EVALUATION OF LOCATION RESTRICTIONS  
**PUBLIC SERVICE COMPANY OF OKLAHOMA**  
 NORTHEASTERN STATIONS 3 & 4

OOLOGAH OKLAHOMA

FIG. No.	12
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**TABLE 1**  
**NORTHEASTERN STATION 3 & 4**  
**BOTTOM ASHPOND**  
**WELL LEVEL DATA**

<b>Well</b>	SP-1	SP-2	SP-4	SP-5R	SP-10	SP-11
<b>Ground Surface Elevation (fmsl)</b>	618.26	614.49	636.16	628.17	614.34	611.78
<b>TOC Elevation (fmsl)</b>	621.26	617.49	639.16	631.17	617.52	615.17
<b>Date</b>	<b>Groundwater Elevations (fmsl)</b>					
04/20/11	604.05	Dry	611.73			
06/07/11	603.77	584.04	607.21			
09/13/11	603.03	588.26	611.11			
12/13/11	604.67	596.15	623.29			
03/13/12	604.88	594.73	619.31			
06/12/12	603.48	596.32	624.58	623.86		
09/18/12	602.76	591.34	615.45	621.55		
12/10/12	603.78	596.72	623.94	623.87		
03/12/13	604.59	594.24	617.19	625.73		
06/11/13	604.26	595.16	619.48	625.48		
09/24/13	603.55	597.00	625.83	623.97		
12/20/13	604.17	596.12	626.87	625.06		
03/05/14	604.08	596.46	627.12	625.72		
06/09/14	604.81	595.67	619.27	625.94		
09/09/14	603.26	596.27	625.71	623.83		
11/03/14	604.03	592.59	621.18	624.09		
03/10/15	604.80	596.62	626.37	627.35		
06/15/15	604.21	596.40	614.66	624.76		
12/14/15	605.90	590.14	614.43	627.42		
03/16/16	603.02	594.66	626.17	624.94		
05/16/16	604.17	596.87	625.64	626.14		
07/20/16	-	-	-	622.81		
09/19/16	603.55	595.72	626.64	622.21		
10/06/16	603.64	591.63	600.86	624.22		
03/14/17	604.40	589.03	618.65	625.45		
05/18/17	586.77	581.68	608.90	570.98		
06/15/17	603.96	582.61	612.61	624.22		
06/27/17	603.71	580.67	610.13	624.22		
07/12/17	603.75	581.68	607.38	624.68	576.97	585.25
Seasonal High	605.90	597.00	627.12	627.42	576.97	585.25

**APPENDIX 1**  
Boring & Monitoring Well Installation Logs

## Boring Logs



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# FIELD BORING LOG

BORING NO.: SP-1

PAGE: 1 of 1

TOTAL DEPTH: 35 FEET BELOW GROUND SURFACE (BGS)

CLIENT: AMERICAN ELECTRIC POWER

PROJECT: NE PLANT POND WELLS - OOLOGAH, OK.

JOB NO.: 216-003-35117075-002

DRILLING CO.: MOHAWK

LOGGED BY: ADAM HOOPER

DRILLER: KEVIN WILKIE

DATE DRILLED: 4/5/2011

RIG TYPE: BK-66

DRILLING METHOD: 6.25" AIR HAMMER

SAMPLING METHOD: LOGGED BY CUTTINGS

Depth BGS	Sample Interval	N: N/A	E: N/A	G.S. ELEV.: N/A	Litho. Symbol	PID (ppm)	Comments
		DESCRIPTION					
0		0' - 1' <u>SILTY CLAY</u> dark brown					
1		1' - 23' <u>LIMESTONE</u> light gray, fine grained, crystalline with trace fossils					
5							
10							
15							
20							
23		23' - 35' <u>LIMESTONE</u> dark gray, crystalline with clay inclusions					
25							
30							
35		Total Depth of Boring at 35' bgs					No water encountered



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# FIELD BORING LOG

BORING NO.: SP-2

PAGE: 1 of 1

TOTAL DEPTH: 35 FEET BELOW GROUND SURFACE (BGS)

CLIENT: AMERICAN ELECTRIC POWER

PROJECT: NE PLANT POND WELLS - OOLOGAH, OK.

JOB NO.: 216-003-35117075-003

DRILLING CO.: MOHAWK

LOGGED BY: ADAM HOOPER

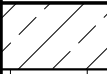
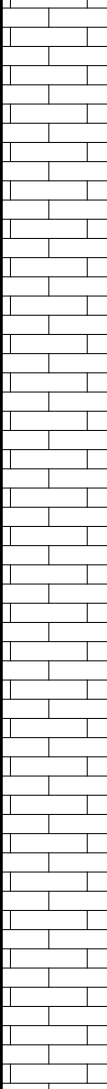
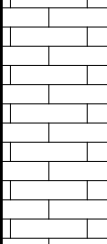
DRILLER: KEVIN WILKIE

DATE DRILLED: 4/5/2011

RIG TYPE: BK-66

DRILLING METHOD: 6.25" AIR HAMMER

SAMPLING METHOD: LOGGED BY CUTTINGS

Depth BGS	Sample Interval	N: N/A	E: N/A	G.S. ELEV.: N/A	Litho. Symbol	PID (ppm)	Comments
		DESCRIPTION					
0		0' - 2' <u>SILTY CLAY</u> dark brown					
5		2' - 28' <u>LIMESTONE</u> light gray, crystalline					
30		28' - 35' <u>LIMESTONE</u> light gray with interbedded shale and clay inclusions					
35		Total Depth of Boring at 35' bgs					No water encountered



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# FIELD BORING LOG

BORING NO.: SP-4

PAGE: 1 of 1

TOTAL DEPTH: 35 FEET BELOW GROUND SURFACE (BGS)

CLIENT: AMERICAN ELECTRIC POWER

PROJECT: NE PLANT POND WELLS - OOLOGAH, OK.

