Hydrogeological Investigation Report for More's Lake

Columbia Water & Light Department

Columbia Municipal Power Plant
Project No. 93647

April 2018
Revision: 1

Hydrogeological Investigation Report for More's Lake

prepared for

Columbia Water & Light Department
Columbia Municipal Power Plant
Columbia, Missouri

Project No. 93647

April 2018

Revision: 1

prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

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INDEX AND CERTIFICATION

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Certification

I hereby certify, as a Professional Engineer, and Registered Geologist in the state of Missouri, that the information in this document was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by the Columbia Water & Light Department or others without specific verification or adaptation by the Engineer/Geologist.

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LIST OF ABBREVIATIONS

Abbreviation	Term/Phrase/Name
amsl	above mean sea level
AST	above ground storage tank
ASTM	American Society for Testing and Materials
bgs	below ground surface
CCR	Coal Combustion Residuals
CCR Unit	Inactive Surface Impoundment (More's Lake)
CFR	Code of Federal Regulations
City	City of Columbia Water & Light Department
CMPP	Columbia Municipal Power Plant
COPC	constituents of potential concern
CSM	Conceptual Site Model
CSR	Code of State Regulations
CWLD	Columbia Water & Light Department
FGD	Flue Gas Desulfurization
ft	Feet
GeoSTRAT	Geosciences Technical Resource Assessment Tool
GMP	Groundwater Monitoring Plan
HSA	hollow-stem auger
IDW	Investigation Derived Waste
K	Hydraulic Conductivity
MDNR	Missouri Department of Natural Resources

Abbreviation	Term/Phrase/Name
MGS	Missouri Geological Survey
MSL	Mean Sea Level
NAICS	North American Industry Classification System
NAVD 88	North American Vertical Datum 1988
NRCS	Natural Resource Conservation Service
NTU	Nephelometric Turbidity Unit
OSHA	Occupational Safety and Health Administration
PDWSS	Public Drinking Water Supply System
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
RCRA	Resource Conservation and Recovery Act
SAP	Sampling and Analysis Plan
Site	Columbia Municipal Power Plant located in Columbia, Missouri
TCEQ	Texas Commission of Environmental Quality
UST	underground storage tank
USDA	United States Department of Agriculture
USGS	United States Geological Survey
USEPA	United Stated Environmental Protection Agency
V_s	Seepage Velocity
VOC	volatile organic compound
WIMS	Well Information Management System
Work Plan	Hydrogeological Investigation Work Plan for More's Lake

1.0 INTRODUCTION

This Hydrogeological Investigation Report (Report) has been prepared by Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) to summarize field activities associated with the installation of groundwater monitoring wells, bedrock borings, and subsurface hydraulic testing at the Coal Combustion Residuals (CCR) Inactive Surface Impoundment (referred to as "inactive CCR Unit") for the City of Columbia Municipal Power Plant (CMPP) located in Columbia, Missouri (Site). The inactive CCR Unit is located directly north of the facility within the property boundaries of CMPP. Both topographic and aerial photographic site vicinity maps illustrating the location of the inactive CCR Unit are provided in Figures 1 and 2, respectively. The City of Columbia is planning a clean closure of the inactive CCR Unit, discussed further herein.

1.1 Purpose

This Report has been prepared to support compliance with the groundwater monitoring requirements published by the United States Environmental Protection Agency (USEPA) in the *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule*, dated April 17, 2015 (USEPA, 2015), and the *Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; Extension of Compliance Deadlines for Certain Inactive Surface Impoundments; Response to Partial Vacatur*, dated August 5, 2016 (USEPA, 2016), collectively referred to herein as the "CCR Final Rule."

1.1.1 CCR Final Rule Program

The CCR Final Rule is found in 40 Code of Federal Regulations (CFR) Part 257 and was published by the USEPA to regulate the disposal CCR as solid waste under subtitle D of the Resource Conservation and Recovery Act (RCRA). This CCR Final Rule applies to all CCR generated electric utility facilities and independent power producers that fall within the North American Industry Classification System (NAICS) code 221112.

This CCR Final Rule established nationally applicable minimum criteria for the safe disposal of CCR in landfills and surface impoundments. CCR includes fly ash, bottom ash, boiler slag, and flue gas desulfurization (FGD) materials. The CCR Final Rule applies to owners and operators of new, existing, and/or laterally expanded landfills and surface impoundments that dispose or otherwise engage in solid waste management of CCR. In June 2016, a United States Court of Appeals granted a settlement between utility industry and environmental groups that removed the effects of the "early closure" provisions for inactive surface impoundments under the USEPA CCR rule (40 CFR §257). With this rule change, all

inactive CCR surface impoundments must now comply with all of the rule requirements applicable to existing/active CCR surface impoundments (location criteria; design and operating requirements; air criteria; inspection requirements; groundwater monitoring and corrective action; closure and post-closure care; and recordkeeping, notification and publicly accessible internet site requirements). The requirements of the CCR Final Rule also apply to CCR units located off-site of the electric utilities' or independent power producers' facilities that receive CCR for disposal (i.e., public or private landfills).

The CCR Final Rule requires CCR units implement groundwater monitoring system (40 CFR §257.91) and program (40 CFR §257.93-§257.95) that are capable of detecting CCR impacts on the groundwater quality, if any, underlying each utility waste landfill and/or surface impoundment. The groundwater monitoring system must consist of a sufficient number of appropriately located wells (at minimum, one upgradient and three downgradient wells) capable of monitoring the quality of background groundwater and the quality of groundwater passing the CCR waste boundary. Monitoring wells must be installed in order to yield representative groundwater samples from the uppermost aquifer. The CCR Final Rule requires groundwater sampling at utility CCR-waste landfills/impoundments for specific CCR chemical constituents of potential concern (COPCs). The CCR rule requires operators of inactive surface impoundments (i.e., More's Lake) to implement groundwater monitoring programs prior to April 17, 2019 that are capable of detecting releases to shallow groundwater. To meet this requirement, owners must install well networks and conduct eight rounds of background monitoring prior to April 17, 2019. If the groundwater monitoring system demonstrates a verified exceedance of a groundwater protection standard for any of the identified CCR COPCs, the owner or operator must initiate corrective action, or demonstrate that a source other than the CCR unit caused the contamination, or the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality.

1.2 Rationale

The focus of this hydrogeologic investigation was for the inactive CCR Unit to support compliance with the groundwater monitoring requirements of the CCR Final Rule. The groundwater monitoring system for CCR units must consist of a sufficient number of appropriately located wells (at minimum, one upgradient and three downgradient wells) capable of monitoring the quality of background groundwater and the quality of groundwater passing the CCR waste boundary. Monitoring wells should be installed in order to yield representative groundwater samples from the uppermost water-bearing zone. These wells should all be screened so that groundwater samples are representative of the same portions of the uppermost groundwater zone present beneath the inactive CCR Unit. Based on an assessment of the

existing groundwater monitoring network in the vicinity of the inactive Surface Impoundment, additional groundwater monitoring coverage was recommended surrounding the inactive CCR Unit.

Clean closure activities are currently being planned and implemented at the inactive CCR Unit. Clean closure activities are estimated to be complete by April 2019.

1.3 Scope of Work

Eight (8) new groundwater monitoring wells were installed. The eight new groundwater monitoring well plus one existing piezometer (PZ-2) are proposed to compose the detection monitoring network. Field activities associated with this groundwater well installation project included the following:

- Utility clearance;
- Advance three (3) deep soil borings (SB-1 through SB-3) into bedrock for logging purposes adjacent to Monitoring Wells MW-1 (SB-1), MW-5 (SB-2), and MW-7 (SB-3);
- Perform packer testing in bedrock at one (1) deep soil boring (SB-2);
- Advance eight (8) soil borings for new monitoring well installations (MW-1 through MW-8);
- Collect continuous soil samples for logging with limited laboratory testing/analysis;
- Construct eight (8) new monitoring wells with flush-mount surface completions;
- Perform well development and conduct in-situ hydraulic conductivity testing (slug tests) at the eight (8) new monitoring wells and three (3) existing piezometers (PZ-2, PZ-4, and PZ-6);
- Management of investigation derived waste (IDW);
- Deploy dedicated bladder sampling pumps;
- Well Surveying; and
- Water level and total depth measurements.

Future groundwater sampling and reporting is outside the scope of this Report. Background groundwater sampling and analysis of the newly established monitoring system will be conducted in accordance with the Groundwater Monitoring Program (GMP) and results will be provided in the first annual groundwater monitoring and corrective action report. The GMP was prepared by Burns & McDonnell (2018) for separate submittal to support compliance with the CCR final rule (§257.93-§257.95). The GMP includes the Sampling and Analysis Plan (SAP) which will define the methods/procedures and techniques for groundwater sampling and analysis.

1.4 Overview

The Report is organized in sections as summarized below:

Section 2.0 Site Setting and History - Section 2.0 summarizes the location and setting of the inactive CCR Unit at CMPP.

Section 3.0 Hydrogeologic Setting - Section 3.0 summarizes the regional and local hydrogeology.

Section 4.0 Hydrogeological Investigation Activities and Results - Section 4.0 describes the methods and procedures that will be followed for both field investigation and installation of groundwater monitoring wells in order for the groundwater monitoring system to support compliance with USEPA's CCR final rule.

Section 5.0 Conceptual Site Model - Section 5.0 describes the existing environmental site conditions by identifying potential sources of impacts, and effected media associated with the inactive CCR Unit.

Section 6.0 Future Activities - Section 6.0 describes additional activities to be performed that are not included in the scope of this hydrogeologic investigation, but are required to support compliance with the CCR Rule.

Section 7.0 References - Section 7.0 includes a bibliography for references made within this Report.

1.5 Work Plan Modifications

Monitoring Well MW-3's location was moved to the south due to overhead utilities.

Drilling of the Bedrock Borings SB-1, SB-2, and SB-3 were completed with mud-rotary drilling methods. Hollow-stem augers were initially used to drill down to approximately 15-20 feet below ground surface to serve as a temporary surface casing for the bedrock borings.

2.0 SITE SETTING AND HISTORY

This section of the Report summarizes the location and setting of the inactive CCR Unit (More's Lake) at CMPP and the history of utility CCR disposal within the inactive CCR Unit. Information presented in this section was cited from previous CMPP hydrogeologic investigations and groundwater monitoring reports.

2.1 Facility Description

The CMPP facility is owned and operated by the City of Columbia Water & Light Department (City). The CMPP is located at 1501 Business Loop 7 East, Columbia, Missouri in Boone County, Missouri, illustrated in Figures 1 and 2. The CMPP facility occupies approximately 25.4 acres and is situated in the Southeast ¼, of the Southwest ¼, of Section 6, in Township 48 North, Range 12 West, at a latitude of 38.964917° N and longitude of 92.317027° W.

The facility is bound on the east by residential while the north, west, and south are bound by mixed industrial, commercial, and residential (Figure 2). The CMPP is located approximately 950 feet (0.18 miles) east of an unnamed intermittent tributary of Bear Creek, about 2,150 feet (0.41 miles) northwest of an unnamed intermittent tributary of Hinkson Creek, and approximately 5,750 feet (1.09 miles) northeast of Flat Branch Creek. Bear Creek and Hinkson Creek are approximately 4,100 feet (0.78 miles) northwest and 4,500 feet (0.85 miles) southeast of the CMPP, respectively. Surface water features in the vicinity of CMPP are shown on Figures 1 and 2.

The CMPP has one CCR unit is comprised of an inactive surface impoundment that formerly received CCR from facility operations. The original surface impoundment, known locally as More's Lake, was constructed as a farm pond no later than 1896, prior to being used for CCR disposal. Further description of the inactive surface impoundment is provided in Section 4.1 of this Report.

2.2 Physiographic Region

Boone County, Missouri is in the Glaciated Region of the Central Lowland Interior Plains physiographic province region. This area is part of the Dissected Till Plains physiographic unit that was glaciated, uplifted, and subsequently eroded into a flat-to-rolling terrain that slopes gently toward the Missouri and Mississippi River Valleys. The main topographic features of the county are the deeply incised valleys of the Missouri River and its tributaries. The Missouri River Valley is 0.2 to 0.7 miles wide in some areas and defines the southern boundary of Boone County and marks the southern extent of continental glacial deposits. The CMPP facility is situated near the middle of Columbia, Missouri and is approximately 40 miles upstream of the confluence of the Missouri and Osage Rivers.

In the City of Columbia, the prominent tributaries of the Missouri River are Perche Creek, Hinkson Creek, and Flat Branch Creek. Along these and other creeks in the area can be found large valleys, cliffs, and cave systems such as that in Rock Bridge State Park located south of the city (approximately 6 miles south of the inactive CCR Unit). These creeks are largely responsible for numerous stream valleys giving Columbia hilly terrain similar to the Ozarks while also having prairie flatland typical of northern Missouri. Columbia also operates several greenbelts with trails and parks throughout town.

2.3 Climate

Columbia, Missouri lies within the humid continental zone and generally has hot summers, cold winters, and wet springs. Average annual precipitation is approximately 45 inches. May and June are generally the wettest months while December and January are the driest. Average high monthly temperatures range from 40.1 degrees Fahrenheit (ºF) in January to 88.9 ºF in July. Average low monthly temperatures range from 22.6 ºF in January to 69.3 ºF in July (High Plains Regional Climate Center, 2017).

3.0 HYDROGEOLOGIC SETTING

Hydrogeology is defined as the geology of groundwater, with particular emphasis on the chemistry and movement of the groundwater. Information presented in this section was obtained from review of the United States Geological Survey (USGS) *Groundwater Atlas of the United States: Kansas, Missouri, Nebraska* (Miller and Appel, 1997), *Geology of Boone County, Missouri* (Unkleskbay, 1952), Missouri Department of Natural Resources (MDNR) Well Information Management System (WIMS), Missouri Geological Survey (MGS) Geosciences Technical Resource Assessment Tool (GeoSTRAT), MGS Geologic Well Logs of Missouri database, and a Geotechnical Engineering Report for City of Columbia for Mores Lake Dam Global Stability Analysis (Crockett Geotechnical Testing Lab, 2014)

3.1 Regional Geology

Missouri is located on the North American craton (or Laurentia) and is an area that has been tectonically stable throughout most of geologic time. The regional geology consists of a thick cover of sediments and sedimentary rocks (Quaternary-age to Cambrian-age) deposited on top of older metamorphic and igneous rocks (Precambrian-age) that form the "crystalline basement complex" (basement rocks) or foundation of the continental crust. The region has undergone some deformation with faults and up-warps and down-warps on the surface of the crystalline basement rocks. In Missouri, most notable structural deformation features are the St. Francois Mountains in southeastern Missouri and the Ozark Uplift (dome) in central Missouri that are related to up-warping of the basement rocks. Basement rocks are exposed only in the St. Francois Mountains of southeastern Missouri at more than 1,000 feet above sea level and buried to depths of as much as 6,000 feet below sea level in southwestern Kansas. Sediments were deposited on the surface of the basement rocks and lithified into sedimentary rocks during diagenesis. The thick deposits of sedimentary rocks in the region predominately consist of limestone and dolomite and interbedded sequences of shale, sandstone, and coal. In most of the region north of the Missouri River, the sedimentary rocks are overlain by unconsolidated to semi-consolidated sediments consisting of glacial drift, loess, colluvium, and alluvium. A summary of the regional geology in Missouri is provided in Table 1.

3.1.1 Faults and Seismic Activity

The Federal CCR Rule requires new CCR landfills, new and existing CCR surface impoundments, and any lateral expansion of these facilities that engage in the disposal of CCR generated by electric utilities and independent power producers not to be located within 200 feet of the outermost damage zone of a Holocene era fault, which includes all faults active within the last 11,700 years and up to the present. According to data extracted from the USGS Interactive Fault Map displaying locations of Quaternary-age

faults in the United States (http://earthquake.usgs.gov/hazards/qfaults/), the nearest Holocene era fault is the Thebes Gap Faults and the Reelfoot scarp and New Madrid Seismic Zone which is located approximately 190 and 220 miles away, respectively. The Thebes Gap Faults generally run northeast-southwest and is south of Cape Girardeau, Missouri. The New Madrid Seismic Zone generally run northeast-southwest and is west of New Madrid, Missouri. According to the Interactive Fault Map, the fault is approximately 70 miles and has been active in the last 15,000 years.

Additional data review using the MGS GeoSTRAT database, identified the following structural features and pre-Holocene faults in the vicinity of the inactive CCR Unit:

- Browns Station Anticline – approximately 7 miles north of the inactive CCR Unit;
- Fox Hollow Fault and Monocline, Bonne Femme Creek graben, Sapp monocline – approximately 9 miles south of the inactive CCR Unit;
- Fish Creek Anticline – approximately 11.5 miles west of the inactive CCR Unit; and
- Woodlandville Fault – approximately 12 miles northwest of the inactive CCR Unit.

As outlined in the preamble to the Federal CCR Rule, a seismic impact zone is defined 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." Burns & McDonnell reviewed available data from United States Geological Survey (USGS) Earthquake Hazards Program (http://earthquake.usgs.gov/hazards/apps/) in order to determine the maximum expected horizontal acceleration for the CMMP inactive CCR surface impoundment. The USGS national seismic hazard map is included in Appendix A. Using data from the USGS website, a map was generated for the state of Missouri and is included in Appendix A. According to data extracted from the USGS website, the maximum expected horizontal acceleration in the vicinity of the CMPP site is 0.06-0.10 g, which is at and below the 0.10 g requirement of the CCR rule. Therefore, the inactive CCR impoundment at the CMPP is not located within a seismic impact zone and consequently is not violating the location restriction standards with respect to seismic impact zones as described in §257.63 of the CCR Rule. The USGS hazard map included in Appendix AB supports that there is a low likelihood of intense seismic activity within the nearby vicinity of the CMPP, being that the area is outside of a seismic impact zone

3.2 Regional Hydrogeology

The principal aquifers in the region include the Ozark Plateau Aquifer system and the Mississippian and Cambrian-Ordovician aquifers. In Missouri, north of the Missouri River, the rocks of the Mississippian and Cambrian-Ordovician aquifers and confining units are stratigraphically equivalent with rocks of the Ozark Plateaus Aquifer system south of the Missouri River. Although these different aquifers are stratigraphically equivalent, generally there is little or no hydraulic connection between them since the Missouri River is a discharge area for both aquifers. In some areas, these aquifers underlie parts of surficial aquifer systems (i.e. glacial-drift or stream-valley aquifers). Areas with overlying glacial till provide a confining layer/cap to the aquifer system where only small to moderate amounts of water can be obtained from wells completed in areas of confining units or having no principal aquifer. A stratigraphic summary of the Missouri Aquifer systems is provided in Table 1. Groundwater flow throughout the region is largely driven by topography and is highly variable in response to regional points of groundwater discharge (e.g., springs, streams, rivers, and shallow stream/river valley alluvial aquifers). Groundwater in aquifers locally move from topographically high recharge areas to regional points of groundwater discharge or localized discharges at surface (e.g., seeps and water supply wells).

3.2.1 Surficial Aquifers

The surficial aquifers are composed of Quaternary-age unconsolidated sediments that provide water for shallow water supply wells and consist primarily of material deposited during multiple advances of continental glaciers from the north. The massive ice sheets planed off and incorporated soil and rock fragments as large as boulders during advances and redistributed these materials on the eroded land surface as water- or ice-laid deposits (or both) during retreats. Surficial aquifers present are composed of glacial outwash, coarse-grained glacial-lake sediment, and coarse- and fine-grained alluvium (some of which may be buried in some places beneath fine-grain sediments). Because of the shallow depth, ease of recharge, and short groundwater flow system, surficial aquifers supply much of the base flow of streams. The hydraulic connection to streams is proportional to the permeability of the deposits. Most of the water in the surficial aquifer system is under unconfined conditions. Groundwater quantity and quality varies considerably in physical and chemical properties depending on the geological formations associated with the aquifer from which the water is taken. Recharge of the surficial aquifers is primarily from precipitation. However, a lesser amount of recharge is provided by infiltration from hydraulically connected stream/rivers (i.e., Missouri River) during high flow conditions, bedrock adjacent to and underlying the alluvium, and downward leakage of water from streams, other than the Missouri River, flowing across the alluvium. The volume of water supplied by precipitation and the volume of recharge that occurs from other streams as they cross the stream/river-valley alluvium depends greatly on the

hydrologic characteristics of the shallow alluvial materials. In areas where surficial materials are sandy and permeable, the amount of recharge water is significant. Where there is a clay or silt cap overlying the more permeable deposits, the recharge is less.

Surficial aquifers can be used in farmstead, irrigation, domestic, and industrial applications. The regional surficial aquifer system includes stream-valley aquifers and glacial-drift aquifers.

3.2.1.1 Glacial-Drift Aquifers

The maximum southern extent of the continental glaciers and glacial-drift deposits was approximately positioned at the present location of the Missouri River in Missouri and just south of the Kansas River in northeastern Kansas. The thickness of glacial drift generally is 50 to 200 feet but locally is greater than 300 feet in eastern Missouri and 400 feet in western Missouri and northeastern Kansas (Miller and Appel, 1997). Meltwater created an extensive stream network in front of the advancing ice, and the streams deposited gravel, sand, and finer sediments as alluvium along the courses of preglacial bedrock valleys. The glacial deposits are generally complex interbedding of fine- and coarse-grained sediments. The complex interbedding of permeable (coarse-grained) and poorly permeable (fine-grained) sediments in the glacial-drift aquifers results in a large number of local confining units. Accordingly, water in these aquifers can be under unconfined conditions in some places and confined conditions in other places. Glacial stream channels may have been filled with coarse grained sediments at the bottom and finer grained and less permeable silt, clay, or till at the top resulting in buried channel or buried valley aquifers under confined or semiconfined conditions.

Although deposits of glacial drift extend over wide areas, most were laid down directly by the ice; are fine grained, poorly sorted, or both; and, therefore, yield only small amounts of water to wells. The glacial-drift aquifers are a primary source of water for supply wells that usually penetrate beds of coarse-grained material (sand and gravel). Yields of shallow water supply wells screened within glacial-drift aquifers are highly variable. Wells screened in predominately fine-grained glacial deposits typically provide low yields and rely on large diameter wells for storage. Glacial-drift aquifers typically do not yield suitable water for a public water supply, unless hydraulically connected to streams or stream-valley aquifers.

Groundwater movement in glacial-drift aquifers generally move along short flow paths to the nearest surface-water body, where it discharges. A small amount of groundwater percolates downward and may infiltrate underlying bedrock aquifers, if hydraulically connected.

3.2.1.2 Stream-Valley Aquifers

Alluvial materials deposited along major rivers/streams in the Missouri River Valley provide another source for surficial aquifers. Alluvium is composed of clay, silt, fine to coarse sand, and fine to medium gravel. The size of the alluvium materials typically increases with depth; finer-grained materials directly underlie the land surface, and coarser sands and gravels are found at depth. The alluvium is generally the thickest toward the center part of the valley near the river, but there are instances where the thickest materials are near a valley wall. Water supply wells in major alluvial aquifers can produce high yields of good-quality water from properly constructed wells in coarse-grained sands and gravels with high permeability.

3.2.2 Bedrock Aquifers

In central Missouri, the regional bedrock aquifers are comprised of permeable hydrogeologic units of the Ozark Pleateaus aquifer system, the Mississippian aquifer, and the Cambrian-Ordovician aquifer. The presence and thickness of the uppermost bedrock aquifers vary locally where it has been eroded (e.g., river and/or glaciers). The regional hydrogeology is summarized in Tables 1 and 2 and illustrated in Figure 3.

3.2.2.1 Ozark Plateaus Aquifer System

The Ozark Plateaus Aquifer system underlies most of central and southern Missouri and consists of three aquifers, separated by two confining units, comprised of Mississippian-age and older rocks. The water-yielding rocks in these aquifers are primarily limestones and dolomites with some sandstones and chert. The confining units within the aquifer system are primarily shale but also consist of limestone, dolomite, and sandstone with minimal permeability and provide hydraulic separation between aquifers. Where these confining units contain more shale, the vertical movement of water between aquifers is more effectively restricted. The hydrogeologic units of the Ozark Plateaus Aquifer system are also equivalent to aquifers and confining units north of the Missouri River in Missouri that include the Mississippian and Cambrian-Ordovician aquifers. A stratigraphic summary of the Ozark Plateau aquifer system is provided in Table 1.

3.2.2.2 Mississippian Aquifer

The Mississippian Aquifer underlies Missouri north of the Missouri River and consist of stratigraphically equivalent rocks of the uppermost aquifer of Ozark Plateaus aquifer system (Springfield Plateau aquifer) situated south of the Missouri River. Limited information indicates that the Mississippian and Springfield Plateau aquifers have little or no hydraulic connection due to the Missouri River serving as both a boundary and discharge area between the two aquifers. The base of the aquifer is bound by a confining unit (equivalent to Ozark Confining Unit rocks) while the top of the aquifer is typically overlain with

overburden materials consisting of either glacial till or alluvium. A stratigraphic summary of the Mississippian aquifer is provided in Table 1.

3.2.2.3 Cambrian-Ordovician Aquifer

The Cambrian-Ordovician aquifer underlies Missouri north of the Missouri River and consists of stratigraphically equivalent rocks that form a part of the middle aquifer (Ozark aquifer) of the Ozark Plateaus aquifer system. The degree to which these aquifers are hydraulically connected in not fully known but is considered hydraulically connected in some places. However, where the Missouri River serves as both a boundary and discharge area for the two aquifers they are considered hydraulically separate. The aquifer consists predominately of carbonate rocks (dolomite and limestone) with some sandstone and is bound by confining units at the top (equivalent to Ozark Confining Unit rocks) and bottom (equivalent to St. Francis Confining Unit rocks). Because of these confining units, groundwater in the Cambrian-Ordovician aquifer is confined in most places. The lowermost aquifer of the Ozark Plateaus aquifer system (St. Francis Aquifer) is equivalent to a poorly known, unnamed minor aquifer in northern Missouri. A stratigraphic summary of the Cambrian-Ordovician aquifer is provided in Table 1.

One CMPP production water supply well is located in the northeast corner of the CMPP property, approximately 200 feet northeast of the inactive CCR Unit, and is identified in the MDNR Public Drinking Water Supply System (PDWSS) as City of Columbia Well #10 (Old Well #4, Bowling Street, W4, Well ID #14074). This well serves as the CMPP's main source of cooling water and backup source of boiler make-up water with a total well depth of 1,505 feet bgs (elevation of 723 ft below mean sea level) and is screened in the Cambrian-Ordovician aquifer (Cotter Dolomite to Potosi Dolomite; refer to Table 1). The drill logs for City of Columbia Well #10 and two additional deep water supply wells in the vicinity of the Site (City Well #11 and Flat Branch Well) were obtained from the MGS Geologic Well Logs of Missouri database and included in Appendix B. A generalized geologic cross section schematic from these water supply well drill logs illustrating the local hydrogeology is shown in Figure 4. As can be seen in in the drill logs and Figure 4, the primary groundwater source of public water supply wells in the area is located deep in the subsurface within limestones/dolomites of the Cambrian-Ordovician aquifer. Near the Missouri River, the major groundwater source of water supply wells is surficial aquifers consisting of alluvium along the river.

Groundwater supply wells in and around the City of Columbia are typically constructed either in surficial alluvium aquifers or in deeper bedrock aquifers that are composed of higher permeability materials that result in higher well yields and improved water quality compared with glacial till aquifers. A majority of the City's bedrock water supply wells are screened deep within the Cambrian-Ordovician aquifer.

4.0 INVESTIGATION ACTIVITIES AND RESULTS

The following sections provide a description of the field activities conducted as part of the hydrogeological investigation activities between May 2017 through November 2017. Field activities included the installation of eight (8) monitoring wells (MW-1 through MW-8) around the inactive ash pond. Additional field activities included limited soil sampling, a bedrock packer test, well development, in-situ hydraulic conductivity and yield testing, surveying, fluid level measurements, low-flow purge pilot test, and disposal of IDW. Field activities were recorded in the field logbook, a copy of which is provide din Appendix S.

4.1 Health and Safety

Drilling and sampling personnel conducted operations in accordance with promulgated Occupational Safety and Health Administration (OSHA) regulations, the Burns & McDonnell Site-specific Health and Safety Plan, and the CMPP Safety and Health Program. Minimum field personnel protective equipment (PPE) included steel-toed boots, hard hat, safety glasses, gloves, hearing protection, and long pants during drilling and well installation activities.

4.2 Utility Clearance

Drillers contacted a public utility locating service for a utility locate prior to on-site drilling activities. The CMPP facility personnel were responsible for locating all utilities owned by the City.

4.3 Monitoring Well Locations

To address the groundwater monitoring requirements presented in the CCR Final Rule, eight (8) new monitoring wells were installed to improve groundwater monitoring coverage at the inactive CCR Unit. Proposed Monitoring Wells MW-1 through MW-8 were installed around the perimeter of the inactive CCR Unit. The new monitoring well locations at the inactive CCR Unit are illustrated in Figure 5.

4.4 Drilling Activities

Drilling of soil borings and well installation activities was conducted by a Missouri-licensed driller (MDNR-certified well contractor), and work performed was in accordance with all Missouri statutes and regulations regarding drilling and well installation and construction (Missouri Well Construction Rules 10 Code of State Regulations [CSR] 23 Chapters 1, 2, and 4).

Soil borings were continuously sampled using hollow-stem auger (HSA) drilling and/or mud-rotary techniques for logging purposes and included limited collection of soil samples for laboratory testing/analysis. The selection of continuous sampling tools was based on subsurface materials

encountered during drilling and compatibility with HSA or mud-rotary fittings and operation requirements. A combination of HSA and mud-rotary drilling methods were used to advance borings to the depth of rock coring. Rock coring was performed at three (3) deep soil borings located separate and adjacent to new Monitoring Wells MW-1 (SB-1), MW-5 (SB-2), and MW-7 (SB-3) for determination of bedrock materials and to perform bedrock packer testing at one of these locations (refer to Section 4.7).

With the exception of the three (3) deep soil borings SB-1, SB-2, and SB-3 terminated into bedrock (separate and adjacent to proposed Monitoring Wells MW-1, MW-5, and MW-7), monitoring well borings were advanced beneath the first (uppermost) water bearing zone in the glacial drift. Once the first water bearing zone was encountered in the subsurface, drilling and soil sampling continued to a depth below the water table to install a monitoring well capable of producing a sufficient volume of groundwater for future monitoring (gauging and sampling). The well total depth was determined in the field by the geologist based on both observations and conditions encountered and to achieve a target depth so that the top of well screen was placed beneath the base elevation of the CCR unit (742 ft amsl). The well total depths ranged between approximately 28 and 57 feet below ground surface. Drilling and well construction details are summarized in Table 3. Monitoring wells (2-inch in diameter) were installed inside a minimum 8.25-inch borehole.

Respective off-set borings that were advanced were abandoned by backfilling with bentonite chips (hydrated in lifts) or high-solids bentonite grout.

4.5 Stratigraphy Encountered

Collected soil and core samples from drilling were visually inspected and field classified by a Burns & McDonnell geologist. Copies of drill logs for each new monitoring well installed (MW-1 through MW-8) and deep bedrock boring (SB-1 through SB-3) are included in Appendix C. Generalized geologic cross-sections across the Site are provided in Appendix D.

The typical geologic sequences encountered beneath the Site included the following (from top to bottom):

- Glacial Drift (overburden)
- Clay and Weathered Shale (Pennsylvanian-age Cherokee Group)
- Interbedded Limestone and Shale (thinly bedded; Pennsylvanian-age Cherokee Group)

The overburden was composed of glacial drift deposits that generally consist of complex interbedding of fine- and coarse-grained sediments. The glacial drift aquifer consists predominately of clay that is

intermixed and interbedded with silt and sand, trace to some gravel, and few to some sand lenses, partings, and beds. The uppermost water bearing zone was encountered within the glacial drift deposits. The thickness of glacial drift sediments ranged from approximately 35.2 feet (SB-3/MW-7) to 47.8 feet (SB-2/MW-5).

Bedrock was encountered at 45.3 feet bgs (SB-1/MW-1), 47.8 feet bgs (SB-2/MW-5), and 35.2 feet bgs (SB-3/MW-7). The top of bedrock elevation ranged from approximately 722 feet amsl (SB-2/MW-5) to 727 feet amsl (SB-3/MW-7). The uppermost bedrock was composed of weathered shale that graded from gray to greenish gray with increasing depth with with few angled fractures (approximately 30˚- 45˚). The thickness of the uppermost shale was about 14.5 feet (SB-1/MW-1), 17.5 feet (SB-2/MW-5), and 9.0 feet (SB-3/MW-7). The shale abruptly transitioned (sharp contact) to underlying limestone with shale partings/beds. The limestone was gray to yellowish gray with chert zones/nodules, pyrite mineralization, stylolites, and some fossils (crinoids and horn coral). The shale partings/beds within the limestone were gray to greenish gray, thinly bedded, with trace to few pyrite mineralization/nodules. The interbedded limestone and shale were weathered to non-weathered with increasing depth. Recovered bedrock cores exhibited some fractures along limestone and shale bedding planes and along stylolites. The bedrock encountered beneath the Site is interpreted as being the Pennsylvanian-age Cherokee Group (based on review of nearby historic drill log discussed below). The underlying Mississippian-age limestones and dolomites of the Keokuk-Burlington Limestone formations were not encountered.

The subsurface geology encountered at the Site was consistent with observations from a previous geotechnical study for a stability analysis of More's Lake dam (Crockett, 2014) that included six piezometers (PZ-1 through PZ-6) and four soil borings (B-7 through B-10) west of the inactive CCR Unit. Drill logs from this study are provided in Appendix E.

For comparison, a historic drill log from a former deep water supply well located in the northeast corner of the CMMP, identified as City of Columbia Well #10 (formerly known as Old Well #4), was obtained from the MGS Geologic Well Logs of Missouri database and indicated the glacial-drift to be approximately 65 feet thick. According to the drill log, the base of the glacial-drift is bound by approximately 15 feet of limey shale and bentonite-rich clay that overlies Mississippian-age carbonate rocks (limestones and dolomites). Based on the historic drill log, the limey shale and bentonite-rich clay represent the Pennsylvanian-age Cherokee Group and the underlying carbonate rocks are identified as the Mississippian-age Keokuk-Burlington Limestone formations (see Appendix B). These hydrogeologic units are stratigrahially equivalent to those that compose the lower portions of the Springfield Plateau aquifer (the uppermost aquifer in the Ozark Aquifer system), located south of the Missouri River (see

Table 1). This log and two other available drill logs from deep water supply wells in the vicinity of the Site are provided in Appendix B. A generalized geologic cross section schematic illustrating the local hydrogeology is shown in Figure 4. As can be seen in in the drill logs and the generalized cross-section schematic shown in Figure 4, the primary groundwater source of public water supply wells in the area is located deep in the subsurface within limestones/dolomites of the Cambrian-Ordovician aquifer. Near the Missouri River (located approximately 10 miles southwest of the facility), the major groundwater source of water supply wells is surficial aquifers consisting of alluvium along the river.

4.6 Soil Sampling and Analysis

During drilling, continuous soil samples were collected and inspected for field classification and logging purposes. Select soil samples had both physical testing and chemical analysis performed at off-site laboratories.

4.6.1 Physical Index Parameter Testing

Subsurface soil samples were collected within both the vadose (unsaturated) and saturated zones and submitted to an off-site material testing laboratory for the following physical index parameter tests:

- Atterberg Limit (by American Society for Testing and Materials [ASTM] D4318)
- Moisture Content (by ASTM D2216)
- Particle Size (by ASTM D422)
- Permeability – Sand (by ASTM D2434) or Clay (ASTM D5084)

Soil samples were collected in sealed bags or Shelby Tubes. Shelby Tube samplers were used to collect undisturbed soil for permeability testing. In addition to permeability testing, soil samples collected from Shelby Tubes were also tested for Atterberg limits, moisture, and particle size. The soil sampling and physical index parameter testing results are summarized in Tables 4 and 5, respectively. Laboratory testing reports are provided in Appendix F.

4.6.2 Chemical Analysis

Subsurface soil samples were collected in the vadose zone (unsaturated zone) and analyzed by an off-site laboratory for the following chemical parameters:

- RCRA Metals – arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver.
- Additional Metals – Aluminum, Antimony, Beryllium, Boron, Calcium, Chromium III, Chromium VI, Cobalt, Iron, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Sodium, Thallium, and Zinc.

- Radium 226 and 228.

Soil samples were collected in laboratory provided jars from each new monitoring well location. A summary of the soil sampling and chemical analysis are provided in Tables 4 and 6, respectively. Laboratory analytical reports are provided in Appendix G.

4.7 Packer Testing

Packer testing was performed to assess the hydrogeological properties of bedrock at the base of the uppermost water-bearing zone. Packer testing was completed in bedrock at one (1) deep open borehole, SB-2, located adjacent to Monitoring Well MW-5 (refer to Figure 5). Deep boreholes advanced into bedrock drilled using wireline coring techniques. Packer testing was performed at one test interval using a single packer from 80-85 feet bgs, approximately 21feet into bedrock (limestone). Packer testing measurements were recorded on field form provided in Appendix H. The estimated hydraulic conductivity of the limestone interval from the packer test was 3.22×10^{-7} cm/sec (1.06×10^{-8} ft/sec).

4.8 Soil Boring Abandonments

Following advancement of deep soil borings SB-1 through SB-3 (not completed as monitoring wells) and completion of bedrock packer testing at SB-2, the boreholes were abandoned by backfilling with high-solids bentonite grout (at least 20% solids by weight) tremied to within 2-feet below ground surface. The bentonite seal was capped with 2-feet of clean soil and/or gravel to the surface.

4.9 Monitoring Well Construction and Installation

Following the advancement of 8.25-inch well borehole to well total depth, monitoring well construction and installation activities were performed. The monitoring wells were constructed of Schedule 40, 2-inch inside diameter PVC, threaded screen and riser. The monitoring wells were screened below the water table, with 10-foot, 0.010-inch machine-slotted PVC well screen and threaded end caps installed to depths ranging from 28 to 53 feet bgs. Monitoring wells were constructed through hollow-stem augers and centralizers were not required. Glues or solvents were not used in the construction of the monitoring wells.

A filter pack consisting of clean, uniform, 20/40-grade silica sand was placed from the bottom of the well screen to at least three (3) feet above the top of the well screen. A minimum three (3) foot thick bentonite seal was placed immediately above the filter pack and consisted of bentonite chips. With the exception of Monitoring Well MW-8, the annular space above the bentonite seal was filled with high-solids bentonite grout slurry (at least 20%-30% by weight), to within approximately two (2) feet bgs. The annular space

for MW-8 was filled with bentonite chips placed in hydrated lifts. A locking, expandable, water-tight plug was installed in the top of the casing.

Monitoring wells were constructed with flush-mount (at grade) surface completions. The top of the well riser was cut to approximately 4 to 9 inches below ground surface. An access vault assembly with bolted, watertight cover was installed. The access well vault assembly extended to a depth of at 12-inches below ground surface. Heavy duty flush-mount protective covers (H-20, full traffic rated) were installed where surface completions are required to withstand high traffic of heavy equipment. The annulus between the access vault and borehole wall was filled with concrete to ground surface outside the access vault. An approximate 2-foot square concrete well pad was centered on the access vault and sloped away from the monitoring well to facilitate water runoff. Bollards were not required for flush-mount surface completions at grade.

Monitoring well construction schematics are provided in Appendix I for newly installed monitoring wells.

4.10 Well Development

Well development was performed on all newly installed monitoring wells and existing Piezometers PZ-2, PZ-4, and PZ-6. Development was conducted to remove fine-grained material from the well and the filter pack near the screen. Development was accomplished by surging and pumping the monitoring wells using a submersible pump. The screen was surged from the bottom to the top by gently raising and lowering the pump over a one- to two-foot interval, then raising the pump and repeating this procedure. The pump was then placed near the bottom of the screen and groundwater pumped until the development parameters were met or until pumped dry. Sediment and volume of water removed were monitored and recorded on a regular basis until development was complete.

The pH, conductivity, temperature, and turbidity of the water was recorded before beginning development. The initial static water level and total depth of the monitoring well was measured and recorded, and the volume of standing water in the well and borehole calculated. These water quality parameters were reevaluated as development continued.

With the exception of Monitoring Well MW-2, all wells were developed dry and were revisited and purged dry a total of three times (well development considered complete). These wells exhibited turbidity values over range (OR) of the field turbidity instrument. The planned well development requirements of stabilized field parameters (pH, specific conductivity, and temperature) and turbidity measurements less than 5 NTUs were not applicable due to the wells being developed dry. Monitoring Well MW-2 was not developed dry and was purged of 8.5 saturated borehole volumes until considered completed with

stabilized field parameters except turbidity. Turbidity values during development at MW-2 stabilized in the mid- to upper 80's in NTUs. Development of monitoring wells were recorded on the Well Development Form found in Appendix J.

To meet the CCR recommended criteria for wells being capable of yielding groundwater samples with low turbidity ($\leq$ 5 NTUs), low-flow groundwater purging and sampling techniques will be implemented. Low-flow purging and sampling utilizes "low-stress" method of extracting groundwater at low flow rates (typically less than 500 mL/min) to minimize water column mixing and agitation, entrainment of suspended sediment in the well, and reduce purge volumes.

Because well developments did not achieve low turbidity values, low-flow purging pilot testing was performed to simulate groundwater sampling to determine if turbidity values < 5 NTUs could be achieved. The low-flow purging pilot testing is discussed further in Section 4.20.

4.11 In-Situ Hydraulic Conductivity and Well Yield Testing

Following well development, in-situ hydraulic conductivity tests ("slug tests") were performed on the newly installed monitoring wells and select existing piezometers to determine permeability and better understand the hydraulic connection between the wells with glacial drift aquifer material under in-situ conditions. The slug tests were performed concurrently with the well yield tests at newly installed monitoring wells and existing Piezometers PZ-2, PZ-4, and PZ-6.

Slug test and well yield test procedures conformed to the standards outlined in ASTM D4044 (ASTM, 2008) and the Texas Commission of Environmental Quality (TCEQ) *Groundwater Classification* guidance document (RG-366/TRRP-8, Revised March 2010), respectively.

In-situ hydraulic conductivity and well yield were determined from direct field testing of wells by expelling groundwater from the wells with a pump or disposable bailer (record volume of water removed) followed by recording water levels with an electronic data logger (pressure transducer) at timed intervals during well recovery/recharge (rising head slug test).

Slug test data was evaluated by using AQTESOLV® computer software by inputting the data gathered from the in-situ hydraulic conductivity tests performed at each well. Estimated hydraulic conductivity values were calculated in AQTESOLV® using both Bouwer and Rice (1976) and Hvorslev (1951) methods for unconfined/semi-confined conditions. The estimated average hydraulic conductivities from wells screened within the glacial drift aquifer (uppermost water bearing zone) ranged from 1.89×10^{-07} cm/sec or 5.4×10^{-4} feet per day (ft/day) at MW-7 to 2.59×10^{-4} cm/sec (0.73 ft/day) at PZ-4, with a site-

wide average of 5.83×10^{-5} cm/sec (0.17 ft/day). The computed hydraulic conductivity results, along with time vs. displacement plots, are provided in Appendix K. The calculated hydraulic conductivities from the slug tests are summarized in Table 7.

Slug test data was also evaluated to determine well yield in accordance with discharge methods presented in the TCEQ guidance document (TCEQ, 2010). Well yield testing results are presented in Appendix L. The calculated well yields are summarized in Table 8 and ranged from 0.45 gallons per day (MW-7) to 693 gallons per day (PZ-4). Piezometer PZ-4 was the only well exhibiting well yields greater than 150 gallons per day and 360 gallons per day, indicating sufficient/sustainable yields according to TCEQ (TCEQ, 2010) and MDNR (MDNR, 2006), respectively.

4.12 Installation of Dedicated Bladder Pumps

Following in-situ hydraulic conductivity testing, monitoring wells chosen for sampling had permanent dedicated bladder pumps installed in each new monitoring well and in existing Piezometers PZ-2 and PZ-6. Dedicated pumps will be used for collecting groundwater samples using low-flow purging and sampling techniques as outlined in the GMP/SAP (Burns & McDonnell, 2018). A Groundwater SAP has been prepared by Burns & McDonnell, under separate cover, that outlines the low-flow purging and sampling techniques. The dedicated pumps installed were QED Model P1150 bladder pumps which are 19.5-inches long (22.75-inches long with the 0.01-inch machine slot inlet screen at the bottom of the pump). The pump assemblies were equipped with ¼-inch outside diameter dedicated tubing (Teflon-lined polyethylene, twin bonded air and water lines), and specialized well caps with dust covers. A Furnco endcap (or equivalent) equipped with adjustable clamp was secured to the top of the well to provide a watertight seal to the pump tubing. QED supplied caps were placed on PZ-2 and PZ-6 due to limited space in the well vault. The bladder pump system was assembled in the field and tubing cut to length with the pump inlet placed approximately 1.0 feet from the bottom of each well. Deployment details for the dedicated bladder pumps are summarized in Table 3.

4.13 Decontamination

All drilling, sampling and investigation equipment were decontaminated with a high pressure, hot-water rinse prior to beginning field activities, between boring/well locations, and upon completion of well installation activities. A source of potable water was provided at the work site. The driller provided and maintained a portable holding tank to contain and transport water (as needed) to complete drilling and well installation activities.

4.14 Management of IDW

Soil cuttings generated during drilling were disposed of at the inactive CCR Unit located on-site at the direction of CMPP personnel.

Liquid IDW that includes purged groundwater and decontamination fluids generated during well installation activities were discharged to the inactive CCR Unit.

All other general waste generated, including all disposable PPE, rope, bailers, paper towels, empty water bottles, etc., will be placed in trash bags. The trash bags will be placed in an appropriate solid waste receptacle.

4.15 Well Surveying

The new groundwater monitoring wells and existing piezometers were surveyed for both vertical and horizontal control. Surveying was performed on June 23, 2017 by Engineering Surveys and Services of Columbia, Missouri, a licensed Missouri Professional Land Surveyor. The well locations were surveyed horizontally to the nearest 0.1 foot and tied into the Missouri State Plane coordinate system. The ground surface and well pad elevations of the well locations were measured to the nearest 0.1 foot relative to MSL and reported using NAVD 88. For all new wells and existing piezometers, the top of the well riser pipe was surveyed to the nearest 0.01 foot relative to MSL and reported using NAVD 88. The survey report is included in Appendix M and summarized in Table 3.

4.16 Groundwater Occurrence

Through the duration of the field activities water level and total depth measurements from both new monitoring wells and existing piezometers were collected using an electronic water level meter. A summary of the groundwater depths and elevations is provided in Table 9.

Hydrographs illustrating groundwater elevations over time of the defined groundwater monitoring network are provided in Appendix N and include water level measurements collected during field activities. The hydrographs show a comparison of the groundwater elevation with respect to elevations of the well screen, ground surface, and base elevation of the inactive CCR Unit (742 ft amsl). More's Lake surface water elevation hydrograph is also included in Appendix N.

Based on a review of the well hydrographs (Appendix N), most wells have achieved static groundwater levels. Monitoring Well MW-7 may not be at static groundwater level and will further monitored with continued gauging. It is important to note that non-static and/or fluctuating groundwater levels observed may likely be as a result of low permeability of glacial drift aquifer and/or effects of dewatering of

More's Lake as part of the clean closure activities taking place. In particular, this dewatering may be the case for Piezometers PZ-1, PZ-3, and PZ-5 installed along the berm. Fluctuations in groundwater elevations throughout the groundwater monitoring network will continue to be monitored in subsequent groundwater monitoring events (see Section 6.2).

4.17 Groundwater Flow

Using the collected water level measurements from November 17, 2017 (see Table 9), potentiometric surface maps were constructed by plotting the water level elevations for each measured well screened in the shallow water-bearing zone. On the potentiometric surface maps, arrows were drawn perpendicular to the potentiometric contour lines to represent the general direction of groundwater flow beneath the Site. The potentiometric surface is illustrated in Figure 6 and shows the overall groundwater flow beneath the Site is generally to the west-northwest. However, it is important to note that some of the water levels measured may not represent static conditions based on review of the hydrographs (see Appendix N). Therefore, future gauging of the established groundwater monitoring network is warranted to further evaluate both groundwater fluctuations and static conditions beneath the Site.

4.18 Hydraulic Gradient

The difference between the highest and lowest elevations for groundwater gauged November 16, 2017 ranged from 741.17 feet amsl (MW-1) to 762.30 feet amsl (MW-3). A potentiometric surface map based on groundwater levels for November 16, 2017 is presented on Figure 6. Table 9 provides a summary of the groundwater levels that were used to create the piezometric surface maps. Groundwater levels have remained stable over the period these measurements were taken.

The hydraulic gradient can be calculated by measuring the distance (on the potentiometric map) over which an observed change in head occurs. Each hydraulic gradient can be calculated using the following equation:

$$i = dh/dL$$

Where:	i	=	hydraulic gradient (feet/feet)
	dh	=	change in head (feet)
	dL	=	horizontal distance (feet)

When the gradient is relatively uniform, one typical gradient can be calculated for a water-bearing zone to be calculate velocity. However, when the hydraulic gradient is significantly variable across the site, a range of hydraulic gradient values can be calculated for each water-bearing zone.

The hydraulic gradient values ranged from approximately 0.020 feet/foot to 0.056 feet/foot with calculations provided in Tables 10 and 11, respectively. The maximum and minimum horizontal distances used in the calculations are shown on Figure 6.

4.19 Estimated Groundwater Velocity

The rate of groundwater flow can be calculated for each water-bearing zone using the following groundwater velocity equation:

$$V = ki/n_e$$

Where:	V	=	estimated linear groundwater velocity (ft/day)
	k	=	hydraulic conductivity (ft/day)
	i	=	hydraulic gradient (ft/ft)
	n_e	=	effective porosity (percent)

The estimated maximum and minimum hydraulic conductivity values that were used in the equation are as follows:

K_{min} = 1.89×10^{-7} cm/sec (5.4×10^{-4} ft/day; MW-7 slug test)

K_{max} = 2.59×10^{-4} cm/sec (0.73 ft/day; PZ-4 slug test)

The assumed porosity and effective porosity of the surficial glacial aquifer ranges from 10 – 40% and 5% – 20%, respectively using accepted literature values for glacial sediments/till materials after Morris and Johnson (1967), Freethey, et al. (1994), and Nanh, et al. (2000). Using the results for the physical index parameter testing (Table 5 and Appendix F), the glacial sediments were primarily composed of lean to fat clay with sand (CL-CH). Because of the fine-grain (CL-CH) composition of the glacial sediments, the estimated maximum and minimum effective porosity of glacial till was assumed to be 15% and 6%.

Based on investigation results, the estimated linear groundwater velocity was calculated using hydraulic gradient data, estimated hydraulic conductivity values, and effective porosity data previously calculated or estimated. The data used in the calculations and the resultant estimated linear groundwater velocities are presented in Tables 10 and 11, respectively. The estimated linear groundwater velocity for November 2017 ranged from approximately 0.03 feet per year to 250 feet per year for the site.

4.20 Low-Flow Groundwater Purge Pilot Test

Because well developments did not achieve low turbidity values, low-flow purge pilot testing was performed at new monitoring wells and select piezometers planned for future sampling to simulate

groundwater purging/sampling to determine whether CCR recommended turbidity values < 5 NTUs could be achieved.

Low-flow groundwater purge pilot testing was conducted from September 23-24, 2017 on newly installed monitoring wells and existing Piezometers PZ-2 and PZ-6 using dedicated bladder pumps. With the exception of Monitoring Wells MW-2 and MW-7, all wells achieved turbidity values < 5 NTUs. Pilot testing turbidity values at Monitoring Wells MW-2 and MW-7 stabilized around 6 NTUs and 20 NTUs, respectively. An additional low-flow groundwater purge pilot test was conducted on November 8, 2017 at Monitoring Wells MW-2 and MW-7 to verify elevated turbidity. Monitoring Well MW-2 achieved turbidity values < 5 NTUs, while Monitoring Well MW-7 stabilized around approximately 50 NTUs. The groundwater purging forms from the low-flow pilot tests with turbidity results and other water quality field parameters (pH, temperature, conductivity, oxidation-reduction potential [ORP], and dissolved oxygen) are provided in Appendix O.

4.21 Well Re-Development by Introduction of Water

Based on the results of the low-flow purge pilot tests, turbidity values > 5 NTUs observed at Monitoring Well MW-7 warranted additional well development be performed in an attempt to further reduce turbidity values to meet the CCR recommended criteria for wells being capable of yielding low turbidity groundwater samples (< 5 NTUs). Due to the combination of fine-grained materials that compose the glacial drift aquifer and the well exhibiting low yield, additional development by adding water was recommended and approved by MDNR. Introduction of potable water allows for removal of fines within the filter pack to improve well communication with the water bearing zone, lower the turbidity of water in the well, and increase the quality of the water to provide collection of a more representative groundwater sample.

Prior to introduction of potable water, laboratory analysis was performed for the same constituents as those that will be part of the analytical suite of parameters being tested for as part of the groundwater monitoring program. Field water quality parameters of pH, conductivity, temperature, and turbidity were also measured and recorded. The laboratory analysis and field parameter results of the potable water source are provided in Appendix P.

Well re-development of MW-7 by adding water and removing it with a disposable bailer resulted in turbidity values out of range of the turbidity instrument. The re-development results are summarized in Appendix J.

5.0 CONCEPTUAL SITE MODEL

A generalized Conceptual Site Model (CSM) is presented to communicate the critical site-specific environmental conditions at the inactive CCR Surface Impoundment (More's Lake) based on available information to address potential groundwater impacts. The CSM incorporates the physical setting and characteristics of the inactive CCR Unit. The CSM provides a summary of existing environmental site conditions by identifying potential sources of impacts, and effected media associated with the inactive CCR Unit at the site. The CSM also establishes the extent of the investigative area. Development and refinement of the CSM will help identify data gaps in the characterization process and can ultimately support both investigation and corrective measure decision making. The CSM is an iterative tool that will continue to be developed and refined as more information is obtained throughout the site and following investigation and corrective measure activities. The following sections provide a brief overview of the conceptual site model developed for the inactive CCR unit.

5.1 Inactive Surface Impoundment (More's Lake) Description

The original surface impoundment, known locally as More's Lake, was constructed as a farm pond no later than 1896. The first power production at the CMPP occurred around 1914. Through the years, the impoundment was used as a settling pond for CCR material, receiving sluiced bottom ash, fly ash, boiler blow-down, cooling tower blow-down, and storm water runoff from the CMPP. The impoundment ceased receipt of CCR in 2015, in accordance with the Federal CCR Rule (40 CFR §257.53), allowing it to be classified as an inactive surface impoundment.

The inactive surface impoundment area is situated at the northern portion of the CMPP facility, within the property boundary, as shown in Figures 1 and 2. The impoundment is not lined and covers about 7.0 acres. The impoundment is operated under MDNR Permit No. 0004979. The base elevation of the inactive surface impoundment is around 742 feet amsl based on test pits dug in the fall of 2016 (Burns & McDonnell, 2016).

To support compliance with the Federal CCR Rule (40 CFR §257.91, §257.93-§257.95), construction of a groundwater monitoring system for the inactive Surface Impoundment was completed in May 2017 and consists of eight (8) monitoring wells (MW-1 through MW-8) and six (6) piezometers (PZ-1 through PZ-6). The piezometers were installed in 2014 (Crockett, 2014) and except for piezometer PZ-2, these piezometers will be utilized for water level gauging purposes (not sampled). Groundwater monitoring was initiated in December 2017 to include sampling of 9 wells (MW-1 through MW-8 and PZ-2) with the remaining five (5) wells utilized for water level purposes only.

The City intends to clean close the surface impoundment by the complete removal of CCR material in accordance with the CCR Federal Rule (40 CFR §257.100(b)(5)). The material removed from the site will either be disposed of in a Subtitle D municipal solid waste landfill or beneficially reused in accordance with Federal regulations.

5.2 Assumptions and Uncertainties

General uncertainties associated with the generalized CSM include the following:

- The effects, if any, the clean closure of the inactive Surface Impoundment will have on groundwater conditions at the Site are not known. Clean closure activities are currently taking place. Clean closure activities are expected to be complete by April 2019.

- No available groundwater quality data is available. Currently collecting groundwater quality data to establish background for the monitoring well network. Groundwater results will be provided in the initial groundwater monitoring report to be submitted no later than August 1, 2019. An updated CSM will be provided at that time.

- Potential off-site impacts to the quality of groundwater beneath and in the vicinity of the inactive Surface Impoundment are unknown at this time. Currently collecting groundwater quality data to establish background for the monitoring well network. Groundwater results will be provided in the initial groundwater monitoring report to be submitted no later than August 1, 2019. An updated CSM will be provided at that time.

General assumptions associated with the generalized CSM include the following:

- CMPP operations will continue in a manner similar to current operations (e.g. the power production well will continue to be used to provide water as a main source of cooling water and backup source of boiler make-up water).

- The inactive CCR unit is currently being clean closed. It is important to note that in the event of a confirmed release, the Federal CCR Rule requires closure [capping or clean close] of an unlined surface impoundment.

5.3 Identification of Potential Sources of Groundwater Impact

The potential sources of groundwater impacts at the site include the following:

- Impounded CCR waste disposed within More's Lake in direct contact with groundwater

- Leakage/releases from the inactive CCR Surface Impoundment
- Accidental spills/releases of impacted materials (solid or liquid) during operational activities at CMPP and/or adjacent properties

Seepage is a major potential groundwater pollutant at any CCR Unit. The main factors that can contribute to CCR seepage include direct contact with groundwater or surface water along with the infiltration and percolation of water through CCR waste from sources that include precipitation or release from man-made sources. Once in contact with the CCR waste, the percolating water may potentially become impacted and can be contained within the CCR waste or moves either vertically downward into contact with groundwater or laterally away from the CCR unit area with natural groundwater or surface water flow.

5.4 Potentially Effected Media

5.4.1 Groundwater

Groundwater quality data is not currently available for the Site. Therefore, potential impacts the inactive CCR Unit and surrounding area may have on quality of groundwater beneath an in the vicinity of the inactive Surface Impoundment are unknown at this time.

Background groundwater sampling and analysis of the newly established monitoring system will be conducted in accordance with the GMP and results will be provided in the first annual groundwater monitoring and corrective action report.

5.4.2 Surface Water

Surface water features near the inactive CCR Unit include an unnamed northward trending ephemeral drainage of Bear Creek west of the inactive CCR Unit and an unnamed southeast-east trending ephemeral drainage of Hinkson Creek southeast of the inactive CCR Unit. Any discharge from the inactive CCR Unit drains to the unnamed tributary to Bear Creek, regulated by NPDES Permit No. MO-0004979.

5.5 Summary of Site-Specific Geology and Hydrogeology

The site-specific geologic and hydrogeologic information summarized in the sections below are based on the investigation results presented in this report. The information has been divided into sections based on the site-specific technical requirements of the CCR Rule (40 CFR 257.91[b]) in order to characterize the overlying geologic units, the uppermost aquifer, and the confining unit defining the lower boundary of the uppermost aquifer.

5.5.1 Soils

Based on a review of available information provided by the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) web soil survey and the NRCS and USDA Soil Survey of Boone County, Missouri (the primary mapped soil unit in the vicinity of the inactive CCR Surface Impoundment (More's Lake) includes the Urban land-Harvester complex and Keswick-Urban land complex. The Urban land-harvester complex usually form on ridges on uplands (2 to 9 percent slopes) from fine-silty loess. A typical soil profile consists of 0-30 inches of silty clay loam, 30-60 inches of clay loam. These soils are moderately well drained with very high runoff rate. The Keswick-Urban land complex usually form on hills or uplands (5 to 9 percent slopes) from loess over clayey till. A typical soil profile consists of 0-7 inches of silt loam, 7-20 inches of clay, and 20-60 inches of clay loam. These soils are moderately well drained with very high runoff rate. A soil survey map of CMPP with unit descriptions, physical soil properties, and engineering properties are provided in Appendix R.

5.5.2 Overlying Geologic Units

Soils underlying the inactive CCR Surface Impoundment area consist of glacial drift sediments. The glacial-drift deposits are generally complex interbedding of fine- and coarse-grained sediments. At the inactive CCR Surface Impoundment, the glacial drift aquifer consists predominately of clay that is intermixed and interbedded with silt and sand, trace to some gravel, and few to some sand lenses, partings, and beds. The uppermost water bearing zone was encountered within the glacial drift. The thickness of glacial drift ranged from 35.2 feet (SB-3/MW-7) to 47.8 feet (SB-2/MW-5).

5.5.3 Aquifer Characterization

The hydrogeology beneath the More's Lake area is characterized by the uppermost groundwater aquifer comprised of glacial drift sediments. At the inactive CCR Surface Impoundment, the glacial drift aquifer consists predominately of clay that is intermixed and interbedded with silt and sand, trace to some gravel, and few to some sand lenses, partings, and beds. The thickness of glacial drift ranged from 35.2 feet to 47.8 feet. groundwater elevations ranged from 741.17 feet amsl to 762.30 feet amsl. The overall groundwater flow is generally to the west-northwest. However, continued gauging of water levels will be performed to further evaluate groundwater fluctuations and any influences the dewatering activities may be having on groundwater elevations/flow direction during closure of the inactive CCR unit.

Based on the estimated maximum and minimum hydraulic gradient (0.020 feet/foot to 0.056 feet/foot), assumed effective porosity (6% and 15%, estimated for glacial till [fine-grain]), and hydraulic conductivity (5.4×10^{-4} to 0.73 ft/day); the estimated linear groundwater velocity for the glacial till aquifer underlying the inactive CCR Unit is between approximately 0.03 to 250 feet/year. The higher values are

representative of higher frequency of fine sand lenses/interbeds available across the well screen while the lower values are typical of clay.

The glacial till sediments that make suitable aquifers are those composed of permeable coarse-grained sediments (sands and gravels), while glacial till composed of fine-grain sediments (clays) are typically poorly permeable and yield small amounts of water to wells. Based on the hydraulic conductivity results (field slug tests and laboratory permeability tests), the uppermost water bearing zone in the glacial drift aquifer is dominated by fine-grain sediments with low permeability.

Groundwater supply wells in and around Columbia are typically constructed either in surficial alluvium aquifers near the Missouri River or in deeper bedrock aquifers that are composed of higher permeability materials that result in higher well yields and improved water quality compared with glacial till aquifers. A majority of the City's water supply is derived from wells screened in the Missouri River alluvium. The City's backup (emergency use) water supply wells are generally screened in bedrock within the Cambrian-Ordovician aquifer.

5.5.4 Lower Boundary Confining Geologic Unit

The glacial drift aquifer is underlain by Pennsylvanian-age bedrock of the Cherokee Group formation. The uppermost bedrock beneath the inactive CCR Surface Impoundment area is a weathered shale which overlies alternating beds of limestone and shale of the Pennsylvanian-age Cherokee Group formation and serves as the uppermost confining bedrock at the Site. The depth to top of bedrock encountered ranged from approximately 35.2 feet bgs to 47.8 feet bgs, with elevations ranging from approximately 722 feet amsl to 727 feet amsl for the Cherokee Group formation. The estimated hydraulic conductivity of the limestone interval from the packer test was 3.22×10^{-7} cm/sec (1.06×10^{-8} ft/sec).

5.5.5 Characteristics of Geologic Units

A summary table presented below includes the hydraulic conductivities, porosities, and effective porosities of each geologic unit encountered during the field investigation activities at the inactive CCR Surface Impoundment area. The data presented in the summary table below was obtained using the methods referenced in the notes.

Characteristics of Geologic Units

	Classification / Lithology	Hydraulic Conductivity	Porosity	Effective Porosity
Overlying Geologic Units	Glacial Drift/Till (fine-grain)	8.0×10^{-08} to 1.1×10^{-06} cm/s (1)	10 – 40% (5)	5 – 20%(6)
Aquifer	Glacial Drift/Till (fine-grain)	1.1×10^{-08} to 2.59×10^{-04} cm/s (2)	10 – 40%(5)	5 – 20%(6)
Lower Confining Unit (Cherokee Group)	Limestone	3.22×10^{-07} cm/s (3)	5 – 15%(6)	0.1 – 5%(6)
	Shale	1×10^{-13} to 2×10^{-09} cm/s (4)	1 – 10%(6)	0.5 – 5%(6)

Notes:
(1) K values based on laboratory permeability tests from collected soil samples in vadose zone.
(2) Aquifer K values based on both laboratory permeability tests from collected soil sample and monitoring well slug tests.
(3) Limestone K value based on packer test.
(4) Shale K value after Freeze and Cherry (1979)
(5) Glacial sediment porosity after Morris and Johnson (1967) and Freethey, et al. (1994).
(6) Limestone and Shale porosity and effective porosity after Domenico and Schwartz (1990)
(7) Glacial sediment effective porosity after Nanh, et al. (2000).

5.6 Conceptual Site Model Summary

Potential primary sources of groundwater impact at the inactive CCR Unit is seepage. Other possible sources of impact may be related to any accidental or incidental spills of contaminated substances during operation activities at the inactive CCR Unit and/or adjacent properties.

The overburden and uppermost aquifer are composed of glacial drift deposits that are generally complex interbedding of fine- and coarse-grained sediments that extend approximately 35 to 48 feet bgs. The glacial drift aquifer consists predominately of clay that is intermixed and interbedded with silt and sand, trace to some gravel, and few to some sand lenses, partings, and beds. The glacial drift aquifer is underlain by Pennsylvanian-aged Cherokee Group formation. These bedrock formations are composed of weathered shale overlying alternating beds of limestone and shale and serves as the uppermost confining zone to perch the glacial drift aquifer beneath the Site. The confining zone slow migration of groundwater from the perched glacial drift aquifer to the underlying Mississippian, Ordovician, and Cambrian aquifers. Underlying the Cherokee Group, is the Mississippian-age carbonates (limestone and dolomite) of the Keokuk-Burlington Limestone formations. The glacial till sediments that make suitable aquifers are those composed of permeable coarse-grained sediments (sands and gravels), while glacial till composed of fine-grain sediments (clays) are typically poorly permeable and yield small amounts of water to wells. Based on the hydraulic conductivity results (field slug tests and laboratory permeability tests), the uppermost water bearing zone in the glacial drift aquifer. The glacial drift aquifer is dominated by fine-grain

sediments with low permeability. Localized sand layers will tend to have increased permeability when compared to adjacent silt or clay layers and therefore provide a preferential pathway for groundwater movement.

Groundwater migration beneath the inactive surface impoundment is dependent upon the hydrogeological properties of the aquifer materials and is also affected by recharge and precipitation, infiltration, and percolation and depth to groundwater. Seepage from the inactive CCR Unit is affected by the permeability of the CCR waste, surface soils, and subsurface soils. Other factors include potential man-made pathways (subsurface piping or utility corridors) and proximity to groundwater and surface water. Groundwater movement can be influenced by variation in the groundwater table. If the water table rises into an area containing CCR waste, the water can force potential COCs to migrate vertically upward or horizontally. Likewise, a falling water table can draw potential COCs downward from above (potentially out of CCR waste material) as well as horizontally.

A majority of the City's water supply is derived from wells screened in the Missouri River alluvium. The City's backup (emergency use) water supply wells and the CMPP's on-Site water supply well (source for cooling water and backup source of boiler make-up water) are generally screened deeper in bedrock within the Cambrian-Ordovician aquifer. The presence of low permeability shale and limestone formations underlying the glacial drift aquifer serves as a separating confining zone for the deeper Cambrian-Ordovician bedrock aquifer.

5.7 Data Gaps and Objectives

Based on the current understanding of the generalized CSM, the data needed to expand and refine the CSM can be summarized as follows:

- Groundwater quality both upgradient and downgradient of the inactive surface impoundment must be investigated for potential impacts originating from potential seepage of the CCR Unit. Groundwater sampling to establish background concentrations for the monitoring network is underway and results will be reported in the first annual groundwater monitoring report due no later than August 1, 2019.

6.0 FUTURE ACTIVITIES

6.1 CCR Groundwater Monitoring System Certification

Evaluation of the groundwater monitoring system in meeting CCR regulations (certification from professional engineer) will be provided as a separate submittal.

6.2 Background Groundwater Sampling

Following the installation of dedicated bladder pumps, the eight new wells and existing Piezometer PZ-2 will be included in the groundwater sampling network. Piezometer PZ-6 was initially proposed for sampling, however due to close proximity of new Monitoring Well MW-8, PZ-6 will not be sampled but instead monitored for groundwater elevation purposes only. A minimum of eight (8) independent samples from each sampled well will be collected to establish background values and allow for statistical evaluation. These wells will be sampled using low-flow purging and sampling techniques and analyzed for both Detection and Assessment Monitoring parameters in accordance with Appendix III and IV of the federal CCR Rule and additional MDNR water quality standard parameters. The specific parameters and analytical methods to be used when analyzing groundwater samples for Detection, Assessment, and MDNR water quality standards are summarized in Table 13.

Background groundwater sampling and analysis of the newly established monitoring system will be conducted in accordance with the GMP and results will be provided in the first annual groundwater monitoring and corrective action report. The GMP was prepared by Burns & McDonnell as a separate submittal to support compliance with the CCR final rule (§257.93-§257.95). The GMP includes the SAP which defines the methods/procedures and techniques for groundwater sampling and analysis.

Background groundwater sampling is scheduled to continue so that eight rounds of background data are obtained prior to April 17, 2019. After background data is collected, the frequency of groundwater sampling and analysis will be reduced to at least semiannually for detection monitoring that include constituents listed in Appendix III to the CCR Final Rule.

6.3 Groundwater Monitoring Reporting

No later than August 1, 2019, an initial groundwater monitoring report will need to be submitted, with annual reports submitted thereafter. The initial annual report will identify background conditions at the inactive Surface Impoundment and outline the recommended statistical methods to be used in detection monitoring for subsequent monitoring. The annual report will document the status of the groundwater monitoring program for the inactive CCR unit, summarize key actions completed, evaluate the data,

describe any problems encountered, discuss actions to resolve the problems, and project key activities for the future monitoring events in the upcoming year. In accordance with the Final Rule requirements, the annual reports will need to be placed in the facility's operating record as required by §257.105(h) and posted to CWLD's publicly accessible Internet website in accordance with §257.107(h).

Continued groundwater sampling/analysis and annual reporting will be discussed with MDNR following the initial background sampling and review of the first groundwater monitoring report.

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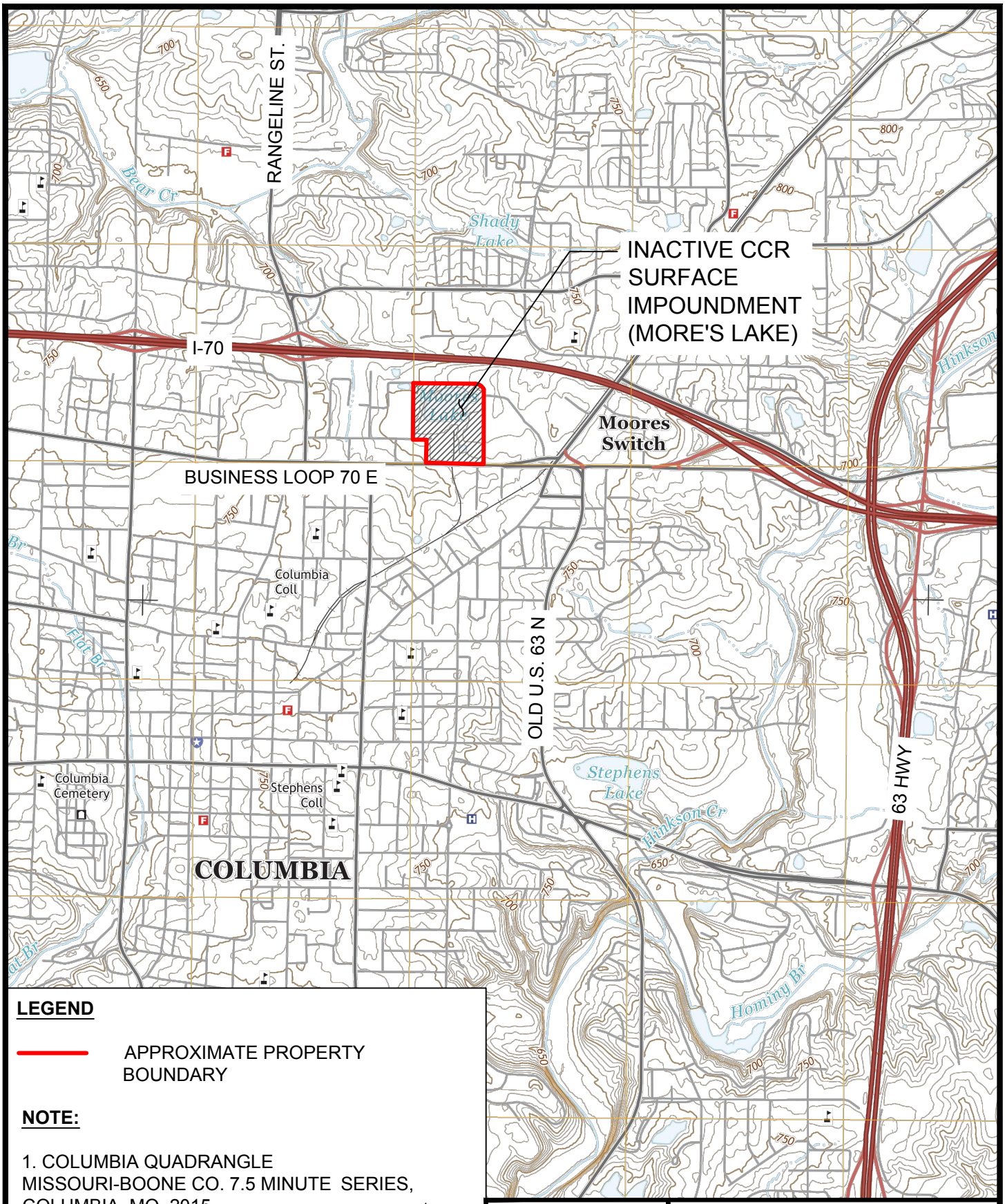
FIGURES



LEGEND

APPROXIMATE PROPERTY BOUNDARY

NOTE:

1. COLUMBIA QUADRANGLE MISSOURI-BOONE CO. 7.5 MINUTE SERIES, COLUMBIA, MO, 2015.
2. CONTOUR INTERVAL 10 FEET.

N

0 2000' 4000'

SCALE IN FEET

BURNS McDONNELL

FIGURE 1
SITE VICINITY TOPOGRAPHIC MAP
COLUMBIA MUNICIPAL POWER PLANT COLUMBIA, MO

COPYRIGHT © 2017 BURNS & McDONNELL ENGINEERING COMPANY, INC.

Z:\Clients\ENV\ColumbiaMO\93647_MoresLake\Design\CADD\Dwgs\Groundwater Work Plan\FIG1-Site Map.dwgDHINEMAN

LEGEND

APPROXIMATE PROPERTY BOUNDARY

NOTE:

1. COLUMBIA QUADRANGLE MISSOURI-BOONE CO. 7.5 MINUTE SERIES, COLUMBIA, MO, 2015.

N

0 2000' 4000'

SCALE IN FEET

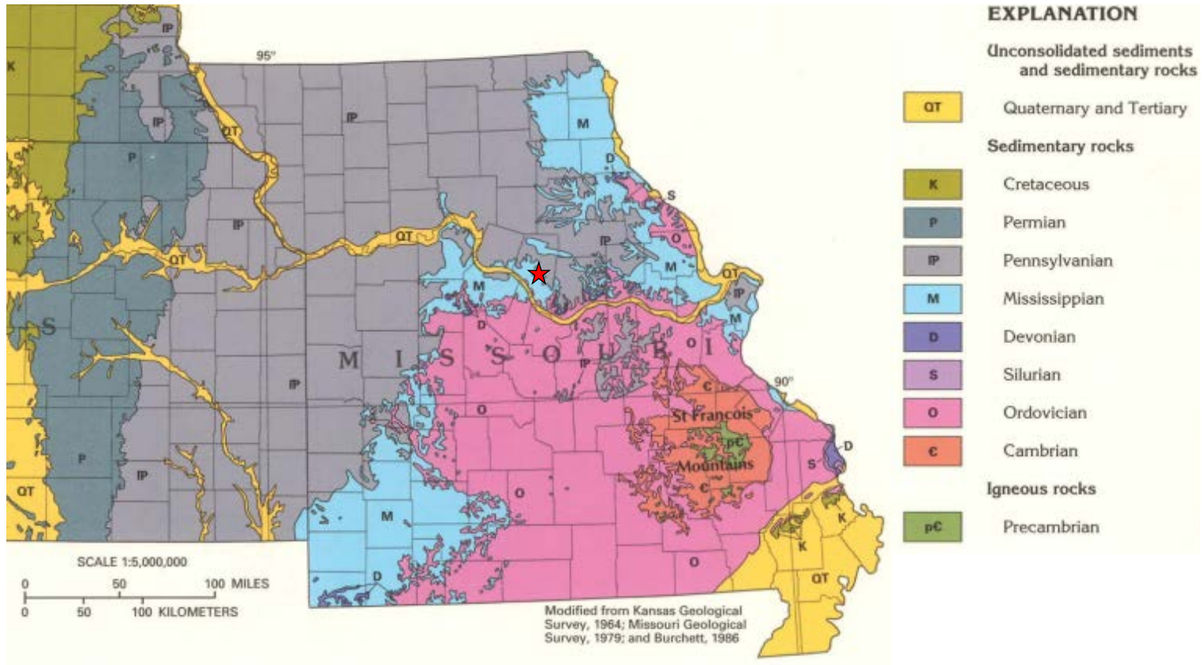
BURNS McDONNELL

FIGURE 2
SITE VICINITY AERIAL MAP
COLUMBIA MUNICIPAL POWER PLANT COLUMBIA, MO

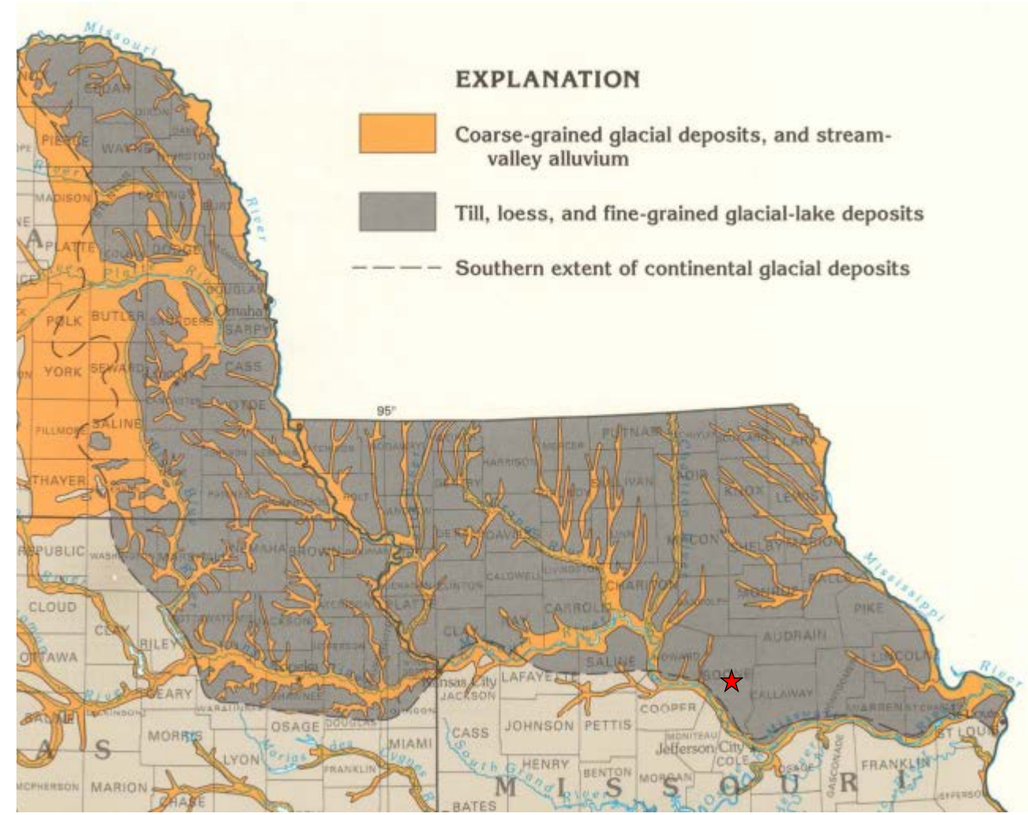
COPYRIGHT © 2017 BURNS & McDONNELL ENGINEERING COMPANY, INC.

Z:\Clients\ENV\ColumbiaMO\93647_MoresLake\Design\CADD\Dwgs\Groundwater Work Plan\FIG2-Map.dwgDHINEMAN

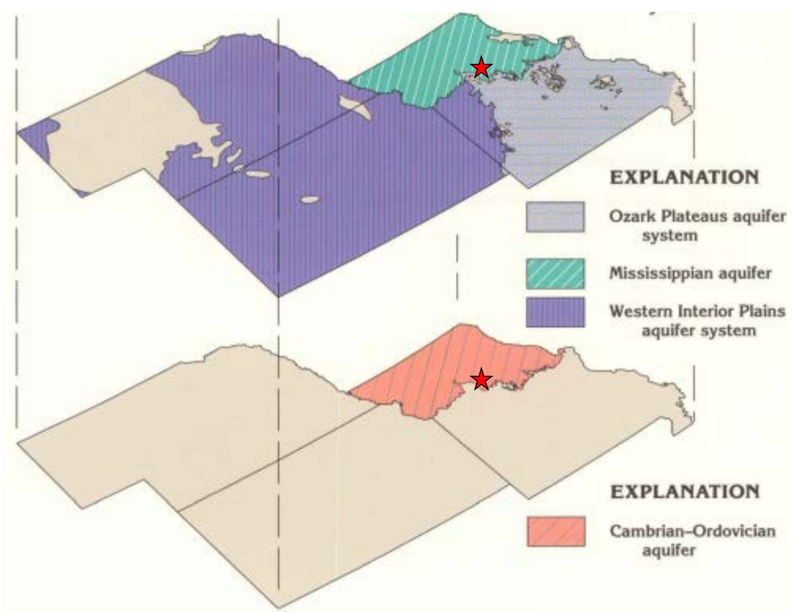
Geologic Map



Surficial Aquifer System



Bedrock Aquifers



★ Approximate location of Columbia Municipal Power Plant (Boone County, MO in Columbia, MO).

The Columbia Municipal Power Plant is situated on glacial-drift deposits with the uppermost bedrock consisting of Mississippian-age sedimentary rocks (predominately limestones/dolomites and shales). Surficial aquifer systems consisting of glacial-drift aquifers are the principal aquifers near the facility. The glacial deposits are generally complex interbedding of fine- and coarse-grained sediments that typically yield only small amounts of water to wells and generally not considered a primary source of water for supply wells unless screened in coarse-grained material (sand and gravel). The Mississippi aquifer, Ozark Plateaus aquifer, and the Cambrian-Ordovician aquifer are the regional bedrock aquifers in north-central Missouri. The majority of the City of Columbia's bedrock water supply wells are screened deep within the Cambrian-Ordovician aquifer.

Reference:

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FIGURE 3

HYDROGEOLOGY OF MISSOURI

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SOUTHWEST

NORTHEAST

SITE BOUNDARY

INACTIVE CCR UNIT

A

B

C

I-70

GLACIAL DRIFT

CHEROKEE GROUP

KEOKUK-BURLINGTON LIMESTONE

SEDALIA FORMATION

CHOUTEAU GROUP

CALLAWAY FORMATION

POWELL DOLOMITE

COTTER DOLOMITE

JEFFERSON CITY DOLOMITE

ROUBIDOUX FORMATION

UPPER GASCONADE

LOWER GASCONADE

VAN BUREN FORMATION

TD = -735 FT MSL
(POTOSI DOLOMITE)

GUNTER SANDSTONE

ELEVATION (FT MSL)

820, 800, 750, 700, 650, 600, 550, 500, 450, 400, 350, 300, 250, 200, 150, 100, 50, 0, -50, -100, -150, -200, -250, -300, -350, -400

0, 500, 1000, 1500, 2000, 2500, 3000, 3500, 4000, 4500, 5000, 5500, 6000, 6500, 7000, 7500, 8000, 8500, 9000, 9500, 10000, 10500, 11000, 11500, 12000

LEGEND

- A — FLAT BRANCH WELL (001523)
- B — CITY WELL #10 (OLD WELL #4, 009527)
- C — CITY WELL #11 (OLD WELL #5, 010158)
- SURFICIAL AQUIFER
- PENNSYLVANIAN CONFINING UNIT
- MISSISSIPPIAN AQUIFER
- ORDOVICIAN-CAMBRIAN CONFINING UNIT
- ORDOVICIAN-CAMBRIAN AQUIFER
- WELL SCREEN

NOTES:

1. CORRELATION OF UNITS IS AN INTERPRETATION AND NOT NECESSARILY A DELINEATION OF ACTUAL EXTENT AND THICKNESS OF INDIVIDUAL UNITS.

2. LITHOLOGY WAS LOGGED BY MISSOURI GEOLOGICAL SURVEY.

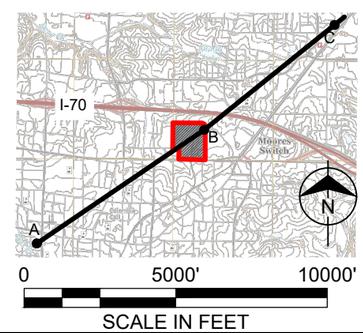

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FIGURE 4
GENERALIZED GEOLOGIC CROSS SECTION
COLUMBIA MUNICIPAL POWER PLANT COLUMBIA, MO

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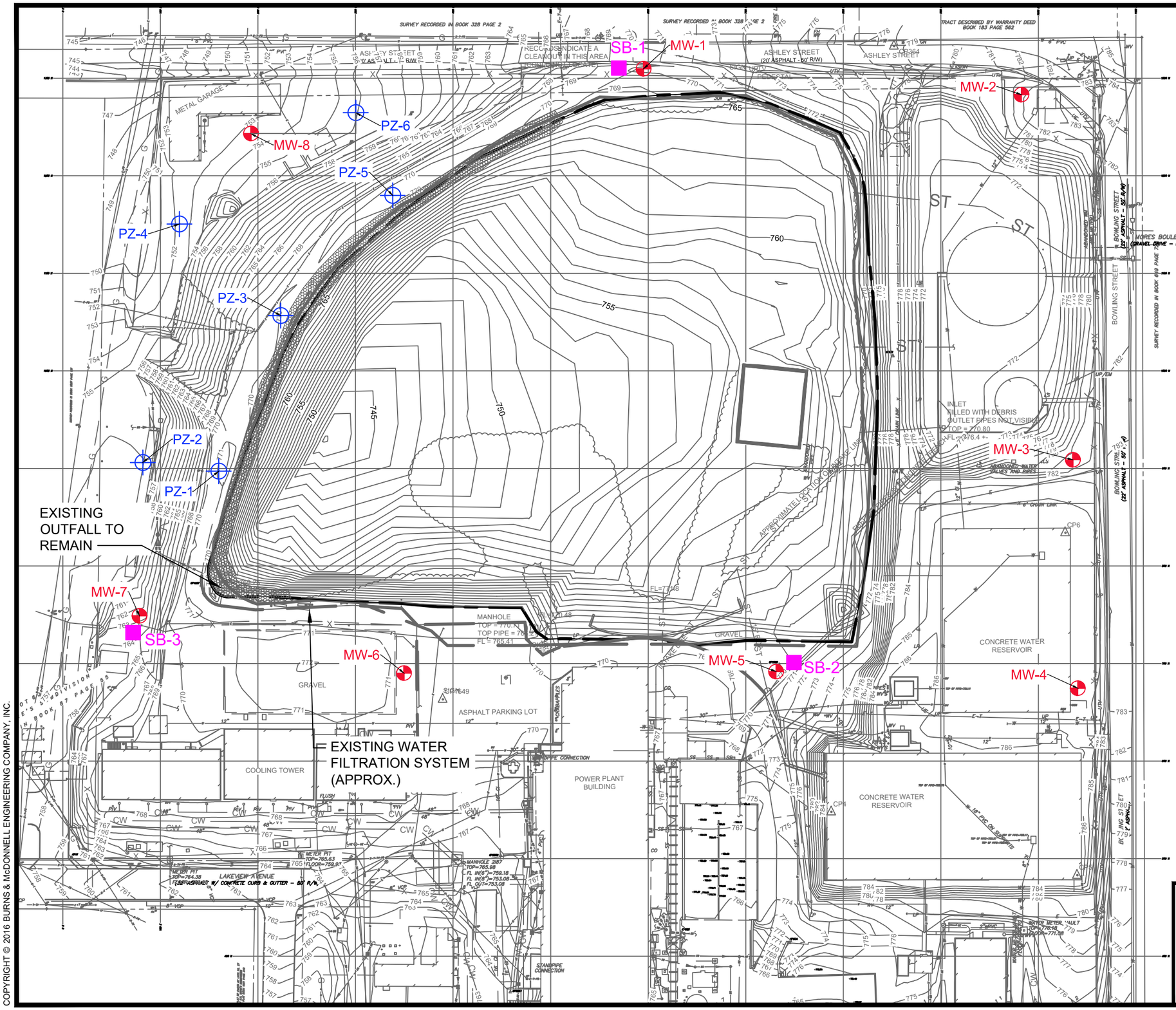
Z:\CLIENTS\ENS\COLUMBIAMO\93647_MORESLAKE\DESIGN\CADD\DWGS\GROUNDWATER WORK PLAN\FIG4-CROSS SECTION.DWGCHOGLUND



LEGEND

- EXISTING PIEZOMETER
- NEW MONITORING WELL
- DEEP BEDROCK BORINGS
- APPROXIMATE PROPERTY BOUNDARY

NOTE:

1. MONITORING WELL AND PIEZOMETER LOCATIONS AND ELEVATIONS SURVEYED BY ENGINEERING SURVEYS AND SERVICES OF COLUMBIA, MO ON JUNE 23, 2017.
2. TOPOGRAPHIC CONTOUR INTERVAL 1 FEET.

BURNS McDONNELL

FIGURE 5
MONITORING WELL AND BEDROCK CORING LOCATIONS
COLUMBIA MUNICIPAL POWER PLANT
COLUMBIA, MISSOURI

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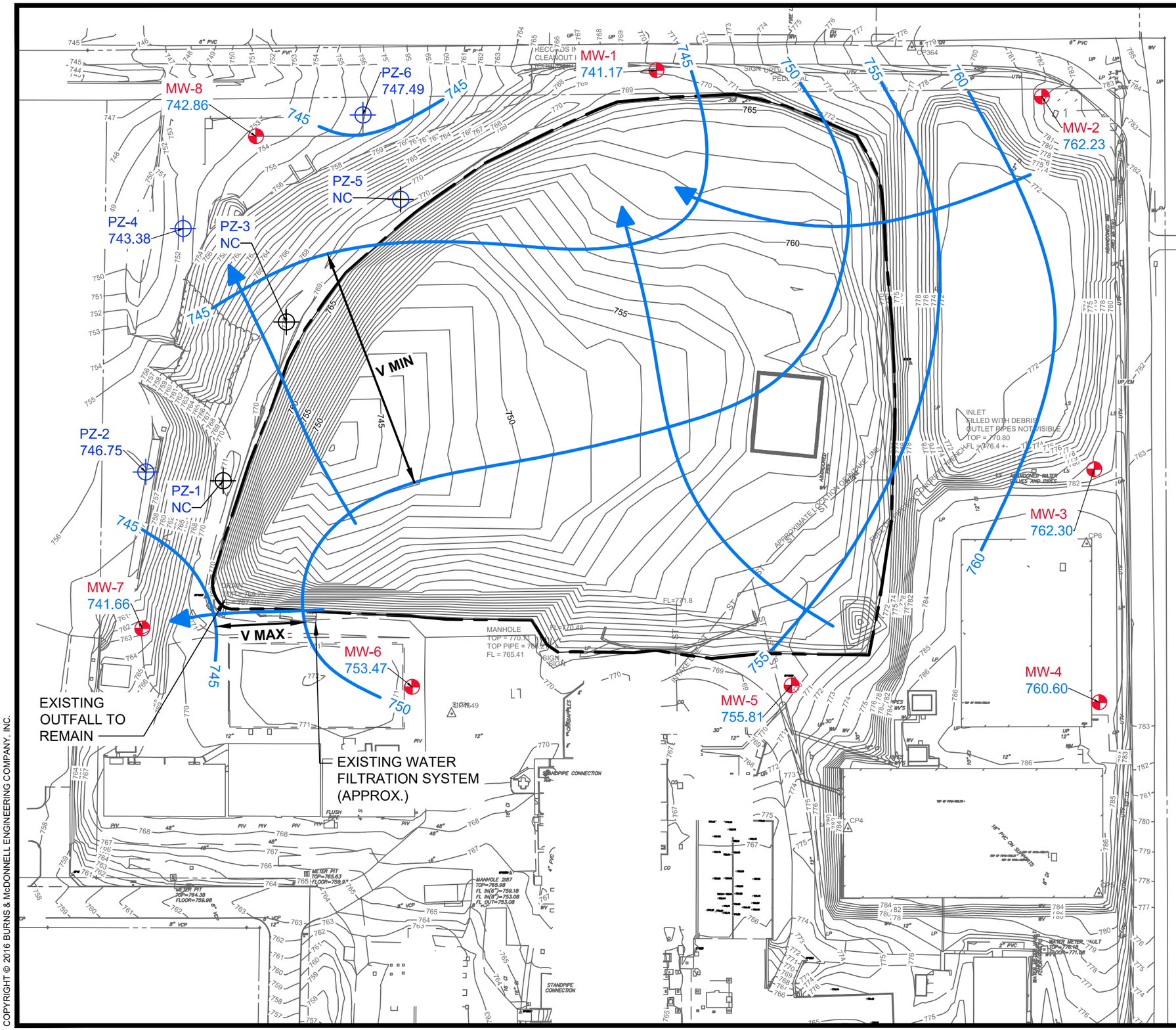
Z:\CLIENTS\ENS\COLUMBIAMO\93647_MORESLAKE\DESIGN\CADD\DWGS\GROUNDWATER WORK PLAN\2017\FIG5-MONITORING WELL AND BEDROCK CORING LOCATIONS.DWG
DHINEMAN



LEGEND

- EXISTING PIEZOMETER
- NEW MONITORING WELL
- APPROXIMATE PROPERTY BOUNDARY
- 762.23 GROUNDWATER ELEVATION
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

NOTE:

1. MONITORING WELL AND PIEZOMETER LOCATIONS AND ELEVATIONS SURVEYED BY ENGINEERING SURVEYS AND SERVICES OF COLUMBIA, MO ON JUNE 23, 2017.
2. TOPOGRAPHIC CONTOUR INTERVAL 1 FEET.
3. N/C = NO DATA COLLECTED.
4. V MIN = MINIMUM AVERAGE. GROUNDWATER VELOCITY.
5. V MAX = MAXIMUM AVERAGE GROUNDWATER VELOCITY.
6. GROUNDWATER ELEVATIONS WERE COLLECTED ON NOVEMBER 16, 2017.

N

0 100' 200'

SCALE IN FEET

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FIGURE 6
POTENTIOMETRIC SURFACE MAP
NOVEMBER 16, 2017
COLUMBIA MUNICIPAL POWER PLANT
COLUMBIA, MO

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TABLES

Table 1
Stratigraphic Summary of Missouri Aquifers
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

Era	System	Series		Missouri	Boone County, MO	Northern Missouri	Central-Southern Missouri	
Paleozoic	Quaternary	Holocene		Residuum/Alluvium/Colluvium	Residuum/Alluvium	Surficial Aquifers or Confining Units	Surficial Aquifers or Confining Units	
		Pleistocene		Glacial-Drift/Loess/Alluvium	Glacial-Drift/Loess/Alluvium			
	Pennsylvanian	Desmoinesian		Marmaton Group	Marmaton Group	Confining Unit	Confining Unit	
				Cherokee Group	Cherokee Group			
	Mississippian	Meramecian		St. Louis Limestone Salem Limestone Warsaw Limestone		Mississippi Aquifer	Springfield Plateau Aquifer	Ozark Aquifer System
		Osagean		Keokuk Limestone Burlington Limestone Elsey Formation Reeds Springs Formation Pierson / Fern Glen Formation	Keokuk Limestone Burlington Limestone			
		Kinderhookian	Chouteau Group	Northview Shale Sedalia Formation Compton Limestone Bachelor Formation	Northview Shale Sedalia Formation Compton Limestone Bachelor Formation	Ordovician-Cambrian Confining Unit	Ozark Confining Unit	
	Devonian	Upper Middle Lower	Sulfur Springs Group	Chattanooga Shale Callaway Formation Fortune Formation	Bushberg Sandstone Glen Park Limestone Grassy Creek Shale Saverton Formation Synder Creek Shale Ceder Valley Limestone		Ozark Aquifer	
	Ordovician	Champlainian		Kimmswick Limestone Decorah Formation Plattin Limestone Joachim Dolomite St. Peter Sandstone Everton Formation		Ordovician-Cambrian Aquifer		
		Canadian		Smithville Dolomite Powell Dolomite Cotter Dolomite Jeffeson City Dolomite Roubidoux Formation	Powell Dolomite Cotter Dolomite Jefferson City Dolomite Roubidoux Formation			
			Upper Lower	Gasconade Dolomite Gunter Sandstone Van Buren Formation	Gasconade Dolomite Gunter Sandstone			
	Cambrian	Upper	Elvins Group	Eminence Dolomite Potosi Dolomite	Eminence Dolomite Potosi Dolomite			
				Derby-Doe Run Dolomite Davis Formation	Doe Run Dolomite Derby Dolomite	St. Francis Confining Unit	St. Francis Confining Unit	
				Bonneterre Dolomite		Unnamed Minor Aquifer	St. Francis Aquifer	
				Regan Sandstone / Lamotte Sandstone				
Precambrian				Crystalline Igneous and Metamorphic Rocks ("basement rocks")				

Modified from Miller, James A. and Appel, Cynthia L., 1997, Groundwater Atlas of the United States: Kansas, Missouri, and Nebraska, United States Geological Survey (USGS), HA 730-D, Figure 93, https://pubs.usgs.gov/ha/ha730/ch_d/.

Principal water-bearing zones in aquifers.

The nomenclature and presence of stratigraphic units may vary locally.

The Mississippi and Ordovician-Cambrian aquifers in northern Missouri are stratigraphically equivalent to aquifers in Central-Southern Missouri (Ozark Aquifer system).

Table 2
Regional Bedrock Aquifers
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

System	Hydrogeologic Unit				
	Western Missouri, Kansas, and Nebraska (modified from Jorgensen and others, 1993)		**Northern Missouri** (modified from Imes, 1985)	**Southern Missouri** (modified from Imes and Emmette, 1994)	
Mississippian	**Western Interior Plains Aquifer System** [1]	Upper aquifer unit	Mississippi Aquifer	**Ozark Plateaus Aquifer System** [3]	Springfield Plateau Aquifer
		Confining unit	Upper Confining Unit		Ozark confining unit
Devonian		Lower aquifer units			Ozark Aquifer
Silurian					
Ordovician			Cambrian-Ordovician Aquifer		
Cambrian					St. Francois confining unit
			Confining unit		St. Francois Aquifer
			Minor aquifer [2]		

Table from Ground Water Atlas of the United States, Segment 3 Kansas, Missouri, and Nebraska (Figure 89; Miller and Appel, 1997).

Western Interior Plains Aquifer System is stratigraphically equivalent to aquifers in Northern Missouri and the Ozark Plateaus Aquifer System in Southern Missouri.

Notes:

1. Contains saline water or brine
2. Poorly known
3. Contains freshwater

Table 3
Summary of Groundwater Monitoring Well Network Construction Details
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

Well ID	Install Date	Well Location						Ground Surface Elevation (ft NAVD88)	Top of Casing Elevation (ft NAVD88)	Total Well Depth (ft bTOC)	Well Screen Length (ft)	Screened Interval						Sand Filter Pack					Dedicated Groundwater Sampling Bladder Pumps			
												Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Thickness	Depth to Top of Pump	Length of Pump	Depth to Pump Bottom	Separation from Bottom
		Northing$_1$	Easting$_1$	Northing$_2$	Easting$_2$	Latitude	Longitude					(ft bTOC)		(ft bgs)		(ft NAVD88)		(ft bTOC)		(ft NAVD88)		(ft)	(ft bTOC)	(ft)	(ft bTOC)	(ft)
MW-1	5/24/2017	1309.61	595.26	1141116.45	1692468.31	38˚ 58' 02.1571"	92˚ 19' 00.9303"	770.20	769.82	42.87	10.00	32.50	42.50	32.88	42.88	737.32	727.32	29.74	42.87	740.08	726.95	13.13	39.75	1.90	41.65	1.22
MW-2	5/23/2017	1283.14	982.64	1141085.68	1692855.37	38˚ 58' 01.8452"	92˚ 18' 56.0303"	781.80	781.03	52.96	10.00	42.59	52.59	43.36	53.36	738.44	728.44	39.83	52.96	741.20	728.07	13.13	49.98	1.90	51.88	1.08
MW-3	5/18/2017	908.83	1035.37	1140710.80	1692903.94	38˚ 57' 58.1387"	92˚ 18' 55.4250"	781.62	781.13	49.58	10.00	39.21	49.21	39.70	49.70	741.92	731.92	36.52	49.58	744.61	731.55	13.06	46.42	1.90	48.32	1.26
MW-4	5/17/2017	674.69	1040.37	1140476.62	1692906.34	38˚ 57' 55.8239"	92˚ 18' 55.4006"	785.39	785.02	57.16	10.01	46.78	56.79	47.15	57.16	738.24	728.23	44.13	57.16	740.89	727.86	13.03	54.23	1.90	56.13	1.03
MW-5	5/19/2017	691.74	731.12	1140497.10	1692597.29	38˚ 57' 56.0325"	92˚ 18' 59.3130"	770.08	769.61	41.18	10.01	30.80	40.81	31.27	41.28	738.81	728.80	28.07	41.18	741.54	728.43	13.11	38.32	1.90	40.22	0.96
MW-6	5/25/2017	690.15	349.67	1140499.76	1692215.86	38˚ 57' 56.0663"	92˚ 19' 04.1425"	770.47	770.07	41.83	10.01	31.45	41.46	31.85	41.86	738.62	728.61	28.77	41.83	741.30	728.24	13.06	38.86	1.90	40.76	1.07
MW-7	5/16/2017	748.88	78.48	1140561.50	1691945.33	38˚ 57' 56.6819"	92˚ 19' 07.5661"	762.67	762.23	33.46	10.01	23.08	33.09	23.52	33.53	739.15	729.14	20.44	33.46	741.79	728.77	13.02	30.38	1.90	32.28	1.18
MW-8	5/18/2017	1243.32	192.84	1141054.64	1692065.18	38˚ 58' 01.5540"	92˚ 19' 06.0363"	753.46	753.09	27.92	10.01	17.54	27.55	17.91	27.92	735.55	725.54	14.83	27.92	738.26	725.17	13.09	25.05	1.90	26.95	0.97
PZ-1	1/13/2014	897.15	159.71	1140708.86	1692028.21	38˚ 57' 58.1368"	92˚ 19' 06.5132"	771.46	770.78	20.00	15.00	5.00	20.00	5.68	20.68	765.78	750.78	3.00	20.00	767.78	750.78	17.00	--	--	--	--
PZ-2	1/13/2014	906.03	81.89	1140708.86	169028.21	38˚ 57' 58.2347"	92˚ 19' 07.4970"	756.19	755.91	19.80	15.00	4.80	19.80	5.08	20.08	751.11	736.11	2.80	19.80	753.11	736.11	17.00	16.92	1.90	18.82	0.98
PZ-3	1/13/2014	1056.64	223.33	1140867.63	1692093.59	38˚ 57' 59.7050"	92˚ 19' 05.6813"	770.77	769.94	20.00	15.00	5.00	20.00	5.83	20.83	764.94	749.94	3.00	20.00	766.94	749.94	17.00	--	--	--	--
PZ-4	1/14/2014	1150.48	119.48	1140962.62	1691990.79	38˚ 58' 00.6459"	92˚ 19' 06.9805"	752.40	752.06	20.13	15.00	5.13	20.13	5.47	20.47	746.93	731.93	3.13	20.13	748.93	731.93	17.00	--	--	--	--
PZ-5	1/14/2014	1179.83	338.16	1140989.53	1692209.78	38˚ 58' 00.9077"	92˚ 19' 04.2070"	771.01	770.02	20.00	15.00	5.00	20.00	5.99	20.99	765.02	750.02	3.00	20.00	767.02	750.02	17.00	--	--	--	--
PZ-6	1/14/2014	1264.67	300.25	1141074.79	1692172.82	38˚ 58' 01.7512"	92˚ 19' 04.6729"	755.87	755.60	20.16	15.00	5.16	20.16	5.43	20.43	750.44	735.44	3.16	20.16	752.44	735.44	17.00	17.32	1.90	19.22	0.94

bTOC = Below top of casing.

ft = feet

NAVD 88 = North American Vertical Datum of 1988.

Notes:

1. Northing and Easting well locations in plant-specific coordinate system.
2. Northing and Easting well locations in Missouri State Plane coordinate system.
3. Wells constructed with 2-inch Schedule 40 PVC.
4. Dedicated groundwater sampling pumps consist of QED Model P1150 with inlet screen at bottom, 1/4-inch twin bonded air and water lines.
5. PZ-1 through PZ-6 construction details taken from historical drilling logs and construction forms.
6. Well locations and elevations surveyed on June 23, 2017 by Engineering Surveys & Services of Columbia, MO.

Table 4
Soil Sampling Summary
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

Soil Boring Identification	Estimated Soil Sample Depth (ft bgs)	Physical Index Parameter Testing				Chemical Analysis	
		Permeability ASTM D2434 or D5084	Atterberg ASTM D4318	Particle Size ASTM D422	Moisture ASTM D2216	Metals	Radium 226+228
MW-1 (SB-1)	6-8	--	--	--	--	1	1
	8-10	--	1	1	1	--	--
	10-12	1	--	--	1	--	--
	32-34	--	1	1	1	--	--
	55-56	--	1	1	1	--	--
MW-2	6-8	--	1	1	1	1	1
MW-3	6-8	--	--	--	--	1	1
	8-10	--	1	1	1	--	--
	42-46	--	1	1	1	--	--
MW-4	6-8	--	--	--	--	1	1
	8-10	--	1	1	1	--	--
MW-5 (SB-2)	6-8	--	--	--	--	1	1
	8-10	--	1	1	1	--	--
	31-33	--	1	1	1	--	--
MW-6	6-8	--	--	--	--	1	1
	8-10	--	1	1	1	--	--
MW-7 (SB-3)	6-8	--	1	1	1	--	--
	8-10	--	--	--	--	1	1
	12-14	1	1	1	1	--	--
	30-32	--	1	1	1	--	--
	30-32	1	1	1	1	--	--
	32-34	--	1	1	1	--	--
	40-44	--	1	1	1	--	--
MW-8	16-18	--	1	1	1	--	--
	20-23	--	--	--	--	2	2
Total Samples		**3**	**17**	**17**	**18**	**9**	**9**

ASTM - American Society for Testing and Materials
bgs - below ground surface
ft - feet

Notes:

1. Physical index parameter soil samples collected in plastic sealable bags for Atterberg, particle size, and moisture.
2. Shelby Tube samplers were used to collect soil for permeability testing and also included Atterberg, moisture, and particle size testing.
3. Soil samples for chemical analsysis were collected in laboratory provided jars.
4. Metals - RCRA 8 (Arsenic, Barium, Cadmium, Chromium, Lead, Mercury, Selenium, and Silver), Aluminum, Antimony, Beryllium, Boron, Calcium, Chromium III, Chromium VI, Cobalt, Copper, Iron, Magnesium, Manganese, Molybdenum, Nickel, Thallium, and Zinc.

Table 5
Summary of Physical Index Testing Results for Soil
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

Soil Boring Identification	Soil Sample Depth (ft bgs)	Physical Index Parameter Testing														
		Permeability ASTM D5084 & D7263 (cm/sec)	Atterberg Limit ASTM D4318			Particle Size (ASTM D422)						Moisture ASTM D2216 (%)	Initial Wet Density (pcf)	Initial Dry Density (pcf)	Soil Class	Soil Description
			Liquid Limit	Plastic Limit	Plasticity Index	Gravel %	Sand %	Silt %	Clay %	Maximum Size (mm)	Size<200 Sieve (%)					
MW-1 (SB-1)	6-8	--	52	21	31	0.2	23.0	38.0	38.8	9.5	76.8	20.6	--	--	CH	FAT CLAY with SAND
	8-10	--	54	22	32	0.0	23.3	34.5	42.2	4.75	76.7	20.7	--	--	CH	FAT CLAY with SAND
	10-12	8.0E-08	--	--	--	--	--	--	--	--	--	20.7	127.7	105.9	--	--
	32-34	--	29	16	13	5.1	44.9	27.7	22.3	19	50	15.4	--	--	CL	SANDY LEAN CLAY
	55-56	--	43	24	19	2.2	3.8	27.9	66.1	12.5	94	17.2	--	--	CL	LEAN CLAY
MW-2	6-8	--	49	18	31	0.0	27.7	33.9	38.4	4.75	72.3	17.9	--	--	CL	LEAN CLAY with SAND
MW-3	6-8	--	48	21	27	0.0	24.8	34.3	40.9	4.75	75.2	20.2	--	--	CL	LEAN CLAY with SAND
	42-46	--	37	17	20	1.5	27.9	39.9	30.7	12.5	70.6	15.9	--	--	CL	LEAN CLAY with SAND
MW-4	8-10	--	41	23	18	0.0	8.9	55.3	35.8	4.75	91.1	20.6	--	--	CL	LEAN CLAY
MW-5 (SB-2)	8-10	--	48	21	27	0.0	21.2	40.3	38.5	4.75	78.8	22.1	--	--	CL	LEAN CLAY with SAND
	31-33	--	32	17	15	1.8	33.7	37.8	26.7	19	64.5	13.1	--	--	CL	SANDY LEAN CLAY
MW-6	8-10	--	53	21	32	0.0	24.7	34.7	40.6	4.75	75.3	20.4	--	--	CH	FAT CLAY with SAND
MW-7 (SB-3)	6-8	--	50	21	29	0.1	34.0	36.1	29.8	9.5	65.9	20.9	--	--	CH	SANDY FAT CLAY
	12-14	1.1E-06	24	20	4	0.7	38.4	47.6	13.3	9.5	60.9	20.3	131.5	109.3	CL-ML	SANDY SILTY CLAY
	30-32	1.1E-08	35	17	18	0.9	31.2	37.1	30.8	9.5	67.9	20.5	126.1	101.6	CL	SANDY LEAN CLAY
	30-32		42	20	22	0.0	15.6	40.7	43.7	4.75	84.4	20.4			CL	LEAN CLAY with SAND
	32-34	--	25	15	10	0.0	41.1	24.6	34.3	4.75	58.9	14.6	--	--	CL	SANDY LEAN CLAY
	40-44	--	30	19	11	0.0	2.1	50.0	47.9	2	97.9	9.9	--	--	CL	LEAN CLAY
MW-8	16-18	--	31	17	14	2.0	35.8	32.0	30.2	12.5	62.2	15.3	--	--	CL	SANDY LEAN CLAY
Maximum		**1.10E-06**	**54.0**	**24.0**	**32.0**	**5.1**	**44.9**	**55.3**	**66.1**	**19.0**	**97.9**	**22.1**	**131.5**	**109.3**	**--**	**--**
Average		**3.97E-07**	**40.2**	**19.4**	**20.7**	**0.8**	**25.7**	**37.4**	**36.2**	**8.5**	**73.5**	**18.2**	**128.4**	**105.6**	**--**	**--**
Minimum		**1.10E-08**	**24.0**	**15.0**	**4.0**	**0.0**	**2.1**	**24.6**	**13.3**	**2.0**	**50.0**	**9.9**	**126.1**	**101.6**	**--**	**--**

% - percent
ASTM - American Society for Testing and Materials
bgs - below ground surface
cm/sec - centimeter per second
ft - feet
mm - millimeter
pcf - pounds per cubic foot

Notes:
1. Shelby Tube samplers were used to collect soil for permeability testing.
2. Split-spoon/barrel samplers were used to collect soil for Atterberg limits, moisture content, and particle size (soil placed in sealed bags).

Table 6
Summary of Soil Analytical Results
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

	Location Code	MW-1 / SB01 6-8 ft bgs				MW-2 / SB01 6-8 ft bgs				MW-3 / SB01 6-8 ft bgs				MW-4 / SB01 6-8 ft bgs				MW-5 / SB01 6-8 ft bgs				MW-6 / SB01 6-8 ft bgs				MW-7 / SB01 8-10 ft bgs				MW-8 / SB02 20'-23' bgs				MW-8 / SB11 (Duplicate) 20'-23' bgs			
	Sample No.	60245163002				60245163001				60244777001				60244415002				60244777004				60245163003				60244415001				60244777002				60244777003			
	Date	23-May-17				22-May-17				17-May-17				16-May-17				19-May-17				25-May-17				15-May-17				18-May-17				18-May-17			
Parameter	Units	Result	Val Qual	RL	DF	Result	Val Qual	RL	DF	Result	Val Qual	RL	DF	Result	Val Qual	RL	DF	Result	Val Qual	RL	DF	Result	Val Qual	RL	DF	Result	Val Qual	RL	DF	Result	Val Qual	Rl	DF	Result	Val Qual	RL	DF
Percent Moisture	%	**16.3**		0.5	1.0	**20.8**			1.0	**17.1**		0.5	1.0	**18.9**		0.5	1.0	**17.5**		0.5	1.0	**18.5**		0.5	1.0	**12.3**		0.5	1.0	**14.0**		0.5	1.0	**13.2**		0.5	1.0
Metals																																					
Aluminum	mg/kg	**14900**			2.0	**29700**		8.2	1.0	**18200**		7.9	1.0	**14600**		8.7	1.0	**9560**		23.5	3.0	**14200**		23.0	3.0	**7860**		7.6	1.0	**7500**		7.3	1.0	**8610**		8.5	1.0
Antimony	mg/kg	0.7	U	0.7	1.0	1.1	U	1.1	1.0	1.1	U	1.1	1.0	1.2	U	1.2	1.0	2.1	U,D3	2.1	2.0	2.0	U	2.0	2.0	1.0	U	1.0	1.0	0.97	U	0.97	1.0	1.1	U	1.1	1.0
Arsenic	mg/kg	**2.8**		0.7	1.0	**8.7**		1.1	1.0	**5.5**		1.1	1.0	**12.3**		1.2	1.0	**14.8**		2.1	2.0	**7.3**		2	2.0	**8.3**		1.0	1.0	**4.6**		0.97	1.0	**4**		1.1	1.0
Barium	mg/kg	**64.8**		0.7	2.0	**113**		0.54	1.0	**254**		0.53	1.0	**185**		0.58	1.0	**108**		1.6	3.0	**172**		1.5	3.0	**55.3**		0.51	1.0	**47.4**		0.48	1.0	**52**		0.56	1.0
Beryllium	mg/kg	**0.58**		0.14	2.0	**0.5**		0.11	1.0	**0.63**		0.11	1.0	**0.77**		0.12	1.0	**2.5**		0.31	3.0	**2.1**		0.31	3.0	**0.8**		0.1	1.0	**0.54**		0.097	1.0	**0.51**		0.11	1.0
Boron	mg/kg	7.0	U	7.0	1.0	10.9	U	10.9	1.0	10.6	U	10.6	1.0	11.6	U	11.6	1.0	20.9	U	20.9	2.0	20.5	U	20.5	2.0	10.2	U	10.2	1.0	9.7	U	9.7	1.0	11.3	U	11.3	1.0
Cadmium	mg/kg	0.35	U	0.35	1.0	0.54	U	0.54	1.0	0.53	U	0.53	1.0	0.58	U	0.58	1.0	1	U,D3	1	2.0	1.0	U	1.0	2.0	0.51	U	0.51	1.0	0.48	U	0.48	1.0	**1**		0.56	1.0
Calcium	mg/kg	**3020**		14.1	2.0	**3910**		10.9	1.0	**2710**		10.6	1.0	**6730**		11.6	1.0	**3030**		31.4	3.0	**3850**		30.7	3.0	**1510**		10.2	1.0	**15000**		9.7	1.0	**16800**		11.3	1.0
Chromium	mg/kg	**18.7**		0.35	1.0	**29.1**		0.54	1.0	**22.4**		0.53	1.0	**20.1**		0.58	1.0	**15.1**		1	2.0	**28.5**		1.0	2.0	**11.8**		0.51	1.0	**12.3**		0.48	1.0	**14.4**		0.56	1.0
Chromium, Hexavalent	mg/kg	2.3	U	2.3	1.0	2.6	U	2.6	1.0	2.4	U	2.4	1.0	5.0	U	5.0	2.0	2.3	U	2.3	1.0	2.5	U	2.5	1.0	2.3	U	2.3	1.0	2.3	U	2.3	1.0	2.3	U	2.3	1.0
Cobalt	mg/kg	**1.8**		0.35	1.0	**18.3**		0.54	1.0	**38.5**		0.53	1.0	**7.7**		0.58	1.0	**41.7**		1	2.0	**8.4**		1.0	2.0	**6.3**		0.51	1.0	**7.1**		0.48	1.0	**9.7**		0.56	1.0
Copper	mg/kg	**9.4**		0.7	1.0	**9.3**		1.1	1.0	**11**		1.1	1.0	**12.4**		1.2	1.0	**13.9**		2.1	2.0	**12.8**		2.0	2.0	**8.8**		1.0	1.0	**13.3**		0.97	1.0	**15.8**		1.1	1.0
Iron	mg/kg	**12800**		7.0	2.0	**17500**		5.4	1.0	**19200**		5.3	1.0	**20100**		5.8	1.0	**20000**		15.7	3.0	**17400**		15.3	3.0	**16100**		5.1	1.0	**12900**		4.8	1.0	**9870**		5.6	1.0
Lead	mg/kg	**7.1**		0.35	1.0	**13.8**		0.54	1.0	**10.1**		0.56	1.0	**12.6**		0.58	1.0	**12**		1.5	3.0	**7.5**		1.0	2.0	**4.6**		0.51	1.0	**10.7**		0.52	1.0	**8.7**		0.53	1.0
Magnesium	mg/kg	**1590**		3.5	1.0	**2420**		5.4	1.0	**1550**		5.3	1.0	**2100**		5.8	1.0	**1710**		10.5	2.0	**2300**		10.2	2.0	**1190**		5.1	1.0	**2770**		4.8	1.0	**2890**		5.6	1.0
Manganese	mg/kg	**25.6**		0.35	1.0	**102**		0.54	1.0	**2290**		0.53	1.0	**171**		0.58	1.0	**568**		1	2.0	**168**		1.0	2.0	**322**		0.51	1.0	**283**		0.48	1.0	**148**		0.56	1.0
Mercury	mg/kg	0.047	U	0.047	1.0	0.063	U	0.063	1.0	0.057	U	0.057	1.0	**0.030**		0.029	1.0	0.038	U	0.038	1.0	0.046	U	0.046	1.0	0.052	U	0.1	1.0	0.048	U	0.048	1.0	0.038	U	0.038	1.0
Molybdenum	mg/kg	1.4	U	1.4	1.0	2.2	U	2.2	1.0	2.1	U	2.1	1.0	2.3	U	2.3	1.0	4.2	U,D3	4.2	2.0	4.1	U	4.1	2.0	2.0	U	2.0	1.0	1.9	U	1.9	1.0	2.3	U	2.3	1.0
Nickel	mg/kg	**8.5**		0.35	1.0	**9.4**		0.54	1.0	**24.5**		0.53	1.0	**17.1**		0.58	1.0	**23.7**		1	2.0	**38.8**		1.0	2.0	**15.9**		0.51	1.0	**18.3**		0.48	1.0	**25.5**		0.56	1.0
Selenium	mg/kg	1.1	U	1.1	1.0	1.6	U	1.6	1.0	1.6	U	1.6	1.0	1.7	U	1.7	1.0	3.1	U,D3	3.1	2.0	3.1	U	3.1	2.0	1.5	U	1.5	1.0	1.5	U	1.5	1.0	1.7	U	1.7	1.0
Silver	mg/kg	0.49	U	0.49	1.0	0.76	U	0.76	1.0	0.74	U	0.74	1.0	0.81	U	0.81	1.0	1.5	U,D3	1.5	2.0	1.4	U	1.4	2.0	0.71	U	0.71	1.0	0.68	U	0.68	1.0	0.79	U	0.79	1.0
Thallium	mg/kg	1.4	U	1.4	1.0	2.2	U	2.2	1.0	2.1	U	2.1	1.0	2.3	U	2.3	1.0	4.2	U,D3	4.2	2.0	4.1	U	4.1	2.0	2.0	U	2	1.0	1.9	U	1.9	1.0	2.3	U	2.3	1.0
Zinc	mg/kg	**21.7**		7.0	1.0	**28.0**		10.9	1.0	**22.9**		10.6	1.0	**48.0**		11.6	1.0	**88.8**		20.9	2.0	**42.0**		20.5	2.0	**27.4**		10.2	1.0	**39.7**		9.7	1.0	**48.2**		11.3	1.0
Radionuclide																																					
Radium-226	pCi/g	**1.159 +/- 0.267**	Ra	0.266	--	**0.995 +/- 0.235**	Ra	0.130	--	**1.096 +/- 0.233**	Ra	0.191	--	**1.380 +/- 0.346**	Ra	0.249	--	**1.197 +/- 0.287**	Ra	0.181	--	**1.242 +/- 0.277**	Ra	0.192	--	**1.062 +/- 0.248**	Ra	0.182	--	**2.086 +/- 0.408**	Ra	0.178	--	**2.250 +/- 0.371**	Ra	0.213	--
Radium-228	pCi/g	**1.394 +/- 0.472**		0.244	--	**1.180 +/- 0.348**		0.229	--	**1.559 +/- 0.384**		0.175	--	**2.158 +/- 0.575**		0.430	--	**1.574 +/- 0.263**		0.263	--	**1.397 +/- 0.368**		0.187	--	**0.924 +/- 0.275**		0.121	--	**1.078 +/- 0.409**		0.319	--	**1.361 +/- 0.346**		0.157	--
Rd-226/228 Combined	pCi/g	**2.553**				**2.175**				**2.655**				**3.538**				**2.771**				**2.639**				**1.986**				**3.164**				**3.611**			

Bold - constituent detected in soil.

% - percent

bgs - below ground surface

D3 - Laboratory qualifier; Sample was diluted due to the presence of high levels of non-target analytes or other matirx interference.

mg/kg - milligrams per kilogram

pCi/g - picoCuries per gram

Ra - The reported Ra-226 results were determined by hermetically sealing the dried, processed sample in an appropriate sized can. Each sample was stored for a minimum of 21 days to ensure that equilibrium between Ra-226 and daughters Bi-214 and Pb-214 was achieved. Reported Ra-226 results were inferred from gamma peaks attributable to Bi-214 and Pb-214.

U - Qualified as non-detect; Sample not detected at or above laboratory reporting limit (not detected).

Notes:

Metals Analytical Method EPA 6010, Preparation Method EPA 3050

Mercury Analytical Method EPA 7471, Preparation Method EPA 7471

Percent Moisture Analytical Method ASTM D2974

Chromium, Hexavalent Analytical Method EPA 7196A, Preparation Method EPA 3060A

Radium 226/228 Analytical Method EPA 901.1, reported on a "dry-weight" basis

Table 7
Summary of Hydraulic Conductivity Results
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

Monitoring Well	Test Date	Rising Head Test Method	Estimated Hydraulic Conductivity (cm/sec)		Average Hydraulic Conductivity		
			Bouwer-Rice	Hvorslev	(cm/sec)	(ft/sec)	(ft/day)
Sand C							
MW-1	6/14/2017	Pump	4.17E-04	8.16E-05	2.49E-04	8.18E-06	0.71
MW-2	6/14/2017	Pump	5.22E-07	9.54E-08	3.09E-07	1.01E-08	0.00088
MW-3	6/13-14/2017	Pump	9.60E-05	1.89E-05	5.74E-05	1.88E-06	0.163
MW-4	6/13-14/2017	Pump	6.01E-05	1.03E-05	3.52E-05	1.15E-06	0.100
MW-5	6/19-25/2017	Pump	3.82E-07	7.74E-08	2.30E-07	7.54E-09	0.00065
MW-6	6/19-22/2017	Pump	5.95E-06	1.04E-06	3.50E-06	1.15E-07	0.0099
MW-7	6/13/2017	Bailer	2.86E-07	1.04E-07	1.89E-07	6.21E-09	0.00054
	6/19-22/2017	Bailer	2.65E-07	1.02E-07			
MW-8	6/14-15/2017	Pump	3.03E-05	5.68E-06	1.80E-05	5.90E-07	0.051
PZ-2	6/15-16/2017	Pump	1.22E-05	3.36E-06	7.77E-06	2.55E-07	0.022
PZ-4	6/15/2017	Pump	4.09E-04	1.08E-04	2.59E-04	8.48E-06	0.73
PZ-6	6/14-15/2017	Pump	1.74E-05	4.67E-06	1.10E-05	3.62E-07	0.03
				Maximum K	**2.59E-04**	**8.48E-06**	**0.73**
				Average K	**5.83E-05**	**1.91E-06**	**0.17**
				Minimum K	**1.89E-07**	**6.21E-09**	**0.00054**

cm/sec. - centimeters per second

K = hydraulic conductivity

Notes:

1. Bouwer-Rice (1976) and Hvorslev (1951) calculations computed by AQTESOLV software by inputting slug test field data.
2. Slug out using bailer for MW-7 test due to minimal water column.
3. AQTESOLV K plots provided in Appendix K.

Table 8
Summary of Well Yield Test Results
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

Well ID	Estimated Direct Well Yield: 2-inch Well			Equivalent Well Yield	
	Field Calculated		Average GPD	4-inch Well: Average GPD	12-inch Well: Average GPD
	GPM	GPD	Glacial Drift	Glacial Drift	Glacial Drift
Flyash Landfill Area					
MW-1	0.07	104.2	104.2	114.6	135.5
MW-2	0.011	15.8	15.8	17.3	20.5
MW-3	0.058	84.1	84.1	92.5	109.3
MW-4	0.050	71.3	71.3	78.4	92.7
MW-5	0.0012	1.7	1.7	1.8	2.2
MW-6	0.0061	8.8	8.8	9.7	11.5
MW-7	0.00076	1.1	0.8	0.8	1.0
	0.00031	0.4			
MW-8	0.029	41.2	41.2	45.3	53.5
PZ-2	0.0097	13.9	13.9	15.3	18.1
PZ-4	0.48	693.2	**693.2**	**762.6**	**901.2**
PZ-6	0.015	22.3	22.3	24.5	28.9

GPD = gallons per day
GPM = gallons per minute

Notes:

1. Equivalent well yield for 4-inch and 12-inch diameter well screens calculated by multiplying the direct well yield test results from the 2-inch diameter well screens by a conversion factor of 1.10 and 1.30, respectively (TECQ, 2010).

2. **Bold** equivalent well yield results are greater than 150 gallons per day (~0.1 gpm) in 4-inch diameter well screen and represents sufficient groundwater bearing unit (TECQ, 2010). Unbold equivalent well yield results are below 150 gallons per day well yield and not representative of a sufficient groundwater bearing unit.

3. **Bold** equivalent well yield results are greater than 360 gallons per day (~0.25 gpm) from a 6-inch diameter well and represents sufficient groundwater bearing unit for potential source of domestic consumption (MDNR, 2006). Unbold equivalent well yield results are below 360 gallons per day well yield and not representative of a sufficient groundwater bearing unit.

Table 9
Summary of Groundwater Depths and Elevations
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

	Date	6/19/2017	6/19/2017	6/26/2017	6/26/2017	7/3/2017	7/3/2017	7/20/2017	7/20/2017	8/23/2017	8/23/2017	11/8/2017	11/8/2017	11/16/2017	11/16/2017
Well ID	**Top of Casing Elev. (feet)**	**Depth to Water (ft)**	**Water Elev. (ft)**	**Depth to Water (ft)**	**Water Elev. (ft)**	**Depth to Water (ft)**	**Water Elev. (ft)**	**Depth to Water (ft)**	**Water Elev. (ft)**	**Depth to Water (ft)**	**Water Elev. (ft)**	**Depth to Water (ft)**	**Water Elev. (ft)**	**Depth to Water (ft)**	**Water Elev. (ft)**
MW-1	769.82	28.28	741.54	28.36	741.46	28.27	741.55	28.29	741.53	28.58	741.24	28.64	741.18	28.65	741.17
MW-2	781.03	27.88	753.15	28.27	752.76	23.30	757.73	19.67	761.36	19.13	761.90	18.94	762.09	18.80	762.23
MW-3	781.13	16.53	764.60	16.83	764.30	16.82	764.31	17.05	764.08	17.66	763.47	18.51	762.62	18.83	762.30
MW-4	785.02	22.60	762.42	22.84	762.18	22.82	762.20	22.90	762.12	23.49	761.53	24.12	760.90	24.42	760.60
MW-5	769.61	13.45	756.16	14.11	755.50	12.94	756.67	12.67	756.94	12.63	756.98	13.36	756.25	13.80	755.81
MW-6	770.07	15.15	754.92	15.28	754.79	15.21	754.86	15.29	754.78	15.70	754.37	16.60	753.47	16.60	753.47
MW-7	762.23	29.44	732.79	29.30	732.93	28.58	733.65	26.23	736.00	22.27	739.96	20.02	742.21	20.57	741.66
MW-8	753.09	7.83	745.26	8.28	744.81	8.24	744.85	8.44	744.65	8.55	744.54	10.48	742.61	10.23	742.86
PZ-1	770.78	16.36 Dry	Dry	Dry	Dry	16.61 Dry	Dry	Dry	Dry	Dry	Dry	na	na	na	na
PZ-2	755.91	8.43	747.48	8.49	747.42	8.51	747.40	8.33	747.58	8.40	747.51	9.05	746.86	9.16	746.75
PZ-3	769.94	11.31	758.63	12.56	757.38	11.99	757.95	12.31	757.63	14.34	755.60	na	na	na	na
PZ-4	752.06	6.65	745.41	6.97	745.09	7.00	745.06	7.21	744.85	8.02	744.04	8.52	743.54	8.68	743.38
PZ-5	770.02	13.80	756.22	Dry	Dry	15.20	754.82	15.78	754.24	14.65	755.37	na	na	na	na
PZ-6	755.60	6.25	749.35	6.65	748.95	6.53	749.07	6.86	748.74	7.26	748.34	7.95	747.65	8.11	747.49
More's Lake	751.85	5.17	749.02	3.30	747.15	4.00	747.85	5.00	748.85	4.50	748.35	4.70	748.55	na	na

Notes:
PZ-1 TD = 16.42
PZ-5 TD = 16.09
Top of Pond Post = 753.43
Top of pond staff Gauge = 751.85 (top number 8.00')
Taken 6/20/2017 <24hrs

Table 10
Estimated Maximum Groundwater Velocity
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

Hydraulic Gradient:

$$i = \frac{dh}{dL}$$

Where:
- i = estimated maxiumum hydraulic gradient (feet/foot)
- dh = head difference between data points (feet)
- dL = horizontal distance over which head difference occurs (feet)

$$i_{max} = \frac{5 \text{ ft}}{90 \text{ ft}}$$ (between 750' and 745' contours - see Figure 6)

i_{max} = 0.056 feet/feet

Estimated Linear Groundwater Velocity:

$$V = \frac{k \times i}{n_e}$$

Where:
- V_{max} = estimated maximum linear groundwater velocity (feet/day)
- k_{max} = estimated maximum hydraulic conductivity
  - = 2.59E-04 cm/sec (see slug test results in Table 7)
  - = 0.73 ft/day
- i = estimated hydraulic gradient (ft/ft)
- n_{emin} = effective porosity (percent)
  - = 0.06 (The minimum effective porosity for till is assumed to be 6%)

$$V_{max} = \frac{(0.71 \text{ ft/day})*(0.056 \text{ ft/ft})}{0.06}$$

V_{max} = 0.679 ft/day

V_{max} = 247.74 ft/year

Note: The information contained in this table relates to Table 7 and Figure 6.

Table 11
Estimated Minimum Groundwater Velocity
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

Hydraulic Gradient:

$$i = \frac{dh}{dL}$$

Where:
- i = hydraulic gradient (feet/foot)
- dh = head difference between data points (feet)
- dL = horizontal distance over which head difference occurs (feet)

$$i_{min} = \frac{5 \quad ft}{245 \quad ft}$$ (between 750' and 745' contours - see Figure 6)

i_{min} = 0.020 feet/feet

Estimated Linear Groundwater Velocity:

$$V_{min} = \frac{k_{min} \times i_{min}}{n_e}$$

Where:
- V = estimated linear groundwater velocity (feet/day)
- k_{min} = estimated minimum hydraulic conductivity
  - = 1.89E-07 cm/sec (see slug test results in Table 7)
  - = 0.00054 ft/day
- i_{min} = 0.020 feet/foot
- n_e = effective porosity (percent)
  - = 0.15 (The maximum effective porosity for till is assumed to be 15%)

$$V_{min} = \frac{(5.4 \times 10^{-4} \text{ ft/day})*(0.020 \text{ ft/ft})}{0.15}$$

V_{min} = 0.0001 ft/day

V_{min} = 0.027 ft/year

Note: The information contained in this table relates to Table 7 and Figure 6.

Table 12
Summary of Water Supply Well Search Results
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

MGS Well ID	PDWS ID	Well Type	Owner	Date Drilled	Depth Drilled (ft)	Depth to Bedrock (ft)	Static Water Level After Drilling (ft)	Elevation (ft amsl)	Water Elevation (ft amsl)	Production (GMP)	Section	Township	Range	Quarter Section
Wells within 0.5 mile of CCR Unit														
009526	3010180	Community Public Well	City of Columbia Well #9	5/31/1957	1,505	70	347	782	435	850	6	48N	11 W	NW, SE, SW
009527	3010181	Community Public Well	City of Columbia Well #10	6/1/1957	1,505	70	347	782	435	850	6	48N	12 W	NW, SE, SW
003229	3010181	Community Public Well	City of Columbia Well #9	5/1/1935	1,200	80	321	778	457	1,100	6	48 N	12 W	NE, SE, SW
001657	3010181	Community Public Well	City of Columbia Well #4	10/11/1911	879	60	283	780	497	not used	6	48 N	12 W	C, SW, SE
001641	3010181	Community Public Well	City of Columbia Well #5	1911	818	45	204	785	581	na	6	48 N	12 W	C, SW, SE
002219	3010181	Community Public Well	City of Columbia Well #8	1928	1,200	50	337	777	440	1,000	6	48 N	12 W	C, SW, SE
na	na	Domestic	Little Dixe Construction	2013	730	35	300	na	na	100	6	48 N	12 W	C, SW, SE
na	na	Domestic	Manor Woods	2016	600	85	220	na	na	150	6	48 N	12 W	NW
019660	na	Community Public Well	Robinwood Subdivision	1/10/1961	626	35	300	743	443	38	6	48 N	12 W	NE, SE, NW
Wells within 1.0 mile of CCR Unit														
009526	3010180	Community Public Well	City of Columbia Well #9	5/31/1957	1,505	70	347	782	435	850	6	48N	11 W	NW, SE, SW
009527	3010181	Community Public Well	City of Columbia Well #10	6/1/1957	1,505	70	347	782	435	850	6	48N	12 W	NW, SE, SW
003229	3010181	Community Public Well	City of Columbia Well #9	5/1/1935	1,200	80	321	778	457	1,100	6	48 N	12 W	NE, SE, SW
001657	3010181	Community Public Well	City of Columbia Well #4	10/11/1911	879	60	283	780	497	not used	6	48 N	12 W	C, SW, SE
001641	3010181	Community Public Well	City of Columbia Well #5	1911	818	45	204	785	581	na	6	48 N	12 W	C, SW, SE
002219	3010181	Community Public Well	City of Columbia Well #8	1928	1,200	50	337	777	440	1,000	6	48 N	12 W	C, SW, SE
na	na	Domestic	Little Dixe Construction	2013	730	35	300	na	na	100	6	48 N	12 W	C, SW, SE
na	na	Domestic	Manor Woods	2016	600	85	220	na	na	150	6	48 N	12 W	NW
019660	na	Community Public Well	Robinwood Subdivision	1/10/1961	626	35	300	743	443	38	6	48 N	12 W	NE, SE, NW
006312	na	Private Well	Jones, Roy	6/14/1940	305	10	na	670	na	15	13	48 N	13 W	na
028467	na	Noncommunity Public Well	Columbia Country Club	12/29/1980	1,095	5	na	705	na	na	7	48 N	12 W	C, SW, SE
017793	na	Private Well	Hollingsworth, D.B.	8/1/1958	166	15	na	676	na	3	31	49 N	12 W	SW, SW
016914	na	Private Well	Proctor, R.L.	11/10/1957	520	20	na	670	na	na	1	48 N	13 W	NW, NE, NE
012240	3010181	Community Public Well	City of Columbia Well #12	3/20/1953	1,100	35	275	711	436	986	8	48 N	12 W	NE, NW, NW

Table 12
Summary of Water Supply Well Search Results
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

MGS Well ID	PDWS ID	Well Type	Owner	Date Drilled	Depth Drilled (ft)	Depth to Bedrock (ft)	Static Water Level After Drilling (ft)	Elevation (ft amsl)	Water Elevation (ft amsl)	Production (GMP)	Section	Township	Range	Quarter Section
Wells within 1.0 mile of CCR Unit (continued)														
013687	na	Private Well	Guitar	2/15/1955	330	35	na	736	na	na	36	49 N	13 W	SE, SE
010158	3010181	Community Public Well	City of Columbia Well #11	5/1/1948	1,200	na	376	806	430	791	5	48 N	12 W	SW, NW, NW
023028	na	Community Public Well	The Colonel's Court MHP	3/14/1964	700	25	na	698	na	na	36	49 N	13 W	SE, SE, SE
001523	na	Private Well	Flat Branch	na	890	na	40	761	721	na	12	48 N	13 W	NE, NE, SW
4213	na	Noncommunity Public Well	Central Dairy	5/8/1937	933	45	45	763	718	40+	12	48 N	13 W	NE, SE, SE
na	na	High Yield Open Loop Heat Pump Supply Well	Boone Electric CO-OP Well #1	12/3/1995	805	110	360	na	na	100	1	48 N	13 W	na
na	na	High Yield Open Loop Heat Pump Return Well	Boone Electric CO-OP Well #2	12/4/1995	840	115	360	na	na	250	1	48 N	13 W	na
na	na	High Yield Open Loop Heat Pump Return Well	Boone Electric CO-OP Well #2	na	890	60	na	na	na	200	1	48 N	13 W	na
na	na	High Yield Open Loop Heat Pump Return Well	Boone Electric CO-OP Well #2	6/4/1999	885	65	na	na	na	180	1	48 N	13 W	na

amsl - above mean sea level
ft - feet
GPM - gallons per minute
MGS - Missouri Geological Survey
PDWS - Public Drinking Water Supply

Notes:
1. Refer to Appendix B with City Well #10 (Old Well #4), City Well #11 (Old Well #5), and Flat Branch Well drill logs.
2. Refer to Appendix Q with Boone County Public Drinking Water Supply System (PDWSS) Reports.

