

# Report 1 - Groundwater Monitoring Network for CCR Compliance

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

September 2017  
Project No. 35157123



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

*A unit of American Electric Power*

**Prepared for:**

American Electric Power  
1 Riverside Plaza  
Columbus, OH 43215

**Prepared by:**

Terracon Consultants, Inc.  
25809 Interstate 30 South  
Bryant, Arkansas 72022  
(501) 847-9292

[terracon.com](http://terracon.com)

**Terracon**

Environmental



Facilities



Geotechnical



Materials

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## **1.0 Objective**

The purpose of this Groundwater Monitoring Network Report (GWMNR) is to demonstrate adequacy and compliance of the existing monitoring well network with 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). PSO is a unit of American Electric Power (AEP).

## **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. (SEE FIGURES 2 and 3). The pond is approximately 29.5 feet deep with an embankment elevation 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 elevation 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 002 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 site. 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>.

Stormwater runoff from the pond's embankment flows into the pond. Surface water flow within the BAP is controlled by an emergency spillway which 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.
- § Golder and AEP, ERA study of the Bottom Ash Pond.

- § 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>.

These features are further illustrated through cross sections that were prepared through the BAP area, with A-A' trending from north to south and B-B' trending from west to southeast. The cross section location map is included in **APPENDIX 2**.

### **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.

### **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>.

## **Downhole Geophysics**

Borehole geophysical logging was conducted within monitoring wells SP-8 and SP-9 by Century Wireline Services on May 4, 2016. The logging method included natural gamma, formation conductivity/resistivity and neutron logging. Logging of each hole was accomplished by lowering the logging tools through the center of the completed well casings.

Natural gamma logs are records of the amount of natural gamma radiation that is emitted from all soils and rocks. In sedimentary formations, the log normally reflects the shale or clay content of the formation under investigation. This is because the radioactive elements tend to concentrate in shale and clay. Clean formations generally have very low natural radioactivity unless a radioactive contaminant such as volcanic ash or granite wash is present or the formation waters contain dissolved radioactive salts. The most common gamma-emitting isotope normally found in sediments or rocks is potassium-40 (K40). Potassium, which contains about 0.012 percent K40, is typically present in feldspars and micas that are found in many different rock types that readily decompose into clays. In hydrogeologic investigations, a common application is the identification of clay or shale deposits that may act as a confining layer for the aquifer. The primary use of natural gamma logs is for identification of lithology and stratigraphic correlation in open or cased, liquid or air filled holes (Keys and MacCary, 1983; Schlumberger, 1987).

The gamma log is interpreted by using the vertical scale (measured as depth in feet) and the horizontal scale provided at the top of the log. The horizontal scale used in this investigation increases from zero on the left, up to 150 counts per second on the right. The clay material typically exhibits high gamma values. Limestone material is typically interpreted by observing when the log has a major baseline shift to the left (low gamma values). This baseline shift occurs when the probe passes through contacts between the clay and rock units.

In addition to natural gamma, each borehole was logged with a formation resistivity/conductivity probe. This type of probe operates using a transmitter and receiver coil. A high-frequency alternating current of constant intensity is sent through the transmitter coil. The alternating magnetic field created induces currents in the formation surrounding the borehole. The currents flow in a circular loops parallel with the transmitter coil and create a magnetic field that induces a voltage in the receiver coil. Because of the constant amplitude and frequency of the transmitter coil, the currents induced are directly proportional to the formation conductivity. The probe is designed in such a way as to eliminate the signal originating from the transmitter. The resistivity associated with the conductivity is calculated based upon the conductivity of the formation (Keys and MacCary, 1983; Schlumberger, 1987).

The formation conductivity probe is used to assist in differentiating the conductive clay layers from the lower conductivity layers such as rock, cherty gravel, or sand. The formation



conductivity is measured in millimho/meter (mmho/m). The scale is read from 100 on the left, up to 0 mmho/m on the right. It should be noted that conductivity is the reciprocal of resistivity. For example, a highly conductive layer such as clay has a relatively low resistivity. A low conductive layer such as sandstone has a relatively high resistivity.

Neutron logging utilizes a neutron emission probe similar to the one used in gamma logging; however, this method relies on the interaction of neutrons with hydrogen atoms of water or hydrocarbon fluids located in pore spaces within the formation to identify changes in porosity throughout the formation (Selley, 1985). The data is presented as neutron counts per second (cps) and the scale is read from 400 cps on the left, up to 800 cps on the right with higher values indicating higher formation porosity.

The geophysical logs recorded within the monitoring wells generally indicate the site is underlain by a limestone unit that extends from ground surface to depths of approximately 28 feet to 50 feet bgs. Below the limestone unit, shale is encountered to boring depth. These results are consistent with lithologies and depths encountered during monitoring well drilling activities. The geophysical log plots are included in **APPENDIX 3**.

#### **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. During the installation of the monitoring wells, little to no groundwater was encountered to a depth of 70-80 feet below ground surface. Based on groundwater level elevations from the July 2017 sampling event, the groundwater in the area of the BAP flows southwest.

Since no groundwater was encountered during the installation of the 70-80 foot deep wells and with an estimated BAP depth of 30 feet, there does not appear to be communication between the surface water and groundwater.

#### **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 7**).

### **3.0 Certified Groundwater Monitoring Network**

In accordance with 40 CFR 257.91, the existing monitoring well network at the Site was evaluated to determine if any of the wells were viable for continued use as part of the groundwater monitoring

well network. The hydrogeologic conditions were also evaluated to determine if the uppermost aquifer unit has an effective well network. The monitoring well network must effectively monitor the uppermost aquifer both in the up-gradient and down-gradient locations at the Site.

### 3.1 Hydrostratigraphic Units

#### 3.1.1 Horizontal and Vertical Position Relative to CCR Unit

Geological data from soil borings and monitoring wells installed at the site show the shallow limestone unit as the groundwater bearing zone. The existing well network monitors the limestone unit and consists of wells SP-1, SP-2, SP-4, SP-5R, SP-10, and SP- 11. Horizontal positions of existing monitoring well locations relative to the CCR Unit are provided in **FIGURE 3**. Vertical positioning of the monitoring wells is shown in **TABLE 2 – WELL CONSTRUCTION DETAILS**.

#### 3.1.2 Overall Flow Conditions

Groundwater is recharged from regional precipitation infiltration. The monitoring wells at the BAP are set in the shallow limestone unit. Based on slug testing, the shallow limestone unit has an estimated hydraulic conductivity of approximately  $10^{-3}$  centimeters per second and an estimated seepage rate of 889 feet per year.

Available potentiometric elevations for are summarized on **TABLE 1** (shallow limestone unit SPs 1-5R, 10, and 11). Based on water level elevations from the July 2017 sampling event, groundwater flow is southwest towards Fourmile Creek (**FIGURE 6**).

### 3.2 Uppermost Aquifer

#### 3.2.1 CCR Rule Definition-40 CFR 257.53

“**Aquifer**” means a geologic formation, group of formations or portion of a formation capable of yielding usable quantities of groundwater to wells or springs.

“**Uppermost Aquifer**” means 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 to the natural ground surface to which the aquifer rises during the wet season.

#### Common Definitions

“**Aquifer**” is a geologic formation(s) that is water bearing. A geological formation or structure that stores and/or transmits water, such as to wells and springs. Use of the term is usually restricted to those water-bearing formations capable of yielding water in sufficient quantity to constitute a usable supply for people’s uses. (USGS, Water Science Glossary of Terms)

### **3.2.2 Identified Onsite Hydrostratigraphic Unit**

The on-site hydrostratigraphic units considered in the area of the BAP are the shallow limestone unit and the deeper shale unit. Groundwater quality is closely related to the mineral content of the formation in which it is encountered. Groundwater from the Oologah Formation, Labette Formation, and Fort Scott Limestone yields fair to poor quality water. (**Oklahoma Geological Survey, Maps Showing Principal Groundwater Resources and Recharge Areas in Oklahoma, 1993**)<sup>5</sup>. The U.S. Geological Survey (USGS) collected water samples from fifty-eight (58) wells in areas underlain by Pennsylvanian and Mississippian Age rocks within the Tulsa Quadrangle (11 miles SW of the Oologah Quadrangle). Of the water samples tested, 27 percent contained more than 250 milligrams per liter (mg/l) sulfate, 20 percent contained more than 250 mg/l chloride, and 62 percent contained more than 500 mg/l total dissolved solids. Seventy-two (72) percent of the wells sampled contained hard or very hard water (Marcher, 1971). Water collected from the shale formations was the most mineralized. (**Page 7, Volume 2, Major Mod 2011, Terracon Project No. 35107130**)<sup>6</sup>.

### **3.3 Review of Existing Monitoring Well Network**

#### **3.3.1 Overview**

A well construction table that summarizes the location, ground surface elevation, borehole depth, installation data, and associated well construction details of the existing wells is included in **TABLE 2**.

#### **3.3.2 Gaps in the Monitoring Well Network**

As shown in Geologic Cross Sections A-A' (Sheet 2) and B-B' (Sheet 3) Appendix 2, the limestone formation is 25-35 feet thick. Existing wells SP-4 and SP-5R are screened within this formation up-gradient of the BAP, and existing wells SPs 1, 2, 10 and 11 are screened in this formation down-gradient of the BAP. Monitoring well SP-3 is considered to be cross-gradient of the BAP (Figure 6 and Sheet 1 in Appendix 2).

#### **3.3.3 Recommended Monitoring Network**

The recommended existing groundwater monitoring well network is intended to meet specifications stated in 252:517-9-2 and 40 CFR 257.91. Recommended wells are further discussed with respect to location to the BP (up-gradient or down-gradient), well depth and well construction. The recommended network would provide an improved understanding of groundwater quality, hydraulics, and groundwater flow at the BAP.

Two up-gradient well locations (existing monitoring wells SP-4 and SP-5R) and four down-gradient well locations (SPs-1, 2, 10 and 11) are recommended to establish a groundwater quality monitoring well network for the BAP. In addition, existing monitoring wells SP-3 may be utilized as a piezometer to obtain additional groundwater flow direction and gradient data for the BAP.

### **3.3.4 Location**


The recommended monitoring well network for groundwater quality of the uppermost water bearing unit for the BAP is illustrated on **FIGURE 6**. The screen depths for the monitoring wells recommended for inclusion in the monitoring network are within the shallow limestone unit that occurs at an elevation of approximately 563 feet amsl to ground surface.