JOB NO.: 216-003-35117075-005

DRILLING CO.: MOHAWK

LOGGED BY: ADAM HOOPER

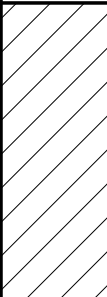
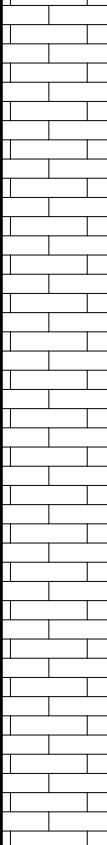
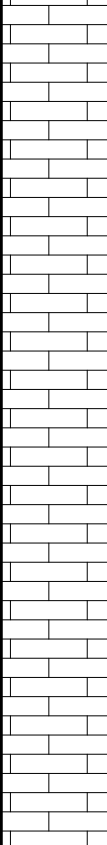
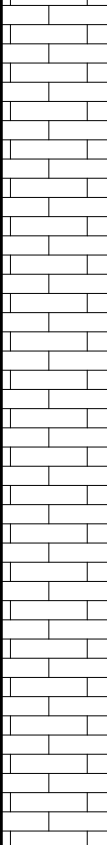
DRILLER: KEVIN WILKIE

DATE DRILLED: 4/6/2011

RIG TYPE: BK-66

DRILLING METHOD: 6.25" AIR HAMMER

SAMPLING METHOD: LOGGED BY CUTTINGS

Depth BGS	Sample Interval	N: N/A	E: N/A	G.S. ELEV.: N/A	Litho. Symbol	PID (ppm)	Comments
		DESCRIPTION					
0							
		0' - 9' <u>CLAY</u> red with limestone and chert gravel					Wet in clay above
10		9' - 16' <u>LIMESTONE</u> light gray, heavily weathered with red clay					
15		16' - 28' <u>LIMESTONE</u> tan/light gray, heavily weathered micritic with chert pebbles					
20		28' - 35' <u>LIMESTONE</u> light gray, crystalline					
35		Total Depth of Boring at 35' bgs					No water encountered



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# FIELD BORING LOG

BORING NO.: SP-5R

PAGE: 1 of 2

TOTAL DEPTH: 75 FEET BELOW GROUND SURFACE (BGS)

CLIENT: AMERICAN ELECTRIC POWER

PROJECT: NE PLANT POND WELLS - OOLOGAH, OK.

JOB NO.: 219-003-35117075-013

DRILLING CO.: MOHAWK

LOGGED BY: ADAM HOOPER

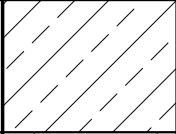
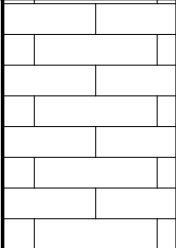
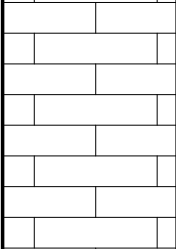
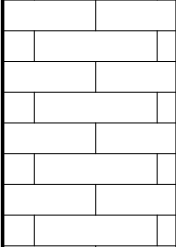
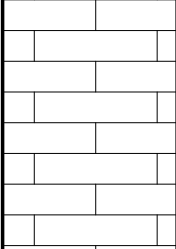
DRILLER: JEREMY

DATE DRILLED: 4/11/2012

RIG TYPE: BK-66

DRILLING METHOD: 6.25" AIR HAMMER

SAMPLING METHOD: LOGGED BY CUTTINGS

Depth BGS	N: N/A	E: N/A	G.S. ELEV.	N/A	Litho. Symbol	Remarks
DESCRIPTION						
0	0' - 4' <u>SILTY CLAY</u> brown					0' - 35' Lithology description provided by original SP-5 boring log. Cuttings for this interval were not obtained during re-drill.
5	4' - 12' <u>LIMESTONE</u> light gray, crystalline with interbedded dark limey shale					
10	12' - 20' <u>LIMESTONE</u> dark gray					
15	20' - 30' <u>LIMESTONE</u> light gray, fine grained, crystalline					
20	30' - 35' <u>LIMESTONE</u> light gray, crystalline with interbedded dark limey shale					
25						
30						





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# FIELD BORING LOG

BORING NO.: SP-5R

PAGE: 2 of 2

TOTAL DEPTH: 75

FEET BELOW GROUND SURFACE (BGS)

Depth BGS	DESCRIPTION	Litho. Symbol	Remarks	
40	35' - 75' <u>LIMESTONE</u> light gray, crystalline		Re-drill of SP-5 35' - 75' Logged by cuttings	
45				
50				
55				
60				Water at 61' bgs after 24 hours.
65				
70				
75	Total Depth of Boring at 75' bgs			



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# FIELD BORING LOG

BORING NO.: SP-10

PAGE: 1 of 1

TOTAL DEPTH: 51.5 FEET BELOW GROUND SURFACE (BGS)

CLIENT: AMERICAN ELECTRIC POWER

PROJECT: OOLOGAH, OK.