Sources:
MGS, Geosciences Technical Resource Assessment Tool (GeoSTRAT), Water Resources, http://dnr.mo.gov/geostrat/.
Well Information Management Systme (WIMS), Wellhead Online Services, Missouri Department of Natural Resources, Well https://dnr.mo.gov/mowells/publicLanding.do

Table 13
Laboratory Analysis of Groundwater
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

CCR Groudwater Monitoring Constituents*				
Constituent	**Analytical Method**	**Sample Container**	**Sample Preservation**	**Holding Time**
Organics / Water Quality				
Sulfate*	EPA Method 300.0	250 mL, HDPE or glass	None required, Cool to 4°C	Analyzed--28 days
Total Organic Carbon (TOC)	SM310B,C,D or EPA Method 9060A	Glass	pH<2 H_2SO_4 or HCl; ≤6°C	Analyzed--28 days
Total Organic Halogens (TOX)	SM5320 or EPA Method 9020/9021	Glass; no headspace	≤6°C	Analyzed--14 days
Inorganics / Water Quality				
Chemical Oxygen Demand (COD)	SM5220C,D, 410.4, or Hach 8000	HDPE or glass	pH<2 H_2SO_4; ≤6°C	Analyzed--28 days
Chloride*	EPA Method 300.0	250 mL, HDPE or glass	None required, Cool to 4°C	Analyzed--28 days
Fluoride*	EPA Method 300.0 or 300.1	250 mL, HDPE or glass	None required	Analyzed--28 days
pH*	SM 4500 H-B	100 mL, HDPE or glass	None required	Analyzed -- 24 hrs
Hardness, as CaCO3	SM2370B,C/130.1	HDPE or glass	pH<2 HNO_3	Analyzed--6 months
Total Dissolved Solids (TDS)*	SM 2540 C	1 L, HDPE or glass	None required, Cool to 4°C	Analyzed -- 7 days
Metals, Total				
Aluminum Antimony** Arsenic** Barium** Beryllium** Boron* Cadmium** Calcium* Chromium** **Chromium III** Cobalt** **Copper** **Iron** Lead** Lithium** **Magnesium** **Manganese** Molybdenum** **Nickel** Selenium** **Silver** **Sodium** Thallium** **Zinc**	SW-846 6010B or SW-846 6020	500 mL, HDPE or glass	Nitric Acid (HNO_3) pH<2 Cool to 4°C	Analyzed--6 months
Chromium VI	7196, 218.6, or SM3500Cr -C,D	HDPE or glass	≤6°C	**Analyzed -- 24 hours**
Mercury**	EPA 7470 or 245.1	250 mL, HDPE or glass	Nitric Acid (HNO_3) pH<2 Cool to 4°C	Analyzed--28 days
Radionuclides				
Radium 226**	EPA 903.0	1.0 L, HDPE or glass	Nitric Acid (HNO_3) pH<2	Analyzed--6 months
Radium 228**				

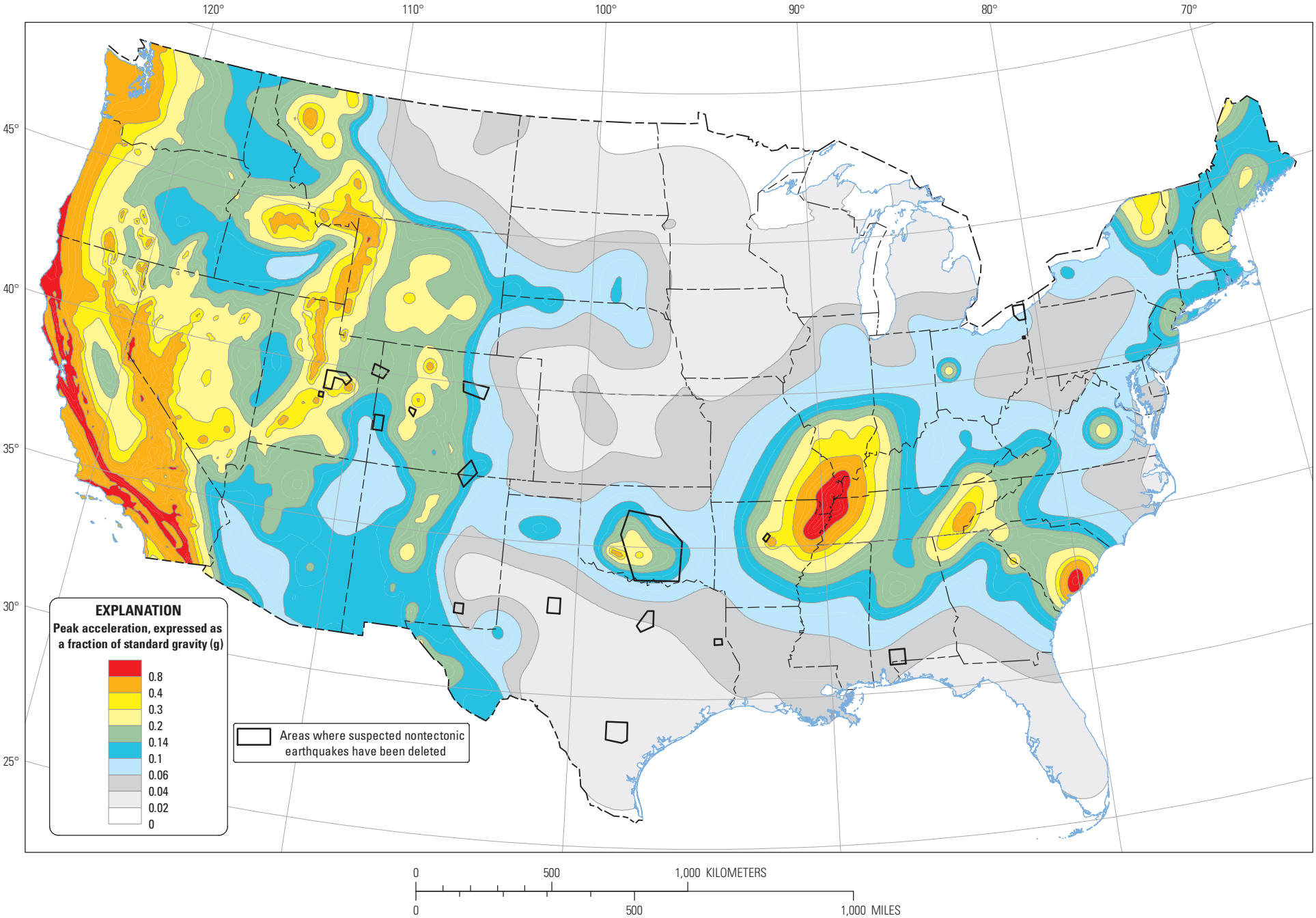
*Constituents included in USEPA CCR Rule, Appendix III (Detection Monitoring) to 40 CFR Part 257.
**Constituents included in USEPA CCR Rule, Appendix IV (Assessment Monitoring) to 40 CFR Part 257.

Bold Constituent = exclusive MDNR groundwater monitoring parameter listed in MDNR CCR Storage and Disposal Sites in Missouri, Division of Environmental Quality (MDNR white paper).

Noted analytical method(s) and sample container(s) are for typical method requirements. These may vary slightly by method updates and/or laboratory sample volume preferences.

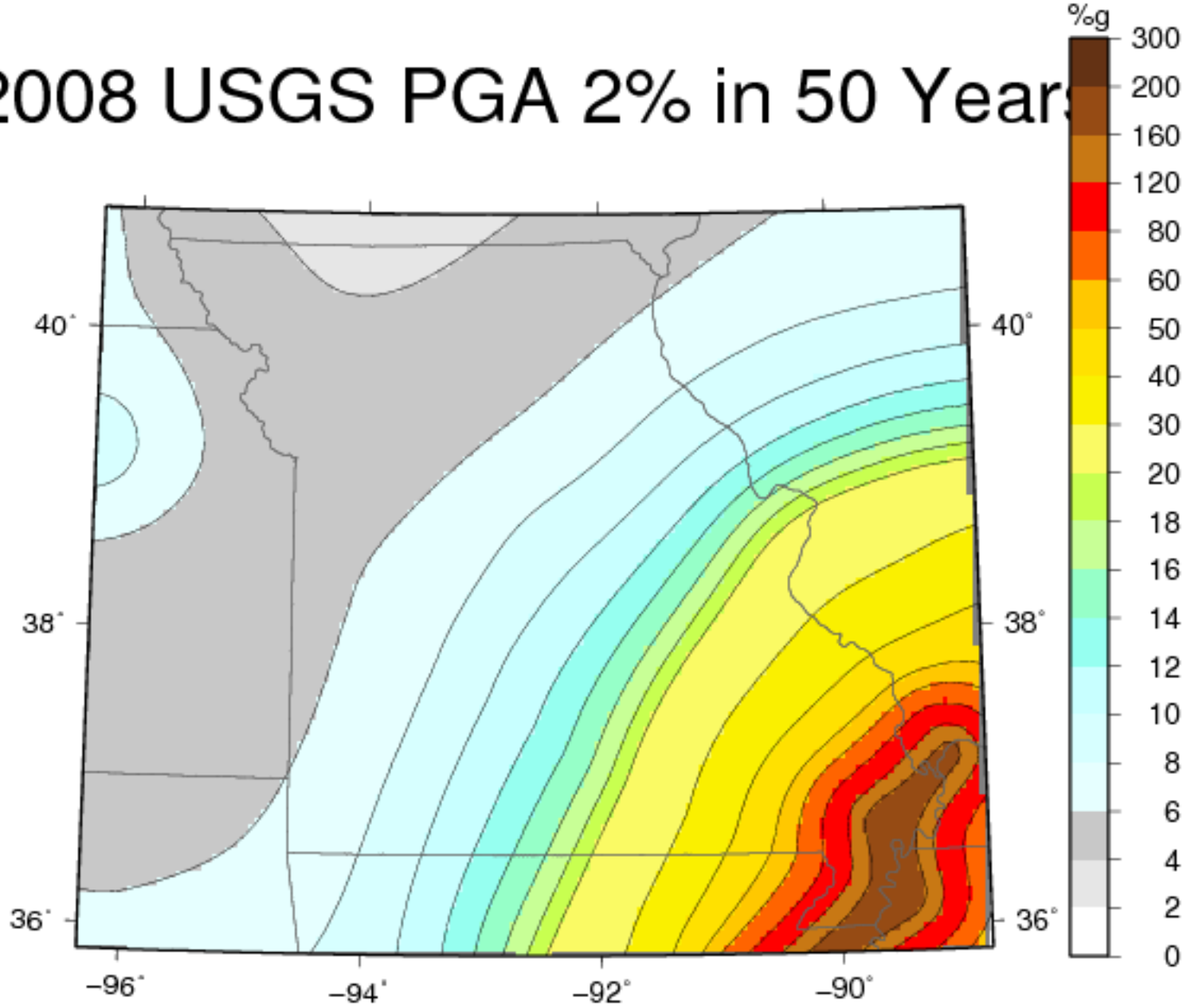
HDPE = high density polyethylene
HNO_3 = nitric acid
H_2SO_4 = sulfuric acid
HCl = hydrochloric acid
°C = degrees Celsius

APPENDIX A – USGS EARTHQUAKE HAZARD MAPS



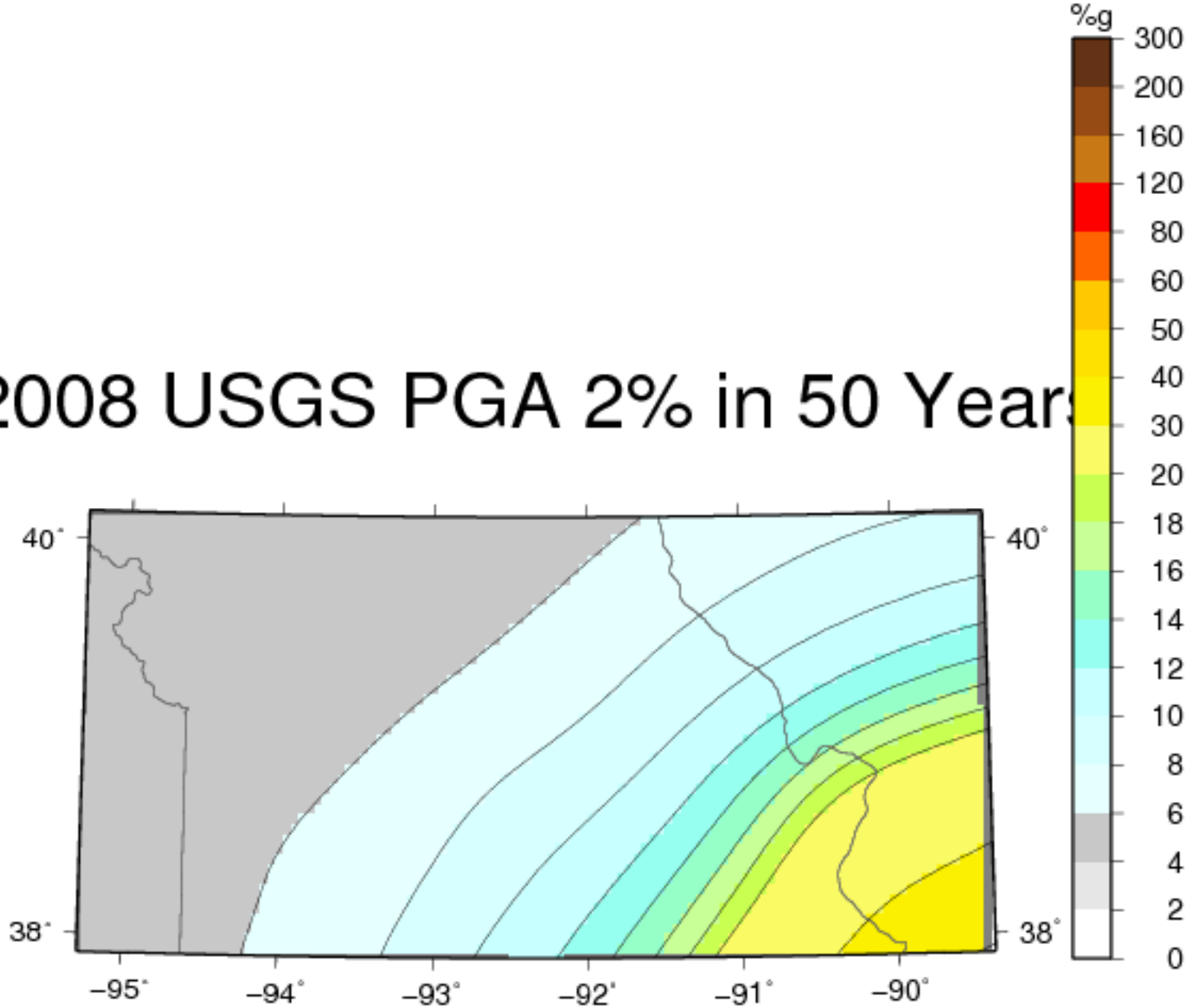
Two-percent probability of exceedance in 50 years map of peak ground acceleration

2008 USGS PGA 2% in 50 Years

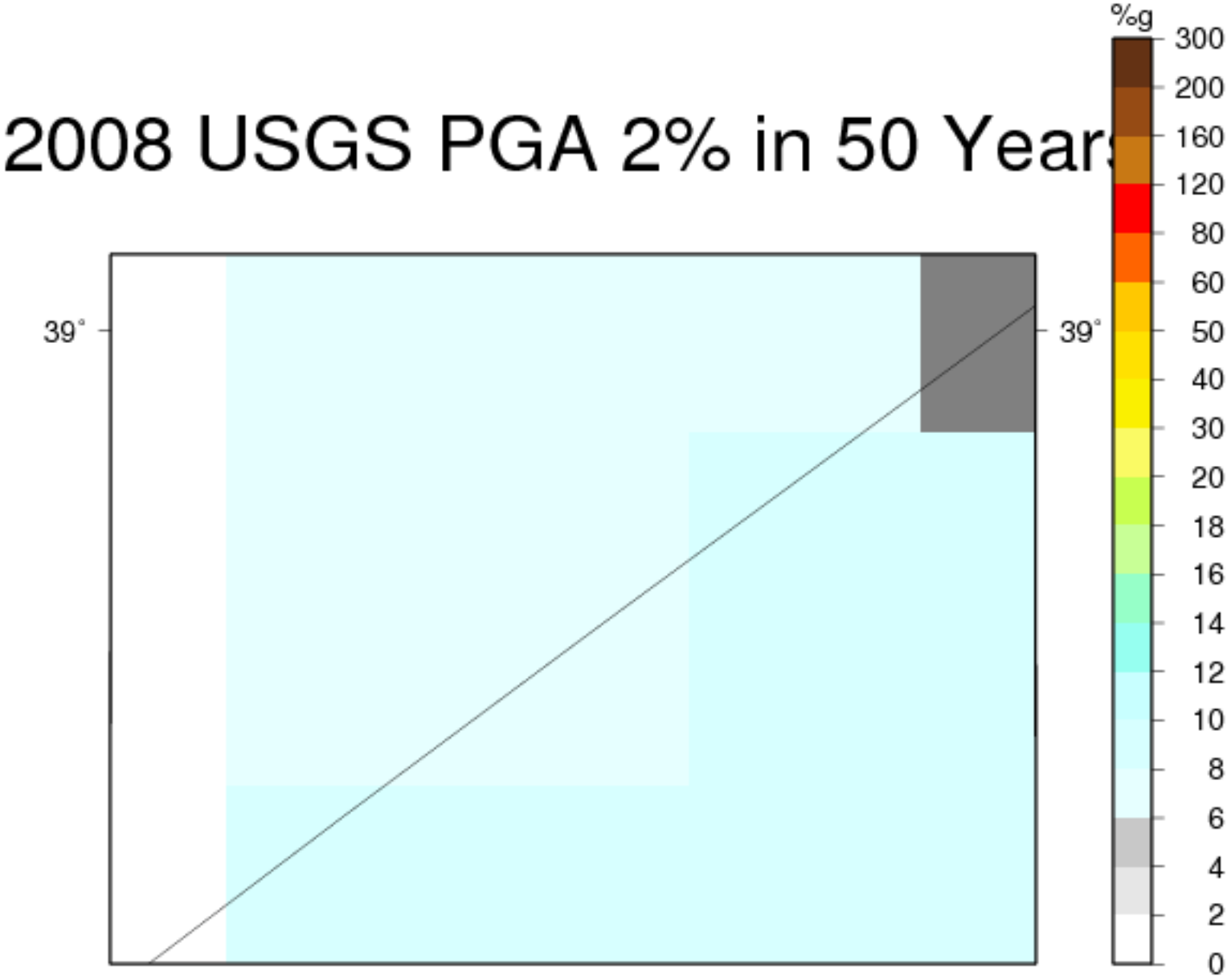


Peak Ground Acceleration

2008 USGS PGA 2% in 50 Years



Peak Ground Acceleration

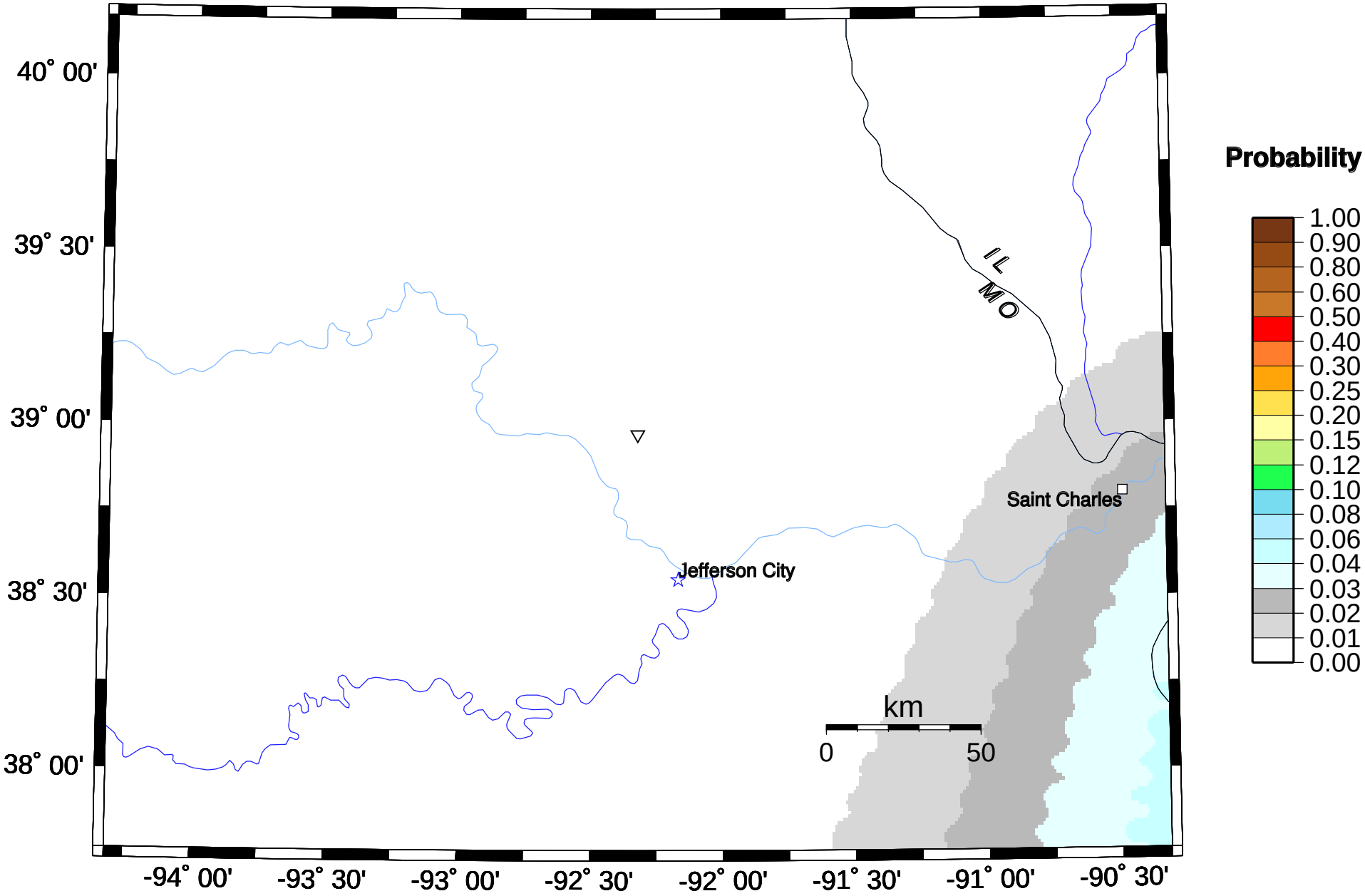


Peak Ground Acceleration

Probability of earthquake with M > 5.0 within 50 years & 50 km

U.S. Geological Survey 2009 PSHA Model

Site: -92.32 d E 38.97

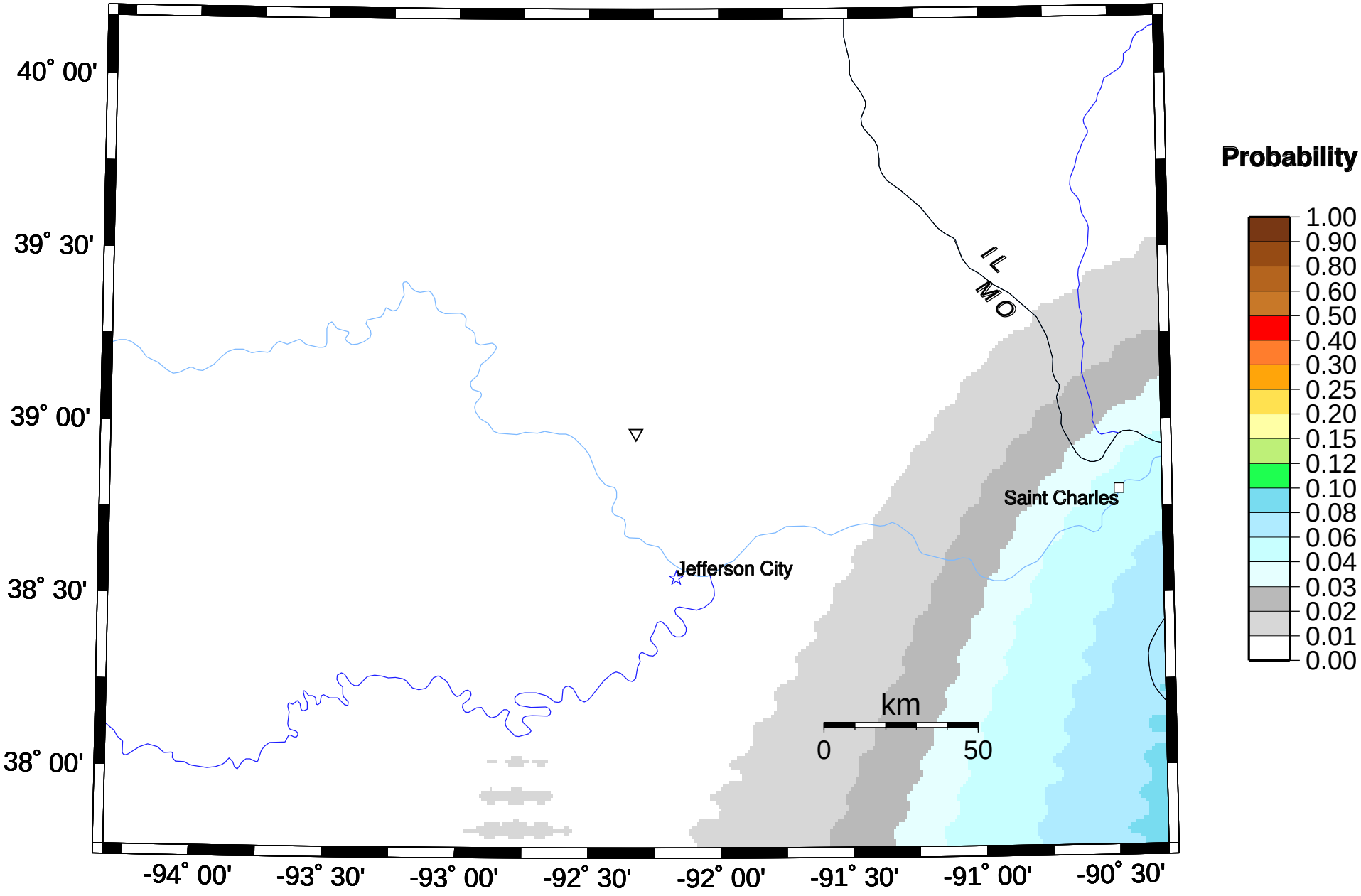


GMT 2017 Feb 28 19:09:26 **Earthquake probabilities from USGS OFR 08-1128 PSHA. 50 km maximum horizontal distance. Site of interest: triangle. Epicenters mb>5 black circles; rivers blue.**

Probability of earthquake with M > 5.0 within 100 years & 50 km

U.S. Geological Survey 2009 PSHA Model

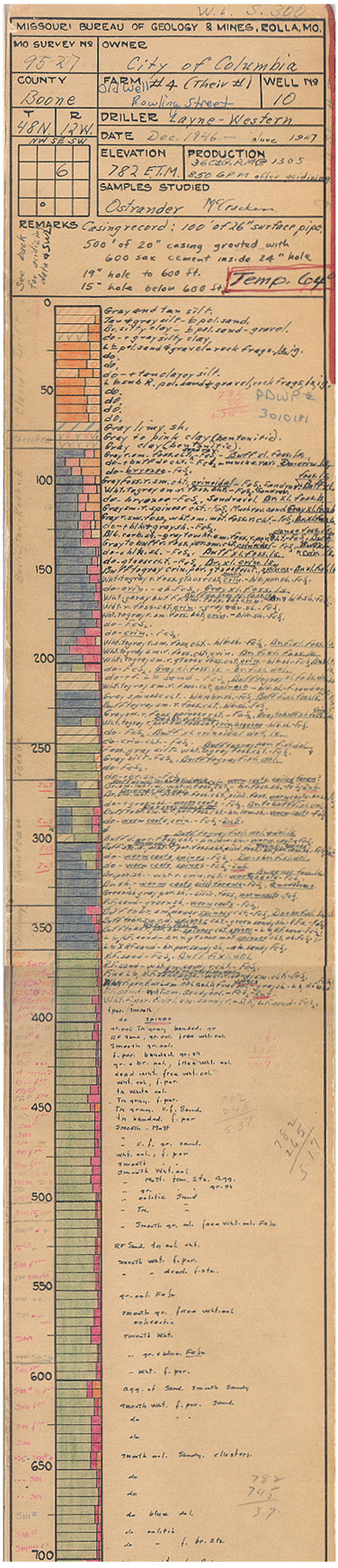
Site: -92.32 d E 38.97

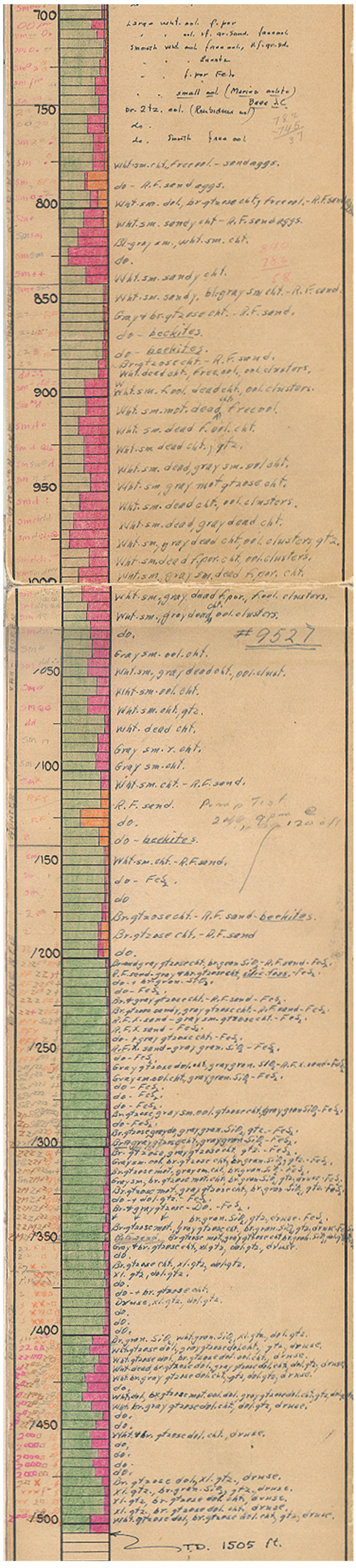


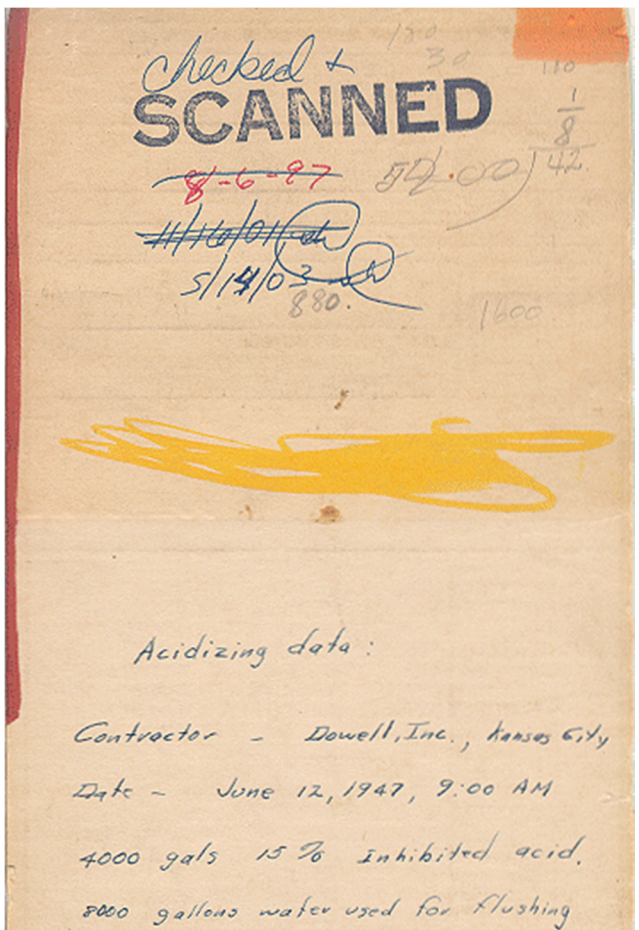
GMT 2017 Feb 28 19:10:51 **Earthquake probabilities from USGS OFR 08-1128 PSHA. 50 km maximum horizontal distance. Site of interest: triangle. Epicenters mb>5 black circles; rivers blue.**

APPENDIX B – AVAILABLE DRILL LOGS OF EXISTING PUBLIC WATER SUPPLY WELLS

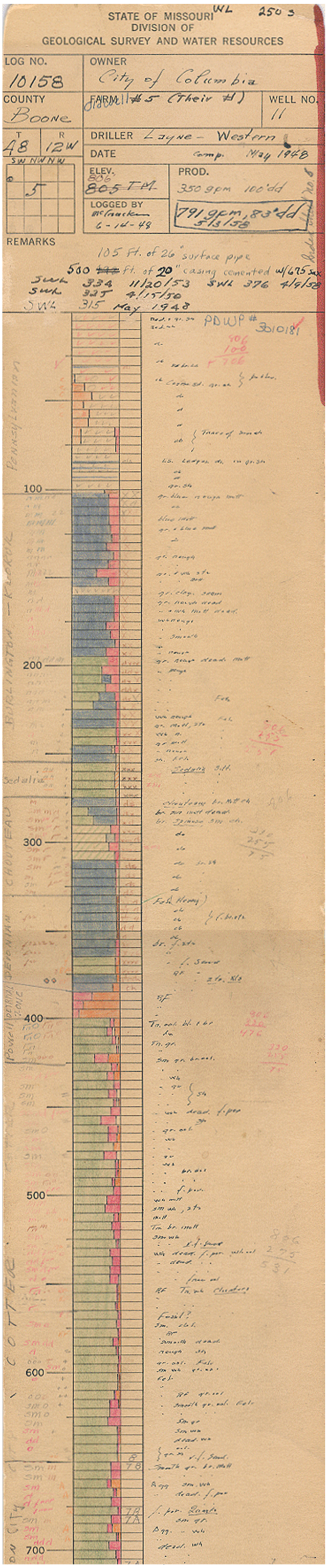
City of Columbia Well #10 (Old Well #4)
Drill Log







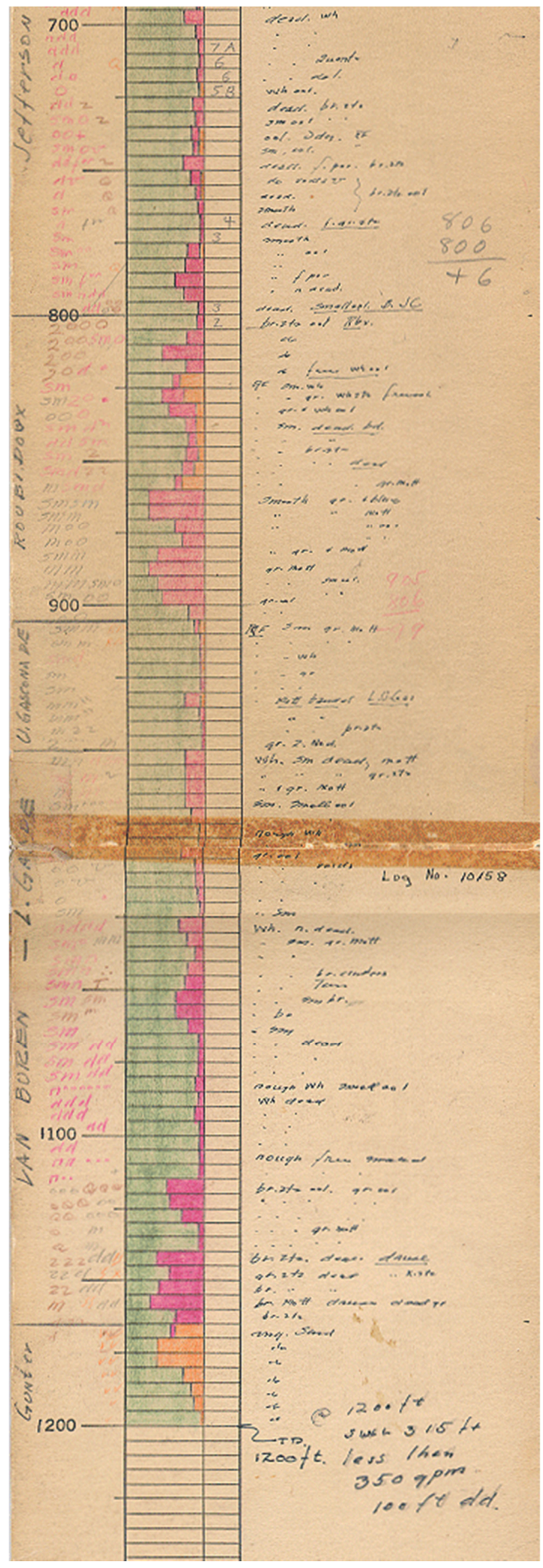
City of Columbia Well #11 (Old Well #5)
Drill Log



STATE OF MISSOURI
DIVISION OF
GEOLOGICAL SURVEY AND WATER RESOURCES

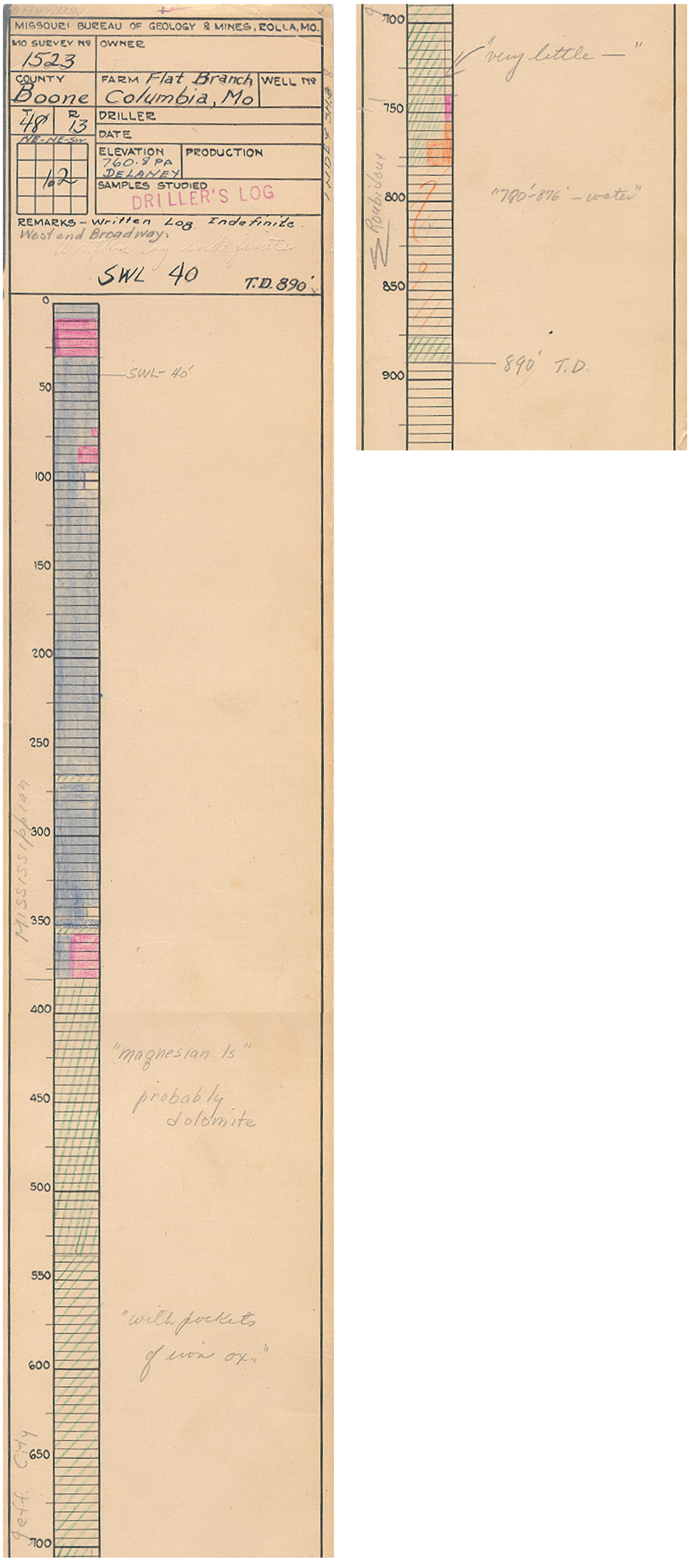
LOG NO. 10158
OWNER City of Columbia
COUNTY Boone
FARM Old Well #5 (Their #)
WELL NO. 11
T 48 R 12W
DRILLER Layne - Western
DATE Comp. May 1948
ELEV. 806 ~~805 TM~~
PROD. 350 gpm 100' dd
LOGGED BY McCracken 6-14-48
791 gpm, 83' dd 5/13/58

REMARKS
105 ft. of 26" surface pipe
500 ft. of 20" casing cemented w/675 sx
SWL 334 11/20/53 SWL 376 4/9/58
SWL 325 4/15/50
SWL 315 May 1948
PDWP # 3010181



Log No. 10158
@ 1200 ft SWL 315 ft
T.D. 1200 ft. less than 350 gpm 100 ft dd.

Flat Branch Well
Drill Log

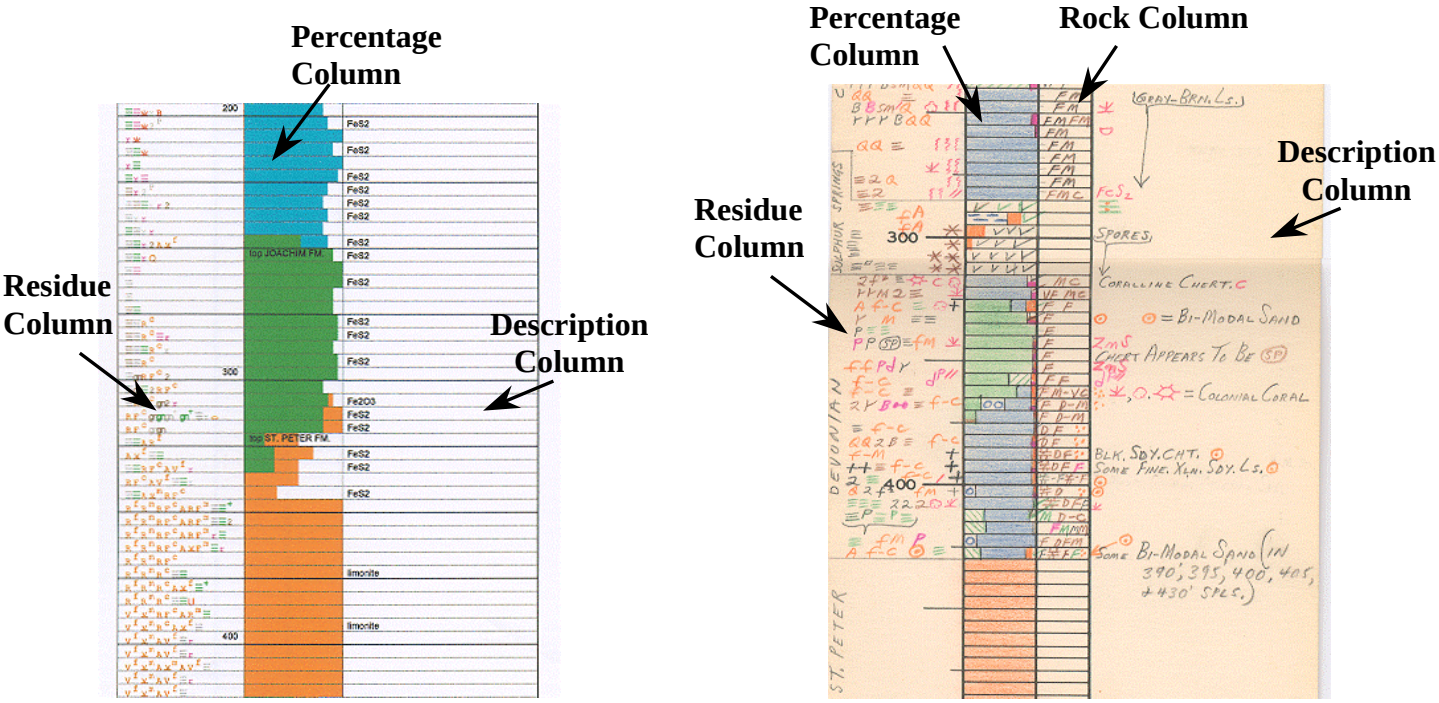


Missouri Department of Natural Resources

Water Resources Center/Division of Geology and Land Survey Well Logs:

An Explanation of the Columns, Colors, & Symbols

This document explains the meanings of the columns, colors and symbols used on Water Resources Center/Division of Geology and Land Survey (WRC/DGLS) well logs, both hand-drawn and computer-generated. There are four columns on hand-drawn logs: the Residue Column, the Percentage Column, the Rock Column and the Description Column. The computer-generated logs contain three columns: the Residue Column, the Percentage Column, and the Description Column.. Figure 1 contains a sample computer-generated log and a sample hand-drawn log with all columns labeled.



Computer-Generated Log

Hand-Drawn Log

Figure 1. Photographs of sample WRC/DGLS computer-generated and hand-drawn well logs.

The Residue Column contains information describing the colors and textures of any shale, quartz, chert and silicified fossils that remain after the rock cuttings are digested in hydrochloric acid. The Percentage Column contains information describing the percentage and lithology of each rock type present in undigested rock cuttings. The Rock column is used to describe the color and crystalline texture of the carbonate rock (hand-drawn logs only). The Description Column on hand-drawn logs contains chemical formulas of any associated minerals and any additional information about the rock. The Description Column on computer-generated logs contains information about associated minerals and rock color and crystalline texture.

The colors and symbols on the following pages are categorized according to the column(s) in which they appear on the logs. The column in which a color or symbol resides defines the meaning of that color or symbol. On both types of logs, there are several instances in which a particular color or symbol is used in two different columns. For example, “d” is used in the Residue Column to indicate “dead,” but “d” is alternately used in the Rock Column to indicate “dense.” Therefore, one must be aware which column is being read in order to correctly interpret the meanings of the colors and symbols.

PERCENTAGE COLUMN LITHOLOGY & SYMBOLS

Lithologic Description

(Computer Generated & Hand Drawn)

- **Chert**
- **Shale/Clay**
- **Dolomite**
- **Druse & Quartz xtls**
- **Metallics** (computer)
- **Sand or Sandstone**
- **Limestone**
- **Coal**
- **Igneous**

Lithologic Description

(Hand Drawn Only)

- **Green Limestone**
- **Red Limestone**
- **Shaly Limestone**
- **Dolomitic Limestone**
- **Silty Dolomite**
- **Silty Dolomite**
- **Siltstone**
- **Felsite, Rhyolite**
- **Felsite, Rhyolite**
- **or** **Siderite - massive**
- **Porphyry**
- **Porphyry**

Residuum/Glacial Drift Symbols

(Hand Drawn Only)

- **or** **Limestone Fragments (angular)**
- **or** **Dolomite Fragments (angular)**
- **or** **Chert Fragments (angular)**
- **or** **Limestone Pebbles (rounded)**
- **or** **Dolomite Pebbles (rounded)**
- **or** **Gravel**
- **or** **Igneous Boulders**
- **or** **Granite Pebbles**
- **or** **Siderite - massive**

Shale Symbols

(Hand Drawn Only)

- **Shale ****
- **Shale - black**
- **Shale - sandy**
- **Shale - limy**
- **Shale - dolomitic**
- **Soil or Loess**
- **Yellow clay or silt**

** shale color indicated by check color

Other

- **No Sample** (hand drawn)
- **No Sample** (computer generated)

2/14/2007

RESIDUE COLUMN COLORS & SYMBOLS

Insoluble Residue Colors

(Computer Generated & Hand Drawn)

- **White**
- **Gray**
- **Brown**
- **Green**
- **Blue**
- **Quartz**
- **Fossils**

Clay/Shale/Silt & Its Modifiers

(Computer Generated & Hand Drawn)

- ≡ **Shale**
- ▱ **Dolomoldic**
- + **Sandy**
- gn **Siltstone/Silt**
- gn or gn **Shaly Silt** (hand drawn)
- P **Porous**
- ≡+ **Shaly sand** (hand drawn)
- +≡ **Sandy shale** (hand drawn)
- ≡ **Sandy shale** (hand drawn)

Other

- G **Glauconite**
- PG **Pelletal Glauconite**
- S.W.L. **Static Water Level** (usually in "Remarks" section on hand drawn log)

Quartz Symbols (always orange)

(Computer Generated & Hand Drawn)

- A **Sandstone** (computer)
- O or * **Masses or Rosettes**
- ∫ **Druse**
- X **Dogtooth Fragments** (computer)
- ⬡ or ↔ **Doubly Terminated**
- ⬠ or → **Singly Terminated**
- Q **Crystalline Quartz**
- R **Rounded**
- F **Frosted**
- V **Angular**
- V̄ or V̲ **Subangular**
- Gn **Granular Silica**
- ≋ **Banded**
- P **Porous**
- f or f **Fine**

Feldspathic Symbols

(Computer Generated & Hand Drawn)

- ••• **Arkose** (computer)
- ••• **Arkose** (hand drawn; may be red, gray, or brown)
- ⋖ or ⋗ **Red Arkose**

2/14/2007

RESIDUE COLUMN COLORS & SYMBOLS

Chert Texture Symbols *

(Computer Generated & Hand Drawn)

Sm	**Smooth**
r	**Rough**
d	**Dead**
2	**Quartzose**
P	**Porous**
f or f	**Fine**
+	**Sandy**
Tr	**Translucent**
○	**Oolitic**
◎	**Ooid Zoned**
⊙	**Ooid Sand Nucleus**
◎	**Ooid Zoned/Sandy**
∴	**Ooids Cluster**
↻	**Oomoldic**
▱	**Dolomoldic**
⁘	**Cryptalgal**
⁘	**Cryptalgal** (hand-drawn)
•—•—• or •—•	**Nodular**
B	**Beekite**

Chert Modifier Symbols *

(Computer Generated & Hand Drawn)

2	**Quartzose**
P	**Porous**
f or f	**Finely**
+	**Sandy**
○	**Oolitic**
◎	**Ooid Zoned**
⊙	**Ooid Sand Nucleus**
◎	**Ooid Zoned/Sandy**
∴	**Ooids Cluster**
↻	**Oomoldic**
▱	**Dolomoldic**
M	**Mottled**
≈	**Banded (2)** (computer)
≈	**Banded (3)** (computer)
†	**Pelloid**
⁘	**Cryptalgal** (computer)
⁘	**Cryptalgal** (hand-drawn)
•—•—• or •—•	**Nodular**
//	**With Spines**

Chert Texture Symbols *

(Hand Drawn Only)

•••	**Ooids, size varies**
⬭	**Pelletal Oolites**
•	**Pisolith**
○ or ○	**Chert w/ooids**
f IIII	**Finely porous spinose chert**
III	**Rough Spinose Chert**
f P	**Finely Porous Chert** (tripolitic)
≈	**Banded**
Sm	**Color Differentiated**
example Sm	**Gray chert surrounded by smooth blue chert**
example SP	**Brown porous chert surrounded by smooth blue chert**

* color of symbol reflects color of chert

2/14/2007

RESIDUE COLUMN COLORS & SYMBOLS

Fossil Symbols (always red)

(Computer Generated & Hand Drawn)

	Crinoids (computer)
B	**Bryozoan**
A	**Graptolite**
G	**Gastropod**
	Brachiopod
ξ	**Worm Cast**
//	**Spines**
	Spine Masses
T	**Trilobites**
	Ozarkocoelia
	Hexagonella
	Cystoids
	Ostracods
U	**Echinoderm**
E	**Endothyra**

Fossil Symbols

(Hand Drawn Only)

	Crinoids
	Bryozoan
	Gastropods
//,// or//	**Spines** (matches color of spines)
, or	**Spine Masses** (matches color of spines)

2/14/2007

ROCK COLUMN COLORS & SYMBOLS

Lithologic Description * (Hand Drawn Only)	
xx	Crystalline
fx	Fine crystalline
vfx	Very fine crystalline
MX or mx	Medium crystalline
CX or cx	Coarse crystalline
VCX or vcx	Very Coarse crystalline
X	Calcite crystals
d	Dense
# #	Fire Clay
≋ ≋	Under clay

Lithologic Description (Computer Generated Only)	
xx	Crystalline
fx	Fine crystalline
vfx	Very fine crystalline
mx	Medium crystalline
cx	Coarse crystalline
vcx	Very Coarse crystalline
X (blu)	Calcite crystals
d	Dense
# #	Fire Clay
≋ ≋	Under clay
brn	Brown **
blu	Blue **
gry	Gray **
tan	Tan **
lt.	Light
dk.	Dark
ls	Limestone
ds	Dolomite/Dolostone

DESCRIPTION COLUMN COLORS & SYMBOLS

(Hand Drawn Only)

	Minerals (always written in red in "Description Column")
do	Means "same description as above"
T. D.	Total Depth

* color of symbol reflects color of rock

** color notation preceding cx, fx, vfx, and mx on computer-generated well logs describes color of rock

2/14/2007

APPENDIX C – INVESTIGATION DRILL LOGS

Drilling Log

Project Name: HYDRO INV More's Lake	Project Number: 93647	Boring Number: MW-1
Ground Elevation:	Location: More's Lake	Page: 1 of 3
Air Monitoring Equipment: PID / LEL - 4 GAS		Total Footage: 43'

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	6 1/4"	43	NA	3	NA

Drilling Company: Geotechnology	Driller(s): Patrick Hart
Drilling Rig: CME	Type of Sampler: Split spoon ~ 20'
Date: 5/23/17 To: 5/24/17	Field Observer(s): Lewis Turner LT

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
1	CLAY, some silt, very dark gray (10YR3/1) damp, medium plasticity, medium consistency.	CL	1, 1, 2	2/2						1446 START
2	CLAY, trace silt dark yellowish brown (10YR4/4) damp medium plasticity, stiff. mottling w/ brownish gray (10YR6/2). roots trace medium sand.	CL	3, 2, 2	2/2						PID=0.0 LEL=0 CO=0 O_2=20.9% H_2S=0
3			4							
4	Some oxidization veins black (10YR2/1)		8							
5			1, 2	2/2						1451
6	trace fine grain sand.		3, 5			1615 6-8' JARS 8-10' Bag				
7			1, 2, 5, 6	2/2		MW-1/ SB01				
8										
9			1, 2, 3, 7	2/2						1615
10	SHELBY TUBE		NA			1628 10-12' MW-1/ ST01				
11										
12	CLAY, trace silt, fine sand, gravel, yellowish brown (10YR5/4) damp, trace plasticity, stiff.	CL	2, 4, 7, 16	2/2						PID=0.0 LEL=0 CO=0 O_2=20.8% H_2S=0
13	6" sand lens fine grain, trace medium and fine gravel.									
14										

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-2-1

Drilling Log Continuation

Boring Number	MW-1
Project Name	HYDRO INV More's Lake
Page	2 of 3
Project Number	93647
Date	5/23/17 - 5/24/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
14	CLAY, trace silt, fine to medium sand, fine gravel. Yellowish brown (10YR 5/4) grayish brown (10YR 5/2) mottling. black oxidization.	CL	7 8	2/2						1640
15			18 22							
16	Becomes yellowish brown (10YR 5/6) 0.1" sand lens.		2 5	1.5/2						
17	0.2" sand lens		9 15							
18	SAND, fine grain, light grayish brown (10YR 6/2) and dark yellowish brown (10YR 4/6) damp, loose, subangular, poorly graded.	SP	4 10	2/2						▽
19	Becomes some silt and clay CLAY with silt and fine sand. yellowish brown (10YR 5/4) moist, trace plasticity, medium consistency.	CL	15 23							wet 1655
20	Sand lenses throughout. (< 0.01" - 0.1") Sand is light brownish gray (10YR 6/2)		5 11	2/2						H_2S=0 PID=0.0 LEL=0 CO=0 O_2=20.9
21			17 31							1705 stop for day 5/23
22	2" sand lens wet.		8 14	2/2						0721 resume drilling 5/24
23			21 34							
24	SAND, fine to coarse, trace fine gravel. brown (10YR 5/3) damp, loose, subangular, well graded., top 1' is silty	SW	12 31	2/2						Chert fragments in split spoon. 0733
25			48 50							
26	CLAY, trace silt, trace sand and gravel. Yellowish brown (10YR 5/4) damp, trace plasticity, stiff. 0.1" sand lens	CL	21 36	2/2						
27			23 20							
28			5 12	2/2						
29			16 22							0747
30	No sample.									Auger grinding hard to advance Drill to 31'
31	CLAY, trace silt, some sand and gravel, yellowish brown (10YR 5/4) damp. trace plasticity, very stiff.	CL	12 14	1/1						
32										

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Boring Number	MW-1
Project Name	Hydro Inv More's Lake
Page	3 of 3
Project Number	93647
Date	5/24/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
32	SAND. Fine to coarse, trace fine gravel, brown (10YR 5/3) wet, loose, subangular, well graded.	SW	20	1.5/2		0810 32-34' MW-1/ SB02 Bag.				
			29							
33			50							Drive 3IN ID SS SS = 18" HARD Boring is wet.
	CLAY, trace silt, sand and gravel, yellowish brown (10YR 5/4) damp. trace plasticity. very stiff.	CL	NA							
34			8							
	CLAY, some fine to coarse sand. Fine gravel very dark greenish gray (10YR 3/10Y) damp trace plasticity stiff. to very stiff. 0.1" sand lens fine to medium grain.	CL	12	2/2						0817
35			16							
			21							
36			7							PID=0 LEL=0 CO=0 O_2=20.8% H_2S=0
			14	2/2						
37	37-38' with sand fine/medium trace coarse.		40							
			49							
38			6							
			14	1.5/2						
39			25							
			37							0834
40			10							
			34	2/2						
41	0.1" sand lens		39							
			43							
42	0.2" sand lens		10	1/1						
	1" SAND. fine sand.		15							0850 STOP
43	Bottom of Boring.									

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Project Name	HYDROENV INV MORES LAKE
Project Number	93647
Boring Number	SB-1
Page	1 of 3
Date	6/6/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
32	CONTINUED FROM MW-1 DRILLING LOG.									* CONTINUED FROM MW-1 DRILLING LOG. SEE LOG FOR INFO.
33										
34										
35										
36										
37										
38										
39										1410 HSA ADVANCE. 1427 15' OF HSA.
40										1441 BEGIN MUD ROTARY.
41										1540 AT 43' BEGIN SAMPLING
42										
43	CLAY, some silt and fine sand, very dark greenish gray (3/10Y GLEY1) damp, trace to medium plasticity, stiff - hard.		NA							1540 START 8 1/4" HSA TO 15' IN SEAL. MUD ROTARY DRILLING THROUGH AUGER. START LOGGING AT 43'
44			6	2/2						
45	less silt/sand. weathered shale. Becomes clay		19 30 41							
46	SHALE, light olive gray (5Y6/1) and olive gray (5Y4/1) highly weathered, trace plasticity. weak, blocky. damp. plastic when wet. some light brown (5YR5/6) and pale yellowish orange (10YR8/6) staining.	Sh	7 18 34 47	2/2						
47										
48			7 21 33 50	2/2						
49										
50.										1610

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Project Name	HYDRO INV MORES LAKE
Project Number	93647
Boring Number	SB-1
Page	2 of 3
Date	6/6-6/7/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
50	SHALE, light olive gray (5Y 6/1) and olive gray (5Y 4/1) highly weathered, trace to medium plasticity, damp, weak blocky.	Sh								1617 6/6/17 Switch rig over to rock core.
51	Several Limestone fragments in core cuttings.			2.9/5						1640 after casing in, stop for day.
52	NO Recovery									0716 6/7/17 Start Rock coring at 50'.
53										
54										Washing away Little recovery
55										0748
56	SHALE, greenish gray (5G 6/1), dusky yellow (5Y 6/4), and grayish red (10R 4/2) damp, weak, weathered, trace plasticity, blocky.	Sh		3.3/5						0755 Clay / Shale washing away w/water Coring.
57										
58	NO Recovery									
59										
60	SANDSTONE, fine grain, weak.									0840
	SHALE, greenish gray (5G 6/1) damp, weak, plastic.									0845
61	LIMESTONE w/shale intermixed, light olive gray (5Y 5/2) yellowish gray (5Y 7/2) weathered, shale partings, olive gray (5Y 4/1) greenish gray (5GY 4/1) shale parting, or 61.4, damp, weak sh, strong ls. Fossiliferous horn coral pyrite. Fine grain	Sh								
62	Shale parting. Stylolite			3.5/5						
63	NO Recovery.									
64										
65										0858
	LIMESTONE w/shale partings, light olive gray (5Y 5/2) yellowish gray (5Y 7/2), weathered shale partings, olive gray (5Y 4/1) greenish gray 5GY 4/1) Ls strong, sh weak plastic, damp. Fossiliferous stylolite. pyrite.	Sh								0905
66		Chertly								
		Sh chertly		5/5						
67	Stylolite									
		Sh								
68		grnu								

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Project Name	HYDRO INV MORRIS LAKE
Project Number	93647
Boring Number	SB-1
Page	3 of 3
Date	6/7/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
68	Limestone, light olive gray yellowish gray (5Y7/2) weathered shale partings olive gray (5Y4/1) damp. Ls. strong, sh weak plastic,	Ls								
69	sh partings and stylolites throughout. Chert nodules throughout/stylolites throughout.									
70										0935
		Cherty sh								0936
71		sh								
		sh								
72		sh		5/5						
		sh								
		Ls								
73		sh								
		Ls								
		Cherty sh								
74		sh								
		sh								
		Ls								0951
75		sh								
		Ls								1005
76		Fracture sh								
77		healed		5/5						
	SHALE, greenish grey (5G4/1) damp, weak to moderate, blocky, slightly plastic when wet.									
78										
79	Limestone, light olive grey (5Y7/2) olive grey (5Y4/1), damp, moderate to strong, non weathered, weak on stylolite.									
		stylolite Ls								1036
80	Bottom of Boring.									Boring abandoned

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log

Project Name: Hydro Inv. More's Lake	Project Number: 93647	Boring Number: MW-2
Ground Elevation:	Location: More's Lake	Page: 1 of 4
Air Monitoring Equipment: PID / LEL - Y gas		Total Footage: 53

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	6 1/4"	53	0	1	NA

Drilling Company: Geotechnology	Driller(s): Patrick Hart
Drilling Rig: CME	Type of Sampler: Split spoon - 2'
Date: 5/22/17 To: 5/23/17	Field Observer(s): Lewis Turner

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
1	CLAY, some silt, very dark grayish brown (10YR 3/2) damp, medium plasticity, medium consistency, roots	CL	NA							1415 START
2	CLAY, trace silt, dark yellowish brown (10YR 4/4) mottling, damp, medium plasticity, medium consistency. trace medium sand.	CL	2 3 4 5	2/2						PID=0 LEL=0 CO=0 O_2=20.9% H_2S=0
3	light brownish gray mottling (10YR 6/2)									
4			2 3	2/2						
5	Oxidization coloration black (10YR 2/1) veins. trace fine grain sand.		5 7							1423
6			2			6-8 Sand 8-10 Clay MW-2/SB01				
7			3 3	2/2						
8			6							
9	CLAY, trace silt and sand, dark yellowish brown (10YR 6/4), damp, trace plasticity, stiff.	CL	2 3 4 6	2/2						1432
10	0.1" sand lens 0.5" sand lens trace gravel		4 10 14	2/2						
11										PID=0 LEL=0 CO=0 O_2=20.8% H_2S=0
12	SAND, some clay, dark yellowish brown (10YR 4/4) damp, fine grain, loose, subangular, poorly graded.	SP	14							
13	CLAY, trace silt and fine sand, yellowish brown (10YR 5/6) damp, trace plasticity, stiff. Some black veins oxidization.	CL	2 3 10 14	2/2						
14										

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-2-1

Drilling Log Continuation

Project Name	Hydro Inv More's Lake
Project Number	93647
Boring Number	MW-2
Page	2 of 4
Date	5/22/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
14	CLAY. Some fine sand. yellowish brown (10YR5/6) damp, trace plasticity. stiff.	CL	7 21 23	2/2						1451
15	SAND, fine to medium grain trace gravel. Yellowish brown (10YR5/6) moist, dense to loose. Subangular, moderately graded.	SP/SW	24							▽
16			7 8 19 25	2/2						
17	2" some clay.									
18			6 10 20 26	2/2						
19	trace fine gravel.									
20			10 18 26 37	2/2						1502
21										PID=0 LEL=0 CO=0 O_2=20.8% H_2S=0 Boring is wet.
22	Trace clay 2.0".		16 11 13 20	2/2						
23	CLAY, trace silt, fine sand. gravel, dark yellowish brown (10YR4/6) damp, trace plasticity, stiff	CL								
24	Some pale brown (10YR6/3) mottling. Oxidization veins.									
25	SAND, trace gravel, fine to coarse sand. fine gravel (10YR5/4) yellowish brown, wet, loose, subangular, well graded.	SW	6 8	2/2						1522
26	CLAY, trace silt and sand, fine gravel, yellowish brown (10YR5/4) damp, medium plasticity, stiff.	CL	13 13 4 7 12 11	2/2						
27										
28	3" fine to medium sand trace coarse.		5 7 12 16	2/2						
29	Becomes light brownish gray (10YR6/3) 3" silt and fine sand.									
30										1546
31	SAND, trace clay lenses, trace fine gravel, sand is fine to medium grain, Yellowish brown (10YR5/4) wet, loose, subangular, well graded. Clay layers brown (10YR 5/3).	SW	31 24 43 44	2/2						
32	two 1" chert fragments in bottom.									

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Boring Number	MW-2
Project Name	Hydro Inv More's Lake
Page	3 of 4
Project Number	93647
Date	5/22/17 - 5/23/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
32	SILT, trace clay and fine sand. Yellowish brown (10YR 5/6) wet, non plastic stiff.	ML	15							
			25	2/2						PID = 0
33			36							CEL = 0
	0.1" sand lens.		48							CO = 0
										O_2 = 20.8%
34			10							H_2S = 0
			12	2/2						1615
35	CLAY, trace silt, some sand at bottom 1.0', brown (10YR 5/3) damp, trace plasticity stiff to medium consistency.	CL	27							
			30							
36	0.3" sand lens.		13							
	4" sand		17							
37	8" silt w/ clay and sand.		36	2/2						
	SAND, fine to medium, brown (10YR 5/3) wet, loose, subangular, poorly graded/moderately graded.	SP/SW	37							
38			11							
	CLAY, trace silt, sand, gravel, brown (10YR 5/3) damp, medium plasticity, stiff	CL	17	2/2						
39			30							Stop for Day.
			35							1645 5/22
40	CLAY, trace silt, sand, gravel, yellowish brown (10YR 5/4) damp, trace plasticity very stiff. several fine sand stringers throughout.	CL	8							0715 START FOR DAY 5/23
			15	2/2						
41			21							
			30							PID = 0
42	Becomes dark grayish brown (10YR 4/2) and dark yellowish brown (10YR 4/6).		10							CEL = 0
			20	2/2						CO = 0
43			37							O_2 = 20.8%
	SAND, fine to coarse, trace gravel, Brown (10YR 5/3) wet, loose, subangular, well graded	SW	41							H_2S = 0
44			11							
			15	2/2						0736
45			18							
			48							
46			26							
			43	1/2						SPLIT SPOON STOPPED ADVANCING 8.42 IN.
47			NA							
	SILT, trace fine sand, yellowish brown (10YR 5/6) damp. nonplastic, medium to soft.	ML	NA							
48			13							
	CLAY, some silt, trace fine sand/gravel, very dark greenish gray (GLEY1 3/10Y) damp, trace plasticity stiff. top 1' is silty and sandy.	CL	25	2/2						
49			24							
50			31							0814

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Boring Number	MW-2
Project Name	Hydro Inv More's Lake
Page	4 of 4
Project Number	93647
Date	5/28/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
50	CLAY, trace silt, fine sand/gravel (very dark greenish gray (GLEY1 3/10Y) damp, trace plasticity, stiff.	CL	9							
			17	2/4						PID=0
51			18							LEL=0
			24							CO=0
52										O_2=20.8%
			10	1/1						H_2S=0
			12							
53										0838 Stop
	Bottom of Boring.									

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log

Project Name: Hydro Inv More's Lake	Project Number: 93647	Boring Number: MW-3
Ground Elevation:	Location: More's Lake	Page: 1 of 3
Air Monitoring Equipment: PID / LEL-4 GAS		Total Footage: 5/17/17 50'

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	6 1/4"	50	NA	2	NA

Drilling Company: Geotechnology	Driller(s): Patrick Hart
Drilling Rig: CME	Type of Sampler: Split spoon ~ 2.0'
Date: 5/17/17 To: 5/17/17	Field Observer(s): Lewis Turner LT

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
1	CLAY, with silt, very dark grayish brown (10YR3/2) damp, medium plasticity, medium consistency, roots.	CL	NA							1250 START
2	CLAY, trace silt, yellowish brown (10YR5/4) mottling, damp, medium plasticity, medium consistency light brownish gray mottling (10YR6/2)	CL	2 3 4 4	2/2						PID = 0.0 LEL = 0 CO = 0 O_2 = 20.8% H_2S = 0
3										
4			2 5	2/2						1257
5	trace fine sand and gravel throughout		6 8							
6			3 5 7 9	2/2		MW/3/ SB01 1305 6-8 8-10				
7	some oxidization coloration veins.									
8			1 3 3 6	2/2						
9										
10										1308
11			2 2 4 6	2/2						PID = 0.0 LEL = 0 CO = 0 O_2 = 20.9% H_2S = 0
12	SAND, dark yellowish brown (10YR4/4) damp, fine grain, loose, subangular, poorly graded.	SP	1 3 10 15	2/2						
13	CLAY, trace fine sand and gravel, yellowish brown (10YR5/6) damp, medium plasticity, stiff	CL								
14										

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-2-1

Drilling Log Continuation

Boring Number	MW-3
Project Name	Hydro Inv More's Lake
Page	2 of 3
Project Number	93647
Date	5/17/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
14	CLAY, trace gravel and sand, yellowish brown (10YR5/6) damp, trace plasticity, stiff. black oxidization veins.	CL	6 19	2/2						1324
15	1" sand layer fine									
	1" sand layer fine.		20 25							
16										
17	SAND, trace clay/silt, fine to medium grain, yellowish brown (10YR5/6) and light brownish gray (10YR6/2) damp, loose, subangular, poorly graded/moderately graded.	SP	4 7 15 27	1.5/2						
18										
19			3 9 11 17	2/2						1331
20										▽ Sampler wet on outside.
21	CLAY, trace silt, fine sand and gravel (10YR5/4) damp, trace plasticity, very stiff, mottling (10YR6/1) oxidization veins.	CL	5 8 12 18	2/2						
22										PID = 0.0 LEL = 0 CO = 0 O_2 = 20.9% H_2S = 0
23			5 6 9 15	2/2						
24	becomes pale brown (10YR6/3) trace medium grain sand.		5 8	2/2						1405
25	2" fine to medium sand lens.		10 15							
26	SAND, trace gravel, fine to coarse sand, fine gravel (10YR5/4) yellowish brown, damp to moist, loose, subangular, well graded.	SW	8 12 23 38	1.5/2						boring has water in bottom
27										
28	CLAY, with sand and gravel, yellowish brown (10YR5/4) moist, nonplastic, stiff. fine to coarse sand, fine gravel.	CL	9 12 24 41	2/2						1422
29	3" sand layer.									
30	sand, trace gravel, clay (10YR5/4) moist, loose well graded	SW	20							
31	CLAY, some silt, trace sand fine to coarse Brown (10YR4/3) damp, trace plasticity, very stiff 2" sand layer	CL	17 10 20	2/2						
32										

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Boring Number	MW-3
Project Name	Hydro Inv More's Lake
Page	3 of 3
Project Number	93647
Date	5/17/2017

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
32	SAND. Some Clay layers, brown (10YR 5/3) damp to moist, loose, subangular, poorly graded.	SP	8	1.5/2						
			10							PID=0
33			20							LEL=0
	CLAY, trace sand Brown (10YR 5/3) damp, nonplastic, stiff.	CL	23							CO=0
34	SAND. fine grain (brown (10YR 5/3) moist, loose subangular, poorly graded.	SP	10							O_2=20.9%
	CLAY, trace sand fine to coarse Brown (10YR 5/3) damp. trace plasticity, stiff.	CL	15	2/2						H_2S=0
35	1" sand lense trace gravel Fine grain		18							1449
			19							
36			28	2/2						Hard at bottom
			29							
37	Sand lense 0.5"		35							
			38							
38	NO sample.		N/A							
39										Very hard cant advance SS
40										1507
			NA							Cant advance SS, Drill down 2' more Rt w/HSA.
41										
42	Chert fragments in slough									
	CLAY, trace silt and sand, trace gravel, very dark greenish gray (GLEY 1 3/10y) damp. trace plasticity, very stiff.	CL	8	2/2		1551 42-46 MW-3/ SB02 Bag.				
43	0.5" sand lenses		17							PID=0
			23							LEL=0
			42							CO=20.9%
44										O_2=20.9%
	0.2" sand seam		9							H_2S=0
			20	2/						1551
45			24	2						Collected Bag Samples 42-46'
			41							
46	0.2" sand seam		5							Cant push Shelby Tube
			11	2/2						
47			23							
			18							
48			6							
			18	2/2						
49			23							
	Bottom of boring.		23							1621 STOP
50										

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log

Project Name: Hydro Inv. More's Lake	Project Number: 93647	Boring Number: MW-4
Ground Elevation:	Location: More's Lake	Page: 1 of 4
Air Monitoring Equipment: PID / LEL-4 gas		Total Footage: 57

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	6 1/4"	57	NA	1	NA

Drilling Company: Geotechnology	Driller(s): Patrick Hart
Drilling Rig: CME	Type of Sampler: Spl.7 spoon - 2'
Date: 5/16/17 To: 5/16/17	Field Observer(s): Lewis Turner

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
1	CLAY, with silt very dark grayish brown (10YR 3/2) damp, medium plasticity, medium consistency, roots.	CL	NA	-						1139 START Drilling.
2	CLAY, trace silt, yellowish brown (10YR 5/4) damp, medium plasticity, medium consistency.	CL	2 3 4 4	2/2						PID=0 LEL=0 CO=0 O_2=20.9% H_2S=0
3										
4	trace gravel and light brownish gray (10YR 6/2) mottling, dark black oxidization layers.		2 4	2/2						1146
5			5 7							
6			1 3 3 5	2/2		1200, 6-8' Jars 8-10' Bags MW-4/ SB01				
7										
8			1 3 3 4	2/2						
9	CLAY, some silt, dark greenish gray (GLEY 1 4/5GY)	CL								1200
10			2 1 2 4	2/2						
11	1" sand layer moist.									▽ water on outside of SS.
12	SAND, dark yellowish brown (10YR 4/4) moist, Fine grain, Subangular, loose, well graded, gravel	SW/SP	1							
13	CLAY, with gravel, trace sand, yellowish brown (10YR 5/6) damp, trace plasticity, very stiff. Sand throughout.	CL	3 9 17	2/2						PID=0 LEL=0 CO=0 O_2=20.9% H_2S=0
14										

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-2-1

Drilling Log Continuation

Boring Number	MW-4
Project Name	Hydro Inv. Mort's Lake
Page	2 of 4
Project Number	93647
Date	5/16/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
14	CLAY, some gravel, trace sand, yellowish brown (10YR 5/6) damp, trace plasticity, very stiff	CL	6 18 20	2/2						1211
15			21							
16			3 6							
17			17	2/2						
	CLAY with sand, yellowish brown (10YR 5/6) damp, nonplastic, loose, stiff/soft.	CL	22							
18										
19	SAND, fine to medium grain, yellowish brown (10YR 5/6) damp, loose, subangular, poorly graded.	SP	4 9 19 21	2/2						1225
20	Some gravel		- -							
21			8 10	1/1						
22	SAND, fine grain, light brownish gray (10YR 6/2) some clay zones w/sand, damp, subangular, poorly graded.	SP	5 8 12 16	2/2						PID=0 LEL=0 CO=0 O_2=20.8% H_2S=0
23										
24	CLAY, trace silt yellowish brown (10YR 5/4) damp, trace plasticity, very stiff. trace gravel rounded. trace fine sand.	CL	5 10	2/						1306
25			13 17	2						
26	Some gray mottling (10YR 6/1)		5 6 9 12	2/2						
27										
28	trace fine sand		5 8 10 15	2/2						
29										1332
30			7 23 34 36	2/2						
31										
32										

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Boring Number	MW-4
Project Name	Hydro Inv. More's Lake
Page	3 of 4
Project Number	97647
Date	5/16/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
32	Clay Continued, yellowish brown (10YR5/4) damp, trace plasticity, stiff.	CL	9							
			12	2/2						PID=0
33			38							LEL=0
			50							CO=0
	SAND, fine grain Dark yellowish brown (10YR 4/6) wet, loose, subangular, poorly graded.	SP								O_2=20.9%
34			10							H_2S=0
			12	2/2						1403
35	Some clay throughout.									
			40							
			46							
36	CLAY, trace silt and fine sand, trace gravel, light yellowish brown (10YR 6/4) damp, non plastic, very stiff. trace gravel.	CL	3							
			6							
			8							
37			10	2/2						
	CLAY, brown (10YR 5/3) damp, medium plasticity, stiff.	CL								
38			8							
	1" sand layer fine to medium grain		12							
			23							
39			36	2/2						
	SAND, brown (10YR 5/3) fine grain, damp loose, subangular, poorly graded.	SP								1436
40										
	Becomes wet.		8							
			15							
41			19	2/2						PID=0
			22							LEL=0
42	CLAY, trace silt and sand, gravel. yellowish brown (10YR 6/4) damp, trace plasticity, very stiff.	CL	7							CO=0
			15							O_2=20.9%
43			17	2/2						H_2S=0
			19							
44										
			9							
			13	2/2						1500
45										
			28							
			41							
46	CLAY, trace silt and sand, trace gravel, very dark greenish gray (GLEY1 3/10Y) damp, trace plasticity, very stiff.	CL								
			17							
			23	2/2						
47	0.5" SAND seam brown (10YR 4/3) clay near is same color.		38							
			43							
48										
			17							SS is wet
			25							on outside
49			38	2/2						
			44							
50										1532

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Project Name	Hydro Inv. More's Lake
Project Number	93647
Boring Number	MW-4
Page	4 of 4
Date	5/16/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
50	CLAY, trace sand and gravel, dark greenish gray (GLEY1 3/10Y) damp, trace plasticity, very stiff.	CL	19							
			25	2/2						
51	SAND, fine grain, trace medium grain (GLEY1 3/10Y) damp, loose, subangular, poorly graded.	SP	29							
			38							PID=0.0 LEL=0 CO=0 O_2=20.8% H_2S=0
52	SILT with fine sand, dark greenish gray (GLEY1 3/10Y) damp, non plastic, medium consistency.	ML	18							
			17	2/2						
53	4" CLAY seam black (10YR 2/1) damp, medium plasticity, very stiff		25							
			30							
54			15							water in bottom of boring 1600
			21	2/2						
55	3" SAND seam fine grain		29							
			37							
56	CLAY, some silt trace sand and gravel black (10YR 2/1) damp, medium plasticity, stiff.	CL	27	1/1						
	1" sand layer		74							1607 STOP
57	Bottom of Boring									

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log

Project Name: Hydro Inv More's Lake	Project Number: 93647	Boring Number: MW-5
Ground Elevation:	Location: More's Lake	Page: 1 of 3
Air Monitoring Equipment: PID/LEL-4gas		Total Footage: 41

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	6 1/4"	41	0	1	NA

Drilling Company: Geotechnology	Driller(s): Patrick Hart
Drilling Rig: CME	Type of Sampler: Split spoon - 2'
Date: 5/19/17 To: 5/19/17	Field Observer(s): Lewis Turner LT

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
	REMOVED.									0820 START
1			NA							Top 1-1.5' Removed gravel/CCR.
2	CLAY, dark yellowish brown (10YR4/4) damp, trace to medium plasticity, black veins oxidization.	CL								to clean soil
3			1, 3, 4, 9	2/2						
4			1, 2	2/2						
5										0825
			3, 5							
6			2, 4, 7, 9	2/2		0830 6-8' Jars 8-10 Bag MW-5/ S801				PID=0.0 LEL=0 CO=0 H2S=0 O2=20.8%
7										
8										
9	trace gravel 2" some sand throughout.		3, 6, 10, 9	2/2						
10	thin sand lens throughout									0835
11	CLAY, trace silt, some fine sand, trace gravel (yellowish brown (10YR5/6) and light brownish gray (10YR6/2) damp. medium plasticity, stiff	CL	6, 9, 11, 12	2/2						
12			4, 5, 9, 17	2/2						
13										
14										

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-2-1

Drilling Log Continuation

Project Name	Hydro Inv. More's Lake
Project Number	93647
Boring Number	MW-5
Page	2 of 3
Date	5/19/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
14	SAND, brown (10YR 5/3) damp to moist, loose, subangular, poorly graded.	SP	5 7	2/2						0855
15	CLAY, trace silt, sand, and gravel (fine) yellowish brown (10YR 5/6) damp, trace plasticity, stiff.	CL	9 12							
16	becomes some sand throughout. 0.1" sand		4	2/2						PID=0.0 LEL=0 CO=0 O_2=20.9% H_2S=0
17	0.1" sand 0.1" sand		3 3 9							
18	SILT, trace sand, yellowish brown (10YR 5/6) damp non plastic, medium plasticity.	ML	5							
19	CLAY, yellowish brown (10YR 5/4) damp, trace plasticity, very stiff. trace sand lens	CL	7 9	2/2						▽
20	SAND, trace gravel, fine to coarse sand, fine gravel (yellowish brown (10YR 5/4), wet, loose, subangular, well graded.	SW	12							wet 0917
21			3 9 9	2/2						
22	CLAY with silt, some sand, trace gravel, dark yellowish brown (10YR 4/6) wet, trace plasticity, stiff.	CL	12							
23	0.5" sand lens		4 7 9	2/2						
24	0.3" sand lens 0.8" sand lens.		11							
25	SAND, fine to medium grain, yellowish brown (10YR 4/6) wet, loose, subangular, moderately graded.	SP/SW	15 21	2/2						0932
26			28 31							
27			12 14	2/2						PID=0 LEL=0 CO=0 O_2=20.8% H_2S=0
28	CLAY, trace silt, some sand, trace gravel, brown (10YR 4/3) damp, trace plasticity, stiff.	CL	19 25							
29	SAND, fine grain, yellowish brown (10YR 4/6) trace gravel, wet, loose, subangular, moderately to poorly graded.	SP	15 17 24	2/2						
30	CLAY, trace silt, sand, gravel, brown (10YR 5/3) damp, trace plasticity, very stiff.	CL	32							0940
31	3" SAND seam, wet. becomes silty		12 17	2/2						
32	CLAY, trace silt and sand very dark gray to black (10YR 3/1, 2/1) damp, trace plasticity very stiff.	CL	22 30							

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Boring Number	MW-5
Project Name	Hydro Inv. More's Lake
Page	3 of 3
Project Number	93647
Date	5/19/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
32	CLAY, trace silt, sand, and gravel, very dark gray to black (10YR 3/1, 2/1) damp, trace plasticity, very stiff.	CL	11	2/2						
			15							
33			20							
			24							
34	3" sand lens									water in cuttings
	2" silt brown (10YR 5/3)		20							
			31	2/2						1010
35	Chert fragments 0.2-1.5"		17							
			20							
36										
			9							PID=0
37			13	2/2						LEL=0
			20							CO=0
			27							H2S=0
38										O2=20.9%
			12							
39			19	2/2						
	1" silt.		24							
	wood fragments		31							1045
40										
			13	1/1						
41			18							1050 stop.
	Bottom of Boring									

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Project Name	HYDRO INV MORRIS LAKE
Project Number	93647
Boring Number	SB-2
Page	1 of 3
Date	5/31/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
32	CONTINUED FROM MW-5 DRILLING LOG.									* CONTINUED FROM MW-5 DRILLING LOG. SEE LOG FOR INFO
33										
34										
35										
36										
37										0815 Advance 8 1/4 HSA to 18' bgs.
38										0905 Begin mud rotary 4" bit
39										1005 at 41' depth. Start sampling
40										
41	CLAY, trace silt, some fine to medium sand and fine gravel, very dark gray (10YR 3/1) damp, trace to medium plasticity. Stiff.	CL								1005 START
42	several <0.1" sand lens, fine to med.		12							Begin split spoon sampling w/ mud rotary.
43			19	2/2						
			24							
44			33							
	CLAY, some silt, fine to coarse sand, some fine to medium gravel. dark gray (10YR 4/1) dark greenish gray (GLEY1 4/10Y) and greenish gray (GLEY1 5/5GY) mottling. damp, trace plasticity. stiff.		8							
45		CL	31	2/2						
			24							
46			25							
	Larger gravel fragments in sample fragments from bit.		8	0.5/2	~~0.5~~ 1/4					
47			12							
			37		1.5					
			39							
48	CLAY, gray (10YR 5/1) damp to dry, nonplastic (plastic when wet), stiff. highly weathered shale.		8							plastic when wet.
49		CL/sh	21	2/2						
			37							
50			50							1045

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Project Name	HYDRO INV MORES LAKE
Project Number	93647
Boring Number	SB-2
Page	2 of 3
Date	5/31/17 - 6/1/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
50	CLAY, gray (10YR5/1) damp to dry, non plastic (when dry). Stiff, blocky highly weathered shale.	SH	36							Slow drilling
51			47							
			50							Clay is highly plastic w/water added.
			refusal							
52										
			47							
53			50 refusal							
54	becomes silty weak friable.	SH	50 refusal							
55										1220
56										missing wireline catch. 1415 5/31/17 stop.
57				4/4						6/1/17 0719 Begin rock coring 56-60'
58										
59	SHALE, medium dark grey (N4) and olive grey (5Y4/1) highly weathered, weak, damp. Some plastic layers, massive, blocky.		SH							
60										0751
										0407
61	Becomes dark greenish gray (5G4/1) 61-62' 30°-45° fractures		SH							
62	45° fracture.			5/5						
63										
64	45° fracture									
	some olive gray 5Y4/1 layers									0836
65	Becomes black (N1) to greyish black (N2) moderately less weathered. 45° angles/amination									
66	Limestone, olive black (5Y2/1) highly weathered, strong, damp. some pyrite. fine grain. some shale partings.		sh partings. LS	4.3/5						0870
67		LS								
68										

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Project Name	HYDRO INV MORRIS LAKE
Project Number	93647
Boring Number	SB-2
Page	3 of 3
Date	6/1/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
68	LIMESTONE, with clay and shale. interbedded.									
69	Limestone olive black (5Y 2/1) shale greenish gray (5GY 4/1) Ls strong, sh plastic, highly weathered. finely bedded.	Ls								
70										0900
	Ls becomes yellowish gray (5Y 7/2) and light olive gray (5Y 5/2) shale dark greenish gray (5GY 4/1)	Ls/sh								0906
71	0.3' Ls pyrite inclusion									
72	Finely bedded Ls/sh			5/5						
	0.7' CHERTY LS									(Hard drilling change 6.7 -chert/Ls
73	Ls									
	0.6' SHALE									
74	Sh									
	Cherty Ls.									
75										~~0977~~ 1020
	Shale and Ls nodules/cherty. greenish gray (5GY 6/1) shale, Ls yellowish gray (5Y 7/2)/									1024
76	light olive gray (5Y 5/2)	Ls								
	Ls gravel in shale.									
77				5/5						
	Limestone, light olive gray (5Y 5/2)/ yellowish gray (5Y 7/2) strong, non weathered), dense.	Ls								
78	Stylolites throughout. fracture at 78'									
	Fracture 30° pyrite nodules									
	Chert nodules 0.3'									
79										
	fracture 25°									
80										1038
	0.2' shale/clay dark greenish gray (5GY 4/1)		sh							1040
	Stylolites									
81										
	shale parting solution cavity fracture. stylolite.			5/5						
82	Stylolite									
	fracture w/ shale parting weathered.									
83	Fracture									
	Stylolite. Fracture weathered solution.									
84										
	Clay shale parting eroded.									
	Cherty									
85										1120
	Bottom of Boring.									Boring Abandoned.

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log

Project Name: Hydro Inv Moro's Lake	Project Number: 93647	Boring Number: MW-6
Ground Elevation:	Location: Moro's Lake	Page: 1 of 3
Air Monitoring Equipment: PID / LEL-4gas		Total Footage: 42

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	6 1/4"	42	NA	1	NA

Drilling Company: Geotechnology	Driller(s): Patrick Hart
Drilling Rig: CME	Type of Sampler: Split spoon - 2'
Date: 5/25/17 To: 5/25/17	Field Observer(s): Lewis Turner LT

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
	REMOVED -(GRAVEL /CCR)									0930 START
1	CLAY		NA							TOP 4' removed. to clean soil
2										
3										
4	CLAY, trace silt, gravel Dark yellowish brown (10YR 4/4) damp, medium plasticity, stiff mottling. gray (Gley 1 5/10Y)	CL	1 3	2/2						one small fleck of coal in top 2" of sample. rest clean.
5			4 7							0945 Decon splitspoons
6			2 4	2/2		0954 6-8 Soils 8-10 Bag MW-6 SB01				
7	0.2" decayed wood fragments.		6 7							PID=0 LEL=0 CO=0 O2=20.8% H2S=0
8	CLAY, some silt, fine sand and gravel, yellowish brown (10YR 5/6) damp, trace to medium plasticity, stiff. mottling light greyish brown (10YR 6/2) black oxidization along veins.	CL	1 3	2/2						
9			3 5							0954
10			2 4	2/2						
11			6 10							
12			3 6	2/2						
13			9 12							
14										

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-2-1

Drilling Log Continuation

Project Name	Hydro Inv. Moe's Lake
Project Number	93647
Boring Number	MW-6
Page	2 of 3
Date	5/25/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
14	CLAY, trace silt, some sand, yellowish brown (10YR 5/6) and grayish brown (10YR 5/2) damp, trace plasticity, stiff.	CL	4	2/2						
15			6							1005
			18							
16	Sand lenses throughout.		25							
			4	2/2						
17			7							
	SAND, fine to medium grain, dark yellowish brown (10YR 4/4) wet, loose, subangular, poorly graded.	SP	11							▽ wet.
18			22							
			9							PID=0 LEL=0 CO=0 O_2=20.8% H_2S=0
19			18	2/2						
	SILT, some clay and fine sand, trace gravel yellowish brown (10YR 5/6) damp, trace plasticity, medium consistency, some light brownish gray (10YR 6/2) sand lenses.	ML	29							
20			33							1011
			NA							
			NA	1.0/2						Boring is wet.
21			10							1' SS.
	SAND, dark yellowish brown (10YR 4/4) trace coarse sand gravel, wet, loose, subangular, well graded.	SW	36							
22	becomes yellowish brown (10YR 5/4) fine grain with silt.		6 10							
23			21	2/2						
			24							
24	CLAY, some silt, some fine sand lenses, trace gravel, yellowish brown (10YR 5/4) and light brownish gray sand (10YR 6/2) damp, trace plasticity, very stiff. sand lenses throughout.	CL	8							
25			20	2/2						1026
			20							
26			33							
	0.9-1.2' Limestone Fragments, 1" sand lens.		10	1.5/2						
27	2" sand lens.		16							15" refusal - SS
			50							
			NA							PID=0 LEL=0 CO=0 O_2=20.8% H_2S=0
28	SAND, trace clay and silt. fine to medium grain dark yellowish brown (10YR 4/6) wet loose, subangular, moderately graded.	SP/SW	7							
29			30	2/2						
	CLAY, some silt, fine to coarse sand, fine gravel, yellowish brown (10YR 5/4) damp, non plastic, stiff.	CL	31							
30			34							1042
			NA							
			NA	1/2						
31	trace black (10YR 2/1) organic matter		17							
32			21							

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Boring Number	MW-6
Project Name	Hydro Inv More's Lake
Page	3 of 3
Project Number	93647
Date	5/25/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
32	CLAY, trace silt, fine sand and gravel, greenish black (Gley1 2.5/10y) damp, trace plasticity	CL	7							
33	stiff.		9	2/2						
			19							
			21							
34	trace. Black organic material, reeds and peat, throughout		8							
			21	2/2						1117
35										
			34							
	SILT, very dark greenish gray (GLEY1 3/10y)	ML	38							
36	damp, nonplastic, medium consistency.		9							PID=0
			22	2/2						LEL=0
37										CO=0
			35							O_2=20.9%
			41							H_2S=0
38										
	SAND, fine grain, dark yellowish brown (10yr 4/4), wet, loose, subangular, poorly graded.	SP	9							
39			20	2/2						
	CLAY, trace to some silt dark gray (10yr 4/1) damp, nonplastic, very stiff.	CL	25							
40			41							1130
			10							
	SAND, fine grain, dark yellowish brown (10yr 4/4) wet, loose, subangular, poorly graded.	SP	21							
41			30	2/2						
	CLAY, trace to some silt, dark gray (10yr 4/1) damp, trace plasticity, very stiff.	CL	42							1139 stop.
42										
	Bottom of Boring									

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log

Project Name: Hydro Inv. More's Lake	Project Number: 93647	Boring Number: MW-7
Ground Elevation:	Location: More's Lake	Page: 1 of 3
Air Monitoring Equipment: PID / LEL - 4 gas		Total Footage: 34

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	6 1/4"	34	0	4	NA

Drilling Company: Geotechnology	Driller(s): Patrick Hart
Drilling Rig: CME	Type of Sampler: Split spoon - 2'
Date: 5/15/17 To: 5/16/17	Field Observer(s): Lewis Turner LT

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
1	CLAY, with silt, brown (10YR 5/3) damp medium plasticity, medium consistency roots.	CL								1508 START
2										
3	CLAY, trace silt, grayish brown (10YR 5/2) damp, medium plasticity, stiff.	CL	1 1 2 2	2/2						
4	2" layer very dark gray (10YR 2/1).									one small coal fragment.
5	SAND, with clay and silt, dark yellowish brown (10YR 4/6) damp, trace plasticity, medium - stiff. poorly graded, subangular fine sand.	SP/CL	1 2	2/2						1527
6			2 3			1540 6-8 Bag 8-10 Jars MW-7/ SB01				PID=0 LEL=0 CO=0 H_2S=0 O_2=20.9%
7	CLAY, trace silt, brownish gray (10YR 6/2) damp, trace plasticity stiff, roots	CL	2 3 8 10	2/2						
8	some silt becomes (10YR 5/6)									
9			2 6 8 6	2/2						
10	SAND, trace silt, light gray (10YR 7/2) damp, loose, subangular, fine to medium grain, poorly graded.	SP								1540
11	SAND, with silt, very fine, yellowish brown (10YR 5/4) damp, subangular, loose, poorly graded	SP	4 8 8 10	2/2						▽
12	SAND, fine to coarse, dark yellowish brown (10YR 4/4) wet, subangular, poorly graded	SP								
13	SHELBY TUBE		NA			1550 12-14' MW-7/ ST01				19"
14										

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-2-1

Drilling Log Continuation

Boring Number	MW-7
Project Name	Hydro Inv. More's Lake
Page	2 of 3
Project Number	93647
Date	5/15/17 - 5/16/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
14	SAND w/ trace gravel and silt, yellowish brown, (10YR 5/6) wet, dense, subangular fine to gravel. poorly graded	SP	25 38	1.5/2						
15										1611
			50 -							
16	becomes fine grain sand									
			8 17 19	2/2						PID=0 LEL=0 CO=0
17	CLAY w trace silt and gravel, yellowish brown (10YR 5/6) wet, trace plasticity. very stiff glacial till	CL	22							O_2=20.8% H_2S=0
18			10 19	2/2						
19			21 36							1629
20	CLAY with trace silt, some sand and gravel. Yellowish brown (10YR 5/4) damp, trace plasticity, very stiff glacial till. Some charcoal fragments.	CL	11 18 26 33	2/2						
21										
22	becomes silty (some silt.) light brownish grey throughout (10YR 6/2).		12 7 25 34	2/2						
23										
24	CLAY, trace silt. dark gray (10YR 5/1) Damp, trace plasticity, very stiff. sand to coarse gravel throughout. till.	CL	13 18	2/2						1710
25			26 37							STOP Drilling For Day 5/15
26			17 17 26 33	2/2						START DRILLING 5/16 0721
27										PID=0 LEL=0 CO=0
28	1" dark reddish brown (5YR 3/2)		11 18 27 34	2/2						O_2=20.8% H_2S=0
29	Trace fine sand inclusion 2"									0749
30	SHELBY TUBE					0759 30-32' MW-7/ ST02				3-4" material collected, low volume.
31										
32										

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Boring Number	MW-7
Project Name	Hydro Inv. More's Lake
Page	3 of 3
Project Number	93647
Date	5/16/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
32	CLAY, trace silt, some sand and gravel.	CL	17			0809 32-34'				
			15	2/2		MW-7/				
33	sand, trace silt and clay dark grey (10YR 4/1) damp, well graded, fine grain, gravel	SW	22			SB02				
			29							
34	CLAY, grey (10YR 6/1) damp to dry, non plastic very stiff	CL								0815 STOP
	BOTTOM OF BORING.									

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Project Name	HYDRO INV MOREES LAKE
Project Number	93647
Boring Number	SB-3
Page	1 of 2
Date	6/2/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
32	CONTINUED FROM MW-7 DRILLING LOG.									* CONTINUED FROM MW-7 DRILLING LOG. SEE LOG FOR INFO
33									8¼"	0940 HSA TO 15' 1031 MUD ROTARY TO 34'
34	CLAY, trace silt, fine to medium sand, fine gravel very dark gray (10YR3/1) damp trace to no plasticity. stiff.	CL	6 9	2/2						1051 START split spoon sampling w/mud rotary.
35	CLAY, gray (10YR5/1) damp to dry, non plastic when dry. becomes highly plastic w/ water. stiff. highly weathered shale.	CL/CH Sh.	17 31							
36	Becomes more dry, friable.		23 31	1.5/2						
37	SHALE, medium light gray (N6) to light olive gray (5Y6/1) dry, highly weathered, weak massive, blocky. becomes plastic when wet.	Sh	50							
38			37 50	0.6/2						
39										40' split spoon refusal. 1124
40		Sh								Switch to NQ core.
41				4/4						1200 set 0.39' OUTER CASING TO 38' BGS
42	SHALE, light olive gray (5Y6/1), damp, highly weathered, blocky, plastic when wet.	Sh				1430 SB-3/ SB01 42-44 BAG				1314 BEGIN CORING 0.34' RET.
43										6/2/17 40-44 1406
44	LIMESTONE olive black (5Y 2/1) to grayish black (N2) slightly weathered, damp, pyrite. Shale partings greenish gray (5GY 6/1). 45 fracture at 45"			1/1						6/6/17 0951 44-45' 0957
45	LIMESTONE with clay and shale interbedded, Limestone olive black (5Y 2/1). Shale greenish gray (5GY 4/1) Ls strong some chert, shale plastic to weak, Finely bedded. pyrite nodules.	Ls		4/5						0958
46										
47										
48	Shale 0.5"	Ls								
49	Shale partings / fracture Shale partings.									
50	Shale/Ls rubble in bit.									1081

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log Continuation

Boring Number	SB-3
Project Name	Hydro Inv. Mark's Lake
Page	2 of 2
Project Number	63647
Date	6/6/17

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
50	LIMESTONE light olive grey (5Y 5/3) yellowish grey (5Y 7/3) strong weathered at fractures. Dense, pyrite									
	stylolite eroded by water-solution									
51	Stylolites throughout.									
	4" pyrite nodule layer.									
52	shale parting 45° fracture. 0.04' thick.			5/5						
	Becomes more shale layers. Shale is olive grey (5Y 4/1).	Ls								
53	Sh/Ls intermixed.									
54	weathered, stylolites weak at stylolites.	Ls								
										1055
55		Ls								1057
	0.3' shale olive grey (5Y 4/1).									
	stylolites									
56	0.1' shale									
57	sh			5/5						
	sh	Ls								
58	stylolites									
59	stylolite.	Ls								
	eroded stylolite fracture.									
	fossiliferous.	Ls								1110
60										1112
61	shale parting. fracture									
	shale parting along stylolite.									
62	shale parting fracture	Ls		5/5						
	shale parting 0.02" fracture	Ls								
63		Ls								
64	shale parting fracture.									
	healed fractures gravel									
	shale parting fracture									
65		Ls								1127 Stop.
	Bottom of Boring									Boring Abandoned

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log

Project Name: Hydro Inv More's Lake	Project Number: 93647	Boring Number: MW-8
Ground Elevation:	Location: More's Lake	Page: 1 of 2
Air Monitoring Equipment: PID/LEL-4gas		Total Footage: 30

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	6 1/4"	30	NA	9	NA

Drilling Company: Geotechnology	Driller(s): Patrick Hart
Drilling Rig: CME	Type of Sampler: Split spoon - 2'
Date: 5/18/17 To: 5/18/17	Field Observer(s): Lewis-Turner LTT

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
1	GRAVEL FILL		N/A	–						1210 START
2–3	CLAY, trace silt and fine gravel fill, very dark greenish gray (GLEY1 3/10Y) damp medium plasticity, medium consistency	CL	2 1 4 7	2/2						PID=0 LEL=0 CO=0 O_2=20.9% H_2S=0
4–5	becomes greenish black (GLEY1 2.5/10Y)		1 4	2/2						1222
6–7	SILT, some clay, very dark grayish brown (10YR 3/2) damp. medium plasticity, soft. becomes wet	ML	2 3 1 3 4 8	2/2						▽ wet.
8–9	CLAY, trace silt, brown (10YR 4/3) damp, medium plasticity, stiff	CL	1 2 3 5	0.5/2						rock in SS low recovery 1235
11–12	CLAY, some silt, yellowish brown (10YR 5/6) damp, medium plasticity, stiff, trace black (10YR 2/1) veins.	CL	2 3 5 7	2/2						PID=0 LEL=0 CO=0 O_2=20.8% H_2S=0
13	3" sand and fine gravel layer. sand fine to coarse. wet		3 4 6	2/2						
14	CLAY, trace silt, brown (10YR 5/3) damp, medium plasticity stiff. trace sand/gravel throughout.	CL	9							1241

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-2-1

Drilling Log Continuation

Project Name	Hydro Inv More's Lake
Project Number	93647
Boring Number	MW-8
Page	2 of 2
Date	5/18/17

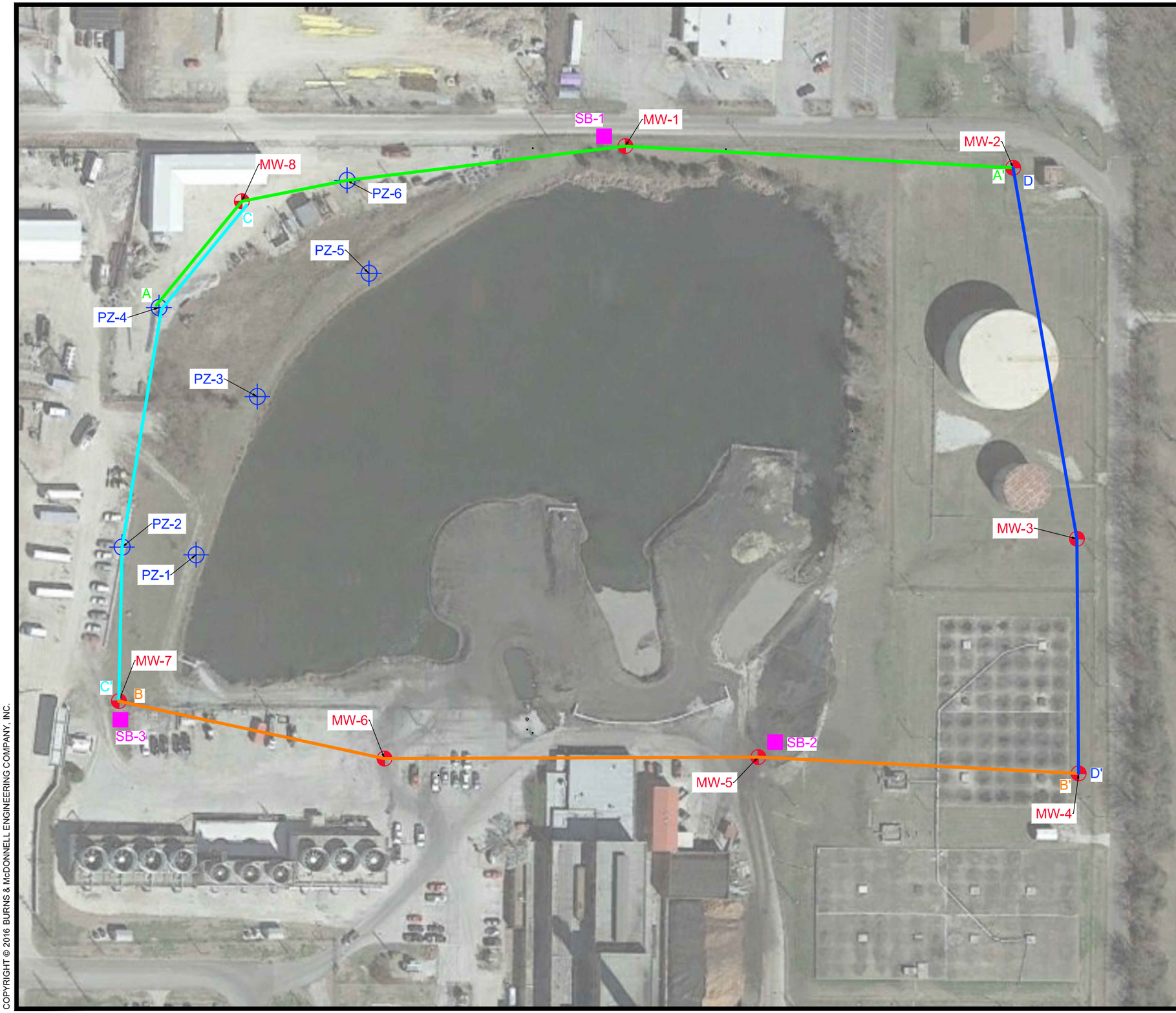
Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
14	SAND, trace silt and clay, trace fine gravel, light yellowish brown (10YR 6/4) damp, loose, subangular, poorly graded to moderate.	SP	5 9	2/2						1246
15			12 21			1259 16-18 MW8/ SB01 Bag.				
16			7 8 20 22	2/2						
17	CLAY, trace silt, some sand and gravel brownish yellow (10YR 6/6), damp, trace plasticity, very stiff.	CL								
18			3 5 9 17	2/2						
19	CLAY, trace silt and sand, very dark grayish brown (10YR 3/2) damp, trace plasticity, very stiff	CL								
20	Chert fragments 1.5" Color change to yellowish brown (10YR 5/4) 2" sand lens.		3 4 7 9	2/2		1315 20-23 MW-8/ SB02 MW-8/ SB11 (Dup) Jars			1304 Large Chert Fragments.
21	Becomes brown (10YR 3/2)									
22			4 7 9 15	2/2						PID = 0 LEL = 0 CO = 0 O_2 = 20.9% H_2S = 0
23										
24	SILT, trace clay, dark gray (10YR 4/1) damp, nonplastic, stiff.	ML	5 8	2/2						1335
25			9 15							
26	Some clay		5 7 10 31	2/2						
27	CLAY, trace silt, light yellowish brown (2.5Y 6/4) damp, trace plasticity, very stiff.	CL								(Hard Drilling.
28			15 25 31 39	2/2						
29	damp.									(weathered) shale, Possibly - Clay Stop 1356
30										
	Bottom of Boring									

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

APPENDIX D – GENERALIZED GEOLOGIC CROSS-SECTIONS



LEGEND

- EXISTING PIEZOMETER
- NEW MONITORING WELL
- DEEP BEDROCK BORINGS

NOTES:

1. MONITORING WELL AND PIEZOMETER LOCATIONS AND ELEVATIONS SURVEYED BY ENGINEERING SURVEYS AND SERVICES OF COLUMBIA, MO ON JUNE 23, 2017.

N

0 100' 200'

SCALE IN FEET

BURNS McDONNELL

CROSS SECTION PROFILE MAP
COLUMBIA MUNICIPAL POWER PLANT
COLUMBIA, MO

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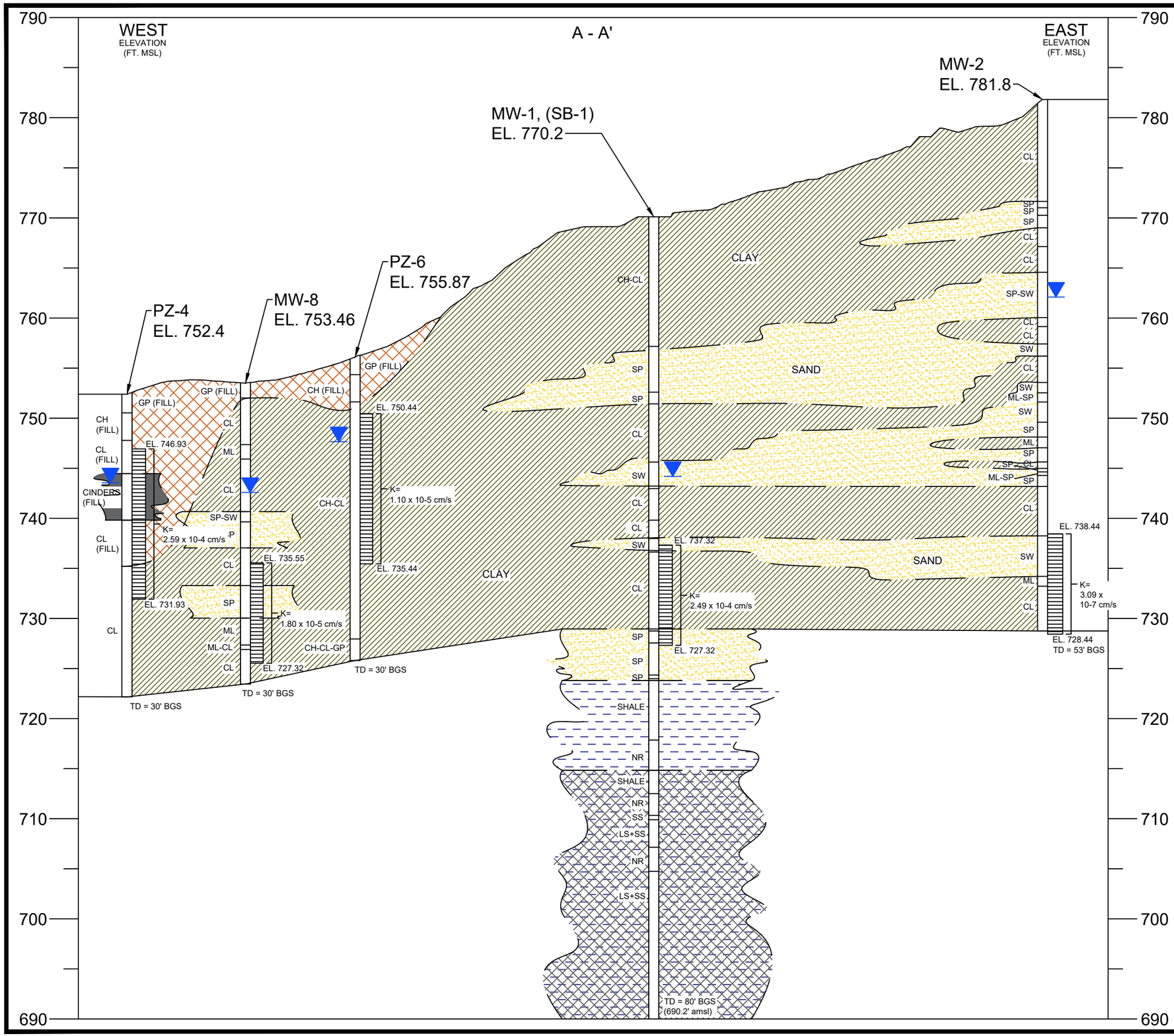

GLACIAL DRIFT LITHOLOGIES

- CLAY, LOW TO MEDIUM PLASTICITY
- ML — SILT, LOW PLASTICITY
- SW — SAND, WELL GRADED
- SP — SAND, POORLY GRADED
- COAL COMBUSTION RESIDUAL (CCR; CINDERS)
- FILL
- LIMESTONE
- SHALE
- INTERBEDDED LIMESTONE AND SHALE
- SAND
- CH — FAT CLAY
- GP — POORLY GRINDED GRAVEL
- INTERPRETED GEOLOGIC CONTACT
- INFERRED GEOLOGIC CONTACT
- 735.55 — SCREENED INTERVAL (ELEVATIONS INDICATED)
- SHALLOW POTENTIOMETRIC SURFACE(11/16/2017)
- 745.00 — GROUNDWATER ELEVATION (11/16/2017)
- K — HYDRAULIC CONDUCTIVITY (cm/sec)

NOTES:

1. CORRELATION OF UNITS IS AN INTERPRETATION AND NOT NECESSARILY A DELINEATION OF ACTUAL EXTENT AND THICKNESS OF INDIVIDUAL UNITS.
2. LITHOLOGY WAS LOGGED BY BURNS & MCDONNELL GEOLOGISTS AND/OR CROCKETT ENGINEERING CONSULTANTS PERSONNEL IN ACCORDANCE WITH UNIFIED SOIL CLASSIFICATION SYSTEM.
3. THE DEEPEST BASE ELEVATION OF THE INACTIVE SURFACE IMPOUNDMENT IS AROUND 742 FEET amsl BASED ON TEST PITS DUG IN FALL 2016 (BURNS & McDONNELL, 2016).

HORIZONTAL 0 100' 200'
SCALE IN FEET

BURNS McDONNELL

GENERALIZED GEOLOGIC CROSS-SECTION A-A'

INACTIVE CCR SURFACE IMPOUNDMENT
COLUMBIA MUNICIPAL POWER PLANT
COLUMBIA, MO

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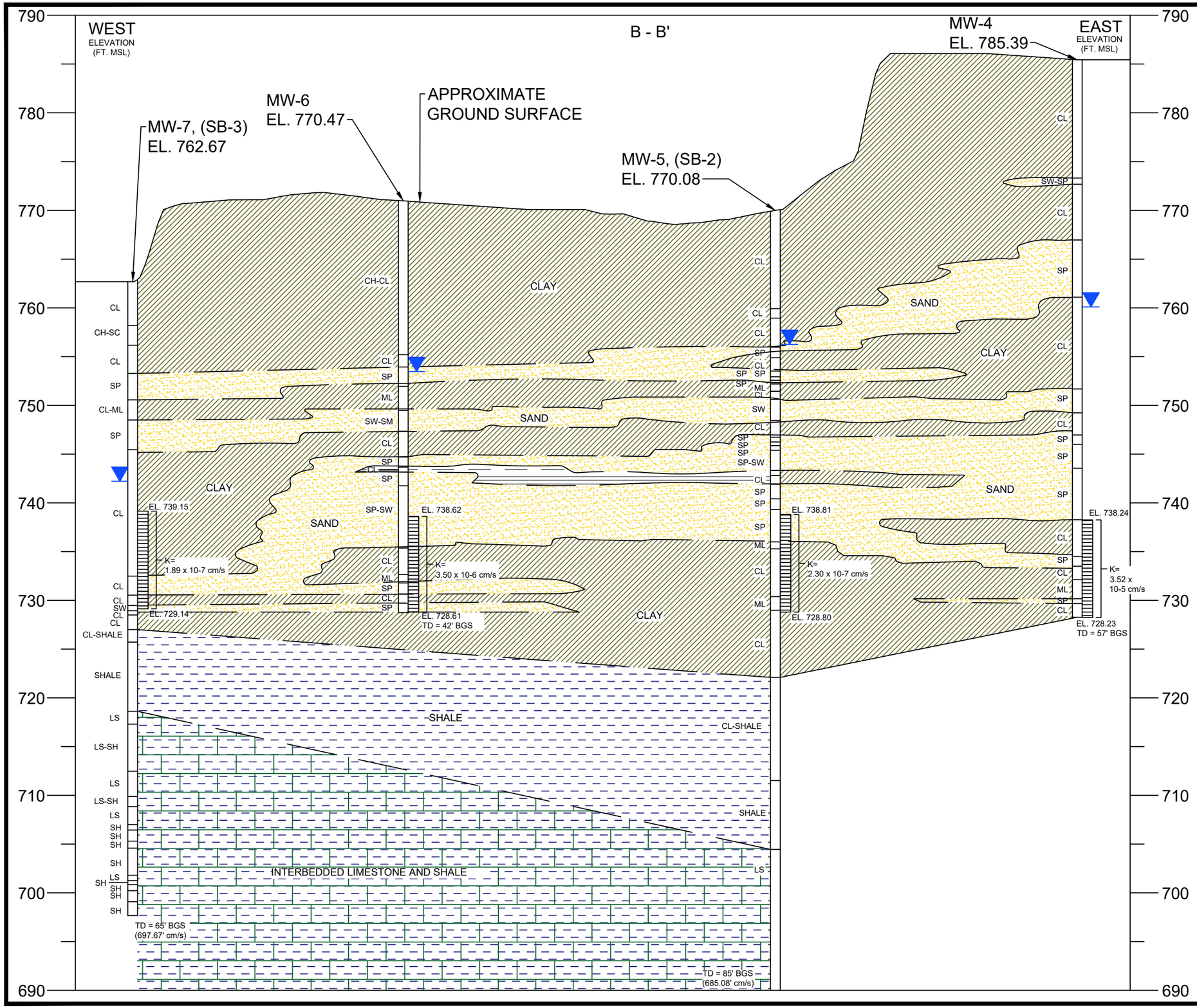

GLACIAL DRIFT LITHOLOGIES

- CLAY, LOW TO MEDIUM PLASTICITY
- ML — SILT, LOW PLASTICITY
- SC — SAND, CLAYEY
- SW — SAND, WELL GRADED
- SP — SAND, POORLY GRADED
- SM — SAND, SOME SILT
- CH — FAT CLAY
- LIMESTONE
- SHALE
- INTERBEDDED LIMESTONE AND SHALE
- SAND
- INTERPRETED GEOLOGIC CONTACT
- INFERRED GEOLOGIC CONTACT
- 735.55 — SCREENED INTERVAL (ELEVATIONS INDICATED)
- SHALLOW POTENTIOMETRIC SURFACE(11/16/2017)
- 745.00 — GROUNDWATER ELEVATION (11/16/2017)
- K — HYDRAULIC CONDUCTIVITY (cm/sec)

NOTES:

1. CORRELATION OF UNITS IS AN INTERPRETATION AND NOT NECESSARILY A DELINEATION OF ACTUAL EXTENT AND THICKNESS OF INDIVIDUAL UNITS.
2. LITHOLOGY WAS LOGGED BY BURNS & MCDONNELL GEOLOGISTS AND/OR CROCKETT ENGINEERING CONSULTANTS PERSONNEL IN ACCORDANCE WITH UNIFIED SOIL CLASSIFICATION SYSTEM.
3. THE DEEPEST BASE ELEVATION OF THE INACTIVE SURFACE IMPOUNDMENT IS AROUND 742 FEET amsl BASED ON TEST PITS DUG IN FALL 2016 (BURNS & McDONNELL, 2016).

HORIZONTAL 0 100' 200'
SCALE IN FEET

BURNS McDONNELL

GENERALIZED GEOLOGIC CROSS-SECTION B-B'

INACTIVE CCR SURFACE IMPOUNDMENT
COLUMBIA MUNICIPAL POWER PLANT
COLUMBIA, MO

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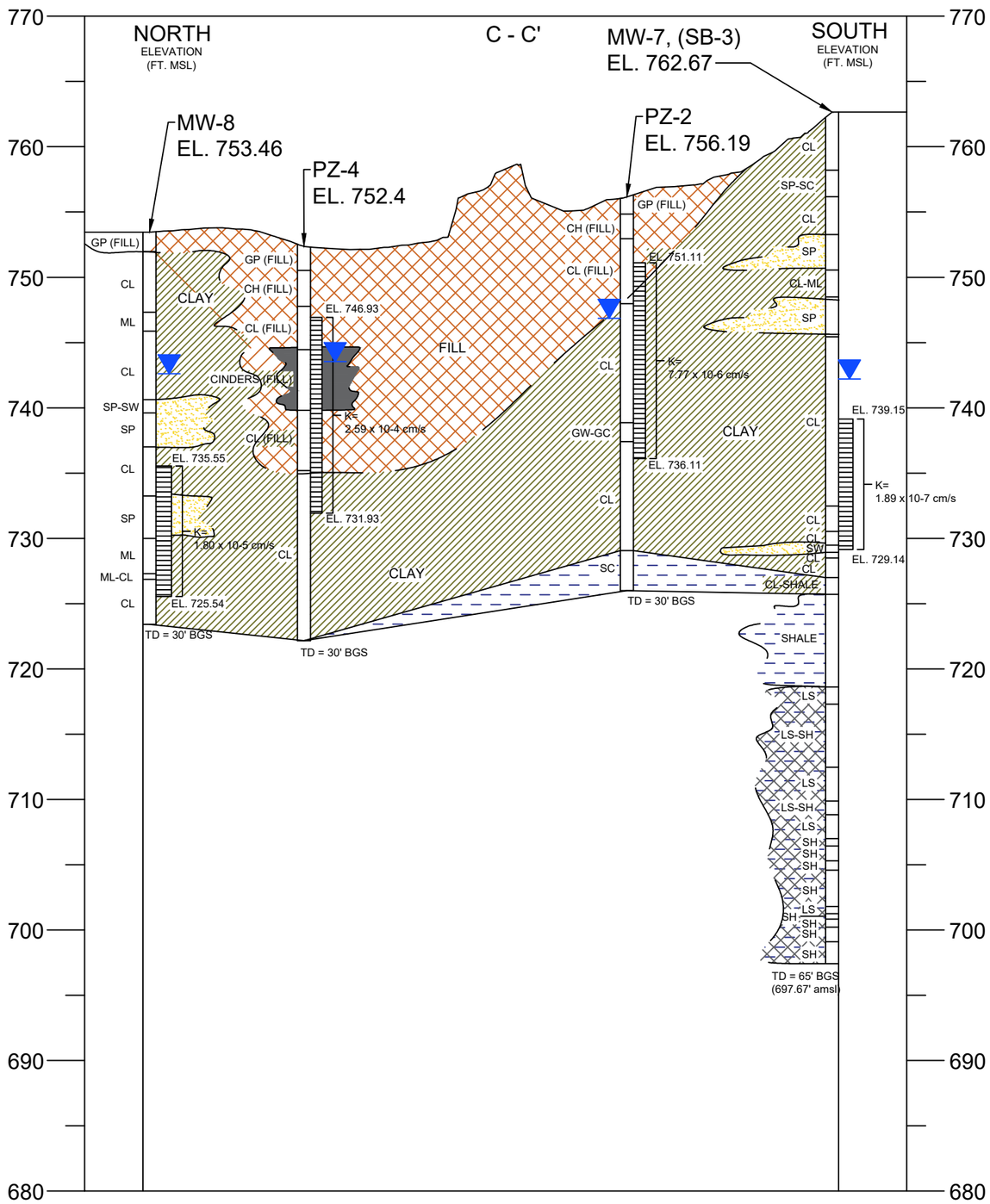

GLACIAL DRIFT LITHOLOGIES

- CLAY, LOW TO MEDIUM PLASTICITY
- ML — SILT, LOW PLASTICITY
- SW — SAND, WELL GRADED
- SP — SAND, POORLY GRADED
- COAL COMBUSTION RESIDUAL (CCR; CINDERS)
- FILL
- LIMESTONE
- SHALE
- INTERBEDDED LIMESTONE AND SHALE
- SAND
- FILL
- CH — FAT CLAY
- GP — POORLY GRINDED GRAVEL
- SC — SAND, CLAYEY
- GC — POORLY GRINDED GRAVEL WITH CLAY AND SAND.
- GM — SAND GRAVEL
- GW — GRAVEL, WELL GRADED WITH SAND
- INTERPRETED GEOLOGIC CONTACT
- INFERRED GEOLOGIC CONTACT
- 735.55 — SCREENED INTERVAL (ELEVATIONS INDICATED)
- SHALLOW POTENTIOMETRIC SURFACE(11/16/2017)
- 745.00 — GROUNDWATER ELEVATION (11/16/2017)
- K — HYDRAULIC CONDUCTIVITY (cm/sec)

NOTES:

1. CORRELATION OF UNITS IS AN INTERPRETATION AND NOT NECESSARILY A DELINEATION OF ACTUAL EXTENT AND THICKNESS OF INDIVIDUAL UNITS.
2. LITHOLOGY WAS LOGGED BY BURNS & MCDONNELL GEOLOGISTS AND/OR CROCKETT ENGINEERING CONSULTANTS PERSONNEL IN ACCORDANCE WITH UNIFIED SOIL CLASSIFICATION SYSTEM.
3. THE DEEPEST BASE ELEVATION OF THE INACTIVE SURFACE IMPOUNDMENT IS AROUND 742 FEET amsl BASED ON TEST PITS DUG IN FALL 2016 (BURNS & McDONNELL, 2016).

HORIZONTAL 0 100' 200'
SCALE IN FEET

BURNS McDONNELL

GENERALIZED GEOLOGIC CROSS-SECTION C-C'

INACTIVE CCR SURFACE IMPOUNDMENT
COLUMBIA MUNICIPAL POWER PLANT
COLUMBIA, MO

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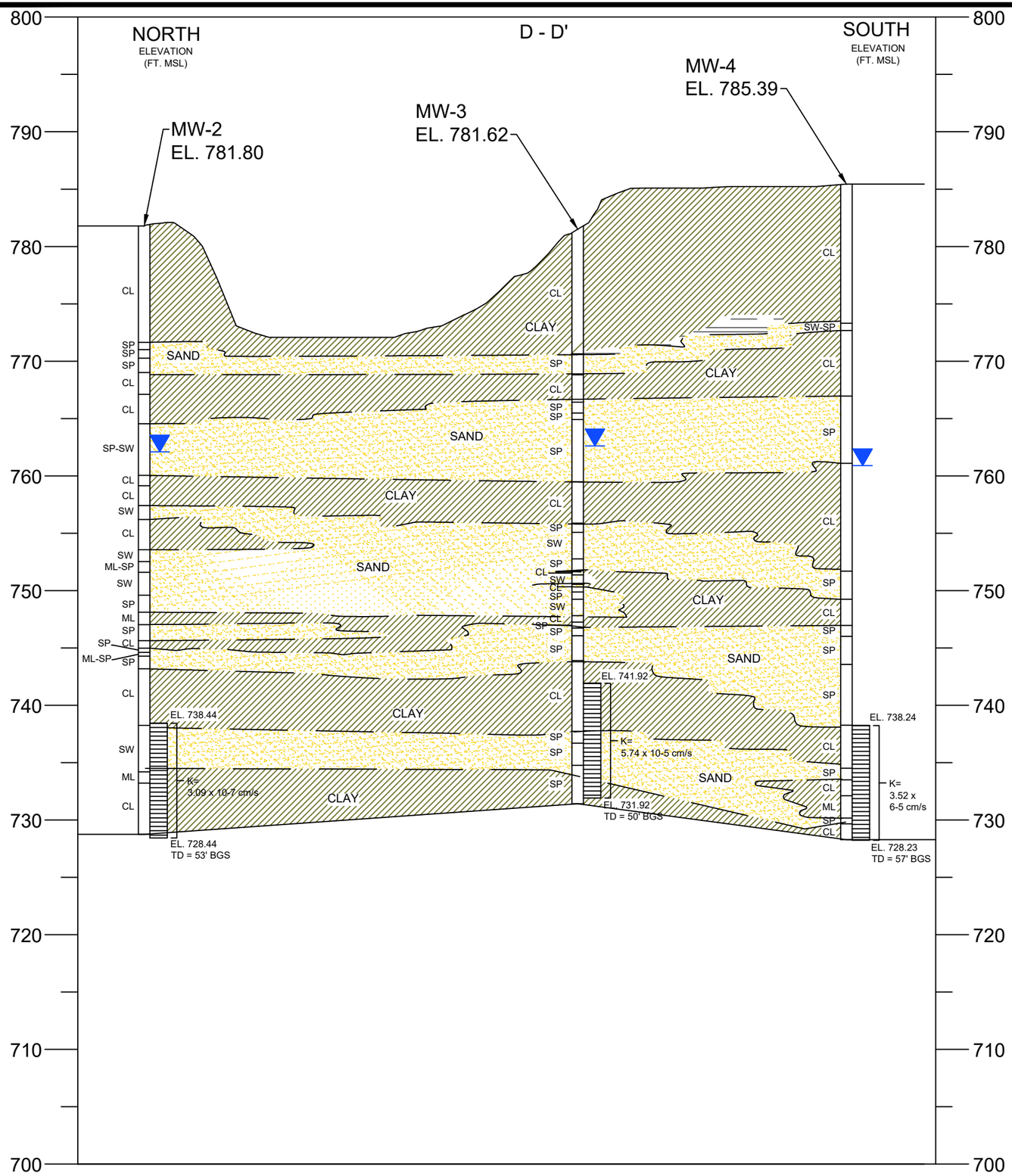

GLACIAL DRIFT LITHOLOGIES

- CLAY, LOW TO MEDIUM PLASTICITY
- ML — SILT, LOW PLASTICITY
- SW — SAND, WELL GRADED
- SP — SAND, POORLY GRADED
- COAL COMBUSTION RESIDUAL (CCR; CINDERS)
- FILL
- LIMESTONE
- SHALE
- INTERBEDDED LIMESTONE AND SHALE
- SAND

INTERPRETED GEOLOGIC CONTACT

INFERRED GEOLOGIC CONTACT

735.55 SCREENED INTERVAL (ELEVATIONS INDICATED)

SHALLOW POTENTIOMETRIC SURFACE(11/16/2017)

745.00 GROUNDWATER ELEVATION (11/16/2017)

K HYDRAULIC CONDUCTIVITY (cm/sec)

NOTES:

1. CORRELATION OF UNITS IS AN INTERPRETATION AND NOT NECESSARILY A DELINEATION OF ACTUAL EXTENT AND THICKNESS OF INDIVIDUAL UNITS.
2. LITHOLOGY WAS LOGGED BY BURNS & MCDONNELL GEOLOGISTS AND/OR CROCKETT ENGINEERING CONSULTANTS PERSONNEL IN ACCORDANCE WITH UNIFIED SOIL CLASSIFICATION SYSTEM.
3. THE DEEPEST BASE ELEVATION OF THE INACTIVE SURFACE IMPOUNDMENT IS AROUND 742 FEET amsl BASED ON TEST PITS DUG IN FALL 2016 (BURNS & McDONNELL, 2016).

HORIZONTAL 0 100' 200'
SCALE IN FEET

BURNS McDONNELL

GENERALIZED GEOLOGIC CROSS-SECTION D-D'

INACTIVE CCR SURFACE IMPOUNDMENT
COLUMBIA MUNICIPAL POWER PLANT
COLUMBIA, MO

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APPENDIX E – EXISTING DRILL LOGS AND CONSTRUCTION DETAILS OF EXISTING MONITORING WELLS

Crockett Geotechnical - Testing Lab
500 Big Bear Boulevard
Columbia, MO 65202
Telephone: 573-447-3981

BORING NUMBER B-1

CLIENT City of Columbia
PROJECT NAME Power Plant Dam Stability Analyses
PROJECT NUMBER G13043
PROJECT LOCATION Columbia, Missouri
DATE STARTED 1/2/14 **COMPLETED** 1/2/14
GROUND ELEVATION 772 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES
GROUND WATER LEVELS:
DRILLING METHOD 6" HSA
AT TIME OF DRILLING 16.00 ft / Elev 756.00 ft
LOGGED BY Lidholm **CHECKED BY** Lidholm
AT END OF DRILLING ---
NOTES Piezometer installed upon completion of drilling
24hrs AFTER DRILLING 11.50 ft / Elev 760.50 ft

DEPTH (ft)	MATERIAL DESCRIPTION		SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0	0.1 TOPSOIL (<1")	771.9										
	3.0 FILL: Fat Clay, brown, trace gray, trace sand, hard	769.0	SH 1	14		9000		120	15			
	5.0 FILL: Lean to Fat Clay, brown, very stiff	767.0	SH 2	19		7000		118	10			
	FILL: Lean Clay, silty, dark brownish gray, stiff		SH 3	20		4000		97	26	36	22	14
10	10.0	762.0	SH 4	15		3000	4970	104	20			
	FILL: Fat Clay, brown, trace gray, trace sand, soft to stiff		SH 5	12		3500	1540	95	29			
	Torvane = 350 psf		SH 6	17		1500	1540	97	26	50	16	34
20	Torvane = 500 psf		SH 7 top	11		1000		97	29			
	--: more sand, dark gray, soft			12		1000	890	86	24			
	Torvane = 500 psf		SH 7 bot									
	26.0 Torvane = 200 psf	746.0	SH 8 top	12		8500		95	30			
	LEAN TO FAT CLAY: brown, trace gray, trace sand and fine gravel, very stiff to hard (Glacial Drift)		SH 8 bot	12								
30	32.5	739.5	SH 9	10		9000		120	15	33	18	15
	COBBLES AND BOULDERS: Dense to very dense (Glacial Drift)											
	35.5	736.5										
	LEAN TO FAT CLAY: Dark gray, with gravel, trace sand, occasional cobbles and boulders, very stiff to hard (Glacial Drift)		SPT 10	14	30-26-32 (58)	7000			14			
40			SPT 11	12	27-39-50/3"	5000			17			
	47.0	725.0	SPT 12	12	8-17-38 (55)				24			
	CLAYEY SAND: Silty, gray, variable grain size (silt to coarse sand), dense (Glacial Drift)											
50			SPT 13	18	11-12-28 (40)				18			
			SPT 14	8	6-14-31 (45)				21			
60	60.0	712.0	SPT 15	6	9-12-30 (42)				22			

Bottom of borehole at 60.0 feet.

SAMPLE LENGTH REPORT - LAT-LONG TEMPLATE.GDT - 7/25/14 15:34 - C:\SERVER FILES\GEOTECH GENERAL\===PROJECTS===\GEOT PROJECTS\2013\G13043 - MORES LAKE DAM STABILITY ANALYSES\G13043.GPJ

Crockett Geotechnical - Testing Lab
500 Big Bear Boulevard
Columbia, MO 65202
Telephone: 573-447-3981

BORING NUMBER B-2

CLIENT City of Columbia
PROJECT NAME Power Plant Dam Stability Analyses
PROJECT NUMBER G13043
PROJECT LOCATION Columbia, Missouri
DATE STARTED 1/10/14 **COMPLETED** 1/10/14
GROUND ELEVATION 758 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES
GROUND WATER LEVELS:
DRILLING METHOD 6" HSA
AT TIME OF DRILLING 9.00 ft / Elev 749.00 ft
LOGGED BY Lidholm **CHECKED BY** Lidholm
AT END OF DRILLING ---
NOTES Piezometer installed upon completion of drilling
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION		SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX
0		1.0 FILL: Gravel, parking lot surface, 1-inch minus crushed limestone aggregate	757.0										
		3.0 FILL: Fat Clay, brown, trace gray, trace sand, very stiff	755.0	SH 1	16		4500						
		FILL: Lean to Fat Clay, brown, stiff		SH 2	5		3000	3150	105	20			
		8.0 LEAN TO FAT CLAY: brown, trace gray, trace sand and fine gravel, medium to very stiff (Glacial Drift)	750.0	SH 3	18		3000	2330	109	19			
10				SH 4	22		8000	1630	110	19			
		17.0	741.0										
		18.5 COBBLES AND BOULDERS: Dense to very dense (Glacial Drift)	739.5										
20		LEAN TO FAT CLAY: Dark gray, with gravel, trace sand, occasional cobbles and boulders, stiff to hard (Glacial Drift)		SPT 5	18	13-21-31 (52)	9000			14			
				SPT 6	16	11-20-35 (55)	3000			16			
		27.0 CLAYEY SAND: Silty, gray, variable grain size (silt to coarse sand), very dense (Glacial Drift)	731.0										
30		30.0	728.0	SPT 7	12	14-26-49 (75)	4500			24			

Bottom of borehole at 30.0 feet.