**4.0 Certification**

**4.1 Limitations**

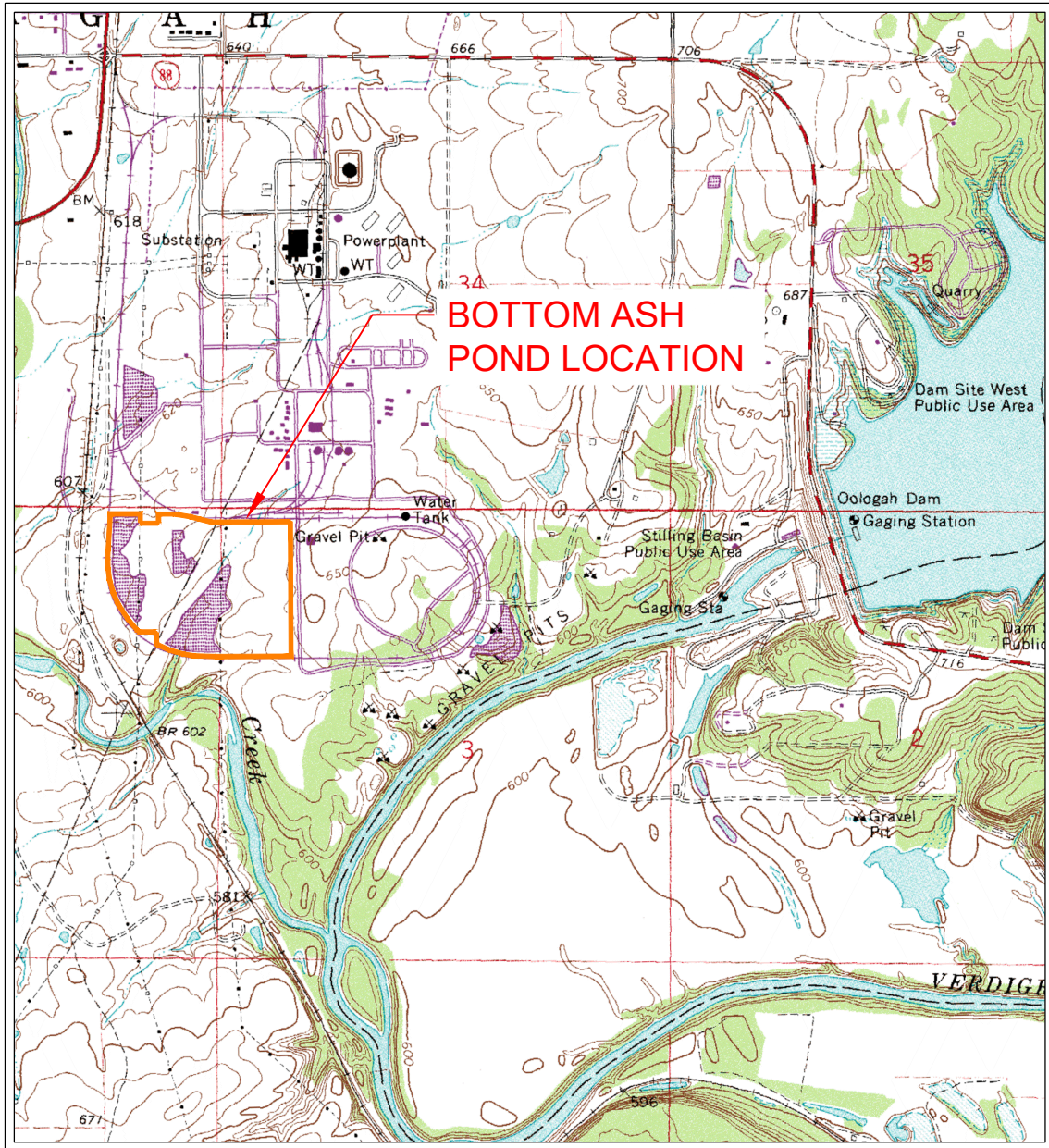
The findings and conclusions resulting from this investigation are based upon information derived from the on-site activities and other services performed under the scope of work as described in this report; such information is subject to change over time if additional information is obtained. Please 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.

**4.2 PE Certification**

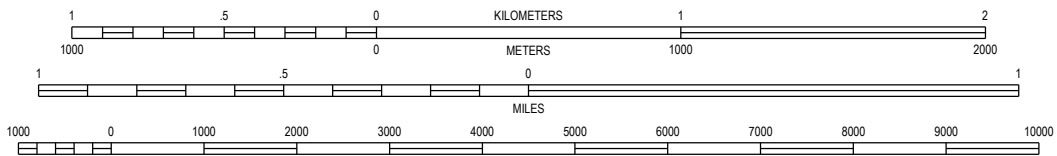
Name: <i>F. Owen Carpenter</i>	Date: <i>11-SEP-2017</i>	 <p><i>Exp. 31-OCT-2017</i></p> <p>Stamp</p>
Company: <i>Terracon</i>	Expiration Date: <i>31-OCT-2017</i>	

## **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.
- 5 Oklahoma Geological Survey, Maps Showing Principal Groundwater Resources and Recharge Areas in Oklahoma, 1993.
- 6 Permit Modification Application Volume 2 – Hydrogeologic Investigation Report, page 4.




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		GROUNDWATER MONITORING NETWORK	1
Checked By: TLB	File No. 001		AMERICAN ELECTRIC POWER	
Approved By: DCM	Date: 07/27/2017		NORTHEASTERN STATIONS 3 & 4	
			OOLOGAH OKLAHOMA	



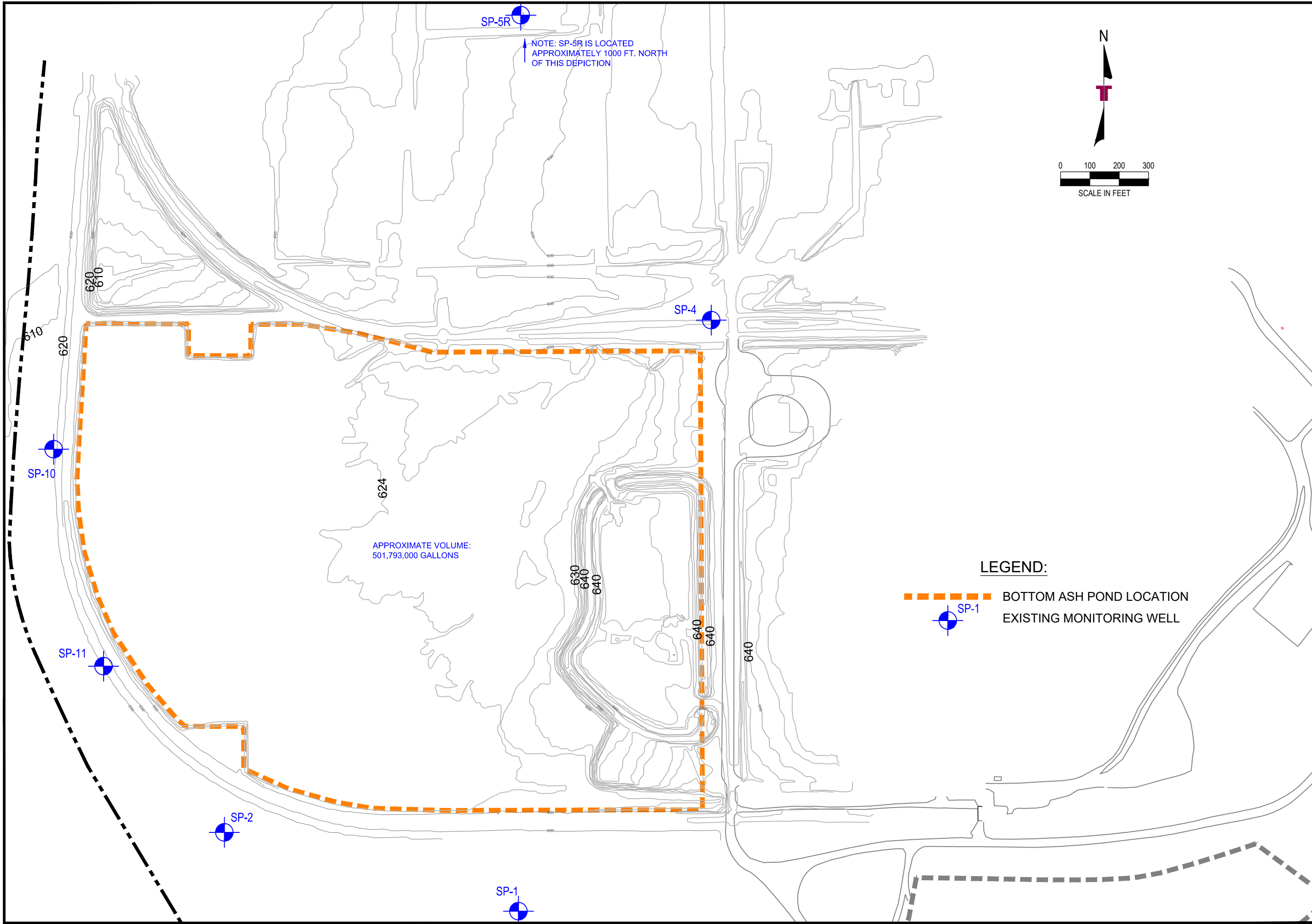
<b>FIGURE 2</b>	
DESIGNED BY: TLB	DRAWN BY: TLB
APPROVED BY: DCM	SCALE: SEE BARSCALE
DATE: 07/27/2017	JOB NO: 216-003-35157123
ACAD NO: 002	SHEET NO: 2 OF 7

**PLANT AND CCR UNIT LOCATION MAP**  
 GROUNDWATER MONITORING NETWORK  
**AMERICAN ELECTRIC POWER**  
 NORTHEASTERN STATIONS 3 & 4  
 OOLOGAH OKLAHOMA

**Terracon**  
 Consulting Engineers and Scientists  
 25809 I-30 SOUTH BRYANT, AR 72022  
 PH. (501) 847-9292 FAX. (501) 847-9210

REV.	DATE	BY	DESCRIPTION



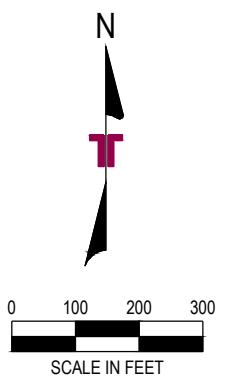


NOTE: SP-5R IS LOCATED APPROXIMATELY 1000 FT. NORTH OF THIS DEPICTION

APPROXIMATE VOLUME: 501,793,000 GALLONS

**LEGEND:**

- BOTTOM ASH POND LOCATION
- EXISTING MONITORING WELL



REV.	DATE	BY	DESCRIPTION

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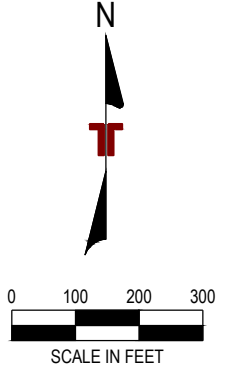
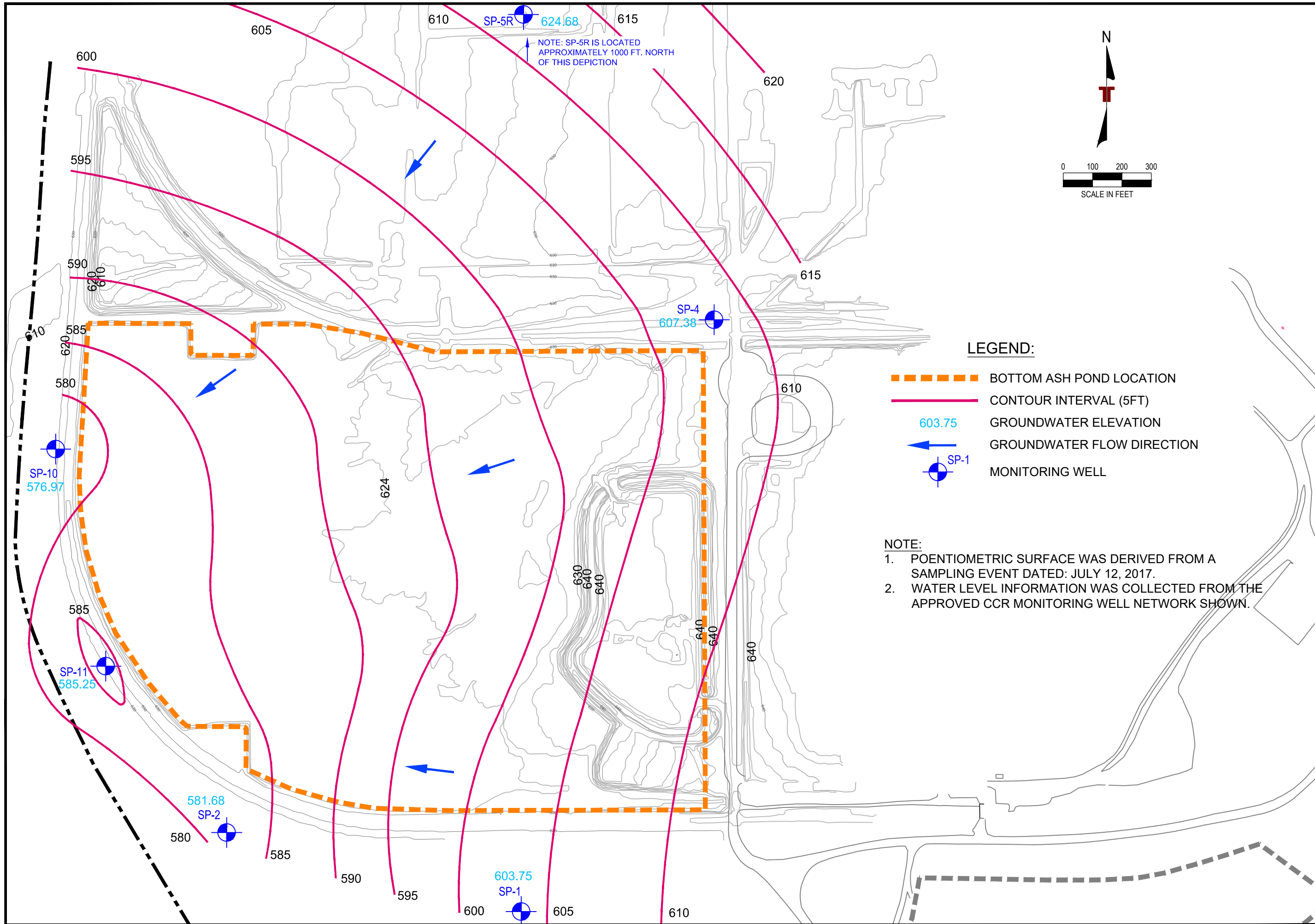
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 FAX. (501) 847-9210