JOB NO.: 216-003-35177188-001

DRILLING CO.: ANDERSON ENGINEERING

LOGGED BY: ADAM HOOPER

DRILLER: GARY MOYERS

DATE DRILLED: 6/28/2017

RIG TYPE: ATV CME-55

DRILLING METHOD: HOLLOW STEM AUGER/AIR ROTARY

SAMPLING METHOD: LOGGED BY CUTTINGS

Depth BGS	Sample Interval	N: 525558.48   E: 2642344.45   GSE: 614.34	Litho. Symbol	Comments
		DESCRIPTION		
0		0'-2' <u>TOPSOIL AND BROWN SILTY CLAY</u>		
5		2'-51.5' <u>LIMESTONE</u> with interbedded shale layers, crystalline, hard, light gray to gray		
10				
15				
20				
25				Frequency of shale layers appear to increase with depth
30				
35				
40				
45				
50				Water not encountered while drilling
		Total Depth of Boring at 51.5' bgs		



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# FIELD BORING LOG

BORING NO.: SP-11

PAGE: 1 of 1

TOTAL DEPTH: 31.5 FEET BELOW GROUND SURFACE (BGS)

CLIENT: AMERICAN ELECTRIC POWER

PROJECT: OOLOGAH, OK.

JOB NO.: 216-003-35177188-002

DRILLING CO.: ANDERSON ENGINEERING

LOGGED BY: ADAM HOOPER

DRILLER: GARY MOYERS

DATE DRILLED: 6/27/2017

RIG TYPE: ATV CME-55

DRILLING METHOD: HOLLOW STEM AUGER/AIR ROTARY

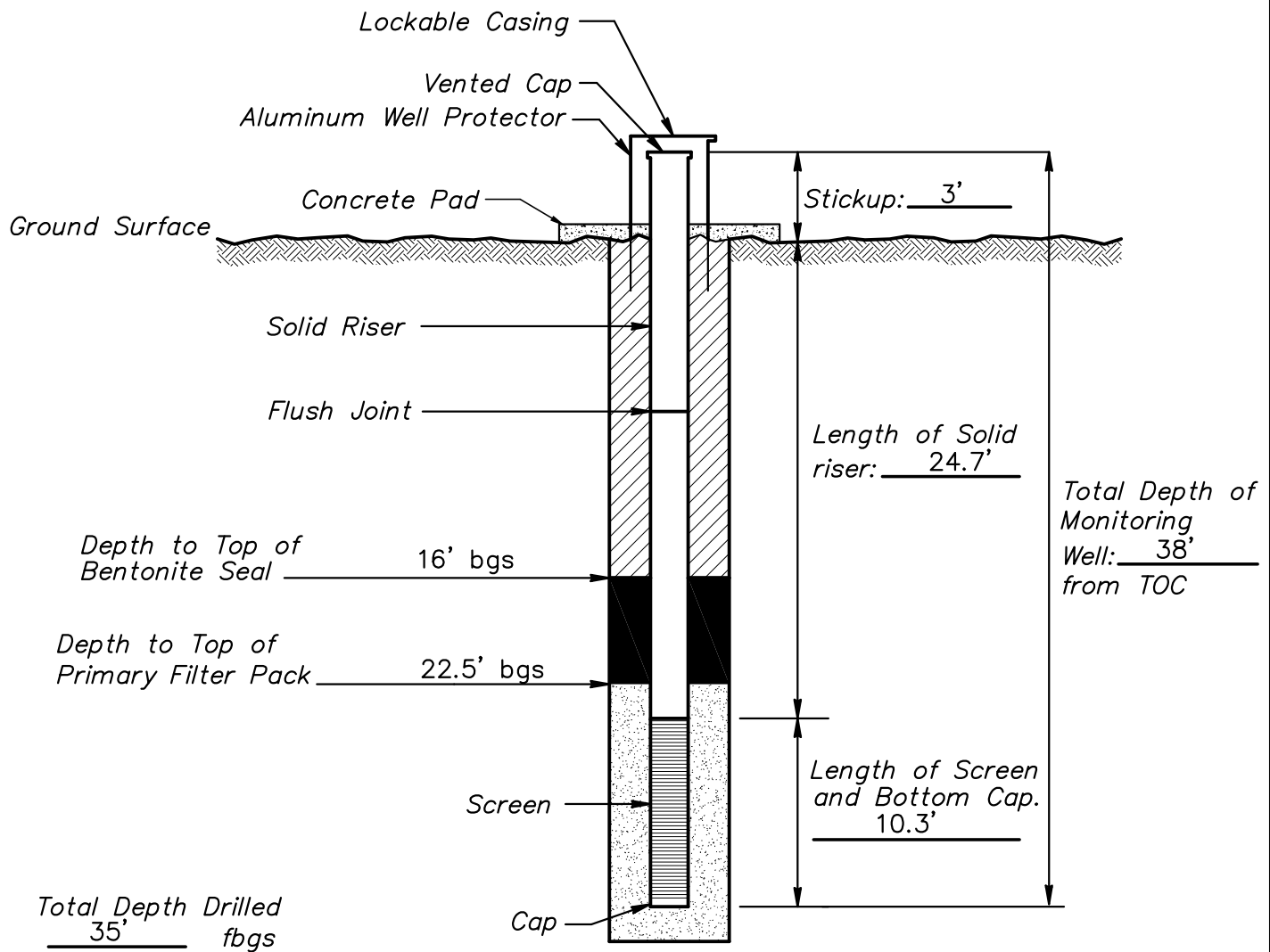
SAMPLING METHOD: LOGGED BY CUTTINGS

Depth BGS	Sample Interval	N: 524822.08   E: 2642532.26   GSE: 611.78	Litho. Symbol	Comments
		DESCRIPTION		
0		0'-2' <u>TOPSOIL AND BROWN SILTY CLAY</u>		
5		2'-31.5' <u>LIMESTONE</u> with interbedded shale layers, crystalline, hard, light gray to gray		
10				
15				
20				
25				Water encountered at 25' bgs while drilling
30				
35		Total Depth of Boring at 31.5' bgs		
40				
45				
50				

## Monitoring Well Installation Logs

# MONITORING WELL INSTALLATION RECORD

Job Name AEP NE PLANT POND WELLS Well Number SP-1  
 Job Number 35117075 Installation Date 4/5/2011 Location OOLOGAH, OK.  
 Datum Elevation N/A Surface Elevation N/A  
 Datum for Water Level Measurement T.O.C.  
 Screen Diameter & Material 2" PVC Slot Size 0.01  
 Riser Diameter & Material 2" PVC Borehole Diameter 6.25"  
 Granular Backfill Material 12-20 SAND Terracon Representative ADAM HOOPER  
 Drilling Method 6.25" AIR HAMMER Drilling Contractor MOHAWK



- Bentonite Grout
- Bentonite Chips
- Granular Backfill

(Not to Scale)



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## MONITORING WELL INSTALLATION RECORD