SAMPLE LENGTH REPORT - LAT-LONG TEMPLATE.GDT - 7/25/14 15:34 - C:\SERVER FILES\GEOTECH GENERAL\===PROJECTS===\GEOT PROJECTS\2013\G13043 - MORES LAKE DAM STABILITY ANALYSES\G13043.GPJ

Crockett Geotechnical - Testing Lab
500 Big Bear Boulevard
Columbia, MO 65202
Telephone: 573-447-3981

BORING NUMBER B-3

CLIENT City of Columbia
PROJECT NAME Power Plant Dam Stability Analyses
PROJECT NUMBER G13043
PROJECT LOCATION Columbia, Missouri
DATE STARTED 1/3/14 **COMPLETED** 1/3/14
GROUND ELEVATION 771 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES
GROUND WATER LEVELS:
DRILLING METHOD 6" HSA
AT TIME OF DRILLING 19.00 ft / Elev 752.00 ft
LOGGED BY Lidholm **CHECKED BY** Lidholm
AT END OF DRILLING ---
NOTES Piezometer installed upon completion of drilling
AFTER DRILLING ---

DEPTH (ft)	MATERIAL DESCRIPTION		SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX
0	0.1 TOPSOIL (<1")	770.9										
	3.0 FILL: Fat Clay, brown, trace gray, trace sand, medium to stiff	768.0	SH 1	12		9000		108	19			
	FILL: Lean to Fat Clay, brown, soft to very stiff		SH 2	11		4000	1610	98	25			
10			SH 3	12		3000	1830	103	22			
			SH 4	13		2000	2670	101	26	51	15	36
	13.0 FILL: Lean Clay, silty, dark brownish gray, stiff	758.0										
			SH 5	18		1500	1620	98	25			
20			SH 6	24		5000		97	26	38	15	23
			SH 7	24		1000	1280	101	21			
30												
	32.0 LEAN TO FAT CLAY: brown, trace gray, trace sand and fine gravel, very stiff to hard (Glacial Drift)	739.0	SH 8	24		0	1730	89	33			
			SH 9	19		5000		104	24	44	17	27
40												
	42.0 --: sandy zone	729.0	SH 10	22				97	26			
	COBBLES AND BOULDERS: Dense to very dense (Glacial Drift)											
	45.0 LEAN TO FAT CLAY: Brown and dark gray, with gravel, trace sand, occasional cobbles and boulders, very stiff to hard (Glacial Drift)	726.0	SPT 11	8	13-20-26 (46)				21			
50	50.6	720.4	SPT 12	6	50-50/1"	4000			23			

Refusal at 50.7 feet.
Bottom of borehole at 50.7 feet.

SAMPLE LENGTH REPORT - LAT-LONG TEMPLATE.GDT - 7/25/14 15:34 - C:\SERVER FILES\GEOTECH GENERAL\===PROJECTS===\GEOT PROJECTS\2013\G13043 - MORES LAKE DAM STABILITY ANALYSES\G13043.GPJ

Crockett Geotechnical - Testing Lab
500 Big Bear Boulevard
Columbia, MO 65202
Telephone: 573-447-3981

BORING NUMBER B-4

CLIENT City of Columbia
PROJECT NAME Power Plant Dam Stability Analyses
PROJECT NUMBER G13043
PROJECT LOCATION Columbia, Missouri
DATE STARTED 1/9/14 **COMPLETED** 1/9/14
GROUND ELEVATION 752 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES
GROUND WATER LEVELS:
DRILLING METHOD 6" HSA
AT TIME OF DRILLING --- Not Encounteed
LOGGED BY Lidholm **CHECKED BY** Lidholm
AT END OF DRILLING --- Not Encounteed
NOTES Piezometer installed upon completion of drilling
2hrs AFTER DRILLING --- Not Encountered

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION		SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX
0		1.5 FILL: Gravel, parking lot surface, 1-inch minus crushed limestone aggregate	750.5										
		4.5 FILL: Fat Clay, brown, trace gray, trace sand, stiff	747.5	SH 1	17		3000	2300	98	26			
		8.0 FILL: Lean to Fat Clay, brown, trace gray, stiff	744.0	SH 2	21		4000	3930	107	21			
10		FILL: Cinders, black, loose		SPT 3	5	2-1-1 (2)				44			
		12.5 FILL: Lean to Fat Clay, brown, trace gray, trace sand, very soft to medium Torvane = 100 psf	739.5	SPT 4	1	1-2-3 (5)				41			
				SPT 5	16	1-1-1 (2)	0			28			
		17.0 LEAN TO FAT CLAY: brown, trace gray, trace sand and fine gravel, very stiff to hard (Glacial Drift)	735.0	SPT 6	12	1-3-4 (7)	2000			26			
20				SPT 7	15	16-26-28 (54)	5000			19			
		28.0	724.0	SPT 8	10	5-8-10 (18)	9000			25			
30		30.0 LEAN TO FAT CLAY: Dark gray, with gravel, trace sand, occasional cobbles and boulders, very stiff to hard (Glacial Drift)	722.0	SPT 9	6	5-14-17 (31)	5500			20			

Bottom of borehole at 30.0 feet.

SAMPLE LENGTH REPORT - LAT-LONG TEMPLATE.GDT - 7/25/14 15:34 - C:\SERVER FILES\GEOTECH GENERAL\===PROJECTS===\GEOT PROJECTS\2013\G13043 - MORES LAKE DAM STABILITY ANALYSES\G13043.GPJ

Crockett Geotechnical - Testing Lab
500 Big Bear Boulevard
Columbia, MO 65202
Telephone: 573-447-3981

BORING NUMBER B-5

CLIENT City of Columbia
PROJECT NAME Power Plant Dam Stability Analyses
PROJECT NUMBER G13043
PROJECT LOCATION Columbia, Missouri
DATE STARTED 1/8/14 **COMPLETED** 1/8/14
GROUND ELEVATION 771 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES
GROUND WATER LEVELS:
DRILLING METHOD 6" HSA
AT TIME OF DRILLING ---
LOGGED BY Lidholm **CHECKED BY** Lidholm
AT END OF DRILLING ---
NOTES Piezometer installed upon completion of drilling
AFTER DRILLING ---

DEPTH (ft)	MATERIAL DESCRIPTION		SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0	0.1 TOPSOIL (<1")	770.9										
	3.0 FILL: Fat Clay and Cinders, brown, trace gray, trace sand, very stiff	768.0	SH 1	19		7000			13			
	FILL: Fat Clay, brown, trace gray, trace sand, medium to stiff Torvane = 500 psf		SH 2	99		1500	1370	97	26	47	16	31
10	10.0	761.0	SH 3	9		3000		98	24			
	FILL: Lean to Fat Clay, brown, trace gray, trace sand, very soft Torvane = 300 psf		SH 4	24		0	340	94	28	36	15	21
	Torvane = 200 psf		SH 5	24		0			31			
20	19.0	752.0										
	LEAN TO FAT CLAY: brown, trace gray, trace sand and fine gravel, stiff to very stiff (Glacial Drift)		SH 6	24		5500	2490	113	13	40	14	26
			SPT 7	12	3-8-11 (19)	5500			19			
30	29.0	742.0										
	LEAN TO FAT CLAY: Brown and gray to dark gray, with gravel, trace sand, occasional cobbles and boulders, very stiff to hard (Glacial Drift)		SH 8	21		7500	4640	119	16			
	--: sandy zone		SPT 9	14	20-46-37 (83)	9000			17			
40			SPT 10	15	11-27-27 (54)	9000			18			
	43.5	727.5										
	COBBLES AND BOULDERS: Dense to very dense (Glacial Drift)		SPT 11	5	13-26-31 (57)	5500			19			
	47.7	723.3	SPT 12	2	50/3"				8			

Refusal at 47.7 feet.
Bottom of borehole at 47.7 feet.

SAMPLE LENGTH REPORT - LAT-LONG TEMPLATE.GDT - 7/25/14 15:34 - C:\SERVER FILES\GEOTECH GENERAL\===PROJECTS===\GEOT PROJECTS\2013\G13043 - MORES LAKE DAM STABILITY ANALYSES\G13043.GPJ

Crockett Geotechnical - Testing Lab
500 Big Bear Boulevard
Columbia, MO 65202
Telephone: 573-447-3981

BORING NUMBER B-6

CLIENT City of Columbia
PROJECT NAME Power Plant Dam Stability Analyses
PROJECT NUMBER G13043
PROJECT LOCATION Columbia, Missouri
DATE STARTED 1/9/14 **COMPLETED** 1/9/14
GROUND ELEVATION 755 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES
GROUND WATER LEVELS:
DRILLING METHOD 6" HSA
AT TIME OF DRILLING ---
LOGGED BY Lidholm **CHECKED BY** Lidholm
AT END OF DRILLING ---
NOTES Piezometer installed upon completion of drilling
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION		SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX
0		1.5 FILL: Gravel, parking lot surface, 1-inch minus crushed limestone aggregate	753.5										
		4.0 FILL: Fat Clay, brown, trace gray, trace sand, hard	751.0	SH 1	12		3000		105	19			
		LEAN TO FAT CLAY: Brown, trace gray, trace sand and fine gravel, occasional cobbles and possible boulders, very stiff to hard (Glacial Drift)		SH 2	25		3500	1650	111	22			
10				SH 3	11		4000		119	15			
				SPT 4	10	20-50/5"	1000			18			
				SPT 5	8	31-50/5"	9000			10			
20				SPT 6	6	33-50/5"	9000			12			
				SPT 7	18	8-15-27 (42)	9000			17			
		28.0	727.0										
30		30.0 LEAN TO FAT CLAY: Dark gray, with gravel, trace sand, occasional cobbles and boulders, very stiff to hard (Glacial Drift)	725.0	SPT 8	16	10-13-20 (33)	8500			19			

Bottom of borehole at 30.0 feet.

SAMPLE LENGTH REPORT - LAT-LONG TEMPLATE.GDT - 7/25/14 15:34 - C:\SERVER FILES\GEOTECH GENERAL\===PROJECTS===\GEOT PROJECTS\2013\G13043 - MORES LAKE DAM STABILITY ANALYSES\G13043.GPJ

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500 Big Bear Boulevard
Columbia, MO 65202
Telephone: 573-447-3981

CROCKETT GEOTECHNICAL - TESTING LAB

BORING NUMBER B-7

CLIENT City of Columbia
PROJECT NAME Power Plant Dam Stability Analyses
PROJECT NUMBER G13043
PROJECT LOCATION Columbia, Missouri
DATE STARTED 6/30/14 **COMPLETED** 6/30/14
GROUND ELEVATION 755 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES
GROUND WATER LEVELS:
DRILLING METHOD 6" HSA
AT TIME OF DRILLING 7.00 ft / Elev 748.00 ft
LOGGED BY Rathe **CHECKED BY** Lidholm
AT END OF DRILLING ---
NOTES
1hrs AFTER DRILLING 7.00 ft / Elev 748.00 ft

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION		SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0		1.0 TOPSOIL: with gravel (12 inches)	754.0										
		FILL: Gravel and cobbles, 1-inch minus crushed limestone aggregate		SPT 1	8	22-18-4 (22)	9000			8			
		3.5 FILL: Lean to Fat Clay, brown, trace root hairs, trace gravel and fine gravel, stiff	751.5	SPT 2	5	3-2-5 (7)	3000			14			
10				SPT 3	1	4-2-1 (3)	9000			16			
		--: black and brown, trace sand, medium		SPT 4	13	3-5-3 (8)	1500			25	38	15	23
		17.0 LEAN TO FAT CLAY: Dark gray and orangish brown, trace fine gravel, trace to with gravel, very stiff (Glacial Drift)	738.0										
20				SPT 5	14	3-6-6 (12)	5000			26			
		25.0 --: light brown, trace fine sand, hard	730.0	SPT 6	15	8-16-18 (34)	9000			20			

Bottom of borehole at 25.0 feet.

SAMPLE LENGTH REPORT - LAT-LONG TEMPLATE.GDT - 7/25/14 15:34 - C:\SERVER FILES\GEOTECH GENERAL\===PROJECTS===\GEOT PROJECTS\2013\G13043 - MORES LAKE DAM STABILITY ANALYSES\G13043.GPJ

Crockett Geotechnical - Testing Lab
500 Big Bear Boulevard
Columbia, MO 65202
Telephone: 573-447-3981

BORING NUMBER B-8

CLIENT City of Columbia
PROJECT NAME Power Plant Dam Stability Analyses
PROJECT NUMBER G13043
PROJECT LOCATION Columbia, Missouri
DATE STARTED 6/30/14 **COMPLETED** 6/30/14
GROUND ELEVATION 751 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES
GROUND WATER LEVELS:
DRILLING METHOD 6" HSA
AT TIME OF DRILLING 5.00 ft / Elev 746.00 ft
LOGGED BY Rathe **CHECKED BY** Lidholm
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION		SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX
0		1.0 FILL: Gravel, parking lot surface, 1-inch minus crushed limestone aggregate	750.0										
		4.0 FILL: Cinders, black, loose	747.0	SPT 1	14	7-3-3 (6)	4000			24			
		▽ Fill: Dark gray, trace light brown, trace fine gravel, trace gravel, soft to medium		SPT 2	10	2-1-2 (3)	500			12			
10				SPT 3	13	1-3-7 (10)	1000			29	42	15	27
				SPT 4	18	2-2-3 (5)	1000			27			
20				SPT 5	10	7-12-13 (25)	500			35			
		25.0 --: with white, trace rust stains, hard	726.0	SPT 6	18	5-11-14 (25)	9000			30			

Bottom of borehole at 25.0 feet.

SAMPLE LENGTH REPORT - LAT-LONG TEMPLATE.GDT - 7/25/14 15:34 - C:\SERVER FILES\GEOTECH GENERAL\===PROJECTS===\GEOT PROJECTS\2013\G13043 - MORES LAKE DAM STABILITY ANALYSES\G13043.GPJ

Crockett Geotechnical - Testing Lab
500 Big Bear Boulevard
Columbia, MO 65202
Telephone: 573-447-3981

BORING NUMBER B-9

CLIENT City of Columbia
PROJECT NAME Power Plant Dam Stability Analyses
PROJECT NUMBER G13043
PROJECT LOCATION Columbia, Missouri
DATE STARTED 6/30/14 **COMPLETED** 6/30/14
GROUND ELEVATION 753 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES
GROUND WATER LEVELS:
DRILLING METHOD 6" HSA
AT TIME OF DRILLING 7.00 ft / Elev 746.00 ft
LOGGED BY Rathe **CHECKED BY** Lidholm
AT END OF DRILLING ---
NOTES
AFTER DRILLING --- Borehole backfilled upon completion

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION		SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0		1.0 FILL: Gravel, parking lot surface, 1-inch minus crushed limestone aggregate	752.0										
		LEAN TO FAT CLAY: Light brown, trace gray, trace reddish orange, trace black, trace gravel, stiff (Glacial Drift)		ST 1	14		3000	1190	107	19			
				ST 2	11		2500		101	24			
10		--: dark gray, trace light brown, trace root hairs, very stiff		ST 3	18		5000			26			
		--: gray and orangish brown, trace fine sand		ST 4	22		5500		105	22			
		19.6 --: with gravel, reddish brown	733.4	SPT 5	9	20-46-50/1"	9000			12			

Refusal at 19.6 feet.
Bottom of borehole at 19.6 feet.

SAMPLE LENGTH REPORT - LAT-LONG TEMPLATE.GDT - 7/25/14 15:34 - C:\SERVER FILES\GEOTECH GENERAL\===PROJECTS===\GEOT PROJECTS\2013\G13043 - MORES LAKE DAM STABILITY ANALYSES\G13043.GPJ

Crockett Geotechnical - Testing Lab
500 Big Bear Boulevard
Columbia, MO 65202
Telephone: 573-447-3981

BORING NUMBER B-10

CLIENT City of Columbia
PROJECT NAME Power Plant Dam Stability Analyses
PROJECT NUMBER G13043
PROJECT LOCATION Columbia, Missouri
DATE STARTED 6/30/14 **COMPLETED** 6/30/14
GROUND ELEVATION 752 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES
GROUND WATER LEVELS:
DRILLING METHOD 6" HSA
AT TIME OF DRILLING 3.50 ft / Elev 748.50 ft
LOGGED BY Rathe **CHECKED BY** Lidholm
AT END OF DRILLING ---
NOTES
0.25hrs AFTER DRILLING 3.50 ft / Elev 748.50 ft

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION		SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX
0		1.0 FILL: Gravel, parking lot surface, 1-inch minus crushed limestone aggregate, with cinders	751.0										
		LEAN TO FAT CLAY: Dark gray, trace light brown, trace fine gravel, stiff (Glacial Drift)		ST 1	17		3000			21			
		--: trace root hairs, with gravel		ST 2	11		3500			19			
10				SPT 3	8	4-5-2 (7)				24			
		--: with gravel and cobbles from 11.0' - to 13.0'											
				SPT 4	18	1-1-2 (3)				34			
20		--: becomes brown, with gravel and sand		SPT 5	12	6-12-15 (27)	3000			22			
		25.0	727.0	SPT 6	5	7-9-11 (20)	8500			17			

Bottom of borehole at 25.0 feet.

SAMPLE LENGTH REPORT - LAT-LONG TEMPLATE.GDT - 7/25/14 15:34 - C:\SERVER FILES\GEOTECH GENERAL\===PROJECTS===\GEOT PROJECTS\2013\G13043 - MORES LAKE DAM STABILITY ANALYSES\G13043.GPJ

MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND LAND SURVEY
(573) 368-2165

MONITORING WELL CERTIFICATION RECORD

REF NO 01000598	DATE RECEIVED 01/15/2014
CR NO	CHECK NO. ONLINE
STATE WELL NO A900508	REVENUE NO. 011514
ENTERED 001233 PH1 PH2 PH3 01/15/2014 01/15/2014 01/15/2014	APPROVED BY / ROUTE

INFORMATION SUPPLIED BY PRIMARY CONTRACTOR OR DRILLING CONTRACTOR

NOTE: THIS FORM IS NOT TO BE USED FOR NESTED WELLS

OWNER NAME CITY OF COLUMBIA	CONTACT NAME CITY OF COLUMBIA			VARIANCE GRANTED BY DNR
OWNER ADDRESS PO BOX 6015	CITY COLUMBIA	STATE MO	ZIP 65205	NUMBER
SITE NAME MORES LAKE DAM		WELL NUMBER PZ1		COUNTY BOONE
SITE ADDRESS 1501 BUSINESS LOOP 70 EAST		CITY COLUMBIA		STATIC WATER LEVEL FT

SURFACE COMPLETION

TYPE
- [ ] ABOVE GROUND
- [X] FLUSH MOUNT

LENGTH AND DIAMETER OF SURFACE COMPLETION
LENGTH 1.0 FT.
DIAMETER 12.0 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
DIAMETER 6.0 IN.
LENGTH 1.0 FT.

SURFACE COMPLETION GROUT
- [X] CONCRETE
- [ ] OTHER

COPY

LOCATION OF WELL
LAT. 38 ° 57' 58.1"
LONG. 92 ° 19' 6.5"

SMALLEST _____ 1/4 LARGEST _____ 1/4 _____ 1/4

SEC. LG002753 TWN. _____ NORTH
RANGE _____ Direction

MONITORING FOR:
- [ ] RADIONUCLIDES
- [ ] EXPLOSIVES
- [ ] SVOCS
- [ ] PETROLEUM PRODUCTS ONLY
- [ ] METALS
- [ ] VOC
- [ ] PESTICIDES/HERBICIDESS

PROPOSED USE OF WELL
- [ ] GAS MIGRATION WELL
- [ ] EXTRACTION WELL
- [ ] PIEZOMETERS
- [ ] DIRECT PUSH
- [X] OBSERVATION
- [ ] OPEN HOLE

- [ ] LOCKING CAP
- [ ] WEEP HOLE

ELEVATION _____FT.

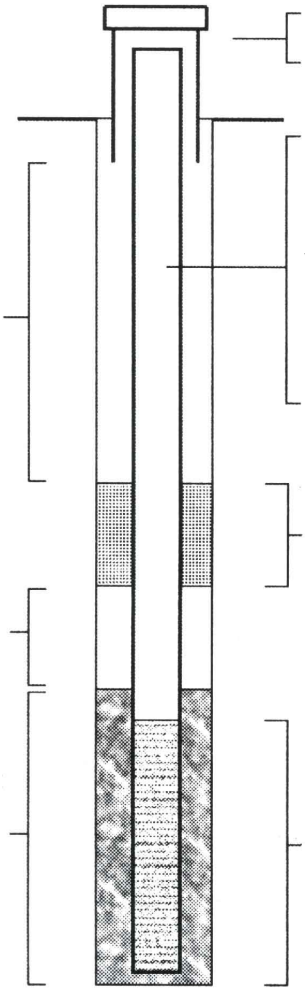
ANNULAR SEAL
LENGTH 2.0FT.
- [ ] SLURRY
- [ ] PELLETS
- [ ] CEMENT/SLURRY
- [ ] CHIPS
- [ ] GRANULAR

IF CEMENT/BENTONITE MIX:
BAGS OF CEMENT USED:
%OF BENTONITE USED:
WATER USED/BAG: GAL.

SECONDARY FILTER PACK
LENGTH: 0.0FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 3.0FT.

LENGTH OF PRIMARY FILTER PACK: 17.0FT.



SURFACE COMPLETTION
- [X] STEEL
- [ ] ALUMINUM
- [ ] PLASTIC

RISER
RISER PIPE DIAMETER 2.0IN.
RISER PIPE LENGTH 5.0FT.
HOLE DIAMETER 7.0IN.
WEIGHT OR SDR# SCH40

MATERIAL
- [ ] STEEL
- [ ] OTHER
- [X] THERMOPLASTIC (PVC)

BENTONITE SEAL
LENGTH: 0.0
- [ ] CHIPS
- [ ] PELLETS
- [ ] GRANULAR
- [ ] SLURRY
- [ ] SATURATED ZONE
- [ ] HYDRATED

SCREEN
SCREEN DIAMETER: 2.0IN.
SCREEN LENGTH: 15.0FT.
DIAMETER OF DRILL HOLE: 7.0IN.
DEPTH TO TOP 5.0FT.

SCREEN MATERIAL
- [ ] STEEL
- [ ] OTHER
- [X] THERMOPLASTIC (PVC)

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	20.0	CL, BROWN SILTY CLAY

TOTAL DEPTH: 20.0 FEET

FOR CASED WELLS, SUBMIT ADDITIONAL AS BUILT DIAGRAMS SHOWING WELL CONSTRUCTION DETAILS INCLUDING TYPE AND SIZE OF ALL CASING, HOLE DIAMETER AND GROUT USED.

SIGNATURE (PRIMARY COUNTRACTOR) x JAMES CLINGMAN	PERMIT NUMBER 001233	DATE WELL DRILLING WAS COMPLETED 01/13/2014
I HEREBY CERTIFY THAT THE MONITORING WELL HEREIN DESCRIBED WAS CONSTRUCTED IN ACCORDANCE WITH MISSOURI DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE CONSTRUCTION OF MONITORING WELLS		[ ] PUMP INSTALLED

SIGNATURE (WELL DRILLER) x JAMES CLINGMAN	PERMIT NUMBER 001233	SIGNATURE (APPRENTICE) x PAUL SCHEETZ	APPRENTICE PERMIT NUMBER 004707

MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND LAND SURVEY
(573) 368-2165

MONITORING WELL CERTIFICATION RECORD

REF NO 01000599	DATE RECEIVED 01/15/2014
CR NO	CHECK NO. ONLINE
STATE WELL NO A900509	REVENUE NO. 011514
ENTERED 001233 PH1 PH2 PH3 01/15/2014 01/15/2014 01/15/2014	APPROVED BY / ROUTE

INFORMATION SUPPLIED BY PRIMARY CONTRACTOR OR DRILLING CONTRACTOR

NOTE: THIS FORM IS NOT TO BE USED FOR NESTED WELLS

OWNER NAME CITY OF COLUMBIA	CONTACT NAME CITY OF COLUMBIA			VARIANCE GRANTED BY DNR
OWNER ADDRESS PO BOX 6015	CITY COLUMBIA	STATE MO	ZIP 65205	NUMBER
SITE NAME MORES LAKE DAM		WELL NUMBER PZ2		COUNTY BOONE
SITE ADDRESS 1501 BUSINESS LOOP 70 EAST		CITY COLUMBIA		STATIC WATER LEVEL FT

SURFACE COMPLETION

TYPE	LENGTH AND DIAMETER OF SURFACE COMPLETION	DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED	SURFACE COMPLETION GROUT
[ ] ABOVE GROUND	LENGTH 1.0 FT.	DIAMETER 6.0 IN.	[X] CONCRETE
[X] FLUSH MOUNT	DIAMETER 12.0 IN.	LENGTH 1.0 FT.	[ ] OTHER

COPY

LOCATION OF WELL

LAT. 38 ° 57' 58.2"
LONG. 92 ° 19' 7.4"

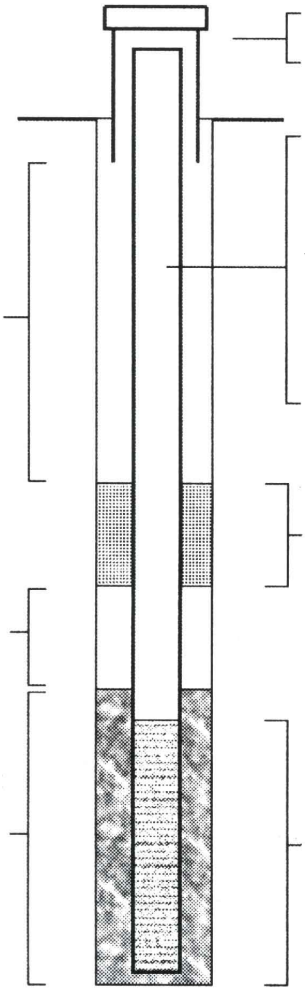
SMALLEST _____ 1/4 LARGEST _____ 1/4 _____ 1/4

SEC. LG002753 TWN. _____ NORTH
RANGE _____ Direction

MONITORING FOR:
[ ] RADIONUCLIDES [ ] PETROLEUM PRODUCTS ONLY
[ ] EXPLOSIVES [ ] METALS [ ] VOC
[ ] SVOCS [ ] PESTICIDES/HERBICIDESS

PROPOSED USE OF WELL
[ ] GAS MIGRATION WELL [X] OBSERVATION
[ ] EXTRACTION WELL [ ] OPEN HOLE
[ ] PIEZOMETERS
[ ] DIRECT PUSH

[ ] LOCKING CAP
[ ] WEEP HOLE



SURFACE COMPLETTION
[X] STEEL [ ] ALUMINUM [ ] PLASTIC

ELEVATION _____FT.

ANNULAR SEAL
LENGTH 2.0FT.
[ ] SLURRY [ ] CHIPS
[ ] PELLETS [ ] GRANULAR
[ ] CEMENT/SLURRY

IF CEMENT/BENTONITE MIX:
BAGS OF CEMENT USED:
%OF BENTONITE USED:
WATER USED/BAG: GAL.

RISER
RISER PIPE DIAMETER 2.0IN.
RISER PIPE LENGTH 5.0FT.
HOLE DIAMETER 7.0IN.
WEIGHT OR SDR# SCH40

MATERIAL
[ ] STEEL [X] THERMOPLASTIC (PVC)
[ ] OTHER

BENTONITE SEAL
LENGTH: 0.0
[ ] CHIPS [ ] PELLETS [ ] GRANULAR
[ ] SLURRY
[ ] SATURATED ZONE [ ] HYDRATED

SECONDARY FILTER PACK
LENGTH: 0.0FT.

SCREEN
SCREEN DIAMETER: 2.0IN.
SCREEN LENGTH: 15.0FT.
DIAMETER OF DRILL HOLE: 7.0IN.
DEPTH TO TOP 5.0FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 3.0FT.

SCREEN MATERIAL
[ ] STEEL [X] THERMOPLASTIC (PVC)
[ ] OTHER

LENGTH OF PRIMARY FILTER PACK: 17.0FT.

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	20.0	CL, BROWN SILTY CLAY
TOTAL DEPTH:	20.0 FEET	

FOR CASED WELLS, SUBMIT ADDITIONAL AS BUILT DIAGRAMS SHOWING WELL CONSTRUCTION DETAILS INCLUDING TYPE AND SIZE OF ALL CASING, HOLE DIAMETER AND GROUT USED.

SIGNATURE (PRIMARY COUNTRACTOR) x JAMES CLINGMAN	PERMIT NUMBER 001233	DATE WELL DRILLING WAS COMPLETED 01/13/2014
I HEREBY CERTIFY THAT THE MONITORING WELL HEREIN DESCRIBED WAS CONSTRUCTED IN ACCORDANCE WITH MISSOURI DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE CONSTRUCTION OF MONITORING WELLS		[ ] PUMP INSTALLED

SIGNATURE (WELL DRILLER) x JAMES CLINGMAN	PERMIT NUMBER 001233	SIGNATURE (APPRENTICE) x PAUL SCHEETZ	APPRENTICE PERMIT NUMBER 004707

MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND LAND SURVEY
(573) 368-2165

MONITORING WELL CERTIFICATION RECORD

REF NO 01000600	DATE RECEIVED 01/15/2014
CR NO	CHECK NO. ONLINE
STATE WELL NO A900510	REVENUE NO. 011514
ENTERED 001233 PH1 PH2 PH3 01/15/2014 01/15/2014 01/15/2014	APPROVED BY / ROUTE

INFORMATION SUPPLIED BY PRIMARY CONTRACTOR OR DRILLING CONTRACTOR

NOTE: THIS FORM IS NOT TO BE USED FOR NESTED WELLS

OWNER NAME CITY OF COLUMBIA	CONTACT NAME CITY OF COLUMBIA			VARIANCE GRANTED BY DNR
OWNER ADDRESS PO BOX 6015	CITY COLUMBIA	STATE MO	ZIP 65205	NUMBER
SITE NAME MORES LAKE DAM		WELL NUMBER PZ3		COUNTY BOONE
SITE ADDRESS 1501 BUSINESS LOOP 70 EAST		CITY COLUMBIA		STATIC WATER LEVEL FT

SURFACE COMPLETION

TYPE
- [ ] ABOVE GROUND
- [X] FLUSH MOUNT

LENGTH AND DIAMETER OF SURFACE COMPLETION
LENGTH 1.0 FT.
DIAMETER 12.0 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
DIAMETER 6.0 IN.
LENGTH 1.0 FT.

SURFACE COMPLETION GROUT
- [X] CONCRETE
- [ ] OTHER

COPY

LOCATION OF WELL
LAT. 38 ° 57' 59.7"
LONG. 92 ° 19' 5.7"

SMALLEST _____ 1/4 LARGEST _____ 1/4 _____ 1/4
SEC. LG002753 TWN. _____ NORTH
RANGE _____ Direction

MONITORING FOR:
- [ ] RADIONUCLIDES
- [ ] EXPLOSIVES
- [ ] SVOCS
- [ ] PETROLEUM PRODUCTS ONLY
- [ ] METALS
- [ ] VOC
- [ ] PESTICIDES/HERBICIDESS

PROPOSED USE OF WELL
- [ ] GAS MIGRATION WELL
- [ ] EXTRACTION WELL
- [ ] PIEZOMETERS
- [ ] DIRECT PUSH
- [X] OBSERVATION
- [ ] OPEN HOLE

- [ ] LOCKING CAP
- [ ] WEEP HOLE

ELEVATION _____FT.

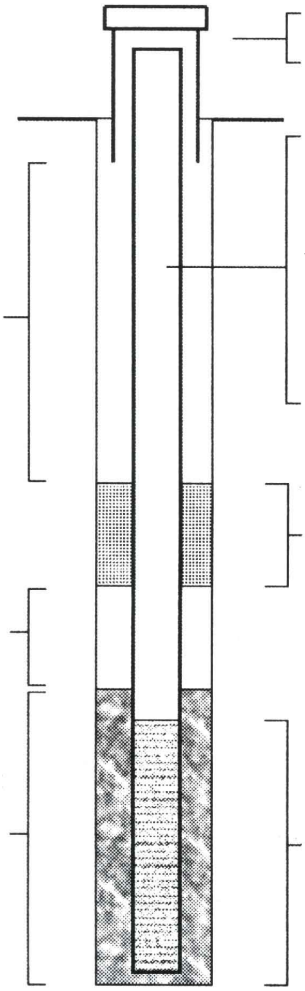
ANNULAR SEAL
LENGTH 2.0FT.
- [ ] SLURRY
- [ ] PELLETS
- [ ] CEMENT/SLURRY
- [ ] CHIPS
- [ ] GRANULAR

IF CEMENT/BENTONITE MIX:
BAGS OF CEMENT USED:
%OF BENTONITE USED:
WATER USED/BAG: GAL.

SECONDARY FILTER PACK
LENGTH: 0.0FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 3.0FT.

LENGTH OF PRIMARY FILTER PACK: 17.0FT.



SURFACE COMPLETTION
- [X] STEEL
- [ ] ALUMINUM
- [ ] PLASTIC

RISER
RISER PIPE DIAMETER 2.0IN.
RISER PIPE LENGTH 5.0FT.
HOLE DIAMETER 7.0IN.
WEIGHT OR SDR# SCH40

MATERIAL
- [ ] STEEL
- [ ] OTHER
- [X] THERMOPLASTIC (PVC)

BENTONITE SEAL
LENGTH: 0.0
- [ ] CHIPS
- [ ] PELLETS
- [ ] GRANULAR
- [ ] SLURRY
- [ ] SATURATED ZONE
- [ ] HYDRATED

SCREEN
SCREEN DIAMETER: 2.0IN.
SCREEN LENGTH: 15.0FT.
DIAMETER OF DRILL HOLE: 7.0IN.
DEPTH TO TOP 5.0FT.

SCREEN MATERIAL
- [ ] STEEL
- [ ] OTHER
- [X] THERMOPLASTIC (PVC)

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	20.0	CL, BROWN SILTY CLAY

TOTAL DEPTH: 20.0 FEET

FOR CASED WELLS, SUBMIT ADDITIONAL AS BUILT DIAGRAMS SHOWING WELL CONSTRUCTION DETAILS INCLUDING TYPE AND SIZE OF ALL CASING, HOLE DIAMETER AND GROUT USED.

SIGNATURE (PRIMARY COUNTRACTOR) x JAMES CLINGMAN	PERMIT NUMBER 001233	DATE WELL DRILLING WAS COMPLETED 01/13/2014
I HEREBY CERTIFY THAT THE MONITORING WELL HEREIN DESCRIBED WAS CONSTRUCTED IN ACCORDANCE WITH MISSOURI DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE CONSTRUCTION OF MONITORING WELLS		[ ] PUMP INSTALLED

SIGNATURE (WELL DRILLER) x JAMES CLINGMAN	PERMIT NUMBER 001233	SIGNATURE (APPRENTICE) x PAUL SCHEETZ	APPRENTICE PERMIT NUMBER 004707

MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND LAND SURVEY
(573) 368-2165

MONITORING WELL CERTIFICATION RECORD

REF NO 01000601	DATE RECEIVED 01/15/2014
CR NO	CHECK NO. ONLINE
STATE WELL NO A900511	REVENUE NO. 011514
ENTERED 001233 PH1 PH2 PH3 01/15/2014 01/15/2014 01/15/2014	APPROVED BY / ROUTE

INFORMATION SUPPLIED BY PRIMARY CONTRACTOR OR DRILLING CONTRACTOR

NOTE: THIS FORM IS NOT TO BE USED FOR NESTED WELLS

OWNER NAME CITY OF COLUMBIA	CONTACT NAME CITY OF COLUMBIA			VARIANCE GRANTED BY DNR
OWNER ADDRESS PO BOX 6015	CITY COLUMBIA	STATE MO	ZIP 65205	NUMBER
SITE NAME MORES LAKE DAM		WELL NUMBER PZ4		COUNTY BOONE
SITE ADDRESS 1501 BUSINESS LOOP 70 EAST		CITY COLUMBIA		STATIC WATER LEVEL FT

SURFACE COMPLETION

TYPE
- [ ] ABOVE GROUND
- [X] FLUSH MOUNT

LENGTH AND DIAMETER OF SURFACE COMPLETION
LENGTH 1.0 FT.
DIAMETER 12.0 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
DIAMETER 6.0 IN.
LENGTH 1.0 FT.

SURFACE COMPLETION GROUT
- [X] CONCRETE
- [ ] OTHER

COPY

LOCATION OF WELL
LAT. 38 ° 58' 0.6"
LONG. 92 ° 19' 7.0"

SMALLEST ____ 1/4 ____ 1/4 ____ 1/4 LARGEST

SEC. LG002753 TWN. ____ NORTH
RANGE ____ Direction

MONITORING FOR:
- [ ] RADIONUCLIDES
- [ ] EXPLOSIVES
- [ ] SVOCS
- [ ] PETROLEUM PRODUCTS ONLY
- [ ] METALS
- [ ] VOC
- [ ] PESTICIDES/HERBICIDESS

PROPOSED USE OF WELL
- [ ] GAS MIGRATION WELL
- [ ] EXTRACTION WELL
- [ ] PIEZOMETERS
- [ ] DIRECT PUSH
- [X] OBSERVATION
- [ ] OPEN HOLE

- [ ] LOCKING CAP
- [ ] WEEP HOLE

ELEVATION ____FT.

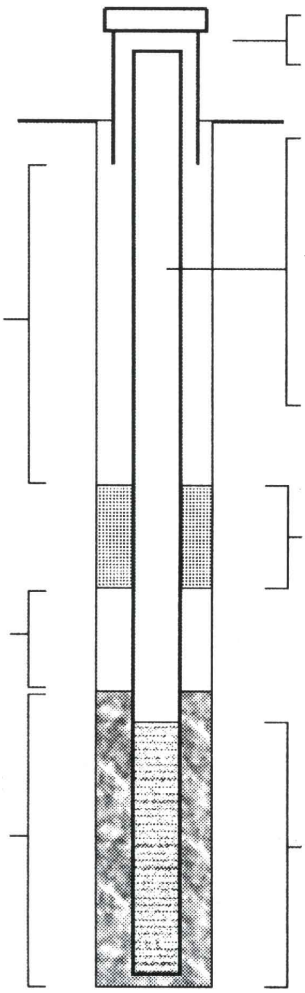
ANNULAR SEAL
LENGTH 2.0FT.
- [ ] SLURRY
- [ ] PELLETS
- [ ] CEMENT/SLURRY
- [ ] CHIPS
- [ ] GRANULAR

IF CEMENT/BENTONITE MIX:
BAGS OF CEMENT USED:
%OF BENTONITE USED:
WATER USED/BAG: GAL.

SECONDARY FILTER PACK
LENGTH: 0.0FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 3.0FT.

LENGTH OF PRIMARY FILTER PACK: 17.0FT.



SURFACE COMPLETTION
- [X] STEEL
- [ ] ALUMINUM
- [ ] PLASTIC

RISER
RISER PIPE DIAMETER 2.0IN.
RISER PIPE LENGTH 5.0FT.
HOLE DIAMETER 7.0IN.
WEIGHT OR SDR# SCH40

MATERIAL
- [ ] STEEL
- [ ] OTHER
- [X] THERMOPLASTIC (PVC)

BENTONITE SEAL
LENGTH: 0.0
- [ ] CHIPS
- [ ] PELLETS
- [ ] GRANULAR
- [ ] SLURRY
- [ ] SATURATED ZONE
- [ ] HYDRATED

SCREEN
SCREEN DIAMETER: 2.0IN.
SCREEN LENGTH: 15.0FT.
DIAMETER OF DRILL HOLE: 7.0IN.
DEPTH TO TOP 5.0FT.

SCREEN MATERIAL
- [ ] STEEL
- [ ] OTHER
- [X] THERMOPLASTIC (PVC)

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	20.0	CL, BROWN SILTY CLAY
TOTAL DEPTH:		20.0 FEET

FOR CASED WELLS, SUBMIT ADDITIONAL AS BUILT DIAGRAMS SHOWING WELL CONSTRUCTION DETAILS INCLUDING TYPE AND SIZE OF ALL CASING, HOLE DIAMETER AND GROUT USED.

SIGNATURE (PRIMARY COUNTRACTOR) x JAMES CLINGMAN	PERMIT NUMBER 001233	DATE WELL DRILLING WAS COMPLETED 01/14/2014
I HEREBY CERTIFY THAT THE MONITORING WELL HEREIN DESCRIBED WAS CONSTRUCTED IN ACCORDANCE WITH MISSOURI DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE CONSTRUCTION OF MONITORING WELLS		[ ] PUMP INSTALLED

SIGNATURE (WELL DRILLER) x JAMES CLINGMAN	PERMIT NUMBER 001233	SIGNATURE (APPRENTICE) x PAUL SCHEETZ	APPRENTICE PERMIT NUMBER 004707

MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND LAND SURVEY
(573) 368-2165

MONITORING WELL CERTIFICATION RECORD

REF NO 01000602	DATE RECEIVED 01/15/2014
CR NO	CHECK NO. ONLINE
STATE WELL NO A900512	REVENUE NO. 011514
ENTERED 001233 PH1 PH2 PH3 01/15/2014 01/15/2014 01/15/2014	APPROVED BY / ROUTE

INFORMATION SUPPLIED BY PRIMARY CONTRACTOR OR DRILLING CONTRACTOR

NOTE: THIS FORM IS NOT TO BE USED FOR NESTED WELLS

OWNER NAME CITY OF COLUMBIA	CONTACT NAME CITY OF COLUMBIA			VARIANCE GRANTED BY DNR
OWNER ADDRESS PO BOX 6015	CITY COLUMBIA	STATE MO	ZIP 65205	NUMBER
SITE NAME MORES LAKE DAM		WELL NUMBER PZ5		COUNTY BOONE
SITE ADDRESS 1501 BUSINESS LOOP 70 EAST		CITY COLUMBIA		STATIC WATER LEVEL FT

SURFACE COMPLETION

TYPE
- [ ] ABOVE GROUND
- [X] FLUSH MOUNT

LENGTH AND DIAMETER OF SURFACE COMPLETION
LENGTH 1.0 FT.
DIAMETER 12.0 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
DIAMETER 6.0 IN.
LENGTH 1.0 FT.

SURFACE COMPLETION GROUT
- [X] CONCRETE
- [ ] OTHER

COPY

LOCATION OF WELL
LAT. 38 ° 58' 1.0"
LONG. 92 ° 19' 3.9"

SMALLEST ____ 1/4 ____ 1/4 ____ 1/4 LARGEST

SEC. LG002753 TWN. ____ NORTH
RANGE ____ Direction

MONITORING FOR:
- [ ] RADIONUCLIDES
- [ ] EXPLOSIVES
- [ ] SVOCS
- [ ] PETROLEUM PRODUCTS ONLY
- [ ] METALS
- [ ] VOC
- [ ] PESTICIDES/HERBICIDESS

PROPOSED USE OF WELL
- [ ] GAS MIGRATION WELL
- [ ] EXTRACTION WELL
- [ ] PIEZOMETERS
- [ ] DIRECT PUSH
- [X] OBSERVATION
- [ ] OPEN HOLE

- [ ] LOCKING CAP
- [ ] WEEP HOLE

ELEVATION ____FT.

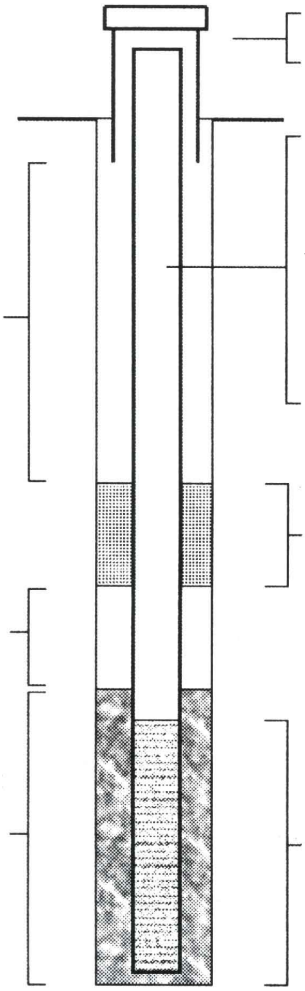
ANNULAR SEAL
LENGTH 2.0FT.
- [ ] SLURRY
- [ ] PELLETS
- [ ] CEMENT/SLURRY
- [ ] CHIPS
- [ ] GRANULAR

IF CEMENT/BENTONITE MIX:
BAGS OF CEMENT USED:
%OF BENTONITE USED:
WATER USED/BAG: GAL.

SECONDARY FILTER PACK
LENGTH: 0.0FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 3.0FT.

LENGTH OF PRIMARY FILTER PACK: 17.0FT.



SURFACE COMPLETTION
- [X] STEEL
- [ ] ALUMINUM
- [ ] PLASTIC

RISER
RISER PIPE DIAMETER 2.0IN.
RISER PIPE LENGTH 5.0FT.
HOLE DIAMETER 7.0IN.
WEIGHT OR SDR# SCH40

MATERIAL
- [ ] STEEL
- [ ] OTHER
- [X] THERMOPLASTIC (PVC)

BENTONITE SEAL
LENGTH: 0.0
- [ ] CHIPS
- [ ] PELLETS
- [ ] GRANULAR
- [ ] SLURRY
- [ ] SATURATED ZONE
- [ ] HYDRATED

SCREEN
SCREEN DIAMETER: 2.0IN.
SCREEN LENGTH: 15.0FT.
DIAMETER OF DRILL HOLE: 7.0IN.
DEPTH TO TOP 5.0FT.

SCREEN MATERIAL
- [ ] STEEL
- [ ] OTHER
- [X] THERMOPLASTIC (PVC)

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	20.0	CL, BROWN SILTY CLAY
TOTAL DEPTH:		20.0 FEET

FOR CASED WELLS, SUBMIT ADDITIONAL AS BUILT DIAGRAMS SHOWING WELL CONSTRUCTION DETAILS INCLUDING TYPE AND SIZE OF ALL CASING, HOLE DIAMETER AND GROUT USED.

SIGNATURE (PRIMARY COUNTRACTOR) x JAMES CLINGMAN	PERMIT NUMBER 001233	DATE WELL DRILLING WAS COMPLETED 01/14/2014
I HEREBY CERTIFY THAT THE MONITORING WELL HEREIN DESCRIBED WAS CONSTRUCTED IN ACCORDANCE WITH MISSOURI DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE CONSTRUCTION OF MONITORING WELLS		[ ] PUMP INSTALLED

SIGNATURE (WELL DRILLER) x JAMES CLINGMAN	PERMIT NUMBER 001233	SIGNATURE (APPRENTICE) x PAUL SCHEETZ	APPRENTICE PERMIT NUMBER 004707

MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND LAND SURVEY
(573) 368-2165

MONITORING WELL CERTIFICATION RECORD

REF NO 01000603	DATE RECEIVED 01/15/2014
CR NO	CHECK NO. ONLINE
STATE WELL NO A900513	REVENUE NO. 011514
ENTERED 001233 PH1 PH2 PH3 01/15/2014 01/15/2014 01/15/2014	APPROVED BY / ROUTE

INFORMATION SUPPLIED BY PRIMARY CONTRACTOR OR DRILLING CONTRACTOR

NOTE: THIS FORM IS NOT TO BE USED FOR NESTED WELLS

OWNER NAME CITY OF COLUMBIA	CONTACT NAME CITY OF COLUMBIA			VARIANCE GRANTED BY DNR
OWNER ADDRESS PO BOX 6015	CITY COLUMBIA	STATE MO	ZIP 65205	NUMBER
SITE NAME MORES LAKE DAM		WELL NUMBER PZ6		COUNTY BOONE
SITE ADDRESS 1501 BUSINESS LOOP 70 EAST		CITY COLUMBIA		STATIC WATER LEVEL FT

SURFACE COMPLETION

TYPE
- [ ] ABOVE GROUND
- [X] FLUSH MOUNT

LENGTH AND DIAMETER OF SURFACE COMPLETION
LENGTH 1.0 FT.
DIAMETER 12.0 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
DIAMETER 6.0 IN.
LENGTH 1.0 FT.

SURFACE COMPLETION GROUT
- [X] CONCRETE
- [ ] OTHER

COPY

LOCATION OF WELL
LAT. 38 ° 58' 1.7"
LONG. 92 ° 19' 4.5"

SMALLEST ____ 1/4 ____ 1/4 ____ 1/4 LARGEST

SEC. LG002753 TWN. ____ NORTH
RANGE ____ Direction

MONITORING FOR:
- [ ] RADIONUCLIDES
- [ ] EXPLOSIVES
- [ ] SVOCS
- [ ] PETROLEUM PRODUCTS ONLY
- [ ] METALS
- [ ] VOC
- [ ] PESTICIDES/HERBICIDESS

PROPOSED USE OF WELL
- [ ] GAS MIGRATION WELL
- [ ] EXTRACTION WELL
- [ ] PIEZOMETERS
- [ ] DIRECT PUSH
- [X] OBSERVATION
- [ ] OPEN HOLE

- [ ] LOCKING CAP
- [ ] WEEP HOLE

ELEVATION ____FT.

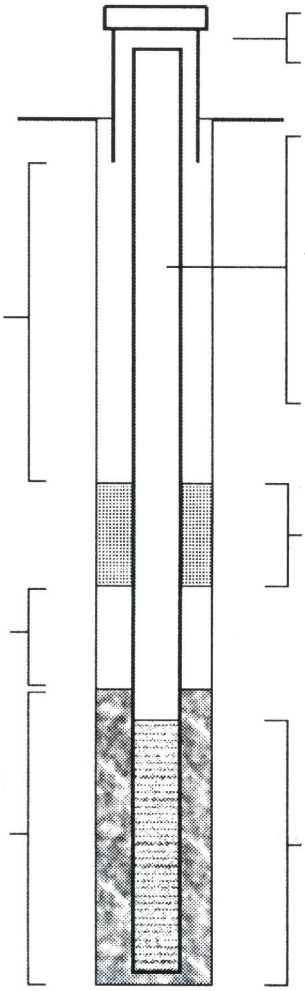
ANNULAR SEAL
LENGTH 2.0FT.
- [ ] SLURRY
- [ ] PELLETS
- [ ] CEMENT/SLURRY
- [ ] CHIPS
- [ ] GRANULAR

IF CEMENT/BENTONITE MIX:
BAGS OF CEMENT USED:
%OF BENTONITE USED:
WATER USED/BAG: GAL.

SECONDARY FILTER PACK
LENGTH: 0.0FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 3.0FT.

LENGTH OF PRIMARY FILTER PACK: 17.0FT.



SURFACE COMPLETTION
- [X] STEEL
- [ ] ALUMINUM
- [ ] PLASTIC

RISER
RISER PIPE DIAMETER 2.0IN.
RISER PIPE LENGTH 5.0FT.
HOLE DIAMETER 7.0IN.
WEIGHT OR SDR# SCH40

MATERIAL
- [ ] STEEL
- [ ] OTHER
- [X] THERMOPLASTIC (PVC)

BENTONITE SEAL
LENGTH: 0.0
- [ ] CHIPS
- [ ] PELLETS
- [ ] GRANULAR
- [ ] SLURRY
- [ ] SATURATED ZONE
- [ ] HYDRATED

SCREEN
SCREEN DIAMETER: 2.0IN.
SCREEN LENGTH: 15.0FT.
DIAMETER OF DRILL HOLE: 7.0IN.
DEPTH TO TOP 5.0FT.

SCREEN MATERIAL
- [ ] STEEL
- [ ] OTHER
- [X] THERMOPLASTIC (PVC)

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	20.0	CL, BROWN SILTY CLAY

TOTAL DEPTH: 20.0 FEET

FOR CASED WELLS, SUBMIT ADDITIONAL AS BUILT DIAGRAMS SHOWING WELL CONSTRUCTION DETAILS INCLUDING TYPE AND SIZE OF ALL CASING, HOLE DIAMETER AND GROUT USED.

SIGNATURE (PRIMARY COUNTRACTOR) x JAMES CLINGMAN	PERMIT NUMBER 001233	DATE WELL DRILLING WAS COMPLETED 01/14/2014
I HEREBY CERTIFY THAT THE MONITORING WELL HEREIN DESCRIBED WAS CONSTRUCTED IN ACCORDANCE WITH MISSOURI DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE CONSTRUCTION OF MONITORING WELLS		[ ] PUMP INSTALLED

SIGNATURE (WELL DRILLER) x JAMES CLINGMAN	PERMIT NUMBER 001233	SIGNATURE (APPRENTICE) x PAUL SCHEETZ	APPRENTICE PERMIT NUMBER 004707

APPENDIX F – SOIL LAB TESTING REPORTS

GEOTECHNOLOGY INC
FROM THE GROUND UP

July 3, 2017 J029854.01

Mr. Brian Weis
Burns and McDonnell Engineering
9400 Ward Parkway
Kansas City, Missouri 64114

Re: Mores Lake
Columbia, Missouri
BMcD Project Number: 93647

Dear Mr. Weis:

Provided herein are the moisture content, Atterberg limit, permeability, and grain size distribution test results for the Mores Lake project. Our services were performed in accordance with ASTM procedures.

This report has been prepared for the exclusive use of Burns and McDonnell Engineering. Our scope of services was limited to performing specific tests on the provided sample and did not include engineering or interpretation of the test results.

Our services shall not be construed to constitute an expressed or implied warranty, including, but not limited to, any warranty for merchantability or fitness for a particular use. We do not accept responsibility for the manner in which the test results are used.

* * * * *

If we can provide further information or services please contact the undersigned.

Yours very truly,

GEOTECHNOLOGY, INC.

Angela Battreal
Soils Laboratory Manager

AGB/CKK:agb/aat

Attachments: Test Report (1)
Summary of Laboratory Results (1)
Atterberg Limits Results (1)
Grain Size Distribution (4)

Geotechnology, Inc.
11816 Lackland Road, Suite 150
St. Louis, MO 63146
314-997-7440

TEST REPORT

Prepared For:
Burns & McDonnell Engineering
9400 Ward Parkway
Kansas City, Missouri 64114

Project No.:	**J029854.01**	**July 3, 2017**
Project Name:	**Mores Lake**	**Page 1 of 1**
Sampled By:	**Client**	
Attention:	**Mr. Brian Weis**	

HYDRAULIC CONDUCTIVITY (PERMEABILITY) TEST & DENSITY DETERMINATION (UNIT WEIGHT) ASTM D5084 & D7263

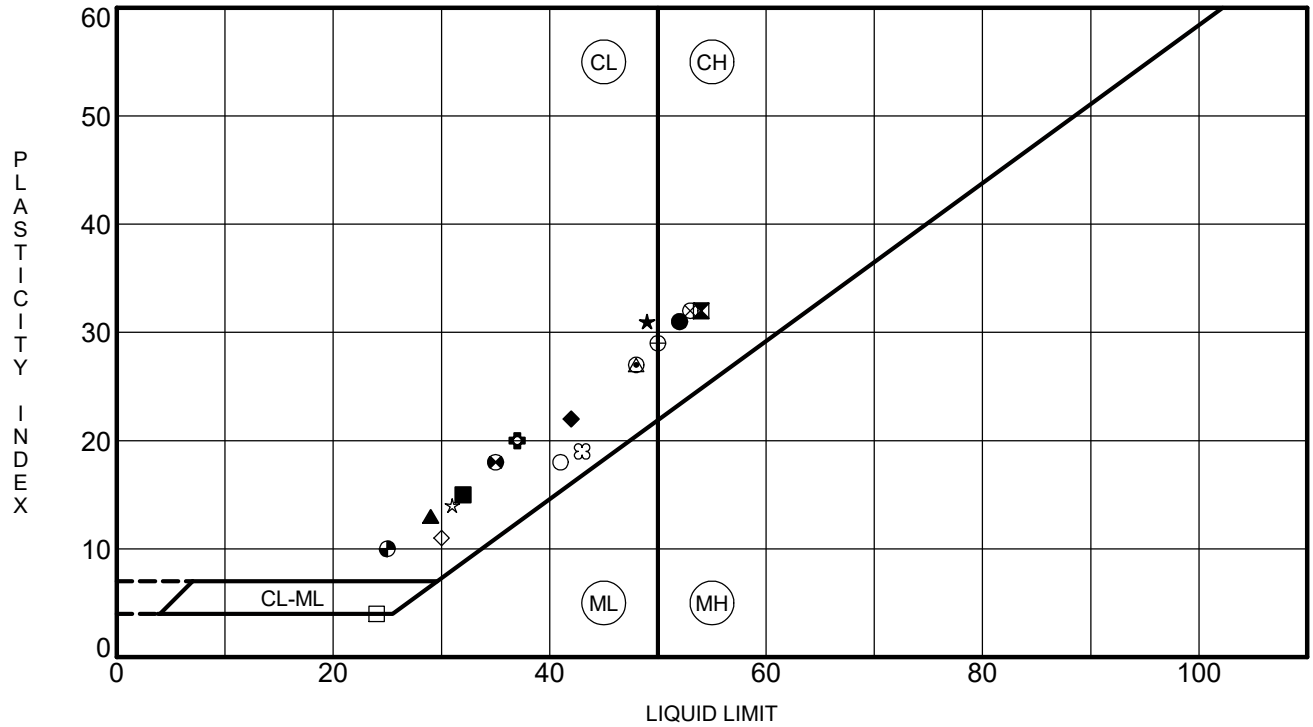
Sample #	Moisture Content (%)	Initial Wet Density (pcf)	Initial Dry Density (pcf)	Hydraulic Conductivity (cm/s)
MW-1/ST-01	20.7	127.7	105.9	8.0×10^{-8}
MW-7/ST-01	20.3	131.5	109.3	1.1×10^{-6}
SB-3/ST-01	24.0	126.1	101.6	1.1×10^{-8}

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Moisture Content (%)	Dry Unit Weight (pcf)	Qu/2 (tsf)	UU/2 (tsf)
MW-1	8.0	52	21	31	9.5	76.8	CH	20.6			
MW-1	10.0	54	22	32	4.75	76.7	CH	20.7			
MW-1	32.0	29	16	13	19	50.0	CL	15.4			
MW-2	8.0	49	18	31	4.75	72.3	CL	17.9			
MW-3	8.0	48	21	27	4.75	75.2	CL	20.2			
MW-3	42.0	37	17	20	12.5	70.6	CL	15.9			
MW-4	8.0	41	23	18	4.75	91.1	CL	20.6			
MW-5	8.0	48	21	27	4.75	78.8	CL	22.1			
MW-6	8.0	53	21	32	4.75	75.3	CH	20.4			
MW-7	6.0	50	21	29	9.5	65.9	CH	20.9			
MW-7	12.0	24	20	4	9.5	60.9	CL-ML	20.3			
MW-7	30.0	35	17	18	9.5	67.9	CL	20.5			
MW-7	32.0	25	15	10	4.75	58.9	CL	14.6			
MW-8	16.0	31	17	14	12.5	62.2	CL	15.3			
SB-1	55.0	43	24	19	12.5	94.0	CL	17.2			
SB-2	31.0	32	17	15	19	64.5	CL	13.1			
SB-3	30.0	42	20	22	4.75	84.4	CL	20.4			
SB-3	40.0	30	19	11	2	97.9	CL	9.9			

GEOTECHNOLOGY INC
FROM THE GROUND UP

Summary of Laboratory Results

Mores Lake
Columbia, Missouri
Project Number : BMcD 93647
J029854.01



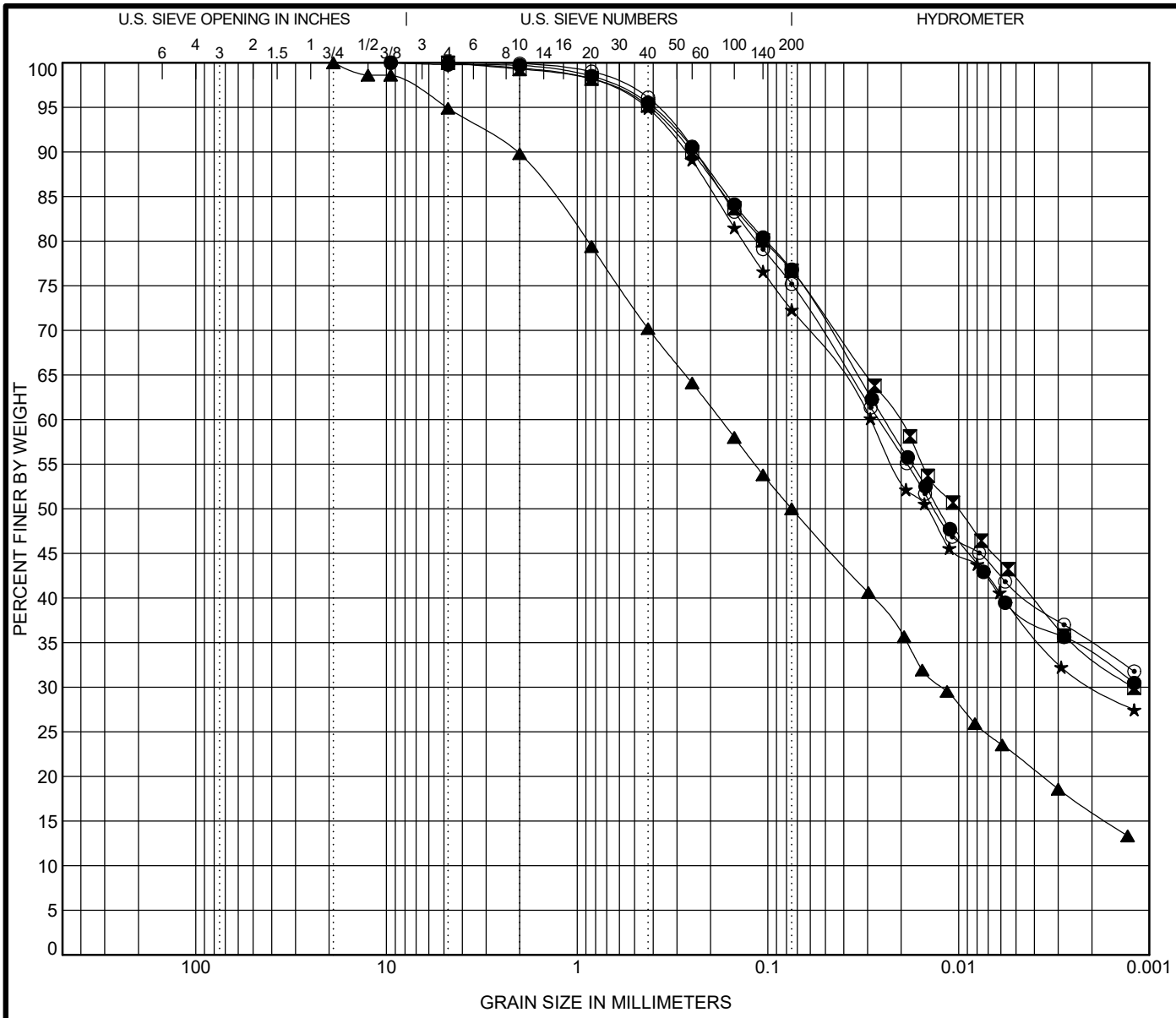
	Sample Identification		LL	PL	PI	Fines	Sample Description
●	MW-1	8.0	52	21	31	77	FAT CLAY with SAND(CH)
⊠	MW-1	10.0	54	22	32	77	FAT CLAY with SAND(CH)
▲	MW-1	32.0	29	16	13	50	SANDY LEAN CLAY(CL)
★	MW-2	8.0	49	18	31	72	LEAN CLAY with SAND(CL)
⊙	MW-3	8.0	48	21	27	75	LEAN CLAY with SAND(CL)
✿	MW-3	42.0	37	17	20	71	LEAN CLAY with SAND(CL)
○	MW-4	8.0	41	23	18	91	LEAN CLAY(CL)
△	MW-5	8.0	48	21	27	79	LEAN CLAY with SAND(CL)
⊗	MW-6	8.0	53	21	32	75	FAT CLAY with SAND(CH)
⊕	MW-7	6.0	50	21	29	66	SANDY FAT CLAY(CH)
□	MW-7	12.0	24	20	4	61	SANDY SILTY CLAY(CL-ML)
⊛	MW-7	30.0	35	17	18	68	SANDY LEAN CLAY(CL)
◕	MW-7	32.0	25	15	10	59	SANDY LEAN CLAY(CL)
☆	MW-8	16.0	31	17	14	62	SANDY LEAN CLAY(CL)
⌘	SB-1	55.0	43	24	19	94	LEAN CLAY(CL)
■	SB-2	31.0	32	17	15	65	SANDY LEAN CLAY(CL)
◆	SB-3	30.0	42	20	22	84	LEAN CLAY with SAND(CL)
◇	SB-3	40.0	30	19	11	98	LEAN CLAY(CL)

GEOTECHNOLOGY INC
FROM THE GROUND UP

ATTERBERG LIMITS RESULTS

Mores Lake
Columbia, Missouri
Project Number : BMcD 93647
J029854.01

US_ATTERBERG_LIMITS J029854.01 - MORE'S LAKE.GPJ 00 CLONE ME.GPJ 7/3/17



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample Identification		Sample Description	LL	PL	PI	Cc	Cu
●	MW-1	8.0	FAT CLAY with SAND(CH)	52	21	31		
⊠	MW-1	10.0	FAT CLAY with SAND(CH)	54	22	32		
▲	MW-1	32.0	SANDY LEAN CLAY(CL)	29	16	13		
★	MW-2	8.0	LEAN CLAY with SAND(CL)	49	18	31		
⊙	MW-3	8.0	LEAN CLAY with SAND(CL)	48	21	27		

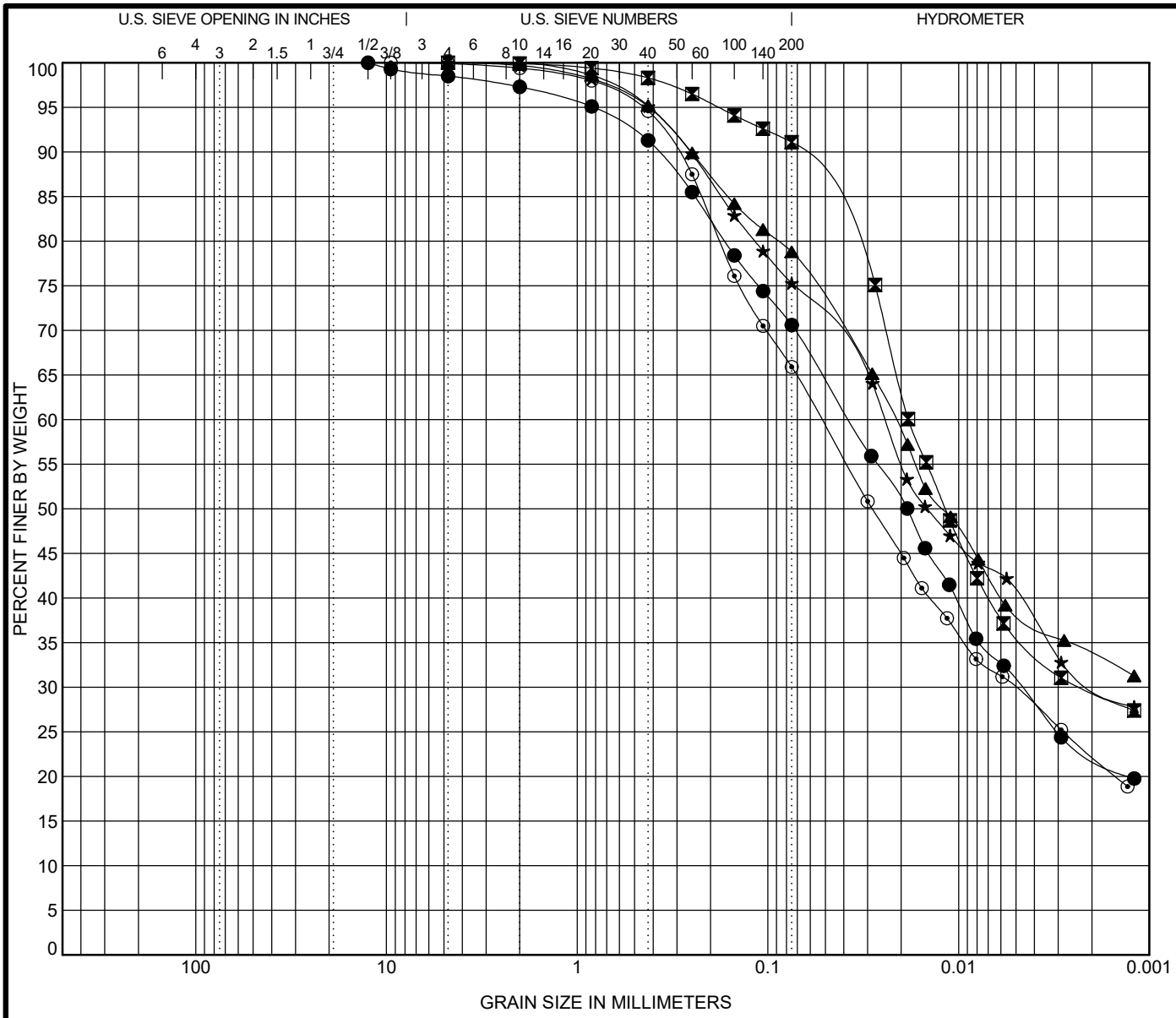
	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	MW-1	8.0	9.5	0.02			0.2	23.0	38.0	38.8
⊠	MW-1	10.0	4.75	0.02	0		0.0	23.3	34.5	42.2
▲	MW-1	32.0	19	0.18	0.01		5.1	44.9	27.7	22.3
★	MW-2	8.0	4.75	0.03	0		0.0	27.7	33.9	38.4
⊙	MW-3	8.0	4.75	0.03			0.0	24.8	34.3	40.9

GEOTECHNOLOGY INC
FROM THE GROUND UP

GRAIN SIZE DISTRIBUTION

Mores Lake
Columbia, Missouri
Project Number : BMcD 93647
J029854.01

US GRAIN SIZE J029854.01 - MORE'S LAKE.GPJ 00 CLONE ME.GPJ 7/3/17



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

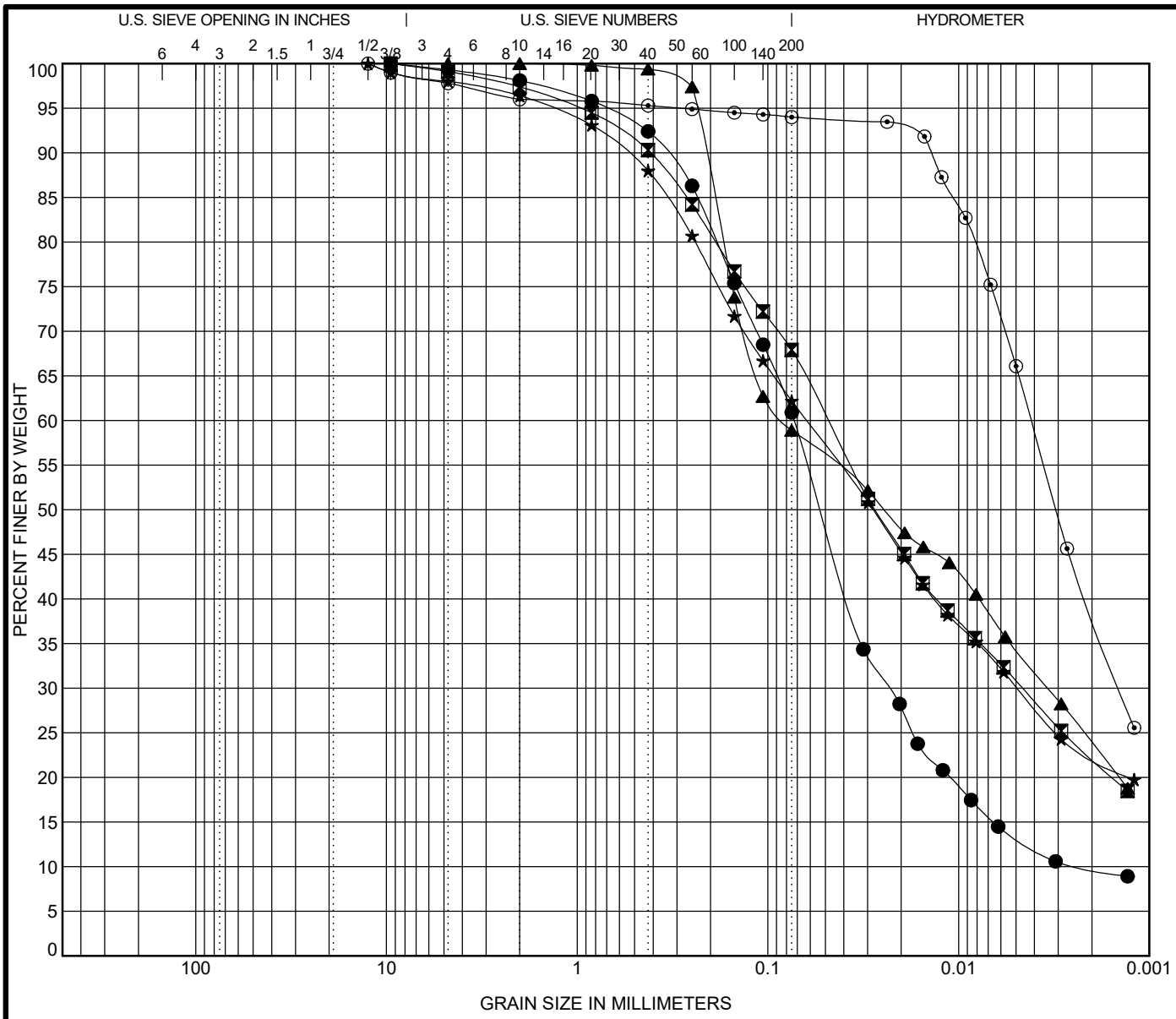
	Sample Identification		Sample Description	LL	PL	PI	Cc	Cu
●	MW-3	42.0	LEAN CLAY with SAND(CL)	37	17	20		
⊠	MW-4	8.0	LEAN CLAY(CL)	41	23	18		
▲	MW-5	8.0	LEAN CLAY with SAND(CL)	48	21	27		
★	MW-6	8.0	FAT CLAY with SAND(CH)	53	21	32		
⊙	MW-7	6.0	SANDY FAT CLAY(CH)	50	21	29		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	MW-3	42.0	12.5	0.04	0		1.5	27.9	39.9	30.7
⊠	MW-4	8.0	4.75	0.02	0		0.0	8.9	55.3	35.8
▲	MW-5	8.0	4.75	0.02			0.0	21.2	40.3	38.5
★	MW-6	8.0	4.75	0.02	0		0.0	24.7	34.7	40.6
⊙	MW-7	6.0	9.5	0.05	0.01		0.1	34.0	36.1	29.8

GEOTECHNOLOGY INC
FROM THE GROUND UP

GRAIN SIZE DISTRIBUTION

Mores Lake
Columbia, Missouri
Project Number : BMcD 93647
J029854.01



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

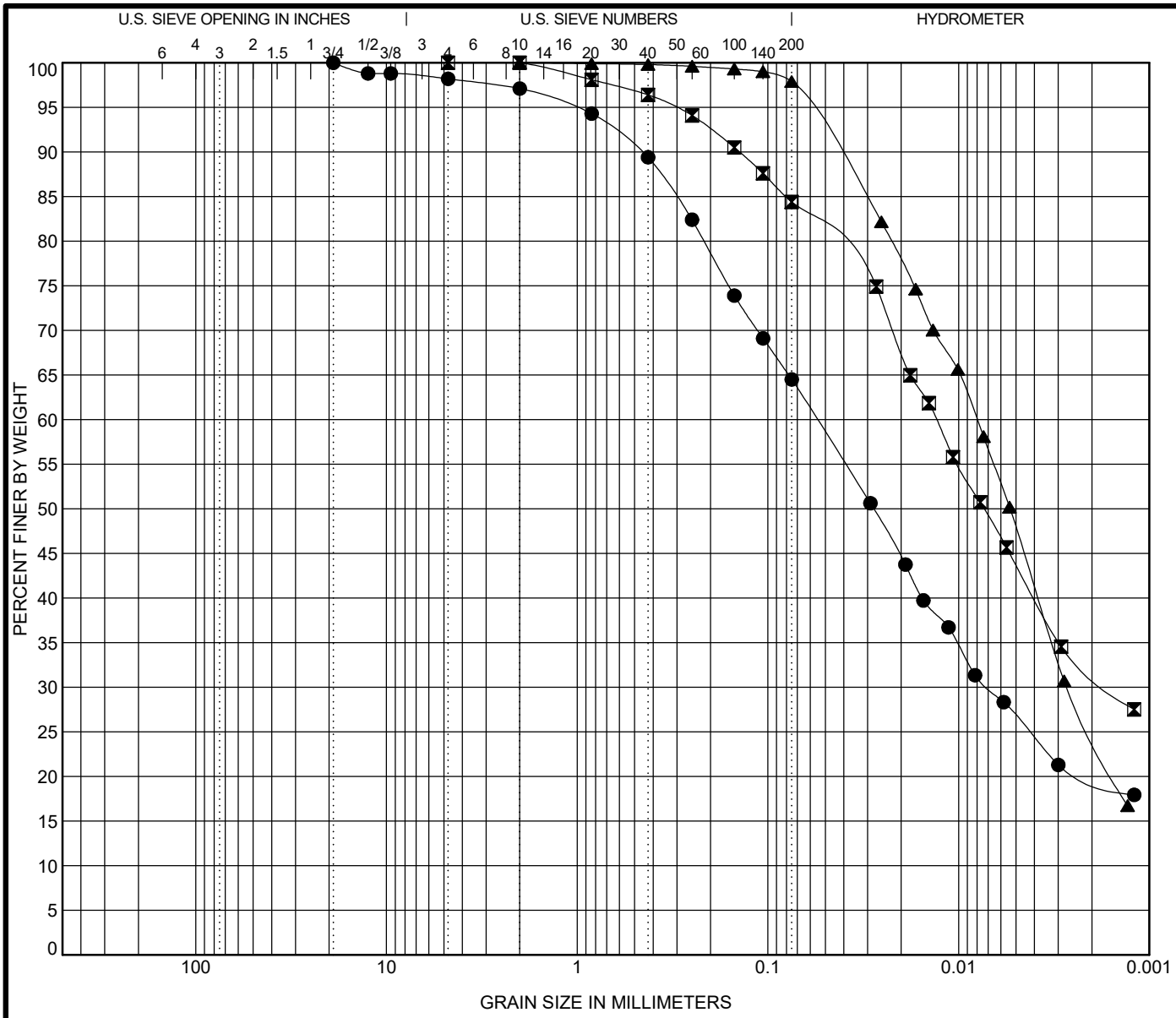
	Sample Identification		Sample Description	LL	PL	PI	Cc	Cu
●	MW-7	12.0	SANDY SILTY CLAY(CL-ML)	24	20	4	3.22	31.86
⊠	MW-7	30.0	SANDY LEAN CLAY(CL)	35	17	18		
▲	MW-7	32.0	SANDY LEAN CLAY(CL)	25	15	10		
★	MW-8	16.0	SANDY LEAN CLAY(CL)	31	17	14		
⊙	SB-1	55.0	LEAN CLAY(CL)	43	24	19		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	MW-7	12.0	9.5	0.07	0.02	0.002	0.7	38.4	47.6	13.3
⊠	MW-7	30.0	9.5	0.05	0		0.9	31.2	37.1	30.8
▲	MW-7	32.0	4.75	0.08	0		0.0	41.1	24.6	34.3
★	MW-8	16.0	12.5	0.06	0		2.0	35.8	32.0	30.2
⊙	SB-1	55.0	12.5	0	0		2.2	3.8	27.9	66.1

GEOTECHNOLOGY INC
FROM THE GROUND UP

GRAIN SIZE DISTRIBUTION

Mores Lake
Columbia, Missouri
Project Number : BMcD 93647
J029854.01



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample Identification		Sample Description	LL	PL	PI	Cc	Cu
●	SB-2	31.0	**SANDY LEAN CLAY(CL)**	**32**	**17**	**15**		
⊠	SB-3	30.0	**LEAN CLAY with SAND(CL)**	**42**	**20**	**22**		
▲	SB-3	40.0	**LEAN CLAY(CL)**	**30**	**19**	**11**		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SB-2	31.0	**19**	**0.06**	**0.01**		**1.8**	**33.7**	**37.8**	**26.7**
⊠	SB-3	30.0	**4.75**	**0.01**	**0**		**0.0**	**15.6**	**40.7**	**43.7**
▲	SB-3	40.0	**2**	**0.01**	**0**		**0.0**	**2.1**	**50.0**	**47.9**

GEOTECHNOLOGY INC
FROM THE GROUND UP

GRAIN SIZE DISTRIBUTION

Mores Lake
Columbia, Missouri
Project Number : BMcD 93647
J029854.01

US GRAIN SIZE J029854.01 - MORE'S LAKE.GPJ 00 CLONE ME.GPJ 7/3/17

APPENDIX G – SOIL ANALYTICAL REPORTS

Pace Analytical Services, LLC
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

June 14, 2017

Brian Weis

Burns & McDonnell
9400 Ward Parkway
Kansas City, MO 64114

RE: Project: Columbia MO 93647
Pace Project No.: 60244415

Dear Brian Weis:
Enclosed are the analytical results for sample(s) received by the laboratory on May 17, 2017. The results relate only to the samples included in this report. Results reported herein conform to the most current, applicable TNI/NELAC standards and the laboratory's Quality Assurance Manual, where applicable, unless otherwise noted in the body of the report.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Alice Spiller

Alice Spiller
alice.spiller@pacelabs.com
(913)563-1409
Project Manager

Enclosures

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CERTIFICATIONS

Project: Columbia MO 93647
Pace Project No.: 60244415

Pennsylvania Certification IDs

1638 Roseytown Rd Suites 2,3&4, Greensburg, PA 15601
L-A-B DOD-ELAP Accreditation #: L2417
Alabama Certification #: 41590
Arizona Certification #: AZ0734
Arkansas Certification
California Certification #: 04222CA
Colorado Certification
Connecticut Certification #: PH-0694
Delaware Certification
Florida/TNI Certification #: E87683
Georgia Certification #: C040
Guam Certification
Hawaii Certification
Idaho Certification
Illinois Certification
Indiana Certification
Iowa Certification #: 391
Kansas/TNI Certification #: E-10358
Kentucky Certification #: 90133
Louisiana DHH/TNI Certification #: LA140008
Louisiana DEQ/TNI Certification #: 4086
Maine Certification #: PA00091
Maryland Certification #: 308
Massachusetts Certification #: M-PA1457
Michigan/PADEP Certification
Missouri Certification #: 235
Montana Certification #: Cert 0082
Nebraska Certification #: NE-05-29-14
Nevada Certification #: PA014572015-1
New Hampshire/TNI Certification #: 2976
New Jersey/TNI Certification #: PA 051
New Mexico Certification #: PA01457
New York/TNI Certification #: 10888
North Carolina Certification #: 42706
North Dakota Certification #: R-190
Oregon/TNI Certification #: PA200002
Pennsylvania/TNI Certification #: 65-00282
Puerto Rico Certification #: PA01457
Rhode Island Certification #: 65-00282
South Dakota Certification
Tennessee Certification #: TN2867
Texas/TNI Certification #: T104704188-14-8
Utah/TNI Certification #: PA014572015-5
USDA Soil Permit #: P330-14-00213
Vermont Dept. of Health: ID# VT-0282
Virgin Island/PADEP Certification
Virginia/VELAP Certification #: 460198
Washington Certification #: C868
West Virginia DEP Certification #: 143
West Virginia DHHR Certification #: 9964C
Wisconsin Certification
Wyoming Certification #: 8TMS-L

Indiana Certification IDs

7726 Moller Road, Indianapolis, IN 46268
Illinois Certification #: 003971
Indiana Certification #: C-49-06
Kansas/NELAP Certification #:E-10177
Kentucky UST Certification #: 80226
Kentucky WW Certification #:98019
Ohio VAP Certification #: CL-0065
Oklahoma Certification #: 2016-075
Texas Certification #: T104704355-16-10
West Virginia Certification #: 330
Wisconsin Certification #: 999788130
USDA Soil Permit #: P330-16-00257

Kansas Certification IDs

9608 Loiret Boulevard, Lenexa, KS 66219
WY STR Certification #: 2456.01
Arkansas Certification #: 15-016-0
Illinois Certification #: 003097
Iowa Certification #: 118
Kansas/NELAP Certification #: E-10116
Louisiana Certification #: 03055
Nevada Certification #: KS000212008A
Oklahoma Certification #: 9205/9935
Texas Certification #: T104704407
Utah Certification #: KS00021
Kansas Field Laboratory Accreditation: # E-92587
Missouri Certification: 10070

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SAMPLE SUMMARY

Project: Columbia MO 93647
Pace Project No.: 60244415

Lab ID	Sample ID	Matrix	Date Collected	Date Received
60244415001	**MW-7/SB01**	Solid	05/15/17 15:40	05/17/17 08:25
60244415002	**MW-4/SB01**	Solid	05/16/17 12:00	05/17/17 08:25

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SAMPLE ANALYTE COUNT

Project: Columbia MO 93647
Pace Project No.: 60244415

Lab ID	Sample ID	Method	Analysts	Analytes Reported	Laboratory
60244415001	**MW-7/SB01**	EPA 6010	TDS	21	PASI-K
		EPA 7471	SMW	1	PASI-K
		ASTM D2974	DWC	1	PASI-K
		EPA 901.1	MAH	2	PASI-PA
		EPA 7196A	SKK	1	PASI-I
60244415002	**MW-4/SB01**	EPA 6010	TDS	21	PASI-K
		EPA 7471	SMW	1	PASI-K
		ASTM D2974	DWC	1	PASI-K
		EPA 901.1	MAH	2	PASI-PA
		EPA 7196A	SKK	1	PASI-I

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ANALYTICAL RESULTS

Project: Columbia MO 93647
Pace Project No.: 60244415

Sample: MW-7/SB01 **Lab ID: 60244415001** Collected: 05/15/17 15:40 Received: 05/17/17 08:25 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP Red. Interference	Analytical Method: EPA 6010 Preparation Method: EPA 3050							
Aluminum	**7860**	mg/kg	7.6	1	05/22/17 15:48	05/23/17 15:38	7429-90-5	
Antimony	ND	mg/kg	1.0	1	05/22/17 15:48	05/23/17 15:38	7440-36-0	
Arsenic	**8.3**	mg/kg	1.0	1	05/22/17 15:48	05/23/17 15:38	7440-38-2	
Barium	**55.3**	mg/kg	0.51	1	05/22/17 15:48	05/23/17 15:38	7440-39-3	
Beryllium	**0.80**	mg/kg	0.10	1	05/22/17 15:48	05/23/17 15:38	7440-41-7	
Boron	ND	mg/kg	10.2	1	05/22/17 15:48	05/23/17 15:38	7440-42-8	
Cadmium	ND	mg/kg	0.51	1	05/22/17 15:48	05/23/17 15:38	7440-43-9	
Calcium	**1510**	mg/kg	10.2	1	05/22/17 15:48	05/23/17 15:38	7440-70-2	
Chromium	**11.8**	mg/kg	0.51	1	05/22/17 15:48	05/23/17 15:38	7440-47-3	
Cobalt	**6.3**	mg/kg	0.51	1	05/22/17 15:48	05/23/17 15:38	7440-48-4	
Copper	**8.8**	mg/kg	1.0	1	05/22/17 15:48	05/23/17 15:38	7440-50-8	
Iron	**16100**	mg/kg	5.1	1	05/22/17 15:48	05/24/17 11:22	7439-89-6	
Lead	**4.6**	mg/kg	0.51	1	05/22/17 15:48	05/23/17 15:38	7439-92-1	
Magnesium	**1190**	mg/kg	5.1	1	05/22/17 15:48	05/23/17 15:38	7439-95-4	
Manganese	**322**	mg/kg	0.51	1	05/22/17 15:48	05/23/17 15:38	7439-96-5	
Molybdenum	ND	mg/kg	2.0	1	05/22/17 15:48	05/23/17 15:38	7439-98-7	
Nickel	**15.9**	mg/kg	0.51	1	05/22/17 15:48	05/23/17 15:38	7440-02-0	
Selenium	ND	mg/kg	1.5	1	05/22/17 15:48	05/23/17 15:38	7782-49-2	
Silver	ND	mg/kg	0.71	1	05/22/17 15:48	05/23/17 15:38	7440-22-4	
Thallium	ND	mg/kg	2.0	1	05/22/17 15:48	05/23/17 15:38	7440-28-0	
Zinc	**27.4**	mg/kg	10.2	1	05/22/17 15:48	05/23/17 15:38	7440-66-6	
7471 Mercury	Analytical Method: EPA 7471 Preparation Method: EPA 7471							
Mercury	ND	mg/kg	0.052	1	05/24/17 10:12	05/24/17 15:21	7439-97-6	
Percent Moisture	Analytical Method: ASTM D2974							
Percent Moisture	**12.3**	%	0.50	1		05/23/17 00:00		
7196 Chromium, Hexavalent	Analytical Method: EPA 7196A Preparation Method: EPA 3060A							
Chromium, Hexavalent	ND	mg/kg	2.3	1	05/24/17 11:25	05/26/17 13:30	18540-29-9	

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ANALYTICAL RESULTS

Project: Columbia MO 93647
Pace Project No.: 60244415

Sample: MW-4/SB01 **Lab ID: 60244415002** Collected: 05/16/17 12:00 Received: 05/17/17 08:25 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP Red. Interference	Analytical Method: EPA 6010 Preparation Method: EPA 3050							
Aluminum	**14600**	mg/kg	8.7	1	05/22/17 15:48	05/23/17 15:40	7429-90-5	
Antimony	ND	mg/kg	1.2	1	05/22/17 15:48	05/23/17 15:40	7440-36-0	
Arsenic	**12.3**	mg/kg	1.2	1	05/22/17 15:48	05/23/17 15:40	7440-38-2	
Barium	**185**	mg/kg	0.58	1	05/22/17 15:48	05/23/17 15:40	7440-39-3	
Beryllium	**0.77**	mg/kg	0.12	1	05/22/17 15:48	05/23/17 15:40	7440-41-7	
Boron	ND	mg/kg	11.6	1	05/22/17 15:48	05/23/17 15:40	7440-42-8	
Cadmium	ND	mg/kg	0.58	1	05/22/17 15:48	05/23/17 15:40	7440-43-9	
Calcium	**6730**	mg/kg	11.6	1	05/22/17 15:48	05/23/17 15:40	7440-70-2	
Chromium	**20.1**	mg/kg	0.58	1	05/22/17 15:48	05/23/17 15:40	7440-47-3	
Cobalt	**7.7**	mg/kg	0.58	1	05/22/17 15:48	05/23/17 15:40	7440-48-4	
Copper	**12.4**	mg/kg	1.2	1	05/22/17 15:48	05/23/17 15:40	7440-50-8	
Iron	**20100**	mg/kg	5.8	1	05/22/17 15:48	05/24/17 11:24	7439-89-6	
Lead	**12.6**	mg/kg	0.58	1	05/22/17 15:48	05/23/17 15:40	7439-92-1	
Magnesium	**2100**	mg/kg	5.8	1	05/22/17 15:48	05/23/17 15:40	7439-95-4	
Manganese	**171**	mg/kg	0.58	1	05/22/17 15:48	05/23/17 15:40	7439-96-5	
Molybdenum	ND	mg/kg	2.3	1	05/22/17 15:48	05/23/17 15:40	7439-98-7	
Nickel	**17.1**	mg/kg	0.58	1	05/22/17 15:48	05/23/17 15:40	7440-02-0	
Selenium	ND	mg/kg	1.7	1	05/22/17 15:48	05/23/17 15:40	7782-49-2	
Silver	ND	mg/kg	0.81	1	05/22/17 15:48	05/23/17 15:40	7440-22-4	
Thallium	ND	mg/kg	2.3	1	05/22/17 15:48	05/23/17 15:40	7440-28-0	
Zinc	**48.0**	mg/kg	11.6	1	05/22/17 15:48	05/23/17 15:40	7440-66-6	
7471 Mercury	Analytical Method: EPA 7471 Preparation Method: EPA 7471							
Mercury	**0.030**	mg/kg	0.029	1	05/24/17 10:12	05/24/17 15:23	7439-97-6	
Percent Moisture	Analytical Method: ASTM D2974							
Percent Moisture	**18.9**	%	0.50	1		05/23/17 00:00		
7196 Chromium, Hexavalent	Analytical Method: EPA 7196A Preparation Method: EPA 3060A							
Chromium, Hexavalent	ND	mg/kg	5.0	2	05/24/17 11:25	05/26/17 13:31	18540-29-9	D3

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QUALITY CONTROL DATA

Project: Columbia MO 93647
Pace Project No.: 60244415

QC Batch: 478123 | Analysis Method: EPA 7471
QC Batch Method: EPA 7471 | Analysis Description: 7471 Mercury
Associated Lab Samples: 60244415001, 60244415002

METHOD BLANK: 1958482 | Matrix: Solid
Associated Lab Samples: 60244415001, 60244415002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Mercury	mg/kg	ND	0.050	05/24/17 14:24	

LABORATORY CONTROL SAMPLE: 1958483

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Mercury	mg/kg	.5	0.52	103	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1958484 1958485

Parameter	Units	60244340001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Mercury	mg/kg	0.13	.45	.43	0.56	0.52	98	90	75-125	8	20	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

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QUALITY CONTROL DATA

Project: Columbia MO 93647
Pace Project No.: 60244415

QC Batch: 477767 | Analysis Method: EPA 6010
QC Batch Method: EPA 3050 | Analysis Description: 6010 MET
Associated Lab Samples: 60244415001, 60244415002

METHOD BLANK: 1957381 | Matrix: Solid
Associated Lab Samples: 60244415001, 60244415002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Aluminum	mg/kg	ND	7.5	05/23/17 15:20	
Antimony	mg/kg	ND	1.0	05/23/17 15:20	
Arsenic	mg/kg	ND	1.0	05/23/17 15:20	
Barium	mg/kg	ND	0.50	05/23/17 15:20	
Beryllium	mg/kg	ND	0.10	05/24/17 11:06	
Boron	mg/kg	ND	10.0	05/23/17 15:20	
Cadmium	mg/kg	ND	0.50	05/23/17 15:20	
Calcium	mg/kg	ND	10.0	05/23/17 15:20	
Chromium	mg/kg	ND	0.50	05/23/17 15:20	
Cobalt	mg/kg	ND	0.50	05/23/17 15:20	
Copper	mg/kg	ND	1.0	05/23/17 15:20	
Iron	mg/kg	ND	5.0	05/24/17 11:06	
Lead	mg/kg	ND	0.50	05/23/17 15:20	
Magnesium	mg/kg	ND	5.0	05/23/17 15:20	
Manganese	mg/kg	ND	0.50	05/23/17 15:20	
Molybdenum	mg/kg	ND	2.0	05/23/17 15:20	
Nickel	mg/kg	ND	0.50	05/23/17 15:20	
Selenium	mg/kg	ND	1.5	05/23/17 15:20	
Silver	mg/kg	ND	0.70	05/23/17 15:20	
Thallium	mg/kg	ND	2.0	05/23/17 15:20	
Zinc	mg/kg	ND	10.0	05/23/17 15:20	

LABORATORY CONTROL SAMPLE: 1957382

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Aluminum	mg/kg	1000	990	99	80-120	
Antimony	mg/kg	100	97.2	97	80-120	
Arsenic	mg/kg	100	93.3	93	80-120	
Barium	mg/kg	100	99.6	100	80-120	
Beryllium	mg/kg	100	99.8	100	80-120	
Boron	mg/kg	100	90.1	90	80-120	
Cadmium	mg/kg	100	96.7	97	80-120	
Calcium	mg/kg	1000	1000	100	80-120	
Chromium	mg/kg	100	102	102	80-120	
Cobalt	mg/kg	100	104	104	80-120	
Copper	mg/kg	100	99.1	99	80-120	
Iron	mg/kg	1000	1040	104	80-120	
Lead	mg/kg	100	100	100	80-120	
Magnesium	mg/kg	1000	950	95	80-120	
Manganese	mg/kg	100	102	102	80-120	

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REPORT OF LABORATORY ANALYSIS

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Lenexa, KS 66219
(913)599-5665

QUALITY CONTROL DATA

Project: Columbia MO 93647
Pace Project No.: 60244415

LABORATORY CONTROL SAMPLE: 1957382

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Molybdenum	mg/kg	100	108	108	80-120	
Nickel	mg/kg	100	101	101	80-120	
Selenium	mg/kg	100	94.1	94	80-120	
Silver	mg/kg	50	47.8	96	80-120	
Thallium	mg/kg	100	101	101	80-120	
Zinc	mg/kg	100	100	100	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1957383 1957384

Parameter	Units	60244515002 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Aluminum	mg/kg	3950	1030	962	8440	8930	434	518	75-125	6	20	M1
Antimony	mg/kg	ND	103	96.2	34.1	43.6	33	45	75-125	25	20	M1,R1
Arsenic	mg/kg	2.2	103	96.2	63.2	76.0	59	77	75-125	18	20	M1
Barium	mg/kg	38.3	103	96.2	119	143	78	108	75-125	18	20	
Beryllium	mg/kg	0.14	103	96.2	66.0	79.8	64	83	75-125	19	20	M1
Boron	mg/kg	ND	103	96.2	68.5	78.8	63	79	75-125	14	20	M1
Cadmium	mg/kg	ND	103	96.2	63.5	76.5	61	79	75-125	19	20	M1
Calcium	mg/kg	5030	1030	962	4780	6110	-24	112	75-125	24	20	M1,R1
Chromium	mg/kg	4.5	103	96.2	77.5	89.7	70	88	75-125	15	20	M1
Cobalt	mg/kg	1.7	103	96.2	67.9	81.4	64	83	75-125	18	20	M1
Copper	mg/kg	8.4	103	96.2	71.8	91.1	61	86	75-125	24	20	M1,R1
Iron	mg/kg	3980	1030	962	7420	7140	333	329	75-125	4	20	M1
Lead	mg/kg	32.5	103	96.2	87.5	114	53	84	75-125	26	20	M1,R1
Magnesium	mg/kg	1340	1030	962	2950	2830	156	154	75-125	4	20	M1
Manganese	mg/kg	62.5	103	96.2	194	183	127	125	75-125	6	20	M1
Molybdenum	mg/kg	ND	103	96.2	68.4	83.1	66	86	75-125	19	20	M1
Nickel	mg/kg	9.2	103	96.2	77.2	89.8	66	84	75-125	15	20	M1
Selenium	mg/kg	ND	103	96.2	60.7	73.5	59	76	75-125	19	20	M1
Silver	mg/kg	ND	51.8	48.2	32.3	37.9	62	79	75-125	16	20	M1
Thallium	mg/kg	ND	103	96.2	63.9	75.6	62	79	75-125	17	20	M1
Zinc	mg/kg	18.5	103	96.2	87.0	115	66	101	75-125	28	20	M1,R1

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1957385 1957386

Parameter	Units	60244645001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Aluminum	mg/kg	12600	996	978	14200	15300	168	280	75-125	7	20	M1
Antimony	mg/kg	ND	99.6	97.8	35.4	31.3	35	32	75-125	12	20	M1
Arsenic	mg/kg	1.5	99.6	97.8	79.4	76.1	78	76	75-125	4	20	
Barium	mg/kg	69.4	99.6	97.8	167	169	98	102	75-125	2	20	
Beryllium	mg/kg	0.23	99.6	97.8	83.0	80.5	83	82	75-125	3	20	
Boron	mg/kg	ND	99.6	97.8	81.9	78.8	78	76	75-125	4	20	
Cadmium	mg/kg	ND	99.6	97.8	80.9	77.7	81	79	75-125	4	20	

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QUALITY CONTROL DATA

Project: Columbia MO 93647
Pace Project No.: 60244415

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1957385 1957386

Parameter	Units	60244645001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Calcium	mg/kg	4400	996	978	5540	5500	114	112	75-125	1	20	
Chromium	mg/kg	9.0	99.6	97.8	93.4	90.4	85	83	75-125	3	20	
Cobalt	mg/kg	2.9	99.6	97.8	85.7	81.9	83	81	75-125	5	20	
Copper	mg/kg	55.7	99.6	97.8	144	128	89	74	75-125	12	20	M1
Iron	mg/kg	5280	996	978	6450	7360	118	212	75-125	13	20	M1
Lead	mg/kg	143	99.6	97.8	127	117	-16	-27	75-125	8	20	M1
Magnesium	mg/kg	1980	996	978	3050	3070	108	111	75-125	0	20	
Manganese	mg/kg	93.8	99.6	97.8	187	182	94	90	75-125	3	20	
Molybdenum	mg/kg	ND	99.6	97.8	86.8	82.5	87	84	75-125	5	20	
Nickel	mg/kg	34.5	99.6	97.8	115	109	80	77	75-125	5	20	
Selenium	mg/kg	ND	99.6	97.8	77.0	73.4	77	75	75-125	5	20	
Silver	mg/kg	ND	49.8	48.9	40.5	38.8	81	79	75-125	4	20	
Thallium	mg/kg	ND	99.6	97.8	79.5	75.2	80	77	75-125	6	20	
Zinc	mg/kg	46.3	99.6	97.8	145	162	99	118	75-125	11	20	

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QUALITY CONTROL DATA

Project: Columbia MO 93647
Pace Project No.: 60244415

QC Batch: 477947 | Analysis Method: ASTM D2974
QC Batch Method: ASTM D2974 | Analysis Description: Dry Weight/Percent Moisture
Associated Lab Samples: 60244415001, 60244415002

METHOD BLANK: 1957857 | Matrix: Solid
Associated Lab Samples: 60244415001, 60244415002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Percent Moisture	%	ND	0.50	05/23/17 00:00	

SAMPLE DUPLICATE: 1957858

Parameter	Units	60244415001 Result	Dup Result	RPD	Max RPD	Qualifiers
Percent Moisture	%	12.3	11.8	4	20	

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QUALITY CONTROL DATA

Project: Columbia MO 93647
Pace Project No.: 60244415

QC Batch: 388793 | Analysis Method: EPA 7196A
QC Batch Method: EPA 3060A | Analysis Description: 7196 Chromium, Hexavalent
Associated Lab Samples: 60244415001, 60244415002

METHOD BLANK: 1792678 | Matrix: Solid
Associated Lab Samples: 60244415001, 60244415002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Chromium, Hexavalent	mg/kg	ND	2.0	05/26/17 13:13	

LABORATORY CONTROL SAMPLE: 1792679

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Chromium, Hexavalent	mg/kg	1020	956	93	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1792680 1792681

Parameter	Units	50170973001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Chromium, Hexavalent	mg/kg	ND	1080	1100	1050	1020	97	93	75-125	3	20	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1792682 1792683

Parameter	Units	50170973001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Chromium, Hexavalent	mg/kg	ND	43.4	43	44.0	42.3	100	97	75-125	4	20	

SAMPLE DUPLICATE: 1792684

Parameter	Units	50171487007 Result	Dup Result	RPD	Max RPD	Qualifiers
Chromium, Hexavalent	mg/kg	ND	ND		20	D3

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ANALYTICAL RESULTS - RADIOCHEMISTRY

Project: Columbia MO 93647
Pace Project No.: 60244415

Sample: MW-7/SB01 **Lab ID: 60244415001** Collected: 05/15/17 15:40 Received: 05/17/17 08:25 Matrix: Solid
PWS: Site ID: Sample Type:

Results reported on a "dry-weight" basis

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Radium-226	EPA 901.1	**1.062 ± 0.248 (0.182)** **C:NA T:NA**	pCi/g	06/13/17 09:52	13982-63-3	Ra
Radium-228	EPA 901.1	**0.924 ± 0.275 (0.121)** **C:NA T:NA**	pCi/g	06/13/17 09:52	15262-20-1	

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ANALYTICAL RESULTS - RADIOCHEMISTRY

Project: Columbia MO 93647
Pace Project No.: 60244415

Sample: MW-4/SB01 **Lab ID: 60244415002** Collected: 05/16/17 12:00 Received: 05/17/17 08:25 Matrix: Solid
PWS: Site ID: Sample Type:

Results reported on a "dry-weight" basis

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Radium-226	EPA 901.1	**1.380 ± 0.346 (0.249)** **C:NA T:NA**	pCi/g	06/13/17 09:53	13982-63-3	Ra
Radium-228	EPA 901.1	**2.158 ± 0.575 (0.430)** **C:NA T:NA**	pCi/g	06/13/17 09:53	15262-20-1	

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QUALITY CONTROL - RADIOCHEMISTRY

Project: Columbia MO 93647
Pace Project No.: 60244415

QC Batch: 260121 | Analysis Method: EPA 901.1
QC Batch Method: EPA 901.1 | Analysis Description: 901.1 Gamma Spec Ingrowth
Associated Lab Samples: 60244415001, 60244415002

METHOD BLANK: 1281423 | Matrix: Solid
Associated Lab Samples: 60244415001, 60244415002

Parameter	Act ± Unc (MDC) Carr Trac	Units	Analyzed	Qualifiers
Radium-226	0.052 ± 0.049 (0.198) C:NA T:NA	pCi/g	06/13/17 07:43	Ra
Radium-228	0.000 ± 0.031 (0.277) C:NA T:NA	pCi/g	06/13/17 07:43	

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QUALIFIERS

Project: Columbia MO 93647
Pace Project No.: 60244415

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to dilution of the sample aliquot.

ND - Not Detected at or above adjusted reporting limit.

J - Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

MDL - Adjusted Method Detection Limit.

PQL - Practical Quantitation Limit.

RL - Reporting Limit.

S - Surrogate

1,2-Diphenylhydrazine decomposes to and cannot be separated from Azobenzene using Method 8270. The result for each analyte is a combined concentration.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

Act - Activity

Unc - Uncertainty: SDWA = 1.96 sigma count uncertainty, all other matrices = Expanded Uncertainty (95% confidence interval). Gamma Spec = Expanded Uncertainty (95.4% Confidence Interval)

(MDC) - Minimum Detectable Concentration

Trac - Tracer Recovery (%)

Carr - Carrier Recovery (%)

Pace Analytical is TNI accredited. Contact your Pace PM for the current list of accredited analytes.

TNI - The NELAC Institute.

LABORATORIES

PASI-I	Pace Analytical Services - Indianapolis
PASI-K	Pace Analytical Services - Kansas City
PASI-PA	Pace Analytical Services - Greensburg

ANALYTE QUALIFIERS

D3	Sample was diluted due to the presence of high levels of non-target analytes or other matrix interference.
M1	Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.
R1	RPD value was outside control limits.
Ra	The reported Ra-226 results were determined by hermetically sealing the dried, processed sample in an appropriate-sized can. Each sample was stored for a minimum of 21 days to ensure that equilibrium between Ra-226 and daughters Bi-214 and Pb-214 was achieved. Reported Ra-226 results were inferred from gamma peaks attributable to Bi-214 and Pb-214.

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QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: Columbia MO 93647
Pace Project No.: 60244415

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
60244415001	**MW-7/SB01**	EPA 3050	477767	EPA 6010	478018
60244415002	**MW-4/SB01**	EPA 3050	477767	EPA 6010	478018
60244415001	**MW-7/SB01**	EPA 7471	478123	EPA 7471	478184
60244415002	**MW-4/SB01**	EPA 7471	478123	EPA 7471	478184
60244415001	**MW-7/SB01**	ASTM D2974	477947		
60244415002	**MW-4/SB01**	ASTM D2974	477947		
60244415001	**MW-7/SB01**	EPA 901.1	260121		
60244415002	**MW-4/SB01**	EPA 901.1	260121		
60244415001	**MW-7/SB01**	EPA 3060A	388793	EPA 7196A	389359
60244415002	**MW-4/SB01**	EPA 3060A	388793	EPA 7196A	389359

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Sample Condition Upon Receipt

WO# : 60244415

60244415

Client Name: B:m

Courier: FedEx ☐ UPS ☐ VIA ☑ Clay ☐ PEX ☐ ECI ☐ Pace ☐ Xroads ☐ Client ☐ Other ☐

Tracking #: _____ Pace Shipping Label Used? Yes ☐ No ☑

Custody Seal on Cooler/Box Present: Yes ☑ No ☐ Seals intact: Yes ☑ No ☐

Packing Material: Bubble Wrap ☐ Bubble Bags ☑ Foam ☐ None ☐ Other ☐

Thermometer Used: CF +2.9 T-266 / CF +0.2 T-239 **Type of Ice:** Wet Blue None

Cooler Temperature (°C): As-read 2.8 **Corr. Factor** CF +2.9 CF +0.2 **Corrected** 3.0

Date and initials of person examining contents: PVS 5/17/17

Temperature should be above freezing to 6°C

Chain of Custody present:	☑Yes ☐No ☐N/A	
Chain of Custody relinquished:	☑Yes ☐No ☐N/A	
Samples arrived within holding time:	☑Yes ☐No ☐N/A	
Short Hold Time analyses (<72hr):	☐Yes ☑No ☐N/A	
Rush Turn Around Time requested:	☐Yes ☑No ☐N/A	
Sufficient volume:	☑Yes ☐No ☐N/A	
Correct containers used:	☑Yes ☐No ☐N/A	
Pace containers used:	☑Yes ☐No ☐N/A	
Containers intact:	☑Yes ☐No ☐N/A	
Unpreserved 5035A / TX1005/1006 soils frozen in 48hrs?	☐Yes ☐No ☑N/A	
Filtered volume received for dissolved tests?	☐Yes ☐No ☑N/A	
Sample labels match COC: Date / time / ID / analyses	☑Yes ☐No ☐N/A	
Samples contain multiple phases? Matrix: SL	☐Yes ☑No ☐N/A	
Containers requiring pH preservation in compliance? (HNO_3, H_2SO_4, HCl<2; NaOH>9 Sulfide, NaOH>10 Cyanide) (Exceptions: VOA, Micro, O&G, KS TPH, OK-DRO)	☐Yes ☐No ☑N/A	
Cyanide water sample checks:		
Lead acetate strip turns dark? (Record only)	☐Yes ☐No	
Potassium iodide test strip turns blue/purple? (Preserve)	☐Yes ☐No	
Trip Blank present:	☐Yes ☐No ☑N/A	
Headspace in VOA vials (>6mm):	☐Yes ☐No ☑N/A	
Samples from USDA Regulated Area: State: MD	☐Yes ☑No ☐N/A	
Additional labels attached to 5035A / TX1005 vials in the field?	☐Yes ☐No ☑N/A	

Client Notification/ Resolution: Copy COC to Client? Y / N Field Data Required? Y / N

Person Contacted: _____ Date/Time: _____

Comments/ Resolution: _____

Project Manager Review: Alice Date: 5/17/17

CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page : 1 Of 1

Section A — Required Client Information:

Company:	BURNS & MCDONNELL
Address:	9400 Ward Parkway
	Kansas City, MO 64114
Email:	bweis@burrsmcd.com
Phone: 816 333 9400	Fax: —
Requested Due Date:	Standard TAT

Section B — Required Project information:

Report To:	~~Lewis~~ Brian Weis
Copy To:	—
Purchase Order #:	—
Project Name:	Columbia MO
Project #:	93647

Section C — Invoice Information:

Attention:	Brian Weis
Company Name:	Burns and McDonnell
Address:	9400 Ward parkway, KCMO 64114
Pace Quote:	—
Pace Project Manager:	alice.spiller@pacelabs.com,
Pace Profile #:	~~9613~~ 10268

Regulatory Agency	State / Location
	MO

Requested Analysis Filtered (Y/N): Hexavalent Chromium = N; Metals by 6010, Mercury = N; Radium 226/228 = N

ITEM #	SAMPLE ID (One Character per box. (A-Z, 0-9 / , -) Sample Ids must be unique)	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED START DATE	COLLECTED START TIME	COLLECTED END DATE	COLLECTED END TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Unpreserved	H2SO4	HNO3	HCl	NaOH	Na2S2O3	Methanol	Other	Analyses Test: Hexavalent Chromium	Metals by 6010, Mercury	Radium 226/228	Residual Chlorine (Y/N)	60244415
1	MW-7 / SB01	SL	G	5/15/17	1540	5/15/17	1540	—	3	X								X	X	X	N	2WGFU 1WGKU 001
2	MW-4 / SB01	SL	G	5/16/17	1200	5/16/17	1200	—	3	X								X	X	X	N	↓ ↓ 002
3																						
4																						
5																						
6																						
7																						
8																						
9																						
10																						
11																						
12																						

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS			
	LT - BMcD	5/16/17		Alice Spiller	5/16/17	1605				
				[illegible]	5/17/17	0825	3.0	Y	Y	Y

SAMPLER NAME AND SIGNATURE	
PRINT Name of SAMPLER:	Lewis Turner
SIGNATURE of SAMPLER:	LT
DATE Signed:	5/16/17

TEMP in C | Received on Ice (Y/N) | Custody Sealed Cooler (Y/N) | Samples Intact (Y/N)

Chain of Custody

Pace Analytical®
www.pacelabs.com

Workorder: 60244415 **Workorder Name:** Columbia MO **Owner Received Date:** 5/17/2017 **Results Requested By:** 5/26/2017

Report To	Subcontract To
Alice Spiller Pace Analytical Kansas 9608 Loiret Blvd. Lenexa, KS 66219 Phone (913)563-1409	Pace Analytical Indianapolis 7726 Moller Road Indianapolis, IN 46268 Phone (317)875-5894

Requested Analysis

Item	Sample ID	Sample Type	Collect Date/Time	Lab ID	Matrix	Preserved Containers: Unpreserved						Hexavalent Chromium in Soil												LAB USE ONLY
1	MW-7/SB01	PS	5/15/2017 15:40	60244415001	Solid	1						X												001
2	MW-4/SB01	PS	5/16/2017 12:00	60244415002	Solid	1						X												
3																								
4																								
5																								

S0171318
LAB USE ONLY

Transfers	Released By	Date/Time	Received By	Date/Time
1	[illegible]	5/17/17 1700	Fedex	
2	Fedex	5/18/17 820	Hayden Pitt	5/18/17 820
3				

Comments

Cooler Temperature on Receipt 3.0 °C **Custody Seal** Y or N **Received on Ice** Y or N **Samples Intact** Y or N

****In order to maintain client confidentiality, location/name of the sampling site, sampler's name and signature may not be provided on this COC document.*
This chain of custody is considered complete as is since this information is available in the owner laboratory.

Sample Condition Upon Receipt

Pace Analytical

Client Name: Pace Kansas Project # 50171318

Courier: ☑ Fed Ex ☐ UPS ☐ USPS ☐ Client ☐ Commercial ☐ Pace Other _____

Tracking #: 7285 6592 5457

Custody Seal on Cooler/Box Present: ☐ yes ☑ no Seals intact: ☐ yes ☑ no

Date/Time 5035A kits placed in freezer _____

Packing Material: ☐ Bubble Wrap ☐ Bubble Bags ☑ None ☐ Other _____

Thermometer 1 2 3 4 5 6 A B C D E F Type of Ice: (Wet) Blue None ☐ Samples on ice, cooling process has begun

Cooler Temperature (Initial/Corrected) 3.0/3.0 Ice Visible in Sample Containers: ☐ yes ☑ no

Temp should be above freezing to 6°C

Date and Initials of person examining contents: 5/18/17 HP

		Comments:
Are samples from West Virginia? Document any containers out of temp.	☐Yes ☑No	1.
Chain of Custody Present:	☑Yes ☐No	2.
Chain of Custody Filled Out:	☑Yes ☐No	3.
Chain of Custody Relinquished:	☑Yes ☐No	4.
Sampler Name & Signature on COC:	☑Yes ☐No	5.
Short Hold Time Analysis (<72hr):	☐Yes ☑No	6.
Rush Turn Around Time Requested:	☐Yes ☑No	7.
Containers Intact:	☑Yes ☐No	8.
Sample Labels match COC: -Includes date/time/ID/Analysis	☑Yes ☐No	9.
All containers needing acid/base pres. have been checked? exceptions: VOA, coliform, TOC, O&G All containers needing preservation are found to be in compliance with EPA recommendation (<2, >9, >12) unless otherwise noted.	☐Yes ☐No ☑N/A	10 (Circle) HNO3 H2SO4 NaOH NaOH/ZnAc
Residual Chlorine Check (SVOC 625 Pest/PCB 608)		11. Present Absent
Residual Chlorine Check (Total/Amenable/Free Cyanide)		12. Present Absent
Headspace in VOA Vials (>6mm):	☐Yes ☐No ☑N/A	13
Headspace Wisconsin Sulfide	☐Yes ☐No	14
Trip Blank Present:	☐Yes ☑No	15
Trip Blank Custody Seals Present	☐Yes ☑No	
Project Manager Review		
Samples Arrived within Hold Time:	☐Yes ☐No	15.
Sufficient Volume:	☐Yes ☐No	16.
Correct Containers Used:	☐Yes ☐No	17.

Client Notification/ Resolution: Field Data Required? Y / N

Person Contacted: _____ Date/Time: _____

Comments/ Resolution: _____

Project Manager Review: _____ **Date:** 5/18/17

Sample Container Count

CLIENT: Pace Kansas

COC PAGE 1 of 1

COC ID#

Project # 50171318

Sample Line Item	DG9H VG9H	AG1U	WGFU	AG0U	SBS DI Bulk Kit R	BP2N	BP2U	BP2S	BP3N	BP3U	BP3S	AG3S	AG1H	BP3B	BP1U	SP5T	AG2U				Matrix SI/Wt/NAL (Soil/Water/Non-Aqueous Liquid)	pH <2	pH >9	pH>12
1			1																		SL			
2			1																		SL			
3																								
4																								
5																								
6																								
7																								
8																								
9																								
10																								
11																								
12																								

Container Codes

DG9H	40mL HCL amber voa vial	AG0U	100mL unpreserved amber glass	BP1N	1 liter HNO3 plastic	DG9P	40mL TSP amber vial
AG1U	1liter unpreserved amber glass	AG1H	1 liter HCL amber glass	BP1S	1 liter H2SO4 plastic	DG9S	40mL H2SO4 amber vial
WGFU	4oz clear soil jar	AG1S	1 liter H2SO4 amber glass	BP1U	1 liter unpreserved plastic	DG9T	40mL Na Thio amber vial
R	terra core kit	AG1T	1 liter Na Thiosulfate amber glass	BP1Z	1 liter NaOH, Zn, Ac	DG9U	40mL unpreserved **amber** vial
BP2N	500mL HNO3 plastic	AG2N	500mL HNO3 amber glass	BP2A	500mL NaOH, Asc Acid plastic	SP5T	120mL Coliform Na Thiosulfate
BP2U	500mL unpreserved plastic	AG2S	500mL H2SO4 amber glass	BP2O	500mL NaOH plastic	JGFU	4oz unpreserved amber wide
BP2S	500mL H2SO4 plastic	AG2U	500mL unpreserved amber glass	BP2Z	500mL NaOH, Zn Ac	U	Summa Can
BP3N	250mL HNO3 plastic	AG3U	250mL unpreserved amber glass	AF	Air Filter	VG9H	40mL HCL clear vial
BP3U	250mL unpreserved plastic	BG1H	1 liter HCL clear glass	BP3B	250mL NaOH plastic	VG9T	40mL Na Thio. clear vial
BP3S	250mL H2SO4 plastic	BG1S	1 liter H2SO4 clear glass	BP3Z	250mL NaOH, Zn Ac plastic	VG9U	40mL unpreserved **clear** vial
AG3S	250mL H2SO4 glass amber	BG1T	1 liter Na Thiosulfate clear glass	C	Air Cassettes	VSG	Headspace septa vial & HCL
AG1S	1 liter H2SO4 amber glass	BG1U	1 liter unpreserved glass	DG9B	40mL Na Bisulfate amber vial	WGFX	4oz wide jar w/hexane wipe
BP1U	1 liter unpreserved plastic	BP1A	1 liter NaOH, Asc Acid plastic	DG9M	40mL MeOH clear vial	ZPLC	Ziploc Bag

Pace Analytical Services, LLC
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

June 21, 2017

Brian Weis

Burns & McDonnell
9400 Ward Parkway
Kansas City, MO 64114

RE: Project: COLUMBIA, MO
Pace Project No.: 60244777

Dear Brian Weis:
Enclosed are the analytical results for sample(s) received by the laboratory on May 20, 2017. The results relate only to the samples included in this report. Results reported herein conform to the most current, applicable TNI/NELAC standards and the laboratory's Quality Assurance Manual, where applicable, unless otherwise noted in the body of the report.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Alice Spiller

Alice Spiller
alice.spiller@pacelabs.com
(913)563-1409
Project Manager

Enclosures

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CERTIFICATIONS

Project: COLUMBIA, MO
Pace Project No.: 60244777

Pennsylvania Certification IDs

1638 Roseytown Rd Suites 2,3&4, Greensburg, PA 15601
L-A-B DOD-ELAP Accreditation #: L2417
Alabama Certification #: 41590
Arizona Certification #: AZ0734
Arkansas Certification
California Certification #: 04222CA
Colorado Certification
Connecticut Certification #: PH-0694
Delaware Certification
Florida/TNI Certification #: E87683
Georgia Certification #: C040
Guam Certification
Hawaii Certification
Idaho Certification
Illinois Certification
Indiana Certification
Iowa Certification #: 391
Kansas/TNI Certification #: E-10358
Kentucky Certification #: 90133
Louisiana DHH/TNI Certification #: LA140008
Louisiana DEQ/TNI Certification #: 4086
Maine Certification #: PA00091
Maryland Certification #: 308
Massachusetts Certification #: M-PA1457
Michigan/PADEP Certification
Missouri Certification #: 235
Montana Certification #: Cert 0082
Nebraska Certification #: NE-05-29-14
Nevada Certification #: PA014572015-1
New Hampshire/TNI Certification #: 2976
New Jersey/TNI Certification #: PA 051
New Mexico Certification #: PA01457
New York/TNI Certification #: 10888
North Carolina Certification #: 42706
North Dakota Certification #: R-190
Oregon/TNI Certification #: PA200002
Pennsylvania/TNI Certification #: 65-00282
Puerto Rico Certification #: PA01457
Rhode Island Certification #: 65-00282
South Dakota Certification
Tennessee Certification #: TN2867
Texas/TNI Certification #: T104704188-14-8
Utah/TNI Certification #: PA014572015-5
USDA Soil Permit #: P330-14-00213
Vermont Dept. of Health: ID# VT-0282
Virgin Island/PADEP Certification
Virginia/VELAP Certification #: 460198
Washington Certification #: C868
West Virginia DEP Certification #: 143
West Virginia DHHR Certification #: 9964C
Wisconsin Certification
Wyoming Certification #: 8TMS-L

Indiana Certification IDs

7726 Moller Road, Indianapolis, IN 46268
Illinois Certification #: 003971
Indiana Certification #: C-49-06
Kansas/NELAP Certification #:E-10177
Kentucky UST Certification #: 80226
Kentucky WW Certification #:98019
Ohio VAP Certification #: CL-0065
Oklahoma Certification #: 2016-075
Texas Certification #: T104704355-16-10
West Virginia Certification #: 330
Wisconsin Certification #: 999788130
USDA Soil Permit #: P330-16-00257

Kansas Certification IDs

9608 Loiret Boulevard, Lenexa, KS 66219
WY STR Certification #: 2456.01
Arkansas Certification #: 15-016-0
Illinois Certification #: 003097
Iowa Certification #: 118
Kansas/NELAP Certification #: E-10116
Louisiana Certification #: 03055
Nevada Certification #: KS000212008A
Oklahoma Certification #: 9205/9935
Texas Certification #: T104704407
Utah Certification #: KS00021
Kansas Field Laboratory Accreditation: # E-92587
Missouri Certification: 10070

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SAMPLE SUMMARY

Project: COLUMBIA, MO
Pace Project No.: 60244777

Lab ID	Sample ID	Matrix	Date Collected	Date Received
60244777001	**MW-3 / SB01**	Solid	05/17/17 13:05	05/20/17 08:40
60244777002	**MW-8 / SB02**	Solid	05/18/17 13:15	05/20/17 08:40
60244777003	**MW-8 / SB11**	Solid	05/18/17 08:00	05/20/17 08:40
60244777004	**MW-5 / SB01**	Solid	05/19/17 08:30	05/20/17 08:40

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SAMPLE ANALYTE COUNT

Project: COLUMBIA, MO
Pace Project No.: 60244777

Lab ID	Sample ID	Method	Analysts	Analytes Reported	Laboratory
60244777001	**MW-3 / SB01**	EPA 6010	JGP, TDS	21	PASI-K
		EPA 7471	SMW	1	PASI-K
		ASTM D2974	DWC	1	PASI-K
		EPA 901.1	MAH	2	PASI-PA
		EPA 7196A	SKK	1	PASI-I
60244777002	**MW-8 / SB02**	EPA 6010	JGP, TDS	21	PASI-K
		EPA 7471	SMW	1	PASI-K
		ASTM D2974	DWC	1	PASI-K
		EPA 901.1	MAH	2	PASI-PA
		EPA 7196A	SKK	1	PASI-I
60244777003	**MW-8 / SB11**	EPA 6010	JGP, TDS	21	PASI-K
		EPA 7471	SMW	1	PASI-K
		ASTM D2974	DWC	1	PASI-K
		EPA 901.1	MAH	2	PASI-PA
		EPA 7196A	SKK	1	PASI-I
60244777004	**MW-5 / SB01**	EPA 6010	JGP	21	PASI-K
		EPA 7471	SMW	1	PASI-K
		ASTM D2974	DWC	1	PASI-K
		EPA 901.1	MAH	2	PASI-PA
		EPA 7196A	SKK	1	PASI-I

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PROJECT NARRATIVE

Project: COLUMBIA, MO
Pace Project No.: 60244777

Method: **EPA 6010**
Description: 6010 MET ICP Red. Interference
Client: BURNS & MCDONNELL
Date: June 21, 2017

General Information:
4 samples were analyzed for EPA 6010. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Sample Preparation:
The samples were prepared in accordance with EPA 3050 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

QC Batch: 478051

A matrix spike and/or matrix spike duplicate (MS/MSD) were performed on the following sample(s): 60244399001

M1: Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.

- MS (Lab ID: 1958234)
  - Calcium
  - Iron
  - Zinc
- MSD (Lab ID: 1958235)
  - Calcium
  - Iron
  - Zinc

QC Batch: 479179

A matrix spike and/or matrix spike duplicate (MS/MSD) were performed on the following sample(s): 60244763001

M1: Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.

- MS (Lab ID: 1962597)
  - Lead
- MSD (Lab ID: 1962598)
  - Lead

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PROJECT NARRATIVE

Project: COLUMBIA, MO
Pace Project No.: 60244777

Method: **EPA 6010**
Description: 6010 MET ICP Red. Interference
Client: BURNS & MCDONNELL
Date: June 21, 2017

Additional Comments:

Analyte Comments:

QC Batch: 478051

D3: Sample was diluted due to the presence of high levels of non-target analytes or other matrix interference.

- MW-5 / SB01 (Lab ID: 60244777004)
  - Silver
  - Cadmium
  - Molybdenum
  - Antimony
  - Selenium
  - Thallium

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PROJECT NARRATIVE

Project: COLUMBIA, MO
Pace Project No.: 60244777

Method: **EPA 7471**
Description: 7471 Mercury
Client: BURNS & MCDONNELL
Date: June 21, 2017

General Information:
4 samples were analyzed for EPA 7471. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Sample Preparation:
The samples were prepared in accordance with EPA 7471 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: COLUMBIA, MO
Pace Project No.: 60244777

Method: **EPA 901.1**
Description: 901.1 Gamma Spec INGROWTH
Client: BURNS & MCDONNELL
Date: June 21, 2017

General Information:
4 samples were analyzed for EPA 901.1. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: COLUMBIA, MO
Pace Project No.: 60244777

Method: **EPA 7196A**
Description: 7196 Chromium, Hexavalent
Client: BURNS & MCDONNELL
Date: June 21, 2017

General Information:
4 samples were analyzed for EPA 7196A. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Sample Preparation:
The samples were prepared in accordance with EPA 3060A with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

Analyte Comments:

QC Batch: 388793

D3: Sample was diluted due to the presence of high levels of non-target analytes or other matrix interference.

- DUP (Lab ID: 1792684)
  - Chromium, Hexavalent

This data package has been reviewed for quality and completeness and is approved for release.