**CCR UNIT LAYOUT AND WELL LOCATIONS**

GROUNDWATER MONITORING NETWORK  
**AMERICAN ELECTRIC POWER**  
 NORTHEASTERN STATIONS 3 & 4  
 OKLOGAH OKLAHOMA

**FIGURE 3**

DESIGNED BY: TLB	
DRAWN BY: TLB	
APP'D BY: DCM	
SCALE: SEE BARSCALE	
DATE: 07/27/2017	
JOB NO. 216-003-35157123	
ACAD NO. 003	
SHEET NO. 3	OF 7



**LEGEND:**

- BOTTOM ASH POND LOCATION
- CONTOUR INTERVAL (5FT)
- GROUNDWATER ELEVATION
- GROUNDWATER FLOW DIRECTION
- MONITORING WELL

**NOTE:**

1. POTENTIOMETRIC SURFACE WAS DERIVED FROM A SAMPLING EVENT DATED: JULY 12, 2017.
2. WATER LEVEL INFORMATION WAS COLLECTED FROM THE APPROVED CCR MONITORING WELL NETWORK SHOWN.

<b>FIGURE 6</b>						
DESIGNED BY: TLB	APP'D BY: DCM	SCALE: SEE BARSCALE	DATE: 08/17/2017	JOB NO: 216-003-35157123	ACAD NO: 006	
					SHEET NO: 6	OF 7

POTENTIOMETRIC SURFACE MAP  
 GROUNDWATER MONITORING NETWORK  
**AMERICAN ELECTRIC POWER**  
 NORTHEASTERN STATIONS 3 & 4  
 OKLAHOMA  
 OOLOGAH

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REV.	DATE	BY	DESCRIPTION



**LEGEND:**  
● DOMESTIC WELL



9,165 FT. ±

REV.	DATE	BY	DESCRIPTION

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NEAREST DOMESTIC WELL LOCATION  
 GROUNDWATER MONITORING NETWORK  
**AMERICAN ELECTRIC POWER**  
 NORTHEASTERN STATIONS 3 & 4  
 OOLOGAH      OKLAHOMA

**FIGURE 7**

DESIGNED BY:	TLB
DRAWN BY:	TLB
APPRD. BY:	DCM
SCALE:	SEE BARSCALE
DATE:	07/27/2017
JOB NO.	216-003-35157123
ACAD. NO.	008A
SHEET NO.:	7 OF 7

**TABLE 1**  
 NORTHEASTERN STATION 3 & 4  
 BOTTOM ASHPOND  
 WELL LEVEL DATA  
 GROUNDWATER ELEVATIONS (FMSL)

Well	SP-1	SP-2	SP-3	SP-4	SP-5R					SP-10	SP-11
Date											
04/20/11	604.05	Dry	584.40	611.73							
06/07/11	603.77	584.04	589.81	607.21							
09/13/11	603.03	588.26	607.85	611.11							
12/13/11	604.67	596.15	619.38	623.29							
03/13/12	604.88	594.73	606.67	619.31							
06/12/12	603.48	596.32	605.83	624.58	623.86						
09/18/12	602.76	591.34	613.27	615.45	621.55						
12/10/12	603.78	596.72	619.83	623.94	623.87						
03/12/13	604.59	594.24	606.74	617.19	625.73						
06/11/13	604.26	595.16	601.47	619.48	625.48						
09/24/13	603.55	597.00	614.76	625.83	623.97						
12/20/13	604.17	596.12	619.11	626.87	625.06						
03/05/14	604.08	596.46	608.66	627.12	625.72						
06/09/14	604.81	595.67	612.61	619.27	625.94						
09/09/14	603.26	596.27	613.22	625.71	623.83						
11/03/14	604.03	592.59	609.48	621.18	624.09						
03/10/15	604.80	596.62	608.99	626.37	627.35						
06/15/15	604.21	596.40	598.64	614.66	624.76						
12/14/15	605.90	590.14	616.96	614.43	627.42						
03/16/16	603.02	594.66	617.38	626.17	624.94						
05/16/16	604.17	596.87	588.01	625.64	626.14						
07/20/16	-	-	599.38	-	622.81						
09/19/16	603.55	595.72	609.01	626.64	622.21						
10/06/16	603.64	591.63	590.77	600.86	624.22						
03/14/17	604.40	589.03	608.81	618.65	625.45						
05/18/17	586.77	581.68	586.31	608.90	570.98						
06/15/17	603.96	582.61	590.22	612.61	624.22						
06/27/17	603.71	580.67	589.77	610.13	624.22						
07/12/17	603.75	581.68	590.16	607.38	624.68					576.97	585.25
Seasonal High	605.90	597.00	619.83	627.12	627.42					576.97	585.25

**TABLE 2**  
**NORTHEASTERN STATION 3 & 4**  
**BOTTOM ASH POND**  
**MONITORING WELL/PIEZOMETER CONSTRUCTION DETAILS**

Well Number	Latitude	Longitude	Ground Surface Elevation	Top of Casing Elevation	Borehole Depth ft. bls	Date Installed	Screen Material	Well Diameter inches	Top of Screen Depth ft. bls	Top of Screen Elevation ft. msl	Bottom of Screen Depth ft. bls	Bottom of Screen Elevation ft. msl
SP-1	36° 25' 03.77705"	95° 42' 14.44814"	618.26	621.26	35	4/5/2011	PVC	2	24.7	596.56	35	583.26
SP-2	36° 25' 06.44515"	95° 42' 26.73557"	614.49	617.49	35	4/5/2011	PVC	2	24.9	592.59	35.2	579.29
SP-3	36° 25' 23.91757"	95° 42' 27.02763"	618.02	621.02	35	4/5/2011	PVC	2	24.6	596.42	34.9	583.12
SP-4	36° 25' 23.73526"	95° 42' 06.38375"	636.16	639.16	35	4/6/2011	PVC	2	25	614.16	35.3	600.86
SP-5	36° 25' 43.92075"	95° 42' 14.32901"	628.17	631.17	35	4/6/2011	PVC	2	24.9	606.27	35.2	592.97
SP-5R*	36° 25' 43.92075"	95° 42' 14.32901"	628.17	631.17	75	4/11/2012	PVC	2	34.7	596.47	75	553.17
SP-10	36° 25' 19.9126"	95° 42' 34.1120"	614.34	617.52	51.5	6/29/2017	PVC	2	40.35	577.17	50.75	563.59
SP-11	36° 25' 11.5887"	95° 42' 32.0272"	611.78	615.17	31.5	6/29/2017	PVC	2	20.77	594.40	31.17	580.61

\* SP-5R replaced SP-5

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

## Boring Logs



Consulting Engineers and Scientists

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

# 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-3

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.: 216-003-35117075-004

DRILLING CO.: MOHAWK

LOGGED BY: ADAM HOOPER

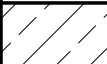
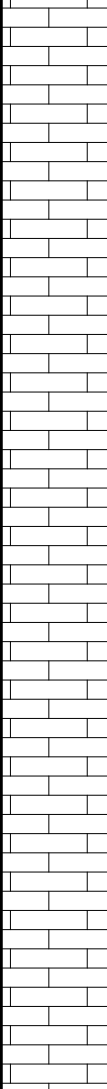
DRILLER: KEVIN WILKIE

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, moist					
5		2' - 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-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
9		9' - 16' <u>LIMESTONE</u> light gray, heavily weathered with red clay					
16		16' - 28' <u>LIMESTONE</u> tan/light gray, heavily weathered micritic with chert pebbles					
28		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

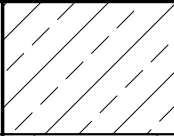
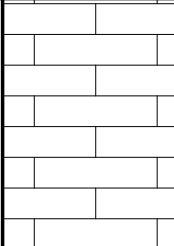
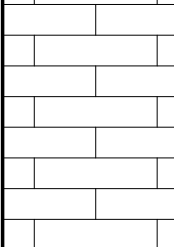
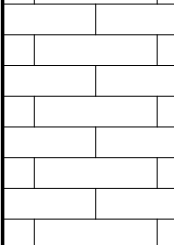
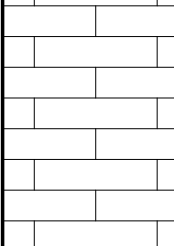
DRILLER: JEREMY

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-6

PAGE: 1 of 1

TOTAL DEPTH: 71' FEET BELOW GROUND SURFACE (BGS)

CLIENT: AEP	PROJECT: NE - CCR WELL INSTALL
JOB NO.: 35157183	DRILLING CO.: AECI
LOGGED BY: RAH	DRILLER: GARY MOYERS
DATE DRILLED: 03/03/2016	RIG TYPE: CME 75 BUGGY
DRILLING METHOD: HSA / AIR ROTARY	
SAMPLING METHOD: 5' CONTINUOUS SAMPLER, LOGGED BY CUTTINGS	

N:	E:	G.S. ELEV.	Litho. Symbol	% Recovery	RQD	Remarks
DESCRIPTION						
Depth BGS						
0	0'-3.5' SILTY CLAY dark brown to black w/ coal dust					
3.5	3.5'-41' LIMESTONE light gray, micritie, dry					3.5' - 71' logged by cuttings
41	41'-71' SHALE W/ INTERBEDDED L.S. light gray to gray					fractures w/ moist cuttings@ 62' bgs
71	Total Depth of Boring at 71' bgs					BoB @ 71' bgs
80						



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# FIELD BORING LOG

BORING NO.: SP-7

PAGE: 1 of 1

TOTAL DEPTH: 81' FEET BELOW GROUND SURFACE (BGS)