PROJECT NUMBER: 216-003-35117075

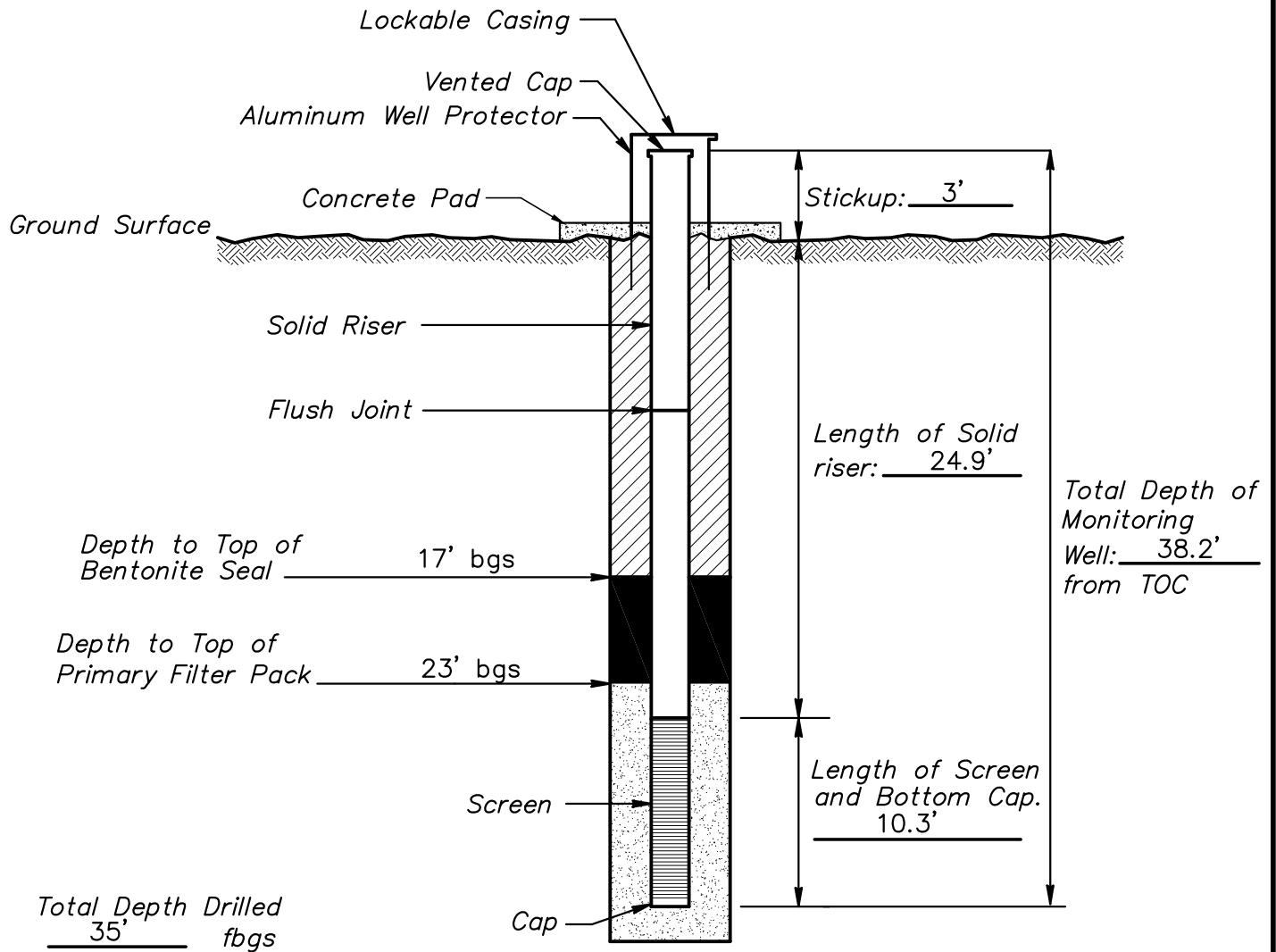
WELL NUMBER: SP-1

DRAWING NUMBER: 007

CHECKED BY: MR

# MONITORING WELL INSTALLATION RECORD

Job Name AEP NE PLANT POND WELLS Well Number SP-2  
 Job Number 35117075 Installation Date 4/5/2011 Location OOLOGAH, OK.  
 Datum Elevation N/A Surface Elevation N/A  
 Datum for Water Level Measurement T.O.C.  
 Screen Diameter & Material 2" PVC Slot Size 0.01  
 Riser Diameter & Material 2" PVC Borehole Diameter 6.25"  
 Granular Backfill Material 12-20 SAND Terracon Representative ADAM HOOPER  
 Drilling Method 6.25" AIR HAMMER Drilling Contractor MOHAWK



- Bentonite Grout
- Bentonite Chips
- Granular Backfill

(Not to Scale)