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ANALYTICAL RESULTS

Project: COLUMBIA, MO
Pace Project No.: 60244777

Sample: MW-3 / SB01 **Lab ID: 60244777001** Collected: 05/17/17 13:05 Received: 05/20/17 08:40 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP Red. Interference	Analytical Method: EPA 6010 Preparation Method: EPA 3050							
Aluminum	**18200**	mg/kg	7.9	1	05/23/17 15:44	05/31/17 18:17	7429-90-5	
Antimony	ND	mg/kg	1.1	1	05/23/17 15:44	05/31/17 18:17	7440-36-0	
Arsenic	**5.5**	mg/kg	1.1	1	05/23/17 15:44	05/31/17 18:17	7440-38-2	
Barium	**254**	mg/kg	0.53	1	05/23/17 15:44	05/31/17 18:17	7440-39-3	
Beryllium	**0.63**	mg/kg	0.11	1	05/23/17 15:44	05/31/17 18:17	7440-41-7	
Boron	ND	mg/kg	10.6	1	05/23/17 15:44	05/31/17 18:17	7440-42-8	
Cadmium	ND	mg/kg	0.53	1	05/23/17 15:44	05/31/17 18:17	7440-43-9	
Calcium	**2710**	mg/kg	10.6	1	05/23/17 15:44	05/31/17 18:17	7440-70-2	
Chromium	**22.4**	mg/kg	0.53	1	05/23/17 15:44	05/31/17 18:17	7440-47-3	
Cobalt	**38.5**	mg/kg	0.53	1	05/23/17 15:44	05/31/17 18:17	7440-48-4	
Copper	**11.0**	mg/kg	1.1	1	05/23/17 15:44	05/31/17 18:17	7440-50-8	
Iron	**19200**	mg/kg	5.3	1	05/23/17 15:44	05/31/17 18:17	7439-89-6	
Lead	**10.1**	mg/kg	0.56	1	06/01/17 13:37	06/02/17 17:48	7439-92-1	
Magnesium	**1550**	mg/kg	5.3	1	05/23/17 15:44	05/31/17 18:17	7439-95-4	
Manganese	**2290**	mg/kg	0.53	1	05/23/17 15:44	05/31/17 18:17	7439-96-5	
Molybdenum	ND	mg/kg	2.1	1	05/23/17 15:44	05/31/17 18:17	7439-98-7	
Nickel	**24.5**	mg/kg	0.53	1	05/23/17 15:44	05/31/17 18:17	7440-02-0	
Selenium	ND	mg/kg	1.6	1	05/23/17 15:44	05/31/17 18:17	7782-49-2	
Silver	ND	mg/kg	0.74	1	05/23/17 15:44	05/31/17 18:17	7440-22-4	
Thallium	ND	mg/kg	2.1	1	05/23/17 15:44	05/31/17 18:17	7440-28-0	
Zinc	**22.9**	mg/kg	10.6	1	05/23/17 15:44	05/31/17 18:17	7440-66-6	
7471 Mercury	Analytical Method: EPA 7471 Preparation Method: EPA 7471							
Mercury	ND	mg/kg	0.057	1	06/01/17 11:01	06/01/17 14:21	7439-97-6	
Percent Moisture	Analytical Method: ASTM D2974							
Percent Moisture	**17.1**	%	0.50	1		06/01/17 00:00		
7196 Chromium, Hexavalent	Analytical Method: EPA 7196A Preparation Method: EPA 3060A							
Chromium, Hexavalent	ND	mg/kg	2.4	1	05/24/17 11:25	05/26/17 13:57	18540-29-9	

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ANALYTICAL RESULTS

Project: COLUMBIA, MO
Pace Project No.: 60244777

Sample: MW-8 / SB02 **Lab ID: 60244777002** Collected: 05/18/17 13:15 Received: 05/20/17 08:40 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP Red. Interference	Analytical Method: EPA 6010 Preparation Method: EPA 3050							
Aluminum	**7500**	mg/kg	7.3	1	05/23/17 15:44	05/31/17 18:20	7429-90-5	
Antimony	ND	mg/kg	0.97	1	05/23/17 15:44	05/31/17 18:20	7440-36-0	
Arsenic	**4.6**	mg/kg	0.97	1	05/23/17 15:44	05/31/17 18:20	7440-38-2	
Barium	**47.4**	mg/kg	0.48	1	05/23/17 15:44	05/31/17 18:20	7440-39-3	
Beryllium	**0.54**	mg/kg	0.097	1	05/23/17 15:44	05/31/17 18:20	7440-41-7	
Boron	ND	mg/kg	9.7	1	05/23/17 15:44	05/31/17 18:20	7440-42-8	
Cadmium	ND	mg/kg	0.48	1	05/23/17 15:44	05/31/17 18:20	7440-43-9	
Calcium	**15000**	mg/kg	9.7	1	05/23/17 15:44	05/31/17 18:20	7440-70-2	
Chromium	**12.3**	mg/kg	0.48	1	05/23/17 15:44	05/31/17 18:20	7440-47-3	
Cobalt	**7.1**	mg/kg	0.48	1	05/23/17 15:44	05/31/17 18:20	7440-48-4	
Copper	**13.3**	mg/kg	0.97	1	05/23/17 15:44	05/31/17 18:20	7440-50-8	
Iron	**12900**	mg/kg	4.8	1	05/23/17 15:44	05/31/17 18:20	7439-89-6	
Lead	**10.7**	mg/kg	0.52	1	06/01/17 13:37	06/02/17 17:50	7439-92-1	
Magnesium	**2770**	mg/kg	4.8	1	05/23/17 15:44	05/31/17 18:20	7439-95-4	
Manganese	**283**	mg/kg	0.48	1	05/23/17 15:44	05/31/17 18:20	7439-96-5	
Molybdenum	ND	mg/kg	1.9	1	05/23/17 15:44	05/31/17 18:20	7439-98-7	
Nickel	**18.3**	mg/kg	0.48	1	05/23/17 15:44	05/31/17 18:20	7440-02-0	
Selenium	ND	mg/kg	1.5	1	05/23/17 15:44	05/31/17 18:20	7782-49-2	
Silver	ND	mg/kg	0.68	1	05/23/17 15:44	05/31/17 18:20	7440-22-4	
Thallium	ND	mg/kg	1.9	1	05/23/17 15:44	05/31/17 18:20	7440-28-0	
Zinc	**39.7**	mg/kg	9.7	1	05/23/17 15:44	05/31/17 18:20	7440-66-6	
7471 Mercury	Analytical Method: EPA 7471 Preparation Method: EPA 7471							
Mercury	ND	mg/kg	0.048	1	06/01/17 11:01	06/01/17 14:23	7439-97-6	
Percent Moisture	Analytical Method: ASTM D2974							
Percent Moisture	**14.0**	%	0.50	1		06/01/17 00:00		
7196 Chromium, Hexavalent	Analytical Method: EPA 7196A Preparation Method: EPA 3060A							
Chromium, Hexavalent	ND	mg/kg	2.3	1	05/24/17 11:25	05/26/17 14:05	18540-29-9	

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ANALYTICAL RESULTS

Project: COLUMBIA, MO
Pace Project No.: 60244777

Sample: MW-8 / SB11 **Lab ID: 60244777003** Collected: 05/18/17 08:00 Received: 05/20/17 08:40 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP Red. Interference	Analytical Method: EPA 6010 Preparation Method: EPA 3050							
Aluminum	**8610**	mg/kg	8.5	1	05/23/17 15:44	05/31/17 18:24	7429-90-5	
Antimony	ND	mg/kg	1.1	1	05/23/17 15:44	05/31/17 18:24	7440-36-0	
Arsenic	**4.0**	mg/kg	1.1	1	05/23/17 15:44	05/31/17 18:24	7440-38-2	
Barium	**52.0**	mg/kg	0.56	1	05/23/17 15:44	05/31/17 18:24	7440-39-3	
Beryllium	**0.51**	mg/kg	0.11	1	05/23/17 15:44	05/31/17 18:24	7440-41-7	
Boron	ND	mg/kg	11.3	1	05/23/17 15:44	05/31/17 18:24	7440-42-8	
Cadmium	**1.0**	mg/kg	0.56	1	05/23/17 15:44	05/31/17 18:24	7440-43-9	
Calcium	**16800**	mg/kg	11.3	1	05/23/17 15:44	05/31/17 18:24	7440-70-2	
Chromium	**14.4**	mg/kg	0.56	1	05/23/17 15:44	05/31/17 18:24	7440-47-3	
Cobalt	**9.7**	mg/kg	0.56	1	05/23/17 15:44	05/31/17 18:24	7440-48-4	
Copper	**15.8**	mg/kg	1.1	1	05/23/17 15:44	05/31/17 18:24	7440-50-8	
Iron	**9870**	mg/kg	5.6	1	05/23/17 15:44	05/31/17 18:24	7439-89-6	
Lead	**8.7**	mg/kg	0.53	1	06/01/17 13:37	06/02/17 17:53	7439-92-1	
Magnesium	**2890**	mg/kg	5.6	1	05/23/17 15:44	05/31/17 18:24	7439-95-4	
Manganese	**148**	mg/kg	0.56	1	05/23/17 15:44	05/31/17 18:24	7439-96-5	
Molybdenum	ND	mg/kg	2.3	1	05/23/17 15:44	05/31/17 18:24	7439-98-7	
Nickel	**25.5**	mg/kg	0.56	1	05/23/17 15:44	05/31/17 18:24	7440-02-0	
Selenium	ND	mg/kg	1.7	1	05/23/17 15:44	05/31/17 18:24	7782-49-2	
Silver	ND	mg/kg	0.79	1	05/23/17 15:44	05/31/17 18:24	7440-22-4	
Thallium	ND	mg/kg	2.3	1	05/23/17 15:44	05/31/17 18:24	7440-28-0	
Zinc	**48.2**	mg/kg	11.3	1	05/23/17 15:44	05/31/17 18:24	7440-66-6	
7471 Mercury	Analytical Method: EPA 7471 Preparation Method: EPA 7471							
Mercury	ND	mg/kg	0.038	1	06/01/17 11:01	06/01/17 14:25	7439-97-6	
Percent Moisture	Analytical Method: ASTM D2974							
Percent Moisture	**13.2**	%	0.50	1		06/01/17 00:00		
7196 Chromium, Hexavalent	Analytical Method: EPA 7196A Preparation Method: EPA 3060A							
Chromium, Hexavalent	ND	mg/kg	2.3	1	05/24/17 11:25	05/26/17 14:06	18540-29-9	

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ANALYTICAL RESULTS

Project: COLUMBIA, MO
Pace Project No.: 60244777

Sample: MW-5 / SB01 **Lab ID: 60244777004** Collected: 05/19/17 08:30 Received: 05/20/17 08:40 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP Red. Interference	Analytical Method: EPA 6010 Preparation Method: EPA 3050							
Aluminum	**9560**	mg/kg	23.5	3	05/23/17 15:44	06/01/17 14:44	7429-90-5	
Antimony	ND	mg/kg	2.1	2	05/23/17 15:44	06/01/17 14:40	7440-36-0	D3
Arsenic	**14.8**	mg/kg	2.1	2	05/23/17 15:44	06/01/17 14:40	7440-38-2	
Barium	**108**	mg/kg	1.6	3	05/23/17 15:44	06/01/17 14:44	7440-39-3	
Beryllium	**2.5**	mg/kg	0.31	3	05/23/17 15:44	06/01/17 14:44	7440-41-7	
Boron	ND	mg/kg	20.9	2	05/23/17 15:44	06/01/17 14:40	7440-42-8	
Cadmium	ND	mg/kg	1.0	2	05/23/17 15:44	06/01/17 14:40	7440-43-9	D3
Calcium	**3030**	mg/kg	31.4	3	05/23/17 15:44	06/01/17 14:44	7440-70-2	
Chromium	**15.1**	mg/kg	1.0	2	05/23/17 15:44	06/01/17 14:40	7440-47-3	
Cobalt	**41.7**	mg/kg	1.0	2	05/23/17 15:44	06/01/17 14:40	7440-48-4	
Copper	**13.9**	mg/kg	2.1	2	05/23/17 15:44	06/01/17 14:40	7440-50-8	
Iron	**20000**	mg/kg	15.7	3	05/23/17 15:44	06/01/17 14:44	7439-89-6	
Lead	**12.0**	mg/kg	1.5	3	06/01/17 13:37	06/05/17 12:47	7439-92-1	
Magnesium	**1710**	mg/kg	10.5	2	05/23/17 15:44	06/01/17 14:40	7439-95-4	
Manganese	**568**	mg/kg	1.0	2	05/23/17 15:44	06/01/17 14:40	7439-96-5	
Molybdenum	ND	mg/kg	4.2	2	05/23/17 15:44	06/01/17 14:40	7439-98-7	D3
Nickel	**23.7**	mg/kg	1.0	2	05/23/17 15:44	06/01/17 14:40	7440-02-0	
Selenium	ND	mg/kg	3.1	2	05/23/17 15:44	06/01/17 14:40	7782-49-2	D3
Silver	ND	mg/kg	1.5	2	05/23/17 15:44	06/01/17 14:40	7440-22-4	D3
Thallium	ND	mg/kg	4.2	2	05/23/17 15:44	06/01/17 14:40	7440-28-0	D3
Zinc	**88.8**	mg/kg	20.9	2	05/23/17 15:44	06/01/17 14:40	7440-66-6	
7471 Mercury	Analytical Method: EPA 7471 Preparation Method: EPA 7471							
Mercury	ND	mg/kg	0.038	1	06/01/17 11:01	06/01/17 14:27	7439-97-6	
Percent Moisture	Analytical Method: ASTM D2974							
Percent Moisture	**17.5**	%	0.50	1		06/01/17 00:00		
7196 Chromium, Hexavalent	Analytical Method: EPA 7196A Preparation Method: EPA 3060A							
Chromium, Hexavalent	ND	mg/kg	2.4	1	05/24/17 11:25	05/26/17 14:06	18540-29-9	

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QUALITY CONTROL DATA

Project: COLUMBIA, MO
Pace Project No.: 60244777

QC Batch: 479142 Analysis Method: EPA 7471
QC Batch Method: EPA 7471 Analysis Description: 7471 Mercury
Associated Lab Samples: 60244777001, 60244777002, 60244777003, 60244777004

METHOD BLANK: 1962414 Matrix: Solid
Associated Lab Samples: 60244777001, 60244777002, 60244777003, 60244777004

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Mercury	mg/kg	ND	0.050	06/01/17 13:52	

LABORATORY CONTROL SAMPLE: 1962415

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Mercury	mg/kg	.5	0.44	89	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1962416 1962417

Parameter	Units	60244956001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Mercury	mg/kg	0.12	.32	.32	0.38	0.39	83	84	75-125	2	20	

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REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: COLUMBIA, MO
Pace Project No.: 60244777

QC Batch: 478051 | Analysis Method: EPA 6010
QC Batch Method: EPA 3050 | Analysis Description: 6010 MET
Associated Lab Samples: 60244777001, 60244777002, 60244777003, 60244777004

METHOD BLANK: 1958232 | Matrix: Solid
Associated Lab Samples: 60244777001, 60244777002, 60244777003, 60244777004

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Aluminum	mg/kg	ND	7.5	05/26/17 12:11	
Antimony	mg/kg	ND	1.0	05/26/17 12:11	
Arsenic	mg/kg	ND	1.0	05/26/17 12:11	
Barium	mg/kg	ND	0.50	05/26/17 12:11	
Beryllium	mg/kg	ND	0.10	05/26/17 12:11	
Boron	mg/kg	ND	10.0	05/26/17 12:11	
Cadmium	mg/kg	ND	0.50	05/26/17 12:11	
Calcium	mg/kg	ND	10.0	05/26/17 12:11	
Chromium	mg/kg	ND	0.50	05/26/17 12:11	
Cobalt	mg/kg	ND	0.50	05/26/17 12:11	
Copper	mg/kg	ND	1.0	05/26/17 12:11	
Iron	mg/kg	ND	5.0	05/26/17 12:11	
Magnesium	mg/kg	ND	5.0	05/26/17 12:11	
Manganese	mg/kg	ND	0.50	05/26/17 12:11	
Molybdenum	mg/kg	ND	2.0	05/26/17 12:11	
Nickel	mg/kg	ND	0.50	05/26/17 12:11	
Selenium	mg/kg	ND	1.5	05/26/17 12:11	
Silver	mg/kg	ND	0.70	05/26/17 12:11	
Thallium	mg/kg	ND	2.0	05/26/17 12:11	
Zinc	mg/kg	ND	10.0	05/26/17 12:11	

LABORATORY CONTROL SAMPLE: 1958233

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Aluminum	mg/kg	1000	881	88	80-120	
Antimony	mg/kg	100	88.6	89	80-120	
Arsenic	mg/kg	100	83.9	84	80-120	
Barium	mg/kg	100	89.2	89	80-120	
Beryllium	mg/kg	100	88.0	88	80-120	
Boron	mg/kg	100	81.4	81	80-120	
Cadmium	mg/kg	100	88.1	88	80-120	
Calcium	mg/kg	1000	879	88	80-120	
Chromium	mg/kg	100	89.6	90	80-120	
Cobalt	mg/kg	100	92.6	93	80-120	
Copper	mg/kg	100	92.2	92	80-120	
Iron	mg/kg	1000	879	88	80-120	
Magnesium	mg/kg	1000	853	85	80-120	
Manganese	mg/kg	100	91.0	91	80-120	
Molybdenum	mg/kg	100	95.9	96	80-120	
Nickel	mg/kg	100	90.4	90	80-120	

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QUALITY CONTROL DATA

Project: COLUMBIA, MO
Pace Project No.: 60244777

LABORATORY CONTROL SAMPLE: 1958233

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Selenium	mg/kg	100	84.9	85	80-120	
Silver	mg/kg	50	45.0	90	80-120	
Thallium	mg/kg	100	93.1	93	80-120	
Zinc	mg/kg	100	89.3	89	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1958234 1958235

Parameter	Units	60244399001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Aluminum	mg/kg	118	2770	2720	2700	2720	93	96	75-125	1	20	
Antimony	mg/kg	ND	277	272	243	248	87	91	75-125	2	20	
Arsenic	mg/kg	ND	277	272	240	245	86	89	75-125	2	20	
Barium	mg/kg	253	277	272	489	509	85	94	75-125	4	20	
Beryllium	mg/kg	ND	277	272	251	257	91	94	75-125	2	20	
Boron	mg/kg	ND	277	272	249	250	83	85	75-125	0	20	
Cadmium	mg/kg	ND	277	272	250	253	90	93	75-125	1	20	
Calcium	mg/kg	219000	2770	2720	247000	214000	1020	-161	75-125	14	20	M1
Chromium	mg/kg	14.6	277	272	259	263	88	91	75-125	1	20	
Cobalt	mg/kg	177	277	272	395	408	79	85	75-125	3	20	
Copper	mg/kg	9.6	277	272	266	272	92	97	75-125	3	20	
Iron	mg/kg	27100	2770	2720	26800	28300	-8	44	75-125	5	20	M1
Magnesium	mg/kg	3120	2770	2720	5510	5480	86	87	75-125	1	20	
Manganese	mg/kg	220	277	272	457	461	85	89	75-125	1	20	
Molybdenum	mg/kg	ND	277	272	257	264	93	97	75-125	2	20	
Nickel	mg/kg	155	277	272	385	384	83	84	75-125	0	20	
Selenium	mg/kg	ND	277	272	234	239	84	87	75-125	2	20	
Silver	mg/kg	ND	138	136	125	126	90	92	75-125	0	20	
Thallium	mg/kg	ND	277	272	223	227	80	83	75-125	2	20	
Zinc	mg/kg	43500	277	272	33100	39900	-3730	-1320	75-125	18	20	M1

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QUALITY CONTROL DATA

Project: COLUMBIA, MO
Pace Project No.: 60244777

QC Batch: 479179 Analysis Method: EPA 6010
QC Batch Method: EPA 3050 Analysis Description: 6010 MET
Associated Lab Samples: 60244777001, 60244777002, 60244777003, 60244777004

METHOD BLANK: 1962595 Matrix: Solid
Associated Lab Samples: 60244777001, 60244777002, 60244777003, 60244777004

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Lead	mg/kg	ND	0.50	06/02/17 17:28	

LABORATORY CONTROL SAMPLE: 1962596

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Lead	mg/kg	100	93.7	94	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1962597 1962598

Parameter	Units	60244763001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Lead	mg/kg	25.5	105	103	99.0	91.5	70	64	75-125	8	20	M1

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QUALITY CONTROL DATA

Project: COLUMBIA, MO
Pace Project No.: 60244777

QC Batch: 479164 | Analysis Method: ASTM D2974
QC Batch Method: ASTM D2974 | Analysis Description: Dry Weight/Percent Moisture
Associated Lab Samples: 60244777001, 60244777002, 60244777003, 60244777004

METHOD BLANK: 1962473 | Matrix: Solid
Associated Lab Samples: 60244777001, 60244777002, 60244777003, 60244777004

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Percent Moisture	%	ND	0.50	06/01/17 00:00	

SAMPLE DUPLICATE: 1962474

Parameter	Units	60244763007 Result	Dup Result	RPD	Max RPD	Qualifiers
Percent Moisture	%	28.9	28.6	1	20	

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QUALITY CONTROL DATA

Project: COLUMBIA, MO
Pace Project No.: 60244777

QC Batch: 388793 | Analysis Method: EPA 7196A
QC Batch Method: EPA 3060A | Analysis Description: 7196 Chromium, Hexavalent
Associated Lab Samples: 60244777001, 60244777002, 60244777003, 60244777004

METHOD BLANK: 1792678 | Matrix: Solid
Associated Lab Samples: 60244777001, 60244777002, 60244777003, 60244777004

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Chromium, Hexavalent	mg/kg	ND	2.0	05/26/17 13:13	

LABORATORY CONTROL SAMPLE: 1792679

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Chromium, Hexavalent	mg/kg	1020	956	93	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1792680 1792681

Parameter	Units	50170973001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Chromium, Hexavalent	mg/kg	ND	1080	1100	1050	1020	97	93	75-125	3	20	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1792682 1792683

Parameter	Units	50170973001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Chromium, Hexavalent	mg/kg	ND	43.4	43	44.0	42.3	100	97	75-125	4	20	

SAMPLE DUPLICATE: 1792684

Parameter	Units	50171487007 Result	Dup Result	RPD	Max RPD	Qualifiers
Chromium, Hexavalent	mg/kg	ND	ND		20	D3

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ANALYTICAL RESULTS - RADIOCHEMISTRY

Project: COLUMBIA, MO
Pace Project No.: 60244777

Sample: MW-3 / SB01 **Lab ID: 60244777001** Collected: 05/17/17 13:05 Received: 05/20/17 08:40 Matrix: Solid
PWS: Site ID: Sample Type:

Results reported on a "dry-weight" basis

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Radium-226	EPA 901.1	**1.096 ± 0.233 (0.191)** **C:NA T:NA**	pCi/g	06/20/17 14:30	13982-63-3	Ra
Radium-228	EPA 901.1	**1.559 ± 0.384 (0.175)** **C:NA T:NA**	pCi/g	06/20/17 14:30	15262-20-1	

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ANALYTICAL RESULTS - RADIOCHEMISTRY

Project: COLUMBIA, MO
Pace Project No.: 60244777

Sample: MW-8 / SB02 **Lab ID: 60244777002** Collected: 05/18/17 13:15 Received: 05/20/17 08:40 Matrix: Solid
PWS: Site ID: Sample Type:

Results reported on a "dry-weight" basis

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Radium-226	EPA 901.1	**2.086 ± 0.408 (0.178)** **C:NA T:NA**	pCi/g	06/20/17 14:30	13982-63-3	Ra
Radium-228	EPA 901.1	**1.078 ± 0.409 (0.319)** **C:NA T:NA**	pCi/g	06/20/17 14:30	15262-20-1	

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ANALYTICAL RESULTS - RADIOCHEMISTRY

Project: COLUMBIA, MO
Pace Project No.: 60244777

Sample: MW-8 / SB11 **Lab ID: 60244777003** Collected: 05/18/17 08:00 Received: 05/20/17 08:40 Matrix: Solid
PWS: Site ID: Sample Type:

Results reported on a "dry-weight" basis

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Radium-226	EPA 901.1	**2.250 ± 0.371 (0.213)** **C:NA T:NA**	pCi/g	06/20/17 14:47	13982-63-3	Ra
Radium-228	EPA 901.1	**1.361 ± 0.346 (0.157)** **C:NA T:NA**	pCi/g	06/20/17 14:47	15262-20-1	

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ANALYTICAL RESULTS - RADIOCHEMISTRY

Project: COLUMBIA, MO
Pace Project No.: 60244777

Sample: MW-5 / SB01 **Lab ID: 60244777004** Collected: 05/19/17 08:30 Received: 05/20/17 08:40 Matrix: Solid
PWS: Site ID: Sample Type:

Results reported on a "dry-weight" basis

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Radium-226	EPA 901.1	**1.197 ± 0.287 (0.181)** **C:NA T:NA**	pCi/g	06/20/17 14:47	13982-63-3	Ra
Radium-228	EPA 901.1	**1.574 ± 0.503 (0.263)** **C:NA T:NA**	pCi/g	06/20/17 14:47	15262-20-1	

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QUALITY CONTROL - RADIOCHEMISTRY

Project: COLUMBIA, MO
Pace Project No.: 60244777

QC Batch: 260753 Analysis Method: EPA 901.1
QC Batch Method: EPA 901.1 Analysis Description: 901.1 Gamma Spec Ingrowth
Associated Lab Samples: 60244777001, 60244777002, 60244777003, 60244777004

METHOD BLANK: 1284174 Matrix: Solid
Associated Lab Samples: 60244777001, 60244777002, 60244777003, 60244777004

Parameter	Act ± Unc (MDC) Carr Trac	Units	Analyzed	Qualifiers
Radium-226	0.051 ± 0.084 (0.154) C:NA T:NA	pCi/g	06/20/17 13:48	Ra
Radium-228	0.066 ± 0.099 (0.161) C:NA T:NA	pCi/g	06/20/17 13:48	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

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QUALIFIERS

Project: COLUMBIA, MO
Pace Project No.: 60244777

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to dilution of the sample aliquot.

ND - Not Detected at or above adjusted reporting limit.

J - Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

MDL - Adjusted Method Detection Limit.

PQL - Practical Quantitation Limit.

RL - Reporting Limit.

S - Surrogate

1,2-Diphenylhydrazine decomposes to and cannot be separated from Azobenzene using Method 8270. The result for each analyte is a combined concentration.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

Act - Activity

Unc - Uncertainty: SDWA = 1.96 sigma count uncertainty, all other matrices = Expanded Uncertainty (95% confidence interval). Gamma Spec = Expanded Uncertainty (95.4% Confidence Interval)

(MDC) - Minimum Detectable Concentration

Trac - Tracer Recovery (%)

Carr - Carrier Recovery (%)

Pace Analytical is TNI accredited. Contact your Pace PM for the current list of accredited analytes.

TNI - The NELAC Institute.

LABORATORIES

PASI-I	Pace Analytical Services - Indianapolis
PASI-K	Pace Analytical Services - Kansas City
PASI-PA	Pace Analytical Services - Greensburg

ANALYTE QUALIFIERS

D3	Sample was diluted due to the presence of high levels of non-target analytes or other matrix interference.
M1	Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.
Ra	The reported Ra-226 results were determined by hermetically sealing the dried, processed sample in an appropriate-sized can. Each sample was stored for a minimum of 21 days to ensure that equilibrium between Ra-226 and daughters Bi-214 and Pb-214 was achieved. Reported Ra-226 results were inferred from gamma peaks attributable to Bi-214 and Pb-214.

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QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: COLUMBIA, MO
Pace Project No.: 60244777

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
60244777001	**MW-3 / SB01**	EPA 3050	478051	EPA 6010	478210
60244777001	**MW-3 / SB01**	EPA 3050	479179	EPA 6010	479370
60244777002	**MW-8 / SB02**	EPA 3050	478051	EPA 6010	478210
60244777002	**MW-8 / SB02**	EPA 3050	479179	EPA 6010	479370
60244777003	**MW-8 / SB11**	EPA 3050	478051	EPA 6010	478210
60244777003	**MW-8 / SB11**	EPA 3050	479179	EPA 6010	479370
60244777004	**MW-5 / SB01**	EPA 3050	478051	EPA 6010	478210
60244777004	**MW-5 / SB01**	EPA 3050	479179	EPA 6010	479370
60244777001	**MW-3 / SB01**	EPA 7471	479142	EPA 7471	479209
60244777002	**MW-8 / SB02**	EPA 7471	479142	EPA 7471	479209
60244777003	**MW-8 / SB11**	EPA 7471	479142	EPA 7471	479209
60244777004	**MW-5 / SB01**	EPA 7471	479142	EPA 7471	479209
60244777001	**MW-3 / SB01**	ASTM D2974	479164		
60244777002	**MW-8 / SB02**	ASTM D2974	479164		
60244777003	**MW-8 / SB11**	ASTM D2974	479164		
60244777004	**MW-5 / SB01**	ASTM D2974	479164		
60244777001	**MW-3 / SB01**	EPA 901.1	260753		
60244777002	**MW-8 / SB02**	EPA 901.1	260753		
60244777003	**MW-8 / SB11**	EPA 901.1	260753		
60244777004	**MW-5 / SB01**	EPA 901.1	260753		
60244777001	**MW-3 / SB01**	EPA 3060A	388793	EPA 7196A	389359
60244777002	**MW-8 / SB02**	EPA 3060A	388793	EPA 7196A	389359
60244777003	**MW-8 / SB11**	EPA 3060A	388793	EPA 7196A	389359
60244777004	**MW-5 / SB01**	EPA 3060A	388793	EPA 7196A	389359

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Sample Condition Upon Receipt

WO#: 60244777

60244777

Client Name: Burns + McDonnell

Courier: FedEx ☐ UPS ☐ VIA ☒ Clay ☐ PEX ☐ ECI ☐ Pace ☐ Xroads ☐ Client ☐ Other ☐

Tracking #: _____ Pace Shipping Label Used? Yes ☐ No ☐

Custody Seal on Cooler/Box Present: Yes ☒ No ☐ Seals intact: Yes ☒ No ☐

Packing Material: Bubble Wrap ☐ Bubble Bags ☒ Foam ☐ None ☐ Other ☐

Thermometer Used: T-266 (CF +2.9) / T-239 (CF +0.2) **Type of Ice:** Wet Blue None

Cooler Temperature (°C): As-read 3.0 **Corr. Factor** CF +2.9 CF +0.2 **Corrected** 3.2

Date and initials of person examining contents: JB 5/20/17

Temperature should be above freezing to 6°C

Chain of Custody present:	☒Yes ☐No ☐N/A	
Chain of Custody relinquished:	☒Yes ☐No ☐N/A	
Samples arrived within holding time:	☒Yes ☐No ☐N/A	
Short Hold Time analyses (<72hr):	☐Yes ☒No ☐N/A	
Rush Turn Around Time requested:	☐Yes ☒No ☐N/A	
Sufficient volume:	☒Yes ☐No ☐N/A	
Correct containers used:	☒Yes ☐No ☐N/A	
Pace containers used:	☒Yes ☐No ☐N/A	
Containers intact:	☒Yes ☐No ☐N/A	
Unpreserved 5035A / TX1005/1006 soils frozen in 48hrs?	☐Yes ☐No ☒N/A	
Filtered volume received for dissolved tests?	☐Yes ☐No ☒N/A	
Sample labels match COC: Date / time / ID / analyses	☒Yes ☐No ☐N/A	
Samples contain multiple phases? Matrix: GL	☐Yes ☒No ☐N/A	
Containers requiring pH preservation in compliance? (HNO_3, H_2SO_4, HCl<2; NaOH>9 Sulfide, NaOH>10 Cyanide) (Exceptions: VOA, Micro, O&G, KS TPH, OK-DRO)	☐Yes ☐No ☒N/A	
Cyanide water sample checks:		
Lead acetate strip turns dark? (Record only)	☐Yes ☐No	
Potassium iodide test strip turns blue/purple? (Preserve)	☐Yes ☐No	
Trip Blank present:	☐Yes ☐No ☒N/A	
Headspace in VOA vials (>6mm):	☐Yes ☐No ☒N/A	
Samples from USDA Regulated Area: State: MO	☐Yes ☒No ☐N/A	
Additional labels attached to 5035A / TX1005 vials in the field?	☐Yes ☐No ☒N/A	

Client Notification/ Resolution: Copy COC to Client? Y / N Field Data Required? Y / N

Person Contacted: _____ Date/Time: _____

Comments/ Resolution: _____

Project Manager Review: Alice Date: 5/22/17

CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page : 1 Of 1

Section A — Required Client Information:

Company:	BURNS & MCDONNELL
Address:	9400 Ward Parkway
	Kansas City, MO 64114
Email:	Bweis@burnsmcd.com
Phone: 816-333-9400	Fax: —
Requested Due Date:	Standard TAT

Section B — Required Project Information:

Report To:	~~Turner, Lewis~~ Brian Weis
Copy To:	—
Purchase Order #:	—
Project Name:	Columbia MO
Project #:	93647

Section C — Invoice Information:

Attention:	Brian Weis
Company Name:	Burns and McDonnell
Address:	9400 Ward parkway, KCMO 64114
Pace Quote:	—
Pace Project Manager:	alice.spiller@pacelabs.com,
Pace Profile #:	9013

Regulatory Agency	
State / Location	MO

Requested Analysis Filtered (Y/N): Hexavalent Chromium ~, Metals by 6010, Mercury ~, Radium 226/228 ~

ITEM #	SAMPLE ID (One Character per box. (A-Z, 0-9 / , -) Sample Ids must be unique)	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED START DATE	COLLECTED START TIME	COLLECTED END DATE	COLLECTED END TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Unpreserved	H2SO4	HNO3	HCL	NaOH	Na2S2O3	Methanol	Other	Hexavalent Chromium	Metals by 6010, Mercury	Radium 226/228	Residual Chlorine (Y/N)	60244777
1	MW-3 / SB01	SL	G	5/17/17	1305	5/17/17	1305	—	3	X								X	X	X	N	WOKH @ WCFH a1
2	MW-8 / SB02	SL	G	5/18/17	1315	5/18/17	1315	—	3	X								X	X	X	N	a2
3	MW-8 / SB11	SL	G	5/18/17	—	5/18/17	—	—	3	X								X	X	X	N	a3
4	MW-5 / SB01	SL	G	5/19/17	0830	5/19/17	0830	—	3	X								X	X	X	N	a4
5																						
6																						
7																						
8																						
9																						
10																						
11																						
12																						

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS			
	LT - BMCD	5/19/17	1507	[signature]	5/20/17	0840	3.2	Y	Y	Y

SAMPLER NAME AND SIGNATURE	
PRINT Name of SAMPLER:	Lewis Turner
SIGNATURE of SAMPLER:	LT
DATE Signed:	5/19/17

TEMP in C | Received on Ice (Y/N) | Custody Sealed Cooler (Y/N) | Samples Intact (Y/N)

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(913)599-5665

June 23, 2017

Brian Weis

Burns & McDonnell
9400 Ward Parkway
Kansas City, MO 64114

RE: Project: COLUMBIA MO
Pace Project No.: 60245163

Dear Brian Weis:
Enclosed are the analytical results for sample(s) received by the laboratory on May 26, 2017. The results relate only to the samples included in this report. Results reported herein conform to the most current, applicable TNI/NELAC standards and the laboratory's Quality Assurance Manual, where applicable, unless otherwise noted in the body of the report.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Alice Spiller

Alice Spiller
alice.spiller@pacelabs.com
(913)563-1409
Project Manager

Enclosures

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CERTIFICATIONS

Project: COLUMBIA MO
Pace Project No.: 60245163

Pennsylvania Certification IDs

1638 Roseytown Rd Suites 2,3&4, Greensburg, PA 15601
L-A-B DOD-ELAP Accreditation #: L2417
Alabama Certification #: 41590
Arizona Certification #: AZ0734
Arkansas Certification
California Certification #: 04222CA
Colorado Certification
Connecticut Certification #: PH-0694
Delaware Certification
Florida/TNI Certification #: E87683
Georgia Certification #: C040
Guam Certification
Hawaii Certification
Idaho Certification
Illinois Certification
Indiana Certification
Iowa Certification #: 391
Kansas/TNI Certification #: E-10358
Kentucky Certification #: 90133
Louisiana DHH/TNI Certification #: LA140008
Louisiana DEQ/TNI Certification #: 4086
Maine Certification #: PA00091
Maryland Certification #: 308
Massachusetts Certification #: M-PA1457
Michigan/PADEP Certification
Missouri Certification #: 235
Montana Certification #: Cert 0082
Nebraska Certification #: NE-05-29-14
Nevada Certification #: PA014572015-1
New Hampshire/TNI Certification #: 2976
New Jersey/TNI Certification #: PA 051
New Mexico Certification #: PA01457
New York/TNI Certification #: 10888
North Carolina Certification #: 42706
North Dakota Certification #: R-190
Oregon/TNI Certification #: PA200002
Pennsylvania/TNI Certification #: 65-00282
Puerto Rico Certification #: PA01457
Rhode Island Certification #: 65-00282
South Dakota Certification
Tennessee Certification #: TN2867
Texas/TNI Certification #: T104704188-14-8
Utah/TNI Certification #: PA014572015-5
USDA Soil Permit #: P330-14-00213
Vermont Dept. of Health: ID# VT-0282
Virgin Island/PADEP Certification
Virginia/VELAP Certification #: 460198
Washington Certification #: C868
West Virginia DEP Certification #: 143
West Virginia DHHR Certification #: 9964C
Wisconsin Certification
Wyoming Certification #: 8TMS-L

Indiana Certification IDs

7726 Moller Road, Indianapolis, IN 46268
Illinois Certification #: 003971
Indiana Certification #: C-49-06
Kansas/NELAP Certification #:E-10177
Kentucky UST Certification #: 80226
Kentucky WW Certification #:98019
Ohio VAP Certification #: CL-0065
Oklahoma Certification #: 2016-075
Texas Certification #: T104704355-16-10
West Virginia Certification #: 330
Wisconsin Certification #: 999788130
USDA Soil Permit #: P330-16-00257

Kansas Certification IDs

9608 Loiret Boulevard, Lenexa, KS 66219
WY STR Certification #: 2456.01
Arkansas Certification #: 15-016-0
Illinois Certification #: 003097
Iowa Certification #: 118
Kansas/NELAP Certification #: E-10116
Louisiana Certification #: 03055
Nevada Certification #: KS000212008A
Oklahoma Certification #: 9205/9935
Texas Certification #: T104704407
Utah Certification #: KS00021
Kansas Field Laboratory Accreditation: # E-92587
Missouri Certification: 10070

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SAMPLE SUMMARY

Project: COLUMBIA MO
Pace Project No.: 60245163

Lab ID	Sample ID	Matrix	Date Collected	Date Received
60245163001	**M-2 / SB01**	Solid	05/22/17 14:30	05/26/17 07:30
60245163002	**M-1 / SB01**	Solid	05/23/17 16:15	05/26/17 07:30
60245163003	**M-6 / SB01**	Solid	05/25/17 09:34	05/26/17 07:30

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SAMPLE ANALYTE COUNT

Project: COLUMBIA MO
Pace Project No.: 60245163

Lab ID	Sample ID	Method	Analysts	Analytes Reported	Laboratory
60245163001	**M-2 / SB01**	EPA 6010	JGP	21	PASI-K
		EPA 7471	SMW	1	PASI-K
		ASTM D2974	DWC	1	PASI-K
		EPA 901.1	MAH	2	PASI-PA
		EPA 7196A	TPD	1	PASI-I
60245163002	**M-1 / SB01**	EPA 6010	JGP	21	PASI-K
		EPA 7471	SMW	1	PASI-K
		ASTM D2974	DWC	1	PASI-K
		EPA 901.1	MAH	2	PASI-PA
		EPA 7196A	TPD	1	PASI-I
60245163003	**M-6 / SB01**	EPA 6010	JGP	21	PASI-K
		EPA 7471	SMW	1	PASI-K
		ASTM D2974	DWC	1	PASI-K
		EPA 901.1	MAH	2	PASI-PA
		EPA 7196A	TPD	1	PASI-I

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PROJECT NARRATIVE

Project: COLUMBIA MO
Pace Project No.: 60245163

Method: **EPA 6010**
Description: 6010 MET ICP Red. Interference
Client: BURNS & MCDONNELL
Date: June 23, 2017

General Information:
3 samples were analyzed for EPA 6010. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Sample Preparation:
The samples were prepared in accordance with EPA 3050 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

QC Batch: 478634

A matrix spike and/or matrix spike duplicate (MS/MSD) were performed on the following sample(s): 60245170008

M1: Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.

- MS (Lab ID: 1960516)
  - Aluminum
  - Antimony
  - Barium
  - Calcium
  - Iron
  - Lead
  - Magnesium
  - Manganese
  - Thallium
  - Zinc
- MSD (Lab ID: 1960517)
  - Aluminum
  - Antimony
  - Calcium
  - Iron

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PROJECT NARRATIVE

Project: COLUMBIA MO
Pace Project No.: 60245163

Method: **EPA 6010**
Description: 6010 MET ICP Red. Interference
Client: BURNS & MCDONNELL
Date: June 23, 2017

QC Batch: 478634

A matrix spike and/or matrix spike duplicate (MS/MSD) were performed on the following sample(s): 60245170008

M1: Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.

- Lead
- Magnesium

R1: RPD value was outside control limits.

- MSD (Lab ID: 1960517)
  - Calcium
  - Chromium
  - Lead

Additional Comments:

Analyte Comments:

QC Batch: 478634

D3: Sample was diluted due to the presence of high levels of non-target analytes or other matrix interference.

- M-6 / SB01 (Lab ID: 60245163003)
  - Silver
  - Boron
  - Cadmium
  - Molybdenum
  - Antimony
  - Selenium
  - Thallium

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PROJECT NARRATIVE

Project: COLUMBIA MO
Pace Project No.: 60245163

Method: **EPA 7471**
Description: 7471 Mercury
Client: BURNS & MCDONNELL
Date: June 23, 2017

General Information:
3 samples were analyzed for EPA 7471. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Sample Preparation:
The samples were prepared in accordance with EPA 7471 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: COLUMBIA MO
Pace Project No.: 60245163

Method: **EPA 901.1**
Description: 901.1 Gamma Spec INGROWTH
Client: BURNS & MCDONNELL
Date: June 23, 2017

General Information:
3 samples were analyzed for EPA 901.1. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: COLUMBIA MO
Pace Project No.: 60245163

Method: **EPA 7196A**
Description: 7196 Chromium, Hexavalent
Client: BURNS & MCDONNELL
Date: June 23, 2017

General Information:
3 samples were analyzed for EPA 7196A. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Sample Preparation:
The samples were prepared in accordance with EPA 3060A with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

This data package has been reviewed for quality and completeness and is approved for release.

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ANALYTICAL RESULTS

Project: COLUMBIA MO
Pace Project No.: 60245163

Sample: M-2 / SB01 **Lab ID: 60245163001** Collected: 05/22/17 14:30 Received: 05/26/17 07:30 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP Red. Interference	Analytical Method: EPA 6010 Preparation Method: EPA 3050							
Aluminum	**29700**	mg/kg	8.2	1	05/30/17 11:35	05/31/17 17:29	7429-90-5	
Antimony	ND	mg/kg	1.1	1	05/30/17 11:35	05/31/17 17:29	7440-36-0	
Arsenic	**8.7**	mg/kg	1.1	1	05/30/17 11:35	05/31/17 17:29	7440-38-2	
Barium	**113**	mg/kg	0.54	1	05/30/17 11:35	05/31/17 17:29	7440-39-3	
Beryllium	**0.50**	mg/kg	0.11	1	05/30/17 11:35	05/31/17 17:29	7440-41-7	
Boron	ND	mg/kg	10.9	1	05/30/17 11:35	05/31/17 17:29	7440-42-8	
Cadmium	ND	mg/kg	0.54	1	05/30/17 11:35	05/31/17 17:29	7440-43-9	
Calcium	**3910**	mg/kg	10.9	1	05/30/17 11:35	05/31/17 17:29	7440-70-2	
Chromium	**29.1**	mg/kg	0.54	1	05/30/17 11:35	05/31/17 17:29	7440-47-3	
Cobalt	**18.3**	mg/kg	0.54	1	05/30/17 11:35	05/31/17 17:29	7440-48-4	
Copper	**9.3**	mg/kg	1.1	1	05/30/17 11:35	05/31/17 17:29	7440-50-8	
Iron	**17500**	mg/kg	5.4	1	05/30/17 11:35	05/31/17 17:29	7439-89-6	
Lead	**13.8**	mg/kg	0.54	1	05/30/17 11:35	05/31/17 17:29	7439-92-1	
Magnesium	**2420**	mg/kg	5.4	1	05/30/17 11:35	05/31/17 17:29	7439-95-4	
Manganese	**102**	mg/kg	0.54	1	05/30/17 11:35	05/31/17 17:29	7439-96-5	
Molybdenum	ND	mg/kg	2.2	1	05/30/17 11:35	05/31/17 17:29	7439-98-7	
Nickel	**9.4**	mg/kg	0.54	1	05/30/17 11:35	05/31/17 17:29	7440-02-0	
Selenium	ND	mg/kg	1.6	1	05/30/17 11:35	05/31/17 17:29	7782-49-2	
Silver	ND	mg/kg	0.76	1	05/30/17 11:35	05/31/17 17:29	7440-22-4	
Thallium	ND	mg/kg	2.2	1	05/30/17 11:35	05/31/17 17:29	7440-28-0	
Zinc	**28.0**	mg/kg	10.9	1	05/30/17 11:35	05/31/17 17:29	7440-66-6	
7471 Mercury	Analytical Method: EPA 7471 Preparation Method: EPA 7471							
Mercury	ND	mg/kg	0.063	1	06/06/17 11:30	06/06/17 15:17	7439-97-6	
Percent Moisture	Analytical Method: ASTM D2974							
Percent Moisture	**20.8**	%	0.50	1		06/15/17 00:00		
7196 Chromium, Hexavalent	Analytical Method: EPA 7196A Preparation Method: EPA 3060A							
Chromium, Hexavalent	ND	mg/kg	2.6	1	06/06/17 10:55	06/07/17 10:21	18540-29-9	

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ANALYTICAL RESULTS

Project: COLUMBIA MO
Pace Project No.: 60245163

Sample: M-1 / SB01 **Lab ID: 60245163002** Collected: 05/23/17 16:15 Received: 05/26/17 07:30 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP Red. Interference	Analytical Method: EPA 6010 Preparation Method: EPA 3050							
Aluminum	**14900**	mg/kg	10.5	2	05/30/17 11:35	06/02/17 14:27	7429-90-5	
Antimony	ND	mg/kg	0.70	1	05/30/17 11:35	05/31/17 17:32	7440-36-0	
Arsenic	**2.8**	mg/kg	0.70	1	05/30/17 11:35	05/31/17 17:32	7440-38-2	
Barium	**64.8**	mg/kg	0.70	2	05/30/17 11:35	06/02/17 14:27	7440-39-3	
Beryllium	**0.58**	mg/kg	0.14	2	05/30/17 11:35	06/02/17 14:27	7440-41-7	
Boron	ND	mg/kg	7.0	1	05/30/17 11:35	05/31/17 17:32	7440-42-8	
Cadmium	ND	mg/kg	0.35	1	05/30/17 11:35	05/31/17 17:32	7440-43-9	
Calcium	**3020**	mg/kg	14.1	2	05/30/17 11:35	06/02/17 14:27	7440-70-2	
Chromium	**18.7**	mg/kg	0.35	1	05/30/17 11:35	05/31/17 17:32	7440-47-3	
Cobalt	**1.8**	mg/kg	0.35	1	05/30/17 11:35	05/31/17 17:32	7440-48-4	
Copper	**9.4**	mg/kg	0.70	1	05/30/17 11:35	05/31/17 17:32	7440-50-8	
Iron	**12800**	mg/kg	7.0	2	05/30/17 11:35	06/02/17 14:27	7439-89-6	
Lead	**7.1**	mg/kg	0.35	1	05/30/17 11:35	05/31/17 17:32	7439-92-1	
Magnesium	**1590**	mg/kg	3.5	1	05/30/17 11:35	05/31/17 17:32	7439-95-4	
Manganese	**25.6**	mg/kg	0.35	1	05/30/17 11:35	05/31/17 17:32	7439-96-5	
Molybdenum	ND	mg/kg	1.4	1	05/30/17 11:35	05/31/17 17:32	7439-98-7	
Nickel	**8.5**	mg/kg	0.35	1	05/30/17 11:35	05/31/17 17:32	7440-02-0	
Selenium	ND	mg/kg	1.1	1	05/30/17 11:35	05/31/17 17:32	7782-49-2	
Silver	ND	mg/kg	0.49	1	05/30/17 11:35	05/31/17 17:32	7440-22-4	
Thallium	ND	mg/kg	1.4	1	05/30/17 11:35	05/31/17 17:32	7440-28-0	
Zinc	**21.7**	mg/kg	7.0	1	05/30/17 11:35	05/31/17 17:32	7440-66-6	
7471 Mercury	Analytical Method: EPA 7471 Preparation Method: EPA 7471							
Mercury	ND	mg/kg	0.047	1	06/06/17 11:30	06/06/17 15:19	7439-97-6	
Percent Moisture	Analytical Method: ASTM D2974							
Percent Moisture	**16.3**	%	0.50	1		06/15/17 00:00		
7196 Chromium, Hexavalent	Analytical Method: EPA 7196A Preparation Method: EPA 3060A							
Chromium, Hexavalent	ND	mg/kg	2.3	1	06/06/17 10:55	06/07/17 10:22	18540-29-9	

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ANALYTICAL RESULTS

Project: COLUMBIA MO
Pace Project No.: 60245163

Sample: M-6 / SB01 **Lab ID: 60245163003** Collected: 05/25/17 09:34 Received: 05/26/17 07:30 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP Red. Interference	Analytical Method: EPA 6010 Preparation Method: EPA 3050							
Aluminum	**14200**	mg/kg	23.0	3	05/30/17 11:35	06/01/17 13:53	7429-90-5	
Antimony	ND	mg/kg	2.0	2	05/30/17 11:35	06/01/17 13:50	7440-36-0	D3
Arsenic	**7.3**	mg/kg	2.0	2	05/30/17 11:35	06/01/17 13:50	7440-38-2	
Barium	**172**	mg/kg	1.5	3	05/30/17 11:35	06/01/17 13:53	7440-39-3	
Beryllium	**2.1**	mg/kg	0.31	3	05/30/17 11:35	06/01/17 13:53	7440-41-7	
Boron	ND	mg/kg	20.5	2	05/30/17 11:35	06/01/17 13:50	7440-42-8	D3
Cadmium	ND	mg/kg	1.0	2	05/30/17 11:35	06/01/17 13:50	7440-43-9	D3
Calcium	**3850**	mg/kg	30.7	3	05/30/17 11:35	06/01/17 13:53	7440-70-2	
Chromium	**28.5**	mg/kg	1.0	2	05/30/17 11:35	06/01/17 13:50	7440-47-3	
Cobalt	**8.4**	mg/kg	1.0	2	05/30/17 11:35	06/01/17 13:50	7440-48-4	
Copper	**12.8**	mg/kg	2.0	2	05/30/17 11:35	06/01/17 13:50	7440-50-8	
Iron	**17400**	mg/kg	15.3	3	05/30/17 11:35	06/01/17 13:53	7439-89-6	
Lead	**7.5**	mg/kg	1.0	2	05/30/17 11:35	06/01/17 13:50	7439-92-1	
Magnesium	**2300**	mg/kg	10.2	2	05/30/17 11:35	06/01/17 13:50	7439-95-4	
Manganese	**168**	mg/kg	1.0	2	05/30/17 11:35	06/01/17 13:50	7439-96-5	
Molybdenum	ND	mg/kg	4.1	2	05/30/17 11:35	06/01/17 13:50	7439-98-7	D3
Nickel	**38.8**	mg/kg	1.0	2	05/30/17 11:35	06/01/17 13:50	7440-02-0	
Selenium	ND	mg/kg	3.1	2	05/30/17 11:35	06/01/17 13:50	7782-49-2	D3
Silver	ND	mg/kg	1.4	2	05/30/17 11:35	06/01/17 13:50	7440-22-4	D3
Thallium	ND	mg/kg	4.1	2	05/30/17 11:35	06/01/17 13:50	7440-28-0	D3
Zinc	**42.0**	mg/kg	20.5	2	05/30/17 11:35	06/01/17 13:50	7440-66-6	
7471 Mercury	Analytical Method: EPA 7471 Preparation Method: EPA 7471							
Mercury	ND	mg/kg	0.046	1	06/06/17 11:30	06/06/17 15:21	7439-97-6	
Percent Moisture	Analytical Method: ASTM D2974							
Percent Moisture	**18.5**	%	0.50	1		06/15/17 00:00		
7196 Chromium, Hexavalent	Analytical Method: EPA 7196A Preparation Method: EPA 3060A							
Chromium, Hexavalent	ND	mg/kg	2.5	1	06/06/17 10:55	06/07/17 10:22	18540-29-9	

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QUALITY CONTROL DATA

Project: COLUMBIA MO
Pace Project No.: 60245163

QC Batch: 479801 Analysis Method: EPA 7471
QC Batch Method: EPA 7471 Analysis Description: 7471 Mercury
Associated Lab Samples: 60245163001, 60245163002, 60245163003

METHOD BLANK: 1965100 Matrix: Solid
Associated Lab Samples: 60245163001, 60245163002, 60245163003

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Mercury	mg/kg	ND	0.050	06/06/17 14:46	

LABORATORY CONTROL SAMPLE: 1965101

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Mercury	mg/kg	.5	0.51	102	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1965102 1965103

Parameter	Units	60245602002 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Mercury	mg/kg	ND	.56	.51	0.55	0.49	97	97	75-125	11	20	

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QUALITY CONTROL DATA

Project: COLUMBIA MO
Pace Project No.: 60245163

QC Batch: 478634 | Analysis Method: EPA 6010
QC Batch Method: EPA 3050 | Analysis Description: 6010 MET
Associated Lab Samples: 60245163001, 60245163002, 60245163003

METHOD BLANK: 1960514 | Matrix: Solid
Associated Lab Samples: 60245163001, 60245163002, 60245163003

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Aluminum	mg/kg	ND	7.5	05/31/17 16:55	
Antimony	mg/kg	ND	1.0	05/31/17 16:55	
Arsenic	mg/kg	ND	1.0	05/31/17 16:55	
Barium	mg/kg	ND	0.50	05/31/17 16:55	
Beryllium	mg/kg	ND	0.10	05/31/17 16:55	
Boron	mg/kg	ND	10.0	05/31/17 16:55	
Cadmium	mg/kg	ND	0.50	05/31/17 16:55	
Calcium	mg/kg	ND	10.0	05/31/17 16:55	
Chromium	mg/kg	ND	0.50	05/31/17 16:55	
Cobalt	mg/kg	ND	0.50	05/31/17 16:55	
Copper	mg/kg	ND	1.0	05/31/17 16:55	
Iron	mg/kg	ND	5.0	05/31/17 16:55	
Lead	mg/kg	ND	0.50	05/31/17 16:55	
Magnesium	mg/kg	ND	5.0	05/31/17 16:55	
Manganese	mg/kg	ND	0.50	05/31/17 16:55	
Molybdenum	mg/kg	ND	2.0	05/31/17 16:55	
Nickel	mg/kg	ND	0.50	05/31/17 16:55	
Selenium	mg/kg	ND	1.5	05/31/17 16:55	
Silver	mg/kg	ND	0.70	05/31/17 16:55	
Thallium	mg/kg	ND	2.0	05/31/17 16:55	
Zinc	mg/kg	ND	10.0	05/31/17 16:55	

LABORATORY CONTROL SAMPLE: 1960515

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Aluminum	mg/kg	1000	964	96	80-120	
Antimony	mg/kg	100	92.6	93	80-120	
Arsenic	mg/kg	100	87.8	88	80-120	
Barium	mg/kg	100	98.7	99	80-120	
Beryllium	mg/kg	100	96.7	97	80-120	
Boron	mg/kg	100	85.8	86	80-120	
Cadmium	mg/kg	100	92.0	92	80-120	
Calcium	mg/kg	1000	953	95	80-120	
Chromium	mg/kg	100	94.9	95	80-120	
Cobalt	mg/kg	100	96.9	97	80-120	
Copper	mg/kg	100	98.7	99	80-120	
Iron	mg/kg	1000	960	96	80-120	
Lead	mg/kg	100	94.7	95	80-120	
Magnesium	mg/kg	1000	864	86	80-120	
Manganese	mg/kg	100	95.5	96	80-120	

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QUALITY CONTROL DATA

Project: COLUMBIA MO
Pace Project No.: 60245163

LABORATORY CONTROL SAMPLE: 1960515

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Molybdenum	mg/kg	100	101	101	80-120	
Nickel	mg/kg	100	94.6	95	80-120	
Selenium	mg/kg	100	89.5	90	80-120	
Silver	mg/kg	50	46.8	94	80-120	
Thallium	mg/kg	100	96.4	96	80-120	
Zinc	mg/kg	100	93.9	94	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1960516 1960517

Parameter	Units	60245170008 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Aluminum	mg/kg	6830	871	845	11500	11400	533	544	75-125	0	20	M1
Antimony	mg/kg	1.1	87.1	84.5	33.7	31.9	37	36	75-125	5	20	M1
Arsenic	mg/kg	12.6	87.1	84.5	78.4	82.7	75	83	75-125	5	20	
Barium	mg/kg	381	87.1	84.5	435	458	61	91	75-125	5	20	M1
Beryllium	mg/kg	0.54	87.1	84.5	77.7	77.6	89	91	75-125	0	20	
Boron	mg/kg	ND	87.1	84.5	71.0	71.2	77	79	75-125	0	20	
Cadmium	mg/kg	3.8	87.1	84.5	72.9	74.0	79	83	75-125	1	20	
Calcium	mg/kg	21400	871	845	21800	14300	47	-848	75-125	42	20	M1,R1
Chromium	mg/kg	8.8	87.1	84.5	83.0	113	85	123	75-125	30	20	R1
Cobalt	mg/kg	5.7	87.1	84.5	73.7	75.6	78	83	75-125	3	20	
Copper	mg/kg	40.1	87.1	84.5	114	118	85	93	75-125	4	20	
Iron	mg/kg	15000	871	845	16700	18300	194	389	75-125	9	20	M1
Lead	mg/kg	704	87.1	84.5	757	1020	61	369	75-125	29	20	M1,R1
Magnesium	mg/kg	3450	871	845	4890	5120	166	197	75-125	4	20	M1
Manganese	mg/kg	529	87.1	84.5	512	606	-20	90	75-125	17	20	M1
Molybdenum	mg/kg	ND	87.1	84.5	73.9	75.4	83	88	75-125	2	20	
Nickel	mg/kg	11.0	87.1	84.5	78.1	93.9	77	98	75-125	18	20	
Selenium	mg/kg	ND	87.1	84.5	66.8	67.4	77	80	75-125	1	20	
Silver	mg/kg	7.0	43.6	42.3	42.3	41.8	81	82	75-125	1	20	
Thallium	mg/kg	ND	87.1	84.5	63.6	64.7	73	76	75-125	2	20	M1
Zinc	mg/kg	361	87.1	84.5	413	441	59	94	75-125	7	20	M1

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QUALITY CONTROL DATA

Project: COLUMBIA MO
Pace Project No.: 60245163

QC Batch: 481093 Analysis Method: ASTM D2974
QC Batch Method: ASTM D2974 Analysis Description: Dry Weight/Percent Moisture
Associated Lab Samples: 60245163001, 60245163002, 60245163003

METHOD BLANK: 1970675 Matrix: Solid
Associated Lab Samples: 60245163001, 60245163002, 60245163003

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Percent Moisture	%	ND	0.50	06/15/17 00:00	

SAMPLE DUPLICATE: 1970676

Parameter	Units	60245163001 Result	Dup Result	RPD	Max RPD	Qualifiers
Percent Moisture	%	20.8	22.2	6	20	

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REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: COLUMBIA MO
Pace Project No.: 60245163

QC Batch: 390804 | Analysis Method: EPA 7196A
QC Batch Method: EPA 3060A | Analysis Description: 7196 Chromium, Hexavalent
Associated Lab Samples: 60245163001, 60245163002, 60245163003

METHOD BLANK: 1801272 | Matrix: Solid
Associated Lab Samples: 60245163001, 60245163002, 60245163003

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Chromium, Hexavalent	mg/kg	ND	2.0	06/07/17 09:56	

LABORATORY CONTROL SAMPLE: 1801273

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Chromium, Hexavalent	mg/kg	1070	959	89	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1801274 1801275

Parameter	Units	50171866001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Chromium, Hexavalent	mg/kg	73.6	229	238	444	369	118	82	75-125	18	20	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1801277 1801278

Parameter	Units	50171866001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Chromium, Hexavalent	mg/kg	73.6	6210	6090	6000	6090	94	97	75-125	2	20	

SAMPLE DUPLICATE: 1801276

Parameter	Units	60245163003 Result	Dup Result	RPD	Max RPD	Qualifiers
Chromium, Hexavalent	mg/kg	ND	ND		20	

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ANALYTICAL RESULTS - RADIOCHEMISTRY

Project: COLUMBIA MO
Pace Project No.: 60245163

Sample: M-2 / SB01 **Lab ID: 60245163001** Collected: 05/22/17 14:30 Received: 05/26/17 07:30 Matrix: Solid
PWS: Site ID: Sample Type:

Results reported on a "dry-weight" basis

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Radium-226	EPA 901.1	**0.995 ± 0.235 (0.130)** **C:NA T:NA**	pCi/g	06/23/17 09:09	13982-63-3	Ra
Radium-228	EPA 901.1	**1.180 ± 0.348 (0.229)** **C:NA T:NA**	pCi/g	06/23/17 09:09	15262-20-1	

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9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

ANALYTICAL RESULTS - RADIOCHEMISTRY

Project: COLUMBIA MO
Pace Project No.: 60245163

Sample: M-1 / SB01 **Lab ID: 60245163002** Collected: 05/23/17 16:15 Received: 05/26/17 07:30 Matrix: Solid
PWS: Site ID: Sample Type:

Results reported on a "dry-weight" basis

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Radium-226	EPA 901.1	**1.159 ± 0.267 (0.266)** **C:NA T:NA**	pCi/g	06/23/17 09:10	13982-63-3	Ra
Radium-228	EPA 901.1	**1.394 ± 0.472 (0.244)** **C:NA T:NA**	pCi/g	06/23/17 09:10	15262-20-1	

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ANALYTICAL RESULTS - RADIOCHEMISTRY

Project: COLUMBIA MO
Pace Project No.: 60245163

Sample: M-6 / SB01 **Lab ID: 60245163003** Collected: 05/25/17 09:34 Received: 05/26/17 07:30 Matrix: Solid
PWS: Site ID: Sample Type:

Results reported on a "dry-weight" basis

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Radium-226	EPA 901.1	**1.242 ± 0.277 (0.192)** **C:NA T:NA**	pCi/g	06/23/17 09:26	13982-63-3	Ra
Radium-228	EPA 901.1	**1.397 ± 0.368 (0.187)** **C:NA T:NA**	pCi/g	06/23/17 09:26	15262-20-1	

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QUALITY CONTROL - RADIOCHEMISTRY

Project: COLUMBIA MO
Pace Project No.: 60245163

QC Batch: 260753 Analysis Method: EPA 901.1
QC Batch Method: EPA 901.1 Analysis Description: 901.1 Gamma Spec Ingrowth
Associated Lab Samples: 60245163001, 60245163002, 60245163003

METHOD BLANK: 1284174 Matrix: Solid
Associated Lab Samples: 60245163001, 60245163002, 60245163003

Parameter	Act ± Unc (MDC) Carr Trac	Units	Analyzed	Qualifiers
Radium-226	0.051 ± 0.084 (0.154) C:NA T:NA	pCi/g	06/20/17 13:48	Ra
Radium-228	0.066 ± 0.099 (0.161) C:NA T:NA	pCi/g	06/20/17 13:48	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

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QUALIFIERS

Project: COLUMBIA MO
Pace Project No.: 60245163

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to dilution of the sample aliquot.

ND - Not Detected at or above adjusted reporting limit.

J - Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

MDL - Adjusted Method Detection Limit.

PQL - Practical Quantitation Limit.

RL - Reporting Limit.

S - Surrogate

1,2-Diphenylhydrazine decomposes to and cannot be separated from Azobenzene using Method 8270. The result for each analyte is a combined concentration.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

Act - Activity

Unc - Uncertainty: SDWA = 1.96 sigma count uncertainty, all other matrices = Expanded Uncertainty (95% confidence interval). Gamma Spec = Expanded Uncertainty (95.4% Confidence Interval)

(MDC) - Minimum Detectable Concentration

Trac - Tracer Recovery (%)

Carr - Carrier Recovery (%)

Pace Analytical is TNI accredited. Contact your Pace PM for the current list of accredited analytes.

TNI - The NELAC Institute.

LABORATORIES

PASI-I	Pace Analytical Services - Indianapolis
PASI-K	Pace Analytical Services - Kansas City
PASI-PA	Pace Analytical Services - Greensburg

ANALYTE QUALIFIERS

D3	Sample was diluted due to the presence of high levels of non-target analytes or other matrix interference.
M1	Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.
R1	RPD value was outside control limits.
Ra	The reported Ra-226 results were determined by hermetically sealing the dried, processed sample in an appropriate-sized can. Each sample was stored for a minimum of 21 days to ensure that equilibrium between Ra-226 and daughters Bi-214 and Pb-214 was achieved. Reported Ra-226 results were inferred from gamma peaks attributable to Bi-214 and Pb-214.

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QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: COLUMBIA MO
Pace Project No.: 60245163

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
60245163001	**M-2 / SB01**	EPA 3050	478634	EPA 6010	478916
60245163002	**M-1 / SB01**	EPA 3050	478634	EPA 6010	478916
60245163003	**M-6 / SB01**	EPA 3050	478634	EPA 6010	478916
60245163001	**M-2 / SB01**	EPA 7471	479801	EPA 7471	479883
60245163002	**M-1 / SB01**	EPA 7471	479801	EPA 7471	479883
60245163003	**M-6 / SB01**	EPA 7471	479801	EPA 7471	479883
60245163001	**M-2 / SB01**	ASTM D2974	481093		
60245163002	**M-1 / SB01**	ASTM D2974	481093		
60245163003	**M-6 / SB01**	ASTM D2974	481093		
60245163001	**M-2 / SB01**	EPA 901.1	260753		
60245163002	**M-1 / SB01**	EPA 901.1	260753		
60245163003	**M-6 / SB01**	EPA 901.1	260753		
60245163001	**M-2 / SB01**	EPA 3060A	390804	EPA 7196A	391007
60245163002	**M-1 / SB01**	EPA 3060A	390804	EPA 7196A	391007
60245163003	**M-6 / SB01**	EPA 3060A	390804	EPA 7196A	391007

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Pace Analytical
www.pacelabs.com

Sample Condition Upon Receipt

WO# : 60245163

60245163

AFS

Client Name: Burns & McD

Courier: FedEx ☐ UPS ☐ VIA ☑ Clay ☐ PEX ☐ ECI ☐ Pace ☐ Xroads ☐ Client ☐ Other ☐

Tracking #: _____ Pace Shipping Label Used? Yes ☐ No ☐

Custody Seal on Cooler/Box Present: Yes ☑ No ☐ Seals intact: Yes ☑ No ☐

Packing Material: Bubble Wrap ☐ Bubble Bags ☑ Foam ☐ None ☐ Other ☐

Thermometer Used: T-266 (CF +2.9) / T-239 (CF +0.2) **Type of Ice:** Wet Blue None

Cooler Temperature (°C): As-read 1.8 **Corr. Factor** CF +2.9 CF +0.2 **Corrected** 2.0

Date and initials of person examining contents: 5/26/17

Temperature should be above freezing to 6°C

Chain of Custody present:	☑Yes ☐No ☐N/A	
Chain of Custody relinquished:	☑Yes ☐No ☐N/A	
Samples arrived within holding time:	☑Yes ☐No ☐N/A	
Short Hold Time analyses (<72hr):	☐Yes ☑No ☐N/A	
Rush Turn Around Time requested:	☐Yes ☑No ☐N/A	
Sufficient volume:	☑Yes ☐No ☐N/A	
Correct containers used:	☑Yes ☐No ☐N/A	
Pace containers used:	☑Yes ☐No ☐N/A	
Containers intact:	☑Yes ☐No ☐N/A	
Unpreserved 5035A / TX1005/1006 soils frozen in 48hrs?	☐Yes ☐No ☑N/A	
Filtered volume received for dissolved tests?	☐Yes ☐No ☑N/A	
Sample labels match COC: Date / time / ID / analyses	☑Yes ☐No ☐N/A	
Samples contain multiple phases? Matrix: SL	☐Yes ☑No ☐N/A	
Containers requiring pH preservation in compliance? (HNO_3, H_2SO_4, HCl<2; NaOH>9 Sulfide, NaOH>10 Cyanide) (Exceptions: VOA, Micro, O&G, KS TPH, OK-DRO)	☐Yes ☐No ☑N/A	
Cyanide water sample checks: Lead acetate strip turns dark? (Record only)	☐Yes ☐No	N/A
Potassium iodide test strip turns blue/purple? (Preserve)	☐Yes ☐No	
Trip Blank present:	☐Yes ☑No ☐N/A	
Headspace in VOA vials (>6mm):	☐Yes ☐No ☑N/A	
Samples from USDA Regulated Area: State: MO	☐Yes ☑No ☐N/A	
Additional labels attached to 5035A / TX1005 vials in the field?	☐Yes ☐No ☑N/A	

Client Notification/ Resolution: Copy COC to Client? Y / N Field Data Required? Y / N

Person Contacted: _____ Date/Time: _____

Comments/ Resolution:

IRWO Rad 20858

IRWO-Cr+6 20859

Project Manager Review: MW for AFS Date: 5/26/17

CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page : 1 Of 1

Section A — Required Client Information:

Company:	BURNS & MCDONNELL
Address:	9400 Ward Parkway
	Kansas City, MO 64114
Email:	bweis@burnsmcd.com
Phone: (816)333-9400	Fax: —
Requested Due Date:	Standard TAT

Section B — Required Project Information:

Report To:	~~Turner Lewis~~ Brian Weis
Copy To:	
Purchase Order #:	—
Project Name:	Columbia MO
Project #:	93647

Section C — Invoice Information:

Attention:	Brian Weis
Company Name:	Burns and McDonnell
Address:	9400 Ward parkway, Kansas City, mo 64114
Pace Quote:	—
Pace Project Manager:	alice.spiller@pacelabs.com,
Pace Profile #:	9013

Regulatory Agency	State / Location
	MO

Matrix codes: Drinking Water DW, Water WT, Waste Water WW, Product P, Soil/Solid SL, Oil OL, Wipe WP, Air AR, Other OT, Tissue TS

ITEM #	SAMPLE ID (One Character per box. (A-Z, 0-9 / , -) Sample Ids must be unique)	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED START DATE	COLLECTED START TIME	COLLECTED END DATE	COLLECTED END TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Preservatives: Unpreserved	H2SO4	HNO3	HCl	NaOH	Na2S2O3	Methanol	Other	Analyses Test: Hexavalent Chromium	Metals by 6010, Mercury	Radium 226/228	Residual Chlorine (Y/N)	60245163
	Requested Analysis Filtered (Y/N)																	N	N	N		
1	MW-2 / SB01	SL	G	5/22/17	1430	5/22/17	1430	-	3	X								X	X	X	N	2(WGFU) WGKU
2	MW-1 / SB01	SL	G	5/23/17	1615	5/23/17	1615	-	3	X								X	X	X	N	
3	MW-6 / SB01	SL	G	5/25/17	0954	5/25/17	0954	-	3	X								X	X	X		
4																						
5																						
6																						
7																						
8																						
9																						
10																						
11																						
12																						

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS			
	LT - BMCD	5/25/17	1105	[signature]	5/26/17	0730	2.0	Y	Y	Y

SAMPLER NAME AND SIGNATURE

PRINT Name of SAMPLER: Lewis Turner

SIGNATURE of SAMPLER: LT

DATE Signed: 5/25/17

TEMP in C	Received on Ice (Y/N)	Custody Sealed Cooler (Y/N)	Samples Intact (Y/N)

APPENDIX H – PACKER TESTING FIELD FORM

CONSTANT HEAD HYDRAULIC CONDUCTIVITY (PACKER) TEST
BORING NO. SB-2
Depth to Test Interval: 80

PROJECT NAME:	More's Lake	SITE LOCATION:	Columbia, MO
PROJECT NUMBER:	93647	SITE NAME:	More's Lake
DATE TEST PERFORMED:	6/1/2017	MADE BY:	Lewis Turner

TIME (minutes)		Gauge	Pressure	Water Loss
Real	Elapsed	Reading	PSI	Gallons
1300	0	0.00	43	0.00
1301	1	0.02	42	0.02
1302	2	0.03	41	0.01
1303	3	0.08	41	0.05
1304	4	0.09	41	0.01
1305	5	0.10	41	0.01
1306	6	0.11	41	0.01
1307	7	0.11	41	0.00
1308	8	0.11	41	0.00
1309	9	0.11	41	0.00
1310	10	0.11	41	0.00
1311	11	0.11	41	0.00
1312	12	0.11	40	0.00
1313	13	0.11	41	0.00
1314	14	0.12	41	0.01
1315	15	0.12	40	0.00
1320	20	0.13	40	0.01
1325	25	0.14	40	0.01
1330	30	0.14	40	0.00
1335	35	0.14	40	0.00
1340	40	0.14	40	0.00
1345	45	0.14	40	0.00

TIME (minutes)		Gauge	Pressure	Water Loss
Real	Elapsed	Reading	PSI	Gallons
1350	50	0.15	40	0.01
1355	55	0.16	40	0.01
1400	60	0.16	40	0.00
1410	70	0.18	40	0.02
1420	80	0.18	40	0.00
1430	90	0.22	40	0.04
1440	100	0.23	40	0.01
1450	110	0.26	40	0.03
1500	120	0.31	40	0.05
1510	130	0.39	40	0.08
1520	140	0.42	40	0.03
1530	150	0.46	40	0.03
1540	160	0.51	40	0.05
1550	170	0.57	40	0.06
1600	180	0.62	40	0.05
1610	190	0.67	40	0.05
1620	200	0.73	40	0.06
1630	210	0.81	40	0.08
1640	220	0.88	40	0.07
1650	230	0.92	40	0.04
1700	240	0.96	40	0.04

* Note: All measurements are made from the same reference point

REFERENCE: U.S. Department of the Interior, Bureau of Reclamation, 1974, Earth Manual, second edition
Field Permeability Tests in Boreholes, USBR No. E-18, pp. 573-578.

$k=q/2\pi LH$ for L>=10r
$k=q/2\pi LH \times \sinh^{-1}(L/2r)$ for 10r>L>=r

r	Borehole diameter (test interval)		1.44	inches
			0.120	**ft**

Dt	Depth to top of test interval*		80.00	ft
Db	Depth to bottom of test interval*		85.00	ft
L	Length of the test interval	L = Db - Dt	**5**	**ft**

lw	Total water loss during test length		0.96	gal
lt	Length of test		240	min
q	Constant rate of flow into the test interval	q = lw / lt, if 0 than 0.001	4.00E-03	gpm
			8.92E-06	**ft^3/sec**

Hi	Height of swivel (or pressure gauge)*		3.1	ft
swl	Depth to static water level*		4.66	ft
P	Pressure within test interval		40	psi
Hp	Conversion from PSI to feet of water	Hp = P x 2.31	92.4	ft
Hg	Distance from static water level to pressure gauge	Hg = swl + Hi	7.76	ft
H	Head of water at test interval	H = Hp + Hg	**100.16**	**ft**

k	Hydraulic Conductivity	1.06E-08	ft/sec
		3.22E-07	**cm/sec**

APPENDIX I – MONITORING WELL DIAGRAMS AND CERTIFICATION RECORD

MISSOURI DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY PROGRAM

MONITORING WELL CERTIFICATION RECORD

NOTE: This form is not to be used for nested wells

OFFICE USE ONLY		DATE RECEIVED	
REFERENCE NO.		CHECK NO.	
STATE WELL NO.		REVENUE NO.	
ENTERED	APPROVED	DATE	ROUTE / /

OWNER AND SITE INFORMATION

PROPERTY OWNER NAME WHERE WELL IS LOCATED	PRIMARY PHONE NUMBER WITH AREA CODE	WELL NUMBER	WELL COMPLETION DATE
City of Columbia, Missouri	(573) 874-6236	MW-1	05/26/2017

PROPERTY OWNER MAILING ADDRESS	CITY	STATE	ZIP CODE
1501 Business Loop 70 East	Columbia	MO	65201

PHYSICAL ADDRESS OF PROPERTY WHERE WELL IS LOCATED	CITY	COUNTY
More's Lake: SW corner of Ashley Street and Bowling Street	Columbia	Boone

NAME OF SITE OR CLEANUP PROJECT	DNR/EPA PROJECT NUMBER OR REGULATORY SITE ID NUMBER (IF APPLICABLE)	VARIANCE NUMBER (IF ISSUED)
More's Lake		

PRIMARY CONTRACTOR NAME (PLEASE PRINT)	PERMIT NUMBER	
John C. Bostwick, R.G.	003839M	Section 256.607(3), RSMo, requires all primary contractors to comply with all rules and regulations promulgated pursuant to Sections 256.600 to 256.640 RSMo.

SURFACE COMPLETION

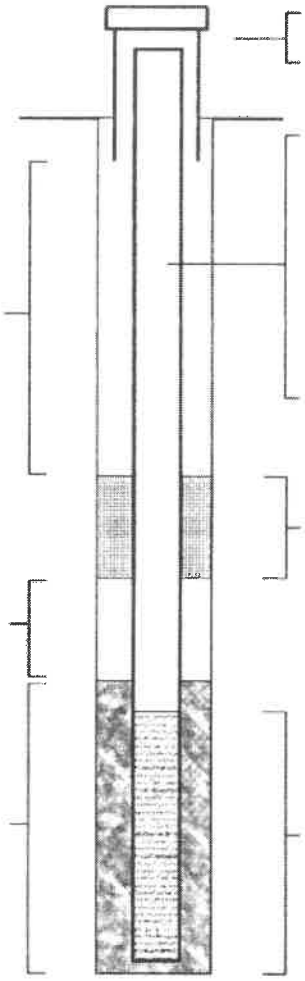
TYPE
- ☐ Above Ground
- ☑ Flush Mount

LENGTH AND DIAMETER OF SURFACE COMPLETION
Length 1 FT.
Diameter 8 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
Diameter 24 IN.
Length 1 FT.

SURFACE COMPLETION GROUT
- ☑ Concrete
- ☐ Other _____

☑ Locking Cap
☐ Weep Hole



SURFACE COMPLETION
☑ Steel ☐ Aluminum ☐ Plastic

Elevation _____ FT.

ANNULAR SEAL
Length 26 FT.
- ☑ Slurry ☐ Chips
- ☐ Pellets ☐ Granular
- ☐ Cement/Slurry

IF CEMENT/BENTONITE MIX:
Bags of Cement Used _____
% of Bentonite Used _____
Water Used Per Bag _____ GAL.

RISER OR CASING (IF OPEN HOLE COMPLETION)
Riser/Casing Diameter 2 IN.
Riser/Casing Length 33 FT.
Diameter Of Drill Hole 8 IN.
Weight Or SDR# S40

MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

BENTONITE SEAL
Length 3
- ☐ Chips ☑ Pellets ☐ Granular
- ☐ Saturated Zone ☐ Hydrated

SECONDARY FILTER PACK LENGTH
N/A FT.

DEPTH TO TOP OF PRIMARY FILTER PACK
30 FT.

LENGTH OF PRIMARY FILTER PACK
13 FT.

SCREEN
Screen Diameter 2 IN.
Screen Length 10 FT.
Diameter Of Drill Hole 8 IN.
Depth To Top 33 FT.

SCREEN MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

For cased wells, submit additional as-built diagrams showing well construction details including type and size of all casing, hole diameter and grout used.

LOCATION OF WELL (D/M/S FORMAT ONLY)
Latitude 38 ° 58 ' 2.2 "
Longitude -92 ° 19 ' 0.9 "

SMALLEST ____ ¼ ____ ¼ LARGEST ____ ¼
Section _____ Township _____ North
Range _____ ☐ E ☐ W

TYPE OF WELL (CHECK ONE)
- ☐ Direct Push ☐ Extraction ☐ Inclinometer
- ☐ Gas Migration ☐ Injection Lysimeter
- ☑ Observation ☐ Open Hole ☐ Other (specify)
- ☐ Piezometer ☐ Standard _____

MONITORING FOR (CHECK ALL THAT APPLY)
- ☐ Explosives ☑ Metals
- ☐ Pesticides/Herbicides ☐ Petroleum
- ☑ Radionuclides ☐ SVOCS
- ☐ VOCS (non-petroleum) ☐ Geotechnical Data

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION (OR ATTACH BORING LOG*)
0	43	Clay, some silt, w/ sand lenses/seams

TOTAL DEPTH: 43 FT.
☐ *Boring Log Attached

STATIC WATER LEVEL N/A FT.
PUMP INSTALLED ☐ Yes ☑ No

I hereby certify that the monitoring well herein described was constructed in accordance with Missouri Department of Natural Resources requirements.

MONITORING WELL INSTALLATION CONTRACTOR	PERMIT NUMBER	DATE	MONITORING WELL INSTALLATION CONTRACTOR APPRENTICE (IF APPLICABLE)	PERMIT NUMBER
	003469M	06/09/2017		

MO 780-1415 (8-16) **SEND COMPLETED FORM ALONG WITH $100 CERTIFICATION FEE TO: MISSOURI DEPARTMENT OF NATURAL RESOURCES, MISSOURI GEOLOGICAL SURVEY, WELLHEAD PROTECTION SECTION, PO BOX 250, ROLLA, MO 65402 PHONE: 573-368-2165 FAX: 573-368-2317 EMAIL: welldrillers@dnr.mo.gov**
RECORD (AND FEE) MAY BE SUBMITTED ONLINE: dnr.mo.gov/mowells

MISSOURI DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY PROGRAM

MONITORING WELL CERTIFICATION RECORD

NOTE: This form is not to be used for nested wells

OFFICE USE ONLY		DATE RECEIVED	
REFERENCE NO.		CHECK NO.	
STATE WELL NO.		REVENUE NO.	
ENTERED	APPROVED	DATE	ROUTE / /

OWNER AND SITE INFORMATION

PROPERTY OWNER NAME WHERE WELL IS LOCATED	PRIMARY PHONE NUMBER WITH AREA CODE	WELL NUMBER	WELL COMPLETION DATE
City of Columbia, Missouri	(573) 874-6236	MW-2	05/24/2017

PROPERTY OWNER MAILING ADDRESS	CITY	STATE	ZIP CODE
1501 Business Loop 70 East	Columbia	MO	65201

PHYSICAL ADDRESS OF PROPERTY WHERE WELL IS LOCATED	CITY	COUNTY
More's Lake: SW corner of Ashley Street and Bowling Street	Columbia	Boone

NAME OF SITE OR CLEANUP PROJECT	DNR/EPA PROJECT NUMBER OR REGULATORY SITE ID NUMBER (IF APPLICABLE)	VARIANCE NUMBER (IF ISSUED)
More's Lake		

PRIMARY CONTRACTOR NAME (PLEASE PRINT)	PERMIT NUMBER	
John C. Bostwick, R.G.	003839M	Section 256.607(3), RSMo, requires all primary contractors to comply with all rules and regulations promulgated pursuant to Sections 256.600 to 256.640 RSMo.

SURFACE COMPLETION

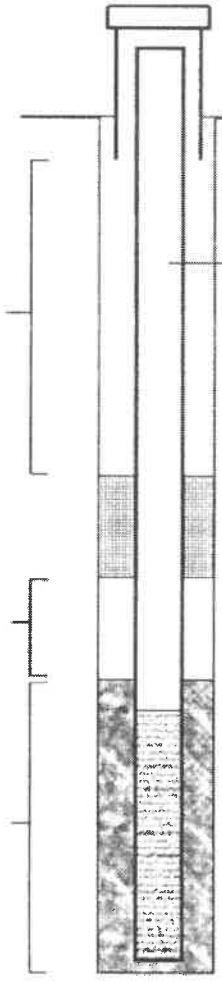
TYPE
- ☐ Above Ground
- ☑ Flush Mount

LENGTH AND DIAMETER OF SURFACE COMPLETION
Length 1 FT.
Diameter 8 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
Diameter 24 IN.
Length 1 FT.

SURFACE COMPLETION GROUT
- ☑ Concrete
- ☐ Other _____

☑ Locking Cap
☐ Weep Hole



SURFACE COMPLETION
☑ Steel ☐ Aluminum ☐ Plastic

Elevation _____ FT.

ANNULAR SEAL
Length 36 FT.
- ☑ Slurry ☐ Chips
- ☐ Pellets ☐ Granular
- ☐ Cement/Slurry

IF CEMENT/BENTONITE MIX:
Bags of Cement Used _____
% of Bentonite Used _____
Water Used Per Bag _____ GAL.

RISER OR CASING (IF OPEN HOLE COMPLETION)
Riser/Casing Diameter 2 IN.
Riser/Casing Length 43 FT.
Diameter Of Drill Hole 8 IN.
Weight Or SDR# S40

MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

BENTONITE SEAL
Length 3
- ☐ Chips ☑ Pellets ☐ Granular
- ☐ Saturated Zone ☐ Hydrated

SECONDARY FILTER PACK LENGTH
N/A FT.

DEPTH TO TOP OF PRIMARY FILTER PACK
40 FT.

LENGTH OF PRIMARY FILTER PACK
13 FT.

SCREEN
Screen Diameter 2 IN.
Screen Length 10 FT.
Diameter Of Drill Hole 8 IN.
Depth To Top 43 FT.

SCREEN MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

For cased wells, submit additional as-built diagrams showing well construction details including type and size of all casing, hole diameter and grout used.

LOCATION OF WELL (D/M/S FORMAT ONLY)
Latitude 38 ° 58 ' 1.9 "
Longitude -92 ° 18 ' 56.0 "

SMALLEST ____ ¼ ____ ¼ LARGEST ____ ¼
Section _____ Township _____ North
Range _____ ☐ E ☐ W

TYPE OF WELL (CHECK ONE)
- ☐ Direct Push ☐ Extraction ☐ Inclinometer
- ☐ Gas Migration ☐ Injection Lysimeter
- ☑ Observation ☐ Open Hole ☐ Other (specify)
- ☐ Piezometer ☐ Standard _____

MONITORING FOR (CHECK ALL THAT APPLY)
- ☐ Explosives ☑ Metals
- ☐ Pesticides/Herbicides ☐ Petroleum
- ☑ Radionuclides ☐ SVOCS
- ☐ VOCS (non-petroleum) ☐ Geotechnical Data

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION (OR ATTACH BORING LOG*)
0	53	Clay, some silt, w/ sand lenses/seams

TOTAL DEPTH: 53 FT.
☐ *Boring Log Attached

STATIC WATER LEVEL N/A FT.
PUMP INSTALLED ☐ Yes ☑ No

I hereby certify that the monitoring well herein described was constructed in accordance with Missouri Department of Natural Resources requirements.

MONITORING WELL INSTALLATION CONTRACTOR	PERMIT NUMBER	DATE	MONITORING WELL INSTALLATION CONTRACTOR APPRENTICE (IF APPLICABLE)	PERMIT NUMBER
	003469M	06/09/2017		

MISSOURI DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY PROGRAM

MONITORING WELL CERTIFICATION RECORD

NOTE: This form is not to be used for nested wells

OFFICE USE ONLY		DATE RECEIVED	
REFERENCE NO.		CHECK NO.	
STATE WELL NO.		REVENUE NO.	
ENTERED	APPROVED	DATE	ROUTE / /

OWNER AND SITE INFORMATION

PROPERTY OWNER NAME WHERE WELL IS LOCATED	PRIMARY PHONE NUMBER WITH AREA CODE	WELL NUMBER	WELL COMPLETION DATE
City of Columbia, Missouri	(573) 874-6236	MW-3	05/26/2017

PROPERTY OWNER MAILING ADDRESS	CITY	STATE	ZIP CODE
1501 Business Loop 70 East	Columbia	MO	65201

PHYSICAL ADDRESS OF PROPERTY WHERE WELL IS LOCATED	CITY	COUNTY
More's Lake: SW corner of Ashley Street and Bowling Street	Columbia	Boone

NAME OF SITE OR CLEANUP PROJECT	DNR/EPA PROJECT NUMBER OR REGULATORY SITE ID NUMBER (IF APPLICABLE)	VARIANCE NUMBER (IF ISSUED)
More's Lake		

PRIMARY CONTRACTOR NAME (PLEASE PRINT)	PERMIT NUMBER	
John C. Bostwick, R.G.	003839M	Section 256.607(3), RSMo, requires all primary contractors to comply with all rules and regulations promulgated pursuant to Sections 256.600 to 256.640 RSMo.

SURFACE COMPLETION

TYPE
- ☐ Above Ground
- ☑ Flush Mount

LENGTH AND DIAMETER OF SURFACE COMPLETION
Length 1 FT.
Diameter 8 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
Diameter 24 IN.
Length 1 FT.

SURFACE COMPLETION GROUT
- ☑ Concrete
- ☐ Other _____

- ☑ Locking Cap
- ☐ Weep Hole

Elevation _____ FT.

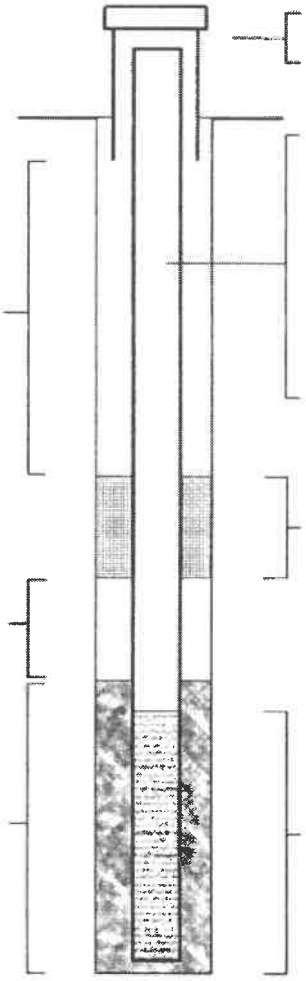
ANNULAR SEAL
Length 33 FT.
- ☑ Slurry ☐ Chips
- ☐ Pellets ☐ Granular
- ☐ Cement/Slurry

IF CEMENT/BENTONITE MIX:
Bags of Cement Used _____
% of Bentonite Used _____
Water Used Per Bag _____ GAL.

SECONDARY FILTER PACK LENGTH
N/A FT.

DEPTH TO TOP OF PRIMARY FILTER PACK
37 FT.

LENGTH OF PRIMARY FILTER PACK
13 FT.



SURFACE COMPLETION
- ☑ Steel ☐ Aluminum ☐ Plastic

RISER OR CASING (IF OPEN HOLE COMPLETION)
Riser/Casing Diameter 2 IN.
Riser/Casing Length 40 FT.
Diameter Of Drill Hole 8 IN.
Weight Or SDR# S40

MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

BENTONITE SEAL
Length 3
- ☑ Chips ☐ Pellets ☐ Granular
- ☐ Saturated Zone ☐ Hydrated

SCREEN
Screen Diameter 2 IN.
Screen Length 10 FT.
Diameter Of Drill Hole 8 IN.
Depth To Top 40 FT.

SCREEN MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

LOCATION OF WELL (D/M/S FORMAT ONLY)
Latitude 38 ° 57 ' 58.0 "
Longitude -92 ° 18 ' 55.4 "

SMALLEST ____ ¼ ____ ¼ LARGEST ____ ¼
Section _____ Township _____ North
Range _____ ☐ E ☐ W

TYPE OF WELL (CHECK ONE)
- ☐ Direct Push ☐ Extraction ☐ Inclinometer
- ☐ Gas Migration ☐ Injection ☐ Lysimeter
- ☑ Observation ☐ Open Hole ☐ Other (specify)
- ☐ Piezometer ☐ Standard _____

MONITORING FOR (CHECK ALL THAT APPLY)
- ☐ Explosives ☑ Metals
- ☐ Pesticides/Herbicides ☐ Petroleum
- ☑ Radionuclides ☐ SVOCS
- ☐ VOCS (non-petroleum) ☐ Geotechnical Data

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION (OR ATTACH BORING LOG*)
0	50	Clay, some silt, w/ sand lenses/seams

TOTAL DEPTH: 50 FT.

☐ *Boring Log Attached

STATIC WATER LEVEL N/A FT.

PUMP INSTALLED ☐ Yes ☑ No

For cased wells, submit additional as-built diagrams showing well construction details including type and size of all casing, hole diameter and grout used.

I hereby certify that the monitoring well herein described was constructed in accordance with Missouri Department of Natural Resources requirements.

MONITORING WELL INSTALLATION CONTRACTOR	PERMIT NUMBER	DATE	MONITORING WELL INSTALLATION CONTRACTOR APPRENTICE (IF APPLICABLE)	PERMIT NUMBER
	003469M	06/09/2017		

 SEND COMPLETED FORM ALONG WITH $100 CERTIFICATION FEE TO: MISSOURI DEPARTMENT OF NATURAL RESOURCES, MISSOURI GEOLOGICAL SURVEY, WELLHEAD PROTECTION SECTION, PO BOX 250, ROLLA, MO 65402 PHONE: 573-368-2165 FAX: 573-368-2317 EMAIL: welldrillers@dnr.mo.gov
RECORD (AND FEE) MAY BE SUBMITTED ONLINE: dnr.mo.gov/mowells

MISSOURI DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY PROGRAM

MONITORING WELL CERTIFICATION RECORD

NOTE: This form is not to be used for nested wells

OFFICE USE ONLY		DATE RECEIVED	
REFERENCE NO.		CHECK NO.	
STATE WELL NO.		REVENUE NO.	
ENTERED	APPROVED	DATE	ROUTE / /

OWNER AND SITE INFORMATION

PROPERTY OWNER NAME WHERE WELL IS LOCATED	PRIMARY PHONE NUMBER WITH AREA CODE	WELL NUMBER	WELL COMPLETION DATE
City of Columbia, Missouri	(573) 874-6236	MW-4	05/26/2017

PROPERTY OWNER MAILING ADDRESS	CITY	STATE	ZIP CODE
1501 Business Loop 70 East	Columbia	MO	65201

PHYSICAL ADDRESS OF PROPERTY WHERE WELL IS LOCATED	CITY	COUNTY
More's Lake: SW corner of Ashley Street and Bowling Street	Columbia	Boone

NAME OF SITE OR CLEANUP PROJECT	DNR/EPA PROJECT NUMBER OR REGULATORY SITE ID NUMBER (IF APPLICABLE)	VARIANCE NUMBER (IF ISSUED)
More's Lake		

PRIMARY CONTRACTOR NAME (PLEASE PRINT)	PERMIT NUMBER	
John C. Bostwick, R.G.	003839M	Section 256.607(3), RSMo, requires all primary contractors to comply with all rules and regulations promulgated pursuant to Sections 256.600 to 256.640 RSMo.

SURFACE COMPLETION

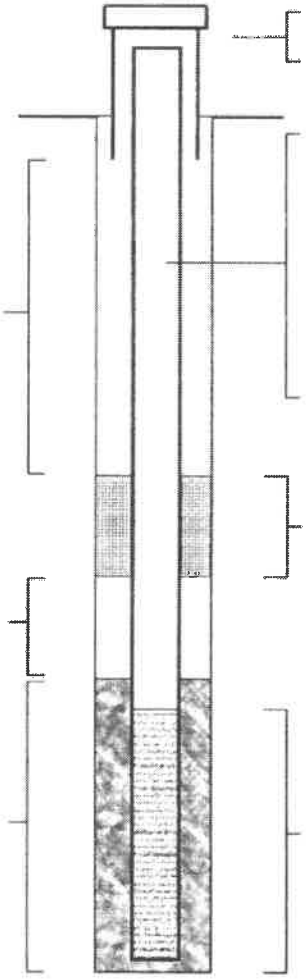
TYPE
- ☐ Above Ground
- ☑ Flush Mount

LENGTH AND DIAMETER OF SURFACE COMPLETION
Length 1 FT.
Diameter 8 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
Diameter 24 IN.
Length 1 FT.

SURFACE COMPLETION GROUT
- ☑ Concrete
- ☐ Other _____

- ☑ Locking Cap
- ☐ Weep Hole



SURFACE COMPLETION
☑ Steel ☐ Aluminum ☐ Plastic

Elevation _____ FT.

ANNULAR SEAL
Length 40 FT.
- ☑ Slurry ☐ Chips
- ☐ Pellets ☐ Granular
- ☐ Cement/Slurry

IF CEMENT/BENTONITE MIX:
Bags of Cement Used _____
% of Bentonite Used _____
Water Used Per Bag _____ GAL.

RISER OR CASING (IF OPEN HOLE COMPLETION)
Riser/Casing Diameter 2 IN.
Riser/Casing Length 47 FT.
Diameter Of Drill Hole 8 IN.
Weight Or SDR# S40

MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

BENTONITE SEAL
Length 3
- ☑ Chips ☐ Pellets ☐ Granular
- ☐ Saturated Zone ☐ Hydrated

SECONDARY FILTER PACK LENGTH
N/A FT.

DEPTH TO TOP OF PRIMARY FILTER PACK
44 FT.

LENGTH OF PRIMARY FILTER PACK
13 FT.

SCREEN
Screen Diameter 2 IN.
Screen Length 10 FT.
Diameter Of Drill Hole 8 IN.
Depth To Top 47 FT.

SCREEN MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

For cased wells, submit additional as-built diagrams showing well construction details including type and size of all casing, hole diameter and grout used.

LOCATION OF WELL (D/M/S FORMAT ONLY)
Latitude 38 ° 57 ' 55.8 "
Longitude -92 ° 18 ' 55.4 "

SMALLEST ¼ ¼ ¼ LARGEST
Section _____ Township _____ North
Range _____ ☐ E ☐ W

TYPE OF WELL (CHECK ONE)
- ☐ Direct Push ☐ Extraction ☐ Inclinometer
- ☐ Gas Migration ☐ Injection ☐ Lysimeter
- ☑ Observation ☐ Open Hole ☐ Other (specify)
- ☐ Piezometer ☐ Standard _____

MONITORING FOR (CHECK ALL THAT APPLY)
- ☐ Explosives ☑ Metals
- ☐ Pesticides/Herbicides ☐ Petroleum
- ☑ Radionuclides ☐ SVOCS
- ☐ VOCS (non-petroleum) ☐ Geotechnical Data

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION (OR ATTACH BORING LOG*)
0	57	Clay, some silt w/ sand lenses/seams

TOTAL DEPTH: 57 FT.
☐ *Boring Log Attached

STATIC WATER LEVEL N/A FT.
PUMP INSTALLED ☐ Yes ☑ No

I hereby certify that the monitoring well herein described was constructed in accordance with Missouri Department of Natural Resources requirements.

MONITORING WELL INSTALLATION CONTRACTOR	PERMIT NUMBER	DATE	MONITORING WELL INSTALLATION CONTRACTOR APPRENTICE (IF APPLICABLE)	PERMIT NUMBER
	003469M	06/09/2017		

MISSOURI DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY PROGRAM

MONITORING WELL CERTIFICATION RECORD

NOTE: This form is not to be used for nested wells

OFFICE USE ONLY		DATE RECEIVED	
REFERENCE NO.		CHECK NO.	
STATE WELL NO.		REVENUE NO.	
ENTERED	APPROVED	DATE	ROUTE / /

OWNER AND SITE INFORMATION

PROPERTY OWNER NAME WHERE WELL IS LOCATED	PRIMARY PHONE NUMBER WITH AREA CODE	WELL NUMBER	WELL COMPLETION DATE
City of Columbia, Missouri	(573) 874-6236	MW-5	05/30/2017

PROPERTY OWNER MAILING ADDRESS	CITY	STATE	ZIP CODE
1501 Business Loop 70 East	Columbia	MO	65201

PHYSICAL ADDRESS OF PROPERTY WHERE WELL IS LOCATED	CITY	COUNTY
More's Lake: SW corner of Ashley Street and Bowling Street	Columbia	Boone

NAME OF SITE OR CLEANUP PROJECT	DNR/EPA PROJECT NUMBER OR REGULATORY SITE ID NUMBER (IF APPLICABLE)	VARIANCE NUMBER (IF ISSUED)
More's Lake		

PRIMARY CONTRACTOR NAME (PLEASE PRINT)	PERMIT NUMBER	
John C. Bostwick, R.G.	003839M	Section 256.607(3), RSMo, requires all primary contractors to comply with all rules and regulations promulgated pursuant to Sections 256.600 to 256.640 RSMo.

SURFACE COMPLETION

TYPE
- ☐ Above Ground
- ☑ Flush Mount

LENGTH AND DIAMETER OF SURFACE COMPLETION
Length 1 FT.
Diameter 8 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
Diameter 24 IN.
Length 1 FT.

SURFACE COMPLETION GROUT
- ☑ Concrete
- ☐ Other _____

- ☑ Locking Cap
- ☐ Weep Hole

Elevation _____ FT.

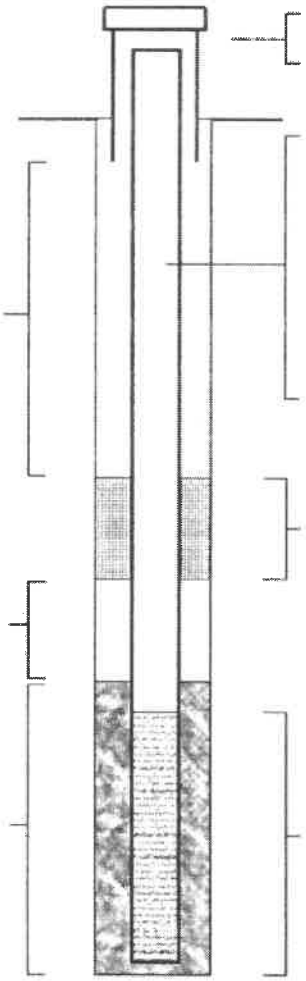
ANNULAR SEAL
Length 24 FT.
- ☑ Slurry ☐ Chips
- ☐ Pellets ☐ Granular
- ☐ Cement/Slurry

IF CEMENT/BENTONITE MIX:
Bags of Cement Used _____
% of Bentonite Used _____
Water Used Per Bag _____ GAL.

SECONDARY FILTER PACK LENGTH
N/A FT.

DEPTH TO TOP OF PRIMARY FILTER PACK
28 FT.

LENGTH OF PRIMARY FILTER PACK
13 FT.



SURFACE COMPLETION
- ☑ Steel ☐ Aluminum ☐ Plastic

RISER OR CASING (IF OPEN HOLE COMPLETION)
Riser/Casing Diameter 2 IN.
Riser/Casing Length 31 FT.
Diameter Of Drill Hole 8 IN.
Weight Or SDR# S40

MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

BENTONITE SEAL
Length 3
- ☑ Chips ☐ Pellets ☐ Granular
- ☐ Saturated Zone ☐ Hydrated

SCREEN
Screen Diameter 2 IN.
Screen Length 10 FT.
Diameter Of Drill Hole 8 IN.
Depth To Top 31 FT

SCREEN MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

For cased wells, submit additional as-built diagrams showing well construction details including type and size of all casing, hole diameter and grout used.

LOCATION OF WELL (D/M/S FORMAT ONLY)
Latitude 38 ° 57 ' 56.1 "
Longitude -92 ° 18 ' 59.3 "

SMALLEST ¼ ¼ LARGEST ¼
Section _____ Township _____ North
Range _____ ☐ E ☐ W

TYPE OF WELL (CHECK ONE)
- ☐ Direct Push ☐ Extraction ☐ Inclinometer
- ☐ Gas Migration ☐ Injection Lysimeter
- ☑ Observation ☐ Open Hole ☐ Other (specify)
- ☐ Piezometer ☐ Standard _____

MONITORING FOR (CHECK ALL THAT APPLY)
- ☐ Explosives ☑ Metals
- ☐ Pesticides/Herbicides ☐ Petroleum
- ☑ Radionuclides ☐ SVOCS
- ☐ VOCS (non-petroleum) ☐ Geotechnical Data

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION (OR ATTACH BORING LOG*)
0	41	Clay, some silt, w/ sand lenses/seams

TOTAL DEPTH: 41 FT.
☐ *Boring Log Attached

STATIC WATER LEVEL N/A FT.
PUMP INSTALLED ☐ Yes ☑ No

I hereby certify that the monitoring well herein described was constructed in accordance with Missouri Department of Natural Resources requirements.

MONITORING WELL INSTALLATION CONTRACTOR	PERMIT NUMBER	DATE	MONITORING WELL INSTALLATION CONTRACTOR APPRENTICE (IF APPLICABLE)	PERMIT NUMBER
	003469M	06/09/2017		

MO 780-1415 (8-16) **SEND COMPLETED FORM ALONG WITH $100 CERTIFICATION FEE TO: MISSOURI DEPARTMENT OF NATURAL RESOURCES, MISSOURI GEOLOGICAL SURVEY, WELLHEAD PROTECTION SECTION, PO BOX 250, ROLLA, MO 65402 PHONE: 573-368-2165 FAX: 573-368-2317 EMAIL: welldrillers@dnr.mo.gov**
RECORD (AND FEE) MAY BE SUBMITTED ONLINE: dnr.mo.gov/mowells

MISSOURI DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY PROGRAM

MONITORING WELL CERTIFICATION RECORD

NOTE: This form is not to be used for nested wells

OFFICE USE ONLY		DATE RECEIVED	
REFERENCE NO.		CHECK NO.	
STATE WELL NO.		REVENUE NO.	
ENTERED	APPROVED	DATE	ROUTE / /

OWNER AND SITE INFORMATION

PROPERTY OWNER NAME WHERE WELL IS LOCATED	PRIMARY PHONE NUMBER WITH AREA CODE	WELL NUMBER	WELL COMPLETION DATE
City of Columbia, Missouri	(573) 874-6236	MW-6	05/30/2017

PROPERTY OWNER MAILING ADDRESS	CITY	STATE	ZIP CODE
1501 Business Loop 70 East	Columbia	MO	65201

PHYSICAL ADDRESS OF PROPERTY WHERE WELL IS LOCATED	CITY	COUNTY
More's Lake: SW corner of Ashley Street and Bowling Street	Columbia	Boone

NAME OF SITE OR CLEANUP PROJECT	DNR/EPA PROJECT NUMBER OR REGULATORY SITE ID NUMBER (IF APPLICABLE)	VARIANCE NUMBER (IF ISSUED)
More's Lake		

PRIMARY CONTRACTOR NAME (PLEASE PRINT)	PERMIT NUMBER	
John C. Bostwick, R.G.	003839M	Section 256.607(3), RSMo, requires all primary contractors to comply with all rules and regulations promulgated pursuant to Sections 256.600 to 256.640 RSMo.

SURFACE COMPLETION

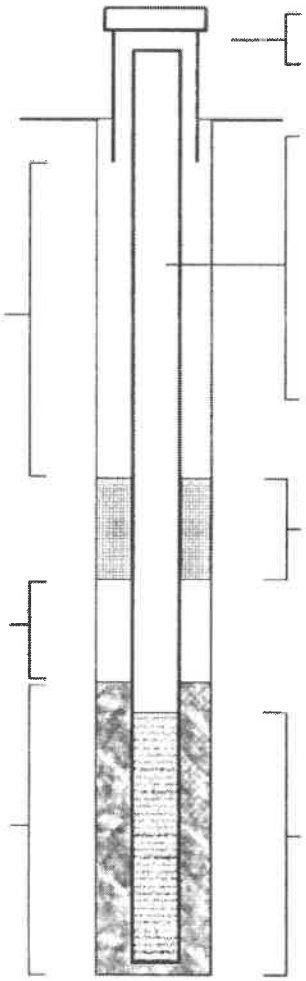
TYPE
- ☐ Above Ground
- ☑ Flush Mount

LENGTH AND DIAMETER OF SURFACE COMPLETION
Length 1 FT.
Diameter 8 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
Diameter 24 IN.
Length 1 FT.

SURFACE COMPLETION GROUT
- ☑ Concrete
- ☐ Other _____

☑ Locking Cap
☐ Weep Hole



SURFACE COMPLETION
☑ Steel ☐ Aluminum ☐ Plastic

Elevation _____ FT.

ANNULAR SEAL
Length 25 FT.
- ☑ Slurry ☐ Chips
- ☐ Pellets ☐ Granular
- ☐ Cement/Slurry

IF CEMENT/BENTONITE MIX:
Bags of Cement Used _____
% of Bentonite Used _____
Water Used Per Bag _____ GAL.

RISER OR CASING (IF OPEN HOLE COMPLETION)
Riser/Casing Diameter 2 IN.
Riser/Casing Length 32 FT.
Diameter Of Drill Hole 8 IN.
Weight Or SDR# S40

MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

BENTONITE SEAL
Length 3
- ☑ Chips ☑ Pellets ☐ Granular
- ☐ Saturated Zone ☐ Hydrated

SECONDARY FILTER PACK LENGTH
N/A FT.

DEPTH TO TOP OF PRIMARY FILTER PACK
29 FT.

LENGTH OF PRIMARY FILTER PACK
13 FT.

SCREEN
Screen Diameter 2 IN.
Screen Length 10 FT.
Diameter Of Drill Hole 8 IN.
Depth To Top 32 FT.

SCREEN MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

LOCATION OF WELL (D/M/S FORMAT ONLY)
Latitude 38 ° 57 ' 56.0 "
Longitude -92 ° 19 ' 4.3 "

SMALLEST ____ ¼ LARGEST ____ ¼ ____ ¼
Section _____ Township _____ North
Range _____ ☐ E ☐ W

TYPE OF WELL (CHECK ONE)
- ☐ Direct Push ☐ Extraction ☐ Inclinometer
- ☐ Gas Migration ☐ Injection ☐ Lysimeter
- ☑ Observation ☐ Open Hole ☐ Other (specify)
- ☐ Piezometer ☐ Standard

MONITORING FOR (CHECK ALL THAT APPLY)
- ☐ Explosives ☑ Metals
- ☐ Pesticides/Herbicides ☐ Petroleum
- ☑ Radionuclides ☐ SVOCS
- ☐ VOCS (non-petroleum) ☐ Geotechnical Data

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION (OR ATTACH BORING LOG*)
0	42	Clay, some silt, w/ sand lenses/seams

TOTAL DEPTH: 42 FT.
☐ *Boring Log Attached

For cased wells, submit additional as-built diagrams showing well construction details including type and size of all casing, hole diameter and grout used.

STATIC WATER LEVEL N/A FT.
PUMP INSTALLED ☐ Yes ☑ No

I hereby certify that the monitoring well herein described was constructed in accordance with Missouri Department of Natural Resources requirements.

MONITORING WELL INSTALLATION CONTRACTOR	PERMIT NUMBER	DATE	MONITORING WELL INSTALLATION CONTRACTOR APPRENTICE (IF APPLICABLE)	PERMIT NUMBER
	003469M	06/09/2017		

MISSOURI DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY PROGRAM

MONITORING WELL CERTIFICATION RECORD

NOTE: This form is not to be used for nested wells

OFFICE USE ONLY		DATE RECEIVED	
REFERENCE NO.		CHECK NO.	
STATE WELL NO.		REVENUE NO.	
ENTERED	APPROVED	DATE	ROUTE / /

OWNER AND SITE INFORMATION

PROPERTY OWNER NAME WHERE WELL IS LOCATED	PRIMARY PHONE NUMBER WITH AREA CODE	WELL NUMBER	WELL COMPLETION DATE
City of Columbia, Missouri	(573) 874-6236	MW-7	05/26/2017

PROPERTY OWNER MAILING ADDRESS	CITY	STATE	ZIP CODE
1501 Business Loop 70 East	Columbia	MO	65201

PHYSICAL ADDRESS OF PROPERTY WHERE WELL IS LOCATED	CITY	COUNTY
More's Lake: SW corner of Ashley Street and Bowling Street	Columbia	Boone

NAME OF SITE OR CLEANUP PROJECT	DNR/EPA PROJECT NUMBER OR REGULATORY SITE ID NUMBER (IF APPLICABLE)	VARIANCE NUMBER (IF ISSUED)
More's Lake		

PRIMARY CONTRACTOR NAME (PLEASE PRINT)	PERMIT NUMBER	
John C. Bostwick, R.G.	003839M	Section 256.607(3), RSMo, requires all primary contractors to comply with all rules and regulations promulgated pursuant to Sections 256.600 to 256.640 RSMo.

SURFACE COMPLETION

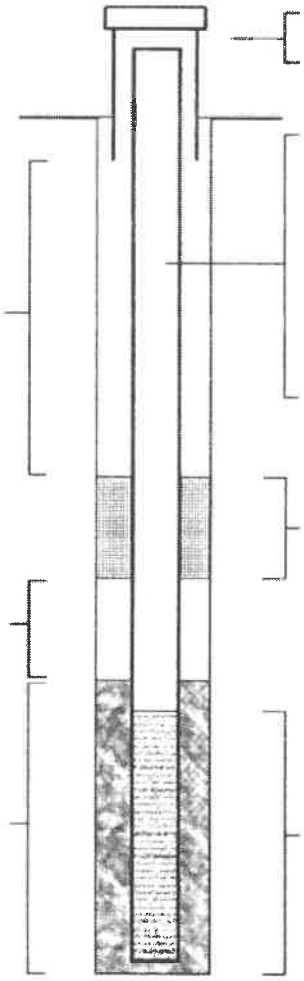
TYPE
- ☐ Above Ground
- ☑ Flush Mount

LENGTH AND DIAMETER OF SURFACE COMPLETION
Length 1 FT.
Diameter 8 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
Diameter 24 IN.
Length 1 FT.

SURFACE COMPLETION GROUT
- ☑ Concrete
- ☐ Other _____

- ☑ Locking Cap
- ☐ Weep Hole



SURFACE COMPLETION
☑ Steel ☐ Aluminum ☐ Plastic

Elevation _____ FT.

ANNULAR SEAL
Length 17 FT.
- ☑ Slurry ☐ Chips
- ☐ Pellets ☐ Granular
- ☐ Cement/Slurry

IF CEMENT/BENTONITE MIX:
Bags of Cement Used _____
% of Bentonite Used _____
Water Used Per Bag _____ GAL.

RISER OR CASING (IF OPEN HOLE COMPLETION)
Riser/Casing Diameter 2 IN.
Riser/Casing Length 24 FT.
Diameter Of Drill Hole 8 IN.
Weight Or SDR# S40

MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

BENTONITE SEAL
Length 3
- ☑ Chips ☐ Pellets ☐ Granular
- ☐ Saturated Zone ☐ Hydrated

SECONDARY FILTER PACK LENGTH
N/A FT.

DEPTH TO TOP OF PRIMARY FILTER PACK
21 FT.

LENGTH OF PRIMARY FILTER PACK
13 FT.

SCREEN
Screen Diameter 2 IN.
Screen Length 10 FT.
Diameter Of Drill Hole 8 IN.
Depth To Top 24 FT.

SCREEN MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

For cased wells, submit additional as-built diagrams showing well construction details including type and size of all casing, hole diameter and grout used.

LOCATION OF WELL (D/M/S FORMAT ONLY)
Latitude 38 ° 57 ' 56.8 "
Longitude -92 ° 19 ' 7.6 "

SMALLEST ¼ ¼ ¼ LARGEST
Section _____ Township _____ North
Range _____ ☐ E ☐ W

TYPE OF WELL (CHECK ONE)
- ☐ Direct Push
- ☐ Gas Migration
- ☑ Observation
- ☐ Piezometer
- ☐ Extraction
- ☐ Injection
- ☐ Open Hole
- ☐ Standard
- ☐ Inclinometer
- Lysimeter
- ☐ Other (specify) _____

MONITORING FOR (CHECK ALL THAT APPLY)
- ☐ Explosives
- ☐ Pesticides/Herbicides
- ☑ Radionuclides
- ☐ VOCS (non-petroleum)
- ☑ Metals
- ☐ Petroleum
- ☐ SVOCS
- ☐ Geotechnical Data

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION (OR ATTACH BORING LOG*)
0	34	Clay, some silt, w/ sand lenses/seams

TOTAL DEPTH: 34 FT.

☐ *Boring Log Attached

STATIC WATER LEVEL N/A FT.

PUMP INSTALLED ☐ Yes ☑ No

I hereby certify that the monitoring well herein described was constructed in accordance with Missouri Department of Natural Resources requirements.

MONITORING WELL INSTALLATION CONTRACTOR	PERMIT NUMBER	DATE	MONITORING WELL INSTALLATION CONTRACTOR APPRENTICE (IF APPLICABLE)	PERMIT NUMBER
	003469M	06/09/2017		

MISSOURI DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY PROGRAM

MONITORING WELL CERTIFICATION RECORD

NOTE: This form is not to be used for nested wells

OFFICE USE ONLY		DATE RECEIVED	
REFERENCE NO.		CHECK NO.	
STATE WELL NO.		REVENUE NO.	
ENTERED	APPROVED	DATE	ROUTE / /

OWNER AND SITE INFORMATION

PROPERTY OWNER NAME WHERE WELL IS LOCATED	PRIMARY PHONE NUMBER WITH AREA CODE	WELL NUMBER	WELL COMPLETION DATE
City of Columbia, Missouri	(573) 874-6236	MW-8	05/26/2017

PROPERTY OWNER MAILING ADDRESS	CITY	STATE	ZIP CODE
1501 Business Loop 70 East	Columbia	MO	65201

PHYSICAL ADDRESS OF PROPERTY WHERE WELL IS LOCATED	CITY	COUNTY
More's Lake: SW corner of Ashley Street and Bowling Street	Columbia	Boone

NAME OF SITE OR CLEANUP PROJECT	DNR/EPA PROJECT NUMBER OR REGULATORY SITE ID NUMBER (IF APPLICABLE)	VARIANCE NUMBER (IF ISSUED)
More's Lake		

PRIMARY CONTRACTOR NAME (PLEASE PRINT)	PERMIT NUMBER	
John C. Bostwick, R.G.	003839M	Section 256.607(3), RSMo, requires all primary contractors to comply with all rules and regulations promulgated pursuant to Sections 256.600 to 256.640 RSMo.

SURFACE COMPLETION

TYPE
- ☐ Above Ground
- ☑ Flush Mount

LENGTH AND DIAMETER OF SURFACE COMPLETION
Length 1 FT.
Diameter 8 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
Diameter 24 IN.
Length 1 FT.

SURFACE COMPLETION GROUT
- ☑ Concrete
- ☐ Other _____

- ☑ Locking Cap
- ☐ Weep Hole

Elevation _____ FT.

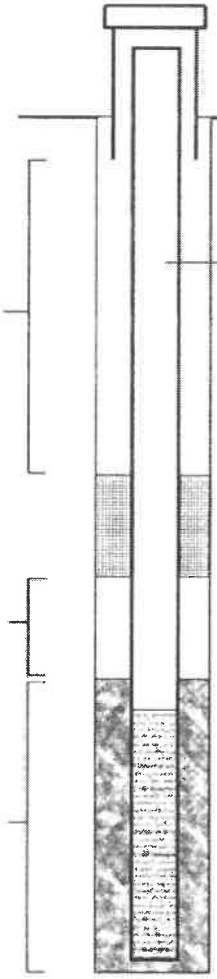
ANNULAR SEAL
Length N/A FT.
- ☐ Slurry ☐ Chips
- ☐ Pellets ☐ Granular
- ☐ Cement/Slurry

IF CEMENT/BENTONITE MIX:
Bags of Cement Used _____
% of Bentonite Used _____
Water Used Per Bag _____ GAL.

SECONDARY FILTER PACK LENGTH
N/A FT.

DEPTH TO TOP OF PRIMARY FILTER PACK
15 FT.

LENGTH OF PRIMARY FILTER PACK
13 FT.



SURFACE COMPLETION
☑ Steel ☐ Aluminum ☐ Plastic

RISER OR CASING (IF OPEN HOLE COMPLETION)
Riser/Casing Diameter 2 IN.
Riser/Casing Length 18 FT.
Diameter Of Drill Hole 8 IN.
Weight Or SDR# S40

MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

BENTONITE SEAL
Length 14
- ☑ Chips ☐ Pellets ☐ Granular
- ☐ Saturated Zone ☐ Hydrated

SCREEN
Screen Diameter 2 IN.
Screen Length 10 FT.
Diameter Of Drill Hole 8 IN.
Depth To Top 18 FT.

SCREEN MATERIAL
- ☐ Steel ☑ Thermoplastic (PVC)
- ☐ Other _____

For cased wells, submit additional as-built diagrams showing well construction details including type and size of all casing, hole diameter and grout used.

LOCATION OF WELL (D/M/S FORMAT ONLY)
Latitude 38 ° 58 ' 1.6 "
Longitude -92 ° 19 ' 6.1 "

SMALLEST ¼ ¼ LARGEST
Section _____ Township _____ North
Range _____ ☐ E ☐ W

TYPE OF WELL (CHECK ONE)
- ☐ Direct Push ☐ Extraction ☐ Inclinometer
- ☐ Gas Migration ☐ Injection Lysimeter
- ☑ Observation ☐ Open Hole ☐ Other (specify)
- ☐ Piezometer ☐ Standard _____

MONITORING FOR (CHECK ALL THAT APPLY)
- ☐ Explosives ☑ Metals
- ☐ Pesticides/Herbicides ☐ Petroleum
- ☑ Radionuclides ☐ SVOCS
- ☐ VOCS (non-petroleum) ☐ Geotechnical Data

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION (OR ATTACH BORING LOG*)
0	28	Clay, some silt, w/ sand lenses/seams

TOTAL DEPTH: 28 FT.

☐ *Boring Log Attached

STATIC WATER LEVEL N/A FT.

PUMP INSTALLED ☐ Yes ☑ No

I hereby certify that the monitoring well herein described was constructed in accordance with Missouri Department of Natural Resources requirements.

MONITORING WELL INSTALLATION CONTRACTOR	PERMIT NUMBER	DATE	MONITORING WELL INSTALLATION CONTRACTOR APPRENTICE (IF APPLICABLE)	PERMIT NUMBER
	003469M	06/09/2017		

MO 780-1415 (8-16) **SEND COMPLETED FORM ALONG WITH $100 CERTIFICATION FEE TO: MISSOURI DEPARTMENT OF NATURAL RESOURCES, MISSOURI GEOLOGICAL SURVEY, WELLHEAD PROTECTION SECTION, PO BOX 250, ROLLA, MO 65402 PHONE: 573-368-2165 FAX: 573-368-2317 EMAIL: welldrillers@dnr.mo.gov**
RECORD (AND FEE) MAY BE SUBMITTED ONLINE: dnr.mo.gov/mowells

APPENDIX J – MONITORING WELL DEVELOPMENT FORMS

Well Development Summary
Columbia Water Light Department - Columbia Municipal Power Plant
Columbia, Missouri

Well ID	Well Development (gallons)						Totals (gallons and days)	3 Borehole Volumes (gallons)	Turbidity (NTUs) At End Development	3 Borehole Volumes Purged?
MW-1	32.5 6/7/2017	6.79 6/14/2017					39.29 gallons 2 days	38.12	Out of Range	**Yes**
MW-2	138 5/30/2017	139 6/14/2017	107.5 6/19/2017				384.5 gallons 3 days	48.47	85.10	**Yes**
MW-3	15 5/26/2017	16 5/30/2017	14 6/7/2017	11.5 6/13/2017			56.5 gallons 4 days	47.23	Out of Range	**Yes**
MW-4	12 5/26/2017	12 5/30/2017	12 6/7/2017	11.2 6/13/2017			47.2 gallons 4 days	47.99	Out of Range	No
MW-5	12 6/8/2017	9 6/9/2017	11 6/12/2017	9.32 6/19/2017			41.32 gallons 4 days	45.18	Out of Range	No
MW-6	13 6/8/2017	12 6/9/2017	12 6/12/2017	9.32 6/19/2017			46.32 gallons 4 days	44.14	Out of Range	**Yes**
MW-7	1.5 5/26/2017	1.5 5/30/2017	1.5 6/8/2017	1.0 6/13/2017	1.32 6/19/2017	20.2 11/16/2017*	27.02 gallons 6 days	19.47	Out of Range	No
MW-8	9 5/26/2017	7 6/7/2017	7 6/8/2017	6.79 6/14/2017			29.79 gallons 4 days	41.27	Out of Range	No
PZ-2	10 6/8/2017	6 6/9/2017	3.71 6/15/2017				19.71 gallons 3 days	32.37	Out of Range	No
PZ-4	18 6/8/2017	11 6/9/2017	7.12 6/15/2017				36.12 gallons 3 days	39.02	Out of Range	No
PZ-6	20 6/8/2017	9 6/9/2017	6.4 6/14/2017				35.4 gallons 3 days	39.76	Out of Range	No

NTUs = Nephelometric Turbidity Units

* - Monitoring Well MW-7 was re-developed on 11/16/207 by introducing potable water and removing with disposable bailer.

WELL DEVELOPMENT RECORD

Project Name: More's Lake	**Project Number:** 93647	**Well Number:** **MW-1**

Project Information		**Elevation of Monitoring Well**	
Facility Name:	Columbia Municipal Power Plant	Ground Surface Elevation (GS):	770.20
Location:	Columbia, Missouri	Top of Casing Elevation (TOC):	769.82

Well Information	
Date Well Installed:	05/24/17
Total Depth of Well:	42.87 feet from TOC
Depth to Top of Screen:	32.47 feet from TOC
Length of Casing Screened:	10.00 feet
Borehole Diameter:	8.25 inches
Well Casing Diameter:	2.00 inches
Type of Formation Screened:	Glacial Till/Drift

Borehole Volume Calculation: Filter Pack Porosity = 30%

Water Column = 14.77 feet Filter Pack = 13.13 ft Saturated Filter Pack = 13.13 ft

1 Saturated Well Volume = 2.41 gallons

1 well volume (gallons) = initial height of water column (ft) x .16

Saturated Filter Pack Volume= **10.30 gallons**

Filter pack volume (gallons) = saturated borehole filter pack volume (assuming 30% porosity) - saturated well filter pack volume

3 Saturated Borehole Volume = **38.12 gallons**

3 Saturated Borehole Volumes (gallons) = 3 x (saturated well casing volume + saturated filter pack)

Development Method

Equipment:				Method Description:
Surge		Bail		
Airlift		**Pump**	**X**	Drillers developed well with submersible pump (12v electric)

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/07/17	1515	28.10	42.74	0.0	0.0	22.6	7.7	0.640	OR	Begin surging screen
06/07/17	1525			0.0	0.0					Finish surging screen
06/07/17	1525			0.0	0.0	20.5	7.5	0.700	OR	Begin pumping - dark gray
06/07/17	1532			8.0	8.0	20.4	7.4	0.710	OR	dark gray
06/07/17	1535			4.5	12.5	20.3	7.4	0.710	OR	**Pumped dry** - allow 90% recharge
06/07/17	1550	28.59		0.0	12.5	23.3	7.7	0.910	OR	Begin surging screen
06/07/17	1555			0.0	12.5					Finish surging screen
06/07/17	1555			0.0	12.5	19.3	7.4	1.000	OR	Begin pumping - dark gray
06/07/17	1559			8.0	20.5	20.3	7.5	0.980	OR	Brown
06/07/17	1602			2.0	22.5	20.0	7.5	0.990	OR	**Pumped dry** - allow 90% recharge
06/07/17	1620	28.75		0.0	22.5	22.1	7.5	1.140	OR	Begin surging screen
06/07/17	1630			0.0	22.5					Finish surging screen

*from TOC unless otherwise noted in Remarks

091294 Form WCI OP6-1

WELL DEVELOPMENT RECORD (Continued)

Project Name: More's Lake **Project Number:** 93647 **Well Number:** **MW-1**

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/07/17	1630			0.0	22.5	19.1	7.4	0.990	OR	Begin pumping - light brown
06/07/17	1636			8.0	30.5	19.2	7.4	0.990	OR	Light brown
06/07/17	1638	40.01	42.74	2.0	32.5	19.0	7.4	0.980	OR	**Pumped dry** third time - complete
06/14/17	1539	28.14	42.74	6.79	39.3	--	--	--	--	slug removal for rising head slug test

*from TOC unless otherwise noted in Remarks

091294 Form WCI OP6-1

WELL DEVELOPMENT RECORD

Project Name: More's Lake	**Project Number:** 93647	**Well Number:** MW-2

Project Information		**Elevation of Monitoring Well**	
Facility Name:	Columbia Municipal Power Plant	Ground Surface Elevation (GS):	781.800
Location:	Columbia, Missouri	Top of Casing Elevation (TOC):	781.030

Well Information		
Date Well Installed:	05/23/17	
Total Depth of Well:	52.96	feet from TOC
Depth to Top of Screen:	42.59	feet from TOC
Length of Casing Screened:	10.00	feet
Borehole Diameter:	8.25	inches
Well Casing Diameter:	2.00	inches
Type of Formation Screened:	Glacial Till/Drift	

Borehole Volume Calculation: Filter Pack Porosity = 30%

Water Column = 35.92 feet Filter Pack = 13.13 ft Saturated Filter Pack = 13.13 ft

1 Saturated Well Volume = 5.86

1 well volume (gallons) = initial height of water column (ft) x .16

Saturated Filter Pack Volume= **10.30**

Filter pack volume (gallons) = saturated borehole filter pack volume (assuming 30% porosity) - saturated well filter pack volume

3 Saturated Borehole Volume = **48.47**

3 Saturated Borehole Volumes (gallons) = 3 x (saturated well casing volume + saturated filter pack)

Development Method

Equipment:				Method Description:
Surge		Bail		
Airlift		**Pump**	**X**	Drillers developed well with submersible pump (12v electric)

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
05/30/17	1530	17.04	52.92	0.0	0.0	20.2	8.1	0.510	295	Begin surging screen
05/30/17	1540			0.0	0.0					Finish surging screen
05/30/17	1541			0.0	0.0	17.9	7.3	0.770	OR	Begin pumping - brown
05/30/17	1549			11.5	11.5	17.7	7.2	0.840	1247 AU	Dark Brown
05/30/17	1557			11.5	23.0	17.0	7.1	0.850	OR	Dark Brown
05/30/17	1565			11.5	34.5	17.5	7.1	0.860	149	Light brown
05/30/17	1573			11.5	46.0	17.3	7.1	0.870	92.8	Light brown
05/30/17	1581			11.5	57.5	17.2	7.0	0.880	84.0	Light brown
05/30/17	1589			11.5	69.0	17.2	7.0	0.880	93.6	Light brown
05/30/17	1597			11.5	80.5	16.9	7.0	0.880	92.7	Light brown
05/30/17	1605			11.5	92.0	17.0	7.1	0.890	89.3	Light brown
05/30/17	1613			11.5	103.5	16.8	7.0	0.890	87.2	Light brown

*from TOC unless otherwise noted in Remarks

091294 Form WCI OP6-1

WELL DEVELOPMENT RECORD (Continued)

Project Name: More's Lake **Project Number:** 93647 **Well Number:** **MW-2**

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
05/30/17	1621			11.5	115.0	16.7	7.0	0.900	84.6	Light brown
05/30/17	1630			11.5	126.5	17.0	7.0	0.900	83.9	Light brown
05/30/17	1640	37.18	52.92	11.5	138.0	16.9	7.0	0.910	85.1	Development complete - turbidity not below
										5 NTU (10% stable measurements)
06/14/17	930	20.10	52.92	139.0	277.0	--	--	--	OR	water removed for rising head slug test #1
06/19/17	1506	27.71	52.92	107.5	384.5	--	--	--	--	water removed for rising head slug test #2

*from TOC unless otherwise noted in Remarks

091294 Form WCI OP6-1

WELL DEVELOPMENT RECORD

Project Name: More's Lake	**Project Number:** 93647	**Well Number:** **MW-3**

Project Information		**Elevation of Monitoring Well**	
Facility Name:	Columbia Municipal Power Plant	Ground Surface Elevation (GS):	781.620
Location:	Columbia, Missouri	Top of Casing Elevation (TOC):	781.130

Well Information	
Date Well Installed:	05/18/17
Total Depth of Well:	49.58 feet from TOC
Depth to Top of Screen:	39.21 feet from TOC
Length of Casing Screened:	10.00 feet
Borehole Diameter:	8.25 inches
Well Casing Diameter:	2.00 inches
Type of Formation Screened:	Glacial Till/Drift

Borehole Volume Calculation: Filter Pack Porosity = 30%

Water Column = 33.71 feet Filter Pack = 13.06 ft Saturated Filter Pack = 13.06 ft

1 Saturated Well Volume = 5.50 gallons

1 well volume (gallons) = initial height of water column (ft) x .16

Saturated Filter Pack Volume= **10.24 gallons**

Filter pack volume (gallons) = saturated borehole filter pack volume (assuming 30% porosity) - saturated well filter pack volume

3 Saturated Borehole Volume = **47.23 gallons**

3 Saturated Borehole Volumes (gallons) = 3 x (saturated well casing volume + saturated filter pack)

Development Method

Equipment:				Method Description:
Surge		Bail		
Airlift		**Pump**	**X**	Drillers developed well with submersible pump (12v electric)

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
05/26/17	1410	15.87	49.54	0.0	0.0	18.1	7.7	0.710	OR	Begin surging screen
05/26/17	1420			0.0	0.0					Finish surging screen
05/26/17	1421			0.0	0.0	17.9	7.4	0.710	OR	Begin pumping - brown
05/26/17	1429			11.1	11.1	17.7	7.3	0.740	OR	Brown
05/26/17	1432			3.9	15.0	16.5	7.1	0.750	OR	**Pumped dry** - allow 90% recharge
05/30/17	1335	16.09	49.54	0.0	0.0	20.1	7.7	0.680	OR	Begin surging screen
05/30/17	1345			0.0	0.0					Finish surging screen
05/30/17	1345			0.0	0.0	17.6	7.5	0.670	OR	Begin pumping - brown
05/30/17	1349			11.1	26.1	17.2	7.4	0.680	OR	Brown
05/30/17	1352	47.20		4.9	31.0	17.1	7.4	0.680	OR	**Pumped dry** - allow 90% recharge
06/07/17	1343	16.28		0.0	0.0	19.7	7.4	0.840	OR	Begin surging screen
06/07/17	1353			0.0	0.0					Finish surging screen

*from TOC unless otherwise noted in Remarks

091294 Form WCI OP6-1

WELL DEVELOPMENT RECORD (Continued)

Project Name: More's Lake | **Project Number:** 93647 | **Well Number:** **MW-3**

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/07/17	1354			0.0	0.0	17.6	7.3	0.860	OR	Begin pumping - brown
06/07/17	1402			11.1	42.1	17.0	7.2	0.860	OR	Brown
06/07/17	1405	47.01	49.56	2.9	45.0	17.1	7.2	0.850	OR	**Pumped dry** third time - complete
06/13/17	1129	16.29	49.50	11.5	56.5	--	--	--	--	pumped for rising head slug test and well yeild test

*from TOC unless otherwise noted in Remarks

091294 Form WCI OP6-1

WELL DEVELOPMENT RECORD

Project Name: More's Lake	**Project Number:** 93647	**Well Number:** **MW-4**

Project Information		**Elevation of Monitoring Well**	
Facility Name:	Columbia Municipal Power Plant	Ground Surface Elevation (GS):	785.390
Location:	Columbia, Missouri	Top of Casing Elevation (TOC):	785.020

Well Information	
Date Well Installed:	05/17/17
Total Depth of Well:	57.16 feet from TOC
Depth to Top of Screen:	46.78 feet from TOC
Length of Casing Screened:	10.01 feet
Borehole Diameter:	8.25 inches
Well Casing Diameter:	2.00 inches
Type of Formation Screened:	Glacial Till/Drift

Borehole Volume Calculation: Filter Pack Porosity = 30%

Water Column = 35.42 feet Filter Pack = 13.03 ft Saturated Filter Pack = 13.03 ft

1 Saturated Well Volume = 5.78 gallons

1 well volume (gallons) = initial height of water column (ft) x .16

Saturated Filter Pack Volume= **10.22 gallons**

Filter pack volume (gallons) = saturated borehole filter pack volume (assuming 30% porosity) - saturated well filter pack volume

3 Saturated Borehole Volume = **47.99 gallons**

3 Saturated Borehole Volumes (gallons) = 3 x (saturated well casing volume + saturated filter pack)

Development Method

Equipment:				Method Description:
Surge		**Bail**	**X**	
Airlift		**Pump**	**X**	Drillers developed well with submersible pump (12v electric) followed by BMcD development with disposable bailer.

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
05/26/17	1020	21.74		0.0	0.0	18.3	7.8	0.690	980	Begin surging screen
05/26/17	1030			0.0	0.0					Finish surging screen
05/26/17	1030			0.0	0.0	18.8	7.7	0.700	OR	Begin pumping - brown
05/26/17	1040			11.5	11.5	16.8	7.4	0.740	OR	Brown
05/26/17	1041			0.5	12.0	16.1	7.2	0.750	OR	**Pumped dry** - allow 90% recharge
05/30/17	1248	22.32		0.0	0.0	18.3	7.6	0.960	OR	Begin surging/purging with bailer
05/30/17	1320			11.5	0.0	17.1	7.3	0.970	OR	Brown
05/30/17	1323	55.80		0.5	0.0	16.9	7.2	0.970	OR	**Bailed dry** - allow 90% recharge
06/07/17	1303	22.25		0.0	0.0	21.1	7.9	0.910	869	Begin surging screen
06/07/17	1313			0.0	0.0					Finish surging screen
06/07/17	1313			0.0	0.0	15.6	7.0	0.990	OR	Begin pumping - brown
06/07/17	1327			11.5	35.5	17.6	7.1	1.000	OR	Brown

*from TOC unless otherwise noted in Remarks

091294 Form WCI OP6-1

WELL DEVELOPMENT RECORD (Continued)

Project Name: More's Lake | **Project Number:** 93647 | **Well Number:** **MW-4**

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/07/17	1328	55.08	57.05	0.5	36.0	16.1	7.0	1.000	OR	**Pumped dry** third time - complete
06/13/17	1354	22.30	57.05	11.2	47.2	--	--	--	--	Pumped for rising head slug test and well yield test

*from TOC unless otherwise noted in Remarks

091294 Form WCI OP6-1

WELL DEVELOPMENT RECORD

Project Name: More's Lake	**Project Number:** 93647	**Well Number:** **MW-5**

Project Information		**Elevation of Monitoring Well**	
Facility Name:	Columbia Municipal Power Plant	Ground Surface Elevation (GS):	770.080
Location:	Columbia, Missouri	Top of Casing Elevation (TOC):	769.610

Well Information		
Date Well Installed:	05/19/17	
Total Depth of Well:	41.18	feet from TOC
Depth to Top of Screen:	30.80	feet from TOC
Length of Casing Screened:	10.01	feet
Borehole Diameter:	8.25	inches
Well Casing Diameter:	2.00	inches
Type of Formation Screened:	Glacial Till/Drift	

Borehole Volume Calculation: Filter Pack Porosity = 30%

Water Column = 29.29 feet Filter Pack = 13.11 ft Saturated Filter Pack = 13.11 ft

1 Saturated Well Volume = 4.78 gallons

1 well volume (gallons) = initial height of water column (ft) x .16

Saturated Filter Pack Volume= **10.28 gallons**

Filter pack volume (gallons) = saturated borehole filter pack volume (assuming 30% porosity) - saturated well filter pack volume

3 Saturated Borehole Volume = **45.18 gallons**

3 Saturated Borehole Volumes (gallons) = 3 x (saturated well casing volume + saturated filter pack)

Development Method

Equipment:				Method Description:
Surge		Bail		
Airlift		**Pump**	**X**	Drillers developed well with submersible pump (12v electric)

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/08/17	857	11.89	41.04	0.0	0.0	18.7	7.6	0.780	567	Begin surging screen
06/08/17	907			0.0	0.0					Finish surging screen
06/08/17	907			0.0	0.0	18.1	7.5	0.780	OR	Begin pumping - dark gray
06/08/17	915			10.4	10.4	17.7	7.5	0.780	OR	dark gray
06/08/17	917			1.6	12.0	17.6	7.4	0.790	OR	**Pumped dry** - allow 90% recharge
06/09/17	755	20.71		0.0	12.0	17.4	7.5	0.840	OR	Begin surging screen
06/09/17	805			0.0	12.0					Finish surging screen
06/09/17	805			0.0	12.0	16.7	7.4	0.890	OR	Begin pumping - brown
06/09/17	812			9.0	21.0	16.9	7.4	0.890	OR	**Pumped dry** - allow 90% recharge
06/12/17	1211	18.41		0.0	21.0	17.8	7.5	0.840	OR	Begin surging screen
06/12/17	1222			0.0	21.0					Finish surging screen
06/12/17	1222			0.0	21.0	16.5	7.4	0.890	OR	Begin pumping - light brown

*from TOC unless otherwise noted in Remarks

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WELL DEVELOPMENT RECORD (Continued)

Project Name: More's Lake | **Project Number:** 93647 | **Well Number:** **MW-5**

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/12/17	1232			10.4	31.4	16.6	7.4	0.890	OR	Light brown
06/12/17	1233	39.07	41.09	0.6	32.0	16.6	7.4	0.900	OR	**Pumped dry** third time - complete
06/19/17	1227	13.45	--	9.32	41.3	--	--	--	--	Pumped for rising head slug test and well yield test

*from TOC unless otherwise noted in Remarks

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WELL DEVELOPMENT RECORD

Project Name: More's Lake	**Project Number:** 93647	**Well Number:** MW-6

Project Information		**Elevation of Monitoring Well**	
Facility Name:	Columbia Municipal Power Plant	Ground Surface Elevation (GS):	770.470
Location:	Columbia, Missouri	Top of Casing Elevation (TOC):	770.070

Well Information	
Date Well Installed:	05/25/17
Total Depth of Well:	41.83 feet from TOC
Depth to Top of Screen:	31.45 feet from TOC
Length of Casing Screened:	10.01 feet
Borehole Diameter:	8.25 inches
Well Casing Diameter:	2.00 inches
Type of Formation Screened:	Glacial Till/Drift

Borehole Volume Calculation: Filter Pack Porosity = 30%

Water Column = 27.41 feet Filter Pack = 13.06 ft Saturated Filter Pack = 13.06 ft

1 Saturated Well Volume = 4.47 gallons

1 well volume (gallons) = initial height of water column (ft) x .16

Saturated Filter Pack Volume= **10.24 gallons**

Filter pack volume (gallons) = saturated borehole filter pack volume (assuming 30% porosity) - saturated well filter pack volume

3 Saturated Borehole Volume = **44.14 gallons**

3 Saturated Borehole Volumes (gallons) = 3 x (saturated well casing volume + saturated filter pack)

Development Method

Equipment:				Method Description:
Surge		Bail		
Airlift		**Pump**	**X**	Drillers developed well with submersible pump (12v electric)

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/08/17	757	14.42	41.76	0.0	0.0	18.2	7.7	0.710	OR	Begin surging screen
06/08/17	807			0.0	0.0					Finish surging screen
06/08/17	807			0.0	0.0	18.9	7.4	0.930	OR	Begin pumping - dark gray
06/08/17	815			10.1	10.1	18.8	7.1	0.940	OR	Gray
06/08/17	817			2.9	13.0	19.1	7.1	0.800	OR	**Pumped dry** - allow 90% recharge
06/09/17	725	16.08		0.0	13.0	17.8	6.9	0.990	OR	Begin surging screen
06/09/17	735			0.0	13.0					Finish surging screen
06/09/17	735			0.0	13.0	17.3	7.1	0.990	OR	Begin pumping - light brown
06/09/17	744			10.1	23.1	17.2	7.1	1.000	OR	Light brown
06/09/17	745			1.9	25.0	17.2	7.0	1.000	OR	**Pumped dry** - allow 90% recharge
06/12/17	1105	15.36		0.0	25.0	17.9	7.3	0.980	OR	Begin surging screen
06/12/17	1115			0.0	25.0					Finish surging screen

*from TOC unless otherwise noted in Remarks

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WELL DEVELOPMENT RECORD (Continued)

Project Name: More's Lake **Project Number:** 93647 **Well Number:** **MW-6**

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/12/17	1115			0.0	25.0	17.2	7.1	0.990	OR	Begin pumping - light brown
06/12/17	1127			10.1	35.1	17.0	7.1	0.990	OR	Light brown
06/12/17	1128	40.55	41.75	1.9	37.0	17.1	7.0	1.000	OR	**Pumped dry** third time - complete
06/19/17	1133	15.15	--	9.32	46.3	--	--	--	--	Pumped for rising head slug test and well yield test

*from TOC unless otherwise noted in Remarks

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WELL DEVELOPMENT RECORD

Project Name:	More's Lake	**Project Number:**	93647	**Well Number:**	**MW-7**

Project Information		**Elevation of Monitoring Well**	
Facility Name:	Columbia Municipal Power Plant	Ground Surface Elevation (GS):	762.670
Location:	Columbia, Missouri	Top of Casing Elevation (TOC):	762.230

Well Information		**Borehole Volume Calculation:**	Filter Pack Porosity = 30%
Date Well Installed:	05/16/17	Water Column = 11.96 feet	Filter Pack = 13.02 ft Saturated Filter Pack = 11.96 ft
Total Depth of Well:	33.46 feet from TOC	1 Saturated Well Volume = 1.95	
Depth to Top of Screen:	23.08 feet from TOC	1 well volume (gallons) = initial height of water column (ft) x .16	
Length of Casing Screened:	10.01 feet	Saturated Filter Pack Volume= **9.38**	
Borehole Diameter:	8.25 inches	Filter pack volume (gallons) = saturated borehole filter pack volume (assuming 30% porosity) - saturated well filter pack volume	
Well Casing Diameter:	2.00 inches	3 Saturated Borehole Volume = **33.99**	
Type of Formation Screened:	Glacial Till/Drift	3 Saturated Borehole Volumes (gallons) = 3 x (saturated well casing volume + saturated filter pack)	

Development Method

Equipment:				Method Description:
Surge		**Bail**	**X**	Drillers developed well with submersible pump (12v electric) followed by BMcD developing with disposable bailer. November redevelopment effort included introducing water to well, surging and pumping (12v electric) followed by developing with a disposable bailer.
Airlift		**Pump**	**X**	

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
05/26/17	900	26.61	31.90	0.0	0.0	23.9	7.6	0.580	OR	Begin surging screen
05/26/17	915			0.0	0.0					Finish surging screen
05/26/17	915			0.0	0.0	21.8	7.4	0.670	OR	Begin pumping - dark gray
05/26/17	917			1.5	1.5	19.9	7.2	0.850	OR	**Pumped dry** - allow 90% recharge
05/30/17	1425	28.24	33.40	0.0	1.5	21.8	7.4	0.670	OR	Begin surging/bailing
05/30/17	1440	32.95		1.5	3.0	19.4	7.2	0.690	OR	**Bailed dry** - allow 90% recharge
06/08/17	725	28.41	33.40	0.0	3.0	16.4	7.6	1.220	OR	Begin surging/bailing
06/08/17	733	32.90	33.43	1.5	4.5	16.1	7.2	1.110	OR	**Bailed dry** third time - complete
06/13/17	1545	28.98	33.43	1.0	5.5	--	--	--	--	Bailed for rising head slug test and well yield test
06/19/17	1019	29.44		1.3	6.8	--	--	--	--	Bailed for rising head slug test and well yield test
11/16/17	1348	21.50	33.43	0.0	0.0	17.9	7.1	1.030	72.7	Initial reading
11/16/17	1400	19.80		0.0	0.0	-	-	-	-	Added water; begin surging; slightly cloudy

*from TOC unless otherwise noted in Remarks

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WELL DEVELOPMENT RECORD (Continued)

Project Name: More's Lake | **Project Number:** 93647 | **Well Number:** MW-7

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
11/16/17	1434	-	-	0.0	0.0	-	-	-	-	Begin pumping
11/16/17	1436	-	-	2.0	5.0	15.6	7.2	0.950	OR	Finished pumping; dark brown
11/16/17	1440	19.51	-	0.0	2.0	-	-	-	-	Added water; begin surging
11/16/17	1450	-	-	0.0	5.0	-	-	-	-	Begin pumping
11/16/17	1454	-	-	4.0	9.0	15.4	7.1	0.850	OR	Finished pumping; light brown
11/16/17	1456	19.31	-	0.0	9.0	-	-	-	-	Added water; begin surging
11/16/17	1506	-	-	0.0	9.0	-	-	-	-	Begin pumping
11/16/17	1510	-	-	4.0	13.0	15.3	7.6	0.470	OR	Finished pumping; dark brown
11/16/17	1523	20.08	-	0.0	13.0	-	-	-	-	Added water; begin surging
11/16/17	1533	-	-	0.0	13.0	-	-	-	-	Begin pumping
11/16/17	1536	-	-	4.0	17.0	15.3	7.5	0.470	OR	Finished pumping; dark brown
11/16/17	1538	20.16	-	0.0	17.0	-	-	-	-	Added water; begin surging
11/16/17	1553	-	-	0.0	17.0	-	-	-	-	Pump not working; switch to bailing
11/16/17	1620	32.45	-	4.0	21.0	14.9	7.2	0.420	OR	Bailed Dry
11/16/17	1643	9.50	-	0.0	21.0	-	-	-	-	Added water; begin bailing
11/16/17	1718	32.35	33.43	6.0	27.0	14.90	8.1	0.410	OR	Bailed dry

*from TOC unless otherwise noted in Remarks

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WELL DEVELOPMENT RECORD

Project Name: More's Lake	**Project Number:** 93647	**Well Number:** **MW-8**

Project Information		**Elevation of Monitoring Well**	
Facility Name:	Columbia Municipal Power Plant	Ground Surface Elevation (GS):	753.460
Location:	Columbia, Missouri	Top of Casing Elevation (TOC):	753.090

Well Information	
Date Well Installed:	05/18/17
Total Depth of Well:	27.92 feet from TOC
Depth to Top of Screen:	17.54 feet from TOC
Length of Casing Screened:	10.01 feet
Borehole Diameter:	8.25 inches
Well Casing Diameter:	2.00 inches
Type of Formation Screened:	Glacial Till/Drift

Borehole Volume Calculation: Filter Pack Porosity = 30%

Water Column = 21.39 feet Filter Pack = 13.09 ft Saturated Filter Pack = 13.09 ft

1 Saturated Well Volume = 3.49

1 well volume (gallons) = initial height of water column (ft) x .16

Saturated Filter Pack Volume= **10.26**

Filter pack volume (gallons) = saturated borehole filter pack volume (assuming 30% porosity) - saturated well filter pack volume

3 Saturated Borehole Volume = **41.27**

3 Saturated Borehole Volumes (gallons) = 3 x (saturated well casing volume + saturated filter pack)

Development Method

Equipment:				Method Description:
Surge		Bail		
Airlift		**Pump**	**X**	Drillers developed well with submersible pump (12v electric).