CLIENT: AEP

PROJECT: NE - CCR WELL INSTALL

JOB NO.: 35157183

DRILLING CO.: AECI

LOGGED BY: RAH

DRILLER: GARY MOYERS

DATE DRILLED: 03/07/2016

RIG TYPE: CME 75 BUGGY

DRILLING METHOD: HSA / AIR ROTARY

SAMPLING METHOD: 5' CONTINUOUS SAMPLER, LOGGED BY CUTTINGS

N:	E:	G.S. ELEV.	Litho. Symbol	% Recovery	RQD	Remarks
DESCRIPTION						
Depth BGS						
0	0'-5' SILTY CLAY brown, dry					5' - 81' logged by cuttings
5	5'-33' LIMESTONE light gray, micritie, dry					
33	33'-81' SHALE W/ INTERBEDDED L.S. light gray to gray					
81	Total Depth of Boring at 81' bgs					fractures w/ moist cuttings@ 44',52' bgs  BoB @ 81' 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

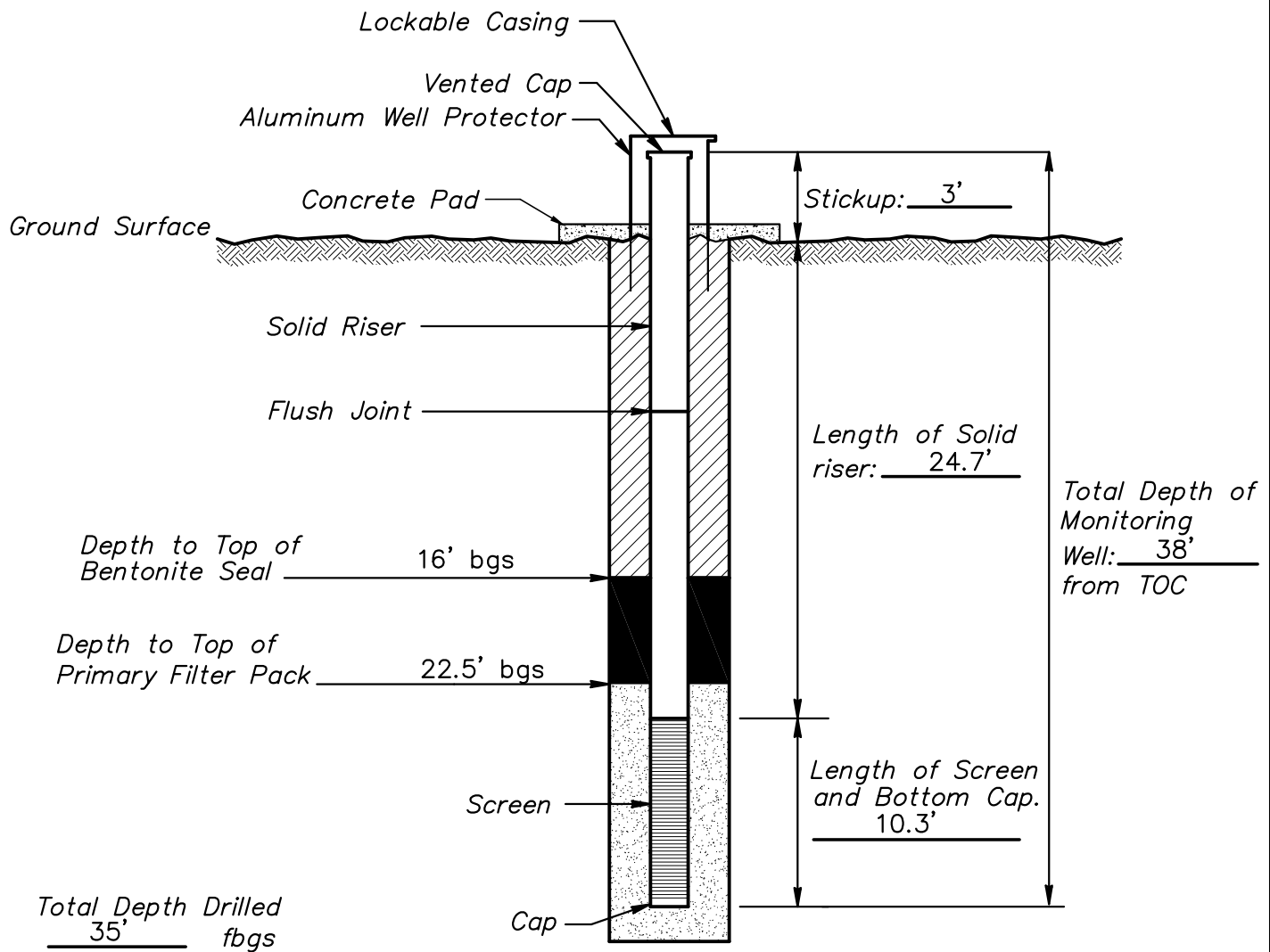
SAMPLING METHOD: LOGGED BY CUTTINGS




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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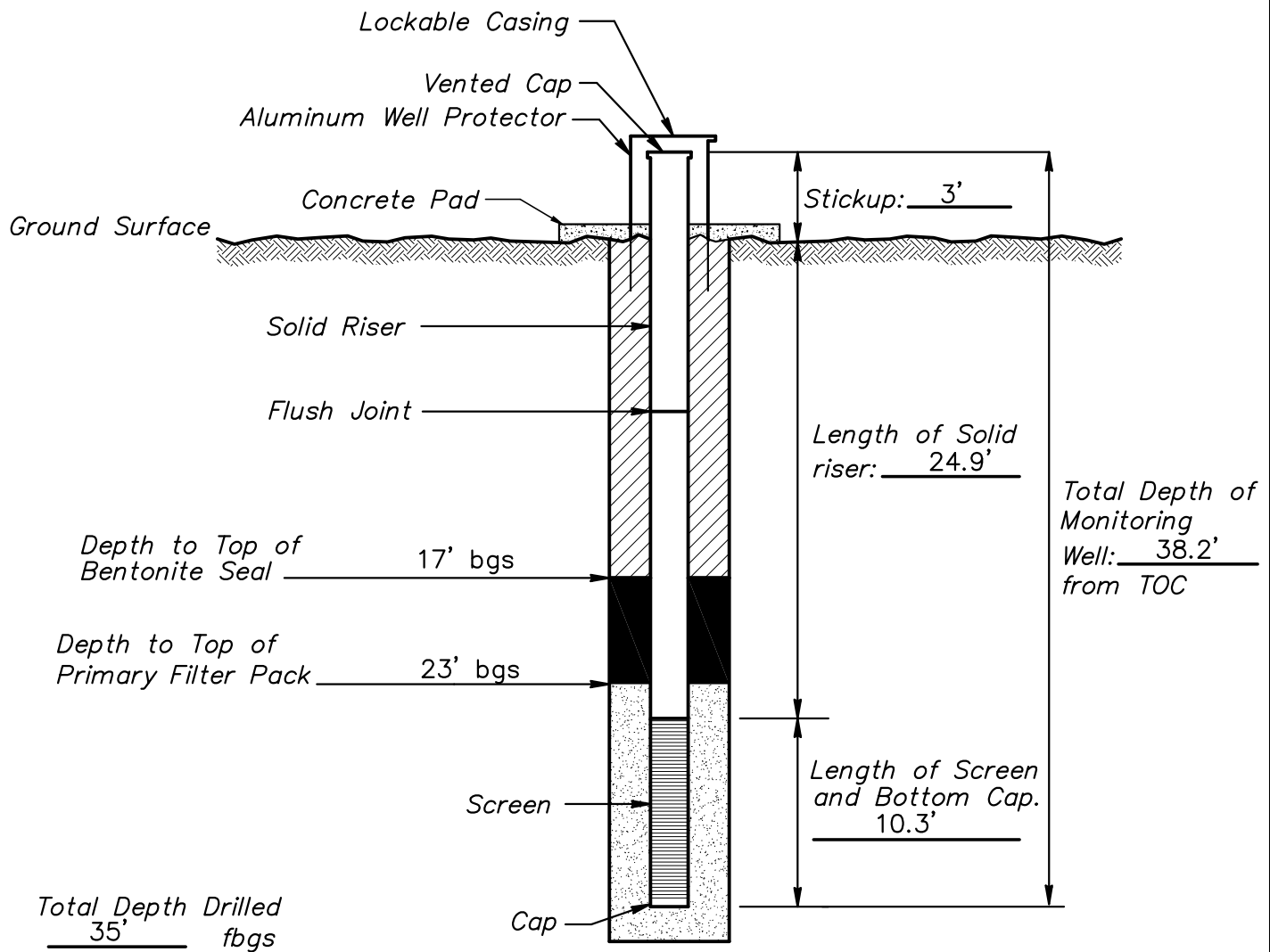
## MONITORING WELL INSTALLATION RECORD

**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

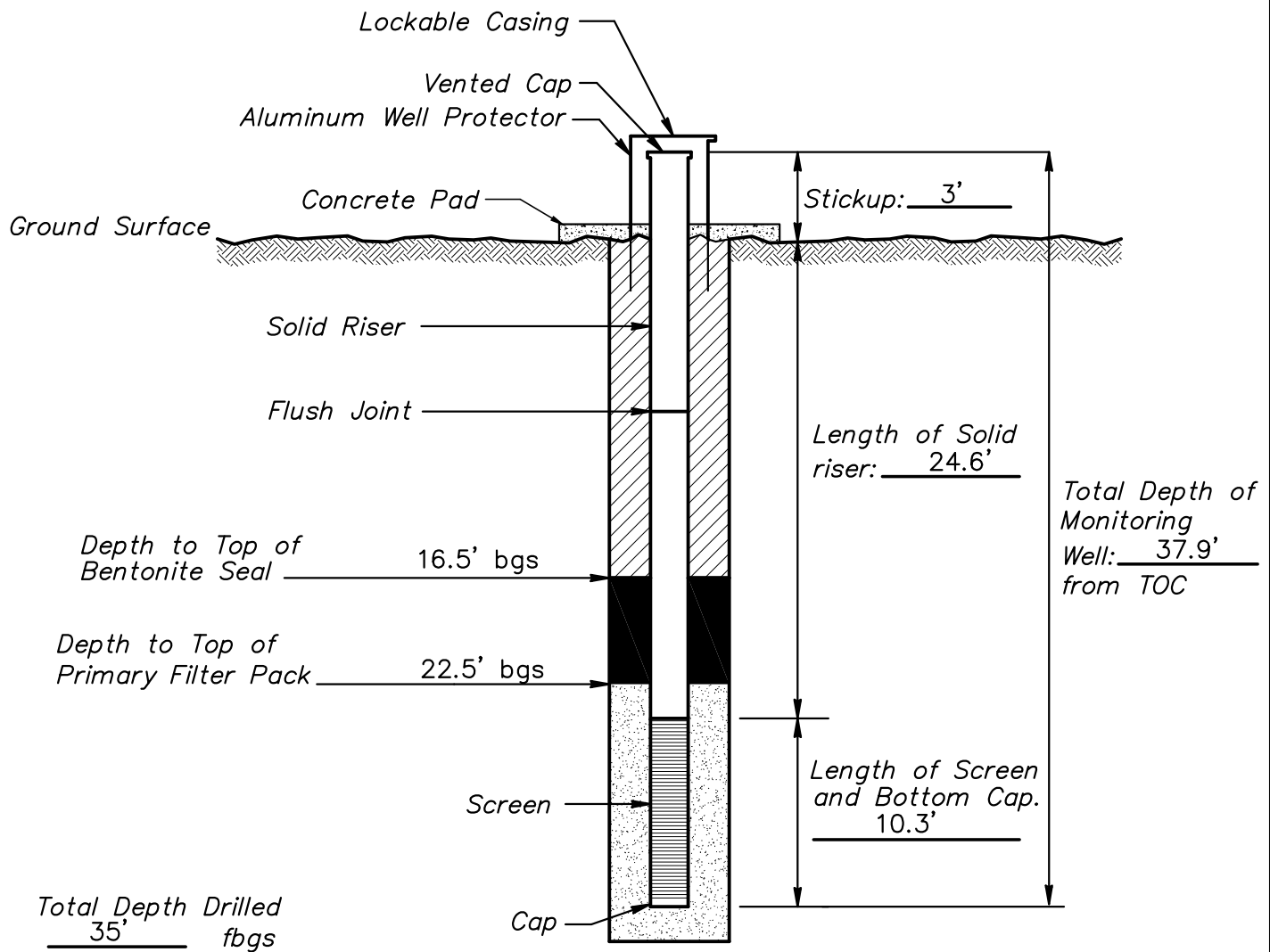
WELL NUMBER: SP-2

DRAWING NUMBER: 008

CHECKED BY: MR

# MONITORING WELL INSTALLATION RECORD

Job Name AEP NE PLANT POND WELLS Well Number SP-3  
 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