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## MONITORING WELL INSTALLATION RECORD

PROJECT NUMBER: 216-003-35117075

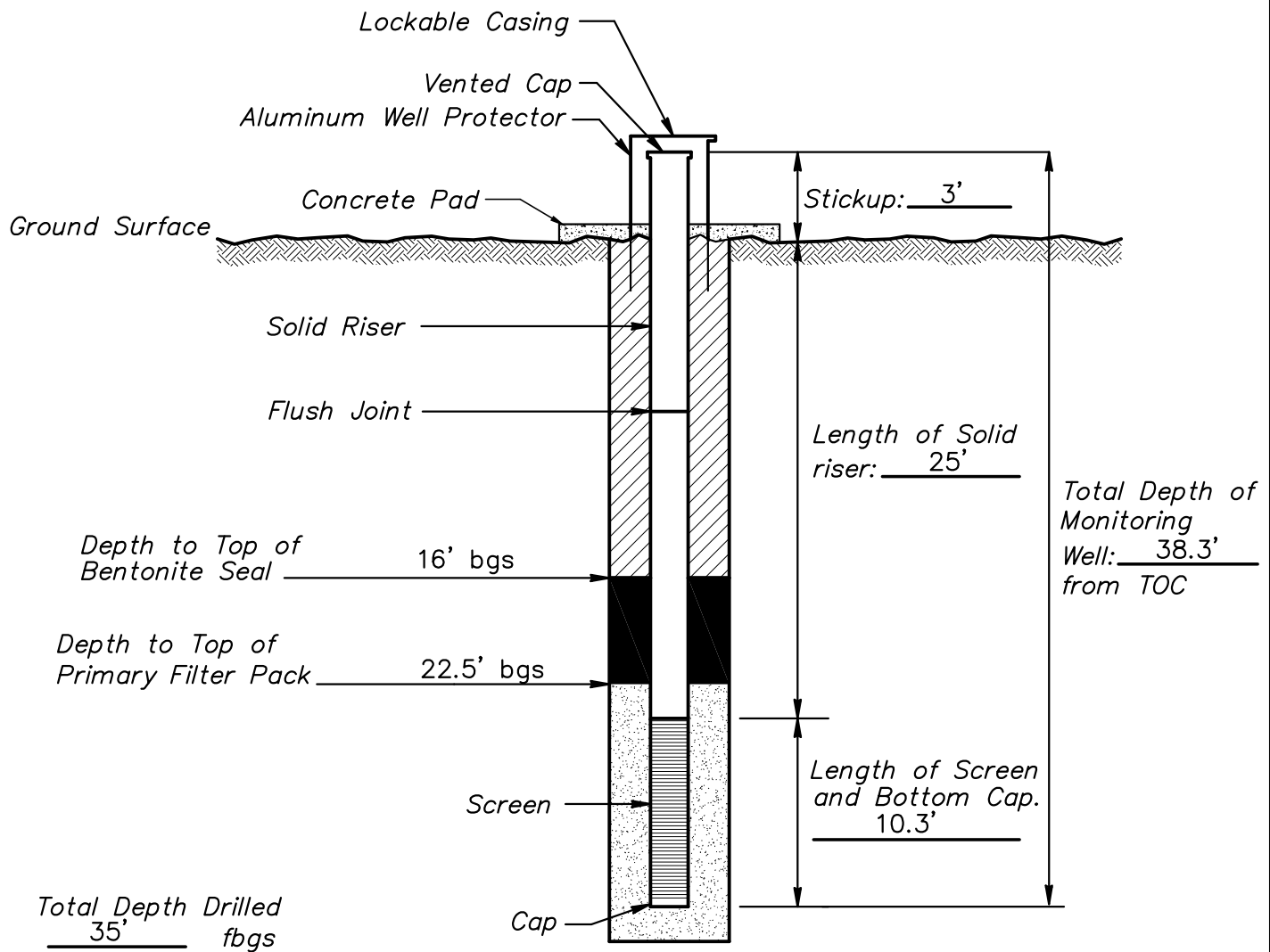
WELL NUMBER: SP-2

DRAWING NUMBER: 008

CHECKED BY: MR

# MONITORING WELL INSTALLATION RECORD

Job Name AEP NE PLANT POND WELLS Well Number SP-4  
 Job Number 35117075 Installation Date 4/6/2011 Location OOLOGAH, OK.  
 Datum Elevation N/A Surface Elevation N/A  
 Datum for Water Level Measurement T.O.C.  
 Screen Diameter & Material 2" PVC Slot Size 0.01  
 Riser Diameter & Material 2" PVC Borehole Diameter 6.25"  
 Granular Backfill Material 12-20 SAND Terracon Representative ADAM HOOPER  
 Drilling Method 6.25" AIR HAMMER Drilling Contractor MOHAWK