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
05/26/17	1317	6.53	27.88	0.0	0.0	17.8	7.1	0.870	125	Begin surging screen
05/26/17	1327			0.0	0.0					Finish surging screen
05/26/17	1328			0.0	0.0	16.5	6.9	2.300	OR	Begin pumping - light brown
05/26/17	1339			9.0	9.0	15.9	7.1	1.470	OR	**Pumped dry** - allow 90% recharge
06/07/17	1430	7.54		0.0	9.0	19.2	7.4	1.420	225	Begin surging screen
06/07/17	1440			0.0	9.0					Finish surging screen
06/07/17	1440			0.0	9.0	17.4	7.2	1.450	OR	Begin pumping - light brown
06/07/17	1446			7.0	16.0	16.9	7.1	1.470	OR	**Pumped dry** - allow 90% recharge
06/08/17	1000	7.68		0.0	16.0	19.1	7.1	0.890	75	Begin surging screen
06/08/17	1005			0.0	16.0					Finish surging screen
06/08/17	1005			0.0	16.0	17.1	7.1	1.460	OR	Begin pumping - light brown
06/08/17	1010	26.81	27.85	7.0	23.0	16.8	7.0	1.590	OR	**Pumped dry** third time - complete

*from TOC unless otherwise noted in Remarks

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WELL DEVELOPMENT RECORD (Continued)

Project Name: More's Lake | **Project Number:** 93647 | **Well Number:** **MW-8**

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/14/17	1131	7.96	27.85	6.79	29.8	--	--	--	--	Pump for rising head slug test and well yield test

*from TOC unless otherwise noted in Remarks

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WELL DEVELOPMENT RECORD

Project Name: More's Lake	**Project Number:** 93647	**Well Number:** **PZ-2**

Project Information		**Elevation of Monitoring Well**	
Facility Name:	Columbia Municipal Power Plant	Ground Surface Elevation (GS):	4624.000
Location:	Columbia, Missouri	Top of Casing Elevation (TOC):	4623.500

Well Information		
Date Well Installed:	01/13/14	
Total Depth of Well:	19.80	feet from TOC
Depth to Top of Screen:	4.40	feet from TOC
Length of Casing Screened:	15.00	feet
Borehole Diameter:	8.25	inches
Well Casing Diameter:	2.00	inches
Type of Formation Screened:	Glacial Till/Drift	

Borehole Volume Calculation: Filter Pack Porosity = 30%

Water Column = 11.39 feet Filter Pack = 17.00 ft Saturated Filter Pack = 11.39 ft

1 Saturated Well Volume = 1.86

1 well volume (gallons) = initial height of water column (ft) x .16

Saturated Filter Pack Volume= **8.93**

Filter pack volume (gallons) = saturated borehole filter pack volume (assuming 30% porosity) - saturated well filter pack volume

3 Saturated Borehole Volume = **32.37**

3 Saturated Borehole Volumes (gallons) = 3 x (saturated well casing volume + saturated filter pack)

Development Method

Equipment:				Method Description:
Surge		Bail	X	
Airlift		**Pump**	**X**	Drillers developed well with submersible pump (12v electric).

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/08/17	1235	8.41	19.40	0.0	0.0	19.6	7.2	1.600	126	Begin surging screen
06/08/17	1245			0.0	0.0					Finish surging screen
06/08/17	1245			0.0	0.0	19.5	6.9	1.670	OR	Begin pumping - brown
06/08/17	1250			6.0	6.0	19.1	7.0	1.670	OR	**Pumped dry** - allow 90% recharge
06/08/17	1625	9.45		0.0	6.0	19.2	7.0	1.430	OR	Begin surging screen
06/08/17	1632			0.0	6.0					Finish surging screen
06/08/17	1632			0.0	6.0	19.3	6.9	1.630	OR	Begin pumping - brown
06/08/17	1637			4.0	10.0	19.4	6.8	1.630	OR	**Pumped dry** - allow 90% recharge
06/09/17	924	8.52		0.0	10.0	19.2	7.2	1.430	OR	Begin surging screen
06/09/17	934			0.0	10.0					Finish surging screen
06/09/17	934			0.0	10.0	17.1	6.8	1.280	OR	Begin pumping - brown
06/09/17	940	18.76	19.80	6.0	16.0	17.4	6.9	1.300	OR	**Pumped dry** third time - complete

*from TOC unless otherwise noted in Remarks

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WELL DEVELOPMENT RECORD (Continued)

Project Name: More's Lake | **Project Number:** 93647 | **Well Number:** **PZ-2**

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/15/17	1009	8.47	19.80	3.71	19.7	--	--	--	--	Pumped for rising head slug test and well yield test

*from TOC unless otherwise noted in Remarks

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WELL DEVELOPMENT RECORD

Project Name: More's Lake	**Project Number:** 93647	**Well Number:** **PZ-4**

Project Information		**Elevation of Monitoring Well**	
Facility Name:	Columbia Municipal Power Plant	Ground Surface Elevation (GS):	752.400
Location:	Columbia, Missouri	Top of Casing Elevation (TOC):	752.060

Well Information		
Date Well Installed:	01/14/14	
Total Depth of Well:	20.13	feet from TOC
Depth to Top of Screen:	4.73	feet from TOC
Length of Casing Screened:	15.00	feet
Borehole Diameter:	8.25	inches
Well Casing Diameter:	2.00	inches
Type of Formation Screened:	Glacial Till/Drift	

Borehole Volume Calculation: Filter Pack Porosity = 30%

Water Column = 13.73 feet Filter Pack = 17.00 ft Saturated Filter Pack = 13.73 ft

1 Saturated Well Volume = 2.24

1 well volume (gallons) = initial height of water column (ft) x .16

Saturated Filter Pack Volume= **10.77**

Filter pack volume (gallons) = saturated borehole filter pack volume (assuming 30% porosity) - saturated well filter pack volume

3 Saturated Borehole Volume = **39.02**

3 Saturated Borehole Volumes (gallons) = 3 x (saturated well casing volume + saturated filter pack)

Development Method

Equipment:				Method Description:
Surge		Bail		
Airlift		**Pump**	**X**	Drillers developed well with submersible pump (12v electric) followed by BMcD developing with disposalbe bailer.

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/08/17	1127	6.40	19.80	0.0	0.0	17.9	6.9	1.420	OR	Begin surging screen
06/08/17	1137			0.0	0.0					Finish surging screen
06/08/17	1137			0.0	0.0	17.1	6.9	1.450	OR	Begin pumping - dark brown
06/08/17	1144			9.0	9.0	16.9	6.9	1.460	OR	**Pumped dry** - allow 90% recharge
06/08/17	1603	6.44		0.0	9.0	18.6	7.0	1.450	OR	Begin surging screen
06/08/17	1608			0.0	9.0					Finish surging screen
06/08/17	1608			0.0	9.0	16.7	6.9	1.460	OR	Begin pumping - dark brown
06/08/17	1615	18.39		9.0	18.0	16.7	6.9	1.470	OR	**Pumped dry** - allow 90% recharge
06/09/17	848	6.53		0.0	18.0	16.9	7.0	1.400	OR	Begin surging screen
06/09/17	858			0.0	18.0					Finish surging screen
06/09/17	858			0.0	18.0	16.9	7.0	1.440	OR	Begin pumping - brown
06/09/17	906	18.19	20.13	11.0	29.0	17.6	7.0	1.440	OR	**Pumped dry** third time - complete

*from TOC unless otherwise noted in Remarks

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WELL DEVELOPMENT RECORD (Continued)

Project Name: More's Lake | **Project Number:** 93647 | **Well Number:** **PZ-4**

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/15/17	1050	6.81	20.13	7.12	36.1	--	--	--	--	Pumped for rising head slug test and well yield test

*from TOC unless otherwise noted in Remarks

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WELL DEVELOPMENT RECORD

Project Name: More's Lake	**Project Number:** 93647	**Well Number:** PZ-6

Project Information		**Elevation of Monitoring Well**	
Facility Name:	Columbia Municipal Power Plant	Ground Surface Elevation (GS):	755.870
Location:	Columbia, Missouri	Top of Casing Elevation (TOC):	755.600

Well Information		
Date Well Installed:	01/14/14	
Total Depth of Well:	20.16	feet from TOC
Depth to Top of Screen:	4.76	feet from TOC
Length of Casing Screened:	15.00	feet
Borehole Diameter:	8.25	inches
Well Casing Diameter:	2.00	inches
Type of Formation Screened:	Glacial Till/Drift	

Borehole Volume Calculation: Filter Pack Porosity = 30%

Water Column = 13.99 feet Filter Pack = 17.00 ft Saturated Filter Pack = 13.99 ft

1 Saturated Well Volume = 2.28

1 well volume (gallons) = initial height of water column (ft) x .16

Saturated Filter Pack Volume= **10.97**

Filter pack volume (gallons) = saturated borehole filter pack volume (assuming 30% porosity) - saturated well filter pack volume

3 Saturated Borehole Volume = **39.76**

3 Saturated Borehole Volumes (gallons) = 3 x (saturated well casing volume + saturated filter pack)

Development Method

Equipment:				Method Description:
Surge		Bail		
Airlift		**Pump**	**X**	Drillers developed well with submersible pump (12v electric).

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/08/17	1050	6.17	20.17	0.0	0.0	20.1	7.6	0.990	OR	Begin surging screen
06/08/17	1100			0.0	0.0					Finish surging screen
06/08/17	1100			0.0	0.0	18.3	7.3	1.030	OR	Begin pumping - brown
06/08/17	1106			10.0	10.0	16.6	7.3	1.030	OR	**Pumped dry** - allow 90% recharge
06/08/17	1536	7.56		0.0	10.0	20.7	7.5	0.990	OR	Begin surging screen
06/08/17	1541			0.0	10.0					Finish surging screen
06/08/17	1541			0.0	10.0	17.6	7.4	0.970	OR	Begin pumping - brown
06/08/17	1549			10.0	20.0	16.5	7.3	0.990	OR	**Pumped dry** - allow 90% recharge
06/09/17	822	6.34		0.0	20.0	17.2	7.6	1.020	OR	Begin surging screen
06/09/17	832			0.0	20.0					Finish surging screen
06/09/17	832			0.0	20.0	15.8	7.4	1.120	OR	Begin pumping - brown
06/09/17	840	19.20	20.16	9.0	29.0	16.6	7.4	0.960	OR	**Pumped dry** third time - complete

*from TOC unless otherwise noted in Remarks

091294 Form WCI OP6-1

WELL DEVELOPMENT RECORD (Continued)

Project Name: More's Lake | **Project Number:** 93647 | **Well Number:** **PZ-6**

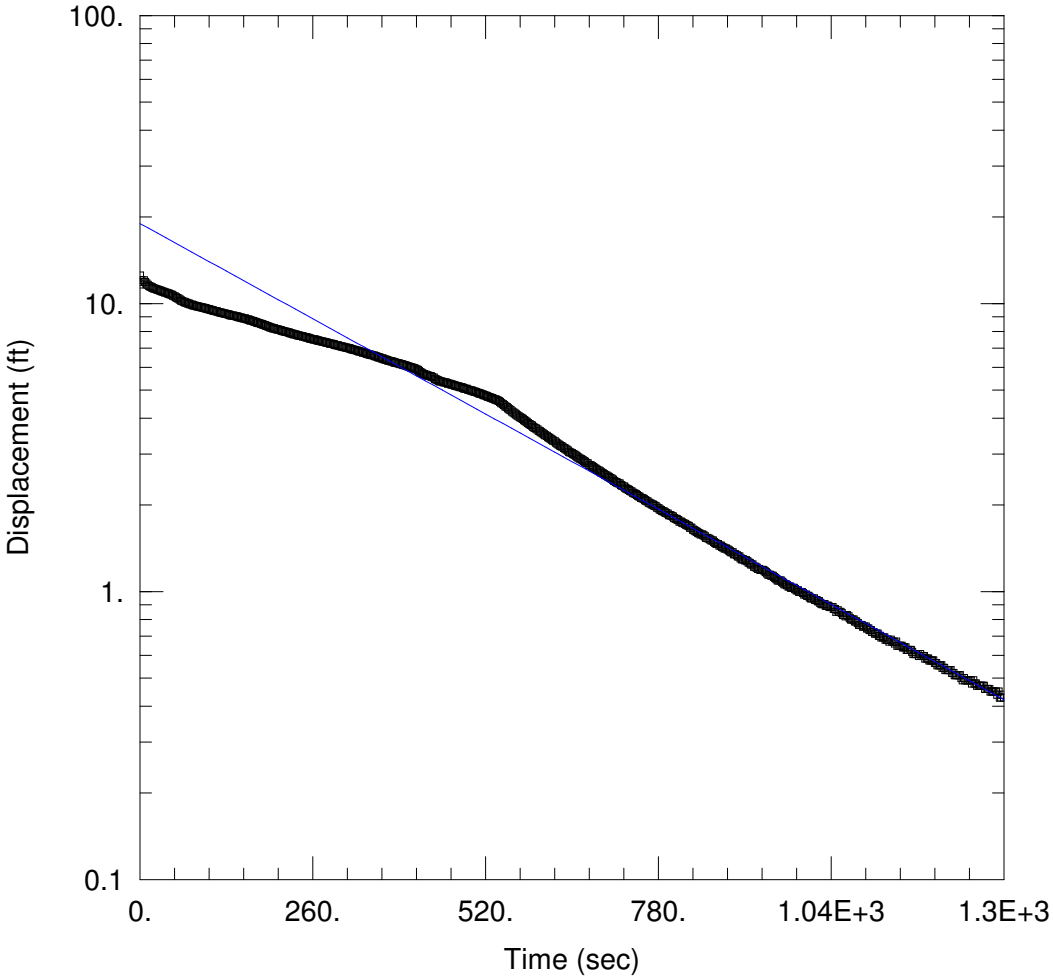
Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed Gallons	Fluid Removed Total	Temp. (ºC)	pH (units)	S.C. (µS/cm)	Turbidity	Fluid Appearance and Remarks (turbidity, color, odor, etc.)
06/14/17	1539	6.44	20.16	6.4	35.4	--	--	--	--	Pumped for rising head slug test and well yield test

*from TOC unless otherwise noted in Remarks

091294 Form WCI OP6-1

APPENDIX K – HYDRAULIC CONDUCTIVITY PLOTS



MW-1 RISING HEAD TEST #1

Data Set: Z:\...\MW-1_BR.aqt
Date: 08/31/17 Time: 10:22:26

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-1
Test Date: 6/14/2017

AQUIFER DATA

Saturated Thickness: 14.73 ft
Anisotropy Ratio (Kz/Kr): 1.

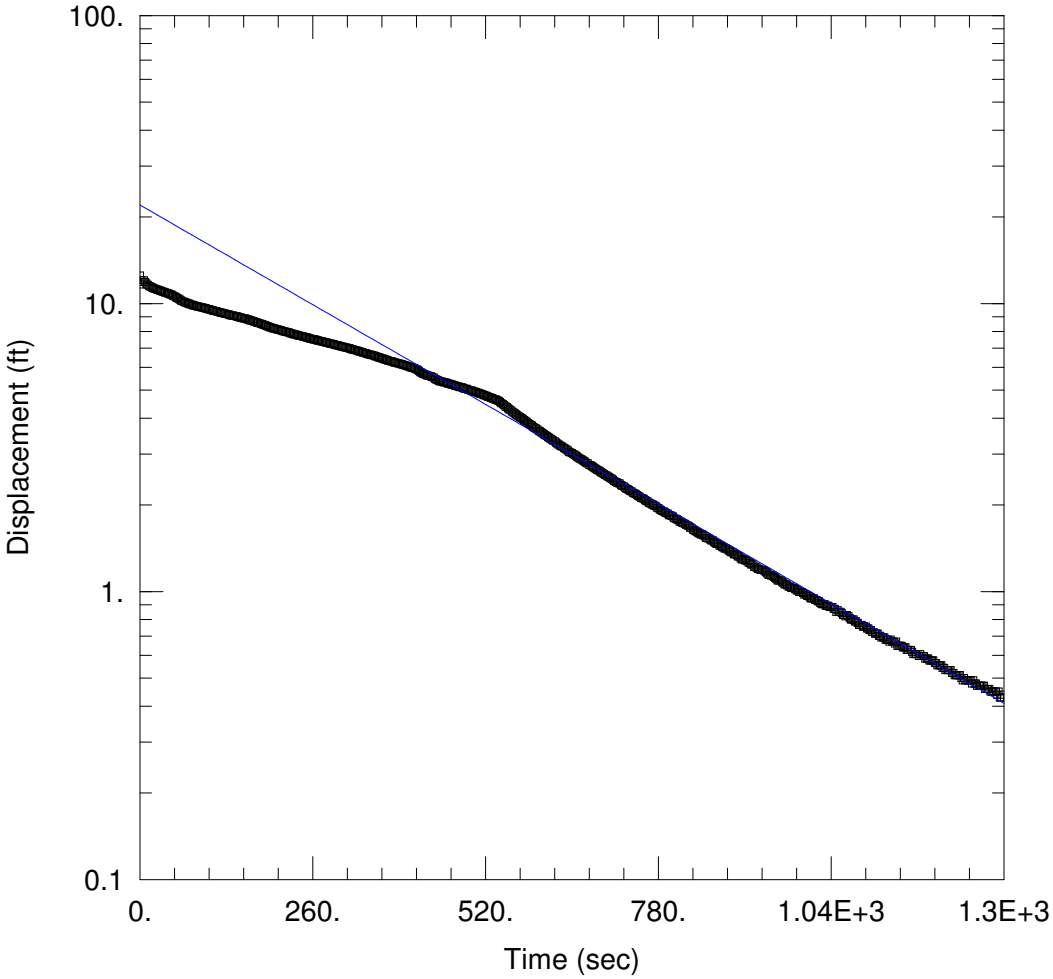
WELL DATA (MW-1)

Initial Displacement: 12.5 ft
Total Well Penetration Depth: 14.36 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 14.73 ft
Screen Length: 10. ft
Well Radius: 0.2604 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.0003109 cm/sec
y0 = 18.96 ft



MW-1 RISING HEAD TEST #1

Data Set: Z:\...\MW-1_HV.aqt
Date: 08/31/17 Time: 10:24:35

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-1
Test Date: 6/14/2017

AQUIFER DATA

Saturated Thickness: 14.73 ft Anisotropy Ratio (Kz/Kr): 1.

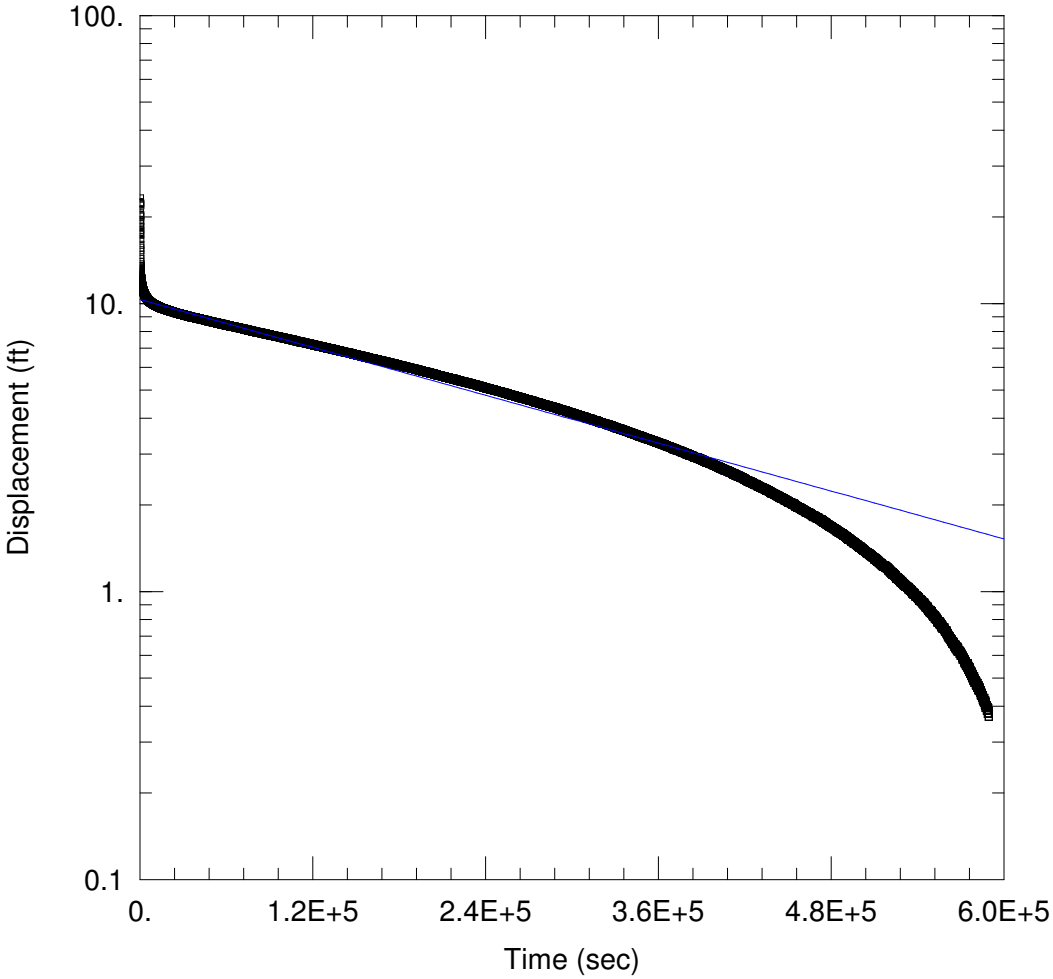
WELL DATA (MW-1)

Initial Displacement: 12.5 ft Static Water Column Height: 14.73 ft
Total Well Penetration Depth: 14.36 ft Screen Length: 10. ft
Casing Radius: 0.0833 ft Well Radius: 0.2604 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 0.0001029 cm/sec y0 = 21.98 ft



MW-2 RISING HEAD TEST

Data Set: Z:\...\MW-2_test2_BR.aqt
Date: 08/31/17 Time: 10:58:27

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-2
Test Date: 6/19/2017

AQUIFER DATA

Saturated Thickness: 27.71 ft
Anisotropy Ratio (Kz/Kr): 1.

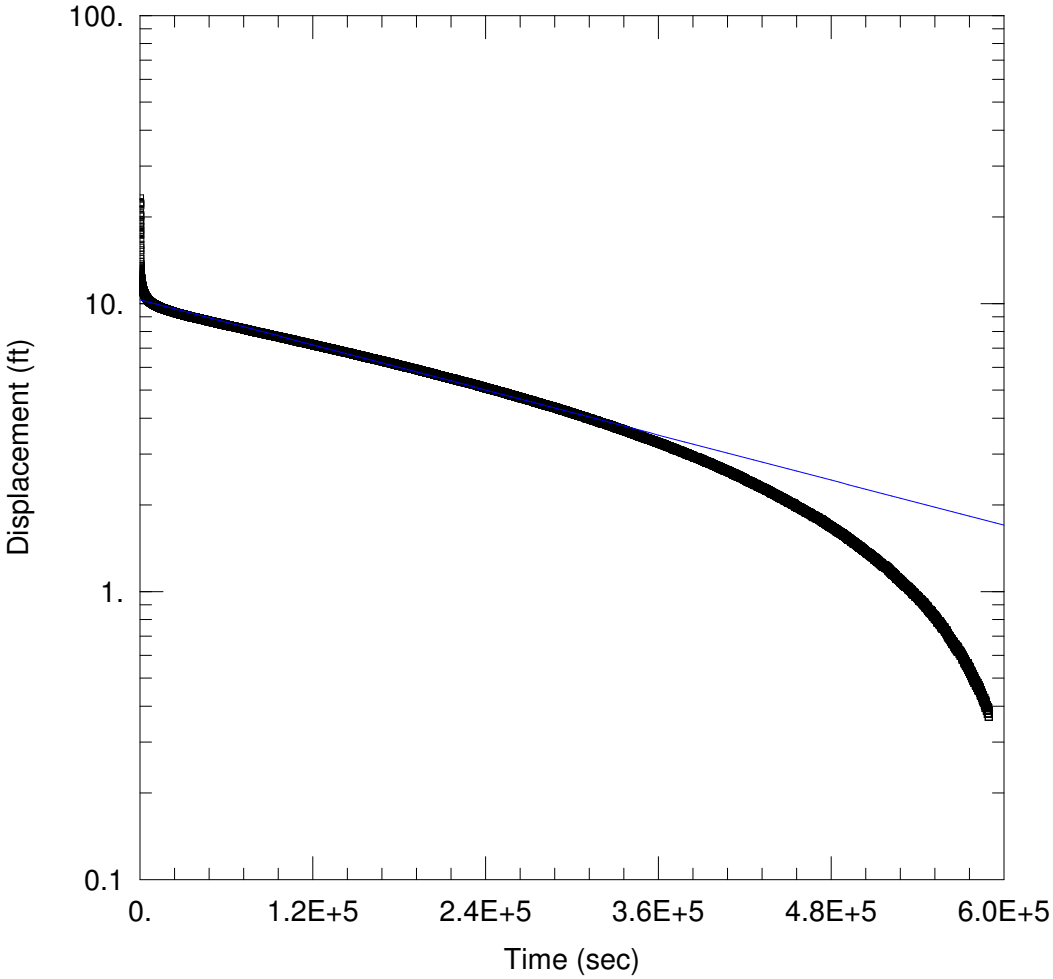
WELL DATA (MW-2)

Initial Displacement: 23.2 ft
Total Well Penetration Depth: 24.88 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 27.71 ft
Screen Length: 10. ft
Well Radius: 0.2604 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 3.485E-7 cm/sec
y0 = 10.33 ft



MW-2 RISING HEAD TEST

Data Set: Z:\...\MW-2_test2_HV.aqt
Date: 08/31/17 Time: 11:00:20

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-2
Test Date: 6/19/2017

AQUIFER DATA

Saturated Thickness: 27.71 ft Anisotropy Ratio (Kz/Kr): 1.

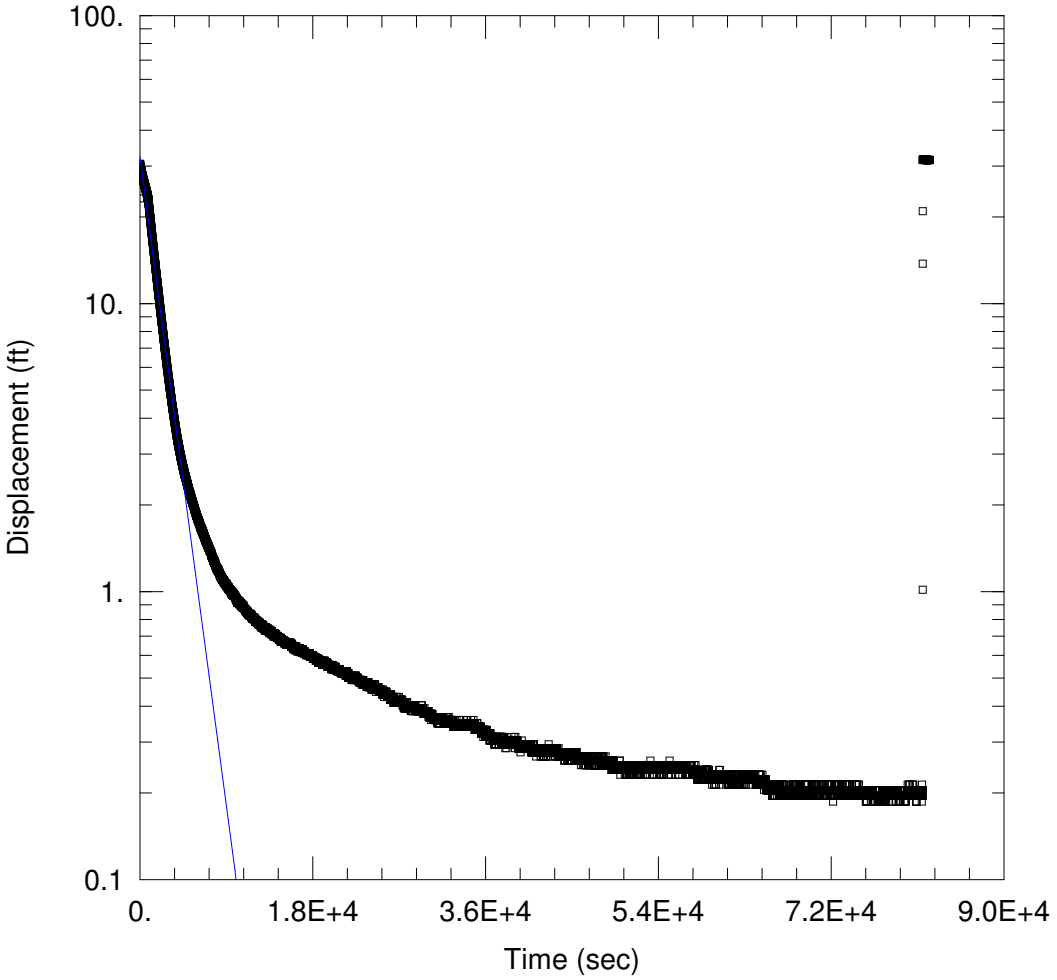
WELL DATA (MW-2)

Initial Displacement: 23.2 ft
Total Well Penetration Depth: 24.88 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 27.71 ft
Screen Length: 10. ft
Well Radius: 0.2604 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 1.009E-7 cm/sec y0 = 10.31 ft



MW-3 RISING HEAD TEST

Data Set: Z:\...\MW-3_test_BR.aqt
Date: 08/31/17 Time: 11:01:56

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-3
Test Date: 6/14/2017

AQUIFER DATA

Saturated Thickness: 33.29 ft
Anisotropy Ratio (Kz/Kr): 1.

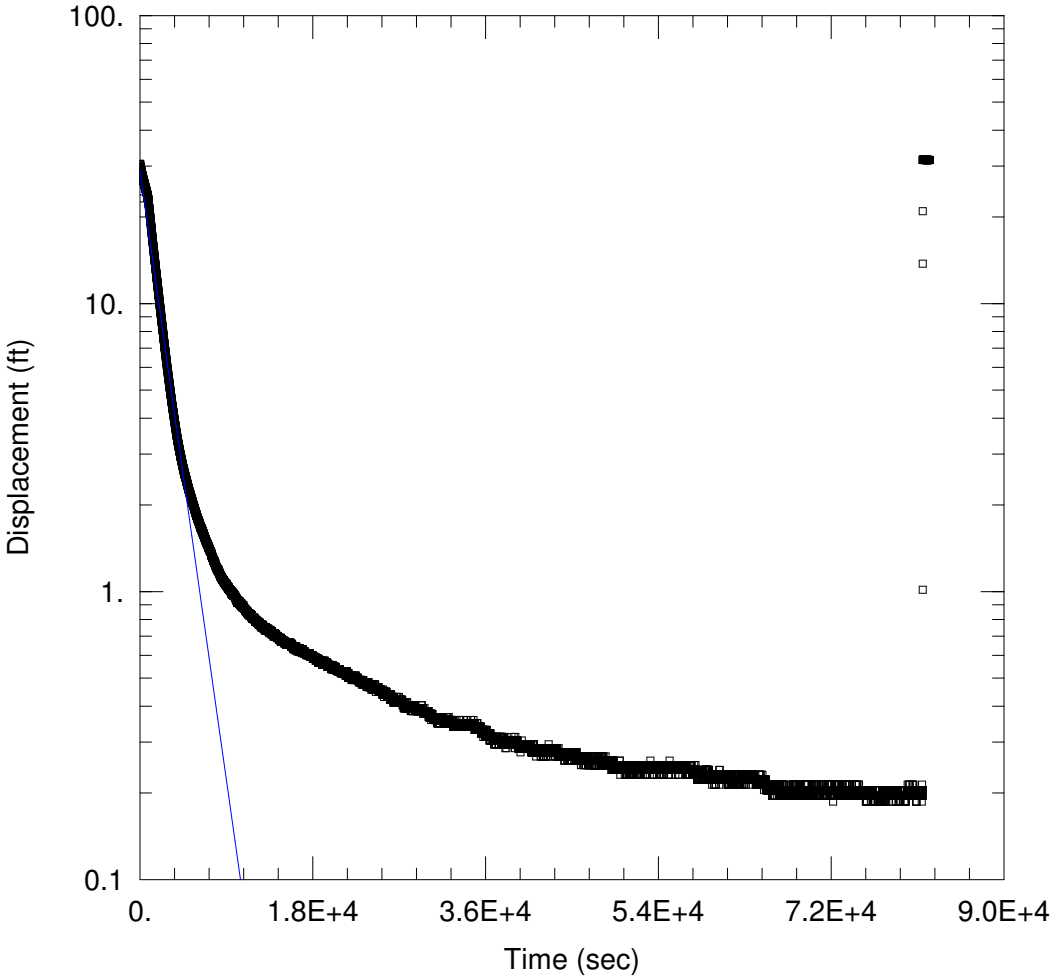
WELL DATA (MW-2)

Initial Displacement: 23.2 ft
Total Well Penetration Depth: 24.88 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 27.71 ft
Screen Length: 10. ft
Well Radius: 0.2604 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 6.072E-5 cm/sec
y0 = 32.31 ft



MW-3 RISING HEAD TEST

Data Set: Z:\...\MW-3_test_HV.aqt
Date: 08/31/17 Time: 11:03:10

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-3
Test Date: 6/14/2017

AQUIFER DATA

Saturated Thickness: 33.29 ft Anisotropy Ratio (Kz/Kr): 1.

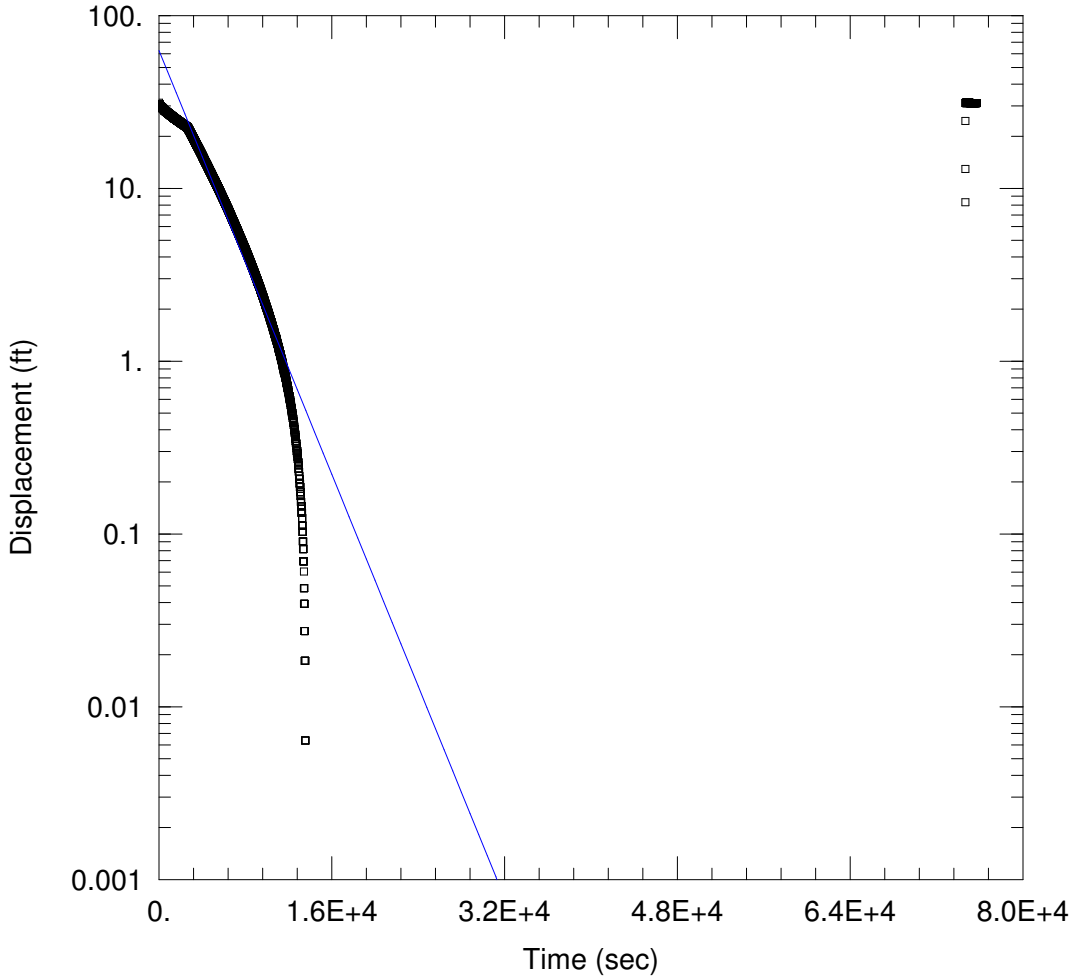
WELL DATA (MW-2)

Initial Displacement: 23.2 ft Static Water Column Height: 27.71 ft
Total Well Penetration Depth: 24.88 ft Screen Length: 10. ft
Casing Radius: 0.0833 ft Well Radius: 0.2604 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 1.819E-5 cm/sec y0 = 29.04 ft



MW-4 RISING HEAD TEST

Data Set: Z:\...\MW-4_test_BR.aqt
Date: 08/31/17 Time: 11:05:18

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-4
Test Date: 6/13/2017

AQUIFER DATA

Saturated Thickness: 34.86 ft
Anisotropy Ratio (Kz/Kr): 1.

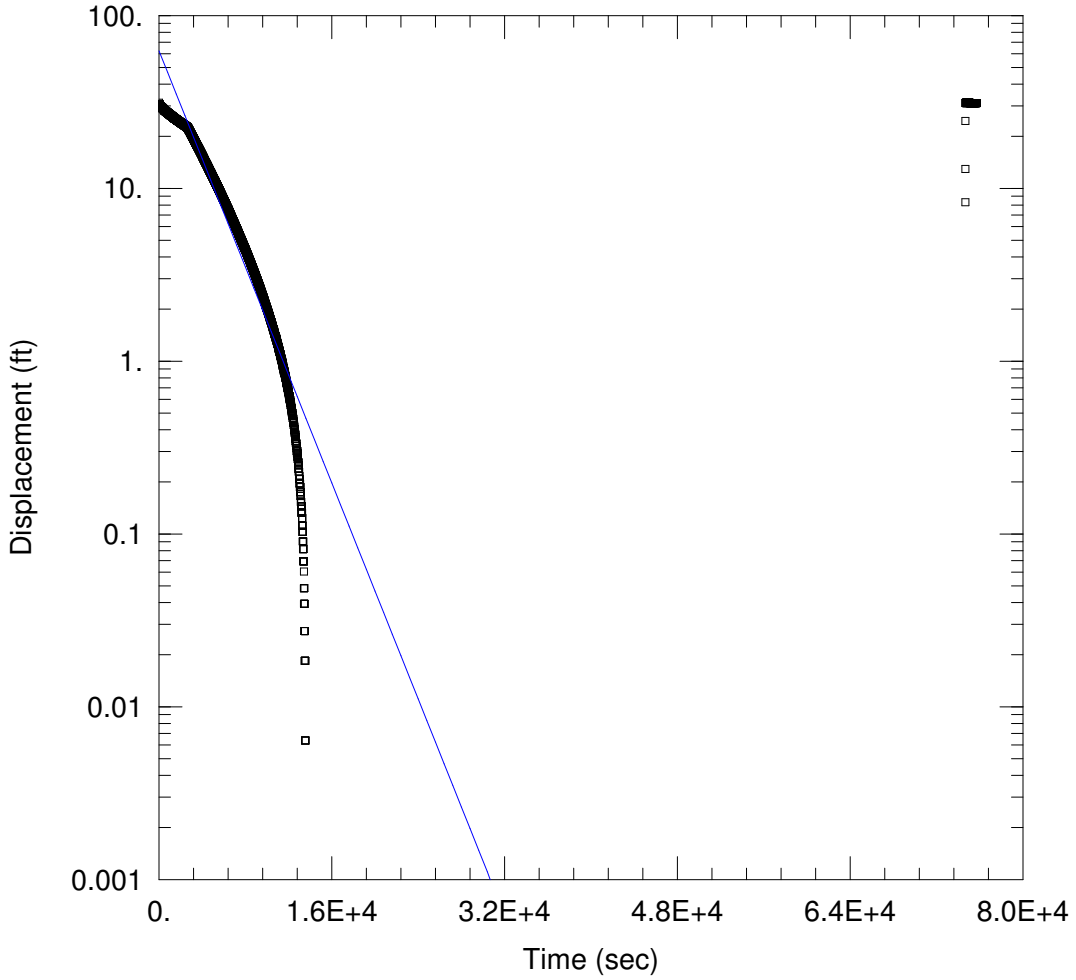
WELL DATA (MW-4)

Initial Displacement: 31.26 ft
Total Well Penetration Depth: 34.48 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 34.86 ft
Screen Length: 10. ft
Well Radius: 0.2604 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 4.358E-5 cm/sec
y0 = 62.79 ft



MW-4 RISING HEAD TEST

Data Set: Z:\...\MW-4_test_HV.aqt
Date: 08/31/17 Time: 11:06:30

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-4
Test Date: 6/13/2017

AQUIFER DATA

Saturated Thickness: 34.86 ft
Anisotropy Ratio (Kz/Kr): 1.

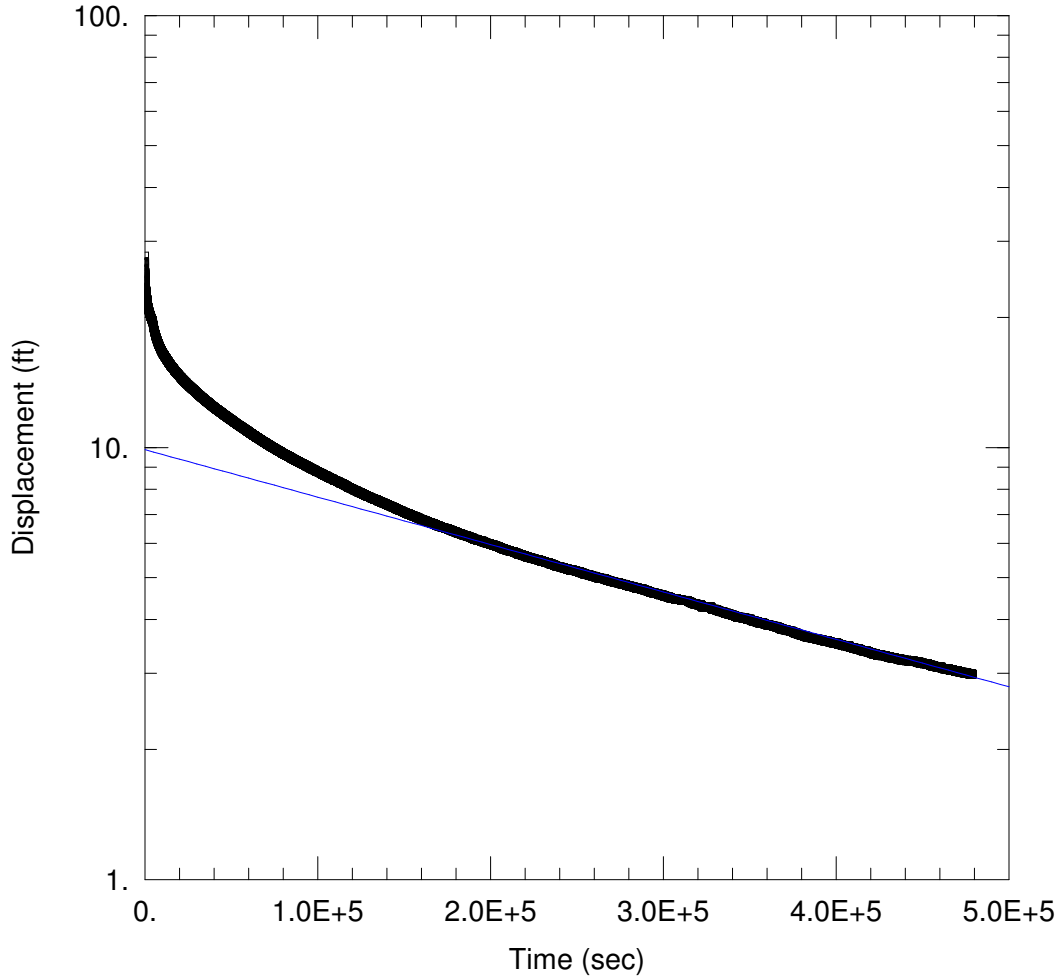
WELL DATA (MW-4)

Initial Displacement: 31.26 ft
Total Well Penetration Depth: 34.48 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 34.86 ft
Screen Length: 10. ft
Well Radius: 0.2604 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 1.208E-5 cm/sec
y0 = 62.45 ft



MW-5 RISING HEAD TEST

Data Set: Z:\...\MW-5_test_BR.aqt
Date: 08/31/17 Time: 11:07:35

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-5
Test Date: 6/19/2017

AQUIFER DATA

Saturated Thickness: 27.73 ft
Anisotropy Ratio (Kz/Kr): 1.

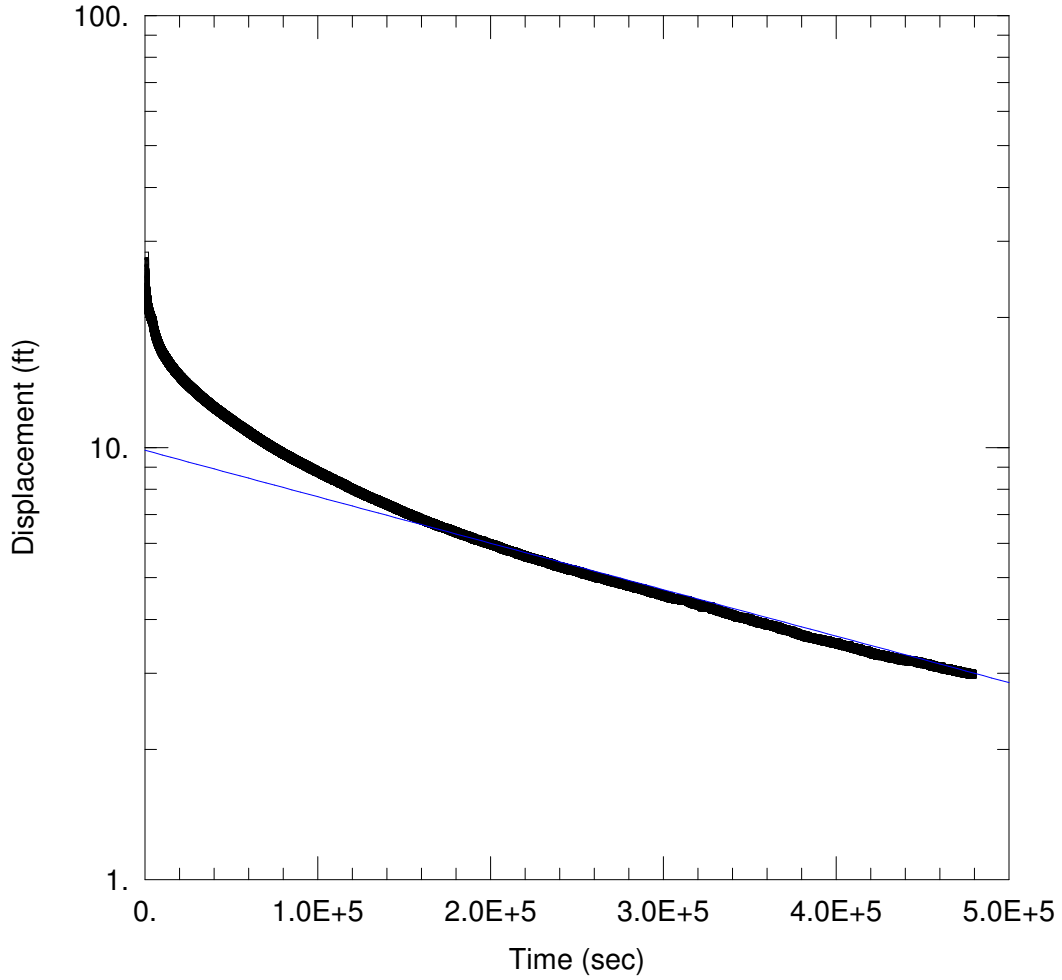
WELL DATA (MW-5)

Initial Displacement: 27.8 ft
Total Well Penetration Depth: 20.39 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 27.73 ft
Screen Length: 10.01 ft
Well Radius: 0.2604 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 2.59E-7 cm/sec
y0 = 9.884 ft



MW-5 RISING HEAD TEST

Data Set: Z:\...\MW-5_test_HV.aqt
Date: 08/31/17 Time: 11:08:40

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-5
Test Date: 6/19/2017

AQUIFER DATA

Saturated Thickness: 27.73 ft Anisotropy Ratio (Kz/Kr): 1.

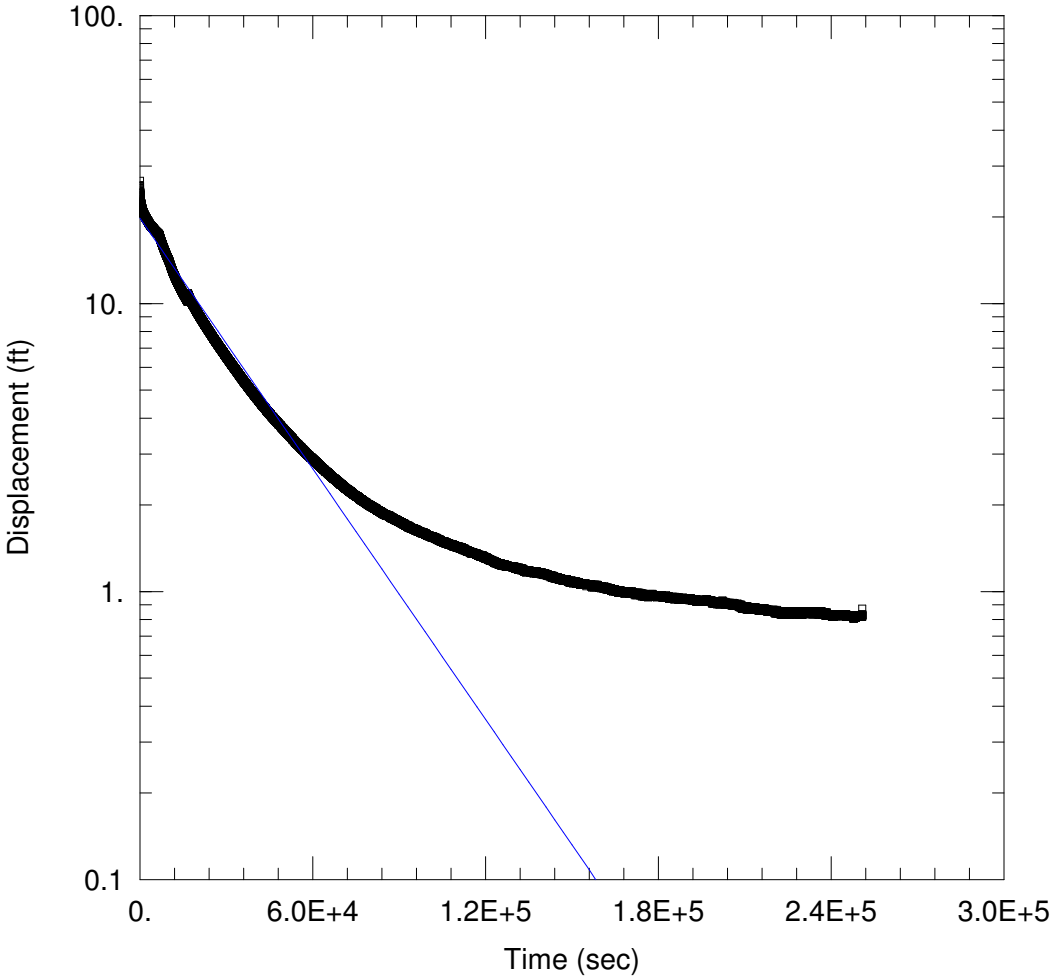
WELL DATA (MW-5)

Initial Displacement: 27.8 ft Static Water Column Height: 27.73 ft
Total Well Penetration Depth: 20.39 ft Screen Length: 10.01 ft
Casing Radius: 0.0833 ft Well Radius: 0.2604 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 8.308E-8 cm/sec y0 = 9.852 ft



MW-6 RISING HEAD TEST

Data Set: Z:\...\MW-6_test_BR.aqt
Date: 08/31/17 Time: 11:09:48

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-6
Test Date: 6/19/2017

AQUIFER DATA

Saturated Thickness: 26.68 ft
Anisotropy Ratio (Kz/Kr): 1.

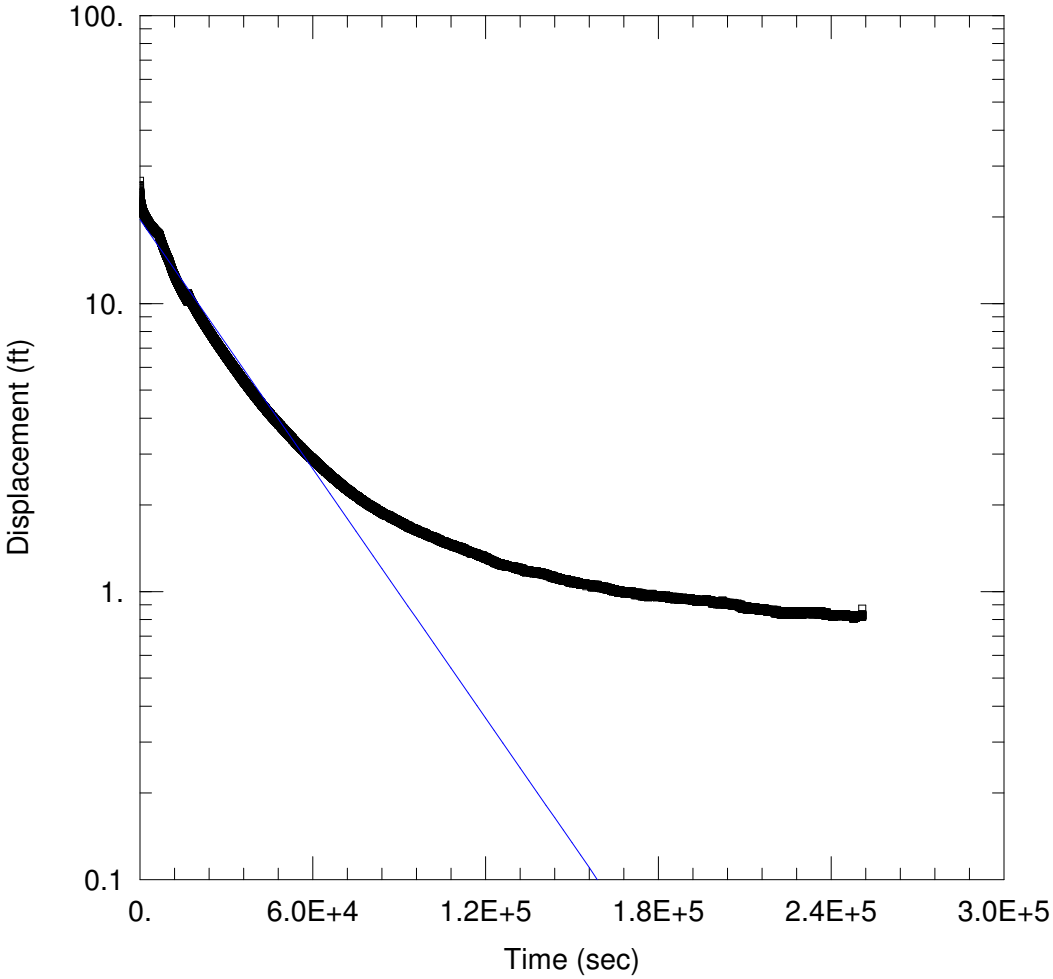
WELL DATA (MW-6)

Initial Displacement: 26.68 ft
Total Well Penetration Depth: 26.31 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 26.68 ft
Screen Length: 10.01 ft
Well Radius: 0.2604 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 3.949E-6 cm/sec
y0 = 19.77 ft



MW-6 RISING HEAD TEST

Data Set: Z:\...\MW-6_test_HV.aqt
Date: 08/31/17 Time: 11:10:55

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-6
Test Date: 6/19/2017

AQUIFER DATA

Saturated Thickness: 26.68 ft Anisotropy Ratio (Kz/Kr): 1.

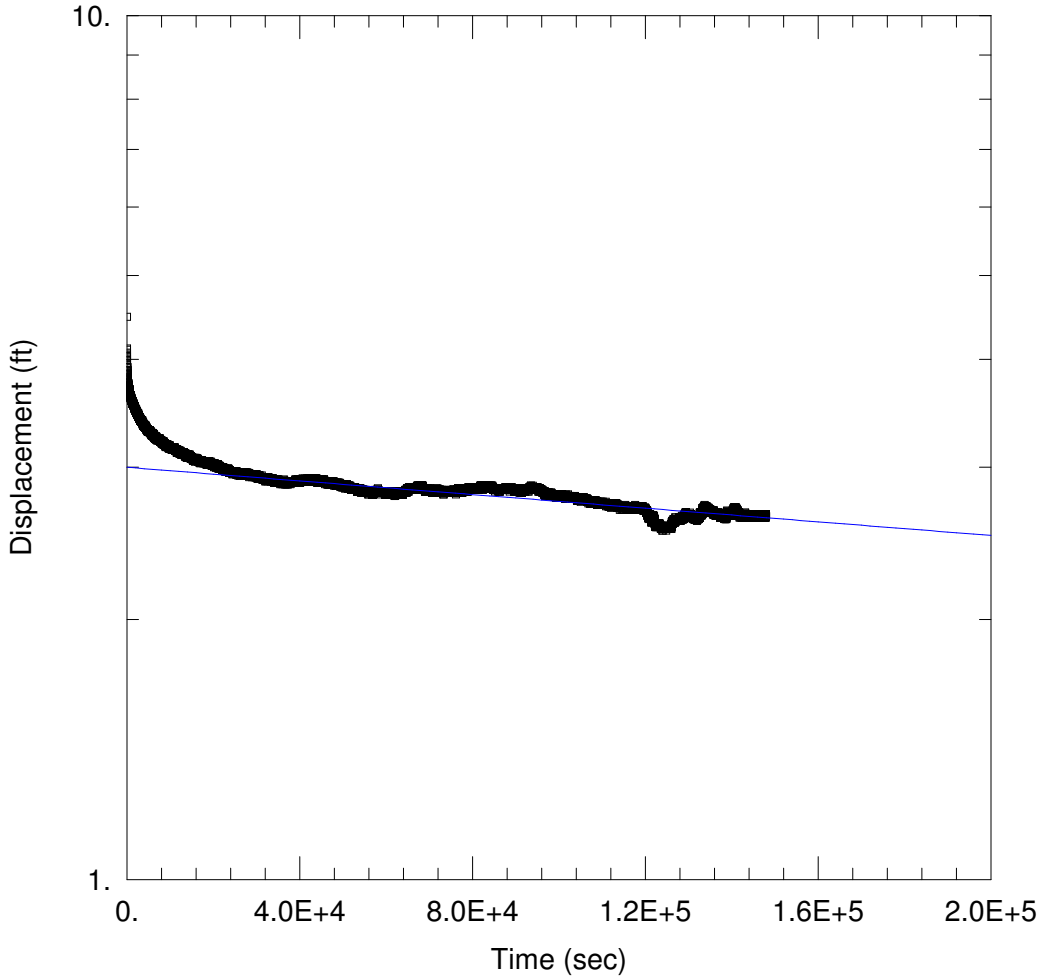
WELL DATA (MW-6)

Initial Displacement: 26.68 ft Static Water Column Height: 26.68 ft
Total Well Penetration Depth: 26.31 ft Screen Length: 10.01 ft
Casing Radius: 0.0833 ft Well Radius: 0.2604 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 1.114E-6 cm/sec y0 = 19.55 ft



MW-7 RISING HEAD TEST #1

Data Set: Z:\...\MW-7_test1_BR.aqt
Date: 08/31/17 Time: 11:12:43

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-7
Test Date: 6/13/2017

AQUIFER DATA

Saturated Thickness: 4.48 ft
Anisotropy Ratio (Kz/Kr): 1.

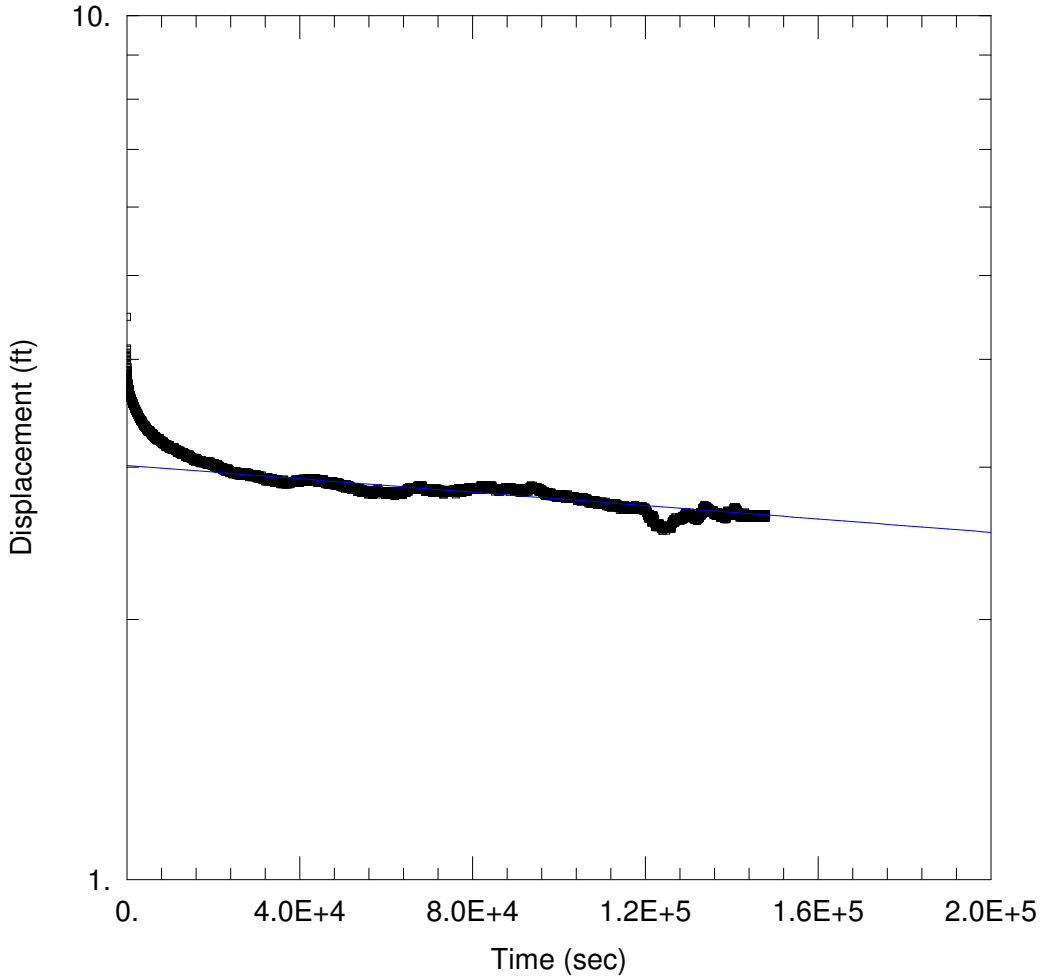
WELL DATA (MW-7)

Initial Displacement: 4.48 ft
Total Well Penetration Depth: 10.01 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 4.48 ft
Screen Length: 10.01 ft
Well Radius: 0.2604 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.911E-7 cm/sec
y0 = 3. ft



MW-7 RISING HEAD TEST #1

Data Set: Z:\...\MW-7_test1_HV.aqt
Date: 08/31/17 Time: 11:13:38

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-7
Test Date: 6/13/2017

AQUIFER DATA

Saturated Thickness: 4.48 ft Anisotropy Ratio (Kz/Kr): 1.

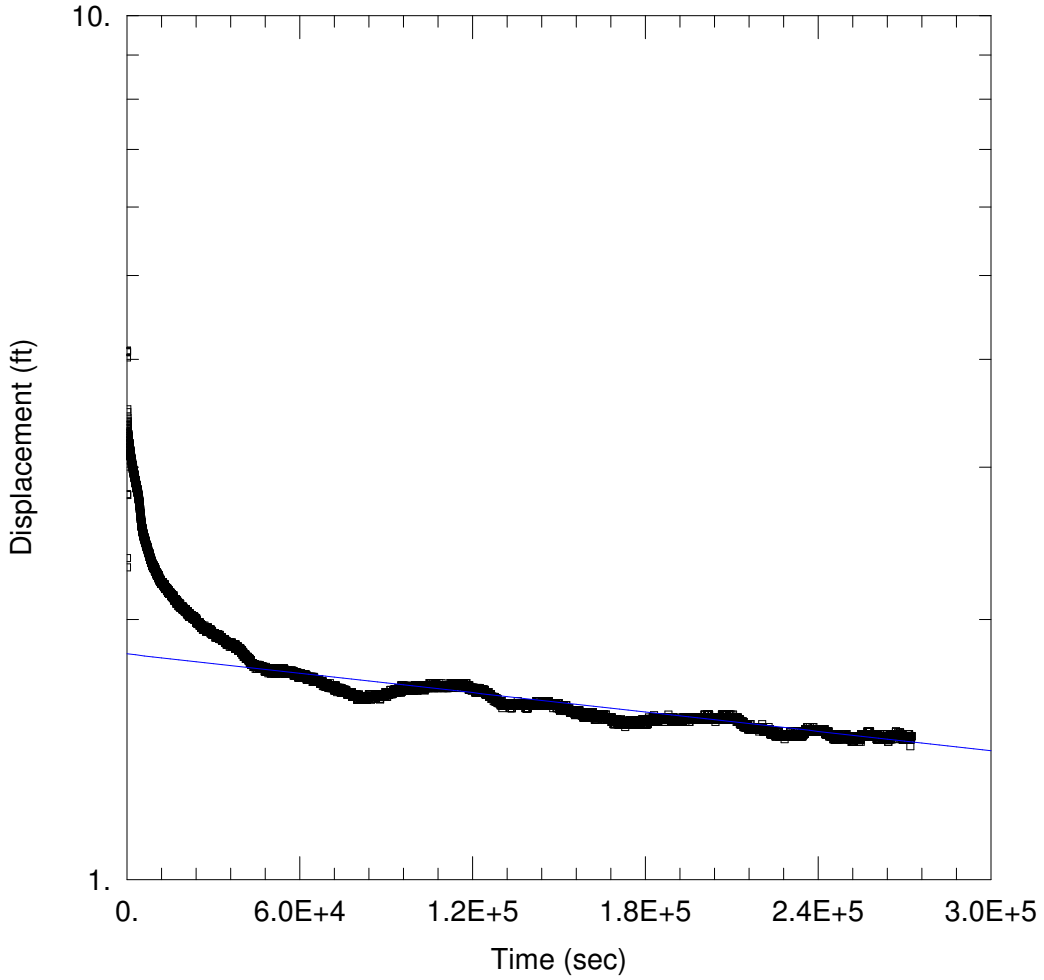
WELL DATA (MW-7)

Initial Displacement: 4.48 ft Static Water Column Height: 4.48 ft
Total Well Penetration Depth: 10.01 ft Screen Length: 10.01 ft
Casing Radius: 0.0833 ft Well Radius: 0.2604 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 9.705E-8 cm/sec y0 = 3.015 ft



MW-7 RISING HEAD TEST #2

Data Set: Z:\...\MW-7_test2_BR.aqt
Date: 08/31/17 Time: 11:14:49

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-7
Test Date: 6/19/2017

AQUIFER DATA

Saturated Thickness: 4.02 ft
Anisotropy Ratio (Kz/Kr): 1.

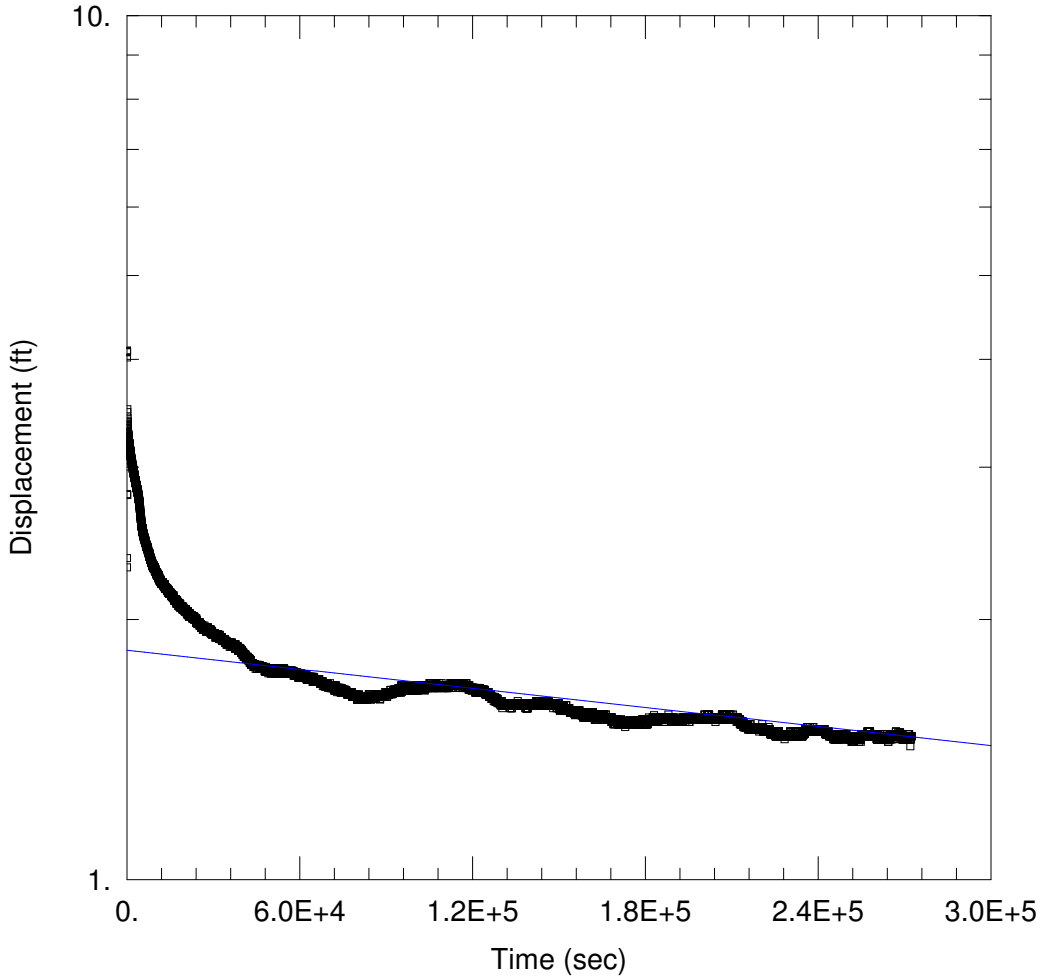
WELL DATA (MW-7)

Initial Displacement: 4.02 ft
Total Well Penetration Depth: 10.01 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 4.02 ft
Screen Length: 10.01 ft
Well Radius: 0.2604 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.984E-7 cm/sec
y0 = 1.824 ft



MW-7 RISING HEAD TEST #2

Data Set: Z:\...\MW-7_test2_HV.aqt
Date: 08/31/17 Time: 11:16:23

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-7
Test Date: 6/19/2017

AQUIFER DATA

Saturated Thickness: 4.02 ft Anisotropy Ratio (Kz/Kr): 1.

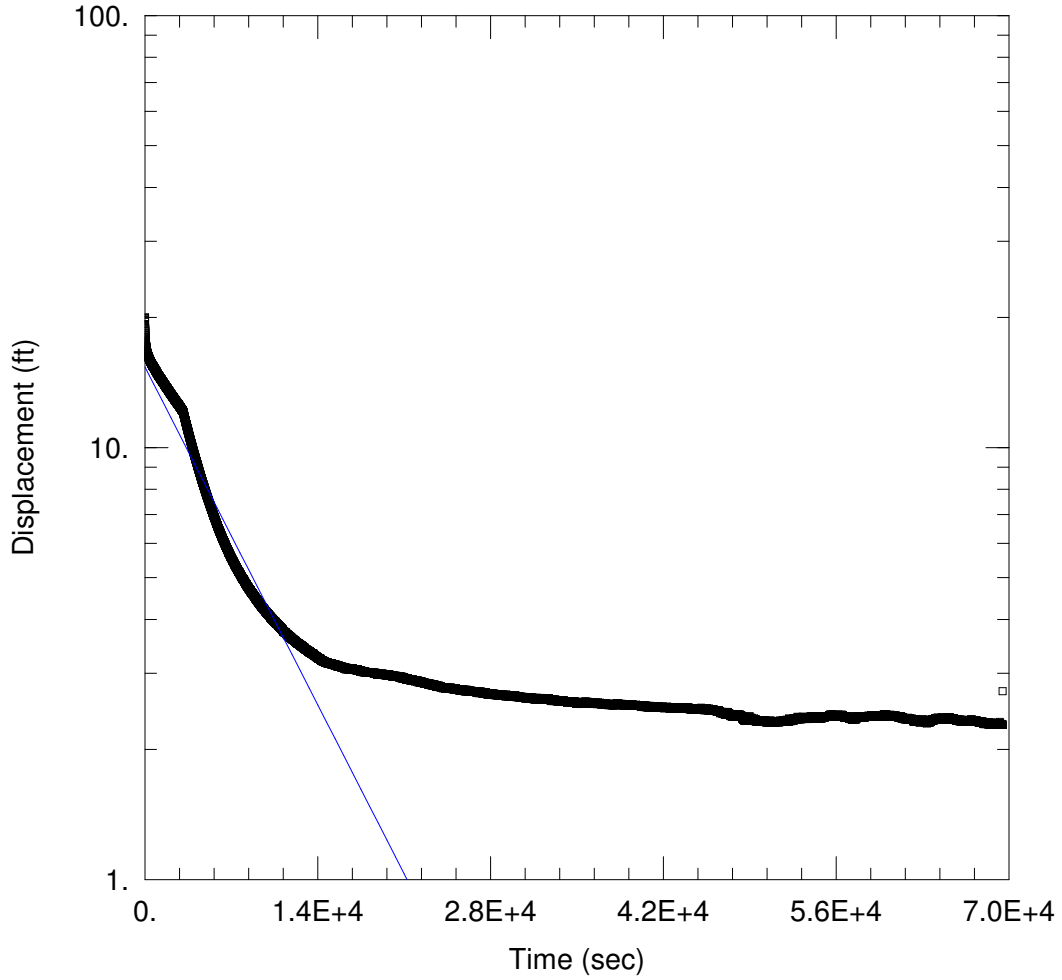
WELL DATA (MW-7)

Initial Displacement: 4.02 ft Static Water Column Height: 4.02 ft
Total Well Penetration Depth: 10.01 ft Screen Length: 10.01 ft
Casing Radius: 0.0833 ft Well Radius: 0.2604 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 1.027E-7 cm/sec y0 = 1.842 ft



MW-8 RISING HEAD TEST

Data Set: Z:\...\MW-8_test_BR.aqt
Date: 08/31/17 Time: 11:17:23

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-8
Test Date: 6/14/2017

AQUIFER DATA

Saturated Thickness: 19.96 ft
Anisotropy Ratio (Kz/Kr): 1.

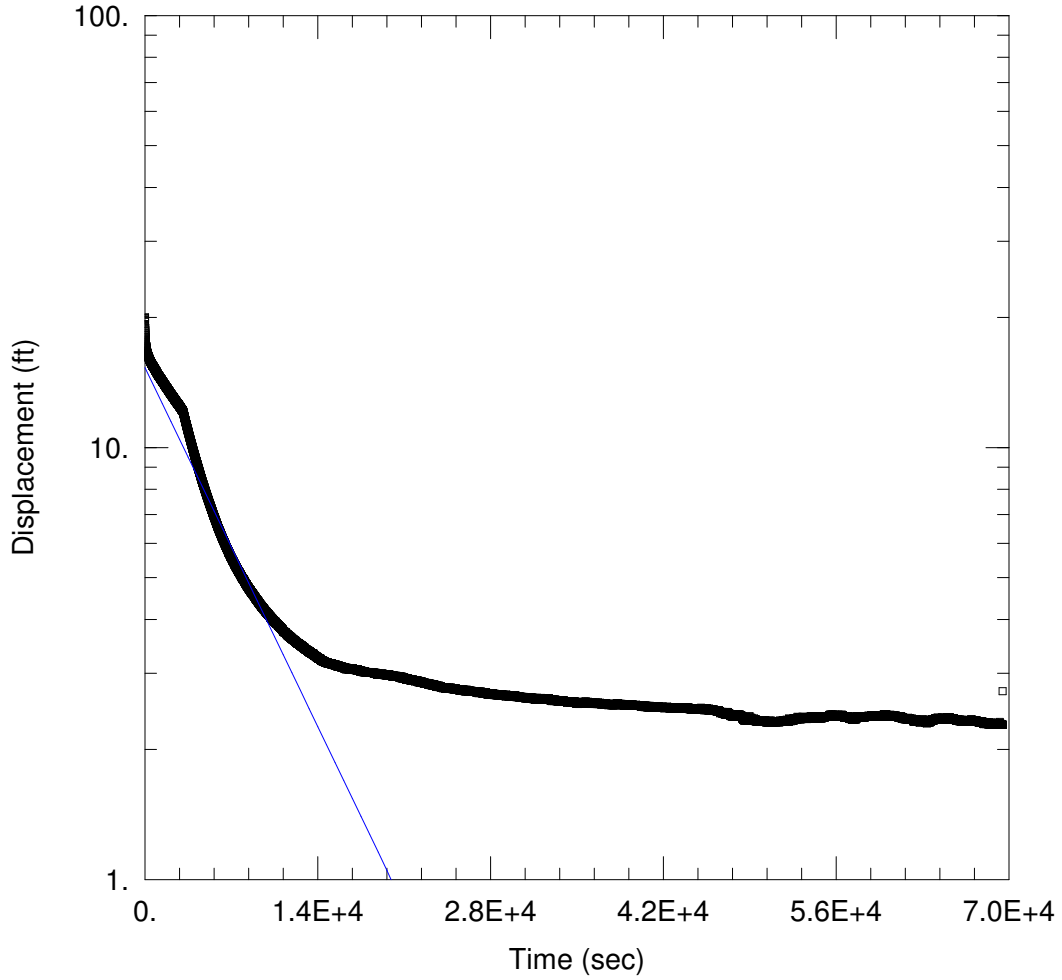
WELL DATA (MW-8)

Initial Displacement: 19.96 ft
Total Well Penetration Depth: 19.59 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 19.96 ft
Screen Length: 10.01 ft
Well Radius: 0.2604 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.446E-5 cm/sec
y0 = 15.36 ft



MW-8 RISING HEAD TEST

Data Set: Z:\...\MW-8_test_HV.aqt
Date: 08/31/17 Time: 11:18:18

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: MW-8
Test Date: 6/14/2017

AQUIFER DATA

Saturated Thickness: 19.96 ft Anisotropy Ratio (Kz/Kr): 1.

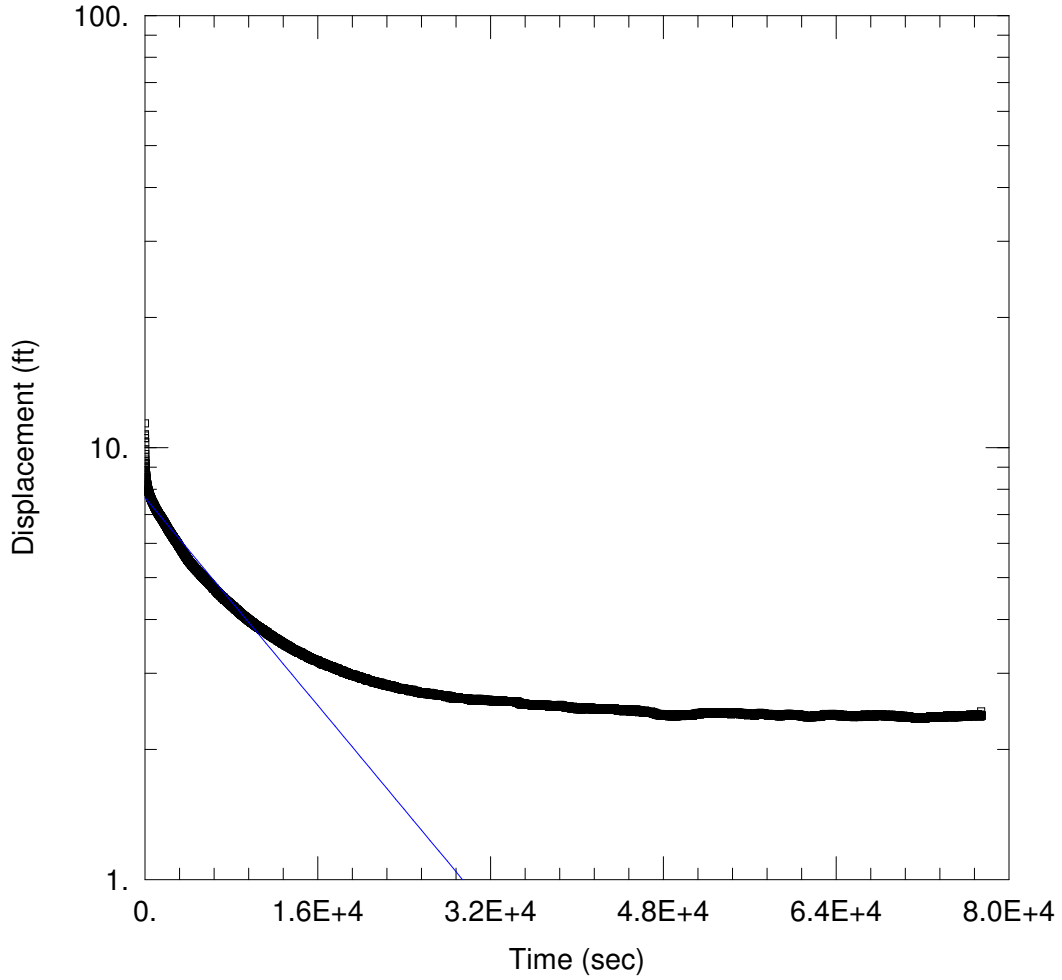
WELL DATA (MW-8)

Initial Displacement: 19.96 ft Static Water Column Height: 19.96 ft
Total Well Penetration Depth: 19.59 ft Screen Length: 10.01 ft
Casing Radius: 0.0833 ft Well Radius: 0.2604 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 4.587E-6 cm/sec y0 = 15.32 ft



PZ-2 RISING HEAD TEST

Data Set: Z:\...\PZ-2_test_BR.aqt
Date: 08/31/17 Time: 11:19:17

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: PZ-2
Test Date: 6/15/2017

AQUIFER DATA

Saturated Thickness: 11.53 ft
Anisotropy Ratio (Kz/Kr): 1.

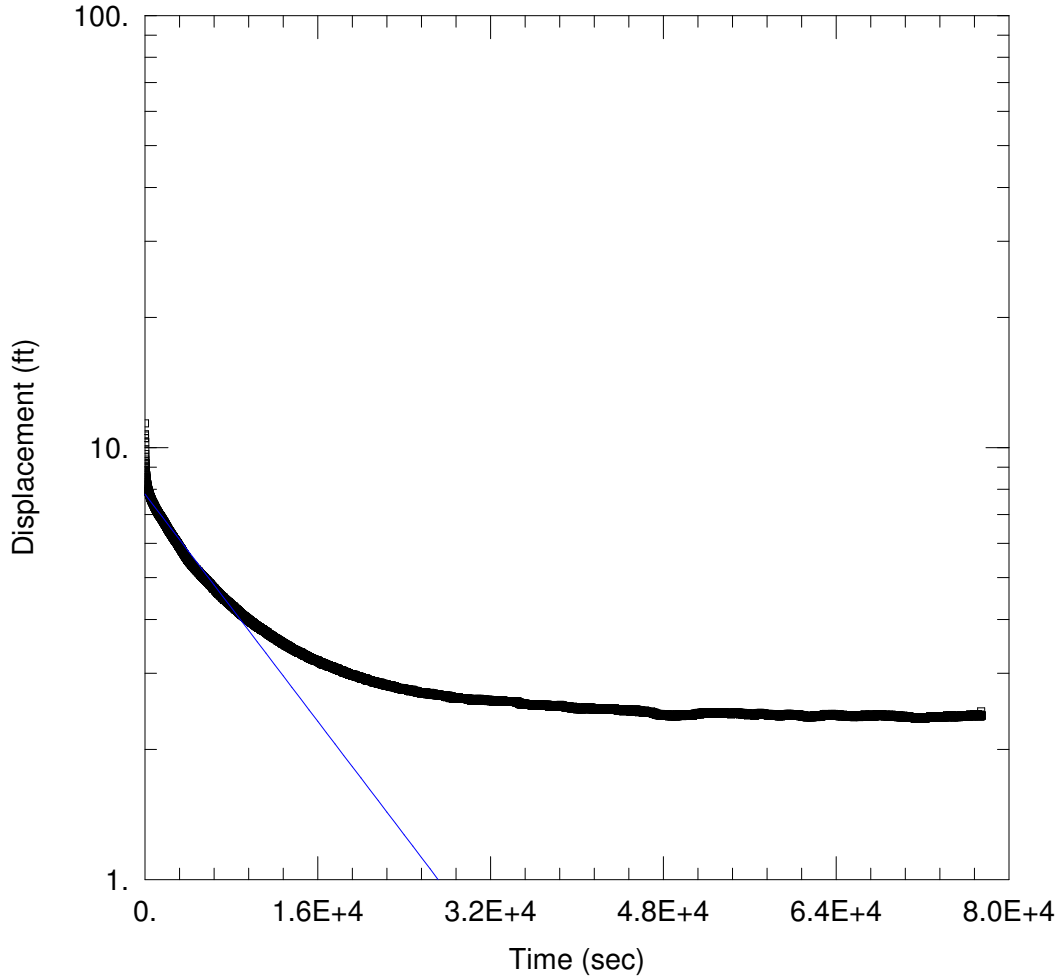
WELL DATA (PZ-2)

Initial Displacement: 11.37 ft
Total Well Penetration Depth: 20. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 11.53 ft
Screen Length: 20. ft
Well Radius: 0.2604 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 7.206E-6 cm/sec
y0 = 7.655 ft



PZ-2 RISING HEAD TEST

Data Set: Z:\...\PZ-2_test_HV.aqt
Date: 08/31/17 Time: 11:20:07

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: PZ-2
Test Date: 6/15/2017

AQUIFER DATA

Saturated Thickness: 11.53 ft Anisotropy Ratio (Kz/Kr): 1.

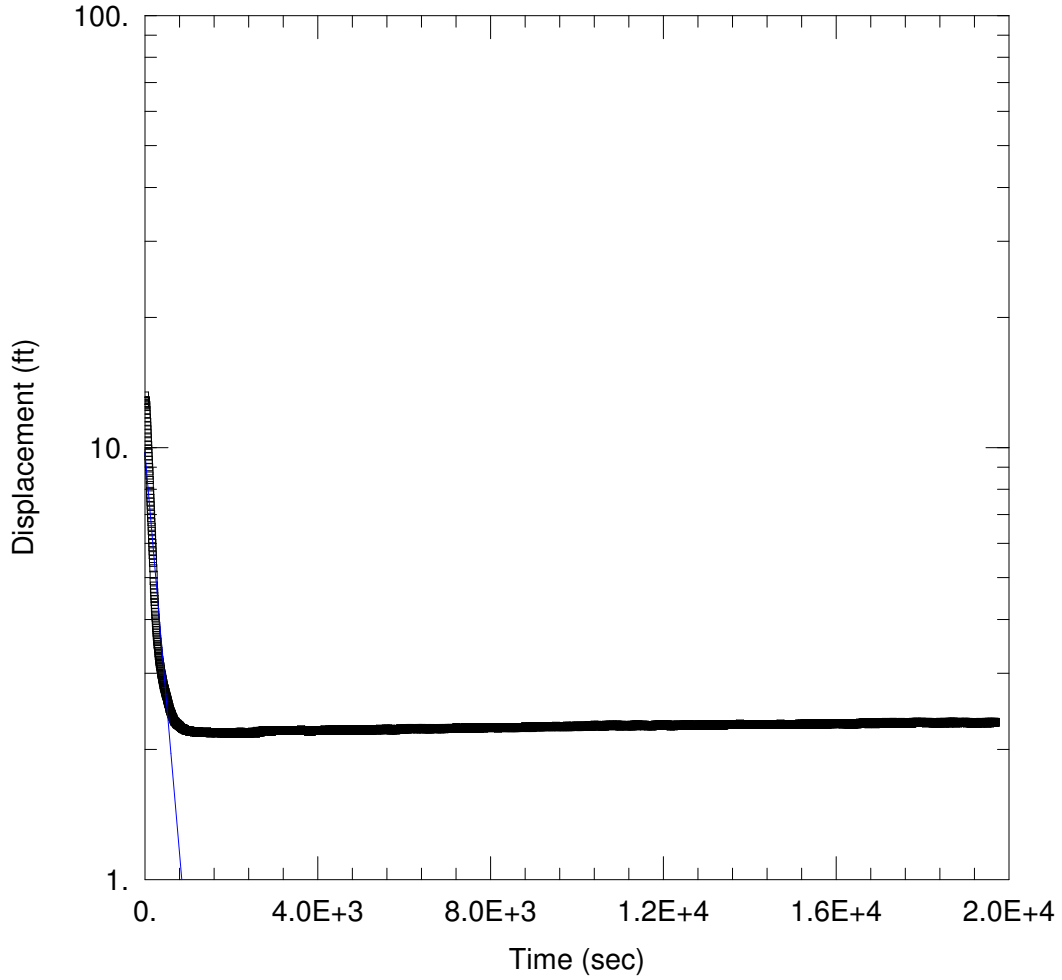
WELL DATA (PZ-2)

Initial Displacement: 11.37 ft Static Water Column Height: 11.53 ft
Total Well Penetration Depth: 20. ft Screen Length: 20. ft
Casing Radius: 0.0833 ft Well Radius: 0.2604 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 3.2E-6 cm/sec y0 = 7.798 ft



PZ-4 RISING HEAD TEST

Data Set: Z:\...\PZ-4_test_BR.aqt
Date: 08/31/17 Time: 11:21:09

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: PZ-4
Test Date: 6/15/2017

AQUIFER DATA

Saturated Thickness: 13.19 ft
Anisotropy Ratio (Kz/Kr): 1.

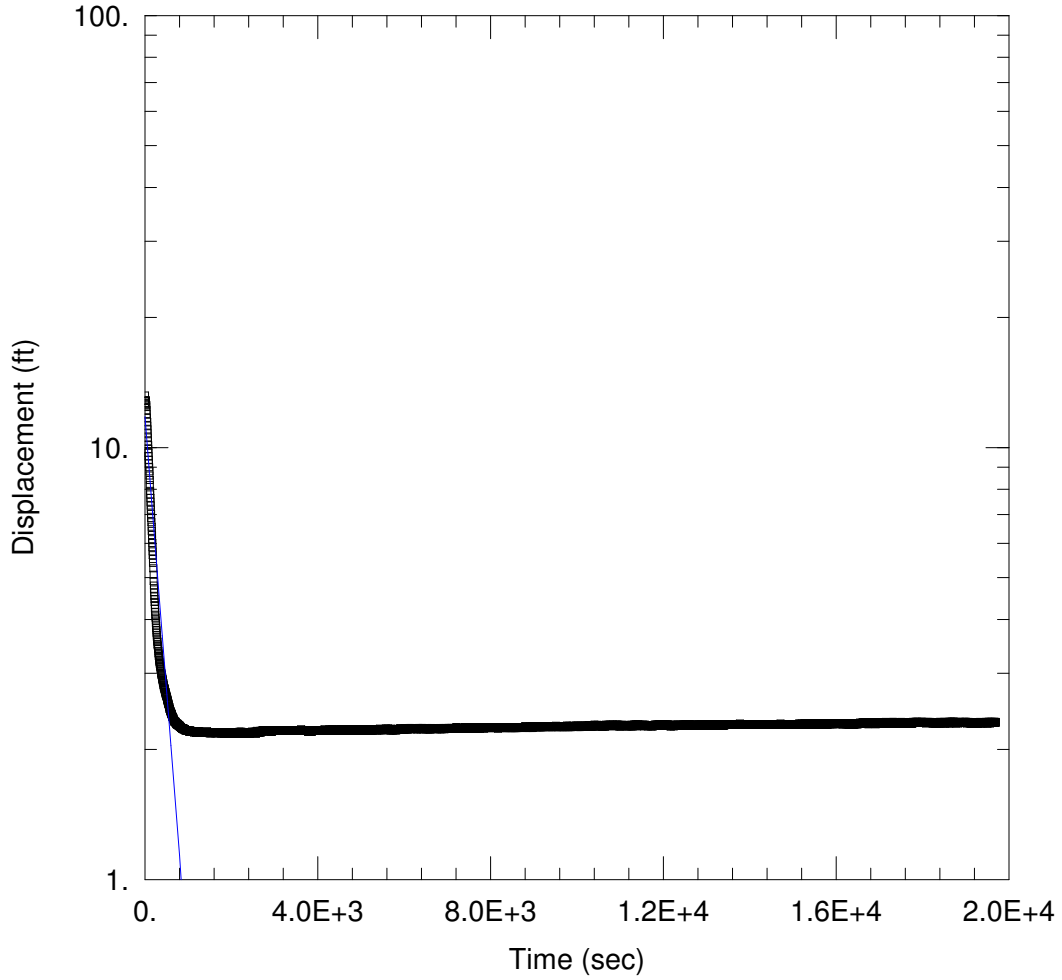
WELL DATA (PZ-4)

Initial Displacement: 13.19 ft
Total Well Penetration Depth: 20. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 13.19 ft
Screen Length: 20. ft
Well Radius: 0.2604 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.0002449 cm/sec
y0 = 9.72 ft



PZ-4 RISING HEAD TEST

Data Set: Z:\...\PZ-4_test_HV.aqt
Date: 08/31/17 Time: 11:22:07

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: PZ-4
Test Date: 6/15/2017

AQUIFER DATA

Saturated Thickness: 13.19 ft
Anisotropy Ratio (Kz/Kr): 1.

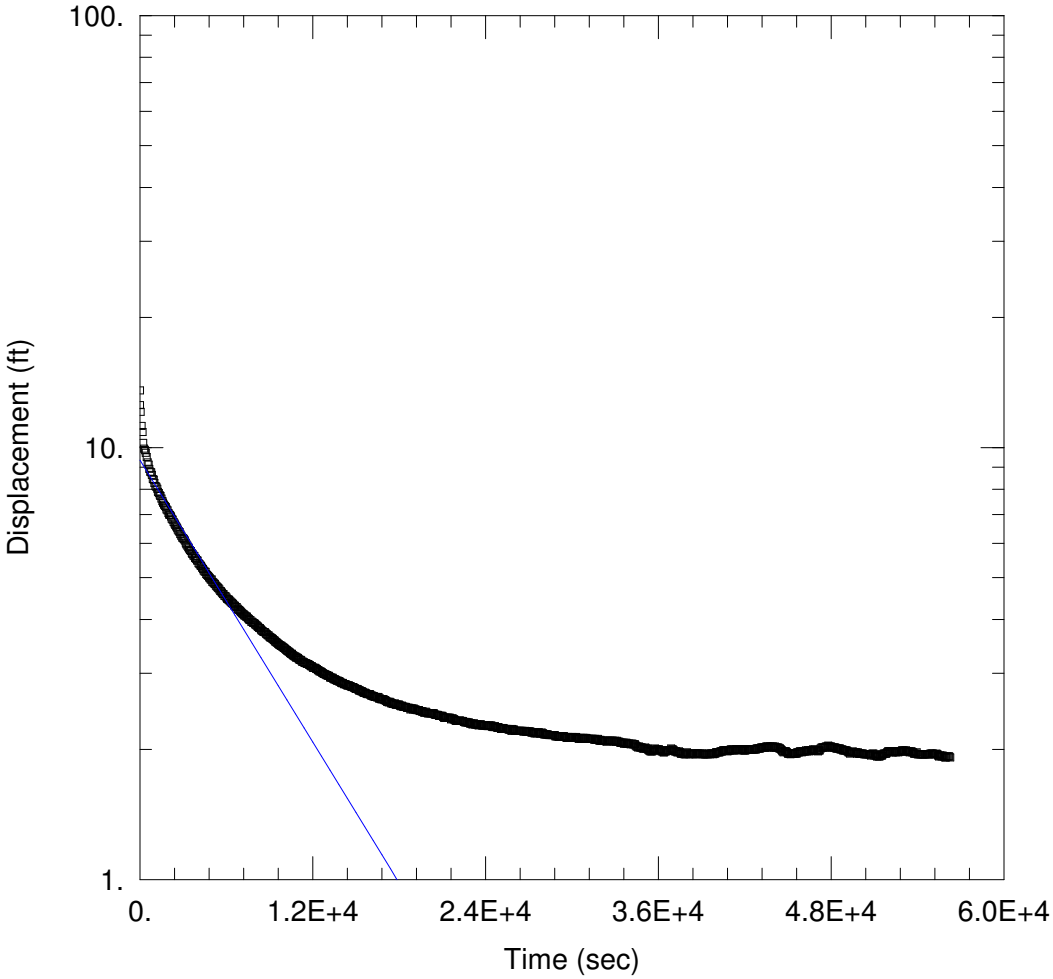
WELL DATA (PZ-4)

Initial Displacement: 13.19 ft
Static Water Column Height: 13.19 ft
Total Well Penetration Depth: 20. ft
Screen Length: 20. ft
Casing Radius: 0.0833 ft
Well Radius: 0.2604 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.0001081 cm/sec
y0 = 11.79 ft



PZ-6 RISING HEAD TEST

Data Set: Z:\...\PZ-6_test_BR.aqt
Date: 08/31/17 Time: 11:23:08

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: PZ-6
Test Date: 6/14/2017

AQUIFER DATA

Saturated Thickness: 13.56 ft
Anisotropy Ratio (Kz/Kr): 1.

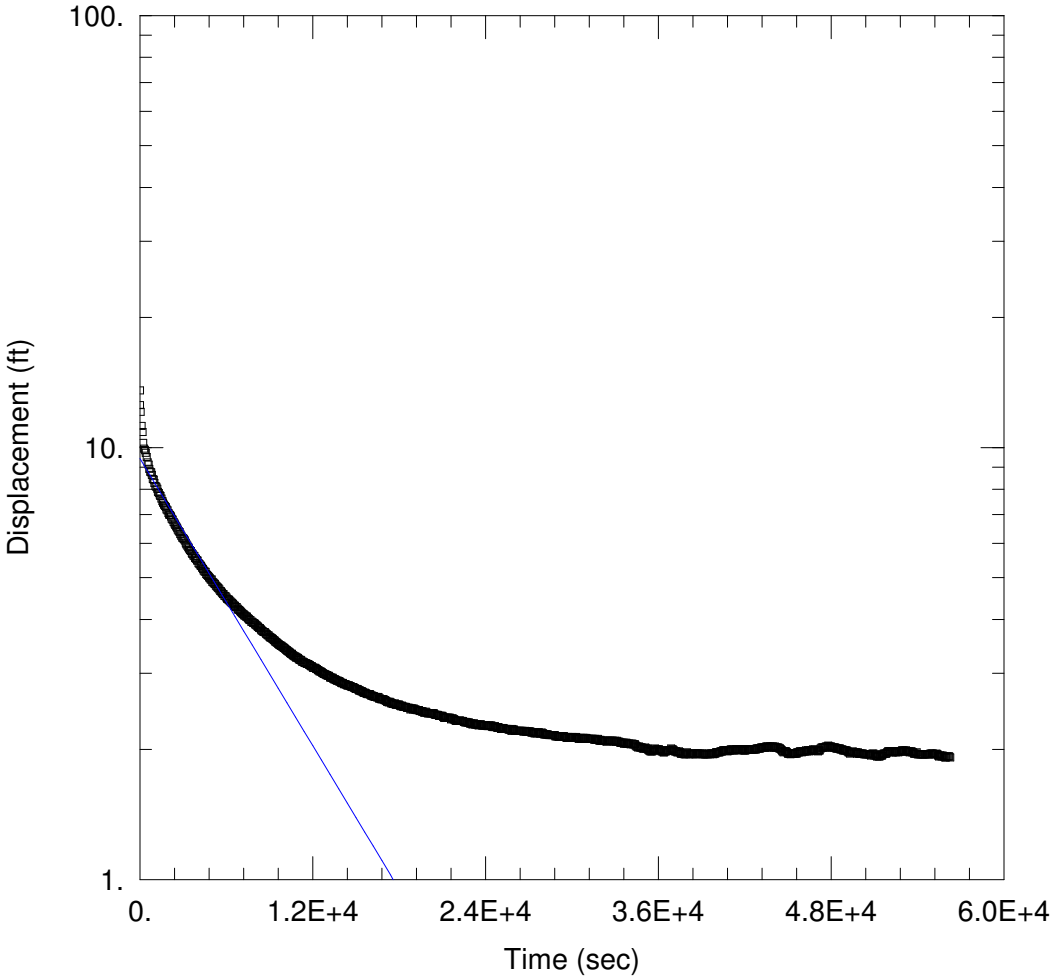
WELL DATA (PZ-6)

Initial Displacement: 13.56 ft
Total Well Penetration Depth: 20. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 13.56 ft
Screen Length: 20. ft
Well Radius: 0.2604 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.119E-5 cm/sec
y0 = 9.344 ft



PZ-6 RISING HEAD TEST

Data Set: Z:\...\PZ-6_test_HV.aqt
Date: 08/31/17 Time: 11:23:52

PROJECT INFORMATION

Company: Burns & McDonnell
Client: CMMP
Project: 93647
Location: Columbia, MO
Test Well: PZ-6
Test Date: 6/14/2017

AQUIFER DATA

Saturated Thickness: 13.56 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (PZ-6)

Initial Displacement: 13.56 ft Static Water Column Height: 13.56 ft
Total Well Penetration Depth: 20. ft Screen Length: 20. ft
Casing Radius: 0.0833 ft Well Radius: 0.2604 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 4.584E-6 cm/sec y0 = 9.421 ft

APPENDIX L – WELL YIELD TEST RESULTS

Well Yield Test Results
Columbia Water and Light Department - Columbia Municipal Power Plant
Columbia, Missouri

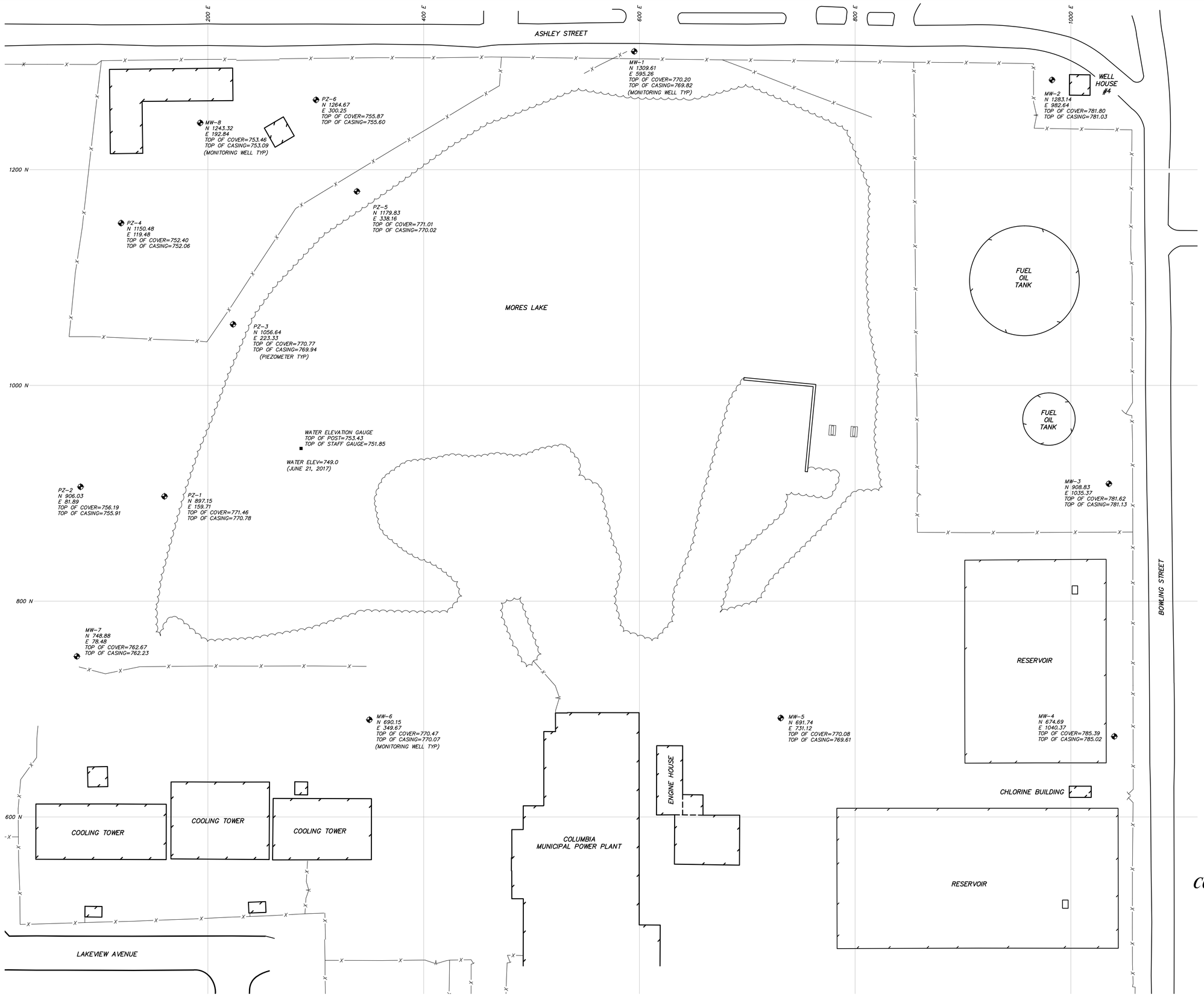
Well ID	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7(1)	MW-7(2)	MW-8	PZ-2	PZ-4	PZ-6
Test Start Time	6/14/17 10:29	6/19/17 15:05	6/13/17 11:28	6/13/17 13:52	6/19/17 12:26	6/19/17 11:32	6/13/17 15:44	6/19/17 10:10	6/14/17 12:16	6/15/17 10:08	6/15/17 10:49	6/14/17 15:37
Static WL (feet bTOC)	28.14	27.71	16.29	22.3	13.45	15.15	28.98	29.44	7.96	8.47	6.81	6.44
TD (feet bTOC)	42.87	52.96	49.58	57.16	41.18	41.83	33.46	33.46	27.92	19.80	20.13	20.16
Water Column (feet)	14.73	25.25	33.29	34.86	27.73	26.68	4.48	4.02	19.96	11.33	13.32	13.72
Well Volume (gallons)	2.40	4.12	5.43	5.69	4.53	4.35	0.73	0.66	3.26	1.85	2.17	2.24
Bailed Volume (gallons)	6.79	107.50	11.50	11.20	9.30	9.30	1.00	1.32	6.40	3.72	7.13	6.40
WL Recovery (feet bTOC)	28.14	28.27	16.44	22.77	14.11	16.57	29.70	29.71	9.05	8.94	6.80	6.60
Water Recovered (feet)	14.73	24.69	33.14	34.39	27.07	25.26	3.76	3.75	18.87	10.86	13.33	13.56
% Recovered	100%	98%	100%	99%	98%	95%	**84%**	93%	95%	96%	100%	99%
Test Stop Time	6/14/17 12:03	6/26/17 10:52	6/13/17 14:45	6/13/17 17:39	6/25/17 1:28	6/20/17 12:46	6/14/17 13:44	6/22/17 9:00	6/14/17 16:00	6/15/17 16:33	6/15/17 11:04	6/14/17 22:31
Time (hours)	1.56	163.78	3.28	3.77	133.03	25.22	21.99	70.83	3.73	6.40	0.25	6.90
Well Yield (gal/min)	0.072	0.011	0.058	0.050	0.0012	0.0061	0.00076	0.00031	0.029	0.0097	0.48	0.015
Well Yield (gal/hr)	4.34	0.66	3.50	2.97	0.070	0.37	0.045	0.019	1.71	0.58	28.89	0.93
Well Yield (gpd)	104.20	15.75	84.06	71.28	1.68	8.85	1.09	0.45	41.15	13.93	**693.24**	22.26
Avg. Well Yield (gal/min)	--	--	--	--	--	--	0.00053		--	--	--	--
Avg. Well Yield (gal/hr)	--	--	--	--	--	--	0.032		--	--	--	--
Avg. Well Yield (gpd)	--	--	--	--	--	--	0.77		--	--	--	--

bTOC - below top of casing
gal/min - gallons per minute
gal/hr - gallons per hour
gpd - gallons per day
TD - well total depth
WL - water level

Notes:

1. Well yield tests performed by direct field testing procedures consisting of data collection using cyclic discharge methods (TCEQ, 2010). Due to low yields only one test performed on most wells.
2. **Bold** % WL Recovered values identify well yield tests not fully completed (< 90%) and indicate low well yields.
3. **Bold** direct well yield results identify wells yielding > 150 gpd (TCEQ, 2010) and > 360 gpd (MDNR, 2006) indicating sufficient/sustainable yields.
4. Well yield test performed concurrently with slug testing (see Table 7 and Appendix K for slug test data).

APPENDIX M – WELL SURVEY REPORT



BENCH MARK

BM – CHISELED SQUARE ON SOUTHEAST CORNER OF CONCRETE BOX ON THE NORTH SIDE OF LAKEVIEW AVENUE AND 65 FEET WEST OF POPLAR STREET.
ELEVATION = 751.15

TBM – CHISELED SQUARE ON SOUTHWEST CORNER OF CONCRETE WALL LOCATED 80 FEET NORTHEAST OF THE SMOKE STACK.
ELEVATION = 775.55

TBM – CHISELED SQUARE ON WINDOW SILL LOCATED 7 FEET SOUTH OF NORTHEAST CORNER OF POWER PLANT.
ELEVATION = 770.58

TBM – CHISELED SQUARE ON NORTHEAST CORNER OF EASTERN MOST COOLING TOWER LOCATED WEST OF THE POWER PLANT.
ELEVATION = 770.59

NOTES:
1. ELEVATIONS GIVEN WERE SURVEYED ON THE NORTH RIM OF THE COVER AND THE NORTH RIM OF THE CASING.
2. INFORMATION SHOWN OTHER THAN MONITORING WELLS AND PIEZOMETERS IS BASED ON ES&S JOB #12592, DATED JANUARY 31, 2014, WAS NOT UPDATED.

6/23/2017

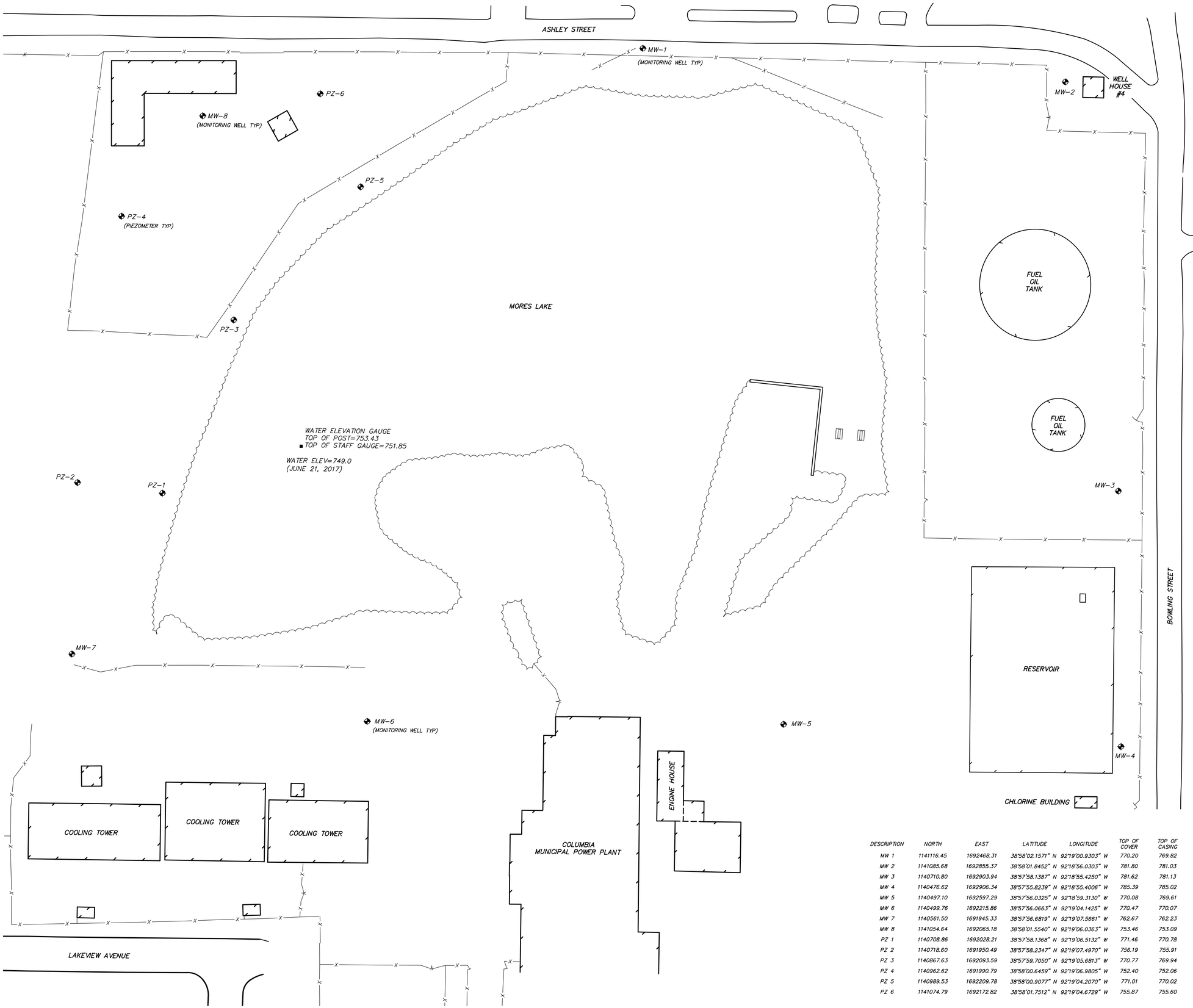
STATE OF MISSOURI
FREDERICK EMIL CARROZ III
NUMBER
PE-2004016655
PROFESSIONAL ENGINEER
PROFESSIONAL LAND SURVEYOR

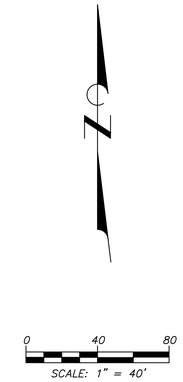
MONITORING WELL & PIEZOMETER PLAN
COLUMBIA MUNICIPAL POWER PLANT
COLUMBIA, BOONE COUNTY, MISSOURI
JUNE 23, 2017

Engineering Surveys & Services
1113 Fay Street, Columbia, Missouri 65201
573 - 449 - 2646 | www.ess-inc.com
Missouri Land Surveying Corporation # 2004004672

ES&S NO. 13452

F:\CURRENT DRAWINGS\BURNSMAC\13452\13452 EXHIBIT.DWG 10/3/2017





BENCH MARK

BM – CHISELED SQUARE ON SOUTHEAST CORNER OF CONCRETE BOX ON THE NORTH SIDE OF LAKEVIEW AVENUE AND 65 FEET WEST OF POPLAR STREET.
ELEVATION = 751.15

TBM – CHISELED SQUARE ON SOUTHWEST CORNER OF CONCRETE WALL LOCATED 80 FEET NORTHEAST OF THE SMOKE STACK.
ELEVATION = 775.55

TBM – CHISELED SQUARE ON WINDOW SILL LOCATED 7 FEET SOUTH OF NORTHEAST CORNER OF POWER PLANT.
ELEVATION = 770.58

TBM – CHISELED SQUARE ON NORTHEAST CORNER OF EASTERN MOST COOLING TOWER LOCATED WEST OF THE POWER PLANT.
ELEVATION = 770.59

NOTES:
1. ELEVATIONS GIVEN WERE SURVEYED ON THE NORTH RIM OF THE COVER AND THE NORTH RIM OF THE CASING.
2. INFORMATION SHOWN OTHER THAN MONITORING WELLS AND PIEZOMETERS IS BASED ON ES&S JOB #12592, DATED JANUARY 31, 2014, WAS NOT UPDATED.