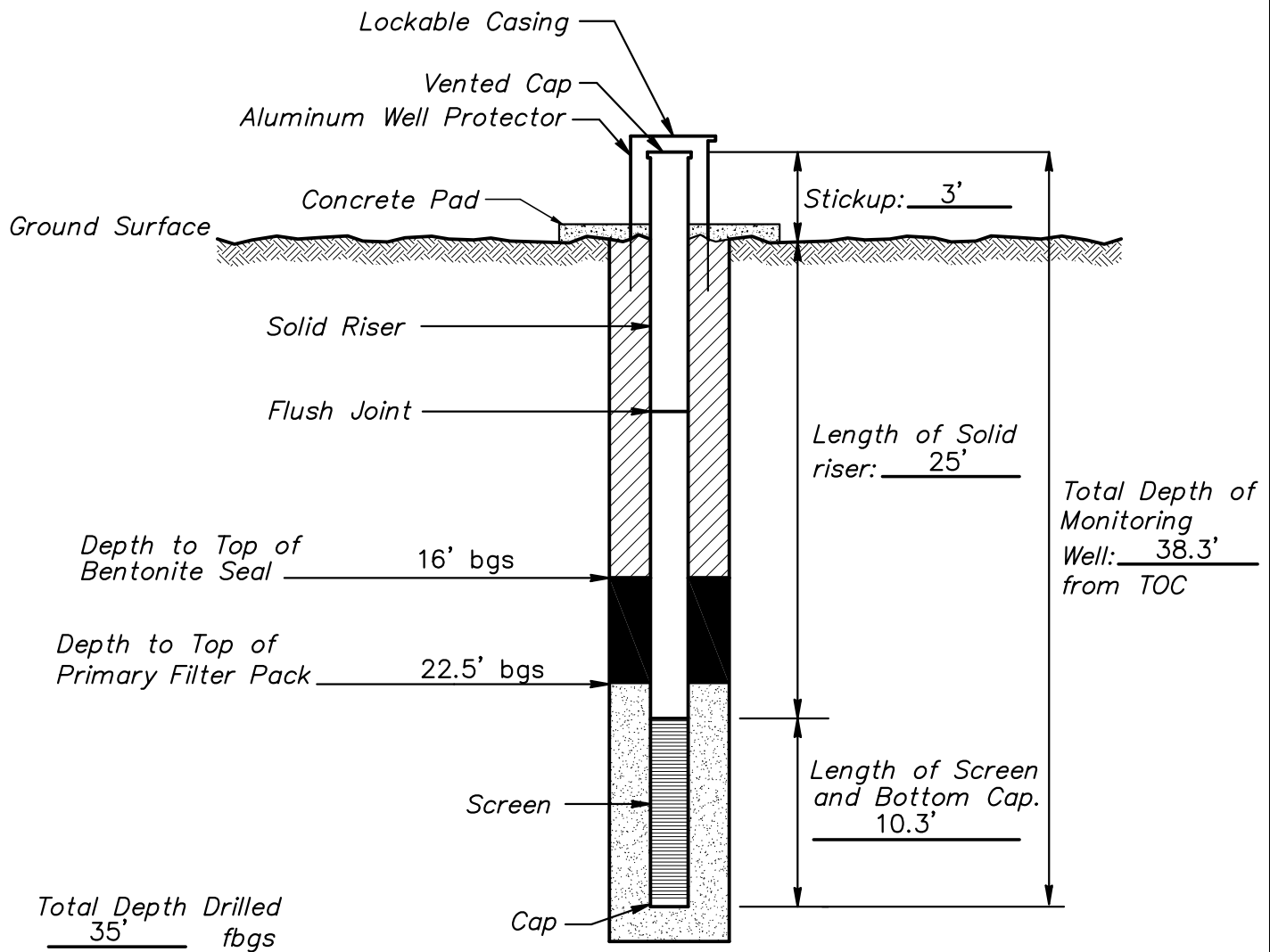
WELL NUMBER: SP-3

DRAWING NUMBER: 009

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

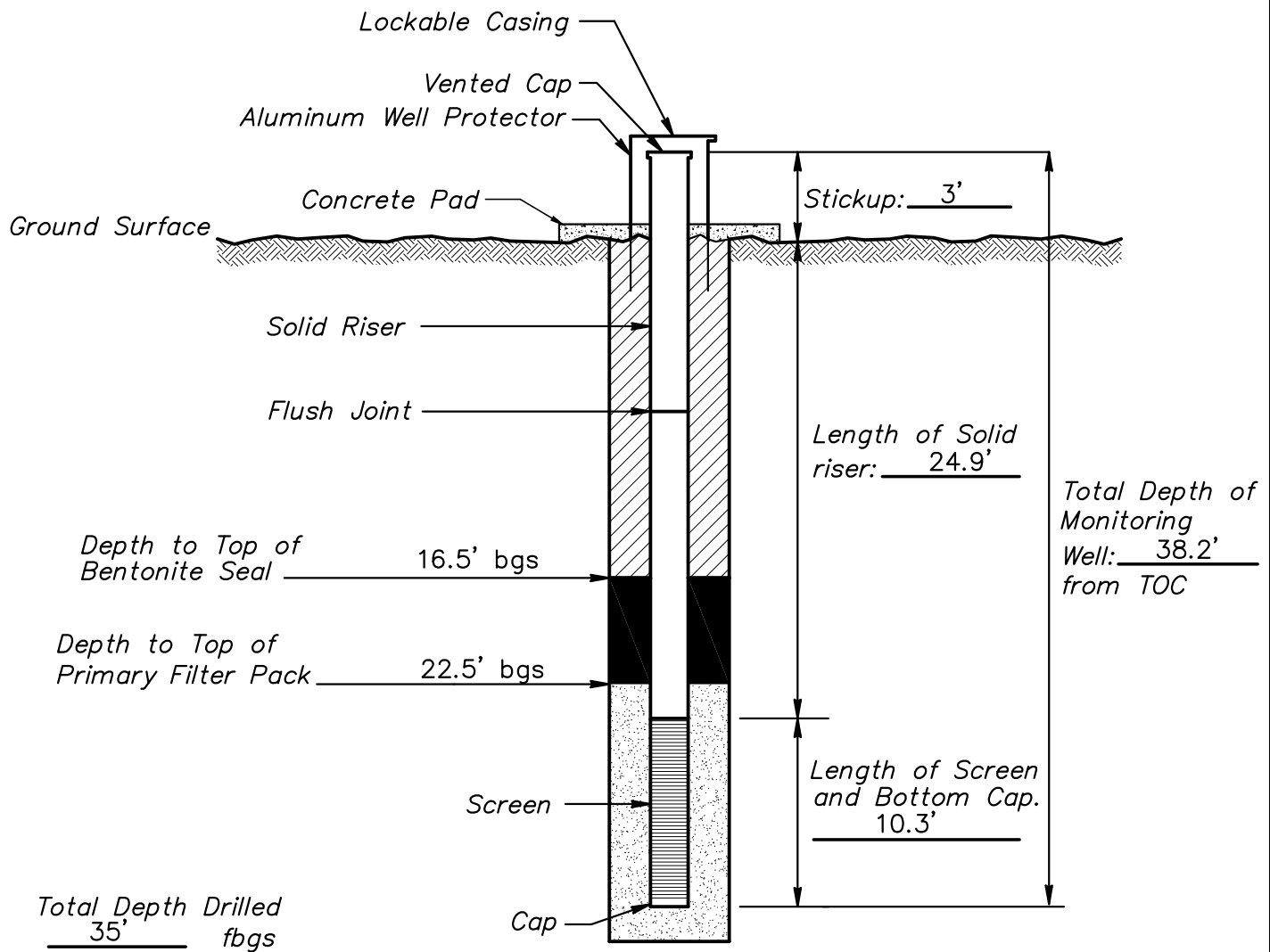
WELL NUMBER: SP-4

DRAWING NUMBER: 010

CHECKED BY: MR

# MONITORING WELL INSTALLATION RECORD

Job Name AEP NE PLANT POND WELLS Well Number SP-5  
 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

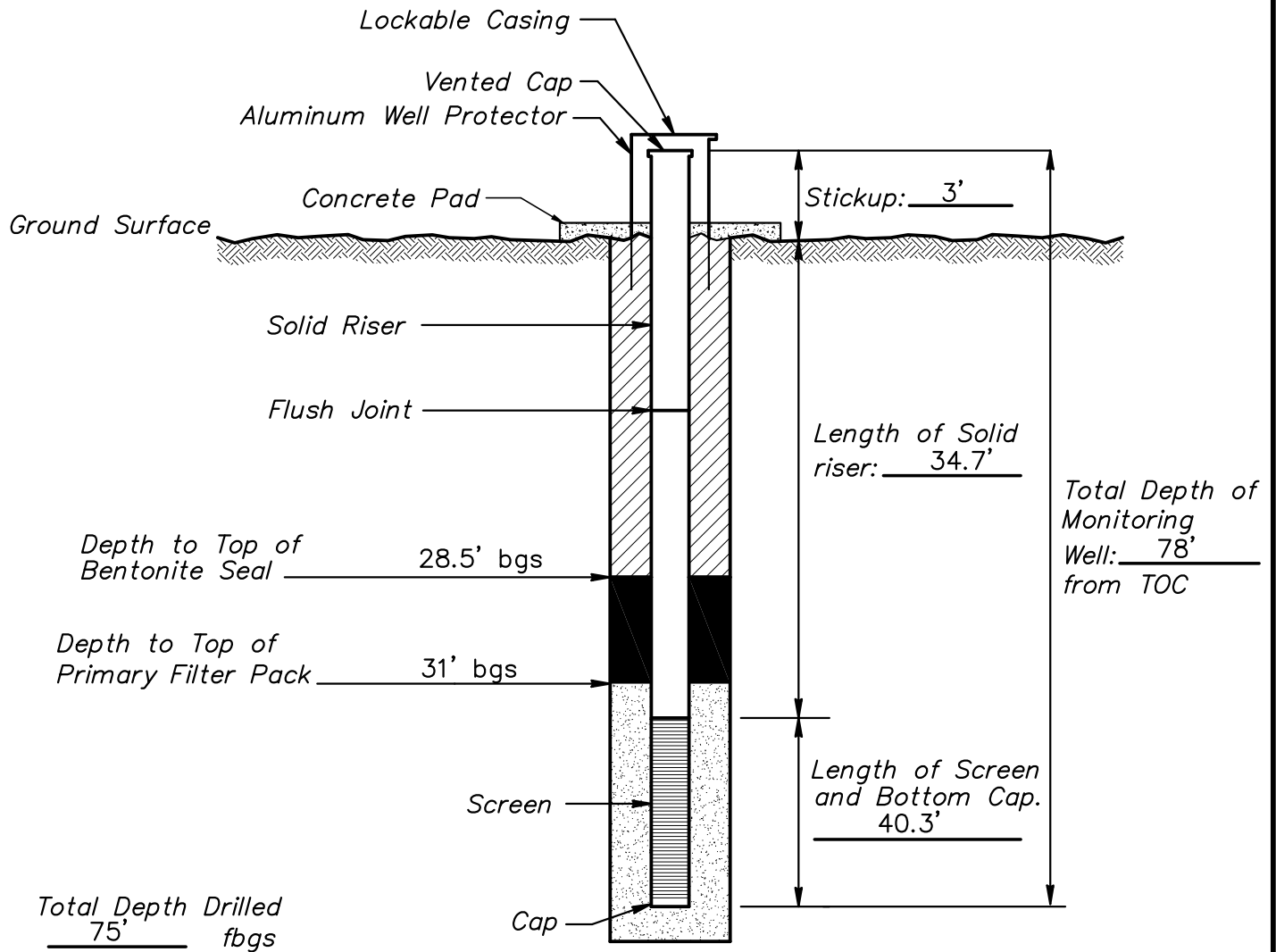
WELL NUMBER: SP-5

DRAWING NUMBER: 011

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)