- Bentonite Grout
- Bentonite Chips
- Granular Backfill

(Not to Scale)



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## MONITORING WELL INSTALLATION RECORD

PROJECT NUMBER: 216-003-35117075

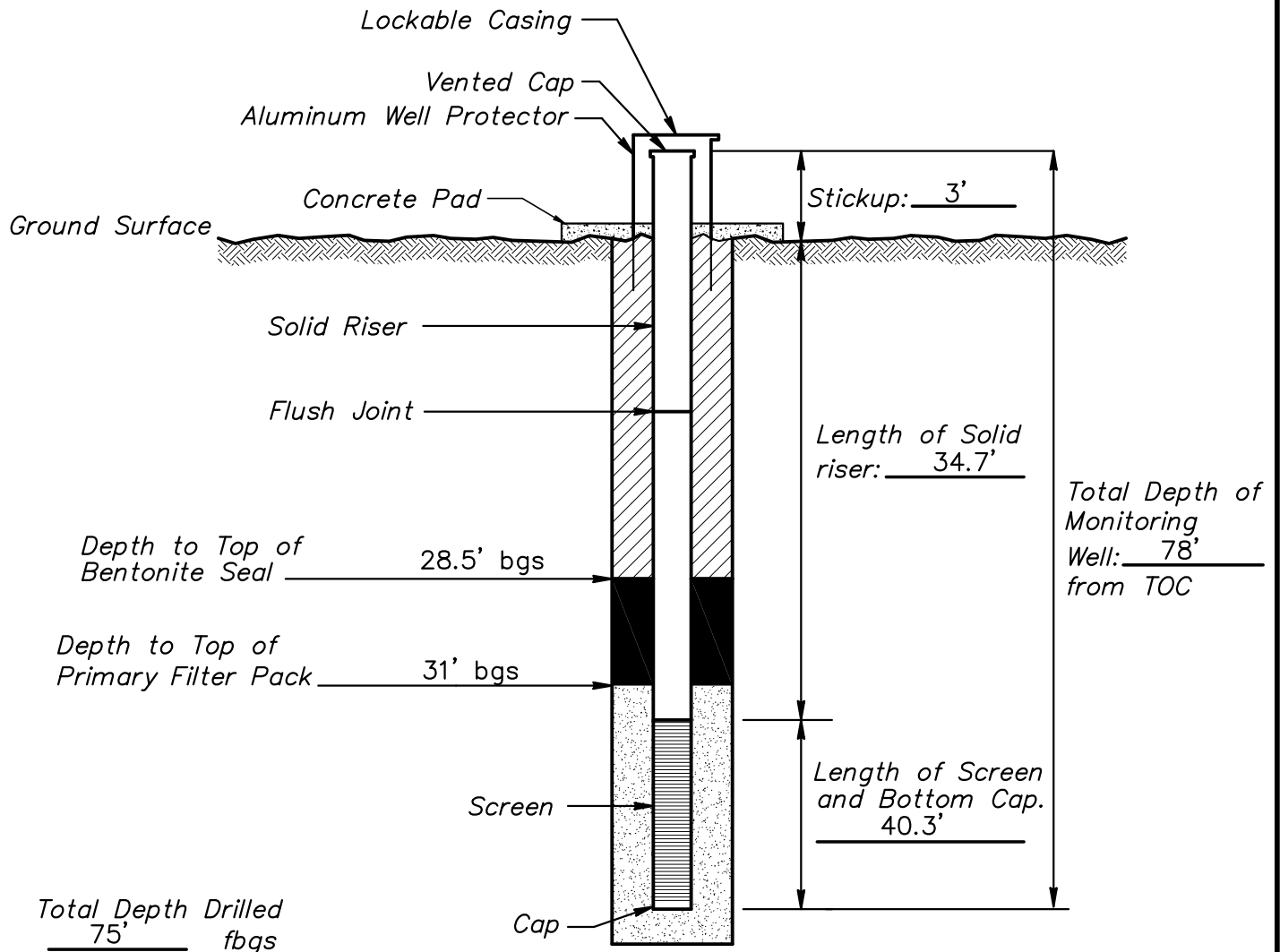
WELL NUMBER: SP-4

DRAWING NUMBER: 010

CHECKED BY: MR

# MONITORING WELL INSTALLATION RECORD

Job Name	AEP NE PLANT POND WELLS	Well Number	SP-5R
Job Number	35117075	Installation Date	4/11/2012
Datum Elevation	N/A	Location	OOLOGAH, OK.
Datum for Water Level Measurement	T.O.C.	Surface Elevation	N/A
Screen Diameter & Material	2" PVC	Slot Size	0.01
Riser Diameter & Material	2" PVC	Borehole Diameter	6.25"
Granular Backfill Material	12-20 SAND	Terracon Representative	ADAM HOOPER
Drilling Method	6.25" AIR HAMMER	Drilling Contractor	MOHAWK