DESCRIPTION	NORTH	EAST	LATITUDE	LONGITUDE	TOP OF COVER	TOP OF CASING
MW 1	1141116.45	1692468.31	38°58'02.1571" N	92°19'00.9303" W	770.20	769.82
MW 2	1141085.68	1692855.37	38°58'01.8452" N	92°18'56.0303" W	781.80	781.03
MW 3	1140710.80	1692903.94	38°57'58.1387" N	92°18'55.4250" W	781.62	781.13
MW 4	1140476.62	1692906.34	38°57'55.8239" N	92°18'55.4006" W	785.39	785.02
MW 5	1140497.10	1692597.29	38°57'56.0325" N	92°18'59.3130" W	770.08	769.61
MW 6	1140499.76	1692215.86	38°57'56.0663" N	92°19'04.1425" W	770.47	770.07
MW 7	1140561.50	1691945.33	38°57'56.6819" N	92°19'07.5661" W	762.67	762.23
MW 8	1141054.64	1692065.18	38°58'01.5540" N	92°19'06.0363" W	753.46	753.09
PZ 1	1140708.86	1692028.21	38°57'58.1368" N	92°19'06.5132" W	771.46	770.78
PZ 2	1140718.60	1691950.49	38°57'58.2347" N	92°19'07.4970" W	756.19	755.91
PZ 3	1140867.63	1692093.59	38°57'59.7050" N	92°19'05.6813" W	770.77	769.94
PZ 4	1140962.62	1691990.79	38°58'00.6459" N	92°19'06.9805" W	752.40	752.06
PZ 5	1140989.53	1692209.78	38°58'00.9077" N	92°19'04.2070" W	771.01	770.02
PZ 6	1141074.79	1692172.82	38°58'01.7512" N	92°19'04.6729" W	755.87	755.60

MONITORING WELL & PIEZOMETER PLAN
COLUMBIA MUNICIPAL POWER PLANT
COLUMBIA, BOONE COUNTY, MISSOURI
DECEMBER 18, 2017

Engineering Surveys & Services
1113 Fay Street, Columbia, Missouri 65201
573 - 449 - 2646 | www.ess-inc.com
Missouri Land Surveying Corporation # 2004004672

ES&S NO. 13452

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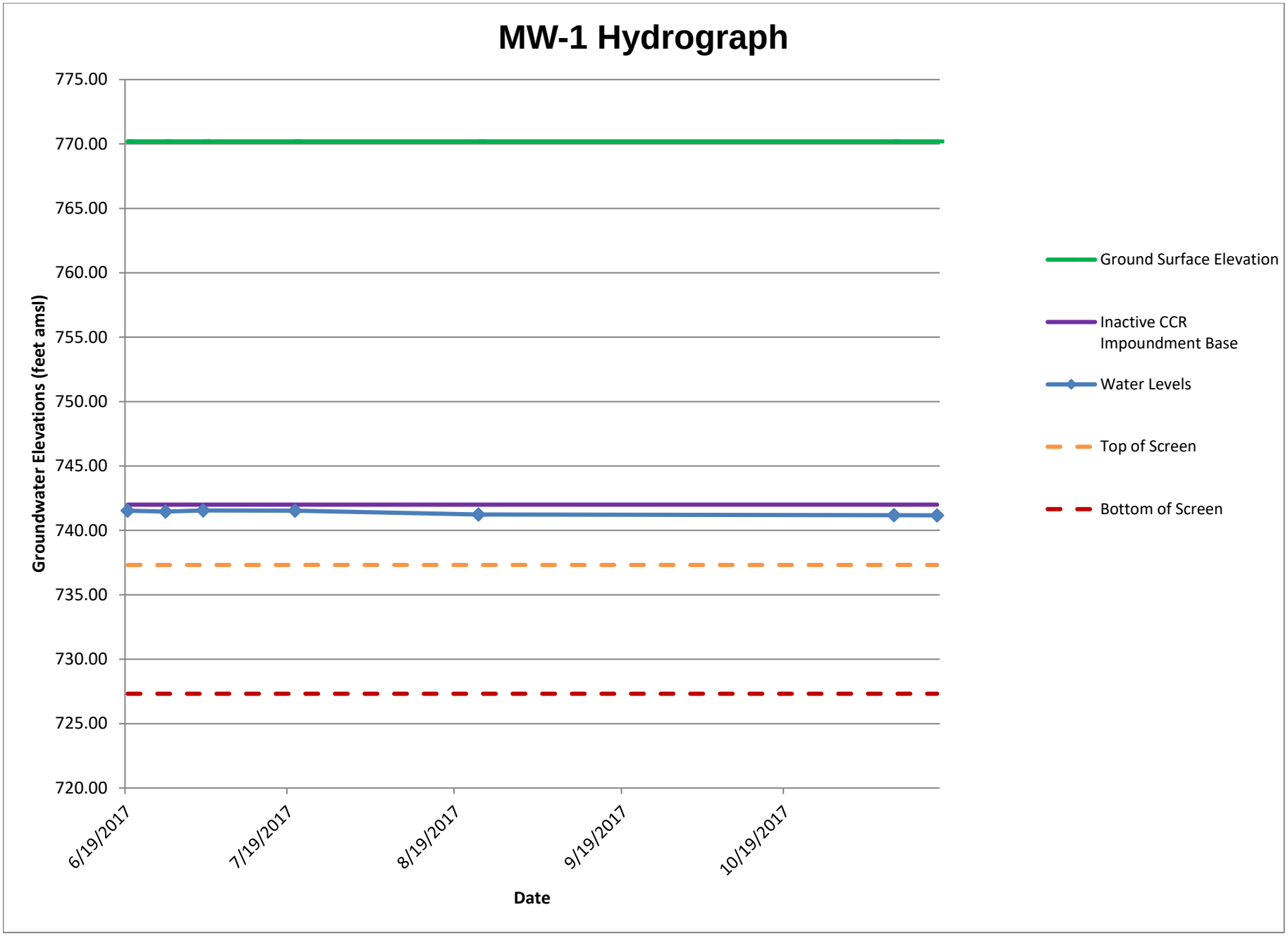
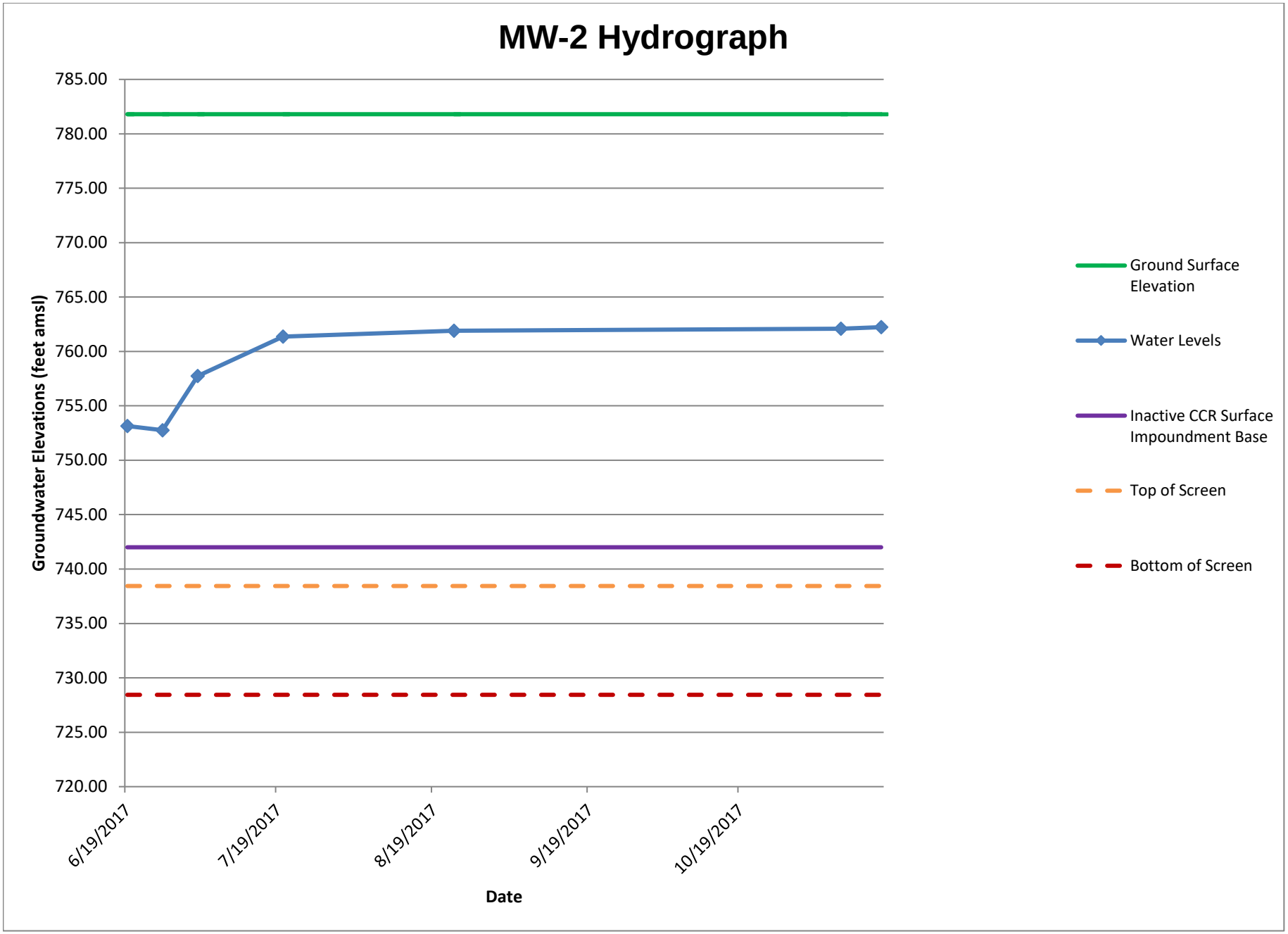
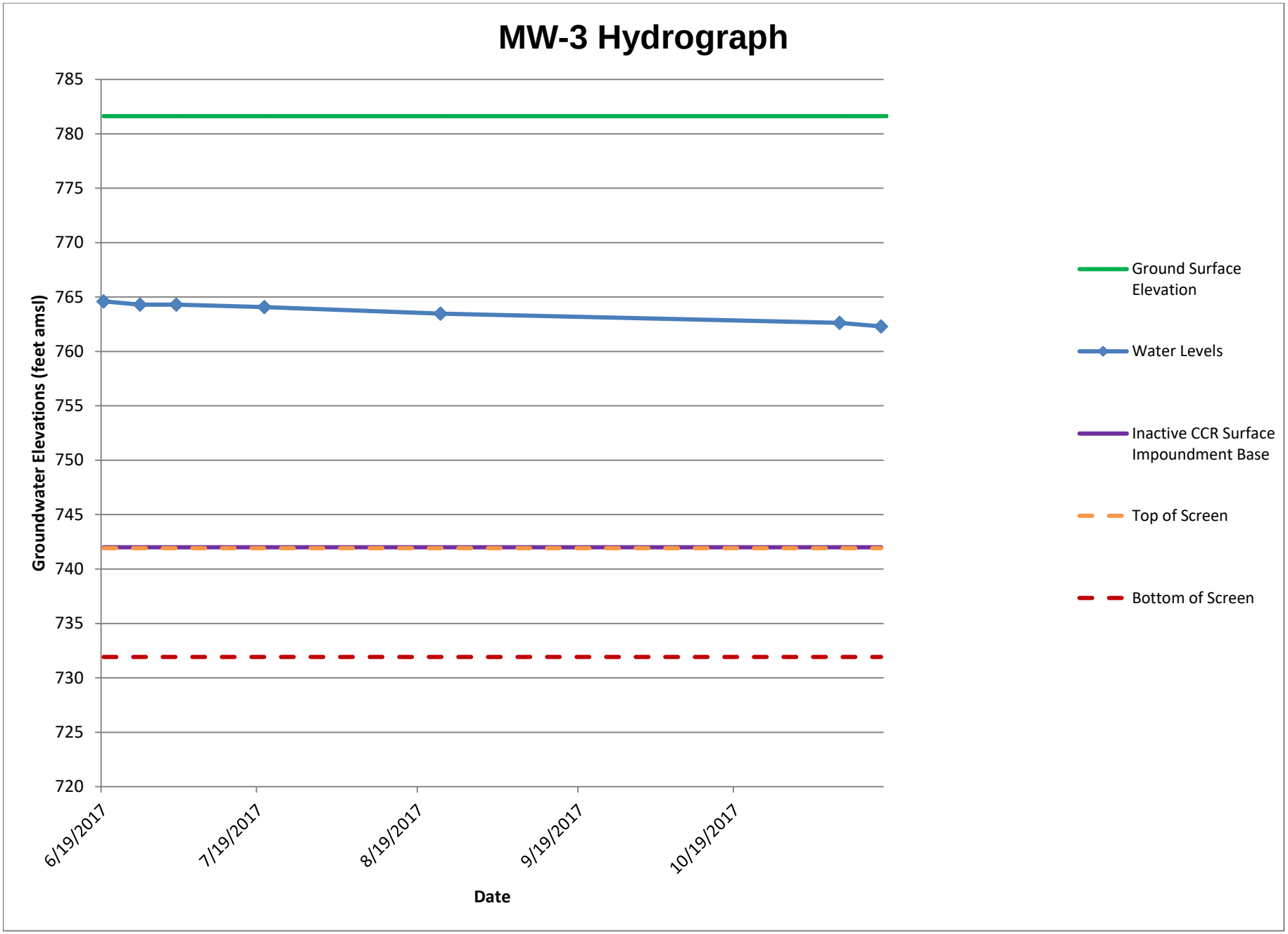
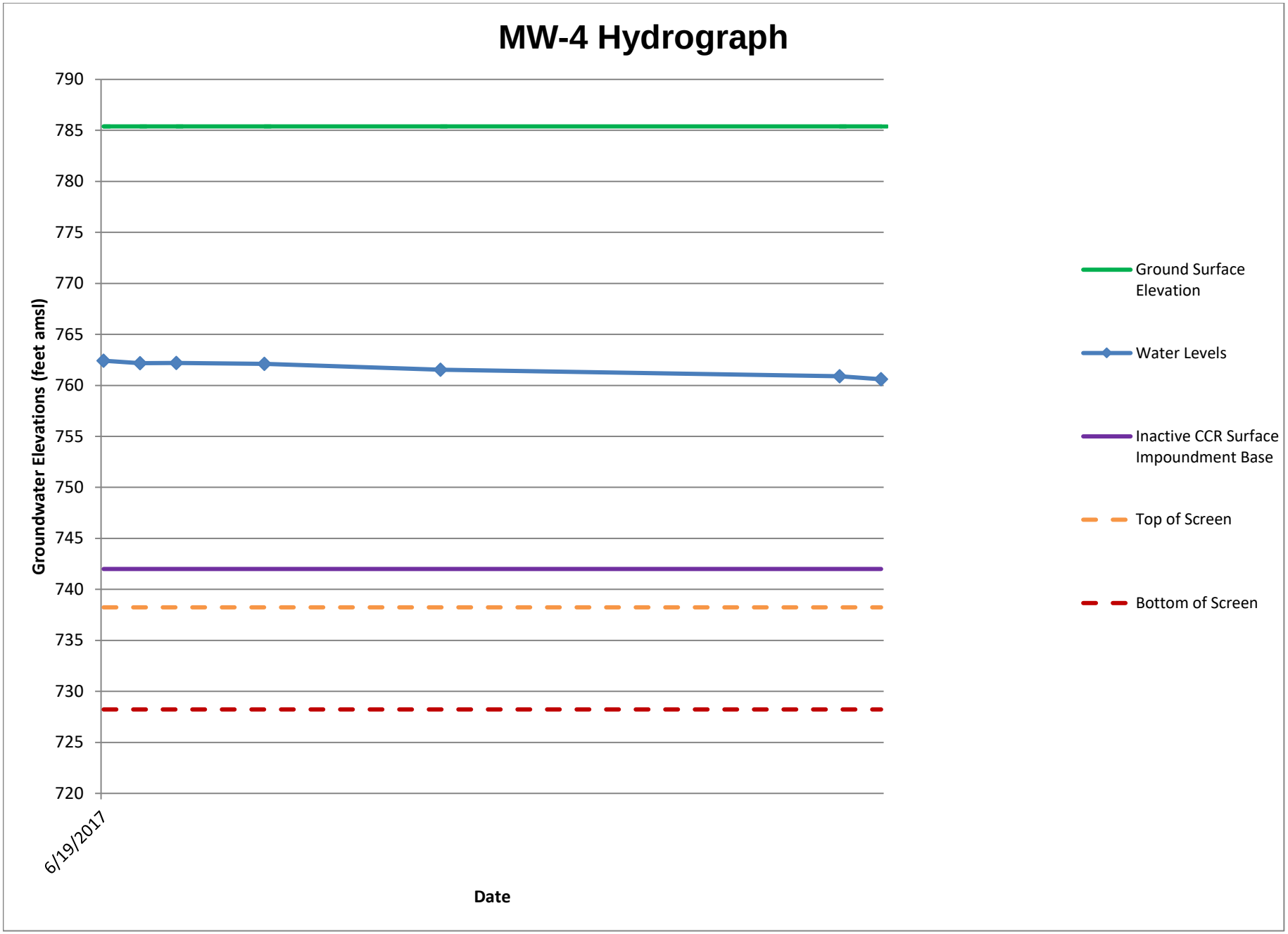
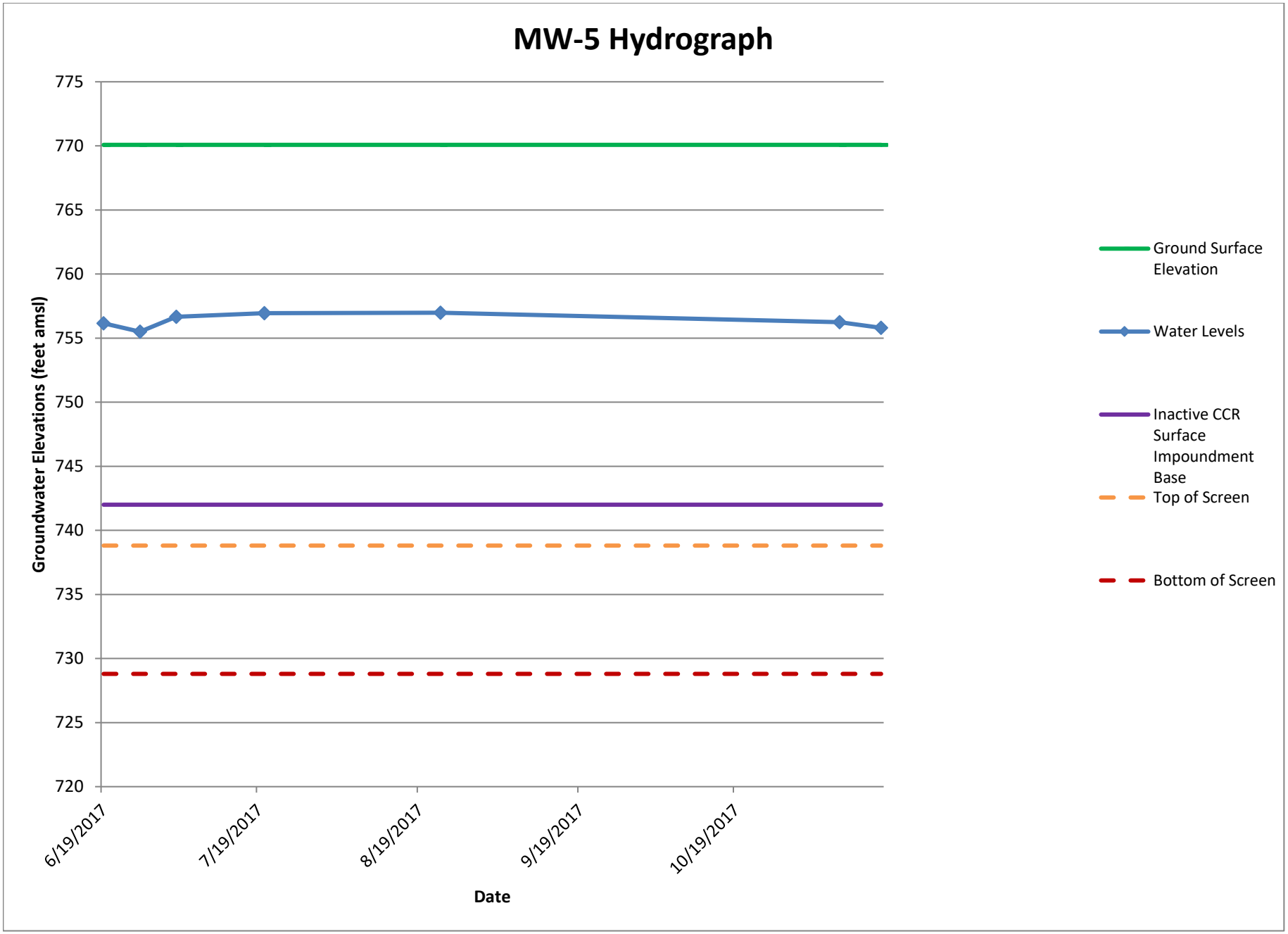
APPENDIX N - HYDROGRAPHS

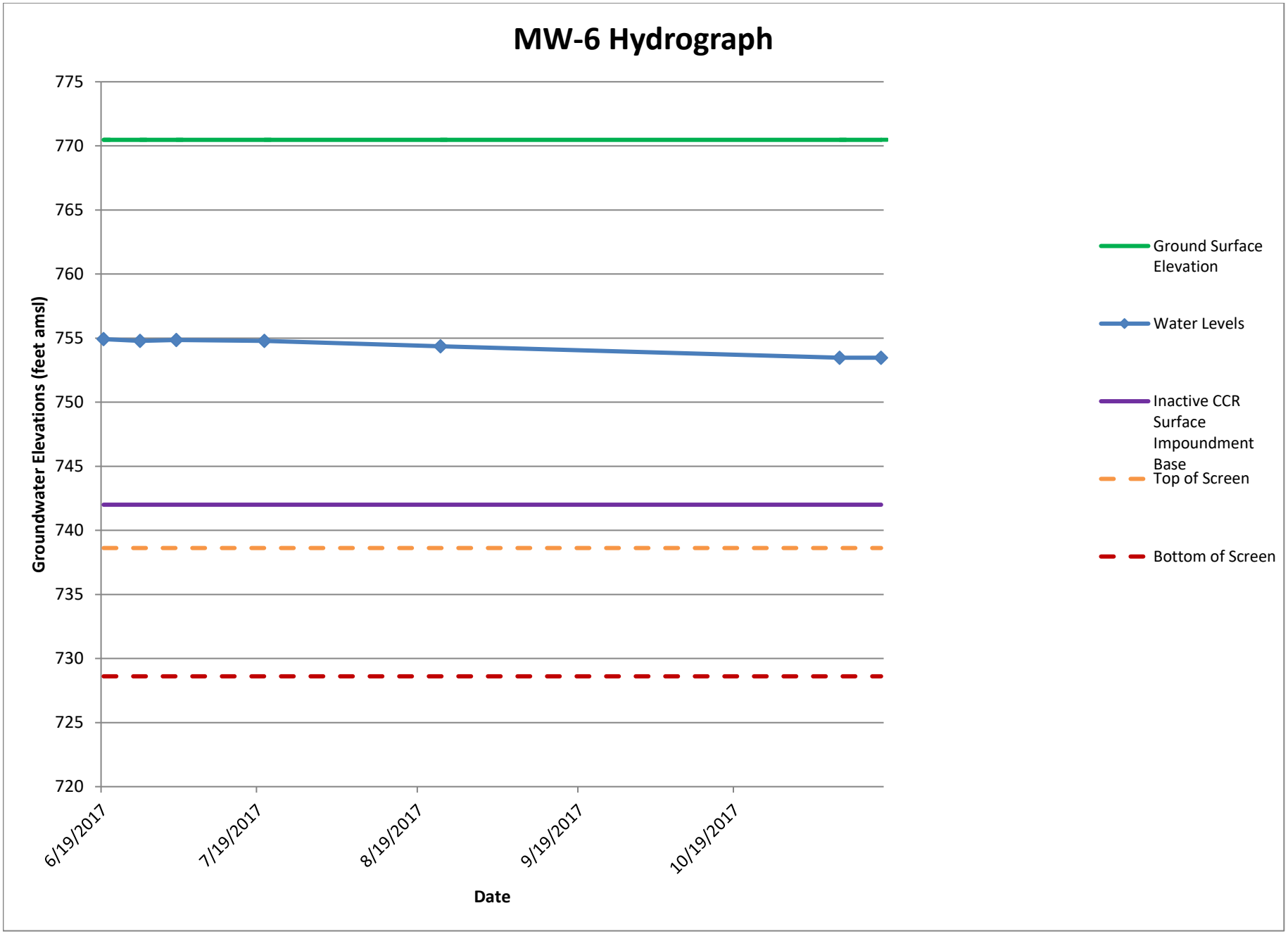

MW-1 Hydrograph
775.00
770.00
765.00
760.00
755.00
750.00
745.00
740.00
735.00
730.00
725.00
720.00
Groundwater Elevations (feet amsl)
6/19/2017
7/19/2017
8/19/2017
9/19/2017
10/19/2017
Date
Ground Surface Elevation
Inactive CCR Impoundment Base
Water Levels
Top of Screen
Bottom of Screen

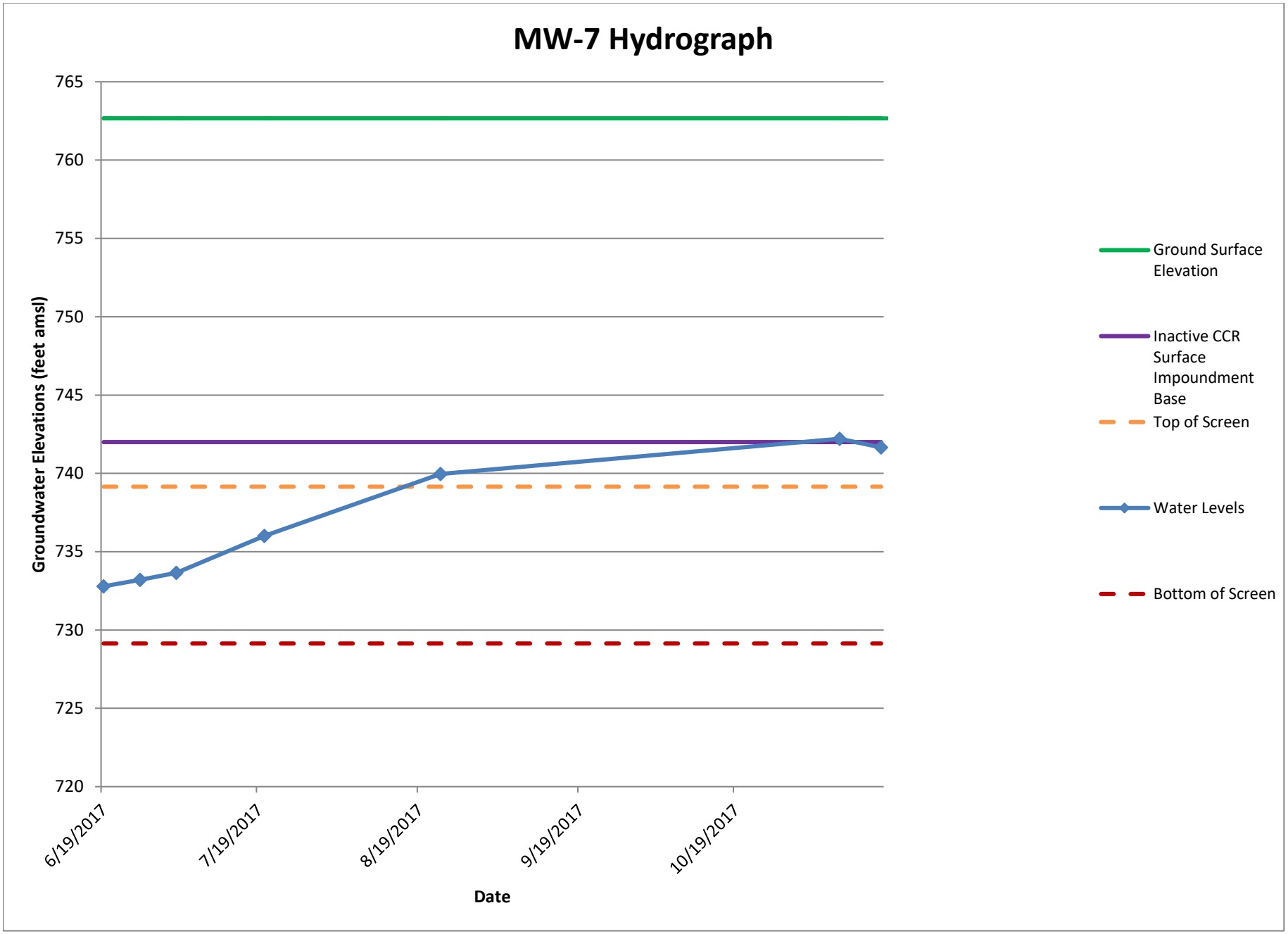

MW-2 Hydrograph
785.00
780.00
775.00
770.00
765.00
760.00
755.00
750.00
745.00
740.00
735.00
730.00
725.00
720.00
Groundwater Elevations (feet amsl)
6/19/2017
7/19/2017
8/19/2017
9/19/2017
10/19/2017
Date
Ground Surface Elevation
Water Levels
Inactive CCR Surface Impoundment Base
Top of Screen
Bottom of Screen

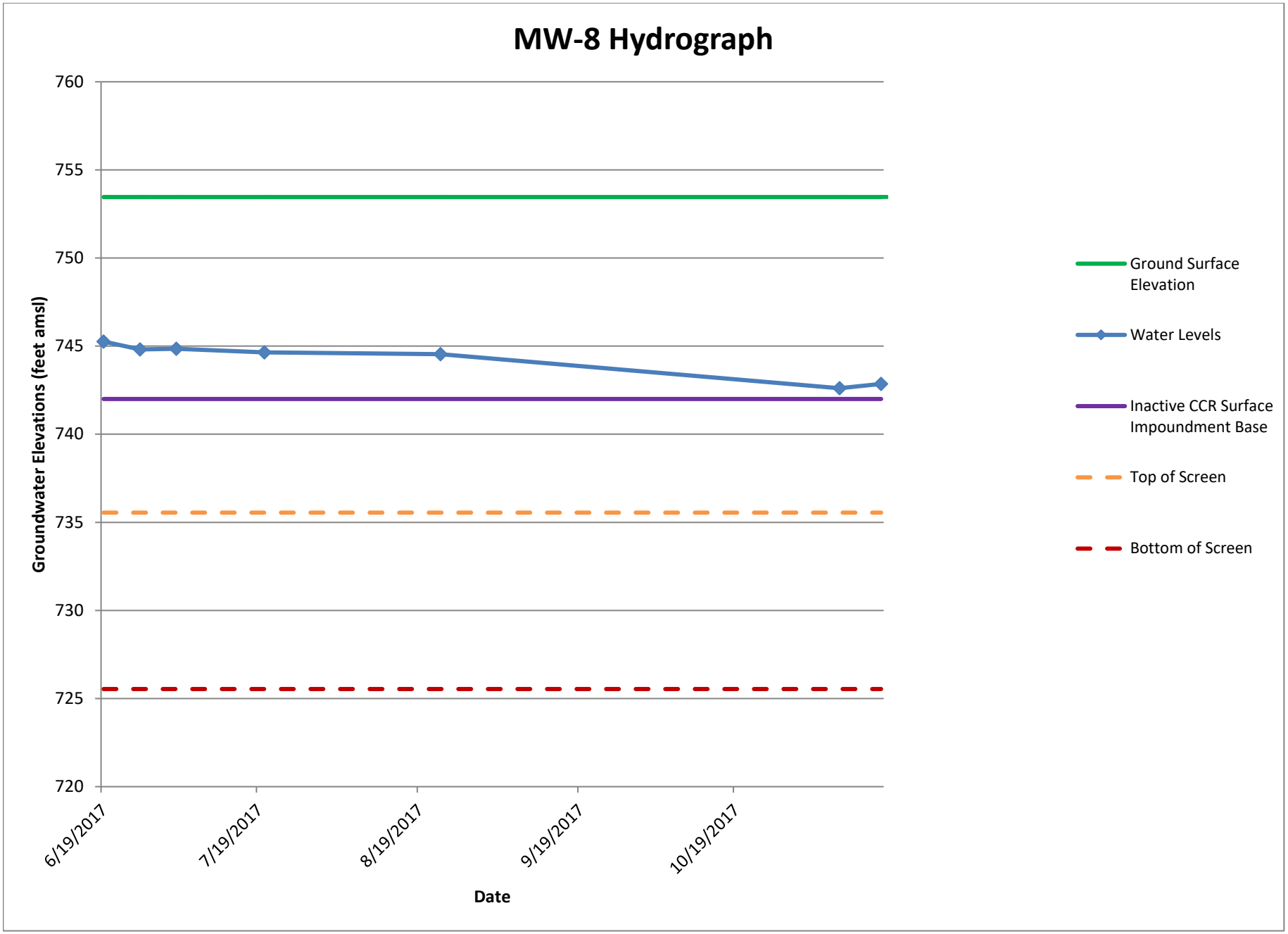

MW-3 Hydrograph
785
780
775
770
765
760
755
750
745
740
735
730
725
720
Groundwater Elevations (feet amsl)
6/19/2017
7/19/2017
8/19/2017
9/19/2017
10/19/2017
Date
Ground Surface Elevation
Water Levels
Inactive CCR Surface Impoundment Base
Top of Screen
Bottom of Screen

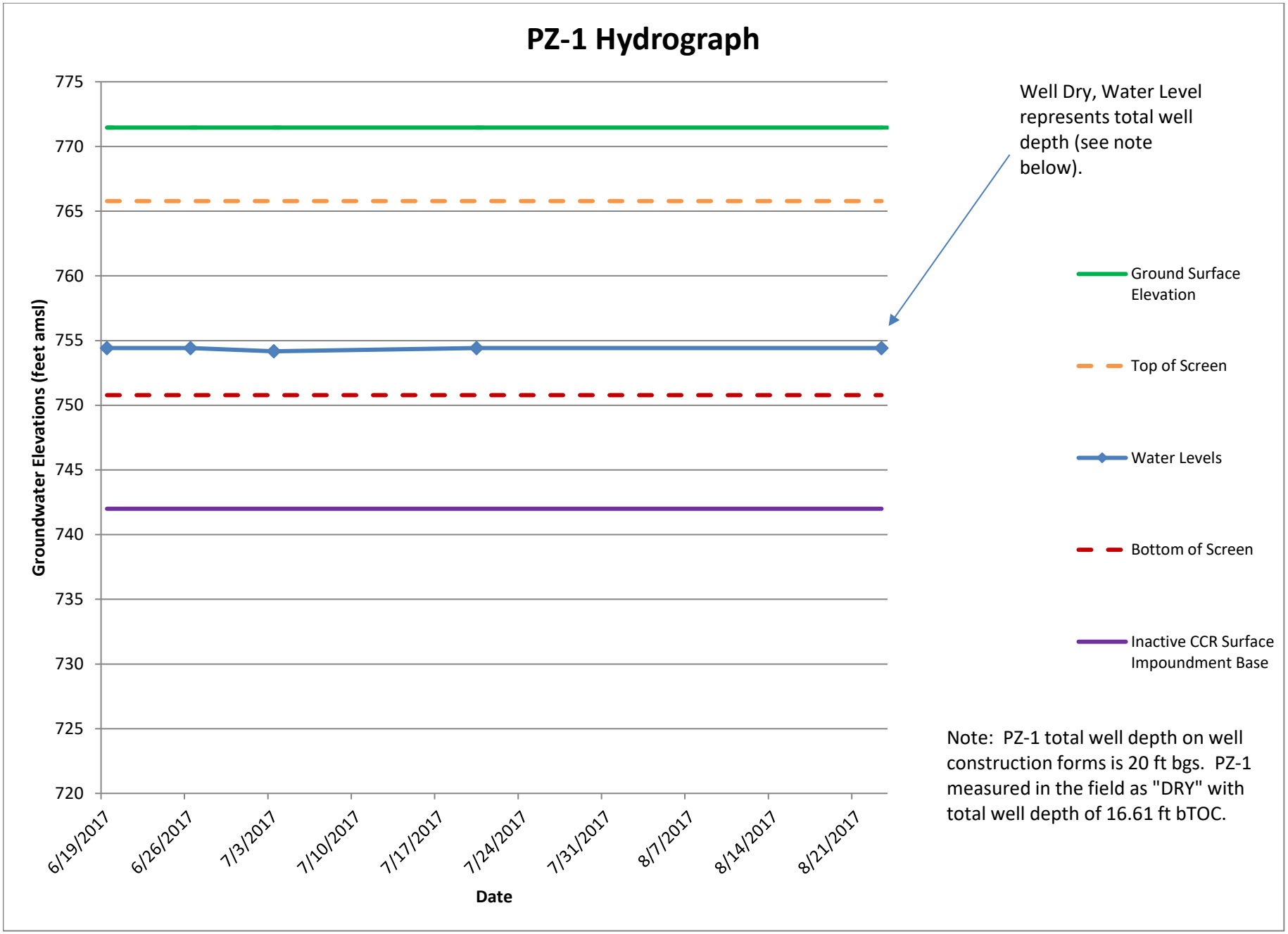

MW-4 Hydrograph
790
785
780
775
770
765
760
755
750
745
740
735
730
725
720
Groundwater Elevations (feet amsl)
6/19/2017
Date
Ground Surface Elevation
Water Levels
Inactive CCR Surface Impoundment Base
Top of Screen
Bottom of Screen

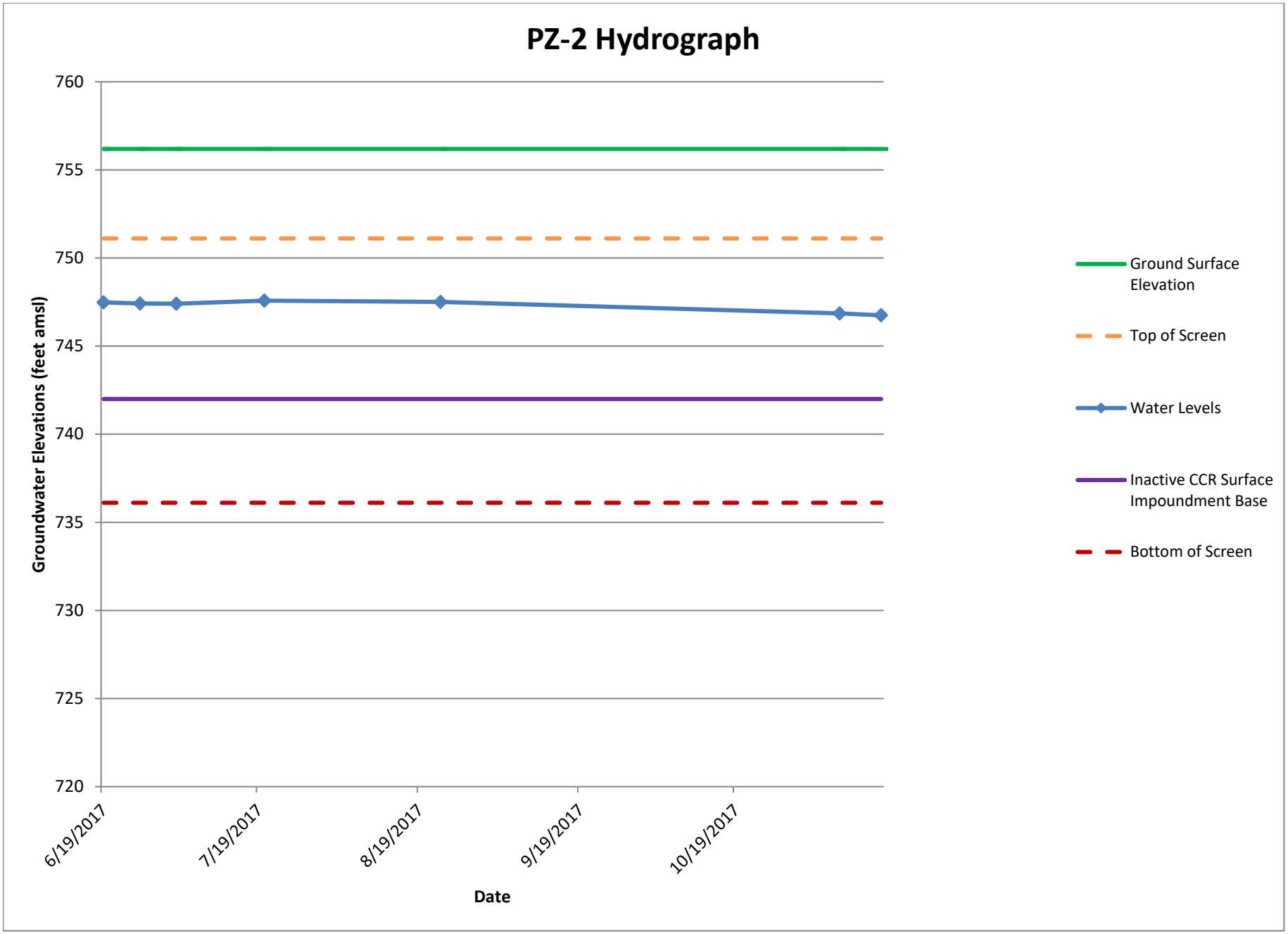

MW-5 Hydrograph
775
770
765
760
755
750
745
740
735
730
725
720
Groundwater Elevations (feet amsl)
6/19/2017
7/19/2017
8/19/2017
9/19/2017
10/19/2017
Date
Ground Surface Elevation
Water Levels
Inactive CCR Surface Impoundment Base
Top of Screen
Bottom of Screen

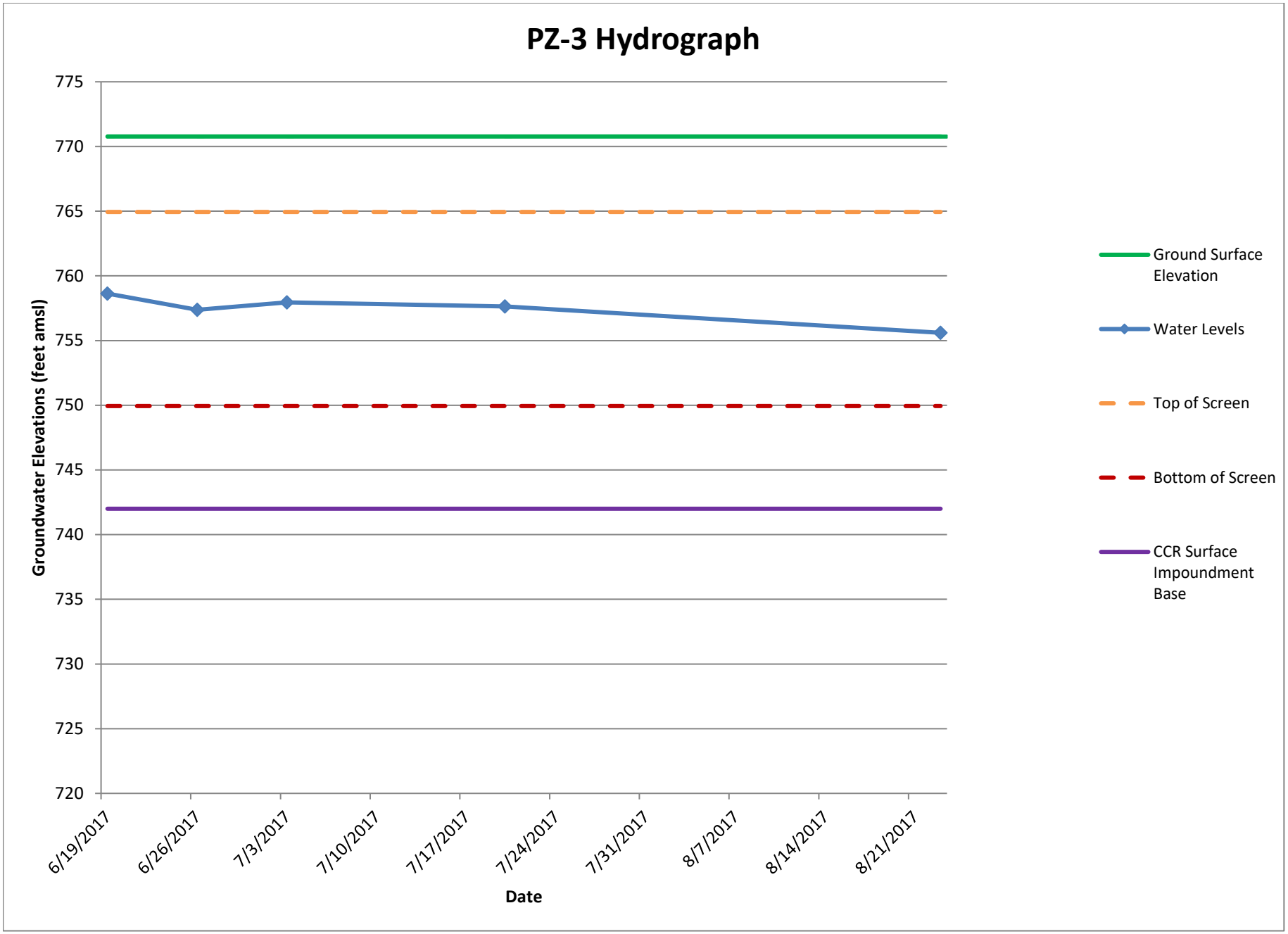

MW-6 Hydrograph
775
770
765
760
755
750
745
740
735
730
725
720
Groundwater Elevations (feet amsl)
6/19/2017
7/19/2017
8/19/2017
9/19/2017
10/19/2017
Date
Ground Surface Elevation
Water Levels
Inactive CCR Surface Impoundment Base
Top of Screen
Bottom of Screen

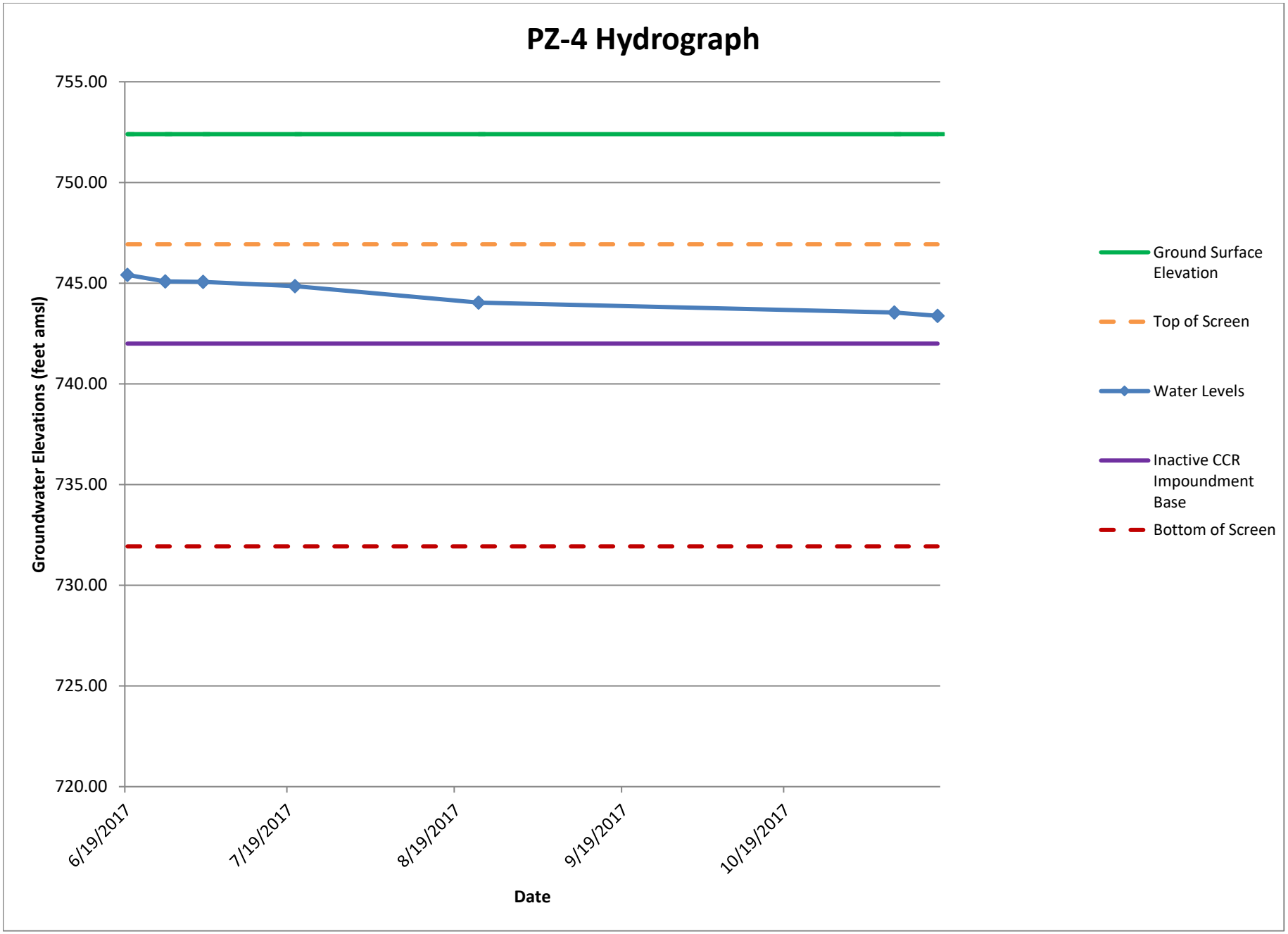

MW-7 Hydrograph
765
760
755
750
745
740
735
730
725
720
Groundwater Elevations (feet amsl)
6/19/2017
7/19/2017
8/19/2017
9/19/2017
10/19/2017
Date
Ground Surface Elevation
Inactive CCR Surface Impoundment Base
Top of Screen
Water Levels
Bottom of Screen

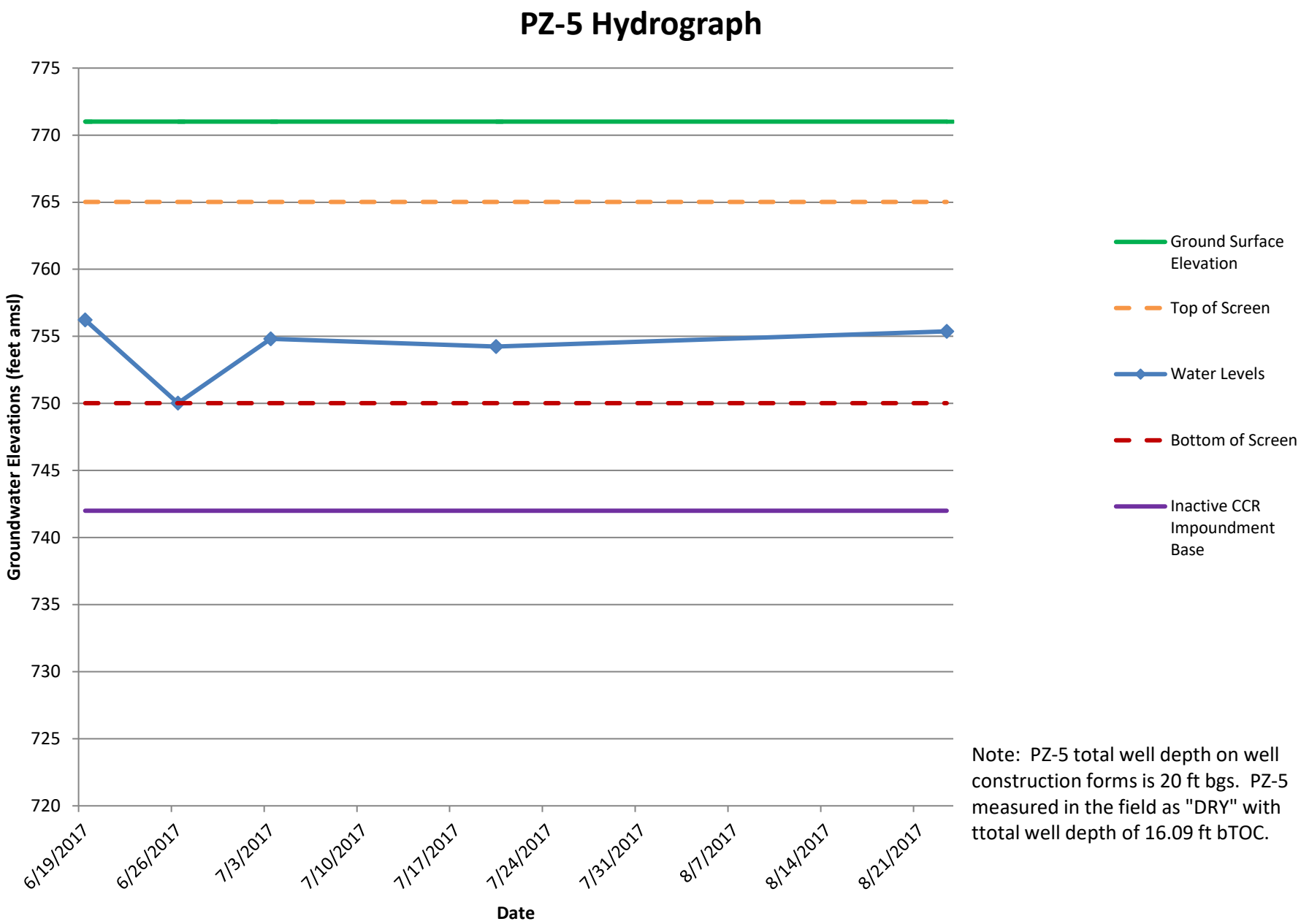

MW-8 Hydrograph
760
755
750
745
740
735
730
725
720
Groundwater Elevations (feet amsl)
6/19/2017
7/19/2017
8/19/2017
9/19/2017
10/19/2017
Date
Ground Surface Elevation
Water Levels
Inactive CCR Surface Impoundment Base
Top of Screen
Bottom of Screen


PZ-1 Hydrograph
775
770
765
760
755
750
745
740
735
730
725
720
Groundwater Elevations (feet amsl)
6/19/2017
6/26/2017
7/3/2017
7/10/2017
7/17/2017
7/24/2017
7/31/2017
8/7/2017
8/14/2017
8/21/2017
Date
Well Dry, Water Level represents total well depth (see note below).
Ground Surface Elevation
Top of Screen
Water Levels
Bottom of Screen
Inactive CCR Surface Impoundment Base
Note: PZ-1 total well depth on well construction forms is 20 ft bgs. PZ-1 measured in the field as "DRY" with total well depth of 16.61 ft bTOC.

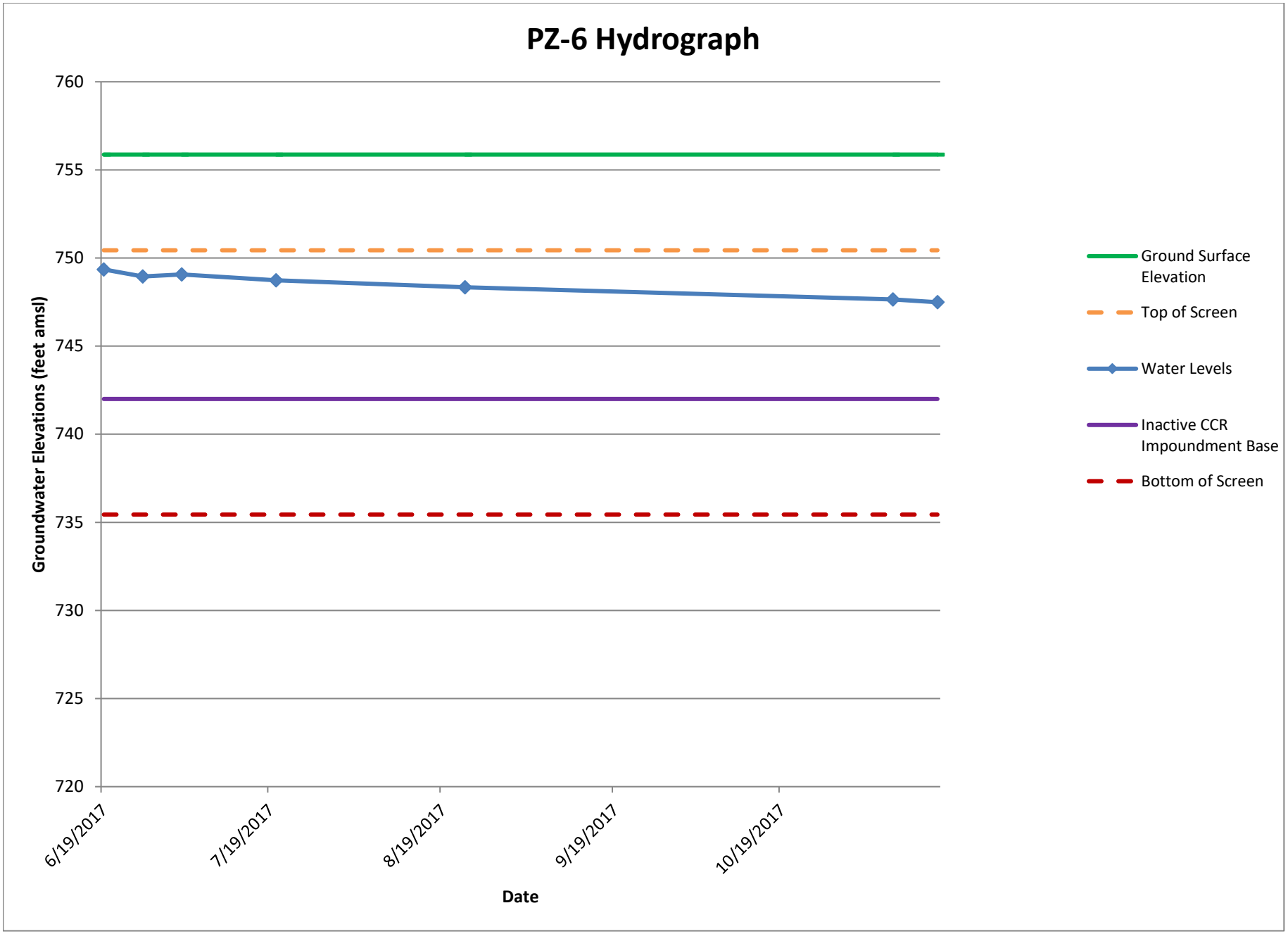

PZ-2 Hydrograph
760
755
750
745
740
735
730
725
720
Groundwater Elevations (feet amsl)
6/19/2017
7/19/2017
8/19/2017
9/19/2017
10/19/2017
Date
Ground Surface Elevation
Top of Screen
Water Levels
Inactive CCR Surface Impoundment Base
Bottom of Screen

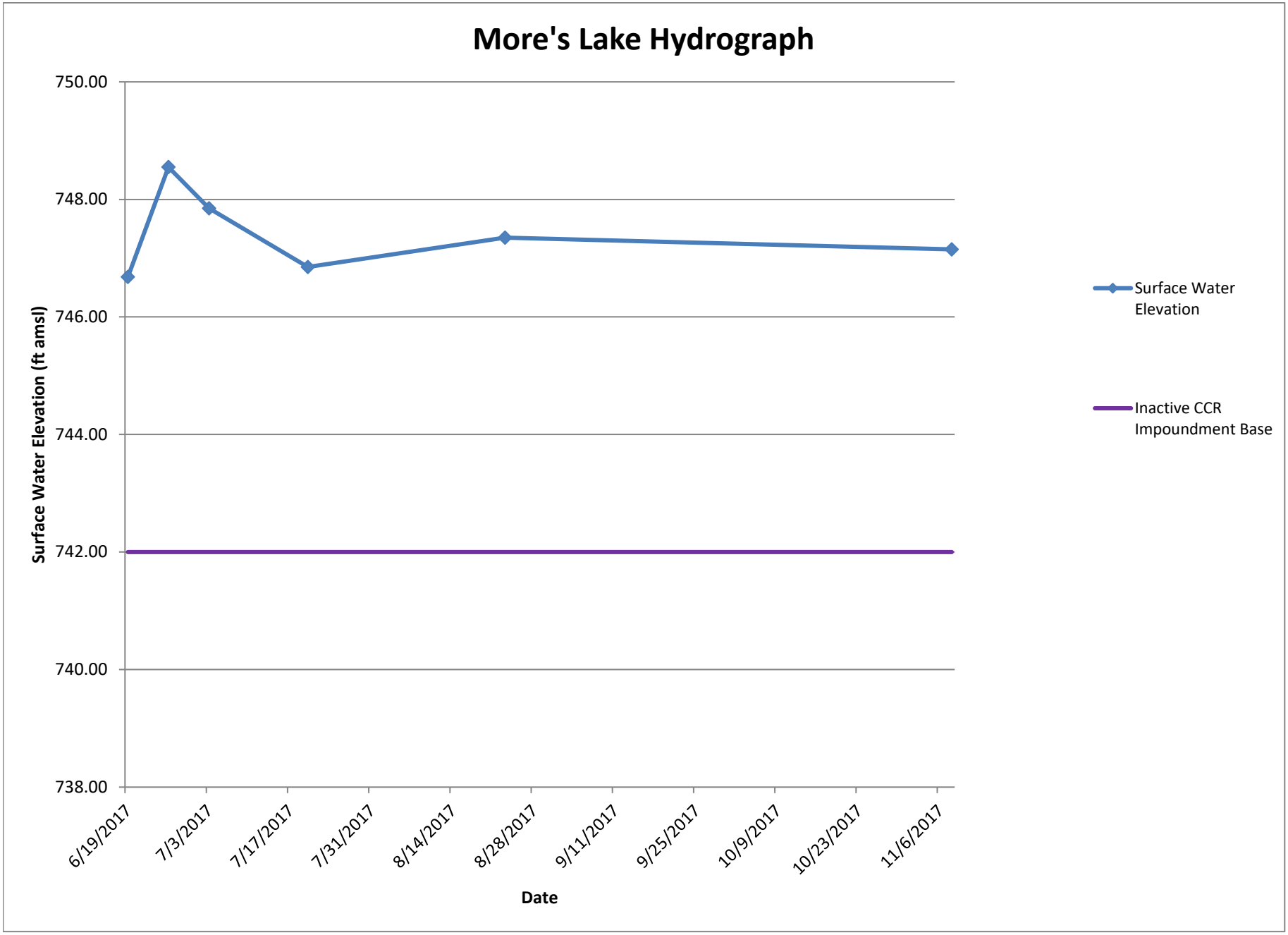

PZ-3 Hydrograph
775
770
765
760
755
750
745
740
735
730
725
720
Groundwater Elevations (feet amsl)
6/19/2017
6/26/2017
7/3/2017
7/10/2017
7/17/2017
7/24/2017
7/31/2017
8/7/2017
8/14/2017
8/21/2017
Date
Ground Surface Elevation
Water Levels
Top of Screen
Bottom of Screen
CCR Surface Impoundment Base


PZ-4 Hydrograph
755.00
750.00
745.00
740.00
735.00
730.00
725.00
720.00
Groundwater Elevations (feet amsl)
6/19/2017
7/19/2017
8/19/2017
9/19/2017
10/19/2017
Date
Ground Surface Elevation
Top of Screen
Water Levels
Inactive CCR Impoundment Base
Bottom of Screen



Note: PZ-5 total well depth on well construction forms is 20 ft bgs. PZ-5 measured in the field as "DRY" with ttotal well depth of 16.09 ft bTOC.


PZ-6 Hydrograph
760
755
750
745
740
735
730
725
720
Groundwater Elevations (feet amsl)
6/19/2017
7/19/2017
8/19/2017
9/19/2017
10/19/2017
Date
Ground Surface Elevation
Top of Screen
Water Levels
Inactive CCR Impoundment Base
Bottom of Screen


More's Lake Hydrograph
750.00
748.00
746.00
744.00
742.00
740.00
738.00
Surface Water Elevation (ft amsl)
6/19/2017
7/3/2017
7/17/2017
7/31/2017
8/14/2017
8/28/2017
9/11/2017
9/25/2017
10/9/2017
10/23/2017
11/6/2017
Date
Surface Water Elevation
Inactive CCR Impoundment Base

APPENDIX O – LOW-FLOW PILOT TEST FIELD FROMS

FIELD GROUNDWATER SAMPLING REPORT

DATE: 9/24/17 SITE: MORE'S LAKE PID READING at WELL HEAD (ppm): –

PROJECT NUMBER: 93647 WEATHER: CLEAR 80°F

WELL NUMBER: MW-1 TOP OF PUMP 39.75

DEPTH TO WATER (ft): 28.54 TOTAL DEPTH (ft): 42.74 WELL DIAMETER (inches): 2

PURGING

CASING VOLUME CALCULATION: _____ ft of water in casing X _____ gallons/foot = _____ total gallons/casing volume

Equipment Used: ☒ Dedicated Bladder Pump ☐ Nondedicated Bladder Pump ☐ Bailer ☐ Other _____

Time (24 hr)	Amount Purged (gals)	Flow Rate (ml/min)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)
0939	I	100	7.09	17.85	1.086	22.6	14.6	2.27	28.85
0944	0.13	100	7.06	17.68	1.064	17.0	-63.4	1.31	28.85
0949	0.26	100	7.05	17.51	1.048	14.39	-114.8	0.75	28.87
0954	0.39	100	7.04	17.52	1.046	11.10	-131.2	0.61	28.87
0959	0.52	100	7.03	17.52	1.051	7.01	-89.7	0.54	28.87
1004	0.65	100	7.02	17.50	1.062	5.54	-28.4	0.50	28.87
1009	0.78	100	7.02	17.53	1.071	4.75	-27.4	0.45	28.87
1014	0.91	100	7.01	17.54	1.080	5.42	-30.5	0.42	28.87
1019	1.04	100	7.00	17.56	1.093	4.93	-34.9	0.43	
			Turbidity in sample line before flow-through			4.85			

Continued on back (circle one) yes / (no)

SAMPLING Equipment Used: ☐ Same as above ☒ Other NA

Sample Time (24 hr)	Total Purged (gals)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)	Obs.
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Ferrous Iron (mg/L): NA

FINAL DEPTH TO WATER (ft TOC): 28.87 TIME FINAL DEPTH TAKEN: 1019

SAMPLE ID: NA SAMPLE ID FOR QC: NA

PARAMETERS REQUESTED FOR ANALYSIS: NA

IDW TOTAL: 1.04 Instrument Model: YSI 556 MPS

	NAME	SIGNATURE	DATE
PREPARED:	Lewis Turner	LT	9/24/17
REVIEWED:			

FIELD GROUNDWATER SAMPLING REPORT

DATE: 9/24/17 SITE: MORE'S LAKE PID READING at WELL HEAD (ppm): —

PROJECT NUMBER: 93647 WEATHER: CLEAR 75°F

WELL NUMBER: MW-2 TOP OF PUMP 49.98

DEPTH TO WATER (ft): 19.02 TOTAL DEPTH (ft): 52.92 WELL DIAMETER (inches): 2

PURGING

CASING VOLUME CALCULATION: _____ ft of water in casing X _____ gallons/foot = _____ total gallons/casing volume

Equipment Used: ☒ Dedicated Bladder Pump ☐ Nondedicated Bladder Pump ☐ Bailer ☐ Other _____

Time (24 hr)	Amount Purged (gals)	Flow Rate (ml/min)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)
0745	I	100	7.00	16.70	0.812	51.9	12.7	1.72	19.14
0750	0.13	100	7.00	16.54	0.810	42.5	-28.9	1.46	19.15
0755	0.26	100	7.01	16.45	0.810	37.6	-52.4	1.26	19.17
0800	0.39	100	7.00	16.38	0.809	22.3	-75.2	1.09	19.22
0805	0.52	100	7.00	16.34	0.808	16.5	-90.4	0.99	19.24
0810	0.65	100	7.00	16.34	0.807	11.1	-91.8	1.10	19.30
0815	0.78	100	6.99	16.34	0.807	12.39	-86.0	0.97	19.34
0820	0.91	100	6.99	16.36	0.807	10.54	-98.0	0.94	19.36
0825	1.04	100	7.00	16.58	0.808	10.10	-106.6	0.90	19.38
0830	1.17	100	6.99	16.54	0.811	9.00	-110.8	0.80	19.41
0835	1.30	100	6.98	16.45	0.810	9.74	-112.0	0.81	19.44
0840	1.43	100	6.98	16.50	0.809	8.16	-113.2	0.80	19.47
0845	1.56	100	6.98	16.44	0.808	5.45	-111.4	0.79	19.50
0850	1.69	100	6.98	16.45	0.808	5.37	-108.6	0.80	19.52
0855	1.82	100	6.98	16.46	0.808	5.25	-119.7	0.79	19.55

Continued on back (circle one) (yes) / no

SAMPLING Equipment Used: ☐ Same as above ☒ Other NA

Sample Time (24 hr)	Total Purged (gals)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)	Obs.
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Ferrous Iron (mg/L): NA

FINAL DEPTH TO WATER (ft TOC): 19.67 TIME FINAL DEPTH TAKEN: 0920

SAMPLE ID: NA SAMPLE ID FOR QC: NA

PARAMETERS REQUESTED FOR ANALYSIS: NA

IDW TOTAL: 2.47 Instrument Model: YSI 556 MPS

	NAME	SIGNATURE	DATE
PREPARED:	Lewis Turner	[signature]	9/24/17
REVIEWED:			

WELL NUMBER: MW-2

Time (24 hr)	Amount Purged (gals)	Flow Rate (ml/min)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)
0900	1.95	100	6.98	16.48	0.809	5.27	-128.8	0.76	19.56
0905	2.08	100	6.98	16.54	0.810	6.59	-128.7	0.79	19.58
0910	2.21	100	6.97	16.55	0.811	6.46	-125.6	0.79	19.62
0915	2.34	100	6.97	16.57	0.811	5.29	-105.8	0.80	19.65
0920	2.47	100	6.97	16.58	0.813	6.89	-106.3	0.81	19.67

COMMENTS

Turbidity check in sample line before Flow-through cell = 4.66

FIELD GROUND-WATER SAMPLING REPORT

DATE: 11/8/17 SITE: Moore's Lake PID READING at WELL HEAD (ppm): —

PROJECT NUMBER: 93647 WEATHER: Clear, Sunny, 50's

WELL NUMBER

MW-2

DEPTH TO WATER (ft): 18.88

TOTAL DEPTH (ft): 52.92 WELL DIAMETER (inches): 2"

PURGING

CASING VOLUME CALCULATION: ____ ft of water X ____ gallons/ = ____ total gallons/casing volume
in casing foot

Equipment Used: Dedicated Bladder Pump Nondedicated Bladder Pump Bailer Other _____

Time (24 hr)	Amount Purged (gals)	Flow Rate (ml/min)	pH	Temp (C)	Conductivity (mmhos/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)
1430	I	100				11.9			18.90
1435	0.13	100				13.41			18.93
1440	0.26	100				12.8			18.97
1445	0.39	100				12.8			18.98
1450	0.52	100				12.3			19.01
1455	0.65	100				11.86			19.04
1500	0.78	100				10.56			19.06
1505	0.91	100				7.17			19.11
1510	1.04	100				5.24			19.14
Continued on back (circle one) yes / no									

SAMPLING Equipment Used: Same as above Other _____

Sample Time (24 hr)	Total Purged (gals)	pH	Temp (C)	Conductivity (mmhos/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)	Obs.

FINAL DEPTH TO WATER (ft TOC): _____ TIME FINAL DEPTH TAKEN: _____

SAMPLE ID: NA SAMPLE ID FOR QC: NA

PARAMETERS REQUESTED FOR ANALYSIS: NA

FERROUS IRON (mg/L): NA IDW TOTAL: _____

METER MODEL No.: LAMOTTE 2020WE

CHECKED FLOW THROUGH CELL FOR LEAKS: ☒ COMMENTS: 100mL/min CPMY 2.5 Discharge 32 PSI

	NAME	SIGNATURE	DATE
PREPARED:	CHRIS HOOLUND	C. Hoolund	11/8/17
REVIEWED:			

WELL NUMBER

MW-2

Time (24 hr)	Amount Purged (gals)	Flow Rate (ml/min)	pH	Temp (C)	Conductivity (mmhos/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)
1515	1.17	125				4.51			19.20
1520	1.30	125				3.94			19.21

COMMENTS

FIELD GROUNDWATER SAMPLING REPORT

DATE: 9/23/17 SITE: MORE'S LAKE PID READING at WELL HEAD (ppm): —

PROJECT NUMBER: 93647 WEATHER: CLEAR 80F

WELL NUMBER: MW-3 TOP OF PUMP 46.42

DEPTH TO WATER (ft): 17.70 TOTAL DEPTH (ft): 49.50 WELL DIAMETER (inches): 2

PURGING

CASING VOLUME CALCULATION: _____ ft of water in casing X _____ gallons/foot = _____ total gallons/casing volume

Equipment Used: ☒ Dedicated Bladder Pump ☐ Nondedicated Bladder Pump ☐ Bailer ☐ Other _____

Time (24 hr)	Amount Purged (gals)	Flow Rate (ml/min)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)
1835	I	100	7.17	18.20	0.752	12.1	-54.6	3.02	18.31
1840	0.13	100	7.09	17.25	0.730	13.7	-116.4	0.90	18.65
1845	0.26	100	7.06	16.98	0.725	11.1	-168.6	0.47	18.81
1850	0.39	100	7.04	16.88	0.722	10.31	-219.2	0.40	18.95
1855	0.52	100	7.03	16.73	0.720	6.29	-241.6	0.26	19.01
1900	0.65	100	7.02	16.67	0.718	5.66	-185.7	0.24	19.01
1905	0.78	100	7.01	16.65	0.717	4.92	-179.4	0.25	19.04
1910	0.91	100	7.01	16.51	0.716	4.28	-180.4	0.28	19.09
1915	1.04	100	7.00	16.43	0.714	3.70	-178.9	0.29	19.13

Continued on back (circle one) yes / (no)

SAMPLING Equipment Used: ☐ Same as above ☒ Other NA

Sample Time (24 hr)	Total Purged (gals)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)	Obs.
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Ferrous Iron (mg/L): NA

FINAL DEPTH TO WATER (ft TOC): 19.13 TIME FINAL DEPTH TAKEN: 1915

SAMPLE ID: NA SAMPLE ID FOR QC: NA

PARAMETERS REQUESTED FOR ANALYSIS: NA

IDW TOTAL: 1.04 Instrument Model: YSI 556 MPS

	NAME	SIGNATURE	DATE
PREPARED:	Lewis Turner	LTT	9/23/17
REVIEWED:			

FIELD GROUNDWATER SAMPLING REPORT

DATE: 9/23/17 SITE: MARE'S LAKE PID READING at WELL HEAD (ppm): —

PROJECT NUMBER: 93647 WEATHER: CLEAR 80°F

WELL NUMBER: MW-4 TOP OF PUMP 54.23

DEPTH TO WATER (ft): 23.74 TOTAL DEPTH (ft): 57.05 WELL DIAMETER (inches): 2

PURGING

CASING VOLUME CALCULATION: _____ ft of water in casing X _____ gallons/foot = _____ total gallons/casing volume

Equipment Used: ☒ Dedicated Bladder Pump ☐ Nondedicated Bladder Pump ☐ Bailer ☐ Other _____

Time (24 hr)	Amount Purged (gals)	Flow Rate (ml/min)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)
1718	I	200	7.01	18.13	0.835	13.0	-94.2	1.98	24.59
1723	0.13	100	6.99	17.13	0.829	14.1	-144.9	1.36	25.81
1728	0.26	100	6.97	17.50	0.837	13.56	-189.4	0.83	26.22
1733	0.39	100	6.98	17.65	0.851	10.47	-197.0	0.72	26.41
1738	0.52	100	6.97	17.56	0.855	8.23	-200.7	0.64	26.59
1743	0.65	100	6.96	17.73	0.855	8.01	-195.7	0.62	26.80
1748	0.78	100	6.95	17.80	0.848	7.31	-187.9	0.57	26.94
1753	0.91	100	6.95	17.79	0.841	5.96	-200.1	0.54	27.11
1758	1.04	100	6.94	17.62	0.832	6.14	-204.4	0.50	27.24
1803	1.17	100	6.94	17.74	0.832	6.52	-181.1	0.48	27.33
1808	1.30	100	6.94	17.61	0.826	5.69	-192.4	0.49	27.42
1813	1.43	100	6.94	17.43	0.822	4.37	-191.0	0.51	27.51
1818	1.56	100	6.93	17.37	0.820	4.94	-190.6	0.52	27.62
Continued on back (circle one) yes / (no)									

SAMPLING Equipment Used: ☐ Same as above ☒ Other NA

Sample Time (24 hr)	Total Purged (gals)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)	Obs.
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Ferrous Iron (mg/L): NA

FINAL DEPTH TO WATER (ft TOC): 27.62 TIME FINAL DEPTH TAKEN: 1818

SAMPLE ID: NA SAMPLE ID FOR QC: NA

PARAMETERS REQUESTED FOR ANALYSIS: NA

IDW TOTAL: 1.56 Instrument Model: YSI 556 MPS

	NAME	SIGNATURE	DATE
PREPARED:	Lewis Turner	LT	9/23/17
REVIEWED:			

FIELD GROUNDWATER SAMPLING REPORT

DATE: 9/23/17 SITE: MORRIS LAKE PID READING at WELL HEAD (ppm): –

PROJECT NUMBER: 93647 WEATHER: CLEAR 80°F

WELL NUMBER: MW-5 Top of pump 38.32

DEPTH TO WATER (ft): 12.69 TOTAL DEPTH (ft): 41.09 WELL DIAMETER (inches): 2

PURGING

CASING VOLUME CALCULATION: _____ ft of water in casing X _____ gallons/foot = _____ total gallons/casing volume

Equipment Used: ☒ Dedicated Bladder Pump ☐ Nondedicated Bladder Pump ☐ Bailer ☐ Other _____

Time (24 hr)	Amount Purged (gals)	Flow Rate (ml/min)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)
1605	I	100	7.26	19.04	0.760	30.5	-109.5	1.88	13.35
1610	0.13	100	7.24	18.58	0.738	32.4	-152.9	1.26	13.84
1615	0.26	100	7.22	18.40	0.726	14.7	-183.8	0.95	14.50
1620	0.39	100	7.22	18.35	0.722	11.0	-195.7	0.76	14.79
1625	0.52	100	7.21	18.24	0.718	10.31	-186.6	0.72	15.11
1630	0.65	100	7.21	18.21	0.716	8.73	-184.9	0.70	15.45
1635	0.78	100	7.21	18.17	0.714	7.88	-188.9	0.68	15.80
1640	0.91	100	7.20	18.03	0.712	6.77	-183.0	0.59	16.15
1645	1.04	100	7.20	18.00	0.712	5.76	-179.4	0.53	16.46
1650	1.17	100	7.19	17.94	0.711	5.80	-181.2	0.49	16.82
1655	1.30	100	7.19	17.96	0.711	4.85	-182.4	0.50	17.19
1700	1.43	100	7.18	17.93	0.711	4.85	-183.6	0.49	17.45

Continued on back (circle one) yes / (no)

SAMPLING Equipment Used: ☐ Same as above ☒ Other NA

Sample Time (24 hr)	Total Purged (gals)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)	Obs.
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Ferrous Iron (mg/L): NA

FINAL DEPTH TO WATER (ft TOC): 17.45 TIME FINAL DEPTH TAKEN: 1700

SAMPLE ID: NA SAMPLE ID FOR QC: NA

PARAMETERS REQUESTED FOR ANALYSIS: NA

IDW TOTAL: 1.43 Instrument Model: YSI 556 MPS

	NAME	SIGNATURE	DATE
PREPARED:	Lewis Turner	[signature]	9/23/17
REVIEWED:			

FIELD GROUNDWATER SAMPLING REPORT

DATE: 9/23/17 SITE: MORE'S LAKE PID READING at WELL HEAD (ppm): —

PROJECT NUMBER: 93647 WEATHER: CLEAR 80 F

WELL NUMBER: MW-6 TOP OF PUMP 38.86

DEPTH TO WATER (ft): 15.72 TOTAL DEPTH (ft): 41.75 WELL DIAMETER (inches): 2

PURGING MAX DD= 22.22'

CASING VOLUME CALCULATION: _____ ft of water in casing X _____ gallons/foot = _____ total gallons/casing volume

Equipment Used: ☒ Dedicated Bladder Pump ☐ Nondedicated Bladder Pump ☐ Bailer ☐ Other _____

Time (24 hr)	Amount Purged (gals)	Flow Rate (ml/min)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)
1455	I	100	6.79	19.16	1.056	40.1	-105.9	2.45	16.65
1500	0.13	100	6.74	18.71	1.047	26.0	-154.2	1.47	17.12
1505	0.26	100	6.73	18.49	1.041	14.18	-183.8	1.12	17.81
1510	0.39	100	6.72	18.40	1.037	6.42	-200.8	0.91	18.29
1515	0.52	100	6.72	18.36	1.034	6.07	-201.6	0.80	18.72
1520	0.65	100	6.71	18.28	1.033	3.99	-190.3	0.68	19.10
1525	0.78	100	6.71	18.25	1.030	5.43	-221.4	0.60	19.49
1530	0.91	100	6.71	18.20	1.026	6.24	-212.7	0.56	19.90
1535	1.04	100	6.71	18.22	1.028	4.12	-208.4	0.55	20.30
1540	1.17	100	6.70	18.20	1.026	4.20	-207.2	0.53	20.71
1545	1.30	100	6.70	18.13	1.023	3.83	-215.6	0.52	21.03

Continued on back (circle one) yes / no

SAMPLING Equipment Used: ☐ Same as above ☒ Other NA

Sample Time (24 hr)	Total Purged (gals)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)	Obs.
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Ferrous Iron (mg/L): NA

FINAL DEPTH TO WATER (ft TOC): 21.03 TIME FINAL DEPTH TAKEN: 1545

SAMPLE ID: NA SAMPLE ID FOR QC: NA

PARAMETERS REQUESTED FOR ANALYSIS: NA

IDW TOTAL: 1.30 Instrument Model: YSI 556 MPS

	NAME	SIGNATURE	DATE
PREPARED:	Lewis Turner	LT	9/23/17
REVIEWED:			

FIELD GROUNDWATER SAMPLING REPORT

DATE: 9/23/17 SITE: MORE'S LAKE PID READING at WELL HEAD (ppm): —

PROJECT NUMBER: 93647 WEATHER: CLEAR 80°F

WELL NUMBER: MW-7 TOP of PUMP 30.38

DEPTH TO WATER (ft): 22.19 TOTAL DEPTH (ft): 33.43 WELL DIAMETER (inches): 2

PURGING

CASING VOLUME CALCULATION: _____ ft of water in casing X _____ gallons/foot = _____ total gallons/casing volume

Equipment Used: ☒ Dedicated Bladder Pump ☐ Nondedicated Bladder Pump ☐ Bailer ☐ Other _____

Time (24 hr)	Amount Purged (gals)	Flow Rate (ml/min)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)
1330	I	100	6.96	17.82	1.083	Over Range (OR)	159.2	3.07	23.05
1335	0.13	100	6.92	17.66	1.072	63	114.6	2.58	23.70
1340	0.26	100	6.93	17.66	1.070	56.7	62.3	2.52	23.85
1345	0.39	100	6.93	17.68	1.069	44.9	22.3	2.52	24.10
1350	0.52	100	6.93	17.64	1.066	39.7	9.7	2.49	24.32
1355	0.65	100	6.94	17.57	1.063	34.5	2.8	2.44	24.50
1400	0.78	100	6.94	17.47	1.062	30.7	-21.6	1.32	24.71
1405	0.91	100	6.94	17.48	1.064	25.1	-57.1	1.20	24.94
1410	1.04	100	6.93	17.57	1.069	20.6	-68.3	1.28	25.19
1415	1.17	100	6.92	17.58	1.070	17.2	-79.1	1.34	25.37
1420	1.30	100	6.92	17.52	1.071	19.6	-90.4	1.37	25.59
1425	1.43	100	6.92	17.56	1.072	23.9	-105.4	1.21	25.82
1430	1.56	100	6.92	17.55	1.071	25.7	-120.6	1.25	26.07

Continued on back (circle one) yes / (no)

SAMPLING Equipment Used: ☐ Same as above ☒ Other NA

Sample Time (24 hr)	Total Purged (gals)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)	Obs.
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Ferrous Iron (mg/L): NA

FINAL DEPTH TO WATER (ft TOC): 26.07 TIME FINAL DEPTH TAKEN: 1430

SAMPLE ID: NA SAMPLE ID FOR QC: NA

PARAMETERS REQUESTED FOR ANALYSIS: NA

IDW TOTAL: 1.56 Instrument Model: YSI 556 MPS

	NAME	SIGNATURE	DATE
PREPARED:	Lewis Turner	[signature]	9/23/17
REVIEWED:			

FIELD GROUND-WATER SAMPLING REPORT

DATE: 11/8/17 SITE: More's Lake PID READING at WELL HEAD (ppm): —

PROJECT NUMBER: 93647 WEATHER: Clear, Sunny, 50's

WELL NUMBER: MW-7

DEPTH TO WATER (ft): 20.02 TOP PUMP: 30.35'

TOTAL DEPTH (ft): 33.43 WELL DIAMETER (inches): 2"

PURGING

CASING VOLUME CALCULATION: _____ ft of water in casing X _____ gallons/foot = _____ total gallons/casing volume

Equipment Used: Dedicated Bladder Pump Nondedicated Bladder Pump Bailer Other _____

Time (24 hr)	Amount Purged (gals)	Flow Rate (ml/min)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)
1235	I	100				26.2			20.25
1240	0.13	100				78.3			20.40
1245	0.26	100				61.1			20.55
1250	0.39	100				64.3			20.80
1255	0.52	100				58.4			20.98
1300	0.65	100				72.3			21.24
1305	0.78	100				65.1			21.48
1310	0.91	100				62.6			21.65
1315	1.04	100				56.8			21.81
1320	1.17	100				51.4			21.99
1325	1.30	100				48.1			22.15
1330	1.43	100				41.4			22.32
1335	1.56	100				44.5			22.52
1340	1.69	100				49.8			22.71
1345	1.82	100				53.6			22.90
Continued on back (circle one) yes / no									

SAMPLING Equipment Used: Same as above Other _____

Sample Time (24 hr)	Total Purged (gals)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)	Obs.

FINAL DEPTH TO WATER (ft TOC): _____ TIME FINAL DEPTH TAKEN: _____

SAMPLE ID: NA SAMPLE ID FOR QC: NA

PARAMETERS REQUESTED FOR ANALYSIS: NA

IDW TOTAL: _____ FLOW THROUGH CELL MODEL NUMBER: NA

	NAME	SIGNATURE	DATE
PREPARED:	CHRIS HOGLUND	[signature]	11/8/17
REVIEWED:			

FIELD GROUNDWATER SAMPLING REPORT

DATE: 9/24/17 SITE: MORE'S LAKE PID READING at WELL HEAD (ppm): —

PROJECT NUMBER: 93647 WEATHER: CLEAR 80°F

WELL NUMBER: MW-8 Top of pump 25.05

DEPTH TO WATER (ft): 8.68 TOTAL DEPTH (ft): 27.85 WELL DIAMETER (inches): 2

PURGING

CASING VOLUME CALCULATION: _____ ft of water in casing X _____ gallons/foot = _____ total gallons/casing volume

Equipment Used: ☒ Dedicated Bladder Pump ☐ Nondedicated Bladder Pump ☐ Bailer ☐ Other _____

Time (24 hr)	Amount Purged (gals)	Flow Rate (ml/min)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)
1042	I	100	6.68	19.57	1.949	9.20	33.2	2.87	9.43
1047	0.13	100	6.63	19.29	2.401	14.4	-20.7	1.10	9.75
1052	0.26	100	6.61	19.12	2.545	13.34	-78.9	0.62	10.27
1057	0.39	100	6.61	19.06	2.595	10.94	-102.4	0.49	10.59
1102	0.52	100	6.61	18.87	2.595	7.74	-118.3	0.45	10.90
1107	0.65	100	6.62	18.87	2.525	5.90	-140.8	0.35	11.18
1112	0.78	100	6.65	18.92	2.326	7.47	-148.2	0.35	11.34
1117	0.91	100	6.68	18.93	2.053	4.47	-169.5	0.32	11.45
1122	1.04	100	6.70	18.87	1.808	3.60	-171.7	0.33	11.62
1127	1.17	100	6.73	18.89	1.690	2.81	-191.5	0.32	11.77
1132	1.30	100	6.74	18.82	1.638	2.55	-189.5	0.33	11.85
1137	1.43	100	6.75	18.81	1.618	2.19	-196.0	0.31	11.94
			Turbidity in Sample line before flow-through			2.47			
Continued on back (circle one) yes / no									

SAMPLING Equipment Used: ☐ Same as above ☒ Other NA

Sample Time (24 hr)	Total Purged (gals)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)	Obs.
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Ferrous Iron (mg/L): NA

FINAL DEPTH TO WATER (ft TOC): 11.94 TIME FINAL DEPTH TAKEN: 1137

SAMPLE ID: NA SAMPLE ID FOR QC: NA

PARAMETERS REQUESTED FOR ANALYSIS: NA

IDW TOTAL: 1.43 Instrument Model: YSI 556 MPS

	NAME	SIGNATURE	DATE
PREPARED:	Lewis Turner	LT	9/24/17
REVIEWED:			

FIELD GROUNDWATER SAMPLING REPORT

DATE: 9/24/17 SITE: MORE'S LAKE PID READING at WELL HEAD (ppm): ~

PROJECT NUMBER: 93647 WEATHER: CLEAR 81°F

WELL NUMBER: PZ-2 TOP OF PUMP 16.92

DEPTH TO WATER (ft): 8.50 TOTAL DEPTH (ft): 19.80 WELL DIAMETER (inches): 2

PURGING

CASING VOLUME CALCULATION: _____ ft of water in casing X _____ gallons/foot = _____ total gallons/casing volume

Equipment Used: ☒ Dedicated Bladder Pump ☐ Nondedicated Bladder Pump ☐ Bailer ☐ Other _____

Time (24 hr)	Amount Purged (gals)	Flow Rate (ml/min)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)
1238	±	100	6.50	21.81	2.002	13.92	-171.5	1.73	8.75
1243	0.13	100	6.49	21.37	2.100	16.3	-199.7	0.96	8.88
1248	0.26	100	6.51	21.42	2.092	14.31	-220.7	0.56	9.08
1253	0.39	100	6.53	21.44	2.030	8.96	-228.0	0.44	9.24
1258	0.52	100	6.55	21.41	1.937	6.95	-215.7	0.47	9.40
1303	0.65	100	6.57	21.40	1.876	7.34	-196.2	0.49	9.52
1308	0.78	100	6.58	21.41	1.825	5.45	-196.9	0.48	9.65
1313	0.91	100	6.58	21.50	1.808	5.24	-191.8	0.44	9.80
1318	1.04	100	6.58	21.51	1.802	4.75	-198.2	0.43	9.95
1323	1.17	100	6.58	21.56	1.799	4.11	-202.4	0.42	10.10
			Turbidity in sample line before flow through			3.67			

Continued on back (circle one) yes / (no)

SAMPLING Equipment Used: ☐ Same as above ☒ Other NA

Sample Time (24 hr)	Total Purged (gals)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)	Obs.
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Ferrous Iron (mg/L): NA

FINAL DEPTH TO WATER (ft TOC): 10.10 TIME FINAL DEPTH TAKEN: 13.23

SAMPLE ID: NA SAMPLE ID FOR QC: NA

PARAMETERS REQUESTED FOR ANALYSIS: NA

IDW TOTAL: 1.17 Instrument Model: YSI 556 mps

	NAME	SIGNATURE	DATE
PREPARED:	Lewis Turner	[illegible]	9/24/17
REVIEWED:			

FIELD GROUNDWATER SAMPLING REPORT

DATE: 9/24/17 SITE: MORE'S LAKE PID READING at WELL HEAD (ppm): —

PROJECT NUMBER: 93647 WEATHER: CLEAR 81°F

WELL NUMBER: PZ-6 TOP OF PUMP. 17.32

DEPTH TO WATER (ft): 7.19 TOTAL DEPTH (ft): 20.16 WELL DIAMETER (inches): 2

PURGING

CASING VOLUME CALCULATION: _____ ft of water in casing X _____ gallons/foot = _____ total gallons/casing volume

Equipment Used: ☒ Dedicated Bladder Pump ☐ Nondedicated Bladder Pump ☐ Bailer ☐ Other _____

Time (24 hr)	Amount Purged (gals)	Flow Rate (ml/min)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)
1147	I	100	7.02	20.36	1.168	6.70	-43.6	3.61	7.45
1152	0.13	100	7.02	19.74	1.130	6.98	-51.9	3.56	7.61
1157	0.26	100	7.03	19.59	1.120	7.25	-61.6	3.63	7.80
1202	0.39	100	7.03	19.52	1.116	4.83	-73.1	3.54	7.95
1207	0.52	100	7.03	19.60	1.118	4.49	-89.3	3.36	8.15
1212	0.65	100	7.03	19.70	1.122	3.26	-97.6	3.21	8.24
1217	0.78	100	7.02	19.74	1.129	3.15	-106.7	3.12	8.30
1222	0.91	100	7.02	19.80	1.134	2.98	-109.1	3.02	8.35
			Turbidity in Sample line before flow-through			3.70			

Continued on back (circle one) yes / (no)

SAMPLING Equipment Used: ☐ Same as above ☒ Other NA

Sample Time (24 hr)	Total Purged (gals)	pH	Temp (C)	Conductivity (mS/cm)	Turbidity (NTUs)	ORP (mV)	D.O. (mg/L)	Depth to Water (ft TOC)	Obs.
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Ferrous Iron (mg/L): NA

FINAL DEPTH TO WATER (ft TOC): 8.35 TIME FINAL DEPTH TAKEN: 1222

SAMPLE ID: NA SAMPLE ID FOR QC: NA

PARAMETERS REQUESTED FOR ANALYSIS: NA

IDW TOTAL: 0.91 Instrument Model: YSI 556 MPS

	NAME	SIGNATURE	DATE
PREPARED:	Lewis Turner	LT	9/24/17
REVIEWED:			

6/26/17 93647 L. TURNER

TIME	ID	WL=
1216	MW-3	16.83
1222	MW-8	8.28
1228	PZ-6	6.65
1230	PZ-4	6.97
1232	PZ-5	DRY
1240	PZ-3	12.56
1250	PZ-1	DRY

1259 COMPLETE WL ROUND. STORE EQUIPMENT STARTING TO RAIN.

1309 CALL CHRIS SNIDER ABOUT COLLECTING WATERLEVELS WEEKLY.

1320 TO LUNCH.

WEDNESDAY, AUGUST 23, 2017 93647 L. TURNER

WEATHER: CLEAR 80°F WIND 5-10 SW

TASK: LOW-FLOW WELL TESTING. (PILOT).

PERSONNEL: LEWIS TURNER

0700 LOAD TRUCK.

0728 DEPART KC OFFICE.

0929 AT SITE, PICK UP KEYS.

0940 BEGIN WL ROUND. DECON BEFORE EACH LOCATION.

TIME	ID	WL	
0942	POND	4.50	FROM GAUGE TOP IS 8.00'
0950	MW-3	17.66	
1000	MW-4	23.49	
1006	MW-5	12.63	
1010	MW-6	15.70	
1016	MW-7	22.27	FERNCO NOT FULLY SEATED (SEAL)
1024	MW-2	19.13	
1030	MW-1	28.58	
1036	MW-8	8.55	
1040	PZ-6	7.26	
1045	PZ-4	8.02	

1055 PZ-2 IS UNDER A TRAILER, GO TO LOCATE SOME ONE TO MOVE.

1103 WAIT FOR SOMEONE AT WELL TO MOVE EQUIPMENT.

1112	PZ-2	8.40	
1125	PZ-1	DRY	
1135	PZ-3	14.34	
1149	PZ-5	~~DRY~~ LT 14.65	

9/23/17 93647 L. TURNER

1150 COMPLETED WL ROUND

1154 TO LUNCH.

1233 BACK AT SITE. BEGIN CALIBRATING METERS.

LAMOTTE 2020WE TURBIDIMETER 10.19/10 0.37/0

YSI 556 MPS: pH 7.00/7.00 4.00/4.00 10.01/10.00, COND 1.409/1.409

ORP 237.5/237.5, DO: 100.6/100% @ 764.29 mmHg.

1310 SET UP AT MW-7 WL= 22.19 TOP OF PUMP = 30.38 (TOP)

1330 BEGIN PURGING AT 100 ml/min VERY TURBID.

MAX DRAW DOWN IS 6.5' (2' SAFETY MARGIN)

1430 TURBIDITY RISING. STOP PURGING. TURBIDITY AND ORP NOT STABLE, WATER LEVEL NOT STABLE.

1443 LOAD EQUIPMENT.

1446 SET UP AT MW-6 WL= 15.72 TOP OF PUMP = 38.86

1455 BEGIN PURGING AT 100 ml/min ~ CLEAR.

MAX ALLOWED DRAW-DOWN 6.5'

1545 STOP PURGING WL 21.03 TURBIDITY <5 FOR 3 READINGS.

1551 LOAD EQUIPMENT. WL NOT STABLE

1554 SET UP AT MW-5 WL= 12.69 TOP = 38.32

1605 BEGIN PURGING MW-5 AT 100 ml/min ~ CLEAR.

1700 STOP PURGING WL= 17.45 TURBIDITY <5 FOR 2 READINGS.

1705 LOAD EQUIPMENT. WL NOT STABLE

1712 SET UP AT MW-4 WL= 23.74 TOP= 54.23

1718 BEGIN PURGING AT 100 ml/min ~ CLEAR

1818 STOP PURGING WL= 27.62 TURBIDITY <5 FOR TWO READINGS.

WL NOT STABLE.

9/23/17 93647 L. TURNER

1820 LOAD EQUIPMENT.

1825 SET UP AT MW-3 WL= 17.70 TOP: 46.42

1835 BEGIN PURGING AT 100 ml/min. ~ CLEAR

1915 STOP PURGING WL= 19.13, TURBIDITY <5 FOR 3 READINGS.

WL NOT STABLE.

1920 LOAD EQUIPMENT.

1930 PLACE IDW WATER IN POND.

1933 OFFSITE TO HOTEL.

9/23/17

THURSDAY, AUGUST 24, 2017 93647 L. TURNER

WEATHER: CLEAR 80°F WIND CALM - 5 MPH S

TASK: LOW-FLOW WELL TESTING (PILOT).

PERSONNEL: LEWIS TURNER.

0650 DEPART HOTEL.

0700 ARRIVE AT SITE.

0705 CALIBRATE METERS

LAMOTTE 2020WE TURBIDIMETER 9.57/10 0.38/0

YSI 556 MPS: pH 7.00/7.00 4.00/4.00 10.01/10.00 COND 1.409/1.409

ORP 237.5/237.5, DO 100.4/100% AT 764.03 mmHg.

0735 SETUP AT MW-2 WL= 19.02 TOP= 49.98

0745 BEGIN PURGING AT 100 mL/min SLIGHTLY TURBID.

0920 STOP PURGING WL= 19.67 <5 TURBIDITY IN SAMPLE LINE BEFORE CELL. IN CELL 5-6 NTU. ALL OTHER PARAMETERS STABLE. WL NOT STABLE.

0923. LOAD TRUCK.

0930 SETUP AT MW-1 WL= 28.54 TOP: 39.75

0939 BEGIN PURGING AT 100 mL/min CLEAR. WL STABLE AT 100 mL/min NOT AT 150-200 mL/min.

1019 STOP PURGING WL= 28.87 ALL PARAMETERS STABLE. TURB <5 NTU AND IN LINE BEFORE CELL = 4.25 NTU. WL STABLE.

1025 LOAD TRUCK

1031 SETUP AT MW-8 WL= 8.68 TOP= 25.05

1042 BEGIN PURGING AT 100 mL/min. CLEAR

1137 STOP PURGING WL= 11.94'. TURBIDITY <5 NTU, ALL PARAMETERS STABLE. WL NOT STABLE. SAMPLE TURB 2.47 NTU.

9/24/17 93647 L. TURNER

1140 LOAD TRUCK.

1145 SETUP AT P2-6 WL= 7.19 TOP= 17.32

1147 BEGIN PURGING AT 100 mL/min. CLEAR

1222 STOP PURGING WL= 8.35 TURBIDITY <5 ALL PARAMETERS STABLE. WL NOT STABLE. SAMPLE TURB 3.20 NTU

1228 LOAD TRUCK. LOCK GATE.

1234 SETUP AT P2-2 WL= 8.50 TOP= 16.92

1238 BEGIN PURGING AT 100 mL/min. CLEAR

1323 STOP PURGING WL= 10.10 TURBIDITY <5, TURBIDITY IN SAMPLE LINE 3.67 NTU. ALL PARAMETERS STABLE. WL NOT STABLE.

1330 LOAD TRUCK.

1337 AT MW-7 TO CHECK TURBIDITY <24 HOURS AFTER PURGING. DIRECT FROM SAMPLE LINE.

MW-7 WL= 24.57

TIME	Flow/min	AMT (mL)	TURBIDITY (NTU)	WL 'TOC
1345 (I)	100 mL	I	42.6	24.57
1346	100	100	56.5	24.66
1347	100	200	38.7	24.73
1348	100	300	31.5	24.80
1349	100	400	31.9	24.86
1350	100	500	29.3	24.93
1355	100	1000	26.0	25.10
1400	100	1500	21.5	25.24

1407 LOAD AND PACK EQUIPMENT.

9/24/17 93647 L. TURNER

1419 PLACE IDW WATER IN POND.

1427 RETURN SITE KEYS. CALL CHRIS H.

1430 DEPART SITE, LUNCH.

1630 AT BLUE SPRINGS.

* UNLOAD TRUCK 9/25/17 FEI EQUIPMENT PLACED AT LOADING DOCK.

9/24/17

APPENDIX P – POTABLE WATER ANALYTICAL REPORT

Pace Analytical Services, LLC
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

November 10, 2017

Brian Weis

Burns & McDonnell
9400 Ward Parkway
Kansas City, MO 64114

RE: Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Dear Brian Weis:
Enclosed are the analytical results for sample(s) received by the laboratory on October 18, 2017. The results relate only to the samples included in this report. Results reported herein conform to the most current, applicable TNI/NELAC standards and the laboratory's Quality Assurance Manual, where applicable, unless otherwise noted in the body of the report.

Some analyses have been subcontracted outside of the Pace Network. The subcontracted laboratory report has been attached.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Colleen Clyne for
Alice Spiller
alice.spiller@pacelabs.com
(913)563-1409
Project Manager

Enclosures

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Pace Analytical Services, LLC
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

CERTIFICATIONS

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

New Orleans Certification IDs

California Env. Lab Accreditation Program Branch: 11277CA
Florida Department of Health (NELAC): E87595
Illinois Environmental Protection Agency: 0025721
Kansas Department of Health and Environment (NELAC): E-10266
Louisiana Dept. of Environmental Quality (NELAC/LELAP): 02006
Pennsylviania Dept. of Env Protection (NELAC): 68-04202
Texas Commission on Env. Quality (NELAC): T104704405-09-TX
U.S. Dept. of Agriculture Foreign Soil Import: P330-10-00119
Commonwealth of Virginia (TNI): 480246

Pennsylvania Certification IDs

1638 Roseytown Rd Suites 2,3&4, Greensburg, PA 15601
L-A-B DOD-ELAP Accreditation #: L2417
Alabama Certification #: 41590
Arizona Certification #: AZ0734
Arkansas Certification
California Certification #: 04222CA
Colorado Certification
Connecticut Certification #: PH-0694
Delaware Certification
Florida/TNI Certification #: E87683
Georgia Certification #: C040
Guam Certification
Hawaii Certification
Idaho Certification
Illinois Certification
Indiana Certification
Iowa Certification #: 391
Kansas/TNI Certification #: E-10358
Kentucky Certification #: 90133
Louisiana DHH/TNI Certification #: LA140008
Louisiana DEQ/TNI Certification #: 4086
Maine Certification #: PA00091
Maryland Certification #: 308
Massachusetts Certification #: M-PA1457
Michigan/PADEP Certification
Missouri Certification #: 235
Montana Certification #: Cert 0082
Nebraska Certification #: NE-05-29-14
Nevada Certification #: PA014572015-1
New Hampshire/TNI Certification #: 2976
New Jersey/TNI Certification #: PA 051
New Mexico Certification #: PA01457
New York/TNI Certification #: 10888
North Carolina Certification #: 42706
North Dakota Certification #: R-190
Oregon/TNI Certification #: PA200002
Pennsylvania/TNI Certification #: 65-00282
Puerto Rico Certification #: PA01457
Rhode Island Certification #: 65-00282
South Dakota Certification
Tennessee Certification #: TN2867
Texas/TNI Certification #: T104704188-14-8
Utah/TNI Certification #: PA014572015-5
USDA Soil Permit #: P330-14-00213
Vermont Dept. of Health: ID# VT-0282
Virgin Island/PADEP Certification
Virginia/VELAP Certification #: 460198
Washington Certification #: C868
West Virginia DEP Certification #: 143
West Virginia DHHR Certification #: 9964C
Wisconsin Certification
Wyoming Certification #: 8TMS-L

Kansas Certification IDs

9608 Loiret Boulevard, Lenexa, KS 66219
WY STR Certification #: 2456.01
Arkansas Certification #: 17-016-0
Illinois Certification #: 200030
Iowa Certification #: 118
Kansas/NELAP Certification #: E-10116
Louisiana Certification #: 03055
Nevada Certification #: KS000212018-1
Oklahoma Certification #: 9205/9935
Texas Certification #: T104704407
Utah Certification #: KS00021
Kansas Field Laboratory Accreditation: # E-92587
Missouri Certification: 10070

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Pace Analytical Services, LLC
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

SAMPLE SUMMARY

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Lab ID	Sample ID	Matrix	Date Collected	Date Received
60255773001	**WATER FROM HYDRANT**	Water	10/17/17 14:35	10/18/17 06:55

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SAMPLE ANALYTE COUNT

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Lab ID	Sample ID	Method	Analysts	Analytes Reported	Laboratory
60255773001	**WATER FROM HYDRANT**	EPA 6010	SMW	25	PASI-K
		EPA 7470	NSM	1	PASI-K
		EPA 9020B	MHB1	1	PASI-N
		EPA 903.1	WRR	1	PASI-PA
		EPA 904.0	VAL	1	PASI-PA
		SM 2540C	JSS	1	PASI-K
		Trivalent Chromium Calculation	JMC1	1	PASI-K
		EPA 300.0	OL	3	PASI-K
		EPA 410.4	JSS	1	PASI-K
		SM 5310C	LDF	1	PASI-K
		EPA 7196	HMM	1	PASI-K

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PROJECT NARRATIVE

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Method: **EPA 6010**
Description: 6010 MET ICP
Client: BURNS & MCDONNELL
Date: November 10, 2017

General Information:
1 sample was analyzed for EPA 6010. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Sample Preparation:
The samples were prepared in accordance with EPA 3010 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

QC Batch: 499575

A matrix spike and/or matrix spike duplicate (MS/MSD) were performed on the following sample(s): 60255773001

M1: Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.

- MSD (Lab ID: 2044245)
  - Calcium

Additional Comments:

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PROJECT NARRATIVE

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Method: **EPA 7470**
Description: 7470 Mercury
Client: BURNS & MCDONNELL
Date: November 10, 2017

General Information:
1 sample was analyzed for EPA 7470. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Sample Preparation:
The samples were prepared in accordance with EPA 7470 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Method: **EPA 9020B**
Description: Total Organic Halides
Client: BURNS & MCDONNELL
Date: November 10, 2017

General Information:
1 sample was analyzed for EPA 9020B. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Internal Standards:
All internal standards were within QC limits with any exceptions noted below.

Surrogates:
All surrogates were within QC limits with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

QC Batch: 92794

A matrix spike/matrix spike duplicate was not performed due to insufficient sample volume.

Additional Comments:

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PROJECT NARRATIVE

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Method: **EPA 903.1**
Description: 903.1 Radium 226
Client: BURNS & MCDONNELL
Date: November 10, 2017

General Information:
1 sample was analyzed for EPA 903.1. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Method: **EPA 904.0**
Description: 904.0 Radium 228
Client: BURNS & MCDONNELL
Date: November 10, 2017

General Information:
1 sample was analyzed for EPA 904.0. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Method: **SM 2540C**
Description: 2540C Total Dissolved Solids
Client: BURNS & MCDONNELL
Date: November 10, 2017

General Information:
1 sample was analyzed for SM 2540C. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Method: **Trivalent Chromium Calculation**
Description: Trivalent Chromium Calculation
Client: BURNS & MCDONNELL
Date: November 10, 2017

General Information:
1 sample was analyzed for Trivalent Chromium Calculation. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Method: **EPA 300.0**
Description: 300.0 IC Anions 28 Days
Client: BURNS & MCDONNELL
Date: November 10, 2017

General Information:
1 sample was analyzed for EPA 300.0. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Method: **EPA 410.4**
Description: 410.4 COD
Client: BURNS & MCDONNELL
Date: November 10, 2017

General Information:
1 sample was analyzed for EPA 410.4. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

QC Batch: 500309

A matrix spike and/or matrix spike duplicate (MS/MSD) were performed on the following sample(s): 60256031001,60256054008

M1: Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.

- MS (Lab ID: 2047632)
  - Chemical Oxygen Demand

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Method: **SM 5310C**
Description: 5310C TOC
Client: BURNS & MCDONNELL
Date: November 10, 2017

General Information:
1 sample was analyzed for SM 5310C. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Method: **EPA 7196**
Description: 7196 Chromium, Hexavalent
Client: BURNS & MCDONNELL
Date: November 10, 2017

General Information:
1 sample was analyzed for EPA 7196. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

QC Batch: 499179

A matrix spike and/or matrix spike duplicate (MS/MSD) were performed on the following sample(s): 60255773001

M1: Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.

- MS (Lab ID: 2042747)
  - Chromium, Hexavalent
- MSD (Lab ID: 2042748)
  - Chromium, Hexavalent

Additional Comments:

This data package has been reviewed for quality and completeness and is approved for release.

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ANALYTICAL RESULTS

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Sample: WATER FROM HYDRANT **Lab ID: 60255773001** Collected: 10/17/17 14:35 Received: 10/18/17 06:55 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Aluminum	ND	ug/L	75.0	1	10/20/17 10:15	10/23/17 17:56	7429-90-5	
Antimony	ND	ug/L	10.0	1	10/20/17 10:15	10/23/17 17:56	7440-36-0	
Arsenic	ND	ug/L	10.0	1	10/20/17 10:15	10/23/17 17:56	7440-38-2	
Barium	**162**	ug/L	5.0	1	10/20/17 10:15	10/23/17 17:56	7440-39-3	
Beryllium	ND	ug/L	1.0	1	10/20/17 10:15	10/23/17 17:56	7440-41-7	
Boron	ND	ug/L	100	1	10/20/17 10:15	10/23/17 17:56	7440-42-8	
Cadmium	ND	ug/L	5.0	1	10/20/17 10:15	10/23/17 17:56	7440-43-9	
Calcium	**40700**	ug/L	100	1	10/20/17 10:15	10/24/17 16:40	7440-70-2	M1
Chromium	ND	ug/L	5.0	1	10/20/17 10:15	10/24/17 16:40	7440-47-3	
Cobalt	ND	ug/L	5.0	1	10/20/17 10:15	10/23/17 17:56	7440-48-4	
Copper	ND	ug/L	10.0	1	10/20/17 10:15	10/23/17 17:56	7440-50-8	
Iron	**163**	ug/L	50.0	1	10/20/17 10:15	10/24/17 16:40	7439-89-6	
Lead	ND	ug/L	5.0	1	10/20/17 10:15	10/24/17 16:40	7439-92-1	
Lithium	**25.1**	ug/L	10.0	1	10/20/17 10:15	10/23/17 17:56	7439-93-2	
Magnesium	**20000**	ug/L	50.0	1	10/20/17 10:15	10/24/17 16:40	7439-95-4	
Manganese	**12.5**	ug/L	5.0	1	10/20/17 10:15	10/24/17 16:40	7439-96-5	
Molybdenum	ND	ug/L	20.0	1	10/20/17 10:15	10/23/17 17:56	7439-98-7	
Nickel	ND	ug/L	5.0	1	10/20/17 10:15	10/23/17 17:56	7440-02-0	
Potassium	**4840**	ug/L	500	1	10/20/17 10:15	10/24/17 16:40	7440-09-7	
Selenium	ND	ug/L	15.0	1	10/20/17 10:15	10/23/17 17:56	7782-49-2	
Silver	ND	ug/L	7.0	1	10/20/17 10:15	10/23/17 17:56	7440-22-4	
Sodium	**45400**	ug/L	500	1	10/20/17 10:15	10/23/17 17:56	7440-23-5	
Thallium	ND	ug/L	20.0	1	10/20/17 10:15	10/24/17 16:40	7440-28-0	
Total Hardness by 2340B	**184000**	ug/L	500	1	10/20/17 10:15	10/24/17 16:40		
Zinc	ND	ug/L	50.0	1	10/20/17 10:15	10/24/17 16:40	7440-66-6	
7470 Mercury	Analytical Method: EPA 7470 Preparation Method: EPA 7470							
Mercury	ND	ug/L	0.20	1	10/30/17 10:35	10/30/17 14:50	7439-97-6	
Total Organic Halides	Analytical Method: EPA 9020B							
Total Organic Halides	**0.22**	mg/L	0.20	10		10/25/17 15:33		
2540C Total Dissolved Solids	Analytical Method: SM 2540C							
Total Dissolved Solids	**341**	mg/L	5.0	1		10/19/17 10:29		
Trivalent Chromium Calculation	Analytical Method: Trivalent Chromium Calculation							
Chromium, Trivalent	ND	mg/L	0.010	1		11/01/17 16:25	16065-83-1	
300.0 IC Anions 28 Days	Analytical Method: EPA 300.0							
Chloride	**37.9**	mg/L	5.0	5		10/31/17 15:16	16887-00-6	
Fluoride	**0.59**	mg/L	0.20	1		10/30/17 01:53	16984-48-8	
Sulfate	**83.3**	mg/L	5.0	5		10/31/17 15:16	14808-79-8	
410.4 COD	Analytical Method: EPA 410.4							
Chemical Oxygen Demand	ND	mg/L	10.0	1		10/26/17 14:13		

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ANALYTICAL RESULTS

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Sample: WATER FROM HYDRANT **Lab ID: 60255773001** Collected: 10/17/17 14:35 Received: 10/18/17 06:55 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5310C TOC	Analytical Method: SM 5310C							
Total Organic Carbon	**1.7**	mg/L	1.0	1		10/25/17 22:55	7440-44-0	
7196 Chromium, Hexavalent	Analytical Method: EPA 7196							
Chromium, Hexavalent	ND	mg/L	0.010	1		10/18/17 13:52	18540-29-9	M1

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QUALITY CONTROL DATA

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

QC Batch: 500815 | Analysis Method: EPA 7470
QC Batch Method: EPA 7470 | Analysis Description: 7470 Mercury
Associated Lab Samples: 60255773001

METHOD BLANK: 2050458 | Matrix: Water
Associated Lab Samples: 60255773001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Mercury	ug/L	ND	0.20	10/30/17 14:45	

LABORATORY CONTROL SAMPLE: 2050459

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Mercury	ug/L	5	4.2	84	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 2050460 2050461

Parameter	Units	60255773001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Mercury	ug/L	ND	5	5	4.9	4.9	97	96	75-125	1	20	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

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QUALITY CONTROL DATA

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

QC Batch: 499575
QC Batch Method: EPA 3010
Analysis Method: EPA 6010
Analysis Description: 6010 MET
Associated Lab Samples: 60255773001

METHOD BLANK: 2044242
Matrix: Water
Associated Lab Samples: 60255773001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Aluminum	ug/L	ND	75.0	10/23/17 17:54	
Antimony	ug/L	ND	10.0	10/23/17 17:54	
Arsenic	ug/L	ND	10.0	10/23/17 17:54	
Barium	ug/L	ND	5.0	10/23/17 17:54	
Beryllium	ug/L	ND	1.0	10/23/17 17:54	
Boron	ug/L	ND	100	10/23/17 17:54	
Cadmium	ug/L	ND	5.0	10/23/17 17:54	
Calcium	ug/L	ND	100	10/24/17 16:34	
Chromium	ug/L	ND	5.0	10/24/17 16:34	
Cobalt	ug/L	ND	5.0	10/23/17 17:54	
Copper	ug/L	ND	10.0	10/23/17 17:54	
Iron	ug/L	ND	50.0	10/24/17 16:34	
Lead	ug/L	ND	5.0	10/24/17 16:34	
Lithium	ug/L	ND	10.0	10/23/17 17:54	
Magnesium	ug/L	ND	50.0	10/24/17 16:34	
Manganese	ug/L	ND	5.0	10/24/17 16:34	
Molybdenum	ug/L	ND	20.0	10/23/17 17:54	
Nickel	ug/L	ND	5.0	10/23/17 17:54	
Potassium	ug/L	ND	500	10/24/17 16:34	
Selenium	ug/L	ND	15.0	10/23/17 17:54	
Silver	ug/L	ND	7.0	10/23/17 17:54	
Sodium	ug/L	ND	500	10/23/17 17:54	
Thallium	ug/L	ND	20.0	10/24/17 16:34	
Total Hardness by 2340B	ug/L	ND	500	10/24/17 16:34	
Zinc	ug/L	ND	50.0	10/24/17 16:34	

LABORATORY CONTROL SAMPLE: 2044243

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Aluminum	ug/L	10000	10600	106	80-120	
Antimony	ug/L	1000	1060	106	80-120	
Arsenic	ug/L	1000	1030	103	80-120	
Barium	ug/L	1000	1080	108	80-120	
Beryllium	ug/L	1000	1070	107	80-120	
Boron	ug/L	1000	1030	103	80-120	
Cadmium	ug/L	1000	1060	106	80-120	
Calcium	ug/L	10000	10100	101	80-120	
Chromium	ug/L	1000	1010	101	80-120	
Cobalt	ug/L	1000	1090	109	80-120	
Copper	ug/L	1000	1060	106	80-120	

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REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

LABORATORY CONTROL SAMPLE: 2044243

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Iron	ug/L	10000	10300	103	80-120	
Lead	ug/L	1000	1030	103	80-120	
Lithium	ug/L	1000	1080	108	80-120	
Magnesium	ug/L	10000	9910	99	80-120	
Manganese	ug/L	1000	1020	102	80-120	
Molybdenum	ug/L	1000	1060	106	80-120	
Nickel	ug/L	1000	1070	107	80-120	
Potassium	ug/L	10000	10100	101	80-120	
Selenium	ug/L	1000	1100	110	80-120	
Silver	ug/L	500	534	107	80-120	
Sodium	ug/L	10000	10700	107	80-120	
Thallium	ug/L	1000	1070	107	80-120	
Total Hardness by 2340B	ug/L		66000			
Zinc	ug/L	1000	1030	103	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 2044244 2044245

Parameter	Units	60255773001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Aluminum	ug/L	ND	10000	10000	10500	10400	105	104	75-125	1	20	
Antimony	ug/L	ND	1000	1000	1040	1050	103	104	75-125	1	20	
Arsenic	ug/L	ND	1000	1000	1030	1040	102	104	75-125	2	20	
Barium	ug/L	162	1000	1000	1220	1210	106	105	75-125	1	20	
Beryllium	ug/L	ND	1000	1000	1060	1050	106	105	75-125	0	20	
Boron	ug/L	ND	1000	1000	1100	1100	102	102	75-125	0	20	
Cadmium	ug/L	ND	1000	1000	1030	1040	103	104	75-125	1	20	
Calcium	ug/L	40700	10000	10000	50500	53800	98	131	75-125	6	20	M1
Chromium	ug/L	ND	1000	1000	988	1040	99	104	75-125	5	20	
Cobalt	ug/L	ND	1000	1000	1040	1050	104	105	75-125	1	20	
Copper	ug/L	ND	1000	1000	1030	1030	103	103	75-125	0	20	
Iron	ug/L	163	10000	10000	10200	10600	100	104	75-125	4	20	
Lead	ug/L	ND	1000	1000	986	1040	98	104	75-125	5	20	
Lithium	ug/L	25.1	1000	1000	1090	1080	106	106	75-125	1	20	
Magnesium	ug/L	20000	10000	10000	29600	31700	96	116	75-125	7	20	
Manganese	ug/L	12.5	1000	1000	1000	1060	99	105	75-125	6	20	
Molybdenum	ug/L	ND	1000	1000	1040	1050	104	105	75-125	0	20	
Nickel	ug/L	ND	1000	1000	1020	1030	102	103	75-125	1	20	
Potassium	ug/L	4840	10000	10000	14800	15700	99	109	75-125	6	20	
Selenium	ug/L	ND	1000	1000	1060	1080	106	107	75-125	1	27	
Silver	ug/L	ND	500	500	522	523	104	105	75-125	0	20	
Sodium	ug/L	45400	10000	10000	55000	55100	96	98	75-125	0	20	
Thallium	ug/L	ND	1000	1000	1010	1050	101	105	75-125	4	20	
Total Hardness by 2340B	ug/L	184000			248000	265000				7		
Zinc	ug/L	ND	1000	1000	1000	1080	100	108	75-125	7	20	

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REPORT OF LABORATORY ANALYSIS

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Lenexa, KS 66219
(913)599-5665

QUALITY CONTROL DATA

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

QC Batch: 92794 | Analysis Method: EPA 9020B
QC Batch Method: EPA 9020B | Analysis Description: 9020B W TOX
Associated Lab Samples: 60255773001

METHOD BLANK: 398880 | Matrix: Water
Associated Lab Samples: 60255773001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Total Organic Halides	mg/L	ND	0.020	10/25/17 10:11	

LABORATORY CONTROL SAMPLE: 398881

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Total Organic Halides	mg/L	.1	0.11	109	85-115	

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QUALITY CONTROL DATA

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

QC Batch: 499281 | Analysis Method: SM 2540C
QC Batch Method: SM 2540C | Analysis Description: 2540C Total Dissolved Solids
Associated Lab Samples: 60255773001

METHOD BLANK: 2043049 | Matrix: Water
Associated Lab Samples: 60255773001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Total Dissolved Solids	mg/L	ND	5.0	10/19/17 10:22	

LABORATORY CONTROL SAMPLE: 2043050

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Total Dissolved Solids	mg/L	1000	973	97	80-120	

SAMPLE DUPLICATE: 2043051

Parameter	Units	60255761001 Result	Dup Result	RPD	Max RPD	Qualifiers
Total Dissolved Solids	mg/L	2710	2760	2	10	

SAMPLE DUPLICATE: 2043052

Parameter	Units	60255029003 Result	Dup Result	RPD	Max RPD	Qualifiers
Total Dissolved Solids	mg/L	411	394	4	10	

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QUALITY CONTROL DATA

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

QC Batch: 500736 | Analysis Method: EPA 300.0
QC Batch Method: EPA 300.0 | Analysis Description: 300.0 IC Anions
Associated Lab Samples: 60255773001

METHOD BLANK: 2050297 | Matrix: Water
Associated Lab Samples: 60255773001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Fluoride	mg/L	ND	0.20	10/29/17 23:24	

LABORATORY CONTROL SAMPLE: 2050298

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Fluoride	mg/L	2.5	2.5	101	90-110	

MATRIX SPIKE SAMPLE: 2050301

Parameter	Units	60255686001 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Fluoride	mg/L	ND	250	264	106	80-120	

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REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

QC Batch: 500980 | Analysis Method: EPA 300.0
QC Batch Method: EPA 300.0 | Analysis Description: 300.0 IC Anions
Associated Lab Samples: 60255773001

METHOD BLANK: 2050937 | Matrix: Water
Associated Lab Samples: 60255773001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Chloride	mg/L	ND	1.0	10/31/17 14:47	
Sulfate	mg/L	ND	1.0	10/31/17 14:47	

LABORATORY CONTROL SAMPLE: 2050938

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Chloride	mg/L	5	4.8	95	90-110	
Sulfate	mg/L	5	5.0	100	90-110	

MATRIX SPIKE SAMPLE: 2050939

Parameter	Units	60255773001 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Chloride	mg/L	37.9	50	86.6	98	80-120	
Sulfate	mg/L	83.3	50	129	91	80-120	

MATRIX SPIKE SAMPLE: 2050940

Parameter	Units	60255803004 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Chloride	mg/L	96.0	50	143	94	80-120	
Sulfate	mg/L	61.4	50	110	96	80-120	

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QUALITY CONTROL DATA

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

QC Batch: 500309 | Analysis Method: EPA 410.4
QC Batch Method: EPA 410.4 | Analysis Description: 410.4 COD
Associated Lab Samples: 60255773001

METHOD BLANK: 2047630 | Matrix: Water
Associated Lab Samples: 60255773001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Chemical Oxygen Demand	mg/L	ND	10.0	10/26/17 14:04	

LABORATORY CONTROL SAMPLE: 2047631

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Chemical Oxygen Demand	mg/L	50	54.6	109	90-110	

MATRIX SPIKE SAMPLE: 2047632

Parameter	Units	60256031001 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Chemical Oxygen Demand	mg/L	28.9	50	71.5	85	90-110	M1

MATRIX SPIKE SAMPLE: 2047634

Parameter	Units	60256054008 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Chemical Oxygen Demand	mg/L	ND	50	55.6	99	90-110	

SAMPLE DUPLICATE: 2047633

Parameter	Units	60256100001 Result	Dup Result	RPD	Max RPD	Qualifiers
Chemical Oxygen Demand	mg/L	140	135	4	25	

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QUALITY CONTROL DATA

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

QC Batch: 500316 | Analysis Method: SM 5310C
QC Batch Method: SM 5310C | Analysis Description: 5310C Total Organic Carbon
Associated Lab Samples: 60255773001

METHOD BLANK: 2047673 | Matrix: Water
Associated Lab Samples: 60255773001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Total Organic Carbon	mg/L	ND	1.0	10/25/17 18:43	

LABORATORY CONTROL SAMPLE: 2047674

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Total Organic Carbon	mg/L	5	5.4	108	80-120	

MATRIX SPIKE SAMPLE: 2047675

Parameter	Units	60255964001 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Total Organic Carbon	mg/L	10700	10000	21600	109	80-120	

SAMPLE DUPLICATE: 2047676

Parameter	Units	60255964002 Result	Dup Result	RPD	Max RPD	Qualifiers
Total Organic Carbon	mg/L	12100	12000	0	25	

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QUALITY CONTROL DATA

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

QC Batch: 499179
QC Batch Method: EPA 7196
Analysis Method: EPA 7196
Analysis Description: 7196 Chromium, Hexavalent
Associated Lab Samples: 60255773001

METHOD BLANK: 2042745
Matrix: Water
Associated Lab Samples: 60255773001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Chromium, Hexavalent	mg/L	ND	0.010	10/18/17 13:50	

LABORATORY CONTROL SAMPLE: 2042746

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Chromium, Hexavalent	mg/L	.1	0.091	91	90-110	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 2042747 2042748

Parameter	Units	60255773001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Chromium, Hexavalent	mg/L	ND	.1	.1	0.084	0.084	76	76	85-115	0	20	M1

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REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS - RADIOCHEMISTRY

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Sample: WATER FROM HYDRANT **Lab ID: 60255773001** Collected: 10/17/17 14:35 Received: 10/18/17 06:55 Matrix: Water
PWS: Site ID: Sample Type:

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Radium-226	EPA 903.1	**0.445 ± 0.377 (0.468)** **C:NA T:85%**	pCi/L	10/31/17 22:03	13982-63-3	
Radium-228	EPA 904.0	**0.840 ± 0.528 (0.998)** **C:69% T:73%**	pCi/L	10/27/17 11:49	15262-20-1	

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QUALITY CONTROL - RADIOCHEMISTRY

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

QC Batch: 276385 | Analysis Method: EPA 904.0
QC Batch Method: EPA 904.0 | Analysis Description: 904.0 Radium 228
Associated Lab Samples: 60255773001

METHOD BLANK: 1358754 | Matrix: Water
Associated Lab Samples: 60255773001

Parameter	Act ± Unc (MDC) Carr Trac	Units	Analyzed	Qualifiers
Radium-228	0.564 ± 0.323 (0.583) C:80% T:94%	pCi/L	10/27/17 11:48	

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QUALITY CONTROL - RADIOCHEMISTRY

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

QC Batch: 276376 | Analysis Method: EPA 903.1
QC Batch Method: EPA 903.1 | Analysis Description: 903.1 Radium-226
Associated Lab Samples: 60255773001

METHOD BLANK: 1358733 | Matrix: Water
Associated Lab Samples: 60255773001

Parameter	Act ± Unc (MDC) Carr Trac	Units	Analyzed	Qualifiers
Radium-226	0.485 ± 0.416 (0.563) C:NA T:88%	pCi/L	10/31/17 21:19	

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QUALIFIERS

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to dilution of the sample aliquot.

ND - Not Detected at or above adjusted reporting limit.

TNTC - Too Numerous To Count

J - Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

MDL - Adjusted Method Detection Limit.

PQL - Practical Quantitation Limit.

RL - Reporting Limit.

S - Surrogate

1,2-Diphenylhydrazine decomposes to and cannot be separated from Azobenzene using Method 8270. The result for each analyte is a combined concentration.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

Act - Activity

Unc - Uncertainty: SDWA = 1.96 sigma count uncertainty, all other matrices = Expanded Uncertainty (95% confidence interval). Gamma Spec = Expanded Uncertainty (95.4% Confidence Interval)

(MDC) - Minimum Detectable Concentration

Trac - Tracer Recovery (%)

Carr - Carrier Recovery (%)

Pace Analytical is TNI accredited. Contact your Pace PM for the current list of accredited analytes.

TNI - The NELAC Institute.

LABORATORIES

PASI-K	Pace Analytical Services - Kansas City
PASI-N	Pace Analytical Services - New Orleans
PASI-PA	Pace Analytical Services - Greensburg

BATCH QUALIFIERS

Batch: 92794

[M5] A matrix spike/matrix spike duplicate was not performed for this batch due to insufficient sample volume.

ANALYTE QUALIFIERS

M1 Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.

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QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: MORE'S LAKE COLUMBIA, MO
Pace Project No.: 60255773

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
60255773001	**WATER FROM HYDRANT**	EPA 3010	499575	EPA 6010	499641
60255773001	**WATER FROM HYDRANT**	EPA 7470	500815	EPA 7470	500871
60255773001	**WATER FROM HYDRANT**	EPA 9020B	92794		
60255773001	**WATER FROM HYDRANT**	EPA 903.1	276376		
60255773001	**WATER FROM HYDRANT**	EPA 904.0	276385		
60255773001	**WATER FROM HYDRANT**	SM 2540C	499281		
60255773001	**WATER FROM HYDRANT**	Trivalent Chromium Calculation	501362		
60255773001	**WATER FROM HYDRANT**	EPA 300.0	500736		
60255773001	**WATER FROM HYDRANT**	EPA 300.0	500980		
60255773001	**WATER FROM HYDRANT**	EPA 410.4	500309		
60255773001	**WATER FROM HYDRANT**	SM 5310C	500316		
60255773001	**WATER FROM HYDRANT**	EPA 7196	499179		

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Sample Condition Upon Receipt

WO#: 60255773
60255773

Client Name: B;M

Courier: FedEx ☐ UPS ☐ VIA ☑ Clay ☐ PEX ☐ ECI ☐ Pace ☐ Xroads ☐ Client ☐ Other ☐

Tracking #: _____ Pace Shipping Label Used? Yes ☐ No ☑

Custody Seal on Cooler/Box Present: Yes ☑ No ☐ Seals intact: Yes ☑ No ☐

Packing Material: Bubble Wrap ☐ Bubble Bags ☑ Foam ☐ None ☐ Other ☐

Thermometer Used: CF 0.0 T-266 / CF +0.3 T-239 **Type of Ice:** (Wet) Blue None

Cooler Temperature (°C): As-read 3.3 **Corr. Factor** CF 0.0 CF +0.3 **Corrected** 3.3

Date and initials of person examining contents: PV 10/18/17

Temperature should be above freezing to 6°C

Chain of Custody present:	☑Yes ☐No ☐N/A	
Chain of Custody relinquished:	☑Yes ☐No ☐N/A	
Samples arrived within holding time:	☑Yes ☐No ☐N/A	
Short Hold Time analyses (<72hr):	☑Yes ☐No ☐N/A	Crot
Rush Turn Around Time requested:	☐Yes ☑No ☐N/A	
Sufficient volume:	☑Yes ☐No ☐N/A	
Correct containers used:	☑Yes ☐No ☐N/A	
Pace containers used:	☑Yes ☐No ☐N/A	
Containers intact:	☑Yes ☐No ☐N/A	
Unpreserved 5035A / TX1005/1006 soils frozen in 48hrs?	☐Yes ☐No ☑N/A	
Filtered volume received for dissolved tests?	☐Yes ☐No ☑N/A	
Sample labels match COC: Date / time / ID / analyses	☑Yes ☐No ☐N/A	
Samples contain multiple phases? Matrix: WT	☐Yes ☑No ☐N/A	
Containers requiring pH preservation in compliance? (HNO_3, H_2SO_4, HCl<2; NaOH>9 Sulfide, NaOH>10 Cyanide) (Exceptions: VOA, Micro, O&G, KS TPH, OK-DRO)	☑Yes ☐No ☐N/A	
Cyanide water sample checks: ☑ N/A		
Lead acetate strip turns dark? (Record only)	☐Yes ☐No	
Potassium iodide test strip turns blue/purple? (Preserve)	☐Yes ☐No	
Trip Blank present:	☐Yes ☐No ☑N/A	
Headspace in VOA vials (>6mm):	☐Yes ☐No ☑N/A	
Samples from USDA Regulated Area: State:	☐Yes ☐No ☑N/A	
Additional labels attached to 5035A / TX1005 vials in the field?	☐Yes ☐No ☑N/A	

Client Notification/ Resolution: Copy COC to Client? Y / N Field Data Required? Y / N

Person Contacted: _____ Date/Time: _____

Comments/ Resolution: _____

Project Manager Review: Alice Date: 10/18/17

F-KS-C-003-Rev.10, August 18, 2016

CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page : 1 Of 1

Section A Required Client Information:		Section B Required Project Information:		Section C Invoice Information:	
Company:	BURNS & MCDONNELL	Report To:	Brian Weis	Attention:	
Address:	Burns & McDonnell	Copy To:		Company Name:	
Kansas City, MO 64114				Address:	
Email:	bweis@burnsmcd.com	Purchase Order #:		Pace Quote:	
Phone:	816-333-9400 Fax:	Project Name:	More's Lake Columbia, MO	Pace Project Manager:	alice.spiller@pacelabs.com
Requested Due Date:		Project #:		Pace Profile #:	10268

Regulatory Agency	
State / Location	
	MO

Requested Analysis Filtered (Y/N)

ITEM #	SAMPLE ID (One Character per box. (A-Z, 0-9 / , -) Sample Ids must be unique)	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED START DATE	COLLECTED START TIME	COLLECTED END DATE	COLLECTED END TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Preservatives: Unpreserved	H2SO4	HNO3	HCl	NaOH	Na2S2O3	Methanol	Other	Analyses Test (Y/N)	300.0 Sulfate,Cl,F	TOC	COD	TDS by 2540C	Metals**	Mercury	Hardness	Hexavalent Chromium**SHORT HOL	Trivalent Chromium Calc	TOX	Radium 226/228		Residual Chlorine (Y/N)	60255773 **Al,Sb,As,Ba,Be,B,Cd,Ca,Cr,Co,Cu,Fe,Pb,Li,Mg,Mn,Mo,Ni,Se,Ag,Na,Tl,Zn
1	Water from hydrant	WT	G	170CT17	2:32P	170CT17	2:35P	16°C	8	3	2	3		3BP3U		AG	2O 2O 2O		X	X	X	X	X	X	X	X	X	X	BP	2O N	AG2S 2BP/N	001
2																																
3																																
4																																
5																																
6																																
7																																
8																																
9																																
10																																
11																																
12																																

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS			
	ES+S	170CT17	1600		10/18	0655	3.3	Y	Y	Y

SAMPLER NAME AND SIGNATURE			TEMP in C	Received on Ice (Y/N)	Custody Sealed Cooler (Y/N)	Samples Intact (Y/N)
PRINT Name of SAMPLER:	David Kilgore					
SIGNATURE of SAMPLER:		DATE Signed: 170CT17				

APPENDIX Q – BOONE COUNTY PUBLIC DRINKING WATER SUPPLY SYSTEM REPORTS

Columbia

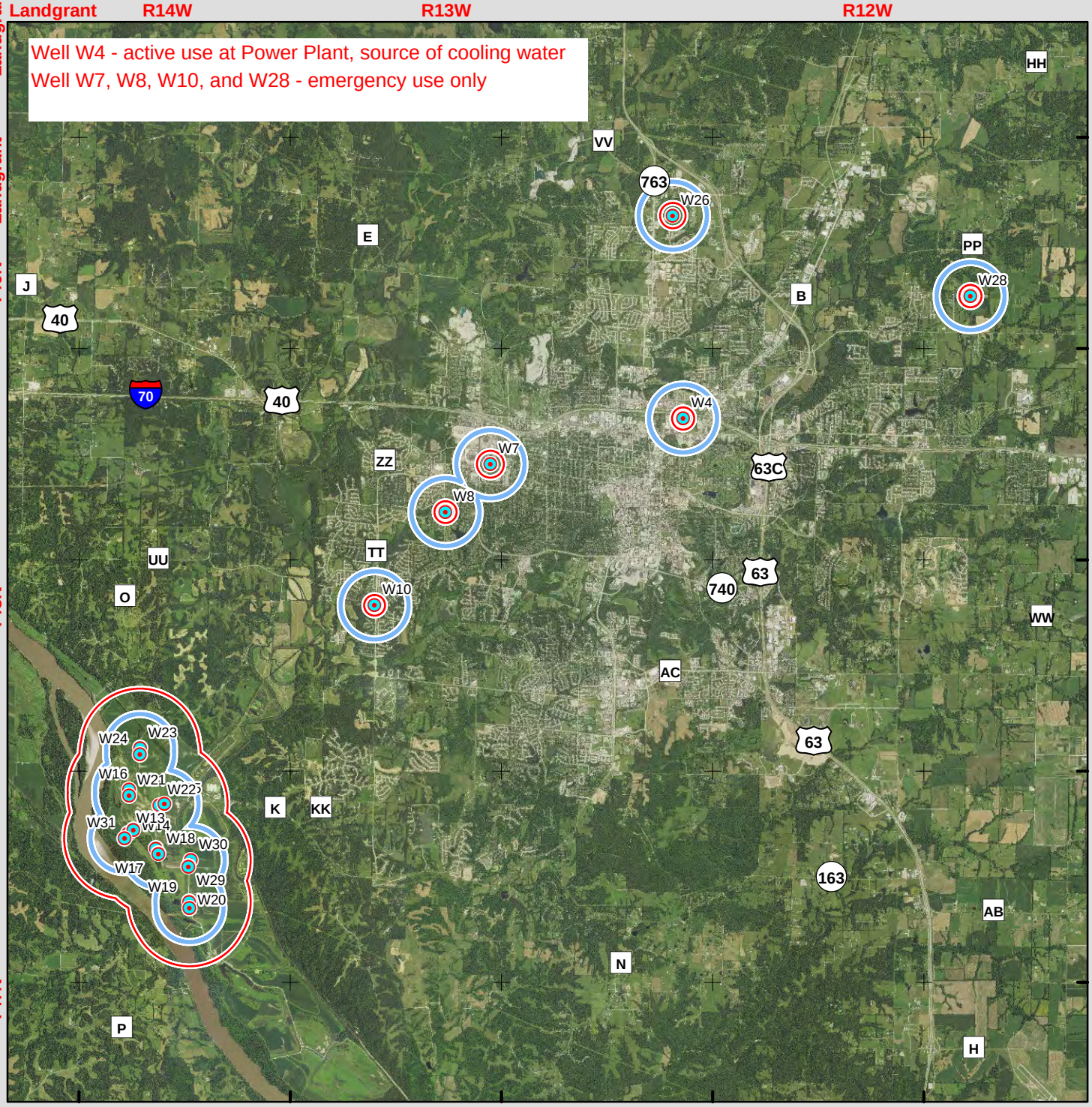
PWSS No. 3010181

21 Wells, Boone County

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 22, 2016

Missouri Department of Natural Resources



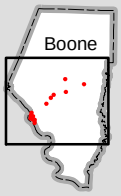
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



Miles

0 2 4

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2014.