Terracon

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## MONITORING WELL INSTALLATION RECORD

PROJECT NUMBER: 216-003-35117075

WELL NUMBER: SP-5R

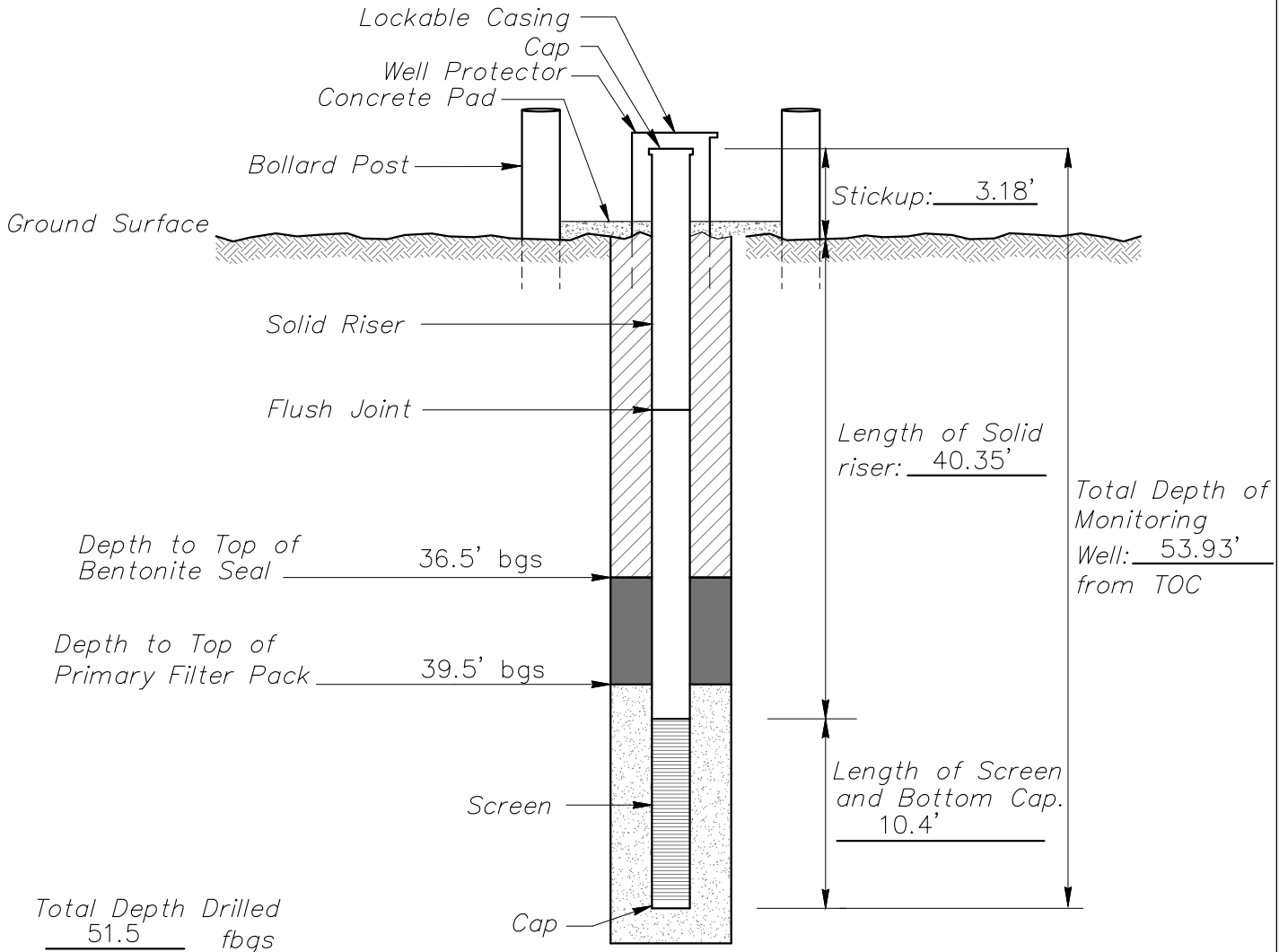
DRAWING NUMBER: 014

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

Consulting Engineers and Scientists

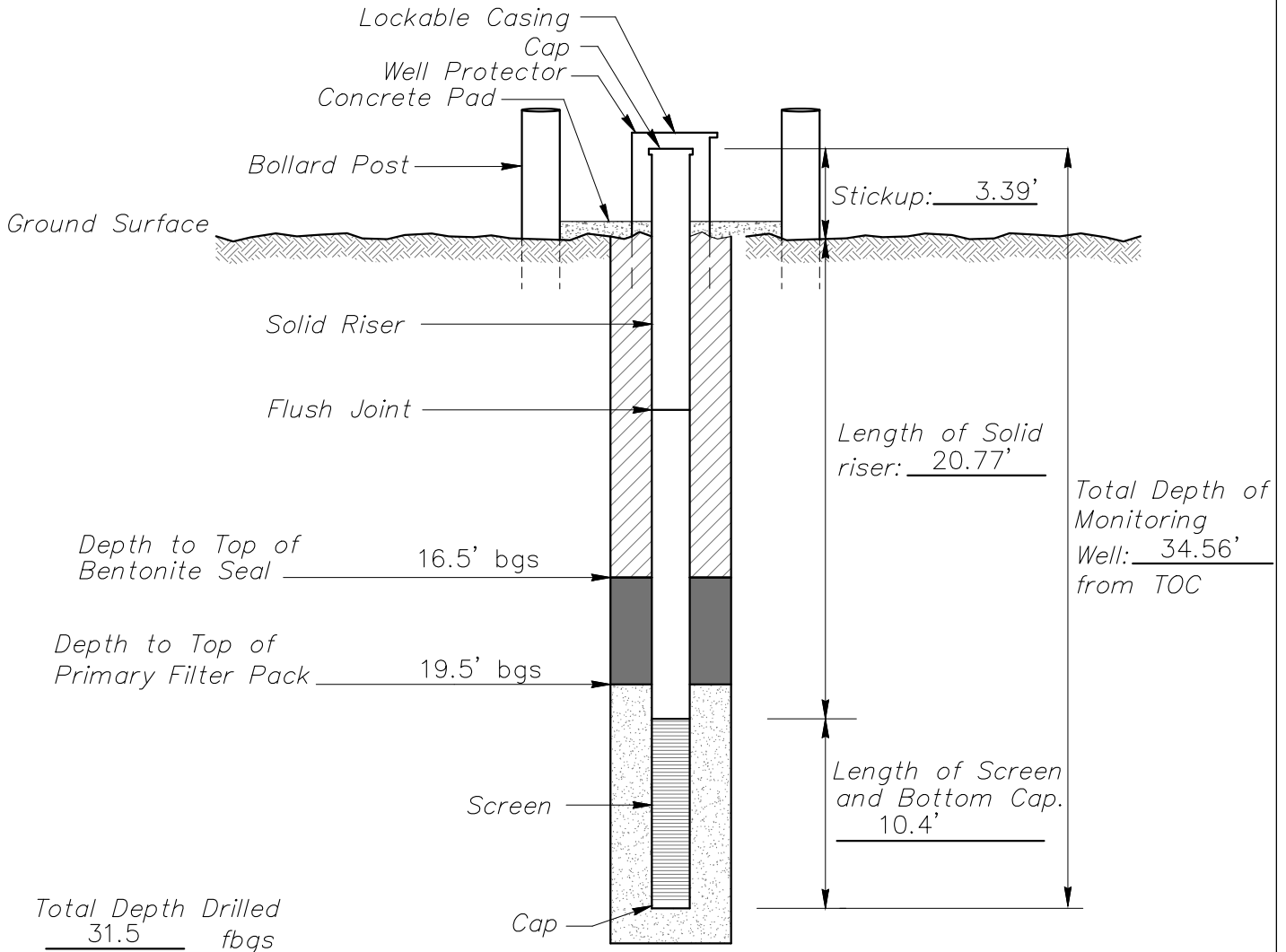
25809 I-30 South BRYANT, AR. 72022  
 PH. (501) 847-9292 FAX. (501) 847-9210