- Bentonite Grout
- Bentonite Chips
- Granular Backfill

(Not to Scale)

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PH. (501) 847-9292

BRYANT, AR, 72022  
FAX. (501) 847-9210

## MONITORING WELL INSTALLATION RECORD

PROJECT NUMBER: 216-003-35117075

WELL NUMBER: SP-5R

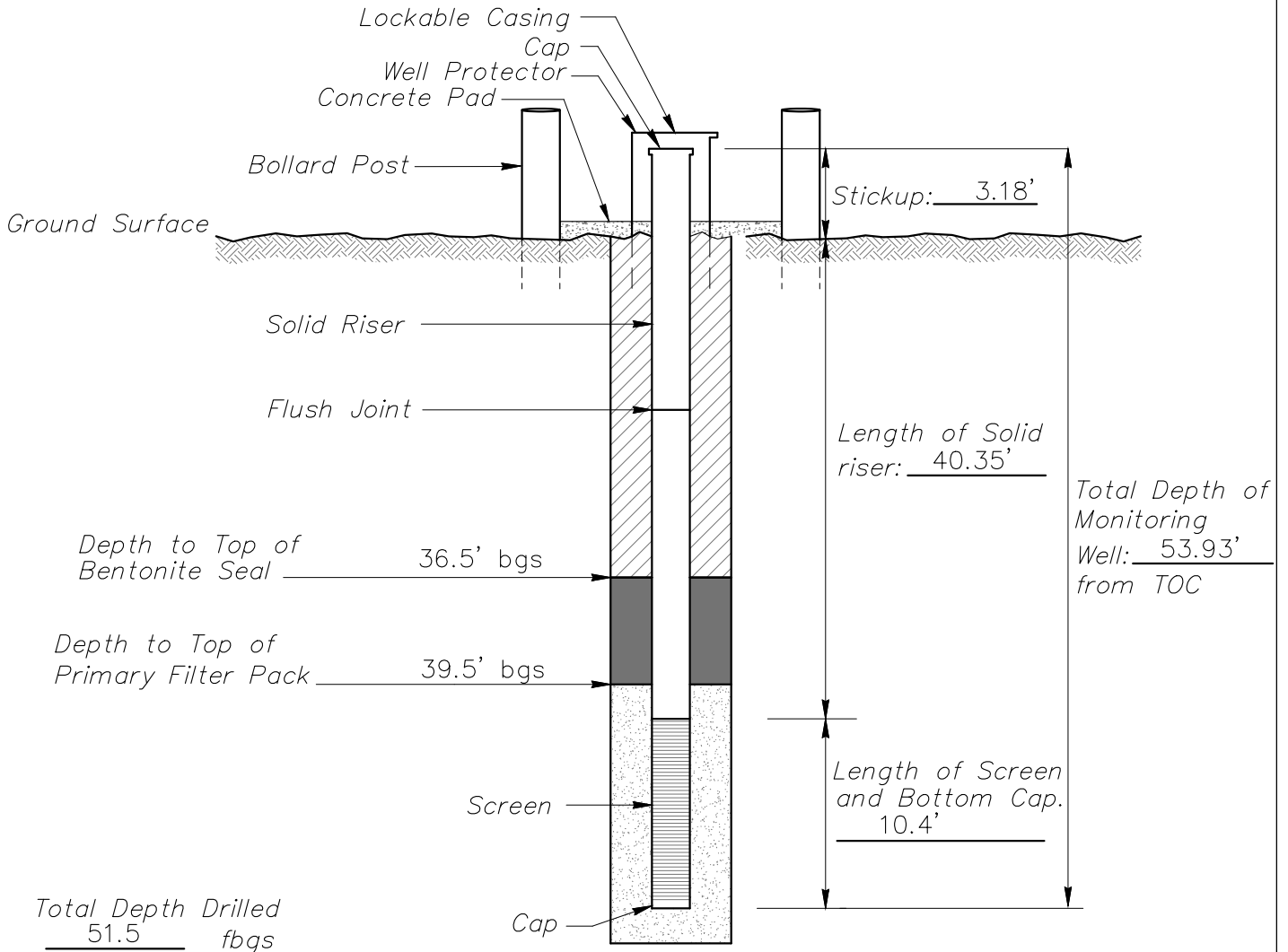
DRAWING NUMBER: 014

CHECKED BY: MR



# MONITORING WELL INSTALLATION RECORD

Job Name AEP NORTHEASTERN POND WELL INSTALLATION Well Number SP-10  
 Job Number 35177188 Installation Date 6/28/2017 Location OOLOGAH, OK.  
 Datum Elevation 617.52' Surface Elevation 614.34'  
 Datum for Water Level Measurement T.O.C.  
 Screen Diameter & Material 2" PVC Slot Size 0.010"  
 Riser Diameter & Material 2" PVC Borehole Diameter 6"  
 Granular Backfill Material 16-30 SAND Terracon Representative ADAM HOOPER  
 Drilling Method HOLLOW STEM AUGER/AIR ROTARY Drilling Contractor ANDERSON ENGINEERING