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Columbia

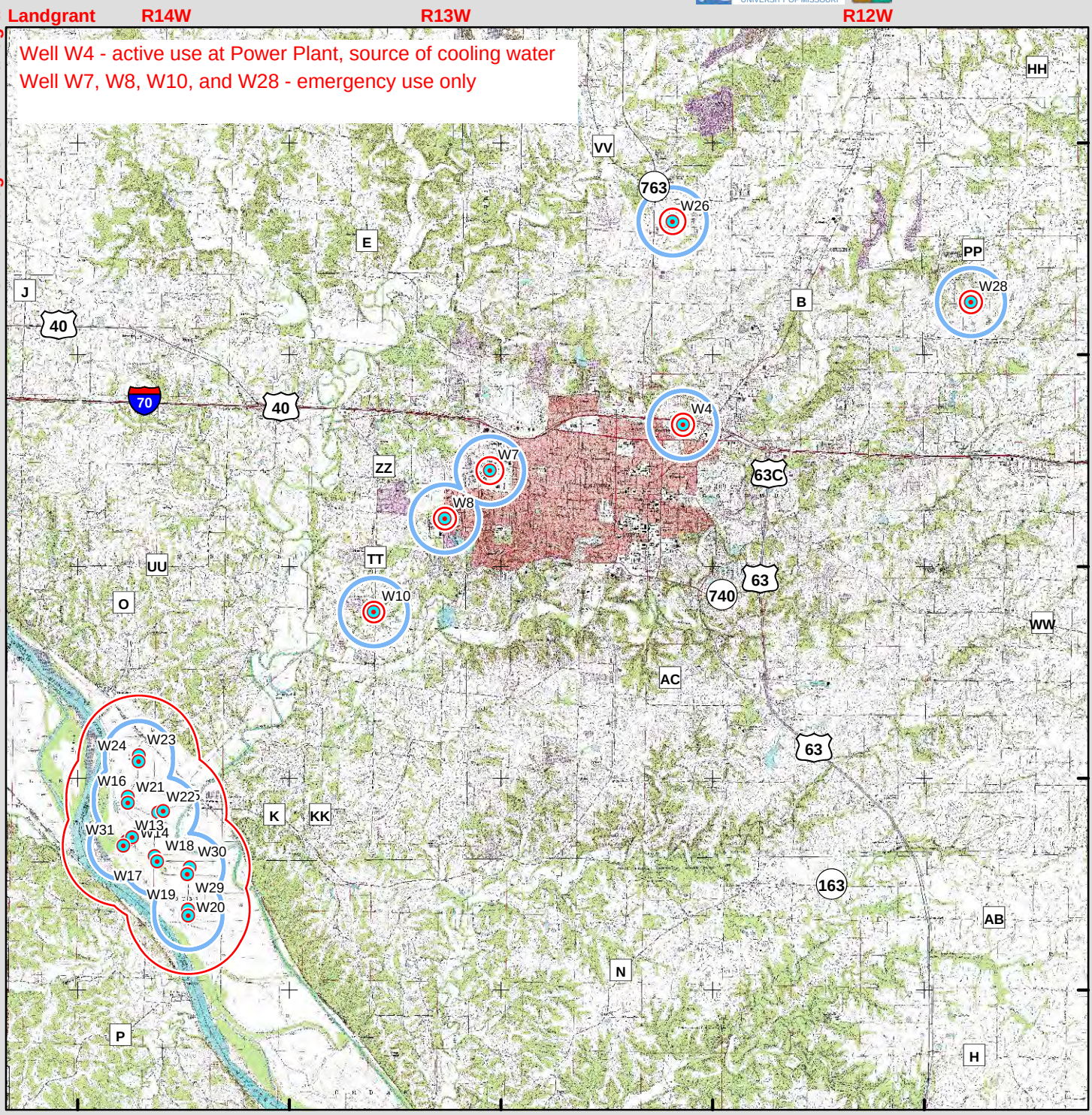
PWSS No. 3010181

21 Wells, Boone County

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 22, 2016

Missouri Department of Natural Resources



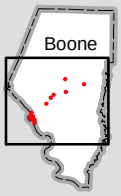
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



Miles

0 2 4

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

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Columbia

Old Well #4, Bowling St. (W4)

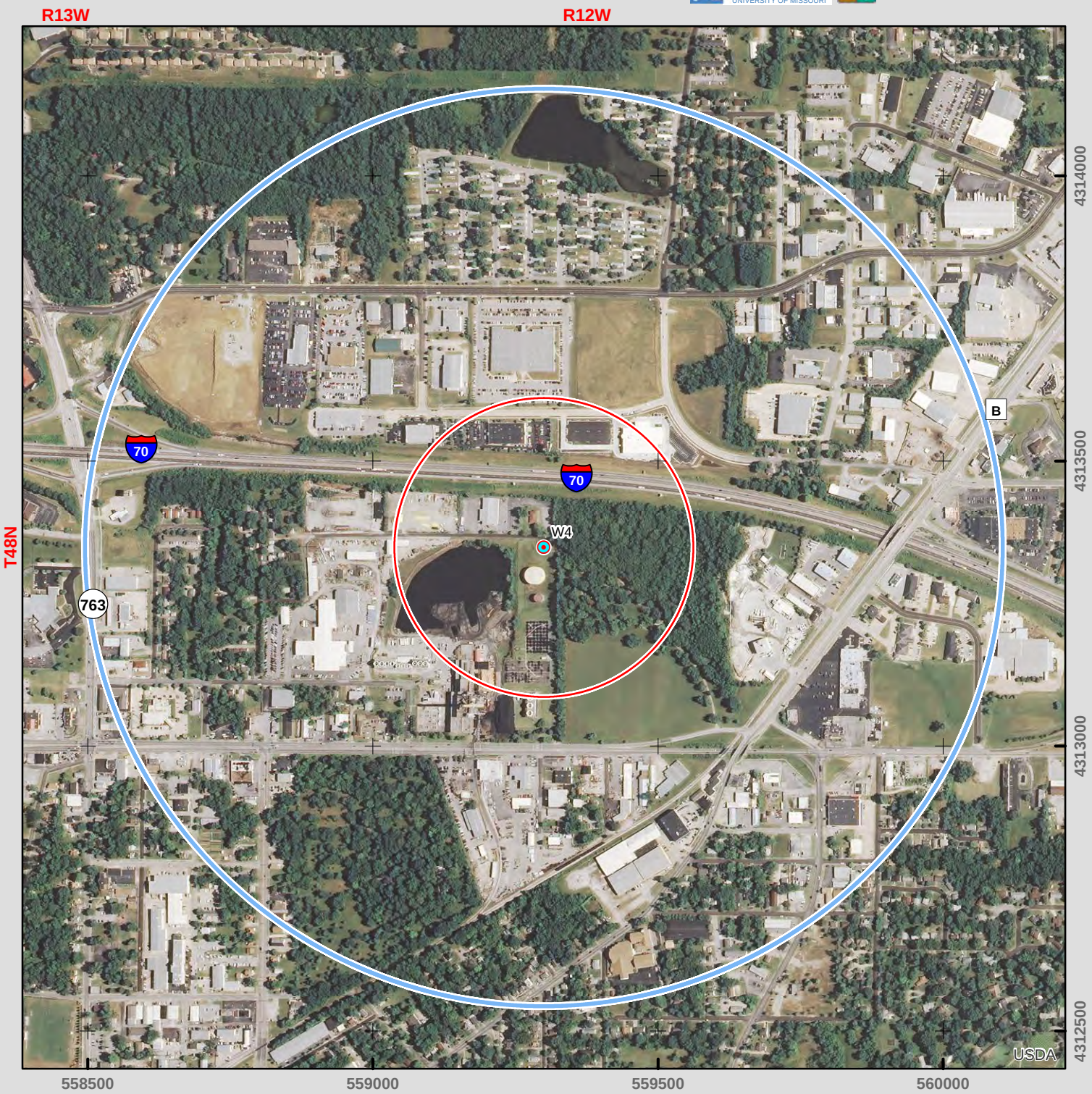
PWSS No. 3010181, Well 1 of 21

Well W4 - active use at Power Plant, source of cooling water

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources



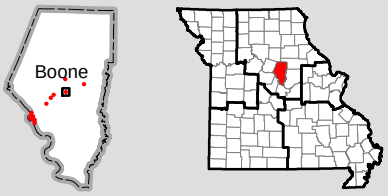
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

Feet

0 790 1,580

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Columbia

Well W7 - Emergency Use Only

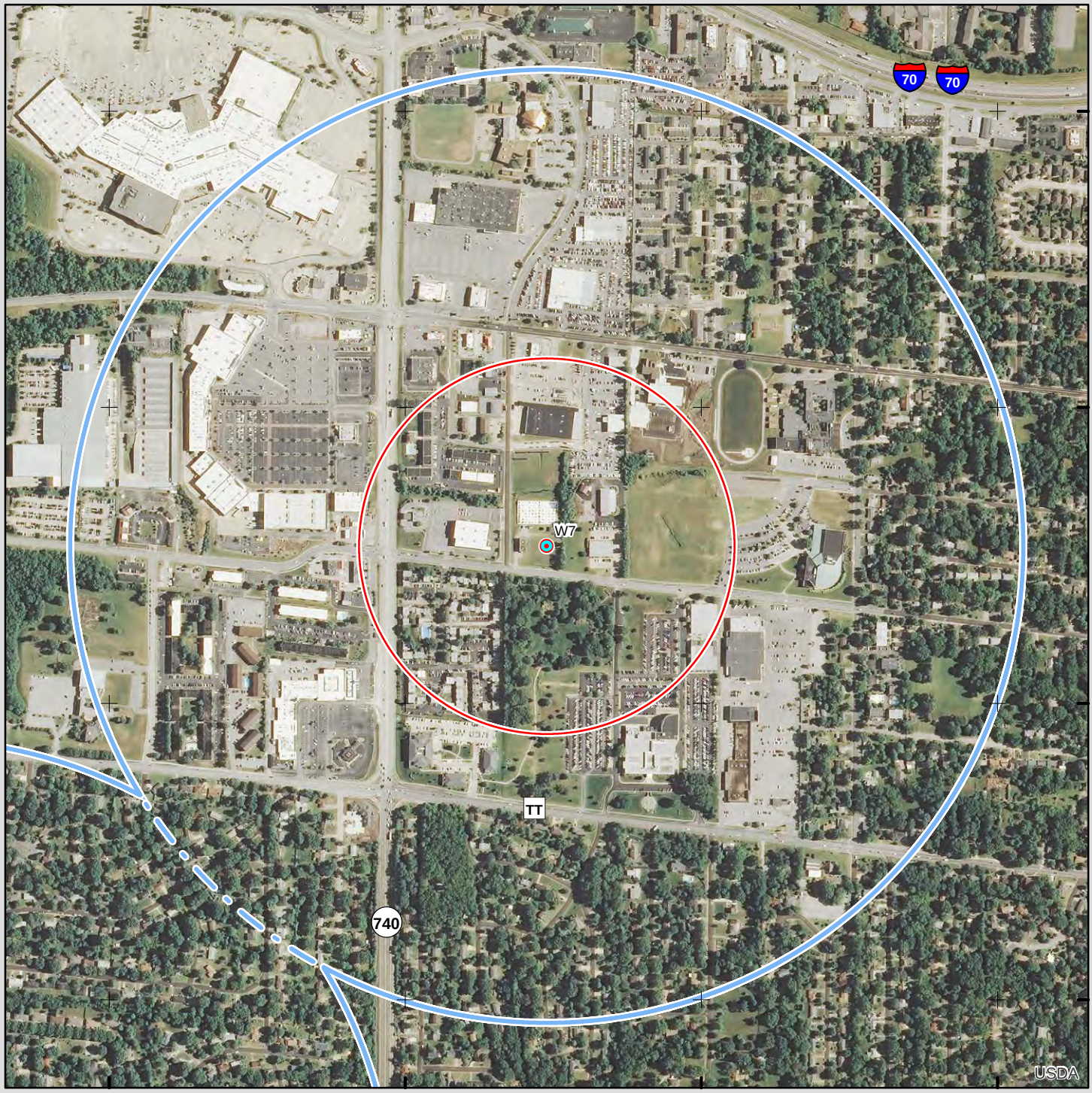
Ash St. At Reservoir Well (W7)

PWSS No. 3010181, Well 2 of 21

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources



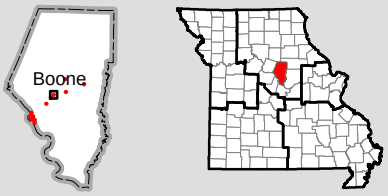
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

N

Feet

0 790 1,580

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Columbia

Well W8 - Emergency Use Only

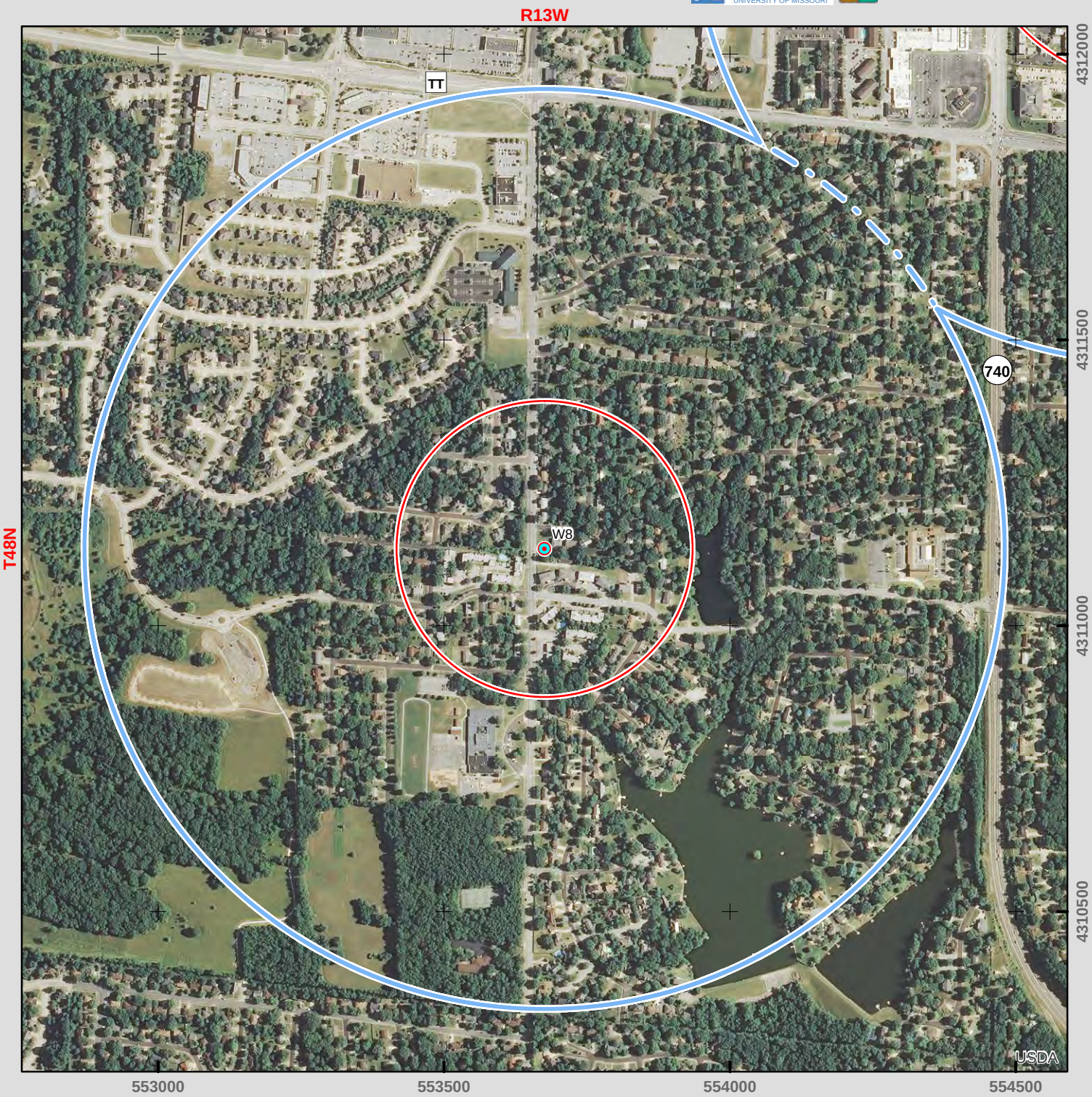
Fairview Church Well (W8)

PWSS No. 3010181, Well 3 of 21

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources



Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

Feet

0 790 1,580

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Columbia

Well W10 - Emergency Use Only

Rt TT (Katy Trail) Well (W10)

PWSS No. 3010181, Well 4 of 21

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources

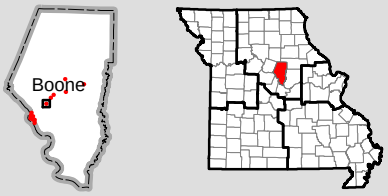
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

Feet

0 790 1,580

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Columbia

Well #13 (W13)

PWSS No. 3010181, Well 5 of 21

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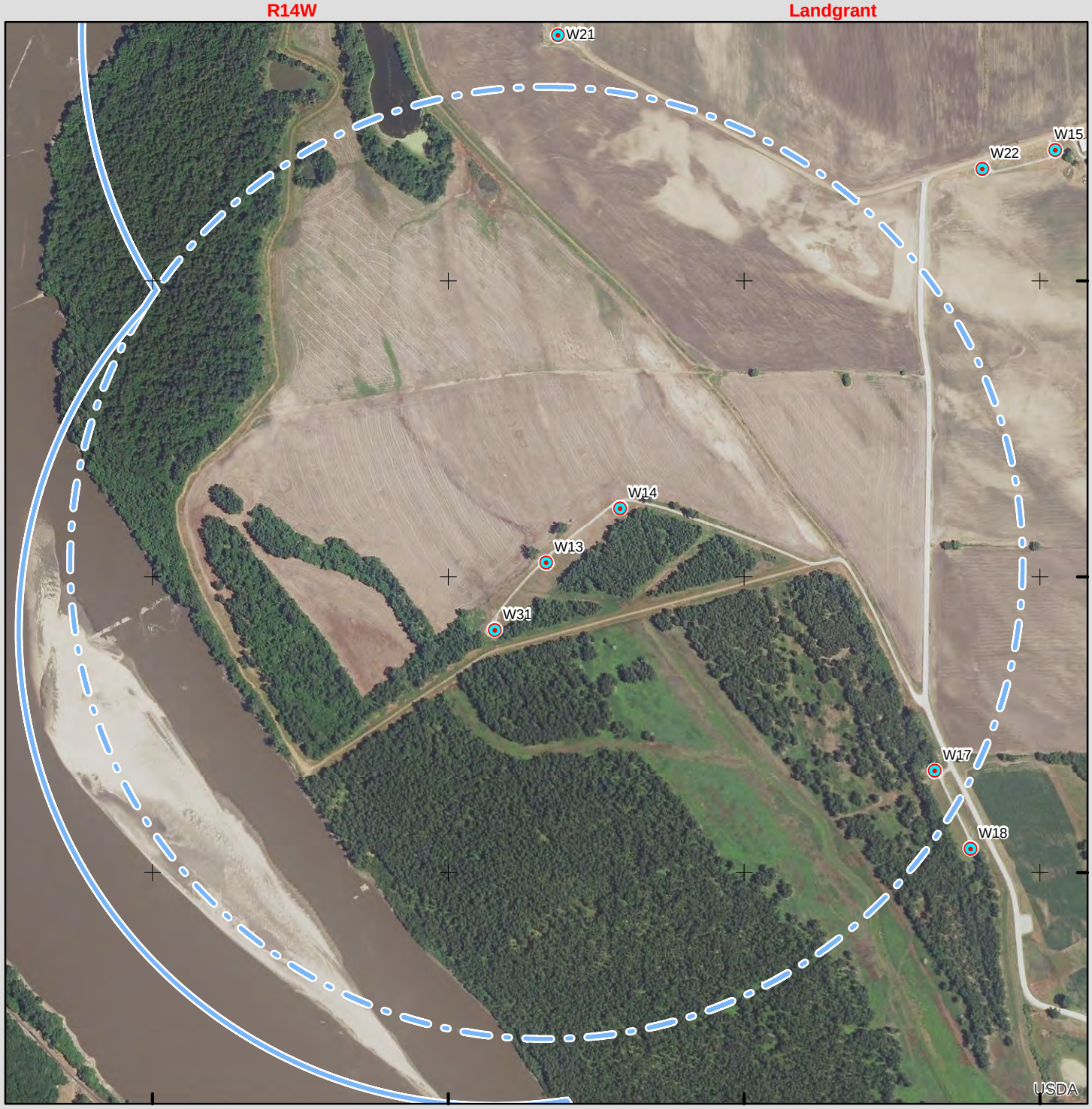
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

Feet

0 790 1,580

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Columbia

Well #14 (W14)

PWSS No. 3010181, Well 6 of 21

Prepared by:

CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources

Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

Feet

0 790 1,580

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Columbia

Well #1 (W15)

PWSS No. 3010181, Well 7 of 21

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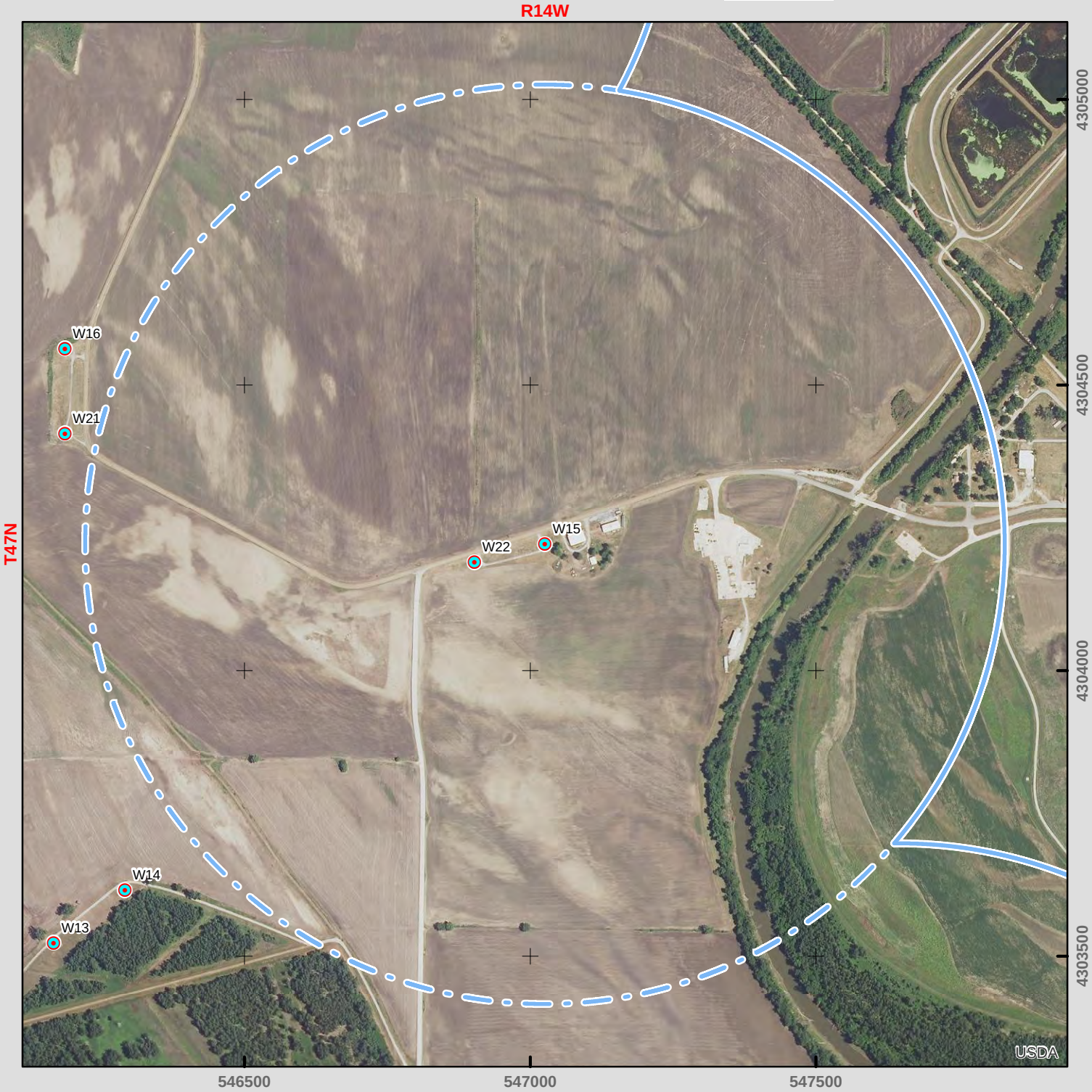
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

N

Feet

0 790 1,580

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Columbia

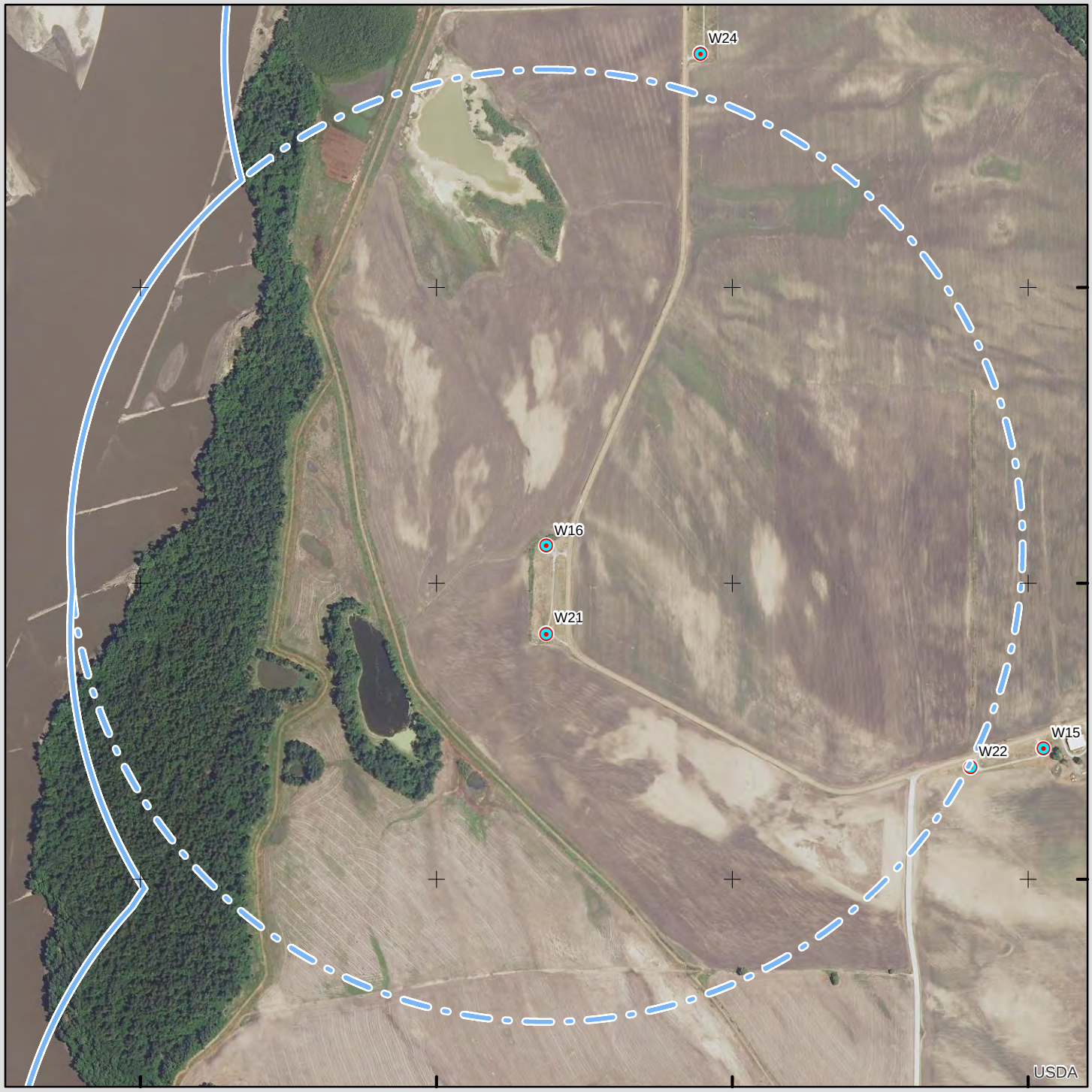
Well #2 (W16)

PWSS No. 3010181, Well 8 of 21

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources



Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

N

Feet

0 790 1,580

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Columbia

Well #3 (W17)

PWSS No. 3010181, Well 9 of 21

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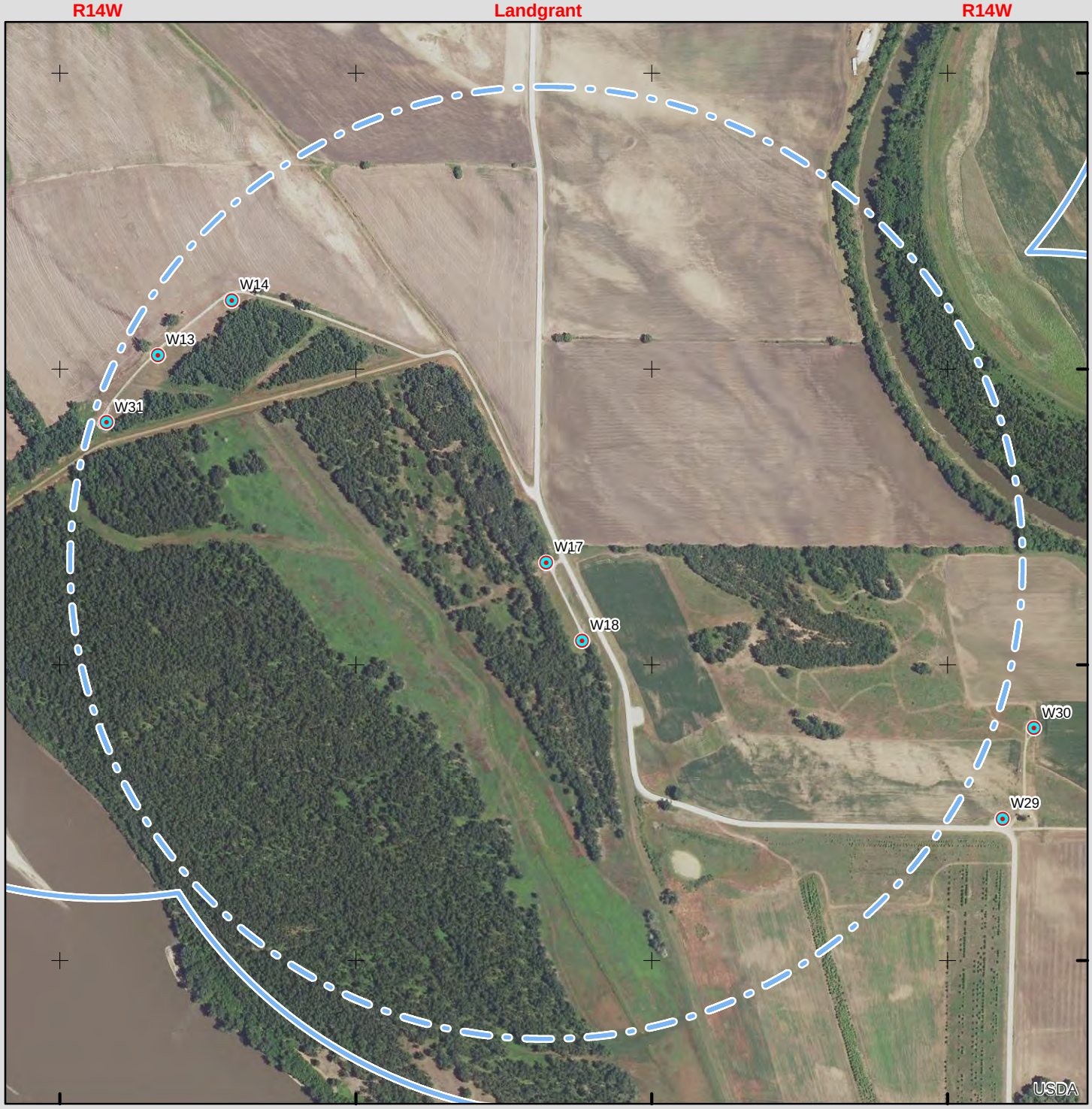
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

N

Feet

0 790 1,580

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Columbia

Well #4 (W18)

PWSS No. 3010181, Well 10 of 21

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources

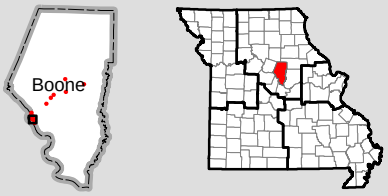
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

Feet

0 790 1,580

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Columbia

Well #5 (W19)

PWSS No. 3010181, Well 11 of 21

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources

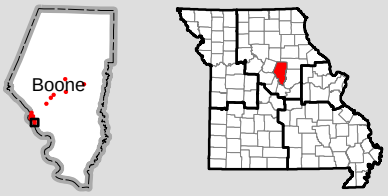
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

Feet

0 790 1,580

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Columbia

Well #6 (W20)

PWSS No. 3010181, Well 12 of 21

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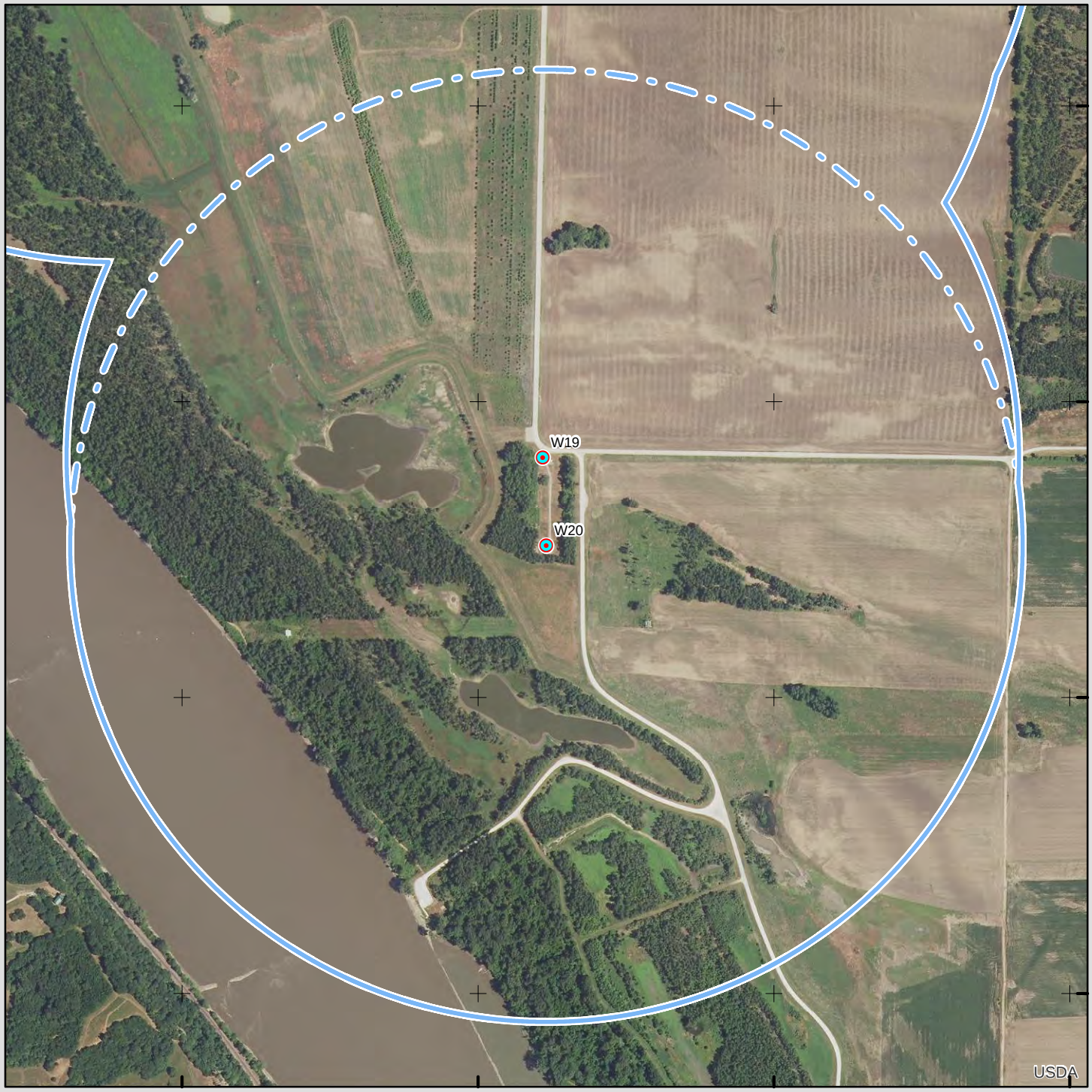
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

N

Feet

0 790 1,580

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Columbia

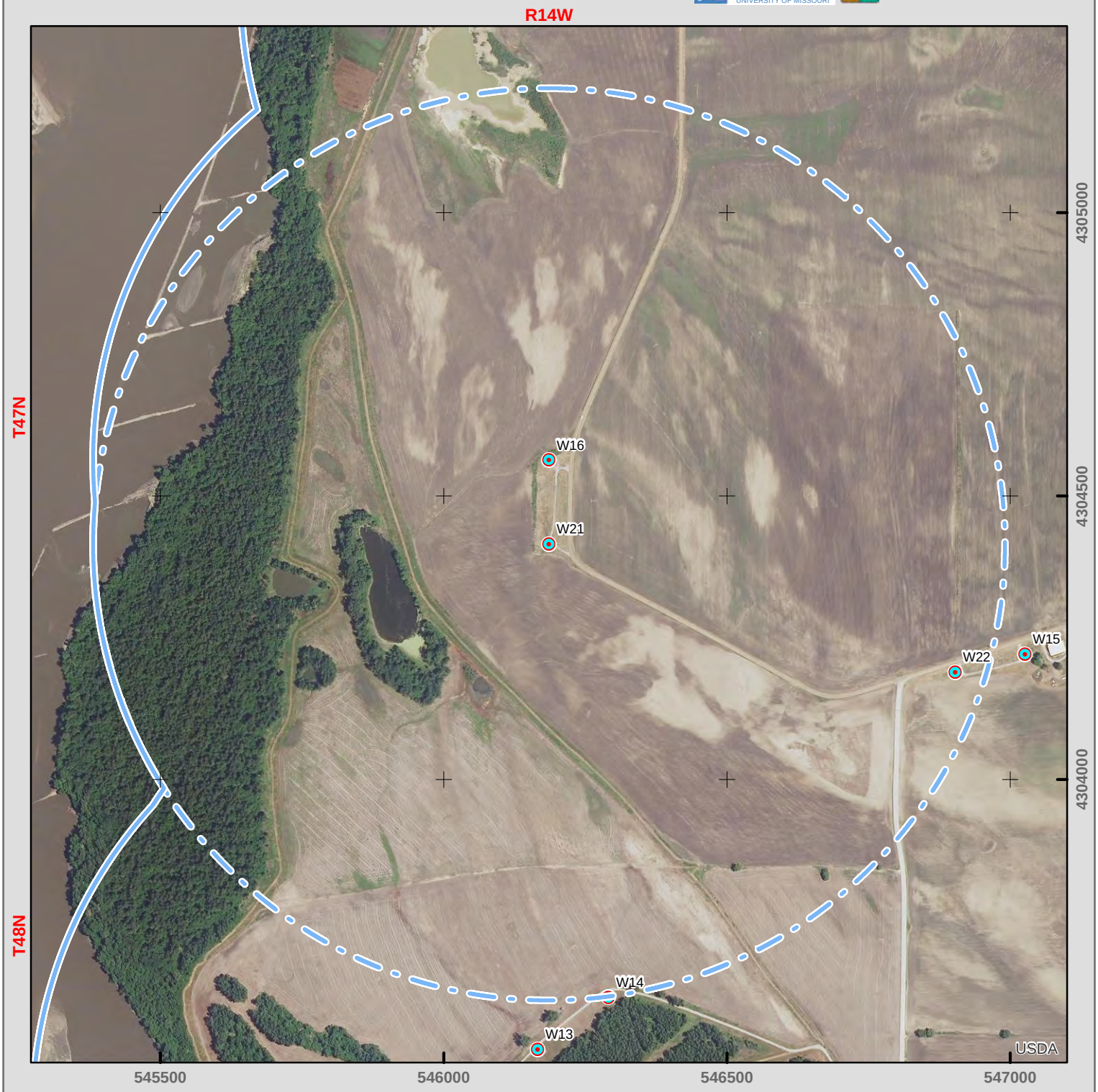
Well #7 (W21)

PWSS No. 3010181, Well 13 of 21

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources



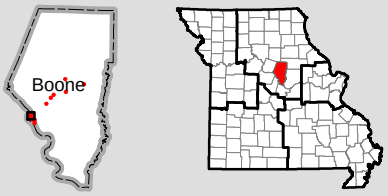
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

N

Feet

0 790 1,580

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Columbia

Well #8 (W22)

PWSS No. 3010181, Well 14 of 21

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources

Well System

System Well

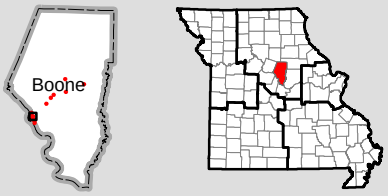
SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.



N

Feet

0 790 1,580

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Columbia

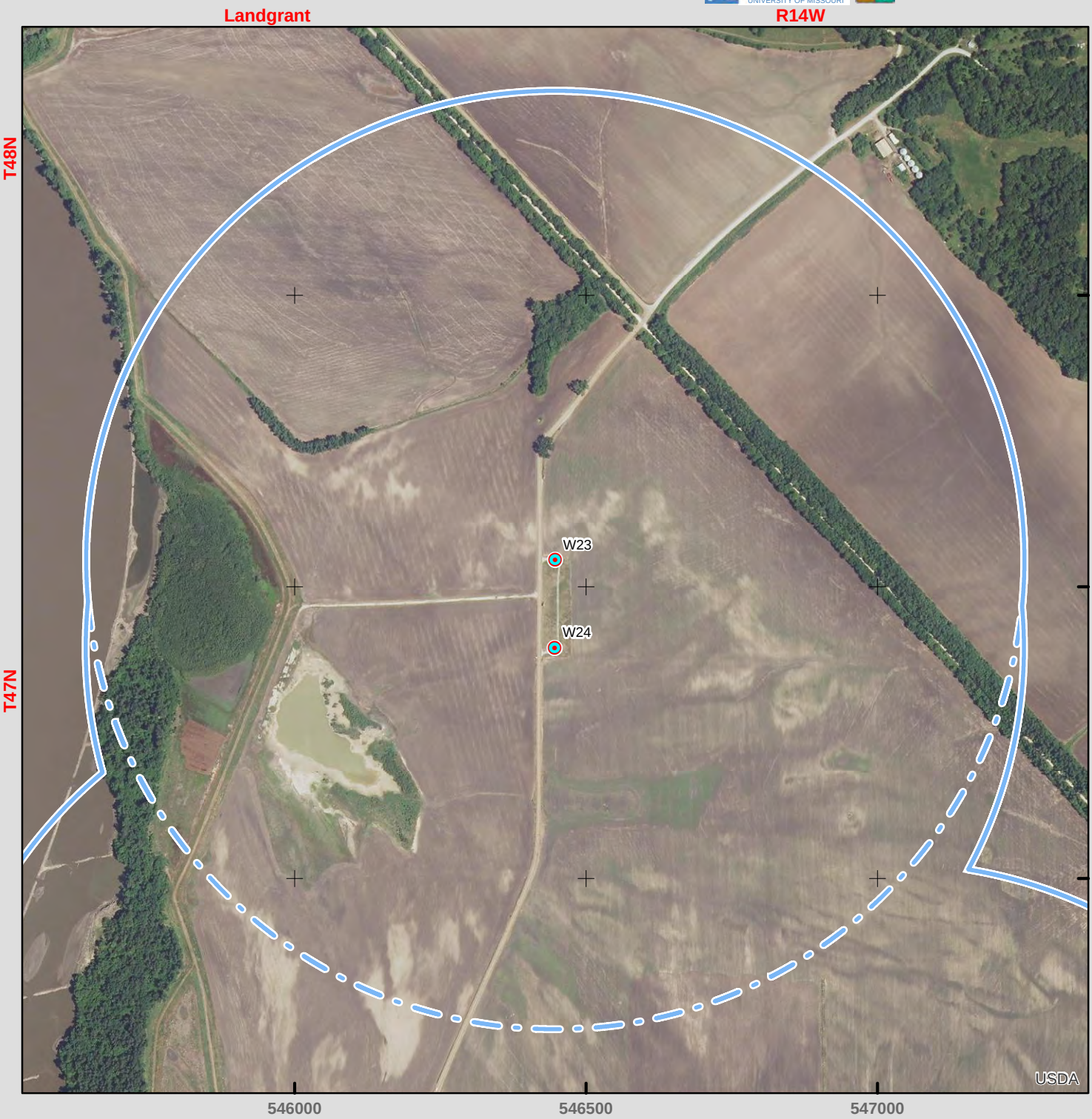
Well #9 (W23)

PWSS No. 3010181, Well 15 of 21

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources



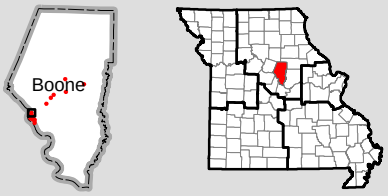
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

Feet

0 790 1,580

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Columbia

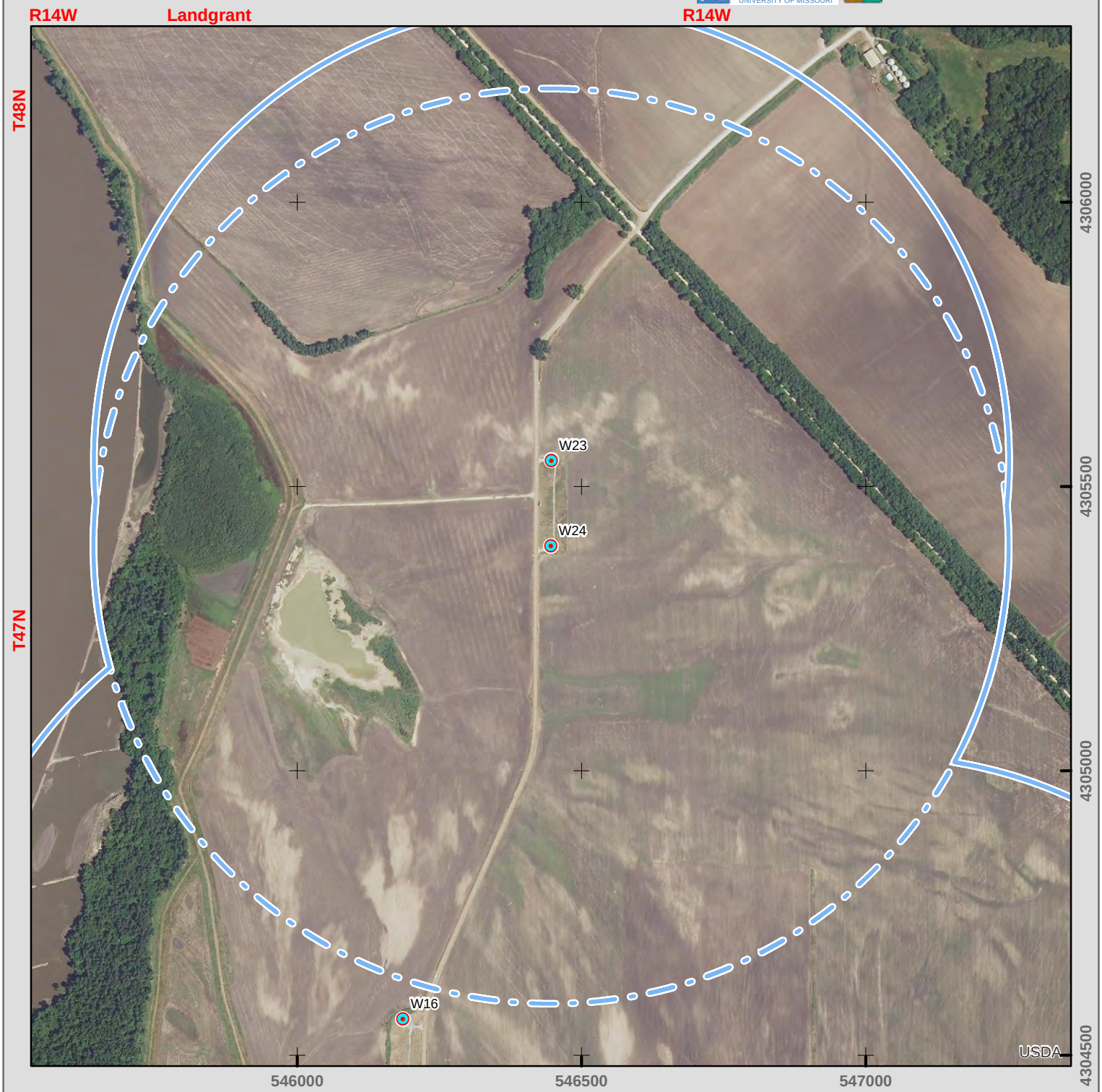
Well #10 (W24)

PWSS No. 3010181, Well 16 of 21

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources



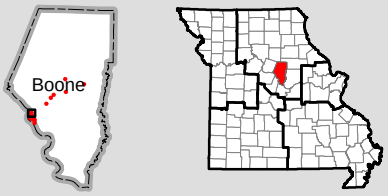
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

Feet

0 790 1,580

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Columbia

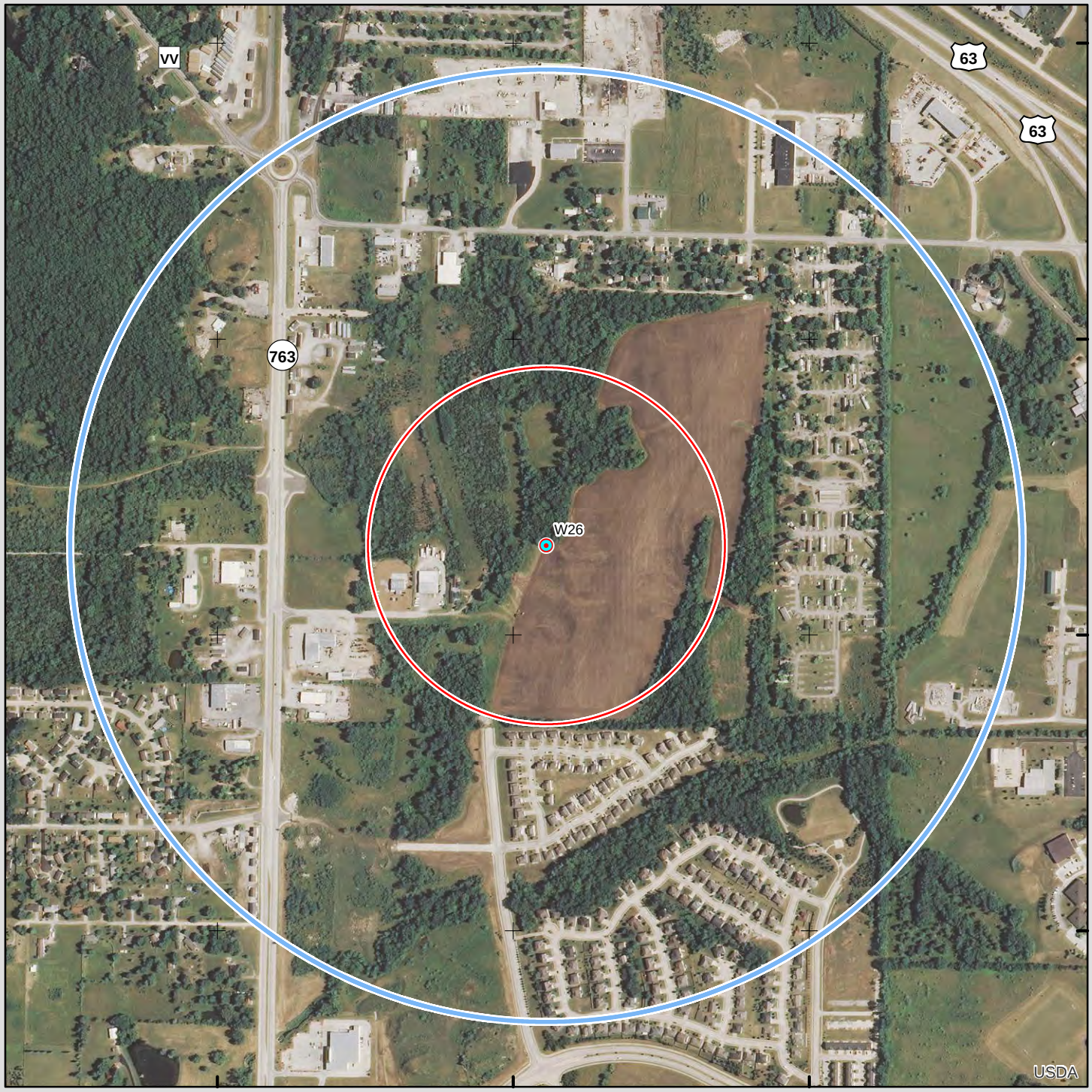
Was Boone PWSD #1 Well (W26)

PWSS No. 3010181, Well 17 of 21

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources



Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

Feet

0 790 1,580

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Columbia

Well W28 (E. Ray Heights) - emergency use only

E. Ray Heights Well (W28)

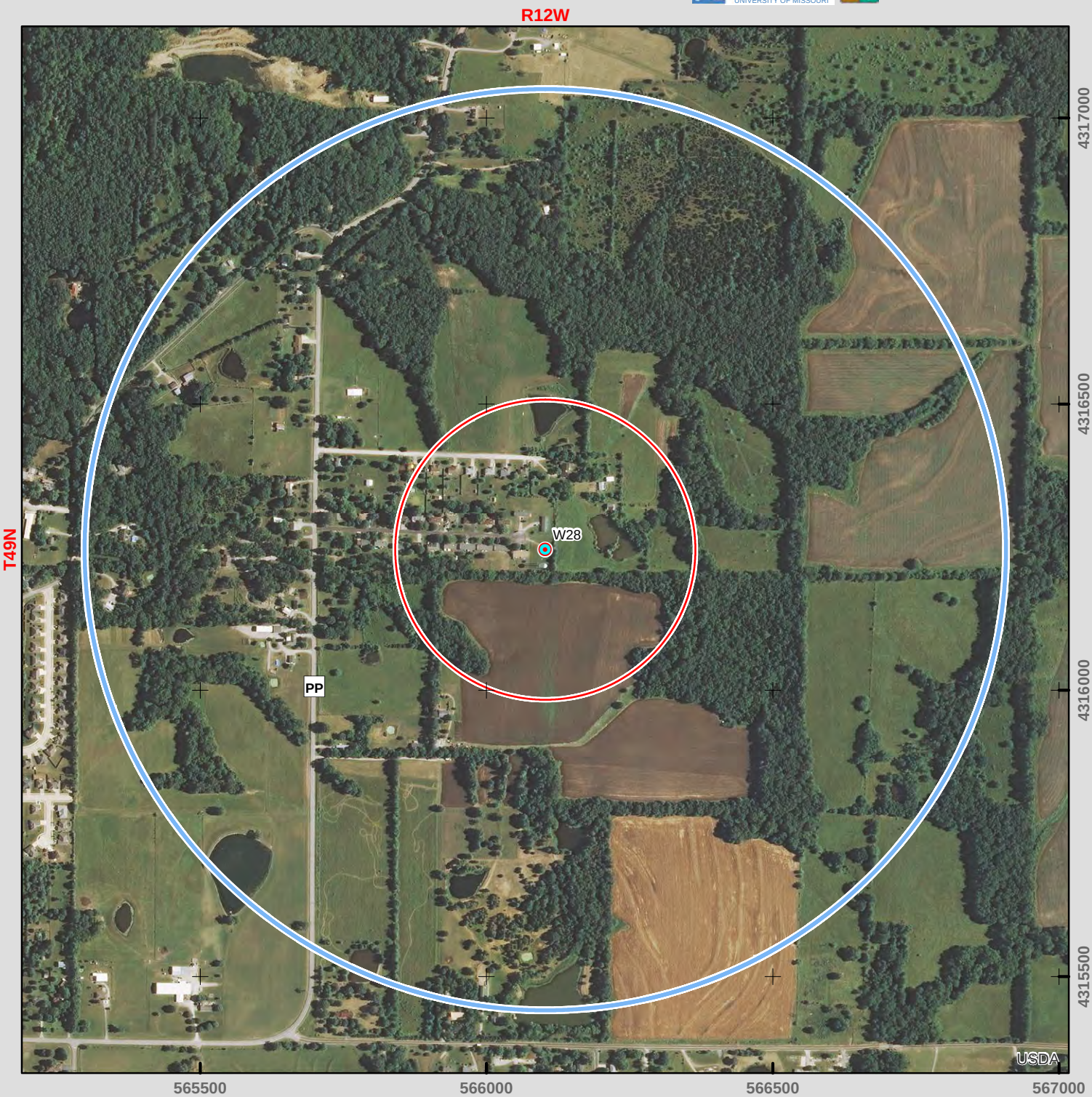
PWSS No. 3010181, Well 18 of 21

Prepared by:

CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources



Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

N

Feet

0 790 1,580

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Columbia

Well #11 (W29)

PWSS No. 3010181, Well 19 of 21

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources

Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

N

Feet

0 790 1,580

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Columbia

Well #12 (W30)

PWSS No. 3010181, Well 20 of 21

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Map Update: Jan 19, 2016

Missouri Department of Natural Resources

Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

N

Feet

0 790 1,580

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Columbia

Well #15, McBaine Bottoms (W31)

PWSS No. 3010181, Well 21 of 21

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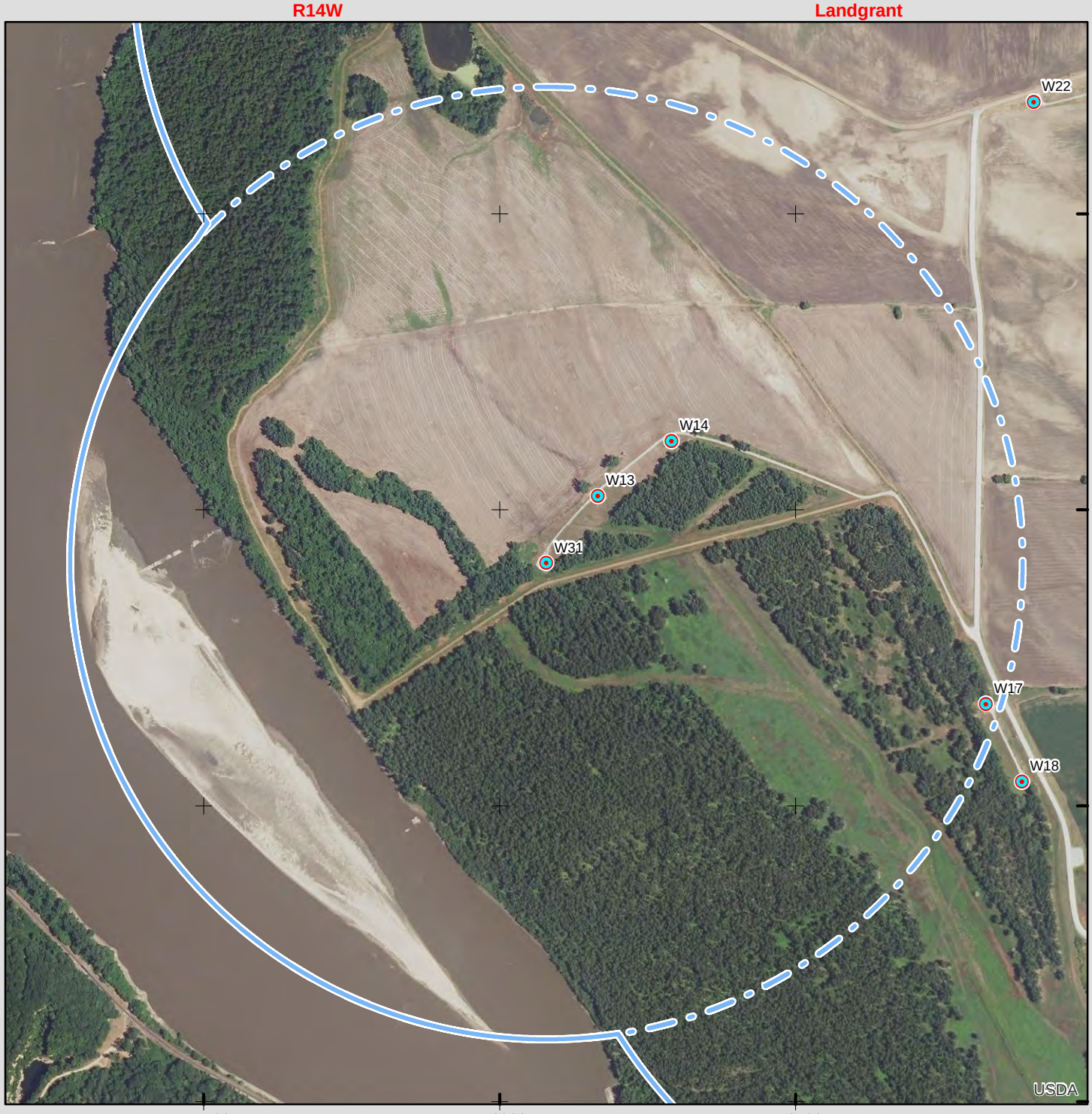

Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
Aerial photos: USDA National Agriculture Inventory Program (NAIP), 2012.

N

Feet

0 790 1,580

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Columbia

Well W4 - active use at Power Plant, source of cooling water

Old Well #4, Bowling St. (W4)

PWSS No. 3010181, Well 1 of 21

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Map Update: Jan 19, 2016

Missouri Department of Natural Resources

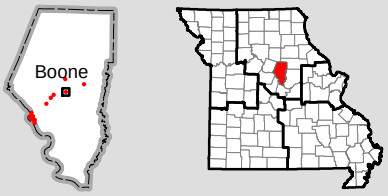
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

N

Feet

0 790 1,580

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Columbia

Well W7 - Emergency Use Only

Ash St. At Reservoir Well (W7)

PWSS No. 3010181, Well 2 of 21

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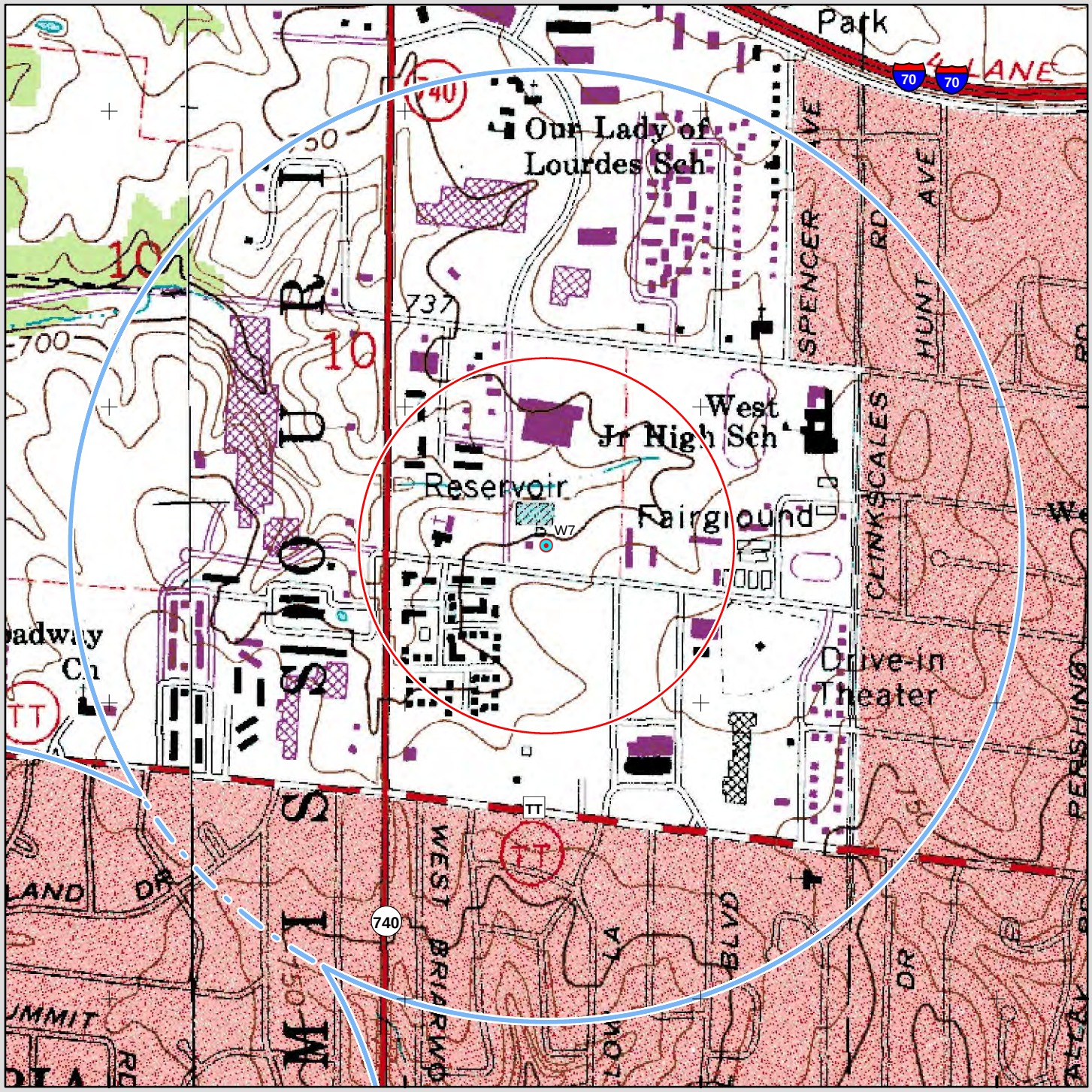
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



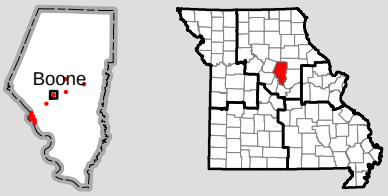
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

Feet

0 790 1,580

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Columbia

Well W8 - Emergency Use Only

Fairview Church Well (W8)

PWSS No. 3010181, Well 3 of 21

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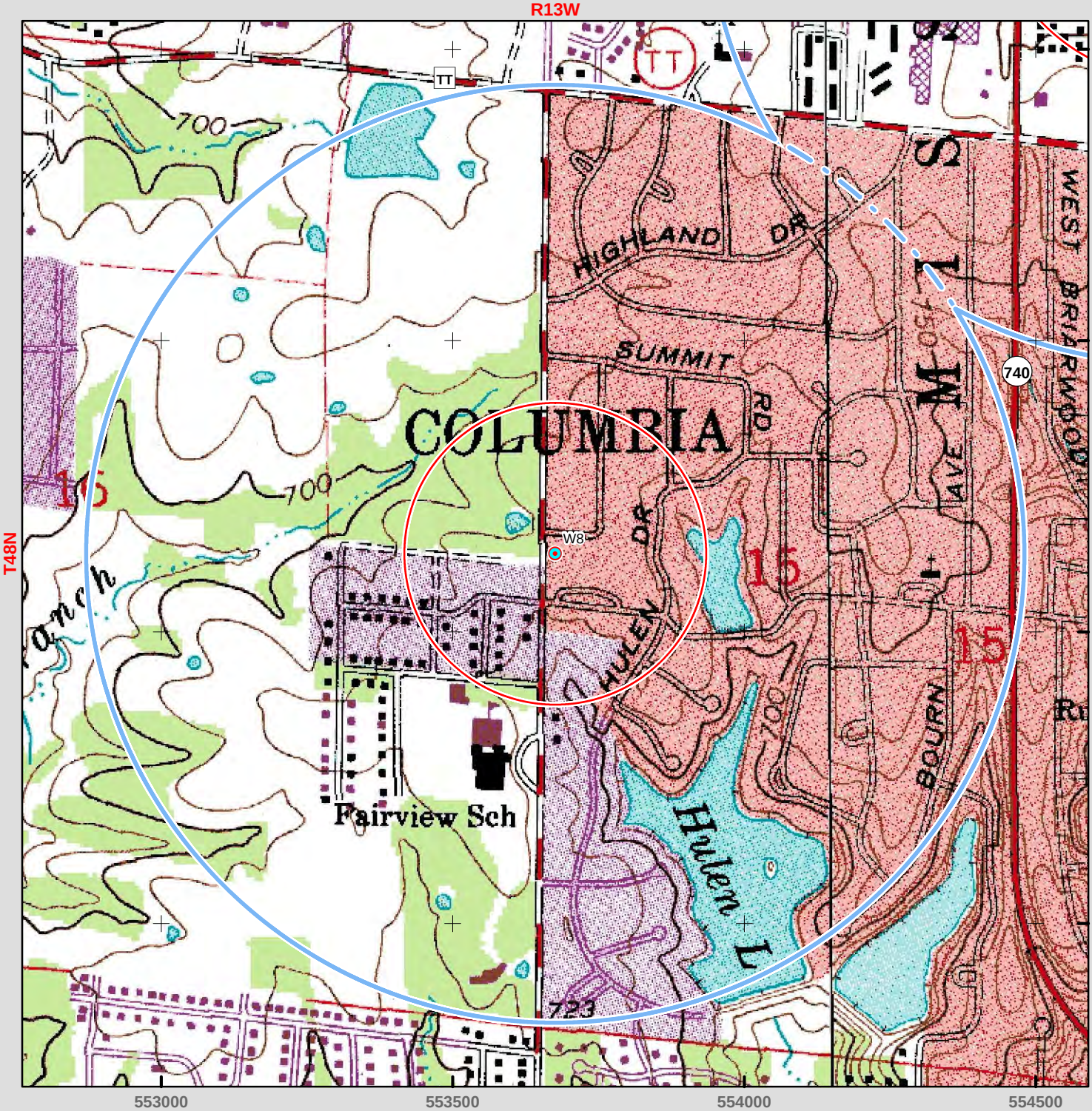
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



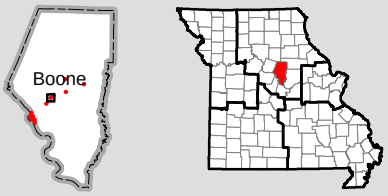
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

Feet

0 790 1,580

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Columbia

Well W10 - Emergency Use Only

Rt TT (Katy Trail) Well (W10)

PWSS No. 3010181, Well 4 of 21

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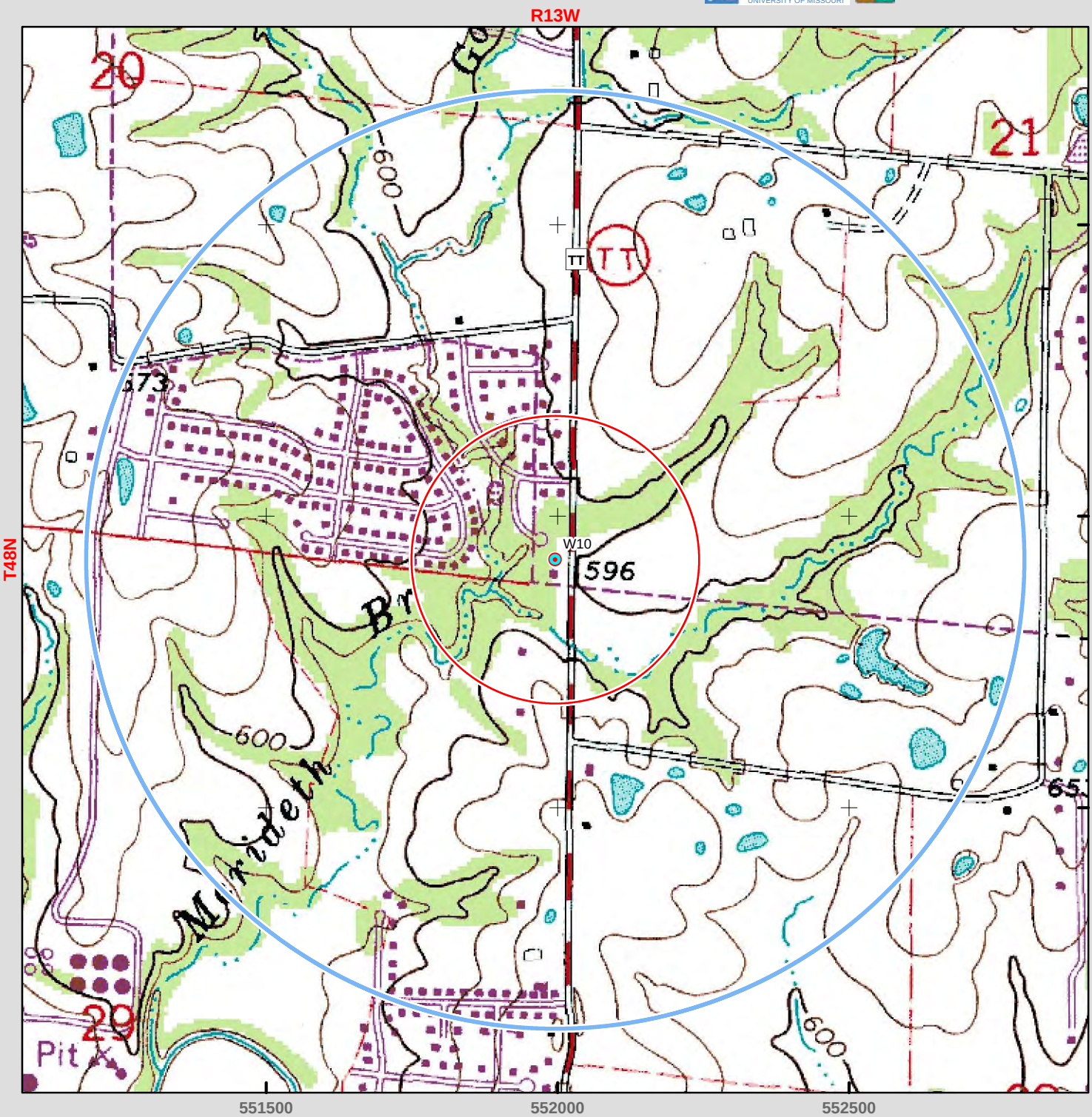
Missouri Department of Natural Resources



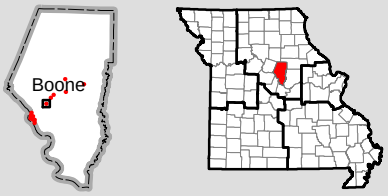
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

Feet

0 790 1,580

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Columbia

Well #13 (W13)

PWSS No. 3010181, Well 5 of 21

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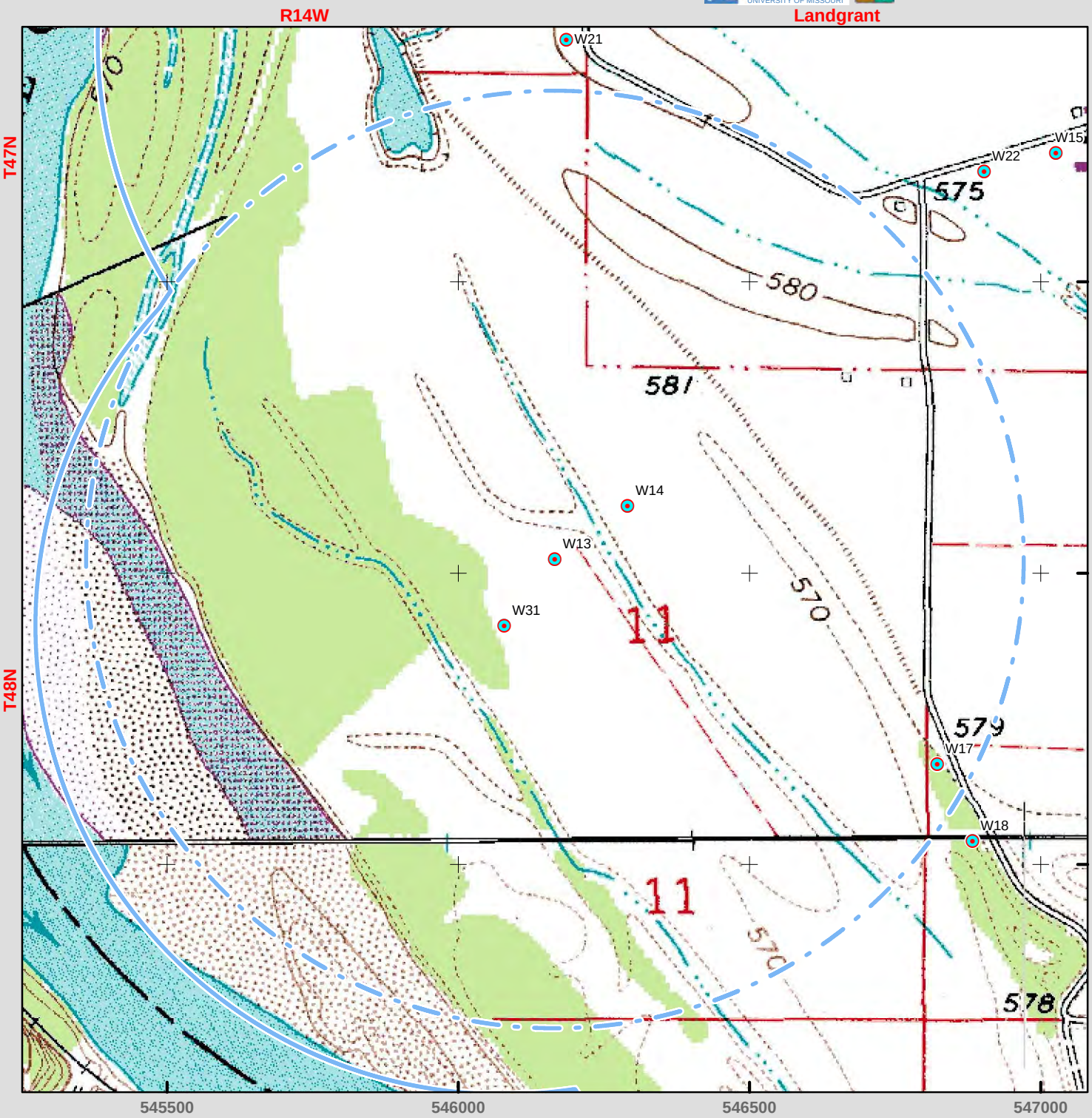

Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

N

Feet

0 790 1,580

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Columbia

Well #14 (W14)

PWSS No. 3010181, Well 6 of 21

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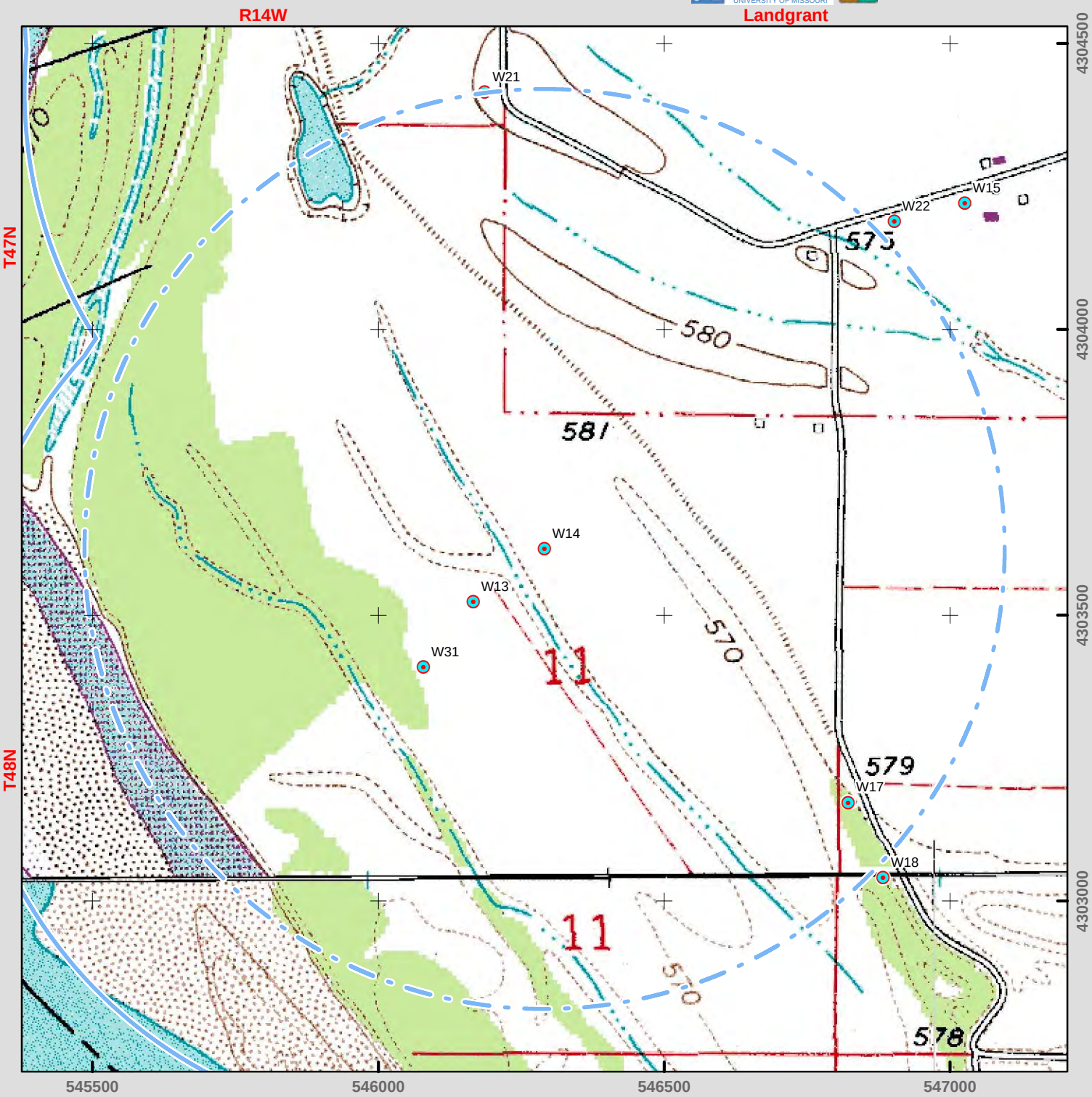
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



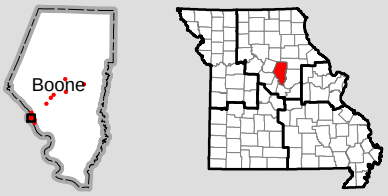
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

N

Feet

0 790 1,580

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Columbia

Well #1 (W15)

PWSS No. 3010181, Well 7 of 21

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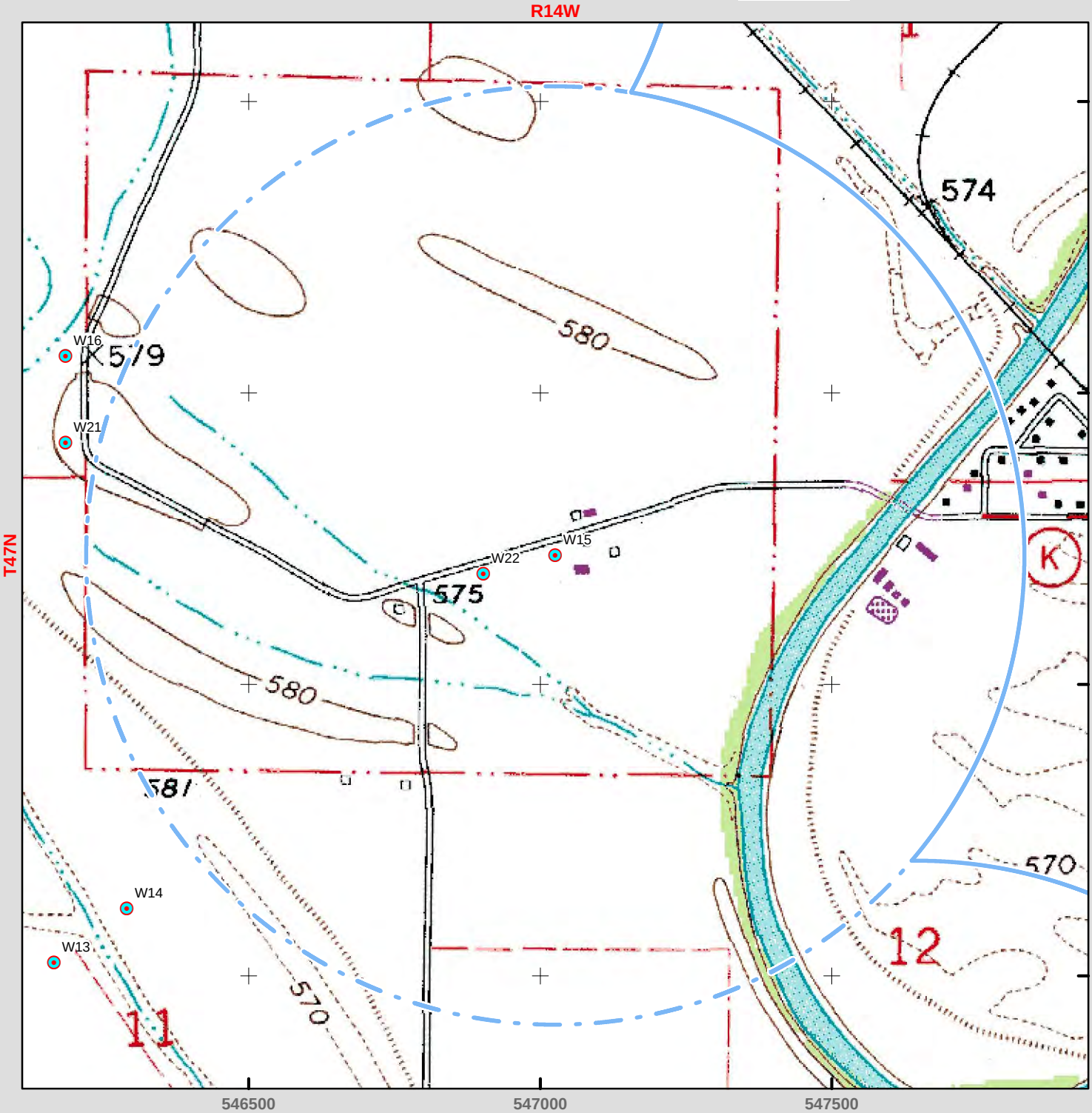

Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

N

Feet

0 790 1,580

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Columbia

Well #2 (W16)

PWSS No. 3010181, Well 8 of 21

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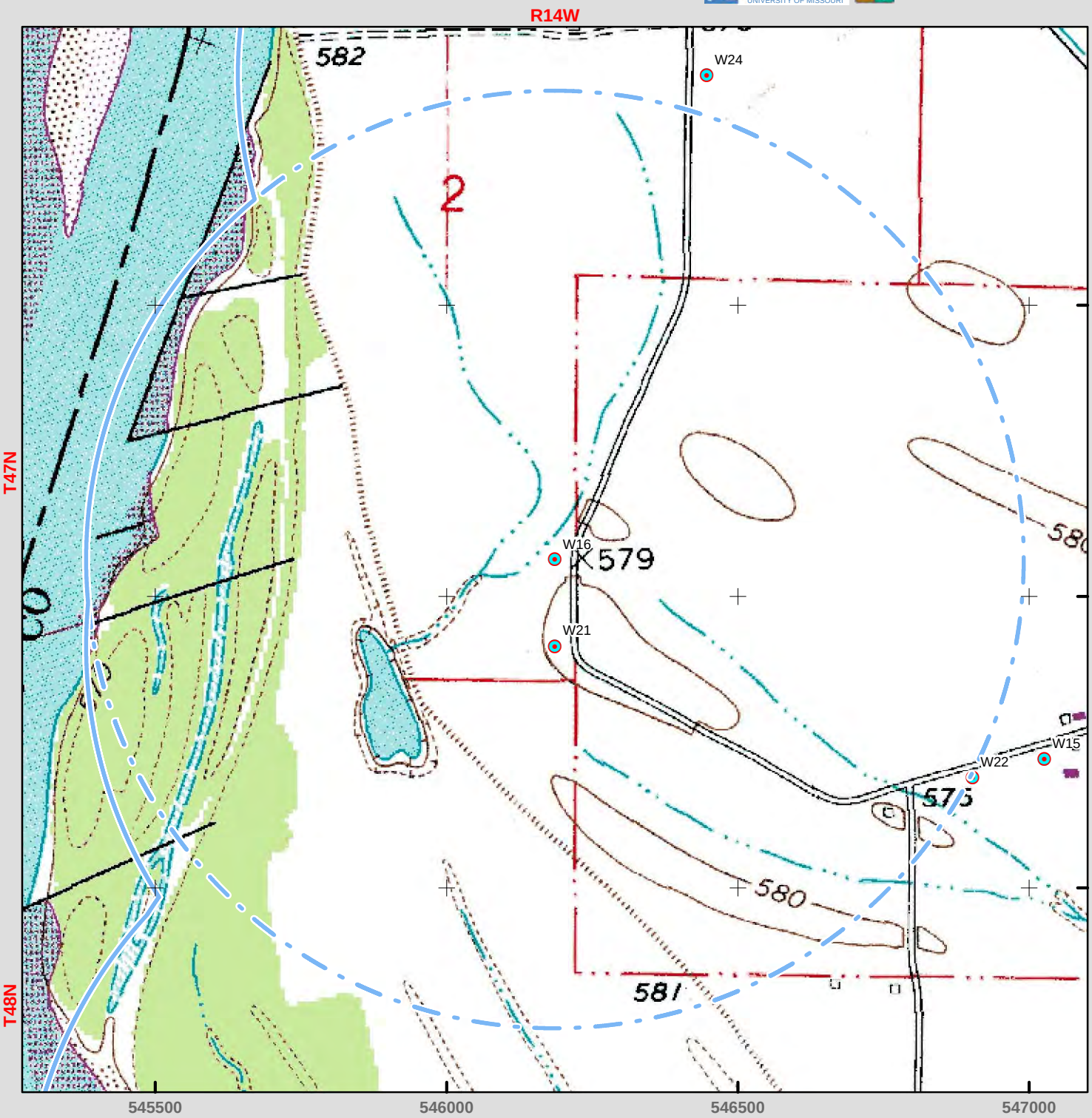
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



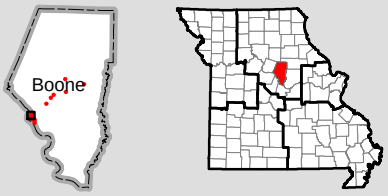
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

Feet

0 790 1,580

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Columbia

Well #3 (W17)

PWSS No. 3010181, Well 9 of 21

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Map Update: Jan 19, 2016

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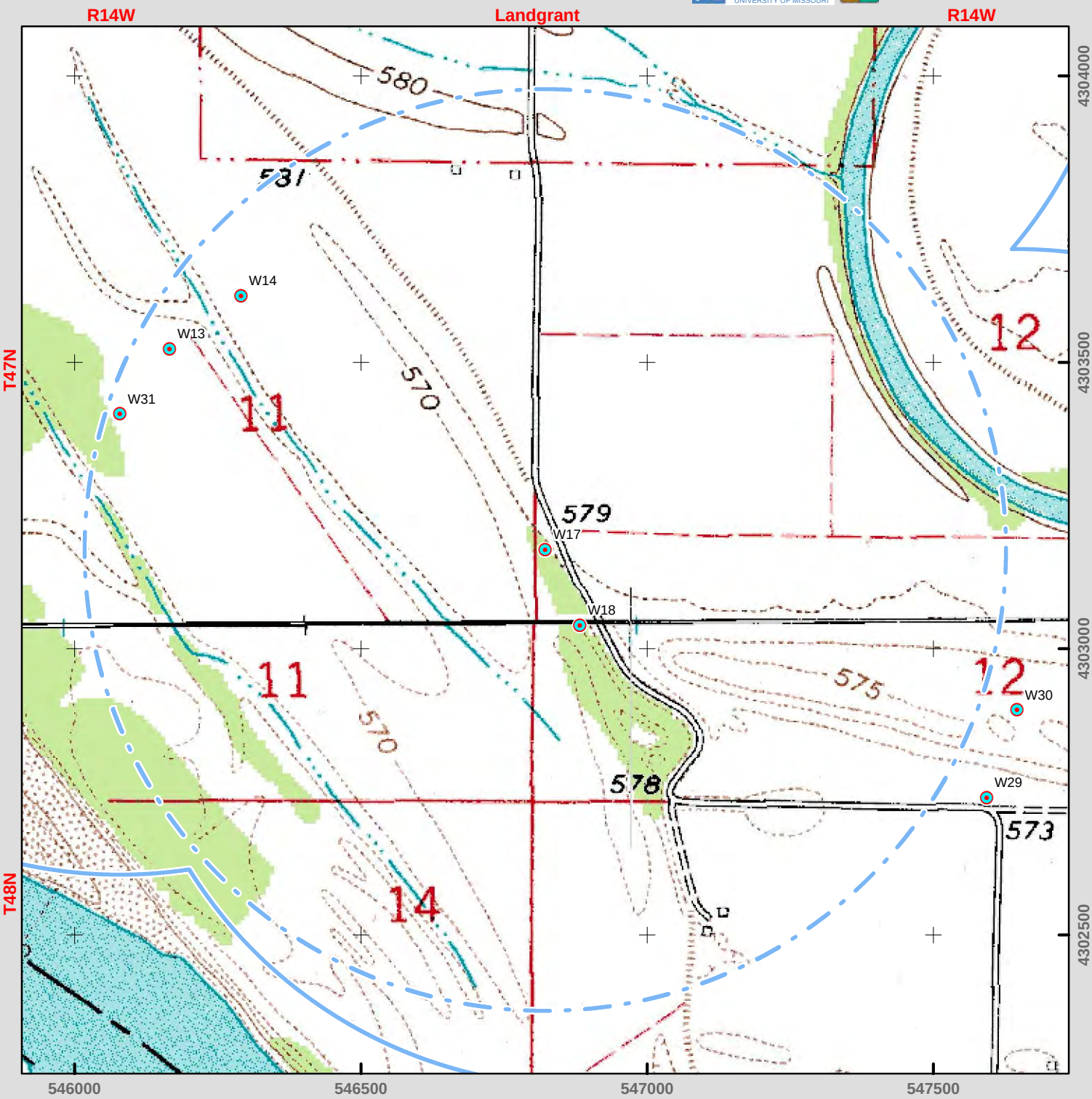


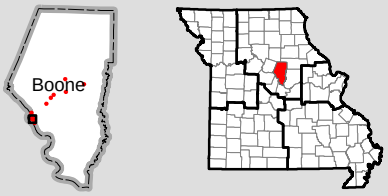
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

Feet

0 790 1,580

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Columbia

Well #4 (W18)

PWSS No. 3010181, Well 10 of 21

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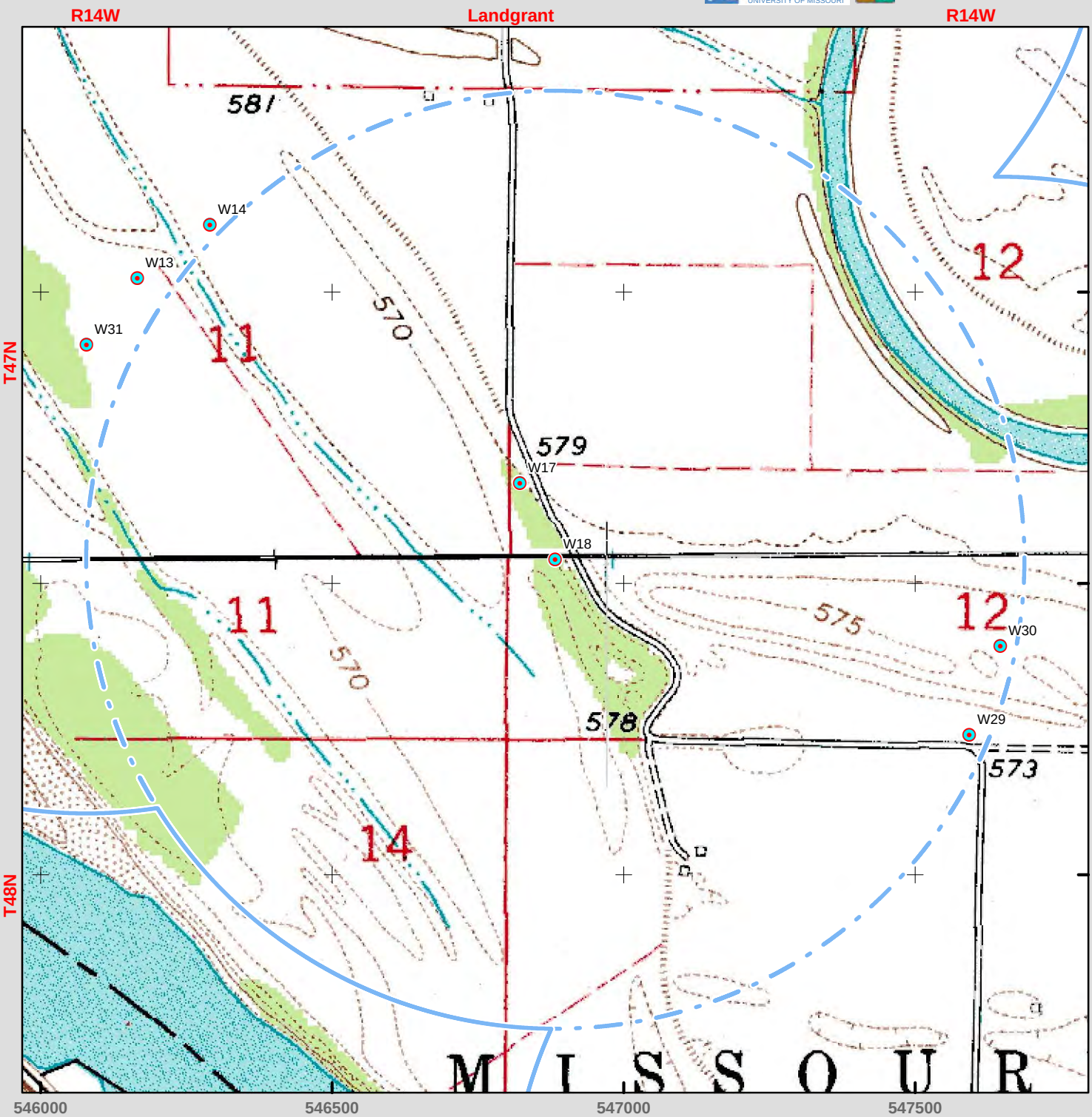
Missouri Department of Natural Resources



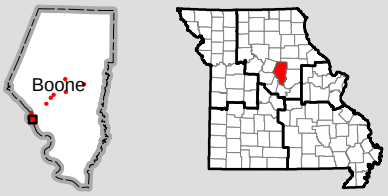
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

Feet

0 790 1,580

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Columbia

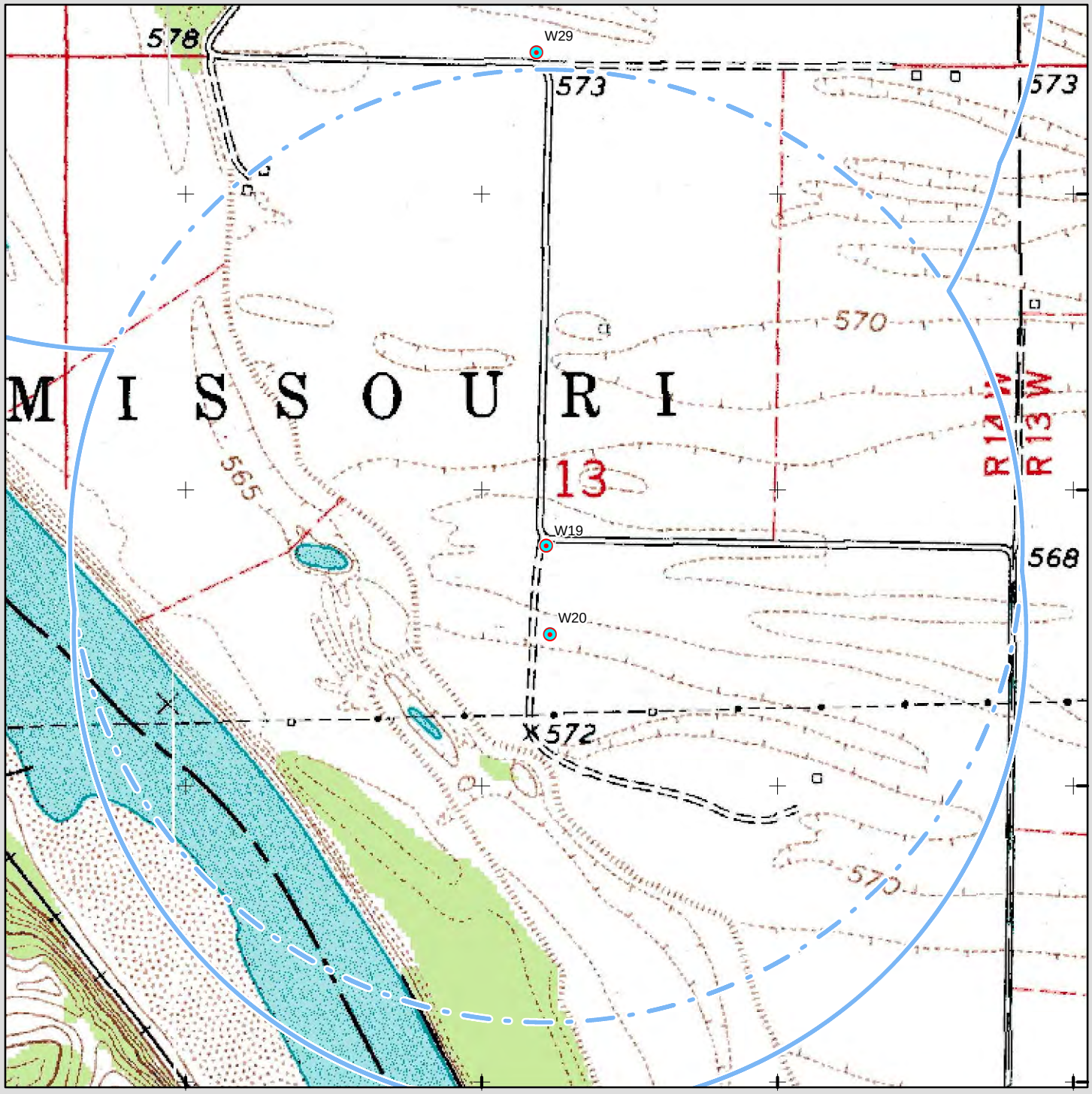
Well #5 (W19)

PWSS No. 3010181, Well 11 of 21

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources



Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

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N

Feet

0 790 1,580

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Columbia

Well #6 (W20)

PWSS No. 3010181, Well 12 of 21

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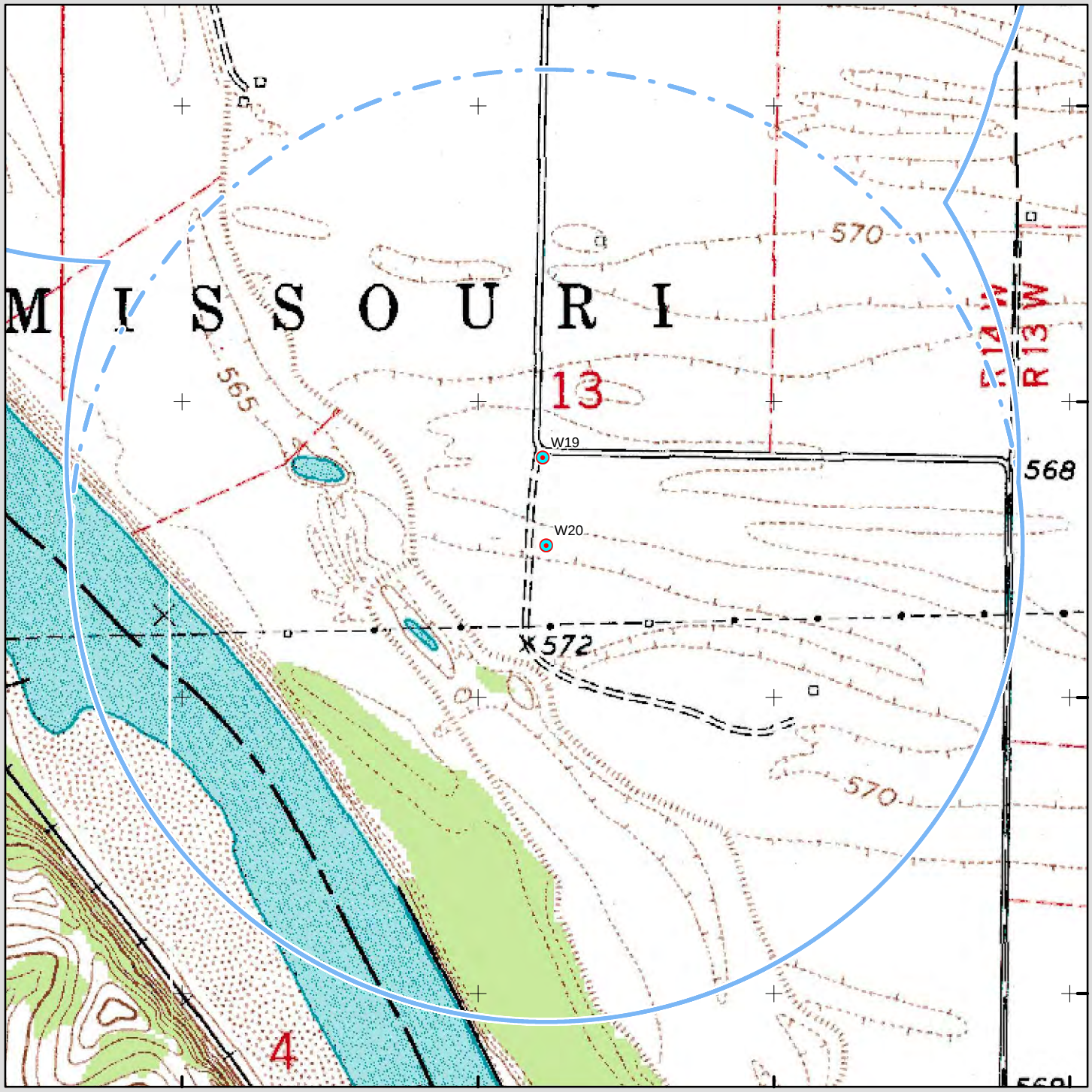
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



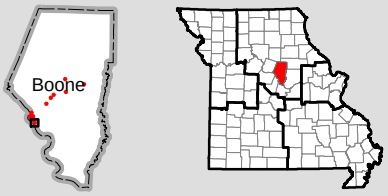
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

N

Feet

0 790 1,580

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Columbia

Well #7 (W21)

PWSS No. 3010181, Well 13 of 21

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Map Update: Jan 19, 2016

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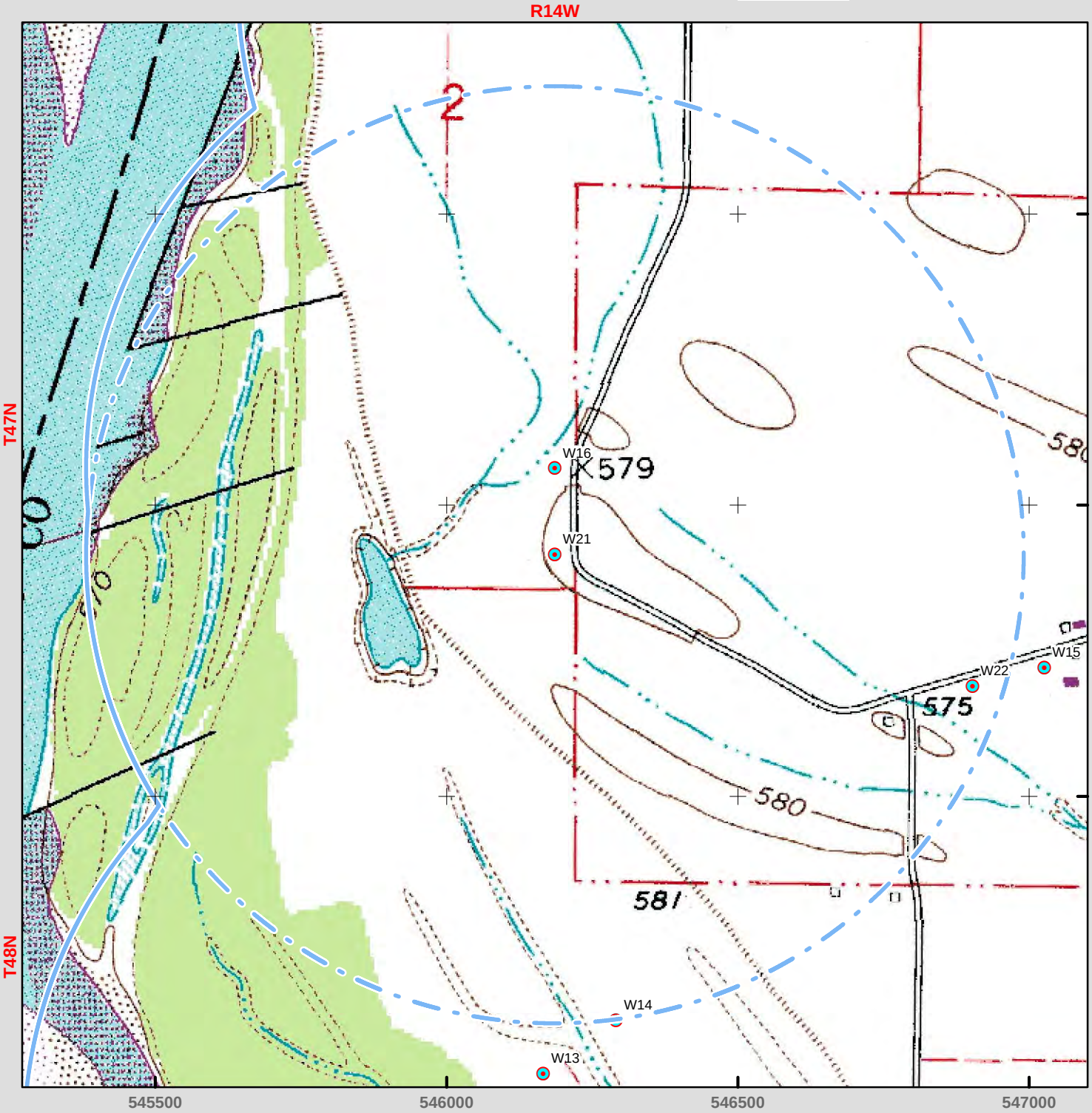


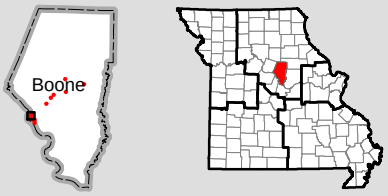
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

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Feet

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Columbia

Well #8 (W22)

PWSS No. 3010181, Well 14 of 21

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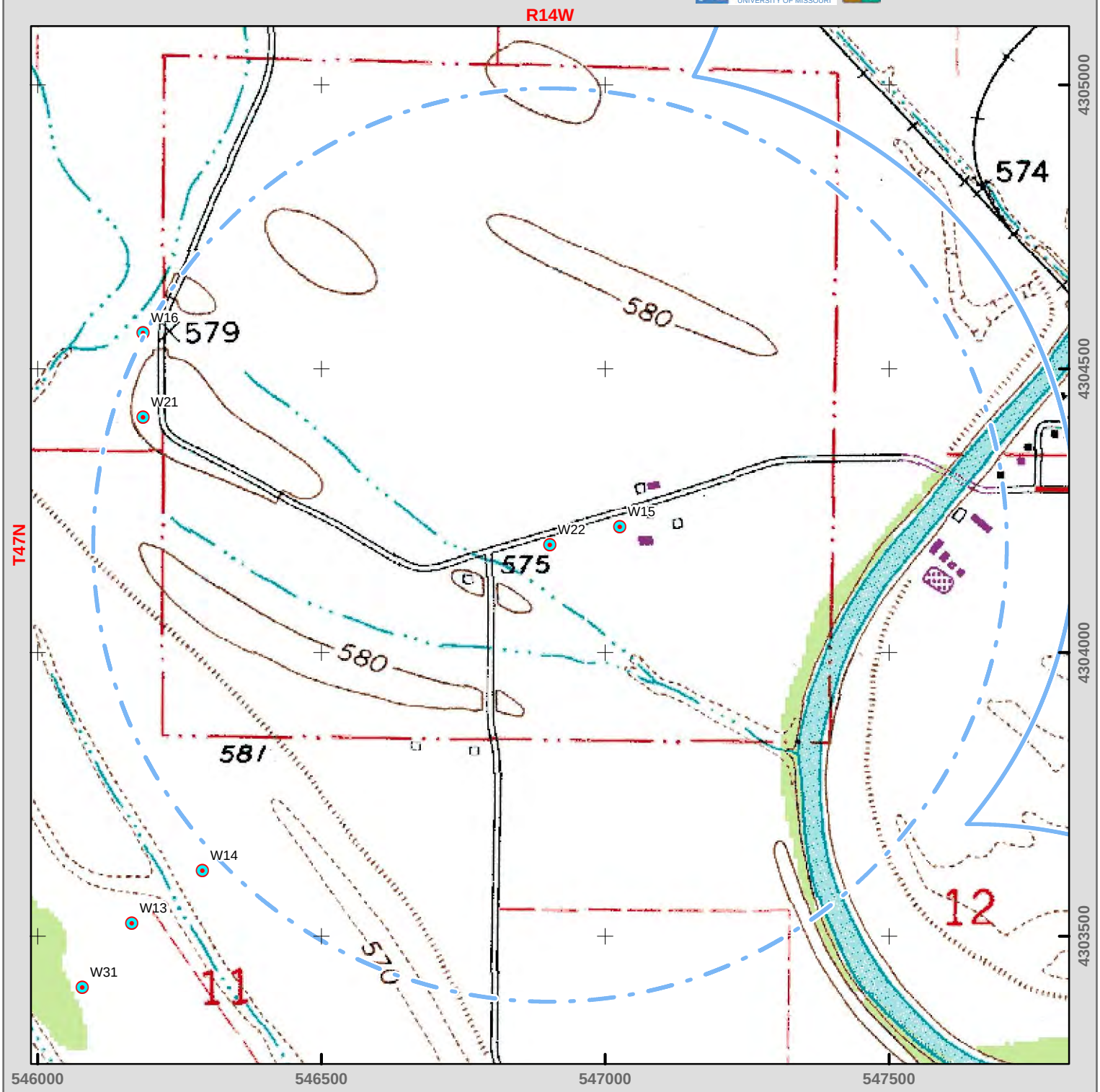
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



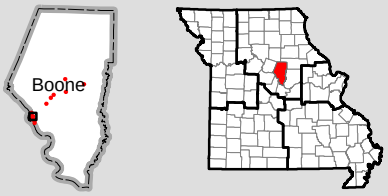
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

N

Feet

0 790 1,580

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Columbia

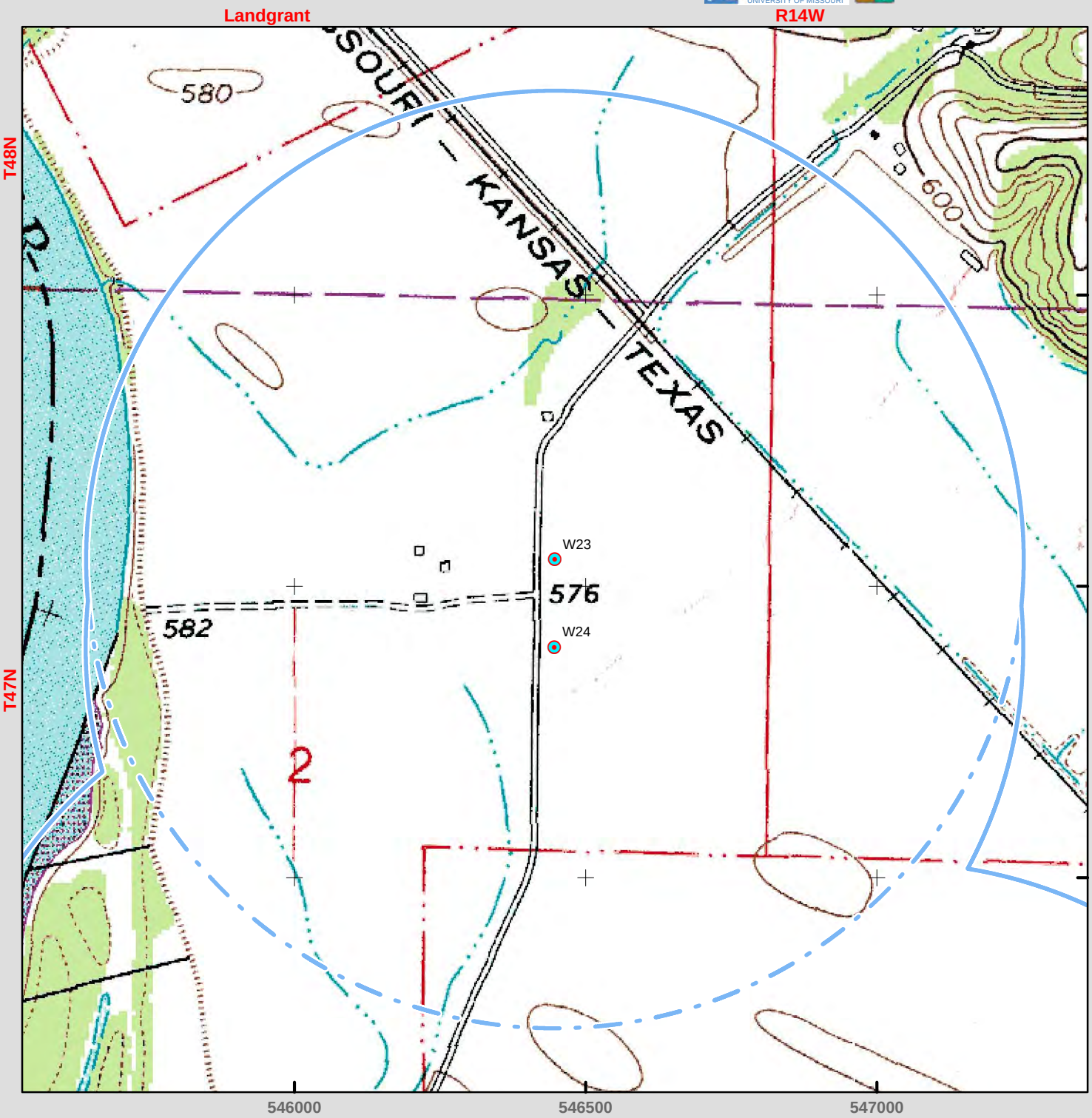
Well #9 (W23)

PWSS No. 3010181, Well 15 of 21

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 19, 2016

Missouri Department of Natural Resources



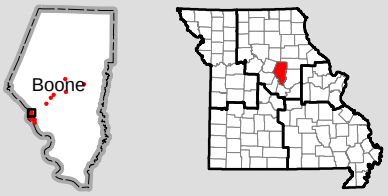
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

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N

Feet

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Columbia

Well #10 (W24)

PWSS No. 3010181, Well 16 of 21

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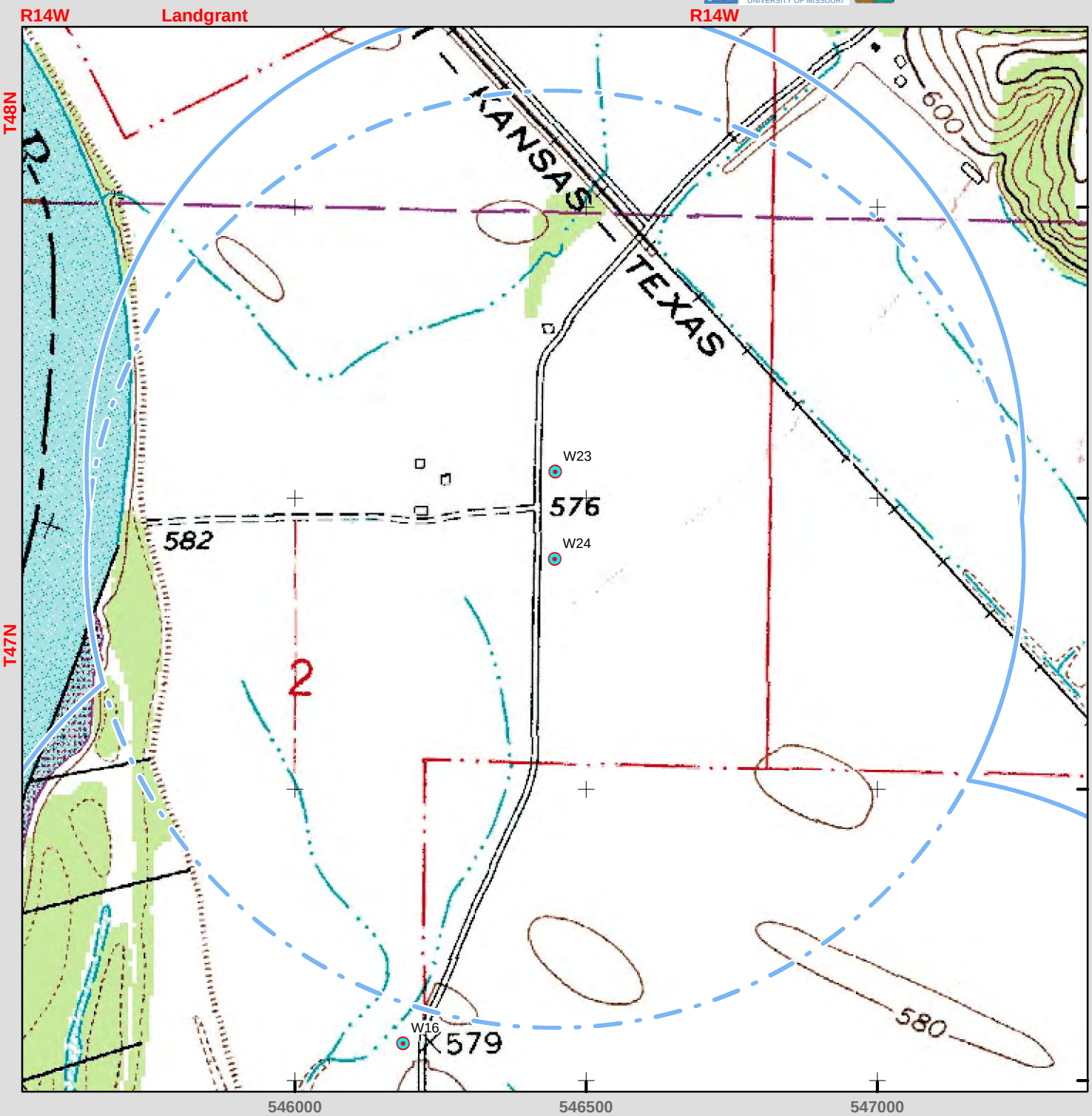
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



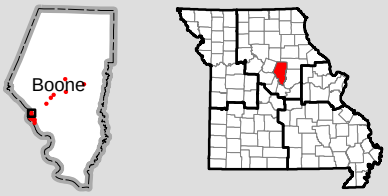
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

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Feet

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Columbia

Was Boone PWSD #1 Well (W26)

PWSS No. 3010181, Well 17 of 21

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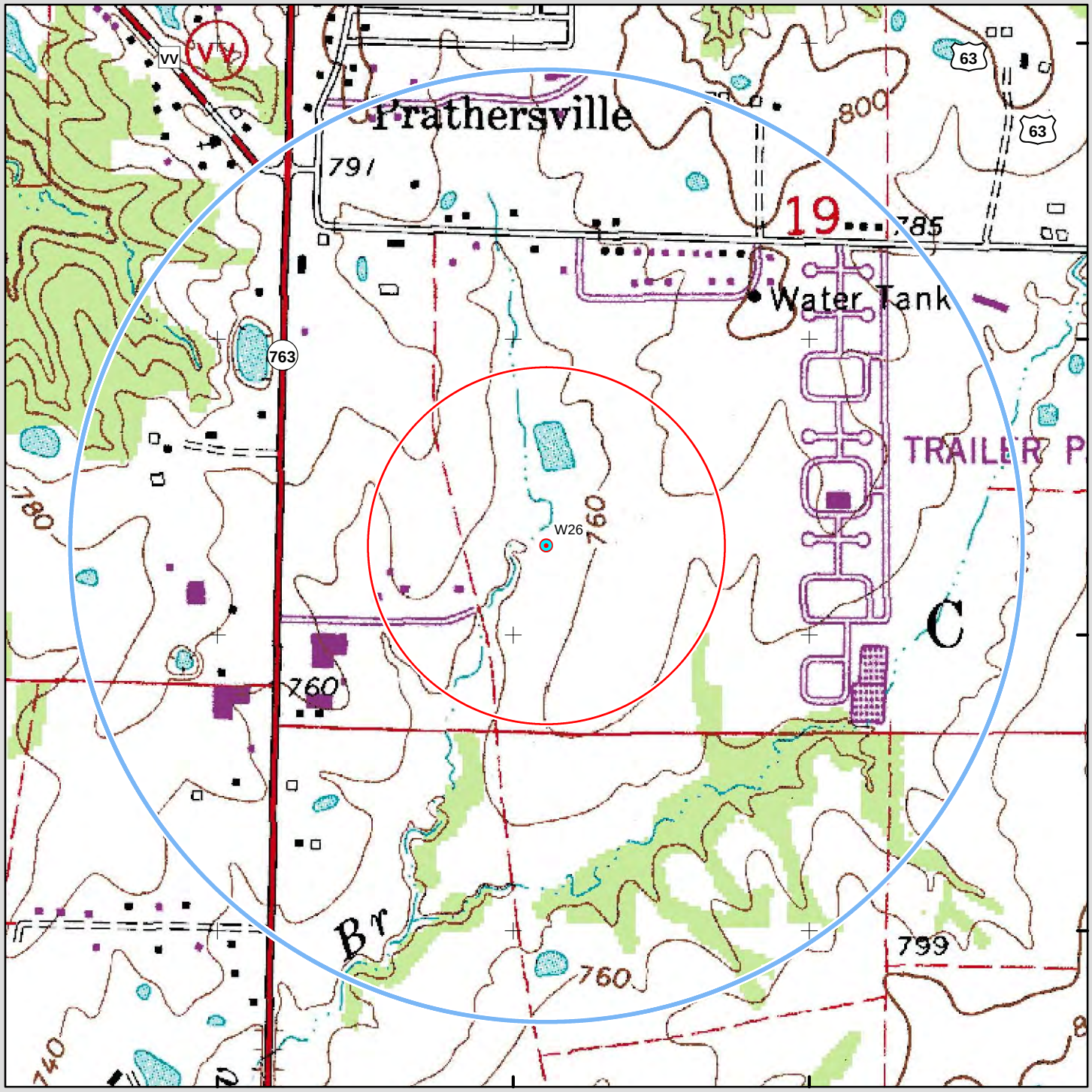
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



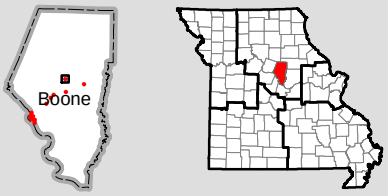
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

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Feet

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Columbia

Well W28 (E. Ray Heights) - emergency use only

E. Ray Heights Well (W28)

PWSS No. 3010181, Well 18 of 21

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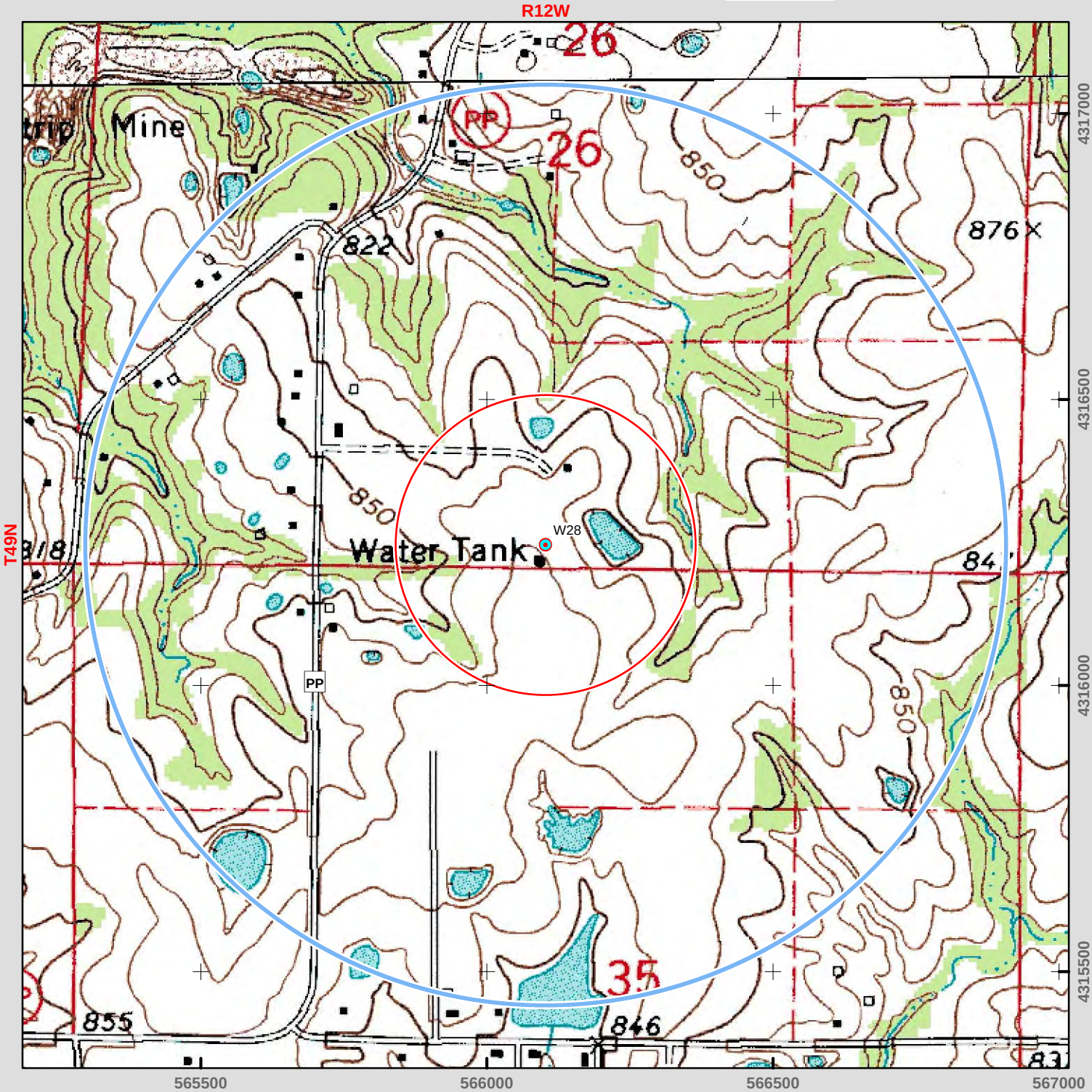
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

N

Feet

0 790 1,580

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Columbia

Well #11 (W29)

PWSS No. 3010181, Well 19 of 21

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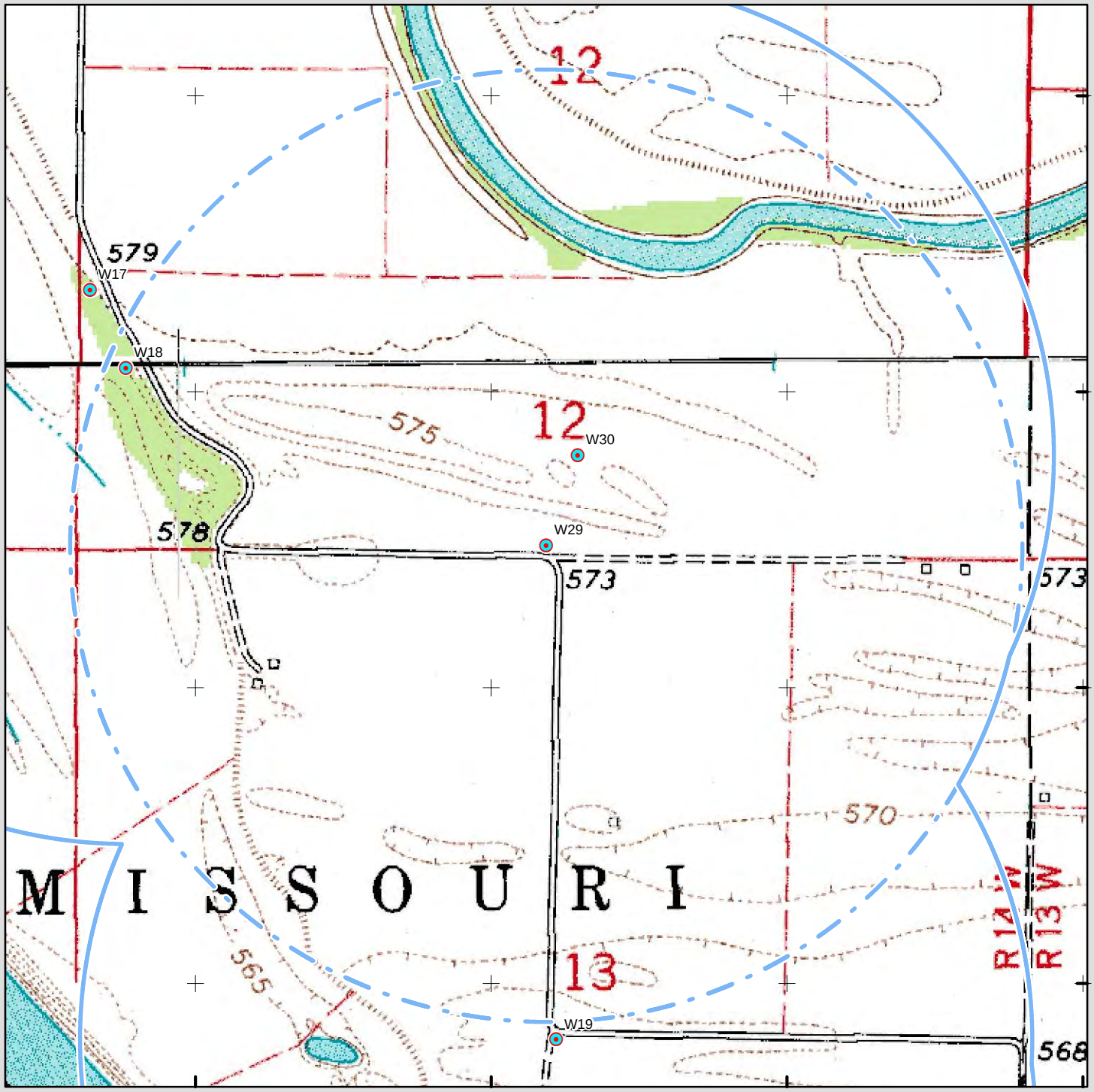
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



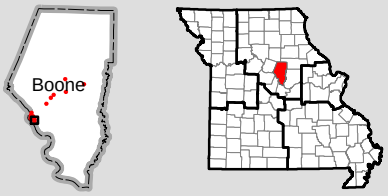
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

N

Feet

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Columbia

Well #12 (W30)

PWSS No. 3010181, Well 20 of 21

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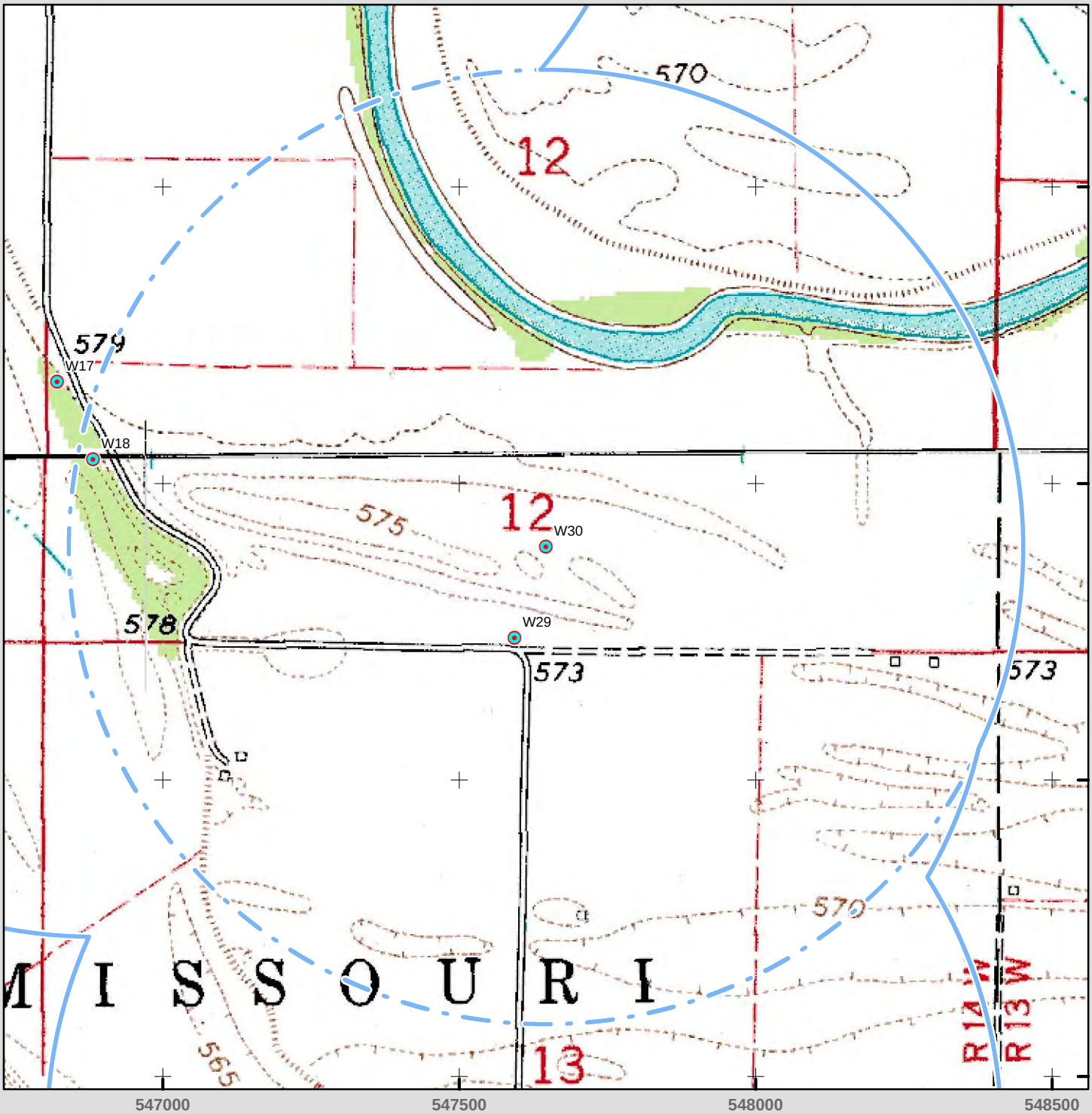
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

N

Feet

0 790 1,580

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Columbia

Well #15, McBaine Bottoms (W31)

PWSS No. 3010181, Well 21 of 21

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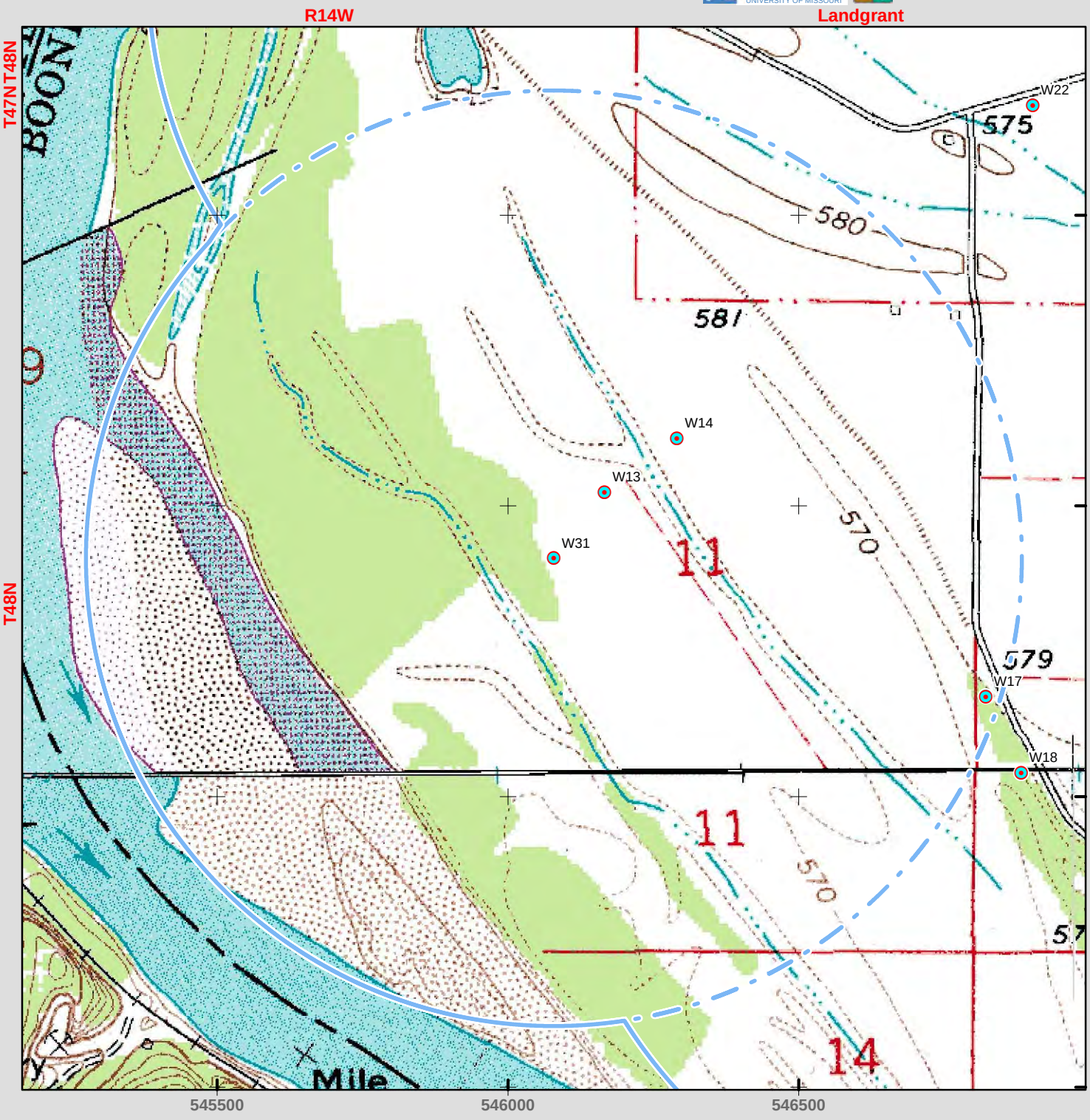
Map Update: Jan 19, 2016

Missouri Department of Natural Resources



Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer

SWAP boundaries for individual wells indicated by dashed line.

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

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Feet

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Columbia

PWSS No. 3010181

Boone County, sheet 1 of 5

21 wells

Well W4 - active use at Power Plant, source of cooling water
Well W7, W8, and W10 - emergency use only

Sheet Update: Jan 25, 2016

Prepared by:

CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Missouri Department of Natural Resources

Well Number	W4	W7	W8	W10	W13
Extended PWS #	3010181104	3010181107	3010181108	3010181110	3010181113
Local Well Name	Old Well #4, Bowling St.	Ash St. At Reservoir	Fairview Church	Rt TT (Katy Trail)	Well #13
Well ID #	14074	12312	12313	12697	13788
DGLS ID #	0009527	0016782	0021800	0024557	
Facility Type	City	City	City	City	City
Status	Emergency	Emergency	Active	Active	Active
Latitude	38.9671	38.95764	38.94751	38.92771	38.879357958
Longitude	-92.3155	-92.36823	-92.380591	-92.40014	-92.4677602761
Location Method	DRG/MAP	DRG/MAP	DRG/MAP	PLSS	DRG/MAP
Method Accuracy (ft)	33	100	10	233	33
USGS 7.5 Quadrangle	Columbia	Columbia	Huntsdale	Huntsdale	Huntsdale
County	Boone	Boone	Boone	Boone	Boone
MoDNR Region	Northeast	Northeast	Northeast	Northeast	Northeast
Date Drilled (year)	1946	1957	1963	1966	2000
Material (C/U)	Consolidated	Consolidated	Consolidated	Consolidated	Unconsolidated
Base of Casing Formation	Cotter	Jefferson City	Roubidoux	Roubidoux	Alluvium
Total Depth Formation	Potosi	Eminence	Elvins	Elvins	Alluvium
Total Depth	1505	1150	1437	1500	98
Ground Elevation (ft)	782	741	750	590	580
Top Seal	Pump Base	Pump Base	Pump Base	Pump Base	Tremie Cement
Bottom Seal	Pressure Grout	Pressure Grout	Pressure Grout	Pressure Grout	Tremie Cement
Casing Depth (ft)	500	600	703	600	64
Casing Size (in)	20	19	19	19	26
Casing Type	Steel	Steel	Steel	Steel	Steel
Elev. of Casing Top (ft)					
Outer Casing Depth (ft)		118			
Outer Casing Size (in)		30			
Screen Length (ft)	No Screen	No Screen	No Screen	No Screen	35
Screen Size (in)	No Screen	No Screen	No Screen	No Screen	26
Static Water Level (ft)	394	266	283		19
Well Yield (gpm)	750	910	900		1400
Head (ft)					90
Draw Down (ft)	75	130	122		
Pump Test Date (year)			1963		
Pump Type	Vertical Turbine	Vertical Turbine	Vertical Turbine	Vertical Turbine	Vertical Turbine
Pump Manufacturer	Layne Western	Layne Western	Layne Western	Layne Western	
Pump Depth (ft)	560	560	700	700	84
Pump Capacity (gpm)	800	800	1100	1200	1400
Pump Meter (Y/N)					Y
VOC Detection (Y/N)	N	N	N	N	N
Nitrate Detection (Y/N)	N	N	N	N	N
Chlorination (Y/N)					
Filtration (Y/N)					
GWUDISW (Y/N)					
Surface Drainage					
State Approved(Y/N)					
Date Abandoned (year)				1979	
Date Plugged (year)					

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Columbia

PWSS No. 3010181

Boone County, sheet 2 of 5

21 wells

Sheet Update: Jan 25, 2016

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Missouri Department of Natural Resources

Well Number	W14	W15	W16	W17	W18
Extended PWS #	3010181114	3010181115	3010181116	3010181117	3010181118
Local Well Name	Well #14	Well #1	Well #2	Well #3	Well #4
Well ID #	13789	13544	13253	13256	13257
DGLS ID #					
Facility Type	City	City	City	City	City
Status	Active	Active	Active	Active	Active
Latitude	38.8801843258	38.8856	38.88873	38.87616	38.87497
Longitude	-92.4663151129	-92.4578	-92.46746	-92.46022	-92.45953
Location Method	DRG/MAP	DRG/MAP	DRG/MAP	DRG/MAP	DRG/MAP
Method Accuracy (ft)	33	33	33	33	33
USGS 7.5 Quadrangle	Huntsdale	Huntsdale	Huntsdale	Huntsdale	Jamestown
County	Boone	Boone	Boone	Boone	Boone
MoDNR Region	Northeast	Northeast	Northeast	Northeast	Northeast
Date Drilled (year)	2000	1970	1970	1970	1970
Material (C/U)	Unconsolidated	Unconsolidated	Unconsolidated	Unconsolidated	Unconsolidated
Base of Casing Formation	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium
Total Depth Formation	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium
Total Depth	93	100	104	103	103
Ground Elevation (ft)	580	575	578	580	580
Top Seal	Tremie Cement	Pump Base	Pump Base	Pump Base	Pump Base
Bottom Seal	Tremie Cement	Cement Grout	Cement Grout	Cement Grout	Cement Grout
Casing Depth (ft)	58	60	69	68	68
Casing Size (in)	26	18	26	26	26
Casing Type	Steel	Steel	Steel	Steel	Steel
Elev. of Casing Top (ft)		590	590	585	585
Outer Casing Depth (ft)	20	20	20	20	20
Outer Casing Size (in)	42	42	42	42	42
Screen Length (ft)	35	35	35	35	35
Screen Size (in)	26	26	26	26	26
Static Water Level (ft)	19	25	25	25	25
Well Yield (gpm)	1400	1200	1300	800	1100
Head (ft)	90	100	100	100	100
Draw Down (ft)		20	25	20	25
Pump Test Date (year)		1994	1994	1994	1994
Pump Type	Vertical Turbine	Vertical Turbine	Vertical Turbine	Vertical Turbine	Vertical Turbine
Pump Manufacturer		Layne Western	Layne Western	Layne Western	Layne Western
Pump Depth (ft)	84	60	65	65	65
Pump Capacity (gpm)	1400	1400	1400	1400	1400
Pump Meter (Y/N)	Y	N			
VOC Detection (Y/N)	N	N	N	N	N
Nitrate Detection (Y/N)	N	N	N	N	N
Chlorination (Y/N)		Y	Y	Y	Y
Filtration (Y/N)		Y	Y	Y	Y
GWUDISW (Y/N)					
Surface Drainage		Satisfactory	Satisfactory	Satisfactory	Satisfactory
State Approved(Y/N)					
Date Abandoned (year)					
Date Plugged (year)					

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Columbia

PWSS No. 3010181

Boone County, sheet 3 of 5

21 wells

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Sheet Update: Jan 25, 2016

Missouri Department of Natural Resources

Well Number	W19	W20	W21	W22	W23
Extended PWS #	3010181119	3010181120	3010181121	3010181122	3010181123
Local Well Name	Well #5	Well #6	Well #7	Well #8	Well #9
Well ID #	13258	13259	13254	13543	13541
DGLS ID #					
Facility Type	City	City	City	City	City
Status	Active	Active	Active	Active	Active
Latitude	38.8647	38.86336	38.88739	38.88532	38.89757
Longitude	-92.45123	-92.45117	-92.46747	-92.45922	-92.46438
Location Method	DRG/MAP	DRG/MAP	DRG/MAP	DRG/MAP	DRG/MAP
Method Accuracy (ft)	33	33	33	33	33
USGS 7.5 Quadrangle	Jamestown	Jamestown	Huntsdale	Huntsdale	Huntsdale
County	Boone	Boone	Boone	Boone	Boone
MoDNR Region	Northeast	Northeast	Northeast	Northeast	Northeast
Date Drilled (year)	1970	1970	1977	1984	1990
Material (C/U)	Unconsolidated	Unconsolidated	Unconsolidated	Unconsolidated	Unconsolidated
Base of Casing Formation	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium
Total Depth Formation	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium
Total Depth	104	113	104	98	95
Ground Elevation (ft)	570	570	578	575	
Top Seal	Pump Base	Pump Base	Pump Base	Pump Base	Cement Grout
Bottom Seal	Cement Grout	Cement Grout	Cement Grout	Cement Grout	
Casing Depth (ft)	69	70	68	63	67
Casing Size (in)	26	26	26	26	26
Casing Type	Steel	Steel	Steel	Steel	Steel
Elev. of Casing Top (ft)	585	585	590	590	590
Outer Casing Depth (ft)	20	20	20	20	
Outer Casing Size (in)	42	42	42	42	
Screen Length (ft)	35	35	35	35	35
Screen Size (in)	26	26	26	26	26
Static Water Level (ft)	25	25	25	25	11
Well Yield (gpm)	1400	1320	1400	1350	2204
Head (ft)	100	100	100	100	100
Draw Down (ft)	28	25	12	15	11
Pump Test Date (year)	1994	1994	1994	1994	1990
Pump Type	Vertical Turbine	Vertical Turbine	Vertical Turbine	Vertical Turbine	Vertical Turbine
Pump Manufacturer	Layne Western	Layne Western	Layne Western	Layne Western	Layne Western
Pump Depth (ft)	65	65	65	65	60
Pump Capacity (gpm)	1400	750	800	1100	1400
Pump Meter (Y/N)					
VOC Detection (Y/N)	N	N	N	N	N
Nitrate Detection (Y/N)	N	N	N	N	N
Chlorination (Y/N)	Y	Y	Y	Y	Y
Filtration (Y/N)	Y	Y	Y	Y	Y
GWUDISW (Y/N)					
Surface Drainage	Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory
State Approved(Y/N)					
Date Abandoned (year)					
Date Plugged (year)					

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Columbia

Well W28 (E. Ray Heights) - emergency use only

PWSS No. 3010181

Boone County, sheet 4 of 5

21 wells

Sheet Update: Jan 25, 2016

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Missouri Department of Natural Resources

Well Number	W24	W26	W28	W29	W30
Extended PWS #	3010181124	3010181126	3010181128	3010181129	3010181130
Local Well Name	Well #10	Was Boone PWSD #1	E. Ray Heights	Well #11	Well #12
Well ID #	13542	12696	13227	13549	13007
DGLS ID #		0027618			
Facility Type	City	City	City	City	City
Status	Active	Emergency	Emergency	Active	Active
Latitude	38.89621	39.01039	38.99272	38.8722206126	38.8735986814
Longitude	-92.4644	-92.3179	-92.2367	-92.4513620528	-92.4507363245
Location Method	DRG/MAP	DRG/MAP	DRG/MAP	DRG/MAP	DRG/MAP
Method Accuracy (ft)	33	100	33	33	33
USGS 7.5 Quadrangle	Huntsdale	Browns	Millersburg	Jamestown	Jamestown
County	Boone	Boone	Boone	Boone	Boone
MoDNR Region	Northeast	Northeast	Northeast	Northeast	Northeast
Date Drilled (year)	1990	1974	1981	1997	1997
Material (C/U)	Unconsolidated	Consolidated	Consolidated	Unconsolidated	Unconsolidated
Base of Casing Formation	Alluvium	Cotter		Alluvium	Alluvium
Total Depth Formation	Alluvium	Eminence	Potosi	Alluvium	Alluvium
Total Depth	95	1350	1650	104	99
Ground Elevation (ft)					
Top Seal	Cement Grout			Cement Slurry	Cement Slurry
Bottom Seal					
Casing Depth (ft)	68	550		85	79
Casing Size (in)	26	12		26	26
Casing Type	Steel	Steel	Steel	Steel	Steel
Elev. of Casing Top (ft)	590				
Outer Casing Depth (ft)					
Outer Casing Size (in)					
Screen Length (ft)	35	No Screen	No Screen	80	60
Screen Size (in)	26	No Screen	No Screen	14	14
Static Water Level (ft)	14	240	394	13	16
Well Yield (gpm)	1400	535	525	2204	2224
Head (ft)	100	145			
Draw Down (ft)	9	16	62	7	7
Pump Test Date (year)	1990	1994	1993	1997	1994
Pump Type	Vertical Turbine	Submersible	Vertical Turbine	Vertical Turbine	Vertical Turbine
Pump Manufacturer	Layne Western			Layne Western	Layne Western
Pump Depth (ft)		370	540	70	70
Pump Capacity (gpm)	1400		600	1400	1400
Pump Meter (Y/N)					
VOC Detection (Y/N)	N	N	N	N	N
Nitrate Detection (Y/N)	N	N	N	N	N
Chlorination (Y/N)	Y	Y	Y		
Filtration (Y/N)	Y	N	N		
GWUDISW (Y/N)					
Surface Drainage	Satisfactory				
State Approved(Y/N)					
Date Abandoned (year)					
Date Plugged (year)					

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Columbia

PWSS No. 3010181

Boone County, sheet 5 of 5

21 wells

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Sheet Update: Jan 25, 2016

Missouri Department of Natural Resources

Well Number	W31
Extended PWS #	3010181131
Local Well Name	Well #15, McBaine Bottoms
Well ID #	18158
DGLS ID #	_____
Facility Type	City
Status	Active
Latitude	38.87834
Longitude	-92.46877
Location Method	GPS
Method Accuracy (ft)	82
USGS 7.5 Quadrangle	Huntsdale
County	Boone
MoDNR Region	Northeast
Date Drilled (year)	2006
Material (C/U)	Unconsolidated
Base of Casing Formation	Alluvium
Total Depth Formation	Alluvium
Total Depth	105
Ground Elevation (ft)	553
Top Seal	Tremie Grout
Bottom Seal	_____
Casing Depth (ft)	70
Casing Size (in)	24
Casing Type	Steel
Elev. of Casing Top (ft)	_____
Outer Casing Depth (ft)	20
Outer Casing Size (in)	42
Screen Length (ft)	35
Screen Size (in)	24
Static Water Level (ft)	24
Well Yield (gpm)	2200
Head (ft)	_____
Draw Down (ft)	_____
Pump Test Date (year)	_____
Pump Type	_____
Pump Manufacturer	_____
Pump Depth (ft)	49
Pump Capacity (gpm)	1400
Pump Meter (Y/N)	_____
VOC Detection (Y/N)	_____
Nitrate Detection (Y/N)	_____
Chlorination (Y/N)	_____
Filtration (Y/N)	_____
GWUDISW (Y/N)	_____
Surface Drainage	_____
State Approved(Y/N)	_____
Date Abandoned (year)	_____
Date Plugged (year)	_____

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Columbia

PWSS No. 3010181

Susceptibility Determination Sheet

21 wells

Sheet Update: Jan 25, 2016

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Missouri Department of Natural Resources

The Missouri Department of Natural Resources (MoDNR) has assembled this information to assess the susceptibility of drinking water sources to contamination. There are many unforseen and unpredictable factors that may cause a source to be contaminated. MoDNR routinely monitors all public supplies to ensure public health is protected. Public water systems and local communities are encouraged to take all measures possible to reduce the susceptibility of their drinking water source to chemical contamination. For more information, call 1-800-361-4827.	Not Susceptible	Moderately Susceptible	Highly Susceptible	Incomplete Data
A system is highly susceptible because of construction deficiencies if:				
A well was not constructed according to plans approved by MoDNR-PDWB,				X
A well was not cased to a depth approved by MoDNR,				X
A well casing is not of sufficient weight,				X
A well is not sufficiently sealed (grouted) around the casing, or A well has developed holes in the casing or other flaws that compromise its integrity.				X
A system is highly susceptible due to direct influence of surface water if:				
A well has tested positive for surface water indicators such as algae or high turbidity.				X
A system is highly susceptible to surface contaminants if:				
A well casing does not extend 12 inches above the well house floor, or 18 inches above the ground surface,				X
A well casing does not extend four feet above the 100-year flood level, or four feet above the highest known flood elevation,				X
A well is not provided with a properly screened vent, or				X
All openings in a well casing are not properly sealed.				X
A system is highly susceptible based on detection histories if:				
Volatile Organic Chemicals (VOCs) have been detected in a well,				X
Synthetic Organic Chemicals (SOCs) have been detected in a well,				X
Inorganic Chemicals (IOCs) have been detected in a well above naturally occurring levels,				X
Nitrates have been detected at or above one-half the MCL,				X
Bacteria has been consistently detected in a well, or				X
Viruses or microbiological contaminants are detected in a well.				X
A system is highly susceptible to weather, vandalism, and sabotage if:				
A well is not in a locked well house of adequate construction.				X (1)
A system is moderately susceptible due to local geology if:				
A producing aquifer is less than 100 feet below the surface,		X (2)		(*)
A producing aquifer has conduit flow conditions due to surficial karst topography,				X
A producing aquifer is not overlain by an impermeable confining layer,				X
A producing aquifer is overlain by a conductive (>5X10e-4) formation (including soil), or				X
A producing aquifer is confined, but there are open wells nearby penetrating that layer.				X
A system is moderately susceptible to contaminants if:				
Any contaminants listed in Appendix F-a are found in the source water area,		X (3)		
Septic systems are present in the source water area,				X
A well is indirectly connected to a surface water body,				X
A submersible well pump cannot be ruled out from containing PCBs or PHAs, or				X
There is a high density of transportation corridors in the source water area.				X
A system is highly susceptible to contamination if:				
Any contaminant sites identified in the source water area are known to have contaminated groundwater that may migrate toward a well.				X

(*) At least one well in the system is susceptible due to this condition, but other wells lack adequate data to make a determination.
(1) This system was not assessed to determine if adequate security devices such as padlocks, gates, and lighting are in place to deter vandals and saboteurs. All water systems should have this type of protection in place.
(2) A well (or wells) serving this system has been determined to be susceptible due to geologic conditions. The water system and the wellhead protection team should take extra care to ensure that all potential contaminants in the source water area are handled properly to avoid contamination of the drinking water supply.
(3) A well (or wells) serving this system has been determined to be susceptible due to the presence of potential contaminant sources. The water system and the wellhead protection team should take extra care to ensure that all potential contaminants in the source water area are handled properly to avoid contamination of the drinking water supply.