## 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)

Terracon

Consulting Engineers and Scientists

25809 I-30 South BRYANT, AR. 72022  
 PH. (501) 847-9292 FAX. (501) 847-9210

## MONITORING WELL INSTALLATION RECORD

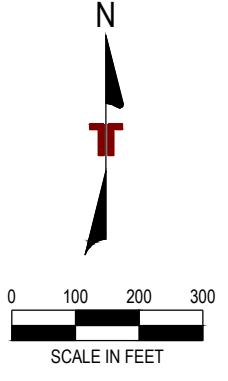
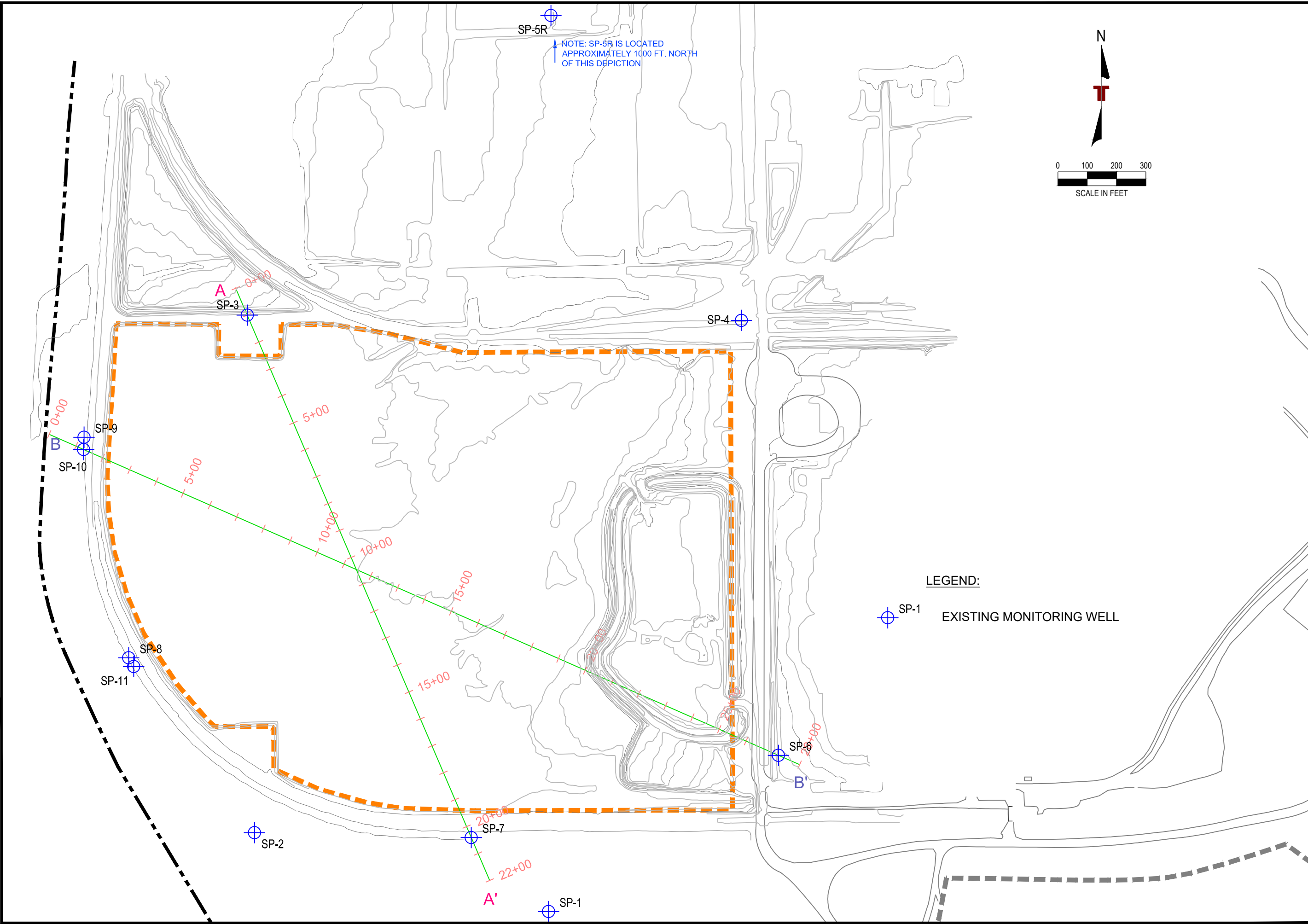
PROJECT NUMBER: 216-003-35177188

WELL NUMBER: SP-11

DRAWING NUMBER: 004

CHECKED BY: RAH

**APPENDIX 2**  
Geologic Cross Sections



SHEET 1					
DESIGNED BY:	TLB	DRAWN BY:	SRE	APP'D BY:	DCM
SCALE:	SEE BARSCALE	DATE:	08/01/2017	JOB NO.	216-003-35157123
ACAD NO.	001	SHEET NO.	1	OF	3

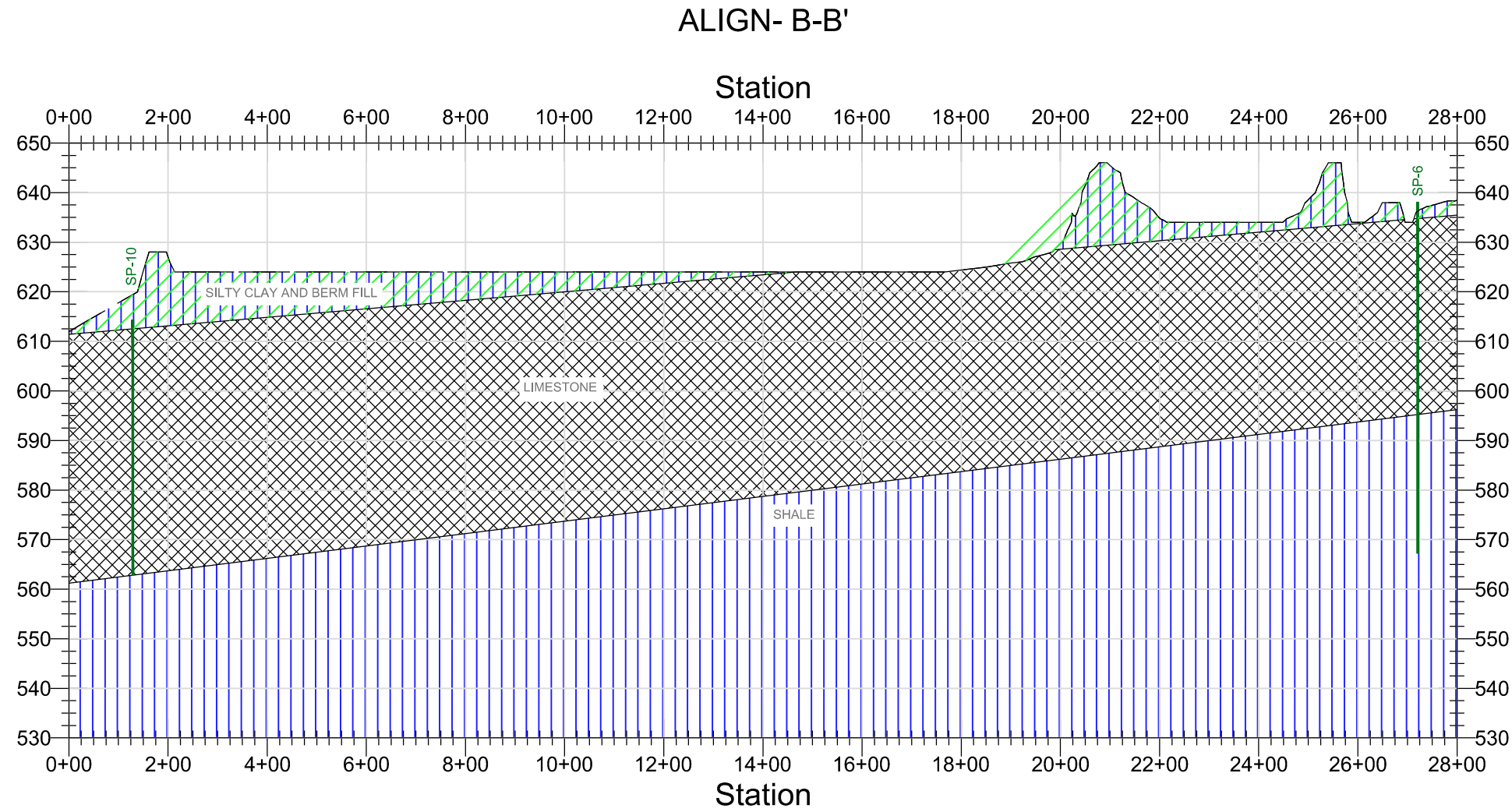
CROSS SECTION LOCATION MAP  
 GROUNDWATER MONITORING NETWORK EVALUATION  
**AMERICAN ELECTRIC POWER**  
 NORTHEASTERN STATIONS 3 & 4  
 OKLAHOMA  
 OOLOGAH

**Terracon**  
 Consulting Engineers and Scientists  
 25809 I-30 SOUTH BRYANT, AR 72022  
 PH. (501) 847-9292 FAX. (501) 847-9210

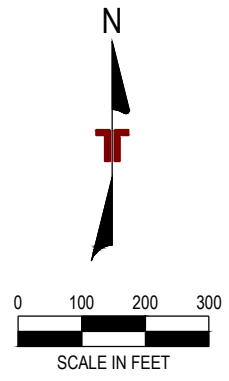
REV.	DATE	BY	DESCRIPTION



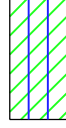


Elevation



Elevation



**LEGEND:**

-  SILTY CLAY AND BERM FILL
-  LIMESTONE
-  SHALE

<b>SHEET 3</b>	
DESIGNED BY: TLB	DRAWN BY: SRE
APPROVED BY: DCM	SCALE: SEE BARS/SCALE
DATE: 08/01/2017	JOB NO. 216-003-35157123
ACAD NO. 001	SHEET NO. 3 OF 3