- Portland/Bentonite Grout
- Bentonite Pellet Plug
- Granular Backfill

(Not to Scale)

Terracon

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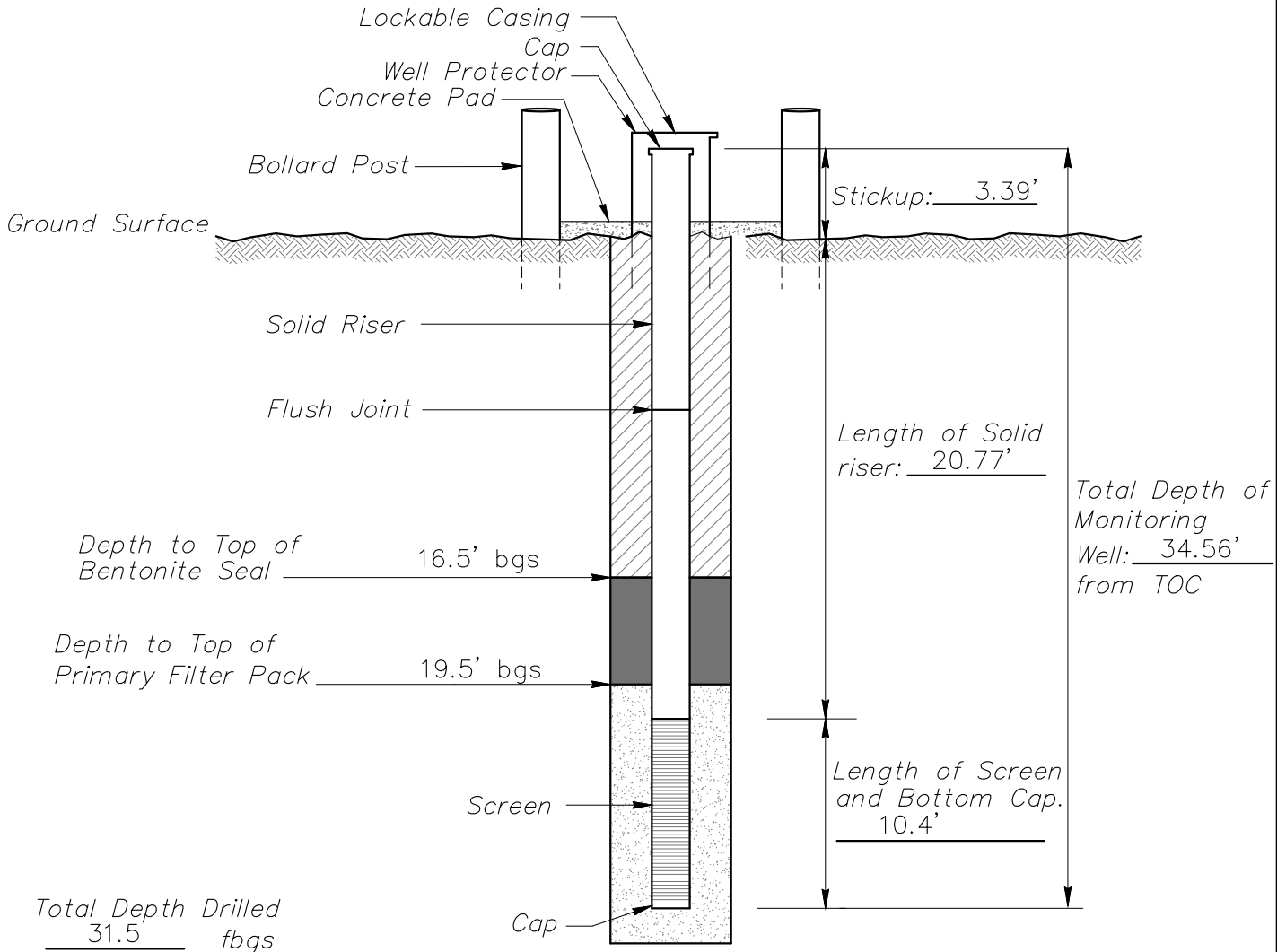
25809 I-30 South BRYANT, AR. 72022  
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## MONITORING WELL INSTALLATION RECORD

PROJECT NUMBER: 216-003-35177188  
 WELL NUMBER: SP-10  
 DRAWING NUMBER: 003 CHECKED BY: RAH

# MONITORING WELL INSTALLATION RECORD

Job Name AEP NORTHEASTERN POND WELL INSTALLATION Well Number SP-11  
 Job Number 35177188 Installation Date 6/27/2017 Location OOLOGAH, OK.  
 Datum Elevation 615.17' Surface Elevation 611.78'  
 Datum for Water Level Measurement T.O.C.  
 Screen Diameter & Material 2" PVC Slot Size 0.010"  
 Riser Diameter & Material 2" PVC Borehole Diameter 6"  
 Granular Backfill Material 16-30 SAND Terracon Representative ADAM HOOPER  
 Drilling Method HOLLOW STEM AUGER/AIR ROTARY Drilling Contractor ANDERSON ENGINEERING



- Portland/Bentonite Grout
- Bentonite Pellet Plug
- Granular Backfill

(Not to Scale)

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## MONITORING WELL INSTALLATION RECORD

PROJECT NUMBER: 216-003-35177188

WELL NUMBER: SP-11

DRAWING NUMBER: 004

CHECKED BY: RAH