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Columbia

PWSS No. 3010181

Susceptibility Determination Sheet

22 wells

Sheet Update: Mar 05, 2015

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Missouri Department of Natural Resources

The Missouri Department of Natural Resources (MoDNR) has assembled this information to assess the susceptibility of drinking water sources to contamination. There are many unforseen and unpredictable factors that may cause a source to be contaminated. MoDNR routinely monitors all public supplies to ensure public health is protected. Public water systems and local communities are encouraged to take all measures possible to reduce the susceptibility of their drinking water source to chemical contamination. For more information, call 1-800-361-4827.	Not Susceptible	Moderately Susceptible	Highly Susceptible	Incomplete Data
A system is highly susceptible because of construction deficiencies if:				
A well was not constructed according to plans approved by MoDNR-PDWB,				X
A well was not cased to a depth approved by MoDNR,				X
A well casing is not of sufficient weight,				X
A well is not sufficiently sealed (grouted) around the casing, or A well has developed holes in the casing or other flaws that compromise its integrity.				X
A system is highly susceptible due to direct influence of surface water if:				
A well has tested positive for surface water indicators such as algae or high turbidity.				X
A system is highly susceptible to surface contaminants if:				
A well casing does not extend 12 inches above the well house floor, or 18 inches above the ground surface,				X
A well casing does not extend four feet above the 100-year flood level, or four feet above the highest known flood elevation,				X
A well is not provided with a properly screened vent, or				X
All openings in a well casing are not properly sealed.				X
A system is highly susceptible based on detection histories if:				
Volatile Organic Chemicals (VOCs) have been detected in a well,				X
Synthetic Organic Chemicals (SOCs) have been detected in a well,				X
Inorganic Chemicals (IOCs) have been detected in a well above naturally occurring levels,				X
Nitrates have been detected at or above one-half the MCL,				X
Bacteria has been consistently detected in a well, or				X
Viruses or microbiological contaminants are detected in a well.				X
A system is highly susceptible to weather, vandalism, and sabotage if:				
A well is not in a locked well house of adequate construction.				X (1)
A system is moderately susceptible due to local geology if:				
A producing aquifer is less than 100 feet below the surface,		X (2)		
A producing aquifer has conduit flow conditions due to surficial karst topography,				X
A producing aquifer is not overlain by an impermeable confining layer,				X
A producing aquifer is overlain by a conductive (>5X10e-4) formation (including soil), or				X
A producing aquifer is confined, but there are open wells nearby penetrating that layer.				X
A system is moderately susceptible to contaminants if:				
Any contaminants listed in Appendix F-a are found in the source water area,		X (3)		
Septic systems are present in the source water area,				X
A well is indirectly connected to a surface water body,				X
A submersible well pump cannot be ruled out from containing PCBs or PHAs, or				X
There is a high density of transportation corridors in the source water area.				X
A system is highly susceptible to contamination if:				
Any contaminant sites identified in the source water area are known to have contaminated groundwater that may migrate toward a well.				X

(1) This system was not assessed to determine if adequate security devices such as padlocks, gates, and lighting are in place to deter vandals and saboteurs. All water systems should have this type of protection in place.
(2) A well (or wells) serving this system has been determined to be susceptible due to geologic conditions. The water system and the wellhead protection team should take extra care to ensure that all potential contaminants in the source water area are handled properly to avoid contamination of the drinking water supply.
(3) A well (or wells) serving this system has been determined to be susceptible due to the presence of potential contaminant sources. The water system and the wellhead protection team should take extra care to ensure that all potential contaminants in the source water area are handled properly to avoid contamination of the drinking water supply.

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APPENDIX R – SOIL SURVEY REPORT

Map Scale: 1:2,710 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 40 80 160 240

Feet: 0 100 200 400 600

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Fine, smectitic, mesic Aquertic Chromic Hapludalfs

Not rated or not available

Soil Rating Lines

Fine, smectitic, mesic Aquertic Chromic Hapludalfs

Not rated or not available

Soil Rating Points

Fine, smectitic, mesic Aquertic Chromic Hapludalfs

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Boone County, Missouri
Survey Area Data: Version 21, Sep 28, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 8, 2015—Jun 9, 2015

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Soil Taxonomy Classification

Soil Taxonomy Classification— Summary by Map Unit — Boone County, Missouri (MO019)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
50002	Keswick-Urban land complex, 5 to 9 percent slopes	Fine, smectitic, mesic Aquertic Chromic Hapludalfs	0.1	0.4%
60025	Urban land-Harvester complex, 2 to 9 percent slopes		22.5	79.5%
99001	Water		5.7	20.1%
Totals for Area of Interest			**28.3**	**100.0%**

Description

This rating presents the taxonomic classification based on Soil Taxonomy.

The system of soil classification used by the National Cooperative Soil Survey has six categories (Soil Survey Staff, 1999 and 2003). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. This table shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Twelve soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in sol. An example is Alfisols.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Udalfs (Ud, meaning humid, plus alfs, from Alfisols).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; type of saturation; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Hapludalfs (Hapl, meaning minimal horizonation, plus udalfs, the suborder of the Alfisols that has a udic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic subgroup is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other taxonomic class. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective Typic identifies the subgroup that typifies the great group. An example is Typic Hapludalfs.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineralogy class, cation-exchange activity class, soil temperature regime, soil depth, and reaction class. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine-loamy, mixed, active, mesic Typic Hapludalfs.

SERIES. The series consists of soils within a family that have horizons similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile.

References:

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.

Soil Survey Staff. 2006. Keys to soil taxonomy. 10th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. (The soils in a given survey area may have been classified according to earlier editions of this publication.)

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Physical Soil Properties

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Report—Physical Soil Properties

Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Physical Soil Properties–Boone County, Missouri														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
50002—Keswick-Urban land complex, 5 to 9 percent slopes														
Keswick	0-7	30-39- 45	30-37- 50	22-25- 27	1.45-1.48 -1.50	4.00-9.00-14.00	0.17-0.20-0. 22	3.0- 4.5- 5.9	1.0- 1.5- 2.0	.32	.32	3	6	48
	7-20	20-25- 35	25-31- 40	35-44- 60	1.55-1.58 -1.60	0.42-1.00-1.40	0.11-0.13-0. 15	6.0- 7.5- 8.9	0.1- 1.0- 1.0	.24	.24			
	20-60	15-23- 30	30-38- 45	30-40- 40	1.60-1.68 -1.75	0.40-0.90-1.40	0.12-0.14-0. 16	4.5- 6.3- 7.5	0.1- 0.3- 0.5	.32	.32			
Urban land	—	—	—	—	—	—	—	—	—					
60025—Urban land-Harvester complex, 2 to 9 percent slopes														
Urban land	—	—	—	—	—	—	—	—	—					
Harvester	0-7	1- 4- 10	55-73- 75	18-23- 27	1.40-1.50 -1.60	4.00-9.00-14.00	0.10-0.15-0. 20	0.1- 1.5- 2.9	0.5- 0.5- 1.0	.55	.55	5	6	48
	7-31	1- 3- 10	50-67- 75	25-30- 35	1.35-1.48 -1.60	1.40-3.00-4.00	0.10-0.15-0. 20	3.0- 4.5- 5.9	0.1- 0.5- 1.0	.49	.49			
	31-80	15-24- 30	30-46- 60	25-30- 35	1.35-1.43 -1.50	1.40-3.00-4.00	0.12-0.14-0. 16	3.0- 4.5- 5.9	0.1- 0.4- 1.0	.37	.37			

Physical Soil Properties–Boone County, Missouri														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
99001—Water														
Water	—	—	—	—	—	—	—	—	—					

Data Source Information

Soil Survey Area: Boone County, Missouri
Survey Area Data: Version 21, Sep 28, 2016

Engineering Properties

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

Hydrologic soil group is a group of soils having similar runoff potential under similar storm and cover conditions. The criteria for determining Hydrologic soil group is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Listing HSGs by soil map unit component and not by soil series is a new concept for the engineers. Past engineering references contained lists of HSGs by soil series. Soil series are continually being defined and redefined, and the list of soil series names changes so frequently as to make the task of maintaining a single national list virtually impossible. Therefore, the criteria is now used to calculate the HSG using the component soil properties and no such national series lists will be maintained. All such references are obsolete and their use should be discontinued. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently. There are four hydrologic soil groups, A, B, C, and D, and three dual groups, A/D, B/D, and C/D. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas.

The four hydrologic soil groups are described in the following paragraphs:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Percentage of rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

References:

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Report—Engineering Properties

Absence of an entry indicates that the data were not estimated. The asterisk '*' denotes the representative texture; other possible textures follow the dash. The criteria for determining the hydrologic soil group for individual soil components is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Engineering Properties–Boone County, Missouri														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
50002—Keswick-Urban land complex, 5 to 9 percent slopes														
Keswick	50	C/D	0-7	Loam	CL	A-7-6, A-6	0- 0- 0	0- 0- 0	90-95-100	80-90-100	75-83-90	60-70-80	34-38-42	15-17-19
			7-20	Clay loam, clay	CL, CH	A-7-6	0- 0- 0	0- 0- 0	95-100-100	90-100-100	80-85-100	65-75-95	45-56-70	25-32-44
			20-60	Clay loam, silty clay loam	CL	A-7-6, A-6	0- 0- 0	0- 0- 0	95-100-100	90-100-100	80-85-100	65-75-95	39-49-50	21-28-29
60025—Urban land-Harvester complex, 2 to 9 percent slopes														
Harvester	40	C	0-7	Silt loam	CL	A-6	0- 0- 0	0- 0- 0	100-100-100	100-100-100	90-95-100	70-80-90	28-33-39	12-15-19
			7-31	Silty clay loam, silt loam	CL	A-6, A-7-6	0- 0- 0	0- 0- 0	100-100-100	100-100-100	90-95-100	70-80-95	35-41-47	17-21-25
			31-80	Silty clay loam, clay loam	CL	A-6, A-7-6	0- 0- 0	0- 0- 0	100-100-100	95-100-100	90-95-95	70-80-90	35-41-47	17-21-25

Data Source Information

Soil Survey Area: Boone County, Missouri
Survey Area Data: Version 21, Sep 28, 2016

Chemical Soil Properties

This table shows estimates of some chemical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Cation-exchange capacity is the total amount of extractable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. Soils having a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils having a high cation-exchange capacity. The ability to retain cations reduces the hazard of ground-water pollution.

Effective cation-exchange capacity refers to the sum of extractable cations plus aluminum expressed in terms of milliequivalents per 100 grams of soil. It is determined for soils that have pH of less than 5.5.

Soil reaction is a measure of acidity or alkalinity. It is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Calcium carbonate equivalent is the percent of carbonates, by weight, in the fraction of the soil less than 2 millimeters in size. The availability of plant nutrients is influenced by the amount of carbonates in the soil.

Gypsum is expressed as a percent, by weight, of hydrated calcium sulfates in the fraction of the soil less than 20 millimeters in size. Gypsum is partially soluble in water. Soils that have a high content of gypsum may collapse if the gypsum is removed by percolating water.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Sodium adsorption ratio (SAR) is a measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration. Soils that have SAR values of 13 or more may be characterized by an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity and aeration, and a general degradation of soil structure.

Report—Chemical Soil Properties

Chemical Soil Properties–Boone County, Missouri								
Map symbol and soil name	**Depth**	**Cation-exchange capacity**	**Effective cation-exchange capacity**	**Soil reaction**	**Calcium carbonate**	**Gypsum**	**Salinity**	**Sodium adsorption ratio**
	In	*meq/100g*	*meq/100g*	*pH*	*Pct*	*Pct*	*mmhos/cm*	
50002—Keswick-Urban land complex, 5 to 9 percent slopes								
Keswick	0-7	20-25	6.0-15	4.5-7.3	0	0	0.0-2.0	0
	7-20	18-36	18-35	4.5-6.0	0	0	0.0-2.0	0
	20-60	18-36	18-35	4.5-6.5	0	0	0.0-2.0	0
Urban land	—	—	—	—	—	—	—	—
60025—Urban land-Harvester complex, 2 to 9 percent slopes								
Urban land	—	—	—	—	—	—	—	—
Harvester	0-7	18-28	13-23	5.1-7.3	0	0	0.0-2.0	0
	7-31	18-28	13-23	5.1-7.3	0	0	0.0-2.0	0
	31-80	14-22	10-17	5.1-7.3	0	0	0.0-2.0	0
99001—Water								
Water	—	—	—	—	—	—	—	—

Data Source Information

Soil Survey Area: Boone County, Missouri
Survey Area Data: Version 21, Sep 28, 2016

available in the “Soil Properties” section and under the heading “Classification of the Soils.”

Minor Components

Winfield and similar soils

Estimated percent of the map unit: 0 to 10 percent
Slope range: 5 to 9 percent
Landform: Summits on hills

Menfro silty clay loam and similar soils

Estimated percent of the map unit: 0 to 5 percent
Slope range: 3 to 9 percent
Landform: Summits on hills

60025—Urban land-Harvester complex, 2 to 9 percent slopes

Map Unit Setting

Landform: Ridges on uplands

Component Description

Urban land

Percent of the map unit: 60 percent

Harvester

Percent of the map unit: 35 percent
Position on the landform: Summits
Parent material: Fine-silty loess
Slope shape: Concave

Component Properties and Qualities

Depth to bedrock: Very deep (more than 60 inches)
Runoff rate: High

Component Hydrologic Properties

Flooding: None
Current depth to water table: More than 6 feet
Drainage class: Moderately well drained

Typical Profile

C1—0 to 6 inches; silty clay loam
C2—6 to 30 inches; silty clay loam
2C3—30 to 60 inches; clay loam

Detailed descriptions of specific horizons are available in the “Soil Properties” section and under the heading “Classification of the Soils.”

Minor Components

Keswick and similar soils

Estimated percent of the map unit: 0 to 3 percent
Slope range: 5 to 9 percent
Landform: Backslopes on hills

Mexico and similar soils

Estimated percent of the map unit: 0 to 2 percent
Slope range: 1 to 3 percent
Landform: Interfluves on hills

60026—Weller silt loam, bench, 2 to 5 percent slopes

Map Unit Setting

Landform: Benches on uplands (fig. 14)

Component Description

Weller

Percent of the map unit: 85 percent
Parent material: Loess
Slope shape: Concave

Component Properties and Qualities

Depth to bedrock: Very deep (more than 60 inches)
Runoff rate: High
Depth to restrictive feature: Abrupt textural change—6 to 14 inches

Component Hydrologic Properties

Flooding: None
Current depth to water table: 24 to 48 inches
Drainage class: Moderately well drained

Typical Profile

Ap—0 to 8 inches; silt loam
Bt—8 to 16 inches; silty clay
Btg1—16 to 54 inches; silty clay loam
2Btg2—54 to 60 inches; silt loam

Detailed descriptions of specific horizons are available in the “Soil Properties” section and under the heading “Classification of the Soils.”

Minor Components

Auxvasse and similar soils

Estimated percent of the map unit: 0 to 10 percent
Slope range: 0 to 3 percent
Landform: Treads on stream terraces

Winfield and similar soils

Estimated percent of the map unit: 0 to 5 percent
Slope range: 2 to 5 percent
Landform: Summits on hills

Table 4 gives the acreage and proportionate extent of each map unit. Other tables (see Contents) give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils or miscellaneous areas.

50000—Adco silt loam, 0 to 2 percent slopes

Map Unit Setting

Landform: Ridges on uplands

Component Description

Adco

Percent of the map unit: 90 percent
Position on the landform: Summits
Parent material: Loess over pedisediment
Slope shape: Convex

Component Properties and Qualities

Depth to bedrock: Very deep (more than 60 inches)
Runoff rate: Very high
Depth to restrictive feature: Abrupt textural change—9 to 18 inches

Component Hydrologic Properties

Flooding: None
Current depth to water table: 12 to 30 inches
Drainage class: Somewhat poorly drained

Typical Profile

Ap—0 to 9 inches; silt loam
E—9 to 16 inches; silt loam
Btg1—16 to 28 inches; silty clay
Btg2—28 to 49 inches; silty clay
2BCg—49 to 60 inches; silty clay loam

Detailed descriptions of specific horizons are available in the “Soil Properties” section and under the heading “Classification of the Soils.”

Minor Components

Putnam and similar soils

Estimated percent of the map unit: 0 to 5 percent
Slope range: 0 to 2 percent
Landform: Interfluves on till plains

Mexico and similar soils

Estimated percent of the map unit: 0 to 5 percent
Slope range: 1 to 3 percent
Landform: Interfluves on hills

50001—Armstrong loam, 5 to 9 percent slopes, eroded

Map Unit Setting

Landform: Hills on uplands

Component Description

Armstrong

Percent of the map unit: 80 percent
Position on the landform: Backslopes
Parent material: Loess over till
Slope shape: Convex

Component Properties and Qualities

Depth to bedrock: Very deep (more than 60 inches)
Runoff rate: Very high

Component Hydrologic Properties

Flooding: None
Current depth to water table: 12 to 36 inches
Drainage class: Somewhat poorly drained

Typical Profile

Ap—0 to 5 inches; loam
2Bt1—5 to 11 inches; clay loam
2Bt2—11 to 31 inches; clay
2Btg—31 to 70 inches; clay loam

Detailed descriptions of specific horizons are available in the “Soil Properties” section and under the heading “Classification of the Soils.”

Minor Components

Keswick and similar soils

Estimated percent of the map unit: 0 to 15 percent
Slope range: 5 to 9 percent
Landform: Backslopes on hills

Leonard and similar soils

Estimated percent of the map unit: 0 to 10 percent
Slope range: 2 to 6 percent
Landform: Head slopes on till plains

50002—Keswick-Urban land complex, 5 to 9 percent slopes

Map Unit Setting

Landform: Hills on uplands

Component Description

Keswick

Percent of the map unit: 50 percent

Parent material: Loess over clayey till
Slope shape: Convex

Component Properties and Qualities

Depth to bedrock: Very deep (more than 60 inches)
Runoff rate: Very high

Component Hydrologic Properties

Flooding: None
Current depth to water table: 12 to 36 inches
Drainage class: Moderately well drained

Typical Profile

Ap—0 to 7 inches; silt loam
2Bt—7 to 20 inches; clay
2Btg—20 to 60 inches; clay loam

Detailed descriptions of specific horizons are available in the “Soil Properties” section and under the heading “Classification of the Soils.”

Urban land (fig. 9)

Percent of the map unit: 40 percent

Minor Components

Leonard and similar soils

Estimated percent of the map unit: 0 to 5 percent
Slope range: 2 to 6 percent
Landform: Head slopes on till plains

Armstrong and similar soils

Estimated percent of the map unit: 0 to 5 percent
Slope range: 5 to 9 percent

50003—Mexico silt loam, 1 to 3 percent slopes

Map Unit Setting

Landform: Ridges on uplands

Component Description

Mexico

Percent of the map unit: 80 percent
Position on the landform: Summits
Parent material: Loess over pedisediment
Slope shape: Linear

Component Properties and Qualities

Depth to bedrock: Very deep (more than 60 inches)
Runoff rate: Very high
Depth to restrictive feature: Abrupt textural change—6 to 14 inches

Component Hydrologic Properties

Flooding: None
Current depth to water table: 12 to 30 inches
Drainage class: Somewhat poorly drained

Typical Profile

Ap—0 to 7 inches; silt loam
E—7 to 10 inches; silt loam
BE—10 to 13 inches; silty clay loam
Btg—13 to 27 inches; silty clay
2Btg—27 to 60 inches; silty clay loam

Detailed descriptions of specific horizons are available in the “Soil Properties” section and under the heading “Classification of the Soils.”

Minor Components

Putnam and similar soils

Estimated percent of the map unit: 0 to 10 percent
Slope range: 0 to 2 percent
Landform: Interfluves on till plains

Adco and similar soils

Estimated percent of the map unit: 0 to 8 percent
Slope range: 0 to 2 percent
Landform: Interfluves on uplands

Leonard and similar soils

Estimated percent of the map unit: 0 to 2 percent
Slope range: 2 to 6 percent
Landform: Head slopes on till plains

50004—Mexico silt loam, 1 to 3 percent slopes, eroded

Map Unit Setting

Landform: Ridges on uplands

Component Description

Mexico

Percent of the map unit: 80 percent
Position on the landform: Summits
Parent material: Loess over pedisediment
Slope shape: Convex

Component Properties and Qualities

Depth to bedrock: Very deep (more than 60 inches)

APPENDIX S – FIELD LOGBOOK

MONDAY, MAY 15, 2017 93647 L.TURNER

WEATHER: CLEAR 80-90's WIND 5-15 SW.

TASK: MONITORING WELL INSTALLATION.

PERSONNEL: LEWIS TURNER.

0630 LOAD TRUCK, PICK UP RENTAL EQUIP AT MAIL ROOM.

0725 DEPART KCC OFFICE.

0926 AT COLUMBIA, BUY ICE.

0940 AT SITE.

0953 DRILLERS, GEOTECHNOLOGIES ONSITE.

1000 CALLED STEPHEN L., WILL MEET W/HIM INSIDE GATE.

1030 MET W/ STEPHEN, HE IS GETTING KEY TO MW-8 LOCATION.

1050 LOOK AT MW-8 LOCATION, THEY WILL MOVE TRAILERS, PREPARE TO SET UP AT MW-8

1110 MOVING TRAILERS. MW-8 ELEVATION = 755.5 WILL DRILL 27.5' TO 728 ELEVATION.

1120 SAFETY MEETING. CALIBRATE PID/LEL 4 GAS.
PID 100.0/100 ppm, LEL 50/50%, OXY 20.9/20.8
CO 50/50 H_2S 20/20

1133 TOWER UP RIG AT MW-8

1159 BEGIN DRILLING MW-8 BORING CME 4¼" ID HSA 6¼" OD

1220 4-6' SS HAD CCR IMPACT BLACK, LOOSE, CINDERS. STOP DRILLING. PULL AND DECON 5' AUGER AND SS SPOON

1235 OFFSET 15' NORTH, BEGIN AUGERING, BLACK SLAG/LOOSE MATERIAL IN TOP 0-6" (CCR IMPACT). STOP AUGERING.

1240 CALL BRIAN WEIS, NO ANSWER, CALL CHRIS HOGLUND,

5/15/17 93647 L.TURNER

* WILL ATTEMPT TO MOVE TO THE EAST, DONT GO MORE NORTH. PER PHONE CALL, TRY DRILLING W/ AUGER W/CENTER BIT TO CHECK FOR CCR MATERIAL IN CUTTINGS.

1300 SET UP RIG AT THIRD BORING ATTEMPT.

1320 CCR IN CUTTINGS 3-4' BGS RUN A SPLIT SPOON. CCR 4-5' IN SPLIT SPOON. PULL AUGERS TO ABANDON BORING.

1345 SHOVEL CCR IMPACTED DRY SOIL INTO BUCKETS TO TAKE TO DESIGNATED IMPOUNDMENT CLEAN UP AREA TO OFFLOAD.

1403 ABANDON 3 BORINGS AT MW-8 W/ BENTONITE CHIPS. BAROID HOLE-PLUG 3/8" CHIPS PLACE IN 3' LIFTS AND HYDRATE W/ POTABLE H_2O. USED BAGS.

1417 AT STAGING AREA NEAR EAST OF PLANT.

1425 SETUP TO DECON AUGERS AND SAMPLER.

1437 FINISH DECON LOOK AT LOCATIONS. MW-5 AND MW-6

1500 SET UP RIG AT MW-7.

1508 BEGIN DRILLING MW-7.

1540 COLLECT MW-7/SB01 FOR metals, radium 226+228, Atterberg, particle size, and moisture, Chrome VI. 6-8' AND 8-10 BGS

1550 COLLECT SHELBY TUBE FROM 12-14' BGS. MW-7/ST01 FOR permeability, Atterberg, particle size, and moisture.

1707 AT 25' SS TO 26' WL = 22.60'

1723 SECURE EQUIPMENT.

1730 OFFSITE TO HOTEL. RE-ICE COOLER

LT 5/15/17

TUESDAY, MAY 16, 2017 93647 L. TURNER

WEATHER: MOSTLY CLEAR 70-85° F

TASK: MONITORING WELL INSTALLATION.

PERSONNEL: LEWIS TURNER

0700 AT SITE TO RESUME DRILLING AT MW-7 LOCATION.

0709 MW-7 WL = 22.31' BGS.

0712 CALIBRATE PID 100.0/100ppm LEL 50/50%

OXY 20.8/20.9 CO 50/50 H2S 20/20

0721 RESUME DRILLING MW7 AT 25' (26-28 SS)

0759 COLLECT SHELBY TUBE FROM 30-32' BGS, VERY HARD MINIMAL AMT IN TUBE/TUBE BENT. WILL SEND MAY TRY AGAIN ON DEEP BORING IF NOT ENOUGH MATERIAL.

MW-7/ST02 FOR PERMEABILITY, ATTERBERG, PARTICLE SIZE, AND MOISTURE. WILL COLLECT 32-34 IN BAG AS BACKUP FOR ATTERBERG, PARTICLE SIZE, AND MOISTURE.

0809 COLLECT MW-7/SB02 32-34' FOR ATTERBERG, PARTICLE SIZE, AND MOISTURE. WL = 23.17' BGS

0815 AT 34' W/HSA. PREPARE TO SET MONITORING WELL.

MEASURE WELL MATERIALS: JOHNSON SCREEN BRAND.

RISER = 10.01, 10.00, 5.00'

SCREEN = 0.010 SLOT, 10.01' END CAP = 0.35' (0.37)

FILTER SIL INDUSTRIAL QUARTZ, 50 lb.

BAROID HOLE PLUG 3/8" CHIPS.

0840 BEGIN ADDING FILTER PACK AFTER PVC MATERIALS PLACED. DRILLERS MEASURE PLACEMENT W/WEIGHTED TAPE. RAISE AUGERS AS NEEDED.

5/16/17 93647 L. TURNER

0924 FINISH FILTER PACK TO 20.98' BGS USING 6 BAGS.

0927 BEGIN ADDING BENTONITE SEAL 3/8" CHIPS. MEASURE W/ WEIGHTED TAPE (DRILLER) RAISE AUGERS AS NEEDED.

0932 FINISH BENTONITE SEAL TO 17.81 USING 1 BAG., CHIPS IN WATER, HYDRATING. ALLOW CHIPS TO HYDRATE/READY GROUTING EQUIPMENT. TREMIE (SIDE DISCHARGE).

0949 BEGIN MIXING BAROID QUIK GROUT POWDER W/WATER TO MAKE 17-20% SOLIDS (20%-30%) BENTONITE GROUT SLURRY.

0957 BEGIN PUMPING IN BENTONITE GROUT. (SIDE DISCHARGE TREMIE)

1005 FINISH GROUTING MW-7 TO 1.0' BGS. 1 BATCH.

1010 TOWER DOWN RIG AND LOAD EQUIPMENT.

1016 GO TO DECON DRILLING EQUIPMENT. LOOK AT MW-3 AND MW-4 LOCATIONS.

1050 DECON FINISHED, DRILLERS WORK ON HYDRAULIC HOSE ON HAMMER.

1110 REPAIR COMPLETE. MOVE RIG UP TO MW-4 LOCATION.

1130 TOWER UP AT MW-4 ELV 785 (783 PREVIOUSLY)

1139 BEGIN DRILLING MW-4.

1200 COLLECT MW-4/SB01 6-8' FOR LABANALYTICAL AND 8-10' FOR GEOTECHNICAL. FOR Metals and Radium 226/228, Atterberg, particle size, moisture content, Chrome VI.

1500 DRILL RIG HYDRAULIC HAMMER FITTING AND HOSE LEAKING DRILLERS TIGHTEN. THEY WILL HAVE A MECHANIC ONSITE TOMORROW AM TO FIX. NOTIFY BRIAN W. ABOUT DOWN TIME TOMORROW.

5/16/17 93647 L. TURNER

1605 COURIER FROM PACE PICKS UP SAMPLES.

1607 AT 57' CLEAN OUT BORING. BORING IS MAKING WATER DEPTH UNKNOWN. WATER LEVEL METER GETTING STUCK TO SIDE OF AUGERS UNABLE TO TAKE WATER LEVEL. THERE IS WATER IN BOTTOM OF BORING.

1620 DRILLERS GET WELL MATERIALS.
RISER = 10.02, 10.01 X4
SCREEN = 0.010 SLOT 10.01 END CAP. 0.37'

1642 RUN IN TREMIE INSIDE AUGERS TO FLUSH ~~BORING~~ INSIDE OF AUGERS. AUGERS ARE SET AT BOTTOM OF BORING. THIS SHOULD HELP SET WELL MATERIALS AND PREVENT BRIDGING/STICKING TO SIDES OF AUGERS. SATURATED W/ WET CUTTINGS FROM SPLIT SPOON.

1650 FLUSH W/ 100 GALLONS OF WATER. MOST GOES OUT OF TOP OF AUGERS TO GROUND. PER WP DOES NOT HAVE TO CONTAIN.

1651 SET IN WELL SCREEN/RISER TO 57'

1653 BEGIN PLACING FILTER PACK. DRILLER CHECK W/ WEIGHTED TAPE. RAISE AUGERS AS NEEDED. FILTERSIL.

1655 CALCULATE VOLUME OF WATER REMAINING IN AUGERS.
WATER VOLUME = 42 GALLONS MINUS 7.7 GALLONS FOR PVC.

1740 FINISH PLACING FILTER PACK TO 43.97' BGS ~ 6 BAGS.

1741 BEGIN PLACING BENTONITE SEAL, THROUGH WATER.

1804 CHIP SEAL PLACED TO 41.00' BGS - 1 BAG, WILL GROUT IN MORNING PULLED AUGER UP SEVERAL FEET. SECURE SITE.

1815 OFFSITE.

LT 5/16/17

WEDNESDAY, MAY 17, 2017 93647 L. TURNER

WEATHER: OVERCAST 70-80'S WIND 5-15 SW

TASK: MW INSTALLATION.

PERSONNEL: LEWIS TURNER

0700 AT SITE, SAFETY MEETING.

0710 DRILLERS LOAD GROUT MATERIALS. CALIBRATE 5 gal meter.

0721 BEGIN MIXING GROUT, BAROID QUICK GROUT BENTONITE POWDER AND WATER (20-30% SOLIDS).

0729 INSTALL SIDE DISCHARGE TREMIE, WILL PULL AUGERS AS NEEDED ONCE GROUT REACHES TOP.

0758 COMPLETE GROUTING AT MW-4, PULLED ALL AUGERS OUT. LOAD EQUIPMENT. MOVE RIG 4 BAGS = 28 BATCHES

0815 BEGIN DECON.

0816 MONR PERSON ONSITE, DRILLERS EXPLAIN RIG DOWN. MONR OFFSITE.

0825 DRILLERS GO TO FILL WATER TANK, SHOW THEM GATE, HYDRANT WRENCH, AND HOSE TO USE. POTABLE WATER.

0839 FILLED WATER TANK, GO BACK TO DECON AUGERS/EQUIPMENT.

0845 GEOTECHNOLOGY MECHANIC ONSITE. SAFETY MEETING.

0850 BEGIN DECON, PRESSURE WASHER NOT FUNCTIONING, WORK ON.

0855 MECHANIC BEGINS HYDRAULIC HAMMER REPAIRS.

0911 POWER WASHER OPERATIONAL, RESUME DECON.

0937 MW-7 WL = 20.70' TD = 33.70' 'BGS
BOTTOM IS SILTY/CLAY SEDIMENT. STICKUP = 1.40'

0944 MW-4 WL = 22.51' TD = 57.48' 'BGS SU = 2.60'

0958 CALL IN TO CONFERENCE CALL.

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1024 END CALL.

1026 GO TO GAUGE PZs

PZ-6 WL= 5.41

PZ-4 WL= 5.30

1120 DRILLERS ATTACHED NEW HOSE, WORKING ON HAMMER PISTON.

1218 RIG HAMMER REPAIRED, LOAD AUGERS FROM DELON.

1240 SET UP AT MW-3 LOCATION MOVED SOUTH AND WEST AWAY FROM OVERHEAD ELECTRIC.

1250 START

1305 COLLECT MW-3/SB01 JARS 6-8' BAG 8-10' FOR metals, Hexchrome VI, radium 226/228, Atterberg, particle size, moist.

1435 MDNR ONSITE, Darrel Hartley, TAYLOR, DAVE.

1507 38-42' HARD DRILLING, CANT ADVANCE SPLIT SPOONS, ADVANCE AUGERS THROUGH, CHERT FRAGMENTS IN SLOUGH OF 42-44 SPLIT SPOON. TALK TO CHRIS HOGLUND SCREEN 40-50' IN THIS ZONE.

1551 ATTEMPT STUBE AT 44-46, NOT ABLE TO PUSH. WILL COLLECT SPLIT SPOON AND BAG. COLLECT BAG SAMPLE FROM 42-44' AND 44-46' WILL MOVE SHELBY TUBE TO MW-2 LOCATION CANT ADVANCE INTO THIS MATERIAL HERE. MATT W/MDNR ONSITE. MW-3/SB02

1620 AT 50' CLEAN BORING W/AUGERS.

1635 PREPARE TO FLUSH INSIDE OF AUGERS, LOWER IN TREMIE.

1645 USED 100 GALLONS SECURE BORING

1700 ALL CREWS OFFSITE AND MDNR.

LT 5/17/17

THURSDAY, MAY 18, 2017 93647 L.TURNER

WEATHER: OVERCAST 70-80's WIND 5-20 SW.

TASK: MONITORING WELL INSTALLATION

PERSONNEL: LEWIS TURNER

0700 AT SITE, SAFETY MEETING.

0710 DRILLERS LOAD WELL MATERIALS.

CALIBRATE PID 100.0/100 LEL 50/50%, OXY 20.9/20.8 CO 50/50, H2S 20/20.

0719 MEASURE WELL MATERIALS FOR MW-3. MDNR ONSITE.

RISER = 10.01, 10.00 X3

SCREEN= 0.010 SLOT, 10.00 END CAP. 0.37'

0725 PLACE SCREEN AND RISER. NEED TO FLUSH BORING MORE. REMOVE AND FLUSH W/ CLEAN WATER.

0731 FINISH FLUSHING W/100 GALLONS. PLACE RISER AND SCREEN.

0732 BEGIN PLACING 20/40 FILTER PACK SAND. (FILTERSIL). RAISE AUGERS AS NEEDED. DRILLER MEASURES W/WEIGHTED TAPE.

0820 FINISH FILTER PACK TO 38.94' BLS ~ 6 BAGS.

0821 BEGIN ADDING BENTONITE SEAL BAROID 3/8" CHIPS BY HANDFULL TO PREVENT BRIDGING. RAISE AUGERS AS NEEDED. FALLING THROUGH WATER.

0835 FINISH BENTONITE SEAL TO 33.15' BLS ~ 1 BAG.

0837 PREPARE TO MIX GROUT, SET TREMIE TO BOTTOM.

0856 BEGIN MIXING BENTONITE GROUT BAROID QUIK-GROUT AND WATER (20-30% HIGH-SOLIDS). 8 BAGS -

0900 BEGIN PUMPING IN GROUT BATCH, SIDE DISCHARGE TREMIED.

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0905 MIX SECOND BATCH OF GROUT. 2 BAGS.

0915 SECOND BATCH PUMPED IN. 1.0' BGS.

0925 FINISHED GROUTING MW-3. MDNR 2 PERSONNEL OFFSITE. LOADING EQUIPMENT.

0936 DRILLERS GO TO GET A LOAD OF POTABLE WATER FROM FIRE HYDRANT.

0954 DRILLERS BACK AT RIG W/WATER, BEGIN DECON.

1010 GO W/DAN TO MOVE TRAILERS OUT OF WAY OF MW-8. CITY MOVED TWO TRAILERS.

1048 FINISH DECON, LOAD EQUIPMENT.

1100 GO TO MW-8 LOCATION DAN COMES TO OPEN GATE AGAIN

1130 TOWERED UP, START DRILLING CCR AT 3-4' BGS PULL AND ABANDON BORING. WILL TRY 50' NORTH OF ORIGINAL MW-8 LOCATION. DECON SPLIT SPOON / AUGER IN BUCKET

1210 BEGIN DRILLING AT 50' NORTH OF MW-8 MAP LOCATION. 2-4' NO CCR MATERIAL. 4-6 NO CCR, BRIAN WEIS OK W/ DISTANCE NORTH.

1221 CONTINUE DRILLING.

1259 COLLECT SOIL SAMPLES MW-8/SB01 FROM 16-18' BAG SAMPLE FOR ATTERBURG, PARTICLE SIZE, MOISTURE.

1315 COLLECT JARS FROM 20-23' BGS FOR METALS, HEX CHROME VI, AND RADIUM 226/228 MW-8/SB02 AND MW-8/SB11 (DUP)

1356 AUGERS AT 28 SPLIT SPOON TO 30. WILL SET WELL AT 28' BGS. PREPARE TO SET WELL. BOTTOM OF BORING WET.

1358 MEASURE MATERIALS:

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RISER = 10.01 X 2

SCREEN = 10.01 0.010 SLOT ENDCAP = 0.37'

1400 SET IN RISER AND SCREEN.

1404 BEGIN PLACING SAND FILTERPACK 20/40 SILICA SAND. RAISE AUGERS AS NEEDED.

1422 FILTERPACK PLACED TO 14.91' BGS USING ~ 5.5 BAGS.

1424 BEGIN PLACING BARIOID 3/8" BENTONITE CHIPS

1427 FINISH PLACING BENTONITE CHIP SEAL. TO 11.84' BGS - 1 BAG. HYDRATE CIPS W/ POTABLE WATER 10 GALLONS ADDED.

1435 WILL PLACE BENTONITE CHIPS TO SURFACE HYDRATE IN 2' LIFTS UNTIL BORING HOLDS WATER. ~ 4 BAGS.

1444 PICKED UP MORE BENTONITE CHIPS FROM STAGING AREA. CALLED ERIC HES. TO PICK UP SOIL CUTTINGS FROM MW-8 LOCATION

1453 FRONT LOADER ARRIVES, BEGIN LOADING SOIL CUTTINGS TO TAKE OUT OF LOT.

1510 GO BACK TO DECON, LOCK GATE.

1516 BEGIN DECON.

1550 FINISH DECON, SETUP RIG AT MW-5 LOCATION

1600 BEGIN HSA AT MW-5, CCR AT 0-6" CALL OFFICE.

1635 WILL SS DOWN TO 6' TO SEPARATE OF CCR.

1648 AT MW-5 CCR 0-1' IN GRAVEL 2-6' CLEAR, CLAY. ABANDON MW-5 TEST HOLE.

1700 SECURE SITE, WILL HAVE POWER PLANT CREW SCRAPE TWO AREAS TOMORROW AT MW-5 AND MW-6.

1715 OFFSITE

LT 5/18/17

FRIDAY, MAY 19, 2017 93647 L. TURNER

WEATHER: OVERCAST, 70's WINDS-15 S

TASK: MW INSTALLATION.

PERSONNEL: LEWIS TURNER.

0615 AT SITE. PREPARE TO BAIL WELLS TO CHECK FOR RECHARGE.

0625 MW-4 WL= 22.31 BAILED DOWN = 47.31' BGS.

WELL IS RECHARGING.

0645 MW-3 WL= 16.61 TD= 50.20 BAILED TO 36.11

0700 DRILLERS ONSITE, MAKE CALLS TO TRY AND HAVE LOCATION AT MW-5 SCRAPED W/ MACHINERY, SAFETY MEETING.

0723 CHRISTIAN IS GOING TO SEND SOMEONE TO SCRAPE BACK TOP 1.5' TO CLEAR AREA TO DRILL.

0815 FINISHED SCRAPING BACK 1.0' TO CLEAN SOIL. MOVE AND SET UP RIG. BUMP TEST 5 GAS METER PID= 100.0/100 CGI 50/50 OXY.= 20.9/20.9 CO= 50/50 H2S= 20/20

0820 START DRILLING.

0830 COLLECT [MW-5/SB01] JARS 6-8' BAG 8-10' FOR METALS, HEX CHROME VI, RADIUM 226/228, ATTERBERG, POTABLE SPEC MOISTURE.

1050 AT 41' PREPARE TO SET MW-5. WILL FLUSH BORING W/ CLEAN POTABLE WATER. ONLY INSIDE AUGERS.

1122 MEASURE MATERIALS SCH 40 PVC

RISER= 10.01 X 3, 5.00'

SCREEN= 0.010 SLOT, 10.01 END CAP= 0.37'

1127 BEGIN FLUSHING INSIDE OF AUGERS TO PREVENT BRIDGING.

1134 FINISH FLUSHING 100 GAL, MOST EXITS OUT TOP OF AUGERS.

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1137 INSTALL RISER/SCREEN. CUT RISER= 2.78' (MW-5).

1140 BEGIN PLACING FILTERPACK 20/40 FILTERSIL. DRILLERS MEASURE WITH WEIGHTED TAPE.

1145 MW-3 WL= 17.11' BGS

1148 MW-4 WL= 23.01' BGS

1219 FINISHED FILTER PACK PLACEMENT TO 27.89 ~ 6 BAGS.

1221 BEGIN ADDING BENTONITE SEAL BAROID 3/8" CHIPS IN WATER.

1225 FINISHED PLACING BENTONITE CHIP SEAL. PREPARE TO GROUT WELL. MIX BATCH OF GROUT 2 BAGS TO WATER. BAROID QUIK-GROUT.

1252 BEGIN PUMPING GROUT INTO WELL ANNULUS. 24.76

1300 MIX SECOND BATCH OF BENTONITE GROUT.

1307 PUMP IN SECOND BATCH OF GROUT.

1312 FINISHED GROUTING MW-5 TO SURFACE.

1315 MOVE RIG TO DECON, CALL DAN TO GET SOIL/ROCK FILLED IN AROUND THE WELL WHERE THEY SCRAPED.

1400 DECON DONE, DRILLERS SIGN COC AND TAKE GEOTECH SAMPLES TO THEIR LAB.

1410 DRILLERS OFFSITE.

1418 AT MW-7 WL= 22.35' BAILED DOWN TO 28.60' ~1420.

1450 WL= 26.09

1508 LAB PICKS UP COOLER.

1510 OFFSITE.

1718 AT KC OFFICE.

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MONDAY, MAY 22, 2017 93647 L. TURNER

WEATHER: OVERCAST 70's WIND 5-15 SW.

TASK: MW Installation

PERSONNEL: LEWIS TURNER

0830 PICK UP TURBIDITY METER AND DEVELOPMENT EQUIPMENT.

0915 DEPART TO SITE.

1130 AT SITE, DRILLERS TO ARRIVE AFTER 1200.

MW-5 WL=12.21 TD=41.39' BGS.

1221 BAILED DOWN TO 31.02' BGS.

1250 DRILLERS ONSITE, STAGE EQUIPMENT.

1255 MW-5 WL: 23.70' BGS. WELL IS RECHARGING.

1300 DRILLERS BEGIN DECON OF EQUIPMENT THAT WAS LEFT FROM FRIDAY.

1338 DECON FINISHED / LOADED SUPPLIES GO TO SETUP AT MW-7

DISCUSSED W/ CHRIS H. ABOUT DRILLERS WANTING TO USE ROTARY W/BENTONITE MUD ON DEEP BORINGS TO ROCK. HE WILL EMAIL STATE FOR APPROVAL.

1404 SET UP AT MW-7.

1415 BEGIN DRILLING AT MW-7 4 1/4" ID AUGERS. 6 1/4" OD.

1430 COLLECT MW-7 / SB01 6-8' IN JARS 8-10' IN BAG FOR metals, Hex Chrome VI, radium 226/228, Atterberg, particle size, and moisture

1431 CALIBRATE PID 100.1/100ppm LEL 50/50% OXY 20.9/20.9%

CO, 50/50 H_2S 20/20.

1532 AT 25' MATERIAL HEAVED 4' INTO AUGERS. WILL FLUSH OUT W/CLEAN WATER. ~50 GALLONS.

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1530 ADVANCE AUGER W/CENTER BIT, FLUSHING WORKED.

1645 STOP MW-7 AT 40' FOR THE DAY. RAIN STARTS.

SECURE EQUIPMENT.

1700 OFFSITE

5/22/17

TUESDAY, MAY 23, 2017 93647 L. TURNER

WEATHER: OVERCAST 60-70°F WIND 5-20 SW.

TASK: MW INSTALLATION

PERSONNEL: LEWIS TURNER

0700 ARRIVE AT SITE, SAFETY MEETING.
CALIBRATE PID 100.1/100.0 LEL 50/50 OXY 20.8/20.9 %,
CO 50/50 H2S 20/20.

0715 RESUME DRILLING AT MW-2 AT 40' BGS.

0838 AT 53' BGS AT MW-2 LOCATION.

0847 FLUSH AUGERS W/ POTABLE WATER THROUGH TREMIE TO CLEAN INSIDE OF AUGERS TO PREVENT BRIDGING.

0852 FINISH FLUSHING AUGERS W/ 100 GALLONS DISCHARGED TO GROUND. DRILLERS GO TO LOAD SUPPLIES.

0907 MEASURE WELL MATERIALS. JOHNSON SCREENS. SCH 40 PVC.
RISER: 10.01, 10.00 X 4", 5.00
SCREEN: 0.010 SLOT 10.00 END CAP = 0.37'

0918 INSTALL RISER AND SCREEN.

0922 BEGIN PLACING 20/40 FILTER SIL INDUSTRIAL QUARTZ SAND. DRILLER CHECKS W/WEIGHTED TAPE. PULL UP AUGERS AS NEEDED.

0947 CHECK MW-1 LOCATION.

1014 FINISH FILTERPACK TO 39.87' BGS USING 7 BAGS.

1017 BEGIN PLACING BENTONITE COATED PELLETS, PEG-PLUG TR30 (TIME RELEASE 30 min). 1/4" PELLETS. 50 lb BUCKETS

1025 FIRST BUCKET OF PELPLUG TR30 IN BEGIN PLACING SECOND.

1031 FINISH PLACING SECOND BUCKET OF TR30 PELLETS. AT 36.71.

1033 ALLOW TR30 BENTONITE PELLETS TO HYDRATE.

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1131 BEGIN MIXING BENTONITE GROUT BAROID QUIK-GROUT BENTONITE POWDER AND WATER. 2 BAGS PER BATCH.

1142 PUMP IN BATCH OF GROUT. PULL AUGERS AFTER BATCH.

1200 FINISH PUMPING FIRST BATCH. THROUGH SIDE-DISCHARGE TREMIE.

1210 MIX SECOND BATCH OF GROUT.

1217 PUMP IN SECOND BATCH THROUGH TREMIE.

1224 FINISHED GROUTING MW-2 TO SURFACE.

1228 LOAD EQUIPMENT.

1239 GO DECON AUGERS/RIG. DRILLERS LOAD WATER TANK (POTABLE).

1245 MW-5 WL = 17.75' BGS

1253 WATER TANK FILLED. DRILLERS BEGIN DECON.

1405 FINISH DECON., LOAD ROAD SIGNS.

1425 SET UP RIG AT MW-1, SET CONES AND ROAD SIGNS.
UTILITIES ARE ON OTHER SIDE OF ROAD. ALL MARKED OK.

1446 START DRILLING AT MW-1.

1451 AT 5' HSA 6' BS. DRILLER HAS A CALL THEY HAVE TO ATTEND.
STOP DRILLING UNTIL CALL OVER.

1513 MW-8 WL = 6.61' TD = 28.00' BGS BAIL WATER

1519 BAILED DOWN TO 18.10' BGS

1525 MW8 WL = 16.96' BGS WELL IS RECHARGING.

1610 RESUME DRILLING AT MW-1 ~6'.

1615 COLLECT MW-1/ST01 6-8' JARS 8-10' BAG FOR Metals, chrome VI, radium 226/228, Atterberg, particle size, moisture.

1628 COLLECT MW-1/ST01 FROM 10-12' SHELBY TUBE. FOR

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Permeability, Atterberg, particle size, and moisture.

1705 STOP DRILLING AT 20'.

1715 SECURE EQUIPMENT

1720 OFFSITE.

5/23/17

WEDNESDAY MAY 24, 2017 93647 L.TURNER

WEATHER: MOSTLY CLEAR 50-70's WIND 5-15 SW

TASK: MW INSTALLATION

PERSONNEL: LEWIS TURNER.

0700 AT SITE. SAFETY MEETING

0710 CALIBRATE PID 100.1/100 ppm LEL 50/50%. O_2 20.8/20.9%
CO 50/50 H_2S 20/20.

0721 RESUME DRILLING AT 20' SPLIT SPOON 20-22 COLLECTED YESTERDAY.

0750 AUGER GRINDING ON ROCK ADVANCE 30-31 NO SAMPLE.

0800 SOIL TOO HARD TO ADVANCE SHELBY TUBE 32-34' WILL COLLECT 4' IN BAGS FOR REFORMED PERMEABILITY TEST.

0810 DRIVE 3" ID SPLIT SPOON TO COLLECT SAMPLE IN BAG FOR REFORMED PERMEABILITY TEST, ATTERBERG, PARTICLE SIZE, AND MOISTURE. 32-34'

0810 COLLECT MW-1 / SB07 FROM SPLIT SPOON INTO BAG FOR REFORMED PERMEABILITY, ATTERBERG, PARTICLE SIZE, AND MOISTURE 32-34' BGS.

0834 DOUG BAUGHMAN W/MDNR ONSITE TO OBSERVE.

0858 AT 43' STOP DRILLING

0905 FLUSH BORING W/WATER INSIDE AUGERS TO CLEAN INSIDE OF SOIL, TO PREVENT BRIDGING CLEAN WATER USED.

0910 FINISH FLUSHING W/ TREMIE. 100 GALLONS.

0914 MEASURE WELL MATERIALS. SCH 40 PVC 2"
RISER = 10.01, 10.00 x 2, 5.00
SCREEN = 10.00 0.010 SLOT ENDCAP = 0.37'

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0914 INSTALLED PVC WELL MATERIALS.

0915 BEGIN ADDING 20/40 FILTERPACK SAND. DRILLERS MEASURE W/ WEIGHTED TAPE. FILTERSIL QUARTZ.

0952 FINISH ADDING FILTERPACK TO 29.87' ~ 8 BAGS.

0955 BEGIN ADDING PEL-PLUG 1/4" TR30 BENTONITE PELLETS FALLING THROUGH WATER. RAISE AUGERS AS NEEDED.

1005 FINISH BENTONITE SEAL TO 26.56' ~ 2x50 lb BUCKETS ALLOW TO HYDRATE FOR 1 HOUR. (TR30 PELLETS).

1101 PREPARE TO GROUT, RAISE AUGERS 5', BEGIN MIXING BENTONITE GROUT. BAROID QUIK-GROUT BENTONITE POWDER TO WATER (20-20 % HIGH SOLIDS). ~ 2 BAGS.

1110 PLACE SIDE DISCHARGE TREMIE FROM BOTTOM UP TO GROUT

1120 PUMP FIRST BATCH OF GROUT FROM BOTTOM UP W/TREMIE.

1125 MIX SECOND BATCH OF GROUT. 2 BAGS / WATER.

1127 PUMP SECOND BATCH OF GROUT.

1134 COMPLETE GROUTING AT MW-1 TO SURFACE.

1140 LOAD EQUIPMENT TO GO DECON. PICK UP STREET SIGNS.

1156 AT DECON LOCATION, NEAR EMPOUNDMENT, WATER FLOWS TO IT.

1205 BEGIN DECON OF AUGERS / RIG.

1300 DECON FINISHED, PAT CHECKS ON UTILITY STATUS OF MW-6.

1318 MW-6 LOCATION NOT CLEAR YET.

1325 CHRIS ONSITE.

1330 DISCUSS NEXT LOCATION, WATER DROP LOCATION BLOCKED OF DUE TO CRANE WORK.

1336 DRILLERS GET CONCRETE / LUMBER FOR PADS.

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1400 BRIAN WEIS AND CHRIS SNIDER MEETING W/CHRISTIAN.

1410 AT MW-8 LOCATION BEGIN DIGGING OUT 3X3' PAD.

1440 CHRIS HOGLUND OFFSITE.

1515 BRIAN W. AND CHRIS S. ONSITE.

1519 MIX CONCRETE AND POUR PAD AT MW-8.

1585 BMCD VISITORS GO BACK TO PLANT

1570 MW-8 CUT RISER 2.46 - 2.49' OFF.

1543 JOEY W/USGS OFFSITE.

1605 PAD AT MW-8 FINISHED - FLUSH MOUNT. LOCK GATE.

1610 AT MW-2 BEGIN DIGGING PAD. / MIX CONCRETE.

1625 CUT OFF 2.48' OF MW-2 RISER.

1626 BEGIN POURING 2X2' PAD AT MW-2.

1654 FINISH PAD AT MW-2 GO TO PLACE TRASH IN BIN.

1707 OFFSITE.

LTA 5/24/17

THURSDAY, MAY 25, 2017 93647 L. TURNER

WEATHER: CLEAR 45-75°F WIND 5-15 SW

TASK: MW INSTALL

PERSONNEL: LEWIS TURNER

0701 ONSITE. SAFETY MEETING

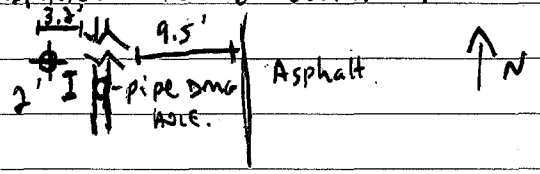
0712 CALIBRATE PID 100.0/100.0 LEL 50/50%, OXY 20.8/20.9
CO 50/50 H_2S 20/20 ppm.

0715 CALL TO HAVE EXCAVATOR SCRAPE MW-6 LOCATION
CLR MATERIL ON SURFACE OF GRAVEL LOT.

0718 DRILLERS GET A LOAD OF WATER, EXCAVATOR IN ABOUT
30 MIN.

0740 BEGIN SCRAPING SURFACE AT MW-6 LOCATION COMO PLANT
WORKERS W/ SKIDSTEER.

0831 WHILE CITY CREW WAS DIGGING W/ SKIDSTEER A 3"
FIBERGLASS PIPE WAS HIT AND OPENED. HAS 0.5" OF WATER
IN THE LINE. DAN SAYS MUST BE AN ABANDONED PIPE FROM
OLD COMMUNITY SWIMMING POOL. NOTIFY CHRISTIAN
OF PIPE. DAN ORDERS 1" ROCK TO FILL HOLE AND WORK ON.
PIPE IS 3.2' FROM WELL (EAST) 9.5' WEST OF
ASPHALT AND 2' SOUTH OF.



0850 CHRISTIAN AT LOCATION MEASURED TO PIPE AND 12" LINE
SHOULD BE. LINE NOT CHARGED, NOT ON ANY OF THEIR MAPS.

0851 CITY BACKFILLING PIT W/ CLEAN GRAVEL.

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0918 SET UP RIG AT MW-6 LOCATION.

0930 START TOP 4' removed by excavation.

0945 AT 4.0-4.2' THERE WAS ONE SMALL ELECK OF RAW COAL.
0.3" IN DIAMETER. REST OF SAMPLES 4.2-8' CLEAN.
NOTIFY BRIAN WEIS. THE IMPACT TO THE WELL
WOULD BE NONE. WOULD NOT SMEAR DOWN. CONTINUE
DRILLING.

0954 COLLECT MW-6/SB01 6-8' IN JARS 8-10' IN BAG.
FOR METALS, HEX CHROME VI, RADIUM 226/228, Atterberg,
particle size, moisture.

1117 SCHEDULE COURIER FOR PACE LAB SAMPLES

1120 RE-ICE W/ FRESH ICE AND SEAL COOLER W/ PACE LAB SAMPLES.

1139 AT 42' BLS. GET WELL MATERIALS.

1140 DRILLERS CLEARED BORING W/ AUGERS.

1215 PREPARE TO SET MW-6 WELL, MEASURE MATERIALS.
JOHNSON SCREEN 2" SCH 40 PVC
RISER: 10.00, 10.01 x 2, 5.00
SCREEN: 0.010 SLOT, 10.01 ENDCAP = 0.37'

1218 FLUSH INSIDE OF AUGERS W/ 50 GALLONS, TO CLEAN TO PREVENT
BRIDGING OF MATERIALS.

1225 INSTALL PVC SCREEN AND RISER.

1227 BEGIN ADDING 20/40 FILTER SIL FILTERPACK SAND, DRILLER
CHECKS W/ WEIGHTED TAPE.

1237 EMAIL FROM BRIAN, MW-3/SB02 4' OF SPLITSPOONS WAS NOT
ENOUGH VOLUME FOR PERM TEST. DRILLERS HAVE A 3" DIA SPOON

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THAT WAS BROUGHT THIS WEEK. PROPOSE TO RE-COLLECT AT SB-2 (MW-5) SOIL BORING USING 3" DIA SAMPLER.

1257 FINISH FILTER PACK TO 28.94 ' BGS USING 6.5 BAGS.

1301 BEGIN ADDING PEL-PLUG 1/4" COATED TR30 BENTONITE PELLETS. FALLING THROUGH WATER. 50 lb BUCKET.

1309 BEGIN ADDING A SECOND BUCKET OF BENTONITE PELLETS.

1314 FINISH ADDING BENTONITE PELLETS TR30 ALLOW FOR HYDRATION AT 25.70 'BGS ~ 2 BUCKETS.

1351 MW-2 WL= 16.86 TD=52.93 'TOC.

1403 BEGIN MIXING BENTONITE GROUT BAROID QUIK GROUT AND WATER. TWO BAGS PER BATCH. SET IN SIDE DISCHARGE TREMIE PIPE.

1409 BEGIN PUMPING IN BENTONITE GROUT THROUGH TREMIE FROM THE BOTTOM UP.

1416 FIRST BATCH IN, RAISE AUGERS, MIX SECOND GROUT BATCH/PUMP IN.

1422 FINISHED GROUTING MW-6 TO SURFACE. LOAD EQUIPMENT.

1431 DRILLERS BEGIN DECON OF AUGERS/RIG/EQUIPMENT.

1540 DRILLERS FINISHED DECON,

1547 BEGIN DIGGING 2X2 PAD AT MW-4.

1605 FINISH DIGGING MW-4 PAD. START DIGGING MW-3.

1620 FINISHED DIGGING MW-3 PAD. GO TO MW-1 TO DIG PAD. COURIER FROM PACE PICKED UP SAMPLES.

1650 FINISHED DIGGING PAD AT MW-1.

1700 SECURE EQUIPMENT, CREWS OFFSITE.

LT 5/25/17

FRIDAY, MAY 26, 2017 93647 L. TURNER

WEATHER: PARTLY CLOUDY 60-75°F WIND 5-25 SW.

TASK: MONITORING WELL PADS AND DEVELOPMENT.

PERSONNEL: LEWIS TURNER

0730 ONSITE, DRILLERS ONSITE, SAFETY MEETING.

0741 DRILLERS GO TO MIX CONCRETE AND POUR 2X2X2' PAD AT MW-1.

0750 CALIBRATE METERS:

ECTestr11 COND: 1.410/1.409

pH: 4.0/4.0 7.0/7.0 10.0/10.0

Lamotte 2020we Turbidity: 10.17/10 0.27/0

0815 FILL OUT COC FOR GEOTECH SAMPLES.

0821 DRILLERS COMPLETED MW-1 PAD. RISER CUT OFF= 2.51'

0824 DECON PV PUMP FOR DEVELOPMENT, NEW HOSE.

0837 GO TO MW-7 TO SETUP FOR DEVELOPMENT. CUT RISER= 1.93'

MW-7 WL= 26.61 TD= 31.90' TOC

ACTUAL TD = 33.44' TOC 1 WV = 4.0 GALLONS.

CASING VOLUME = 1.1 GALLONS FILTER PACK VOL = 2.9 GALLONS. LT 5/26

0900 BEGIN SURGING SCREEN w/ pump off.

0915 FINISH SURGING. + TOPPED OFF GROUT 2' w/ BENTONITE CHIPS.

0915 BEGIN PUMPING

0917 PURGED DRY, WAIT FOR RECHARGE. 1.5 GALLONS.

90 PERCENT RECHARGE ~~25.09~~ 27.29' TOC LT 5/26

0950 WL= 28.75'

0958 LOAD UP EQUIPMENT AND GO TO DECON PUMP.

1000 DECON PUMP/NEW HOSE.

5/26/17 93647 L.TURNER

1011 FINISH DECON, GO TO MW-4 TO DEVELOP.

MW-4 CUT RISER = 3.28' TOP OF W/ CHIP BENTONITE 3'

MW-4 WL = 21.74' TD = 57.05

ACTUAL TD = 57.86 1 WV = 11.4 GALLONS

CASING VOL = 5.8 GAL FILTERPACK VOL = 5.6 GAL.

1022 BEGIN SURGING SCREEN.

1030 FINISH SURGING. BEGIN PUMPING AT BOTTOM.

1041 PURGED DRY AT 12.0 GALLONS ALLOW 90% RECHARGE.

90% = 25.28' TOC WL = 55.02

1046 DRILLERS GO TO POUR PAD AT MW-3 2x2x2'

1051 WL = 50.17

1114 WL = 44.95

1120 PAD AT MW-3 COMPLETE TOPPED OFF 3.5' OF GROUT W/ BENTONITE CHIPS. HYDRATED. MW-3 CUT OFF 0.8' RISER

1136 PULL PUMP FROM MW-4, DRILLERS BEGIN POURING PAD

1210 FINISH PAD AT MW-4.

1221 BAILC AND DECON PUMP/NEW HOSE DRILLERS TAKE GROUTALK SA.

1251 FINISH DECON, PLACE IDW WATER IN POND ENCLOSURE.

1300 DRILLERS OFFSITE TO LOAD PACKER AND BORING EQUIPMENT FOR NEXT WEEK, I WILL USE PUMP TO CONTINUE DEVELOPMENT

1310 GO TO MW-8 TO BEGIN DEVELOPMENT.

MW-8 WL = 6.53 TD = 27.88 TOC

ACTUAL TD = 27.92 1 WV = 9.1 GALLONS

Casing vol = 3.5 GAL Filterpack vol = 5.6 VOL

1317 BEGIN SURGING SCREEN.

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1327 FINISH SURGING SCREEN

1328 BEGIN PUMPING AT BOTTOM.

1339 PURGED DRY AT 9 GALLONS ALLOW 90% RECHARGE.

90% = 8.67' TOC WL = 26.01

1347 DECON PUMP/NEW HOSE

1357 GO TO MW-3 TO DEVELOPE.

MW-3 WL = 15.87 TD = 49.54

ACTUAL TD = 49.58' 1 Volume = 11.1 GALLONS

Casing Volume = 5.5 gal Filterpack vol = 5.6 GAL.

1410 BEGIN SURGING SCREEN

1420 FINISH SURGING.

1421 BEGIN PUMPING AT BOTTOM.

1432 PURGED DRY AT 15 GALLONS ALLOW 90% RECHARGE

90% = 19.24' TOC WL = 47.81

1441 GO TO DECON.

1450 DECON PUMP.

1505 DECON COMPLETE.

1520 OFFSITE 1730 AT OFFICE

5/26/17

TUESDAY, MAY 30, 2017 93647 L. TURNER

WEATHER: MOSTLY CLEAR 75°F - 85°F CALM

TASK: WELL PADS AND DEVELOPMENT.

PERSONNEL: LEWIS TURNER

0736 DEPART KC OFFICE.

0949 AT SITE, GEOTECHNOLOGY ONSITE.

0951 HOLD SAFETY MEETING.

1005 DRILLERS BEGIN DIGGING PAD AT MW-7

1025 PAD COMPLETED AT MW-7 2'x2'x2'. (4.01)

1034 BEGIN DIGGING PAD AT MW-5 CUT RISER = 1.45' (MW-5)

1040 CALIBRATE LAMOTTE 2020 WE TURBIDIMETER 9.94/10 0.66/0

COND: 1.410/1.409 pH 7.0/7 4.0/4 10.1/10

1107 PAD AT MW-5 COMPLETE, DRILLERS GO TO BUY MORE CONCRETE.

1130 DRILLERS BACK.

1133 BEGIN DIGGING PAD AT MW-6 CUT RISER = 3.57' (MW-6)

1219 FINISH PAD AT MW-6, GO TO LOAD EQUIPMENT FOR WELL DEVELOPMENT.

1232 AT MW-4 TO DEVELOP.

MW-4 WL: 22.32' TD: 57.06' TOC

* WILL SURGE AND PURGE WATER W/ BAILER TO REMOVE MORE FINES THAN THE PUMP WOULD BEFORE GOING DRY. LOWER TO BOTTOM OF WELL EACH TIME.

1248 BEGIN BAILING MW-4 TAKE READINGS.

1323 PURGED DRY SECOND TIME ~ 12 GALLONS WL: 55.80 TD: 57.06

1330 AT MW-3 TO DEVELOP.

5/30/17 93647 L. TURNER

MW-3 WL: 16.09 TD: 49.54' TOC

1335 PLACE PUMP AND SURGE SCREEN

1345 FINISH SURGING, BEGIN PUMPING AT BOTTOM.

1352 PURGED DRY AT 16 GALLONS.

1357 PULL AND DECON PUMP WL: 47.20' TOC.

1410 DECON COMPLETE

1417 AT MW-7 TO DEVELOP.

MW-7 WL: 28.24 TD: 33.40' TOC.

* WILL SURGE AND BAIL AT SAME TIME W/ BAILER TO REMOVE MORE FINES BEFORE GOING DRY.

1425 START BAILING.

1440 PURGED DRY 1.5 GALLONS WL: 32.95

1449 CITY CREW COMING OUT TO SCRAPE LOCATION.

1459 CCR MATERIAL IS DEEPER, TO FAST, DIG 3'

1520 FINISHED EXCAVATING AREA (CITY CREW). SET AUGER IN BENTONITE CHIPS.

1522 GO TO MW-2 TO DEVELOP

MW-2 WL: 17.04 TD: 52.92' BGS.

Actual TD: 52.92 1 volume = 11.40

Casing Vol: 5.9 gal Filterpack vol: 5.6 gal

1530 BEGIN SURGING SCREEN.

1540 FINISH SURGING SCREEN.

1541 BEGIN PUMPING

1640 FINISH PUMPING TURBIDITY DID NOT REACH 5 NTU.

WL: 37.18 TD: 52.92' TOC

5/30/17 93647 L. TURNER

MW-2 DEVELOPMENT FINISHED, PER THE WORK PLAN TURBIDITY REMAINED ± 10% OVER 3 READINGS AT LEAST ONE BORING VOLUME APART. ALL OTHER PARAMETERS WERE STABLE.

1710 DECON, DROP EQUIPMENT OFF. WATER IDW TO POND.

1720 OFFSITE

5/30/17

WEDNESDAY, MAY 31, 2017 93647 L. TURNER

TASK: SB-2 Drilling.

WEATHER: MOSTLY CLEAR 60-80° WIND 5-20 SW.

PERSONNEL: LEWIS TURNER

0655 AT SITE, SAFETY MEETING, CALIBRATE METER

0710 CITY CREW WILL BACKFILL AROUND AUGER SET IN CLEAN FILL SOIL TO BEGIN DRILLING AT SB-2

0718 BEGIN BACKFILLING W/ CLEAN 1/8-1" GRAVEL.

0807 CITY CREW FINISHED BACKFILLING PIT, CLEAN GRAVEL IN MOST OF HOLE, MATERIAL FROM PIT USED TO MAKE TOP FLAT. THIS WILL PREVENT DRILLING THROUGH CCR.

0805 SET UP RIG. WILL ADVANCE HSA TO 15-20' BGS TO SET A/A CASING, ALSO SEALING ANY CHANCE OF CCR GETTING IN THE BORING. (TEMPORARY CASING). WILL ADVANCE 4" TRICONE MUD ROTARY BIT THROUGH AUGER CASING.

0806 CONTINUOUS SAMPLING WILL START AT 41' BGS FROM WHERE MW-5 SAMPLING STOPPED. WILL COLLECT ONE SHELBY TUBE 30-35' INTERVAL (ELEVATION ADJUSTED) FOR THE MW-3 LOCATION ONE THAT LACKED PROPER VOLUME IN DAG TEST FOR A REFORMED FORM TEST.

0815 BEGIN ADVANCING HSA TO 18.0' BGS W/ CENTER BIT. NO CCR MATERIAL NOTED IN CUTTINGS.

0830 AT 18.0' W/ AUGERS. (TEMPORARY CASING). SET UP RIG FOR MUD ROTARY DRILLING, CHANGE TOOLING.

0852 FILL TUB W/ CLEAN WATER DRILLING MUD WILL USE BAROID QUIK-GEL BENTONITE POWDER.

5/31/17 93647 L. TURNER

0857 BEGIN MIXING DRILLING MUD. WATER/BENTONITE.
MW-5 WL= 11.87' WILL MONITOR WHILE MUD
ROTARY DRILLING.

0905 BEGIN ROTARY DRILLING AT 18' BGS W/ 4" BIT

0913 LEAKING WATER AT CONNECTION TO DRILL HEAD, STOP FOR
REPAIR (GASKETS.)

0935 RESUME DRILLING

0938 COLLECT SHELBY TUBE 30-31' BGS 0.6' COLLECTED
BEFORE TUBE BENT. COLLECT 3" SPLIT SPOON BELOW AS
A BACKUP SAMPLE FOR REFORMED PERMEABILITY.

COLLECTED SHELBY TUBE SB-2/ST01 FROM 30-31' BGS

COLLECTED BAG SAMPLE SB-2/SB01 FROM 31-33' BGS FOR
PERMEABILITY, PARTICLE SIZE, ATTERBERG, AND MOISTURE.
BAG SAMPLE WOULD BE RUN FOR REFORMED PERMEABILITY
IF NOT ENOUGH VOLUME IN SHELBY TUBE.

0955 RESUME DRILLING AT 33' BGS.

1005 AT 41' RESUME SPLIT SPOON SAMPLING.
MW-5 WL= 11.86' BGS.

1045 HIGHLY WEATHERED SHALE AT 48' BGS. DAMP TO DRY, BECOMES
PLASTIC WHEN WET. BLOCKY/FRIABLE.

1238 SPLIT SPOON REFUSALS, SWITCH TO ROCK CORING.

1300 SET OUTER STEEL CASING TO BOTTOM OF BORING/BENTONITE SEAL

1415 CASING IN DRILLERS CANT LOCATE WIRELINE CATCH RETRIEVER
FOR THE CORE BARREL, ALSO SWAPPING AT LEAD BARREL AS THE
TOLERANCE IS TOO MUCH AND WATER WOULD GO AROUND.

5/31/17 93647 L. TURNER

1428 DRILLERS GO TO MEET SOMEONE HALFWAY TO THEIR OFFICE.

1440 SITE EQUIPMENT SECURED.

1517 WORK ON PAPERWORK TO SCAN, WELL COMPLETION LOGS ETC.

1600 OFFSITE

5/31/17

THURSDAY, JUNE 1, 2017 93647 L. TURNER

WEATHER: OVERCAST 65-85°F WIND 5-15 SW.

TASK: SB-2 BORING/PACKER TEST.

PERSONNEL: LEWIS TURNER

0650 ONSITE, SAFETY MEETING

0659 CALIBRATE 4 GAS METER: PID 100.1/100 LEL 50/50% OXY 20.8/20.9
CO 50/50 ppm H_2S 20/20 ppm.

0700 DRILLERS SETTING UP FOR ROCK CORING.

0719 BEGIN ROCK CORING AT SB-2 (56') WEAK HIGHLY WEATHERED SHALE.

0745 GEOLOGICAL SURVEY ONSITE. JOEY BAUGHMAN

0751 56-60' CORED

0802 BEGIN 60-65' RUN.

0826 60-65 RUN STOP.

0830 65-70' RUN START.

0900 65-70 RUN COMPLETE. Limestone at 66.3'

0906 70-75' RUN START. 3 ON then 2' RUN CHERT/LS CHANGE BIT

0933 70-73 RUN COMPLETE.

1020 73-75 RUN COMPLETE.

1024 75-80 RUN START.

1038 75-80 RUN COMPLETE.

1040 80-85 RUN START.

1101 80-85 RUN COMPLETE.

1120 COMPLETE BORING SB-2 FLUSH BORING

1135 PACKER WILL SEAL 2.5' OUT OF END OF CORE RODS SET CORE ROD AT 77.5' BGS. TEST INTERVAL WILL BE 80-85'

6/1/17 93647 L. TURNER

WITH A SINGLE PACKER (INFLATING) AT TOP.

Diameter of Boring = 0.24' radius = 0.12'

Depth to top of test interval = 80'

Depth to bottom of test interval = 85'

WL = 4.66' TARGET psi = 42.5 (0.5 X DEPTH)

TEST METERS TOTALIZER/FLOW METER ACCURATE 1 CAL USED.

STARTING TOTALIZER = 391.01 ZERO OUT.

HEIGHT OF PRESSURE GAUGE = 3.10' Above ground surface.

1149 PACKER IS IN, INFLATED. MONITOR 2 MIN.

1150 NO PRESSURE LOSS, NO LEAKS. IN BLADDER

1151 TEST W/WATER. WATER COMING OUT OF TOP OF CASING, DRILLERS WORK ON RESEATING PACKER. DETERMINE ONE OF TWO PACKERS LEAKING AIR PUSHING WATER UP.

1215 STILL LEAKING. FIRST PACKER BLADDER LEAKED SECOND PACKER PUSHING WATER OUT OF CASING/LEAK.

1230 PULL WIRE RODS AND PLACE TEFLON TAPE ON THREADS TO TRY AND SEAL. TO SEE IF THIS IS THE ISSUE.

1240 CORE RODS SEALED AND BACK DOWN TO DEPTH. SET PACKER TO SEAL AT 80' (80-85' INTERVAL TO TEST). TEST - OK NO LEAKS.

1300 BEGIN PACKER TEST AT 42.5 psi (1 min readings for 10 min).

1700 PACKER TEST COMPLETE. 0.96 GALLONS TOTAL 4 HOURS (240 min).
JOEY OFFSITE, STOP TEST.

1707 PULL PACKER OUT. UNABLE TO TAKE WL WHILE DEPLOYED. WL: 4.71

1711 PULL CORE RODS OUT OF BORING

1720 OFFSITE

6/1/17

FRIDAY, JUNE 2, 2017 93647 L.TURNER

WEATHER: PARTLY CLOUDY - SUNNY 70-85°F WIND 5-20 SW.

TASK: BEGIN SB-3

PERSONNEL: LEWIS TURNER

0655 ONSITE, SAFETY MEETING.

0706 CALIBRATE PID 100.0/100 ppm LEL 50/50% OXY 20.8/20.9%
CO 50/50 ppm H_2S 20/20 ppm.

0710 DRILLERS BEGIN TRIPPING OUT CASING AND AUGERS FROM SB-2.

0719 ALL CASING OUT BEGIN MIXING BENTONITE GROUT. TWO BAGS OF BARRID QUIK-GROUT POWDER BENTONITE TO WATER.

0758 FINISHED ABANDONMENT OF SB-2 USING BATCHES (6 BAGS OF GROUT).

0805 BEGIN DECON, RIG, HSA, CASING, AND CORE BOX.

0902 FINISHED DECON. GO TO SETUP AT MW-7/SB-3 LOCATION.

0914 SET UP AT SB-3 LOCATION, HSA DRILL TO 15' TO GET SURFACE SEAL FOR MUD ROTARY.

0940 AUGERS IN TO 15' SET UP FOR MUD ROTARY DRILLING 4" BIT. MIX BARRID QUIK-GEL BENTONITE POWDER AND CLEAN WATER, FOR DRILL MUD.

0950 BEGIN DRILLING SB-3 MUD ROTARY 15-30'.

1032 PUSH SHELBY TUBE 30-32' GOOD RECOVERY SB-3/ST01 FOR Permeability, Atterberg, particle size, and moisture. TUBE IS A REPLACEMENT FOR MW-7/ST02 THAT HAD VERY LOW VOLUME.

1037 CONTINUE DRILLING TO 34', BASE OF MW-7 BORING LOG TO BEGIN CONTINUOUS SAMPLING.

1051 BEGIN SAMPLING 34' BGS.

6/2/17 93647 L.TURNER

1128 AT 40' SPLIT SPOON REFUSAL ON LAST TWO, WILL BEGIN ROCK CORING, WEATHERED SHALE. BEGIN SETTING RIG UP FOR CORING

1200 SETTING OUTER 0.29' DIA CASING DOWN TO 38' BGS

1241 OUTER CASING SET, DRILLERS GO TO GET A LOAD OF WATER.

1300 DRILLERS BACK W/WATER.

1314 BEGIN ROCK CORING W/0.24' DIA BIT.

1330 WATER LEAKING AROUND SECOND CASING TO AUGER/TO SURFACE. ATTEMPT TO FIX AFTER 5' RUN.

1331 NO RECOVERY OF 40-45 CORE. ROCK LODGED IN BARREL.

1340 RESUME CORING AFTER CASING RESEATED. IS NOW SEALED. 40-44

1406 ~~40-44~~ CORE RUN COMPLETE.

1426 START 44' RUN STOP FOR DAY

1430 COLLECT SHALE WEATHERED IN BAG 42-44' SB-3/SB01

1435 DRILLERS OFFSITE SECURED EQUIPMENT, DOT REGULATIONS THEY HAVE TO LEAVE TO DRIVE BACK TODAY. HOURS.

1440 DEPART SITE. LOOK AT PUMPS SECURED ON WAY OUT.

1730 AT KC OFFICE.

6/2/17

TUESDAY, JUNE 6, 2017 93647 L. TURNER

WEATHER: CLEAR 70-85°F WIND 5-15 E

TASK: SB-3 DRILLING

PERSONNEL: LEWIS TURNER

0730 DEPART ICC OFFICE

0940 AT SITE. GEOTECHNOLOGY ONSITE, SAFETY MEETING.

0950 CALIBRATE PID 100.0/100.0 LEL 50/50% O_2: 20.9/20.9%
CO 50/50 ppm H_2S 20/20 ppm

0951 RESUME CORING 44-45' TO COMPLETE RUN.

0957 44-45 RUN COMPLETE

0958 BEGIN 45-50 RUN.

1028 FINISH 45-48 AND 48-50' RUNS.

1026 BEGIN 50-55' RUN.

1055 FINISH 50-55' RUN 4 +1' RUN.

1110 FINISH 55-60 RUN

1117 BEGIN 60-65' RUN.

1127 FINISH 60-65' RUN.

1130 BEGIN TRIPPING OUT CORE RODS AND OUTER STEEL CASING TO ABANDON SB-3 COMPLETE.

1158 CASING PULLED UP SOME, PLACE TREMIE PIPE TO BOTTOM OF BORING. BEGIN MIXING BENTONITE GROUT 2 BAGS OF BAROID QUICK GROUT BENTONITE POWDER TO WATER TO MAKE SLURRY BATCH.

1205 GROUTED TO TOP OF CASING. PULL REST OF CASING OUT TO LET IT DROP OUT.

1215 CASING OUT PLACE TREMIE IN TO GROUT LAYER MIX AND PUMP MORE GROUT. BRIAN WEIS ONSITE.

6/6/17 93647 L. TURNER

1225 PULL AUGERS AND GROUT TOP UP AS REMOVED.

1237 LOAD EQUIPMENT TO GO DECON.

1244 BRIAN W. LEAVES DRILL SITE. ABANDONMENT OF SB-3 COMPLETE (6 BAGS OF BENTONITE USED.

1254 BEGIN DECON, RIG, AUGERS, CASING, CORE RODS, TREMIE.

1321 DECON COMPLETE, LOAD EQUIPMENT.

1350 GO TO SB-1 (MW-1) LOCATION.

1356 DRILLERS SET UP WORKING ROAD SIGNS. SET UP RIG AT SB-1.

1410 BEGIN DRILLING W 6¼" HSA TO 15' TO CREATE A SEAL FOR MUD ROTARY DRILLING. (SB-1 WEST OF MW-1)

1423 HSA AT 15' SEAL W/ BAROID 3/8" BENTONITE CHIPS.
CHANGE DRILL HEAD TO MUD ROTARY SET UP.

1430 BEGIN MIXING DRILL MUD. BAROID QUIK-GEL BENTONITE POWDER W/ WATER (POTABLE).

1441 BEGIN MUD ROTARY DRILLING FROM 15' BGS TO TARGET DEPTH OF 43' BGS (MW-1 BORING DEPTH) TO CONTINUE SAMPLING. WILL ATTEMPT A SHELBY TUBE AT 30' TO REPLACE BAG SAMPLE FROM MW-1 FAILED SHELBY TUBE DUE TO HARD SOIL.

1510 AT 30' PUSH SHELBY TUBE (2')

1514 SHELBY TUBE SB-1/ST01 ONLY PUSHED 4" NOT ENOUGH VOLUME BUT WILL SEND TO LAB TO HOLD FOR BACKUP VOLUME FOR MW-1/S802.

1516 RESUME MUD ROTARY 4" BIT DRILLING TO 43'.

1540 AT 43' BEGIN CONTINUOUSLY SAMPLING.

1600 BRIAN W. OFFSITE.

6/6/17 93647 L. TURNER

1617 SWITCH RIG OVER TO BEGIN ROCK CORING. SPLIT SPOON REFUSAL. PUSH STEEL CASING TO 50'.

1640 CASING IN, DRILL HEAD CHANGED

1655 SECURE SITE, GET WATER

1700 OFFSITE.

6/6/17

WEDNESDAY, JUNE 7, 2017 93647 L. TURNER

WEATHER: MOSTLY CLEAR 60-85°F WIND 5-15 SW

TASK: SB-1 DRILLING / WELL DEVELOPMENT.

PERSONNEL: LEWIS TURNER.

0700 AT SITE, SAFETY MEETING.

CALIBRATE PID 100.0/100.1 LEL 50/50 OXY 20.5/20.9%

CO 50/50 ppm. H_2S 20/20 ppm.

0709 DRILLERS COMPLETE CORE RODS TO BEGIN DRILLING AT 50'

0716 BEGIN ROCK CORING AT SB-1 AT 50'.

0748 FIRST RUN SAMPLE FELL OUT OF CORE BARREL. PULL ROD TO ATTEMPT TO RETRIEVE. LITTLE CLAY/SHALE RECOVERY. 50-55'

0755 START 55-60' RUN

0840 55-60' RUN COMPLETE

0840 COLLECT 55-56' SHALE INTO JAR SB-1/SB01 FOR ATTERBERG, PARTICLE SIZE, AND MOISTURE. WON'T RUN PERM DUE TO SHALE, CAN'T PUSH SHELBY TUBE. PER CHRIS HOLLAND. 50-55 NOT ENOUGH RECOVERY SO CORRECTED 55-56'

0845 START 60-65' RUN

0858 COMPLETE 60-65' RUN

0905 START 65-70' RUN.

0935 COMPLETE 65-70' RUN.

0936 START 70-75' RUN

0951 FINISH 70-75' RUN

1005 START 75-80' RUN

1036 FINISH 75-80' RUN COMPLETED SB-1 BORING.

6/7/17 93647 L.TURNER

1043 TRIP OUT CORE RODS. MIX BENTONITE SLURRY GROUT BAROID QUIK-GROUT AND CLEAN WATER. PUMP IN TO OUTER CASING.

1050 PLACE TREMIE PIPE TO BOTTOM OF BORING.

1058 GROUT UP INSIDE OF CASING THEN START PULLING IT TO ALLOW GROUT TO DROP OUT INTO BORING.

1115 CASING OUT, TOP OFF GROUT. GROUTED INSIDE OF HSA AT 15' BGS THROUGH TREMIE.

1120 PULL AUGERS.

1131 TOP OFF GROUT, ALL AUGERS OUT. SB-1 ABANDONED w/ BATCHES (~6 BAGS OF BENTONITE).

1137 LOAD EQUIPMENT, TOWER DOWN RIG.

1202 GO TO DECON AREA.

1214 BEGIN DECON, RIG, AUGERS, CASING, CORE RODS.

1220 CALIBRATE pH 7.0/7 4.0/4 10.0/10 COND 1.410/1.409
TURBIDITY 10.14/10 0.87/0 BUMP TEST.

1250 FINISH DECON

1300 AT MW-4 TO DEVELOP WL=22.25

1303 BEGIN SURGING MW-4

1313 FINISH SURGING MW-4

1313 BEGIN PURGING MW-4 PUMP NEAR BOTTOM.

1328 PURGED DRY AT 12.0 GALLONS TURBIDITY OVERRANGE.
* IS CONSIDERED DEVELOPED PER WP (PURGED DRY THREE TIMES).
FINAL WL= 55.08 TD= 57.05 'TOC

1330 DECON PUMP AND TUBING.

6/7/17 93647 L.TURNER

1340 AT MW-3 TO DEVELOP - WL= 16.28

1343 BEGIN SURGING MW-3

1353 FINISH SURGING MW-3

1354 BEGIN PURGING MW-3

1405 PURGED DRY AT 14 GALLONS TURBIDITY OVERRANGE.
* IS CONSIDERED DEVELOPED PER WP (PURGED DRY THREE TIMES)
FINAL WL= 47.01 TD= 49.58 'TOC

1410 DECON PUMP AND TUBING.

1420 GO TO MW-8 CALL BAN TO OPEN GATE.

1425 AT MW-8 TO DEVELOP WL= 7.54

1430 BEGIN SURGING MW-8

1440 FINISH SURGING MW-8

1440 BEGIN PUMPING MW-8

1446 PURGED DRY AT GALLONS SECOND TIME

1455 DECON PUMP AND TUBING. WL= 25.14

1508 AT MW-1 TO DEVELOP
MW-1 WL= 28.10 TD= 42.74 'TOC
Actual TD= 42.87' 1 VOL= 8.0 gal.
Casing VOL= 2.4 GAL Filterpack VOL= 5.6 gal.

1515 BEGIN SURGING SCREEN MW-1.

1525 FINISH SURGING SCREEN MW-1.

1525 BEGIN PUMPING MW-1.

1535 PURGED DRY AT 12 GALLONS ALLOW 90% RECHARGE TO PUMP AGAIN 90% = 29.56' WL= 40.17

1548 WL= 28.59' WELL RECHARGED, SURGE/PUMP TO CONTINUE

6/7/17 93647 L.TURNER

1550 SURGE SCREEN

1555 FINISH SURGING, START PUMPING

1602 PURGED DRY AT 10.0 GALLONS SECOND TIME. ALLOW 90% RECHARGE.

1620 WL=28.75

1620 BEGIN SURGING

1670 FINISH SURGING.

1630 BEGIN PUMPING

1638 PURGED DRY AT 10 GALLONS THIRD TIME. TURBIDITY OVERRANGE. * IS CONSIDERED DEVELOPED PER WP (PURGED DRY THREE TIMES).

FINAL WL= 40.01 TD= 42.74 'TOC.

1645 DECON PUMP.

1655 GO TO OFFLOAD IDW.

1700 PLACE IDW WATER INTO POND, STAGE EQUIPMENT

1710 OFFSITE.

6/7/17

THURSDAY, JUNE 8, 2017 93647 L.TURNER

WEATHER: WEST WIND 5-15 58-80°F SUNNY

TASK: WELL DEVELOPMENT

PERSONNEL: LEWIS TURNER

0700 AT SITE, SAFETY MEETING.

0709 LOAD TANK IN TRUCK.

0711 CALIBRATE pH 7.0/7 4.0/4 10.0/10 COND 1.410/1.409

TURBIDITY BLANK TEST 9.96/10 0.19/0

0720 GO TO MW-7 TO DEVELOP.

MW-7 WL= 28.41 TD= 33.40

WELL VOLUME TOO LOW TO PUMP. WILL USE BAILER.

0725 BEGIN SURGING/PURGING

0733 FINISH PURGED DRY AT 1.5 GALLONS (GRAY) TURBIDITY OVERRANGE. * IS CONSIDERED DEVELOPED PER WP (PURGED DRY THREE TIMES).

FINAL WL= 32.90 TD= 33.43' TOC.

0740 DECON BAILER.

0748 GO TO MW-6.

0750 MW-6 WL= 14.42 TD= 41.76' TOC

ACTUAL TD= 41.83' 1 VOL= 10. GALLONS

CASING VOL= 4.5 gal FILTER VOL= 5.6 gal

0757 BEGIN SURGING MW-6

0807 FINISH SURGING MW-6

0807 BEGIN PUMPING MW-6

0817 FINISH PURGED DRY AT 13 GALLONS, WILL ALLOW 90% RECHARGE. 90% = 17.16' WL= 39.04

6/8/17 93647 L.TURNER

0840 WL= 33.41 WILL COME BACK LATER.

0845 PULL AND DECON PUMP.

0852 GO TO MW-5 TO DEVELOP.

MW-5 WL= 11.89 TD= 41.08

ACTUAL TD= 41.18' 1 VOL= 10.4 gallons

CASING VOL= 4.8 gallons FILTER VOL= 5.6 gallons

0857 BEGIN SURGING MW-5.

0907 FINISH SURGING MW-5.

0907 BEGIN PUMPING MW-5

0917 PUMPED DRY WILL ALLOW 90% RECHARGE (12 GAL)

90% = 14.82' WL= 38.75'

0936 WL= 33.50

0945 PULL AND DECON PUMP

0950 GO TO MW-8

0956 MW-8 WL= 7.68'

1000 BEGIN SURGING SCREEN MW-8

1005 FINISH SURGING SCREEN MW-8

1005 BEGIN PUMPING.

1010 PURGED DRY AT 7.0 GALLONS TURBIDITY OVER RANGE.

* IS CONSIDERED DEVELOPED PER WP (PURGED DRY THREE TIMES).

FINAL WL= 26.81 TD= 27.85' TOC

1021 DECON PUMP AND TUBING.

1046 AT PZ-6 WL= 6.17 TD= 20.17

ACTUAL TD = 20.17 1 VOL= 8.3 GALLONS

CASING VOL= 2.3 GAL FILTER VOL= 6.0 GAL

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1050 BEGIN SURGING PZ-6

1100 FINISH SURGING PZ-6

1100 BEGIN PUMPING PZ-6

1106 PURGED DRY AT 10 GALLONS ALLOW 90% RECHARGE.

90% = 7.57' WL= 18.41' TOC

1117 WL= 15.11

1118 PULL PUMP AND DECON.

1125 AT PZ-4 TO DEVELOP.

PZ-4 WL= 6.40 TD= 19.80 (soft)

Actual TD= 1 VOL= 7.9 GALLONS

CASING VOL= 2.2 GAL. FILTER VOL= 5.8 GAL.

1127 BEGIN SURGING.

1137 FINISH SURGING.

1137 PUMP, LOTS OF SEDIMENT.

1144 PURGED DRY AT 9 GALLONS ALLOW 90% RECHARGE.

90% = 7.74' WL= 18.55'

1200 PULL AND DECON PUMP. WL = 13.15 DECON EXTRA RINSE.

1211 GO TO PZ-2, CHECK IN AT OFFICE, HAVE TRUCK ON WELL MOVED.

1232 TRUCK MOVED OFF OF WELL.

PZ-2 WL= 8.41 TD= 19.40 (soft)

Actual TD= 1 VOL= 6.5 GALLONS

CASING VOL= 1.8 gal. FILTER VOL= 4.7 gal

1235 SURGE PZ-2

1245 FINISH SURGING PZ-2

6/8/17 93647 L.TURNER

1245 START PUMPING PZ-2

1250 PURGED DRY AT 6 GALLONS. ALLOW 90% RECHARGE.

90% = 9.51' WL= 18.12

1300 DECON PUMP

1312 GO TO MW-6 TO CHECK WATER LEVEL.

1325 MW-6 WL= 21.82. MAKE CALLS WHILE WAITING

1326 MW-5 WL= 27.40. FOR WELL RECHARGE.

1448 MW-6 WL= 20.65' NECK OFFSITE. JEFF ONSITE. (SAFETY.)

1520 PZ-6 WL= 7.58'

1531 PZ-4 WL= 6.45'

1535 PZ-6 WL= 7.56'

1536 SET UP TO DEVELOP PZ-6 WL= 7.56'

1536 BEGIN SURGING PZ-6

1541 FINISH SURGING PZ-6

1541 BEGIN PUMPING.

1549 PURGED DRY 8.0 GALLONS ALLOW 90% RECHARGE.

1550 DECON PUMP AND TUBING. WL= 18.56'

1600 SET UP AT PZ-4 WL= 6.44'

1603 BEGIN SURGING

1608 FINISH SURGING.

1608 PUMPING

1615 PURGED DRY GALLONS ALLOW 90% RECHARGE WL= 18.39'

1617 PULL AND DECON PUMP. EXTRA RINSE.

1625 PZ-2 WL= 9.45'

1626 BEGIN SURGING PZ-2

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1632 FINISH SURGING. PZ-2

1632 BEGIN PUMPING PZ-2

1637 PURGED DRY AT GALLONS ALLOW 90% RECHARGE

WL= 18.37'

1640 PULL AND DECON PUMP.

1655 PLACE IDW INTO POND

1710 OFFSITE

6/8/17

FRIDAY, JUNE 9, 2017 93647 L. TURNER

WEATHER: CLEAR 65-80 WIND 5-15 S

TASK: MW/PZ DEVELOPMENT.

PERSONNEL: LEWIS TURNER

0700 ONSITE, SAFETY MEETING

0710 CALIBRATE pH 7.0/7 4.0/4 10.1/10 COND 1.410/1.409

TURBIDITY 9.87/10 0.19/0

0721 GO TO BEGIN DEVELOPMENT.

0723 MW-6 WL: 16.08 WELL RECHARGED 90%.

0725 SURGE MW-6.

0735 FINISH SURGING MW-6.

0735 BEGIN PUMPING MW-6

0745 PURGED DRY AT 12 GALLONS WILL ALLOW 90% RECHARGE.

WL: 39.65'

0746 PULL PUMP AND DECON.

0753 MW-5 WL: 20.75 NOT AT 90% BUT NOT RISING

POSSIBLY STATIC. WILL SURGE/PURGE DRY SECOND TIME.

0755 SURGE MW-5

0805 FINISH SURGING MW-5

0805 BEGIN PUMPING.

0812 PURGED DRY SECOND TIME AT 9.0 GALLONS ALLOW 90%

RECHARGE.

0820 AT PZ-6 WL: 6.34'

0822 START SURGING PZ-6.

0832 FINISH SURGING PZ-6.

0832 BEGIN PUMPING PZ-6.

6/9/17 93647 L. TURNER

0840 PURGED PZ-6 DRY THIRD TIME AT 9 GALLONS. TURBIDITY OVERRANGE.

* IS CONSIDERED DEVELOPED PER WP (PURGED DRY THREE TIMES).

FINAL WL: 19.20 TD: 20.16' TOC.

0842 PULL AND DECON PUMP.

0845 AT PZ-4 WL: 6.53'

0848 START SURGING PZ-4

0858 FINISH SURGING PZ-4

0858 BEGIN PUMPING PZ-4

0906 PURGED PZ-4 DRY AT 11 GALLONS, TURBIDITY OVERRANGE/HIGH

* IS CONSIDERED DEVELOPED PER WP (PURGED DRY THREE

TIMES) FINAL WL: 18.19 TD: 20.13

0908 PULL AND DECON PUMP.

0918 GO TO PZ-2 TO DEVELOP.

0921 AT PZ-2 WL: 8.52

0924 START SURGING PZ-2

0934 FINISH SURGING PZ-2

0934 BEGIN PUMPING PZ-2

0940 PURGED PZ-2 DRY AT 6 GALLONS, TURBITY OVER RANGE.

* IS CONSIDERED DEVELOPED PER WP (PURGED DRY THREE TIMES).

FINAL WL: 18.78 TD: 19.80

0942 PULL AND DECON PUMP.

0951 BACK AT SITE, UNLOAD IDW WATER TO POND.

DRILLERS LOAD EQUIPMENT, CALLED CHRISTIAN ABOUT 5

SOIL PILES, MAY NOT GET TO UNTIL MONDAY.

1005 SIGN COC FOR TWO GEOTECH SAMPLES.

6/9/17 93647 L. TURNER

1010 GEOTECHNOLOGY CREW OFFSITE.

1017 GATHER INFO ON ORDERING EQUIPMENT FOR SLUG AND WELL YIELD TESTS NEXT WEEK.

1048 RETURN KEYS TO CHRISTIAN.

1130 OPEN AND MAKE SURE ALL DEDICATED PUMP MATERIALS ARRIVED.

1215 ORDER TRANSDUCERS, PUMP, TUBING TO BEGIN SLUG TESTS NEXT WEEK.

1240 LOAD EQUIPMENT.

1300 OFFSITE TO ICC OFFICE.

1512 AT ICC OFFICE, PUT PID AT MAIL ROOM FOR FED COURIER

1530 SCAN PAPERWORK, ENTER DATA ON ELECTRONIC DEVELOPMENT FORMS.

1630 OFF WORK

6/9/17

MONDAY JUNE 12, 2017 93647 L. TURNER

WEATHER: PARTLY CLOUDY, 85-92°F WIND 5-15 SW. 102° HEAT INDEX

TASK: WELL DEVELOPMENT, HYDRAULIC TESTS.

PERSONNEL: LEWIS TURNER

0800 DEPART ICC OFFICE, SAFETY MOMENT.

1011 ARRIVE AT SITE, PICK UP KEYS. NOTIFY CHRISTIAN OF EQUIPMENT ARRIVING.

1036 CALIBRATE pH 4.0/4 7.0/7.0 10.1/10 COND 1.410/1.409
TURBIDITY 9.94/10 0.21/0

1050 SET UP AT MW-6 WL = 15.36'

1105 BEGIN SURGING SCREEN AT MW-6

1115 FINISH SURGING SCREEN AT MW-6

1115 BEGIN PUMPING MW-6

1128 FINISH PUMPING PURGED DRY AT 12 GALLONS TURBID.
* IS CONSIDERED DEVELOPED PER WP (PURGED DRY 3 TIMES)
FINAL WL = 40.55 TD = 41.75 'TOC

1135 PULL AND DECON PUMP.

1147 DECON COMPLETE.

1201 SET UP AT MW-5 WL = 18.41'

1211 BEGIN SURGING SCREEN AT MW-5.

1222 FINISH SURGING SCREEN AT MW-5.

1222 BEGIN PUMPING MW-5

1233 PURGED DRY AT 11 GALLONS, TURBID.
* IS CONSIDERED DEVELOPED PER WP (PURGED DRY 3 TIMES).
FINAL WL = 39.07 TD = 41.09 'TOC

1241 PULL AND DECON PUMP.

6/12/17 93647 L. TURNER

1301 BEGIN WATER LEVEL ROUND OF REMAINING WELLS AND PZ.

TIME	ID	WL 'TOC	TD 'TOC
1050	MW-6	15.36	41.75
1301	MW-5	18.41	41.09
1311	MW-4	22.33	57.05
1317	MW-3	16.28	49.50
1324	MW-7	29.12	33.43
1337	PZ-2	8.45	19.80
1349	PZ-6	6.36	20.16
1356	MW-8	7.89'	27.85
1409	PZ-4	6.70	20.13
1416	MW-1	28.12	42.74
1424	MW-2	20.60	52.92
1447	PZ-1	16.36	16.42 WATER IN END CAP
1500	PZ-3	12.72	19.85
1517	PZ-5	15.85	16.09

1525 COMPLETE WATER LEVEL ROUND.

1537 AT TRUCK, GO TO PICK UP DIVERS AND PUMP.

1600 NO TUBING ARRIVED, ALSO NO OPTICAL READER FOR TRANSDUCERS.

1610 CALL FEI, THEY ARE OVERNIGHTING TUBING AND READER TO PICKUP AT FEDEX IN COLUMBIA AT 0900 TOMORROW.

1635 EQUIPMENT ORDERED.

1650 OFFSITE, BUY SUPPLIES/BULLETS.

LT 6/12/17

TUESDAY JUNE 13 2017 93647 L. TURNER

WEATHER: CLEAR 75-92°F WIND 5-15 SW. 105° HEAT INDEX

TASK: SLUG / WELL YIELD TESTING.

PERSONNEL: LEWIS TURNER

0730 AT HOME DEPOT TO BUY ADDITIONAL SUPPLIES.

0840 GO TO FEDEX TO PICKUP OPTICAL READER AND TUBING FEI SHIPPED.

0900 PICKED UP READER / TUBING, GO TO SITE.

0905 AT SITE. PREPARE TO DO SLUG TESTS / YIELD TESTS. SAFETY MEET. SETUP PUMP W/ NEW TUBING. SETUP DATA LOGGERS.

1000 PUMP SET UP.

1005 TRYING TO GET DATA LOGGER SOFTWARE / DRIVERS TO UPDATE.

1017 SETUP DATA LOGGER - DIVER 20m SN# H2413 10 SEC INTERVALS.
MW-3 WL = 16.29 TD = 49.50 90% = 19.61'

1054 START DIVER 5 SEC INTERVAL 1054:38

1100 DEPLOY PUMP / TRANSDUCER APPROX 2' FROM BOTTOM OF WELL.

1121 START PUMP.

1129 11.5 GALLONS PUMPED TO BOTTOM OF PUMP, TURN OFF AND PULL OUT PUMP. CLOSED GATE VALVE.

1140 DECON PUMP / TUBING, GET WATER AT HYDRANT.

1210 TO LUNCH.

1305 BACK FROM LUNCH. AT MW-4

1315 MW-4 WL = 22.30 TD = 57.05 90% = 25.78'

1320 PROGRAM DATA LOGGER DIVER 20m SN# 35667 5 sec intervals START AT 1320:07

1323 DEPLOY TRANSDUCER THEN PUMP. 2' FROM BOTTOM.

6/13/17 93647 L. TURNER

1346 START PUMP

1354 STOP PUMP BEGIN TEST 11.2 GALLONS PULLED PUMP OUT

1410 DECON PUMP AND TUBING. WATER FROM HYDRANT. GO TO MW-6

1447 MW-6 WL= 16.53 TD= 41.75' NOT AT FULL

STATIC RECHARGE YET FROM DEVELOPMENT YESTERDAY.

1455 MW-7 WL= 28.98 TD= 33.43. 90%= 29.43

1510 PROGRAM DIVER 20m SN# U0001 5 sec Intervals.

1524 DEPLOY TRANSDUCER THEN PUMP 1' FROM BOTTOM DUE TO

SHORT WATER COLUMN. START AT 1523:21 DEPLOY PUMP.

1532 START PUMP.

1540 NOT ENOUGH TO PUMP PULL PUMP AND BAIL.

1545 START TEST 1.0 GALLONS REMOVED

1612 DECON PUMP GO GET WATER FROM HYDRANT.

1635 MW-4 WL= 27.53

1642 MW-3 WL= 16.89

1650 STORE EQUIPMENT, TOW TO POND (WATER).

1705 OFFSITE

LT 6/13/17

WEDNESDAY, JUNE 14 2017 93647 L. TURNER

99' INDEX.

WEATHER: PARTLY CLOUDY TO OVERCAST 80-90°F WIND 5-25 W

TASK: SLUG TESTS AND WELL YIELD TESTS.

PERSONNEL: LEWIS TURNER

0700 AT SITE, LOAD EQUIPMENT GET WATER AT HYDRANT.

0719 GO TO CHECK WATER LEVELS.

0730 MW-3 WL= 16.49

0740 MW-4 WL= 22.83

0751 AT MW-2 WL= 20.10 TD= 52.92

0801 SET UP DATA LOGGER DIVER 20m SN# R2285 2Sec Interval

0802 START LOGGER AT 08 02:04 AND DEPLOY. THEN DEPLOY PUMP.

APPROX 2' FROM BOTTOM DIVER 2' FROM BOTTOM.

0816 START PUMPING MW-2 90%= 23.38'

0825 20 gal removed WL= 29.65

0835 40 gal removed 1 gal = 20sec. WL= 33.71

0846 60 gal removed WL= 36.80

0856 80 gal removed WL= 39.45

0907 100 gal removed WL= 41.45

0918 120 gal WL= 43.80 TURBIDITY OVER RANGE

0930 134 gallons removed STOP PUMP AND BEGIN TEST REMOVE PUMP

WL= BTP.

0948 DECON PUMP AND TUBING.

0959 GO TO CHECK WL AND PULL TRANSDUCERS AT MW3 AND 4.

1006 MW-3 WL= 16.44 PULL DIVER TRANSDUCER

1016 SPOKE TO CHRIS H. ABOUT PULLING TRANSDUCERS AT 90%

RECHARGE DETERMINE DATA IS FINE AT THAT POINT.

6/14/17 93647 L. TURNER

1020 DOWNLOAD LOGGER FROM MW-3 TEST 1 DATA.

1026 DATA LOOKS GOOD, CURVED, SAVE TO FOLDER.

1036 MW-4 WL: 22.77 PULL DIVER TRANSDUCER.

1050 DOWNLOAD LOGGER DATA FROM MW-4 TEST 1.

1059 DATA LOOKS GOOD, CURVE OK, SAVE TO FOLDER

1102 DECON BOTH TRANSDUCERS.

1107 AT MW-1 WL= 28.14 TD= 42.74 90%: 29.60

1113 PROGRAM DATALOGGER DIVER 20m SN# 35667 2 sec intervals

1113 START LOGGER AT 1113:10 DEPLOY APPROX 2' FROM BOTTOM AND THEN DEPLOY PUMP 0.5' ABOVE TRANSDUCER.

1125 START PUMPING MW-1

1131 STOP PUMP 6.79 GALLONS REMOVED, REMOVE PUMP. TEST START

1140 DECON PUMP.

1156 AT MW-8 WL= 7.96 TD= 27.85 90% = 9.95'

1200 PROGRAM DATA LOGGER DIVER 20m SN# 42413 3 sec intervals

1201 START LOGGER AT 1201:25 DEPLOY APPROX 2' FROM BOTTOM AND THEN PUMP 0.5' UP ABOVE TRANSDUCER. START PUMP 1212

1216 6.40 GALLONS PUMPED OUT STOP AND REMOVE PUMP. TEST START.

1225 TO LUNCH

1323 BACK FROM LUNCH, DECON PUMP. GET WATER AT HYDRANT.

1339 FINISH DECON.

1344 MW-7 WL= 29.70 NOT FULLY RECHARGED OR AT 90%. (29.43')

1346 CITY PERSONNEL HAVE GOTTEN ALL SOIL PILES AT WELLS MW-4, 3, 2, 1 AND 7. ALL SOIL PICKED UP.

6/14/17 93647 L. TURNER.

1350 CALLED BRIAN WEISS ABOUT THE POSSIBILITY OF NOT RUNNING ALL THREE YIELD TESTS ON SLOW RECOVERY WELLS. HE WILL CHECK AND GET BACK TO ME.

1412 MW-2 WL= 35.33'

1420 MW-1 WL= 28.14'

1428 PULLED LOGGER AT MW-1, DECON.

1440 THUNDER STORM IN AREA STOP WORK UNTIL IT PASSES.

1448 DOWNLOAD LOGGER DATA FROM MW-1 TEST 1

1455 DATA LOOKS GOOD, CURVE - SAVE TO FOLDER.

1515 30 MIN SINCE LIGHTNING STORM CELL PASSED.

1520 P2-6 WL= 6.44 TD= 20.16 90%= 7.81

1525 PROGRAM DATA LOGGER DIVER 20m SN# 35667 3 sec intervals.

1526 START LOGGER AT 0526:12 DEPLOY APPROX 2' FROM BOTTOM, THEN PLACE PUMP 0.5' ABOVE TRANSDUCER.

1535 START PUMPING P2-6.

1539 PUMPED 6.4 GALLONS OUT STOP AND REMOVE PUMP TO START TEST.

1547 DECON PUMP W/ WATER FROM HYDRANT.

1600 MW-8 WL= 9.05 WILL LET RUN OVERNIGHT.

1615 MW-2 WL= 35.01

1624 MW-7 WL= 29.70

1629 MW-6 WL= 15.67

1641 STORE EQUIPMENT.

1655 OFFSITE

LT 6/14/17

THURSDAY JUNE 15, 2017 93647 L. TURNER

WEATHER: OVERCLOUD TO PARTLY CLOUDY RAIN OVERNIGHT.

TASK: SLUG AND YIELD TESTING

PERSONNEL: LEWIS TURNER

0700 AT SITE, SAFETY MOMENT.

0709 PZ-6 WL= 6.60 REMOVE DIVER TRANSDUCER.

0721 DOWNLOAD LOGGER DATA FROM PZ-6 TEST 1.

0726 DATA LOOKS GOOD.

0735 MW-8 WL= 8.05 REMOVE DIVER TRANSDUCER. DECON.

0742 DOWNLOAD LOGGER DATA FROM MW-8 TEST 1.

0745 DATA LOOKS GOOD.

0749 MW-2 WL= 33.64' NOT AT 90% YET LOGGER WILL BE FULL OF READINGS AT 1020 AM, WILL RETURN.

0757 CHRIS SNIDER CALLED. WILL DO ONE TEST IF LOGGER DATA IS GOOD. ALSO NEED TO SURVEY AND COLLECT POND LEVELS PERIODICALLY.

0844 WL = 29.92 MW-7 LOWER THAN YESTERDAY PULL LOGGER DOWNLOAD DATA, DECON.

0855 FRED ESS SURVEY ON-SITE SHOW WELL LOCATIONS

0935 FINISH SHOWING FRED ALL WELL LOCATIONS. FRED OFFSITE.

0940 DATA FROM MW-7 IS "NOISY" UP AND DOWN BUT THIS IS CONSISTENT W/ MANUAL WATER LEVEL MEASUREMENTS. (FLUCUATION)

0941 SAVE DATA TO FOLDER.

0950 AT PZ-2 WL= 8.47 TD= 19.80 90%= 9.60

0955 PROGRAM DATA LOGGER ZOM SN# 35667 5 SEC Intervals

0958 START LOGGER AT 0955:55 DEPLOY IN PZ. THEN SET PUMP.

1000 START PUMP

6/15/17 93647 L. TURNER

1009 STOP PUMP AND REMOVE TO START TEST 3.717 gallons REMOVED.

1017 DECON PUMP.

1029 AT PZ-4 WL= 6.81 TD= 20.13 90%=

1032 PROGRAM DATA LOGGER ZOM SN# H2413 4 sec Intervals.

1032 START LOGGER AT 1032:22 DEPLOY IN PZ 2' FROM BOTTOM SET PUMP

1045 START PUMP

1050 STOP PUMP AND REMOVE TO START TEST 7.125 GALLONS REMOVED.

1105 DECON PUMP

* DUE TO RAIN IN FORCAST FOR FRIDAY / SATURDAY WILL NOT START MW-5 OR MW-6 TESTS AS WELL WOULD HAVE TO REMAIN OPEN OVER WEEKEND (FLUSH MOUNT).

1125 MW-2 WL= 33.34' DATA LOGGER FULL.

1132 TO FEDEX.

1141 PACKAGE WAS DIVERTED TO KANSAS CITY DUE TO STORMS LAST NIGHT. WILL NOT ARRIVE UNTIL TOMORROW. CALL FRI TO NOTIFY NO CHARGE.

1155 TO LUNCH.

1251 BACK FROM LUNCH.

1254 MW-2 WL= 33.19 PULL DATA LOGGER. LOGGER STOPPED 1042:02

1300 DOWNLOAD DATA FROM MW-2 TEST 1. DATA FULL. CURVE OK, START OF TEST HAS A FEW BUMPS WHEN PUMP LOST VAC. DATA SHOULD BE USABLE. MIGHT RETEST NEXT WEEK.

6/15/17 93647 L. TURNER

1320 SAVE TO FOLDER.

1339 REPAIR HOSE ON 12V PUMP. CRIMPED AND HAS A HOLE. DAMAGED PULLING OUT OF LAST TEST PZ-4. CUT ALL ZIP TIES.

1439 CARMEN CALLED ABOUT NEXT WEEK.

1445 NEW TUBING PLACED ON PUMP PUT ZIP TIES ON POWER CHORD TO KEEP FROM TANGLING.

1530 FINISH W/PUMP, PACK FOR STORAGE OVER WEEKEND.

1613 PZ-4 WL = 6.80 PULL TRANSDUCER, DECON.

1622 DOWNLOAD LOGGER DATA FROM PZ-4 TEST 1

1625 DATA LOOKS GOOD - CURVE, SAVE TO FOLDER.

1633 PZ-2 WL = 8.94' ALMOST BACK TO STATIC WILL COLLECT TOMORROW. SEAL WELL.

1650 MW-2 WL = 32.85'

1657 GO TO STORE EQUIPMENT

1705 OFFSITE.

6/15/17

FRIDAY, JUNE 16, 2017 93647 L. TURNER

WEATHER: PARTLY CLOUDY / OVERCAST 73-90°F WIND 5-15 SW/E

TASK: SLUG/YIELD TESTS DEPLOY DEDICATED PUMPS.

PERSONNEL: LEWIS TURNER.

0700 AT SITE, SAFETY MOMENT / WEATHER.

0710 MW-2 WL: 31.84'

0738 PZ-2 WL: 8.49' PULL TRANSDUCER

0743 DOWNLOAD LOGGER DATA FROM PZ-2 TEST 1

0750 DATA LOOKS GOOD - CURVE SAVE TO FOLDER.

0806 GO THROUGH DRILLER INVOICE FOR 5/20 5/27 WEEKS FOR BRIAN WEIS.

0900 SENT EMAIL, GO TO TALK TO CHRISTIAN (POND LEVEL)

0922 CHECK QED PUMP MATERIALS THAT ARRIVED TODAY.

0937 HAVE 10 FULL DEDICATED PUMP SETS AND TUBING.

0940 CALCULATE WATER LEVEL MAP FROM ESTIMATED MSL ELV.

0952 TO FEDEX

0959 MW-2 WL = 31.66

1015 PICKED UP TWO LOGGERS, NOT NEEDED NOW NOT DOING ADDITIONAL TESTS, WILL RETURN TO F&E W/ TURBIDITER.

MONDAY JUNE 19, 2017 93647 L. TURNER

WEATHER: SUNNY 75-89°F

TASK: SLUG TESTING.

PERSONNEL: LEWIS TURNER

0700 LOAD TRUCK, DEPART

0918 AT SITE, PICKED UP KEYS, SAFETY MEETING

0935 LOAD TRUCK

0940 MW-7 WL=29.44

0943 PROGRAM LOGGER SN# P9761 10 SEC

0943 STARTED AT 0943:15 FULL 5.56 DAYS.

0957 DEPLOY, SET UP TO BAIL.

1002 BEGIN BAILING MW-7 TRANSDUCER STUCK ON BAILER-FIX.

1019 1.321 GALLONS REMOVED, START TEST WL=32.09

1022 DECON.

1029 MW-2 WL=27.88.

1035 DECON PUMP.

1101 MW-6 WL=15.15

1105 PROGRAM TRANSDUCER SN# R2285 10 SEC

1106 START 1106:09 10 SEC INTERVAL

1107 SET IN WELL.

1126 START PUMPING.

1133 STOP PUMP START TEST UT 29.321 GALLONS

1145 DECON PUMP.

1201 MW-5 WL=13.45.

1205 PROGRAM LOGGER START AT 1204:27 DEPLOY.

1215 PLACE PUMP.

6/19/17 93647 L. TURNER

1221 START PUMP.

1227 STOP PUMP 9.321 START TEST.

1229 DECON PUMP.

1300 TO LUNCH.

1342 BACK ONSITE.

1343 MW-2 WL=27.71

1351 PROGRAM LOGGER SN# 142413 15 SEC 8.33 DAYS.

1352 START 1352:02 DEPLOY/PUMP.

1403 START PUMP

1415 20 gal WL=33.50 water clear.

1425 40 gal WL=38.14

1437 60 gal WL=40.60

1448 80 gal WL=42.32

1501 100 gal WL=46.05 TURBID. 104 gal STOP of PUMP.

1506 STOP PUMPED 107.5 GALLONS REMOVED.

1512 WL=40.50 DECON PUMP. PLACE IN INTO POND.

1516 BEGIN WATER LEVEL ROUND. 1525 SEE SURVEY CREW DOING WELLS.

TIME	ID	WL	ID
0940	MW-7	29.44	-
1029	MW-2	27.88	-
1102	MW-6	15.15	-
1201	MW-5	13.45	-
1517	MW-1	28.28	-
1522	PZ-6	6.25	-

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TIME	ID	WL	
1527	PZ-4	6.65	
1534	MW-8	7.83	
1540	PZ-5	13.80	
1546	PZ-2	8.43	
1601	MW-3	16.53	
1605	MW-4	22.60	
0756	PZ-1	16.36	6/20/17
0805	PZ-5	11.31	6/20/17

1613 COMPLETE WL ROUND, NOTICED SURVEY CREW SEALED MW-5, 6, AND 7 WITH DATA LOGGERS IN THEM.

1615 OPEN AND VENT MW-5, 6, AND 7, WILL CHECK ON THURSDAY IF DATA WILL BE USABLE.

1620 OFFSITE TO KC OFFICE.

1625 CALLED CHRISTIAN ABOUT CLEAN FILL AROUND MW-5.

1815 AT BLUE SPRINGS.

LT 6/19/17

TUESDAY
JUNE 20, 2017 93647 L. TURNER

WEATHER: SUNNY 80-95°F WIND 5-15 SW PARTLY CLOUDY

TASK: SLUG TESTING.

PERSONNEL: LEWIS TURNER

0740 ARRIVE ON SITE. CARLYN W. ONSITE, SAFETY MEET.
COLLECT WATER LEVELS AT PZ-1 AND PZ-5.

0756 PZ-1 16.36

0805 PZ-5 11.31

0815 LOAD TRUCK TO DEPLOY PUMPS.

0826 AT MW-3 TO DEPLOY PUMP DUE TO LOW YIELD WILL SET PUMP 1.2' FROM BOTTOM.

0915 PUMP SET AT MW-3.

0919 AT MW-4 TO DEPLOY PUMP DUE TO YIELD WILL SET 1.0' FROM BOTTOM

0934 PUMP SET AT MW-4.

0943 AT MW-1 TO DEPLOY PUMP DUE TO LOW YIELD WILL SET PUMP AT 1.0' FROM BOTTOM.

1008 PUMP SET AT MW-1

1017 AT PZ-6 TO DEPLOY PUMP DUE TO LOW YIELD WILL SET PUMP 1.0' FROM BOTTOM.

1023 PUMP SET AT PZ-6.

1026 AT MW-8 TO DEPLOY PUMP, DUE TO LOW YIELD WILL SET PUMP AT 1.0' FROM BOTTOM.

1040 PUMP SET AT MW-8.

1047 AT PZ-2 TO DEPLOY PUMP, DUE TO LOW YIELD WILL SET PUMP AT 1.0' FROM BOTTOM.

6/20/17 93647 L.TURNER

1100 PUMP SET AT PZ-2.

1106 GO TO STORE EQUIPMENT.

1123 AT LUNCH.

1225 AT SITE, TAKE WATER LEVELS AT WELLS W/ TRANSDUCERS.

1242 MW-7 WL= 30.06

1246 MW-6 WL= 16.57

1250 MW-5 WL= 20.82

1259 MW-2 WL= 35.71

1315 TAKE ZIP TIES OFF AND TUBING FROM PUMP 12V. TO RETURN TO FIELD ENV.

1350 PUMP PACKED UP.

1437 DEPART SITE

1619 AT KC.

6/20/17

THURSDAY, JUNE 22, 2017 93647 L.TURNER

WEATHER: PARTLY CLOUDY 80-95°F WIND 5-15 SW.

TASK: SLUG/YIELD TESTING.

PERSONNEL: LEWIS TURNER.

0700 DEPART KC.

0854 AT SITE, PREPARE TO COLLECT DATA LOGGERS.

0900 MW-7 WL= 29.71

0903 MW-6 WL= 14.95 PULL DATA LOGGER

0918 DOWNLOAD DATA, SEE WHEN SURVEY CREW SEALED WELL FROM BEING VENTED. 1610:09 TO 1610:29 TEST STARTED AT APPROX 1132:59

0942 SPOKE W/ JEFF BINDER, SHOW DATA SHOULD BE GOOD WELL JUST EXPLAIN IN TEXT. DATA SHOULD NOT BE AFFECTED.

0945 SAVE DATA TO FOLDER

0950 MW-5 WL= 16.45'

0957 AT MW-6 TO DEPLOY PUMP DUE TO YIELD WILL SET 1.0' FROM BOTTOM OF WELL.

1019 PUMP SET AT MW-6.

1025 MW-2 WL= 32.57

1042 GO TO HOME DEPOT TO BUY SUPPLIES TO EXTEND WELL PIPE (FURNCO COUPLING AND RISER) AND BUCKETS TO PLACE OVER MW-5 AND MW-2 TO ALLOW THEM TO RUN TEST OVER WEEKEND WITHOUT RAIN GETTING IN WELL PIPE. BUY 3 SETS MAY NEED MW-7 ALSO.

1130 AT SITE, SET UP TO PLACE RISER EXTENSION ON MW-5

1206 STICK UP AT MW-5 INSTALLED VENTED W/ BUCKET ON TOP.

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1210 GO TO INSTALL TEMPORARY STICKUP AT MW-2.

1230 TEMPORARY STICKUP RISER INSTALLED / VENTED W/ BUCKET OVER TO PREVENT SURFACE WATER INFILTRATION.

1235 TO LUNCH.

1317 AT SITE

1320 MW-7. WL= 29.62

1350 MW-7 WL= 29.62 PULL DATA LOGGER

1355 DOWNLOAD DATA. DATA LOOKS OK. REVIEW W/ SURVEY CREW

1359 SEALING WELL BRIEFLY. SAVE TO FOLDER.

1405 MW-7 DEPLOY PUMP DUE TO YIELD WILL SET 1.0 FOOT FROM BOTTOM

1424 PUMP SET AT MW-7.

1427 GO UNLOAD EQUIPMENT, RETURN KEYS.

1435 DEPART SITE.

1649 AT KC OFFICE, UNLOAD TRUCK PUT LOGGERS IN MAIL ROOM FOR FEE PICKUP.

1731 RETURN TRUCK

1746 OFFSITE

6/28/17

MONDAY JUNE 26, 2017 93647 L.TURNER

WEATHER: CLEAR 74-80°F WIND 5-15 SE

TASK: DATA LOGGER PICKUP.

PERSONNEL: LEWIS TURNER (SITE)

0740 DEPART KC OFFICE.

0950 AT SITE PREPARE TO COLLECT DATA LOGGERS (MW-5/MW-2)

1010 MW-5 WL= 14.11 PULL DATA LOGGER.

1019 DOWNLOAD DATA. STOPPED AT 6/25/17 1:28:18AM FULL. SAVE TO FOLDER.

1030 DEPLOY PUMP, DUE TO YIELD WILL SET 1.0' FROM BOTTOM.

1040 PUMP AT MW-5 SET, PLACED RUBBER FURNCO CAP ON TO PREVENT WATER RUNOFF ENTERING WELL.

1050 MW-2 WL= 28.87 PULL DATA LOGGER.

1100 DOWNLOAD DATA, SAVE TO FOLDER.

1104 DEPLOY PUMP, DUE TO YIELD WILL SET 1.0' FROM BOTTOM.

1115 PUMP AT MW-2 SET, PLACED RUBBER FURNCO CAP.

1130 GO TO TAKE WATER LEVEL MEASUREMENTS.

TIME	ID	WL	
1010	MW-5	14.11	
1050	MW-2	28.87	
1130	MW-1	28.36	
1140	PZ-2	8.49	
1147	POND	3.30'	TOP OF GAUGE 8.0'
1150	MW-7	29.30	
1157	MW-6	15.28	
1202	MW-4	22.84	

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TIME	ID	WL=
1216	MW-3	16.83
1222	MW-8	8.78
1228	PZ-6	6.65
1230	PZ-4	6.97
1232	PZ-5	DRY
1240	PZ-3	12.56
1250	PZ-1	DRY

1259 COMPLETE WL ROUND. STORE EQUIPMENT STARTING TO RAIN.

1309 CALL CHRIS SNIDER ABOUT COLLECTING WATERLEVEL WEEKLY.

1320 TO LUNCH.

WEDNESDAY, AUGUST 23, 2017 93647 L. TURNER

WEATHER: CLEAR 80°F WIND 5-10 SW

TASK: LOW-FLOW WELL TESTING. (PILOT).

PERSONNEL: LEWIS TURNER

0700 LOAD TRUCK.

0728 DEPART KC OFFICE.

0929 AT SITE, PICKUP KEYS.

0940 BEGIN WL ROUND. DECON BEFORE EACH LOCATION.

TIME	ID	WL	
0942	POND	4.50	FROM GAUGE TOP IS 8.00'
0950	MW-3	17.66	
1000	MW-4	23.49	
1006	MW-5	12.63	
1010	MW-6	15.70	
1016	MW-7	22.27	FERNCO NOT FULLY SEATED (SEAL)
1024	MW-2	19.13	
1030	MW-1	28.58	
1036	MW-8	8.55	
1040	PZ-6	7.26	
1045	PZ-4	8.02	

1058 PZ-2 IS UNDER A TRAILER, GO TO LOCATE SOME ONE TO MOVE.

1103 WAIT FOR SOMEONE AT WELL TO MOVE EQUIPMENT.

1112	PZ-2	8.40
1125	PZ-1	DRY
1135	PZ-3	14.34
1149	PZ-5	~~DRY~~ WT 14.65

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1150 COMPLETED WL ROUND

1154 TO LUNCH.

1233 BACK AT SITE. BEGIN CALIBRATING METERS.

LAMOTTE 2020WE TURBIDIMETER 10.19/10 0.37/0

YSI 556 MPS: pH 7.00/7.00 4.00/4.00 10.01/10.00, COND 1.409/1.409

ORP 237.5/237.5, DO: 100.6/100% @ 764.29 mmHg.

1310 SETUP AT MW-7 WL = 22.19 TOP OF PUMP = 30.38 (TOP)

1330 BEGIN PURGING AT 100 mL/min VERY TURBID.

MAX DRAW DOWN IS 6.5' (2' SAFETY MARGIN)

1430 TURBIDITY RISING. STOP PURGING. TURBIDITY AND ORP NOT STABLE, WATER LEVEL NOT STABLE.

1443 LOAD EQUIPMENT.

1446 SET UP AT MW-6 WL = 15.72 TOP OF PUMP = 38.86

1455 BEGIN PURGING AT 100 mL/min ~ CLEAR.

MAX ALLOWED DRAW-DOWN 6.5'

1545 STOP PURGING WL 21.03 TURBIDITY <5 FOR 3 READINGS.

1551 LOAD EQUIPMENT. WL NOT STABLE

1554 SET UP AT MW-5 WL = 12.69 TOP = 38.32

1605 BEGIN PURGING MW-5 AT 100 mL/min. ~ CLEAR.

1700 STOP PURGING WL: 17.45 TURBIDITY <5 FOR 2 READINGS.

1705 LOAD EQUIPMENT. WL NOT STABLE

1712 SET UP AT MW-4 WL = 23.74 TOP = 54.23

1718 BEGIN PURGING AT 100 mL/min ~ CLEAR

1818 STOP PURGING WL = 27.62 TURBIDITY <5 FOR TWO READINGS.

WL NOT STABLE.

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1820 LOAD EQUIPMENT.

1825 SET UP AT MW-3 WL = 17.70 TOP = 46.42

1835 BEGIN PURGING AT 100 mL/min. ~ CLEAR

1915 STOP PURGING WL: 19.13, TURBIDITY <5 FOR 3 READINGS.

WL NOT STABLE.

1920 LOAD EQUIPMENT.

1930 PLACE IDW WATER IN POND.

1933 OFFSITE TO HOTEL.

9/23/17

THURSDAY, AUGUST 24, 2017 93647 L.TURNER

WEATHER: CLEAR 80°F WIND CALM - 5 MPH S

TASK: LOW-FLOW WELL TESTING (PILOT).

PERSONNEL: LEWIS TURNER.

0650 DEPART HOTEL.

0700 ARRIVE AT SITE.

0705 CALIBRATE METERS

LAMOTTE 2020WE TURBIDIMETER 9.57/10 0.38/0

YSI 556 MPS: pH 7.00/7.00 4.00/4.00 10.01/10.00 COND 1.409/1.409

ORP 237.5/237.5, DO 100.4/100% AT 764.03 mmHg.

0735 SETUP AT MW-2 WL= 19.02 TOP= 49.98

0745 BEGIN PURGING AT 100 mL/min SLIGHTLY TURBID.

0920 STOP PURGING WL= 19.67 <5 TURBIDITY IN SAMPLE LINE BEFORE CELL. IN CELL 5-6 NTU. ALL OTHER PARAMETERS STABLE. WL NOT STABLE.

0923. LOAD TRUCK.

0930 SETUP AT MW-1 WL= 28.54 TOP: 39.75

0939 BEGIN PURGING AT 100 mL/min CLEAR. WL STABLE AT 100 mL/min NOT AT 150-200 mL/min.

1019 STOP PURGING WL= 28.87 ALL PARAMETERS STABLE, TURB <5 NTU AND IN LINE BEFORE CELL = 4.25 NTU. WL STABLE.

1025 LOAD TRUCK

1031 SETUP AT MW-8 WL= 8.68 TOP= 25.05

1042 BEGIN PURGING AT 100 mL/min. CLEAR

1137 STOP PURGING WL= 11.94', TURBIDITY <5 NTU, ALL PARAMETERS STABLE. WL NOT STABLE. SAMPLE TUBE 2.47 NTU.

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1140 LOAD TRUCK.

1145 SETUP AT P2-6 WL= 7.19 TOP= 17.32

1147 BEGIN PURGING AT 100 mL/min. CLEAR.

1222 STOP PURGING WL= 8.35 TURBIDITY <5 ALL PARAMETERS STABLE. WL NOT STABLE. SAMPLE TUBE 3.70 NTU

1228 LOAD TRUCK. LOCK GATE.

1234 SETUP AT P2-2 WL= 8.50 TOP= 16.92

1238 BEGIN PURGING AT 100 mL/min - CLEAR

1323 STOP PURGING WL= 10.10 TURBIDITY <5, TURBIDITY IN SAMPLE LINE 3.67 NTU. ALL PARAMETERS STABLE. WL NOT STABLE.

1330 LOAD TRUCK.

1337 AT MW-7 TO CHECK TURBIDITY <24 HOURS AFTER PURGING. DIRECT FROM SAMPLE LINE.

MW-7 WL= 24.57

TIME	Flow/min	AMT (mL)	TURBIDITY (NTU)	WL TOC
1345 (I)	100 mL	I	42.6	24.57
1346	100	100	56.5	24.66
1347	100	200	38.7	24.73
1348	100	300	31.5	24.80
1349	100	400	31.9	24.86
1350	100	500	29.3	24.93
1355	100	1000	26.0	25.10
1400	100	1500	21.5	25.24

1407 LOAD AND PACK EQUIPMENT.

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1419 PLACE IDW WATER IN POND.

1427 RETURN SITE KEYS. CALL CHRIS H.

1430 DEPART SITE, LUNCH.

1630 AT BLUE SPRINGS.

* UNLOAD TRUCK 9/25/17 FEI EQUIPMENT PLACED AT LOADING DOCK.

9/24/17

11/8/17

Wednesday November 8, 2017

Weather:

Personell: Chris Haslund

Task: WLs & MW-2 & MW-7 Turbidity

1011 Depart Magellan Columbia, Mo terminal

1030 MW-2 WL: 18.94' Top Pump: 49.88'

1050 PZ-2 WL: 9.05' Top Pump: 16.62'

1055 Arrive @ Plant, Check in at office

1108 MW-3 WL: 18.~~33~~51 (CH) Top Pump: 46.38'

1120 MW-4 WL: 24.12' Top Pump: 54.25'

1129 MW-5 WL: 13.36' Top Pump: 38.00'

1139 MW-6 WL: 16.60' Top Pump: 38.83'

1150 PZ-6 WL: 7.95' Top Pump: 17.33'

1157 MW-8 WL: 10.48' Top Pump: 24.74'

1210 PZ-4 WL: 8.52' ~~Top Pump~~ (CH) TD: 20.15

↳ no Pump

1230 MW-7 WL: 20.02 ToP Pump: 30.38'

Calibrate Turbidity Meter (Hach 2020WP)

10.84/10.00 NTU, 0.86/0 NTU

1235 Start low-flow pursing MW-7, 100mL/min

measure turbidity only, see purge log.

13.45 STOP Purging @ MW-7 NTU=53.6

1359 Pond = 4.7

1401 Check out @ office

1405 Arrive @ MW-2

11/8/17 C. Hoglund

CH

1419 Backpack centrifuge not discharging air, call FEI trouble shoot

1430 Begin Pursing MW-2

1520 Stop Pursing MW-2, NTU = 3.94

1535 MW-1 WL: 28.64 Top Pump = 39.77'

1540 off-site

1550 Drop off (1) 20# + (1) 5# CO_2 canister from separate project

~~1809 Get ice in Lenexa, KS, ice & pack sample cooler. CH~~ CH

Different Project

~~1830 Ship sample cooler @ Fed Ex Lenexa, KS~~ CH

~~# 671101331326 - overnight~~ CH

Thursday, November 16, 2017
Weather: Clear 40s ESE 5-10 mph
Task: Water levels & MW-7 redevelopment
Personnel: Joshua Bragg

0920 Arrive onsite
0930 Check in with power plant
0939 Meeting staff down at fire hydrant
0953 Begin round of WLs

Time	ID	WL (ftBTOC)	Notes
1002	MW-3	18.83'	
1014	MW-4	24.42'	
1030	MW-5	13.80'	
1042	PZ-6	8.11'	
1050	MW-8	10.23'	Free standing water
1058	PZ-4	8.68'	
~~101~~ 1119	MW-7	20.57'	
1135	MW-6	16.60'	
1246	MW-1	28.65'	
1240	MW-2	18.80'	
1254	PZ-2	9.16'	

1148 Offsite for lunch
1230 Back onsite
1232 Continue WLs
1312 Calibrate pH meter stick
4.1/4.0 10.1/10.0 7.0/7.0
1318 Calibrate Conductivity stick 1970/2000

J. Bragg

11-16-17 ~~96347~~ 93647

1334 Check turbidimeter 10.56/1000 0.78/0 NTU

1346 Begin development. Initially not adding water as ~~WL is i~~ water column is above filter pack

Collect initial GW quality parameters of water to be introduced

Turbidity	Temp	Conductivity	pH
5.61 NTU	15.6	0.390	8.8

1553 Pump not working. Proceed with bailing

1620 Bail MW-7

Late Entry ~~B~~ 1346 Begin development of MW-7

1623 Head to get more water from plant for well introduction

1643 Begin redeveloping again

1718 Finished Bailing. Start housekeeping

1738 Off site. Back to Kansas City Headquarters

Joshua Bragg 11-16-17

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