**CROSS SECTION B-B'**

GROUNDWATER MONITORING NETWORK EVALUATION  
**AMERICAN ELECTRIC POWER**  
 NORTHEASTERN STATIONS 3 & 4  
 OKLAHOMA


**Terracon**  
 Consulting Engineers and Scientists

25809 I-30 SOUTH  
 PH. (501) 847-9292

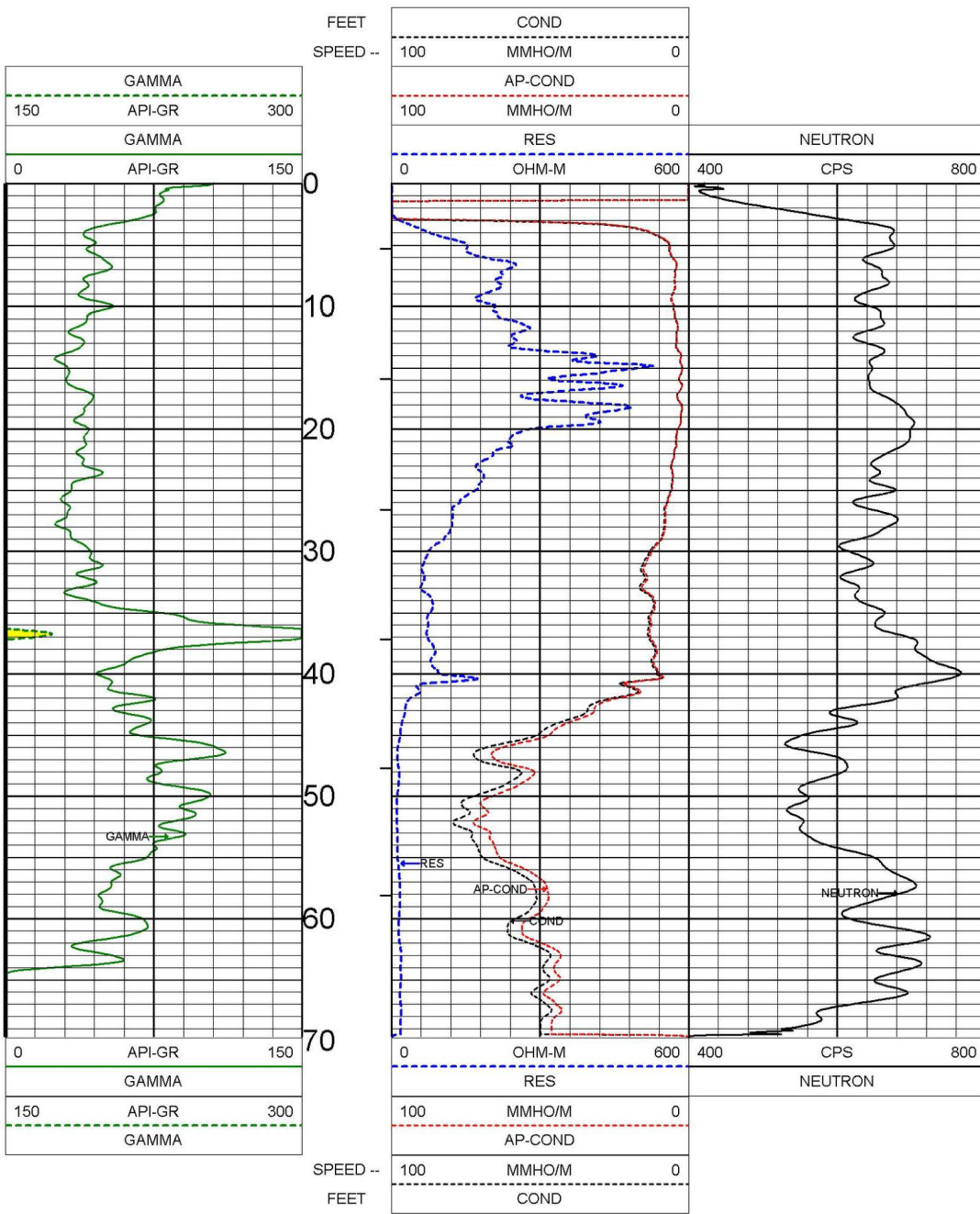
BRYANT, AR 72022  
 FAX. (501) 847-9210

REV.	DATE	BY	DESCRIPTION

**APPENDIX 3**  
Geophysical Log Plots

		<b>AMERICAN ELECTRIC POWER</b> <b>GAMMA-CONDUCTIVITY-NEUTRON</b> <b>SP-8</b>	
COMPANY : AMERICAN ELECTRIC POWER WELL : SP-8 WELL EXT : FIELD : NA COUNTY : ROGERS STATE : OKLAHOMA COUNTRY : USA API NO. : UNIQ ID :		LOCATION : LATITUDE : LONGITUDE : SECTION: N/A TOWNSHIP: N/A RANGE: N/A	
PERMANENT DATUM DRI. MEASURED FROM LOG MEASURED FROM ELEV. PERM. DATUM		DISPLAY7_JL38 .GL FT N/A	
DATE : 05/04/16 12:25 DEPTH DRILLER : DEPTH LOGGER : FIRST READING : LAST READING : BIT SIZE : 4 CASING - DRILLER : 74 CASING - LOGGER : 74 CASING O.D. : 2.0 CASING THICKNESS : N/A CASING TYPE : PVC FLUID TYPE : DRILL M FLUID DENSITY : 8.3 FLUID VISCOSITY : MUD SOURCE : RM @ MEAS TEMP : RMC @ MEAS TEMP : CIRC STOPPED :		Elevations: N/A N/A N/A FT FT N/A N/A Other Services: N/A N/A N/A	
RECORDED BY : R HECK REMARKS 1 : 9088, 9510 REMARKS 2 : LOG MEASURED - 37.75 INCHES - 1.3, 15 FT TOP OF CASING REMARKS 3 : ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS			

<b>1:120, GAMMA-CONDUCTIVITY-NEUTRON SP-8 05/04/16</b>			
<b>LOG PARAMETERS</b>			
MATRIX DENSITY : 2.71	NEUTRON MATRIX : LIMESTONE	MATRIX DELTA T : 49	
MAGNETIC DECL : 40	ELECT. CUTOFF : 99999	BIT SIZE : 4 IN	
PRESENTATION NAME/DATE: 9512 - Slim Hole Induction - Conduction - Neutron - NEUDISPLAY7_JL38/2016			




<b>1:120, GAMMA-CONDUCTIVITY-NEUTRON SP-8 05/04/16</b>			
<b>LOG PARAMETERS</b>			
MATRIX DENSITY : 2.71	NEUTRON MATRIX : LIMESTONE	MATRIX DELTA T : 49	
MAGNETIC DECL : 40	ELECT. CUTOFF : 99999	BIT SIZE : 4 IN	
PRESENTATION NAME/DATE: 9512 - Slim Hole Induction - Conduction - Neutron - NEUDISPLAY7_JL38/2016			

TOOL CALIBRATION SP-8 05/04/16 12:25							
TOOL 9510A TM VERSION 2002							
SERIAL NUMBER 747							
				STANDARD		RESPONSE [CPS]	
DATE	TIME	SENSOR		Point1	Point2	Point1	Point2
1 Nov13,13	15:12:07	GAMMA [API-GR]		1.000	340.000	0.000	335
2 May04,16	17:43:55	AP-COND [MMHO/M]		0.000	690.000	52809	88982
3 Sep25,14	13:19:22	TEMP [DEG-F]		39.500	132.600	26556	31296
4 Sep25,14	13:26:21	A []		0.350		0.000	
5 Mar27,03	10:28:37	B [CPS]		Default		Default	

TOOL CALIBRATION SP-8 Mar27,03 10:28:37							
TOOL 9068A TM VERSION 2002							
SERIAL NUMBER 642							
				STANDARD		RESPONSE [CPS]	
DATE	TIME	SENSOR		Point1	Point2	Point1	Point2
1 Apr28,16	10:26:20	NEUTRON [UNKNOW]		1.000		0.000	

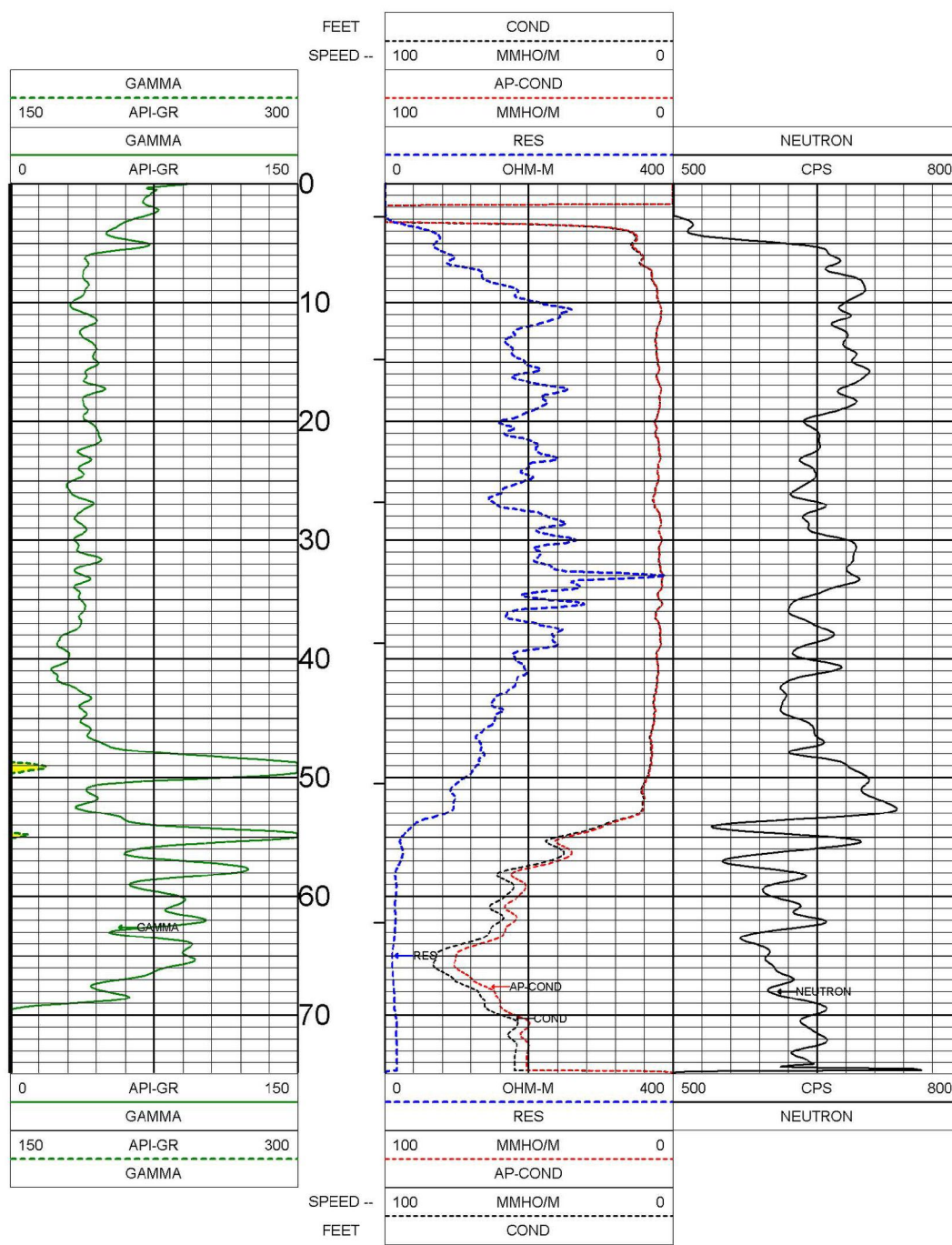


		<b>AMERICAN ELECTRIC POWER</b> <b>GAMMA-CONDUCTIVITY-NEUTRON</b> <b>SP-9</b>	
COMPANY : AMERICAN ELECTRIC POWER WELL : SP-9 WELL EXT : FIELD : NA COUNTY : ROGERS STATE : OKLAHOMA COUNTRY : USA API NO. : N/A UNIQ ID : N/A			
LOCATION : N/A LATITUDE : N/A LONGITUDE : N/A SECTION: N/A TOWNSHIP: N/A RANGE: N/A			
PERMANENT DATUM : N/A LOG MEASURED FROM : GL ELEV. FROM DATUM : N/A DATE : 05/04/16 11:26 DEPTH DRILLER : 78 DEPTH LOGGER : FIRST READING : LAST READING : BIT SIZE : 4 CASING - DRILLER : 78 CASING - LOGGER : CASING O.D. : 2.0 CASING THICKNESS : CASING TYPE : N/A CEMENT TYPE : DRILLM FLUID TEMPERATURE : 83 FLUID VISCOSITY : FLUID DENSITY : FLUID PH : MUD SOURCE : N/A RIN @ MEAS TEMP : N/A @ N/A F RIN @ MEAS TEMP : N/A @ F RIN @ MEAS TEMP : N/A @ F CIRC STOPPED : N/A			
RECORDING BY : R HECK REMARKS 1 : 9512_9068 REMARKS 2 : LOG MEASURED - 34.75 INCHES / 2.90 FT TOP OF CASING REMARKS 3 : ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS			

**1:120, GAMMA-CONDUCTIVITY-NEUTRON SP-9 05/04/16**

**LOG PARAMETERS**

MATRIX DENSITY : 2.71	NEUTRON MATRIX : LIMESTONE	MATRIX DELTA T : 49
MAGNETIC DECL : 40	ELECT. CUTOFF : 99999	BIT SIZE : 4 IN
PRESENTATION NAME/DATE: 9512 - Slim Hole Induction - Conduction - Neutron - NEUDISPLAY7_JL38/2016		



**1:120, GAMMA-CONDUCTIVITY-NEUTRON SP-9 05/04/16**

**LOG PARAMETERS**

MATRIX DENSITY : 2.71	NEUTRON MATRIX : LIMESTONE	MATRIX DELTA T : 49
MAGNETIC DECL : 40	ELECT. CUTOFF : 99999	BIT SIZE : 4 IN
PRESENTATION NAME/DATE: 9512 - Slim Hole Induction - Conduction - Neutron - NEUDISPLAY7_JL38/2016		

TOOL CALIBRATION SP-9 05/04/16 11:26  
 TOOL 9510A TM VERSION 2002  
 SERIAL NUMBER 747

DATE	TIME	SENSOR	STANDARD		RESPONSE [CPS]		
			Point1	Point2	Point1	Point2	
1	Nov13,13	15:12:07	GAMMA [API-GR]	1.000	340.000	0.000	335
2	May04,16	17:41:32	AP-COND [MMHO/M]	0.000	690.000	52809	88982
3	Sep25,14	13:19:22	TEMP [DEG-F]	39.500	132.600	26556	31296
4	Sep25,14	13:26:21	A []	0.350		0.000	
5	Mar27,03	10:28:37	B [CPS]	Default		Default	

TOOL CALIBRATION SP-9 Mar27,03 10:28:37  
 TOOL 9068A TM VERSION 2002  
 SERIAL NUMBER 642

DATE	TIME	SENSOR	STANDARD		RESPONSE [CPS]		
			Point1	Point2	Point1	Point2	
1	Apr28,16	10:26:20	NEUTRON [UNKNOW]	1.000		0.000	