Technical Memorandum

To: J. Hamrick, J. Cain, Cotter Corporation
From: E. Lawrence, HydroSolutions
Date: August 23, 2011
Subject: Lincoln Park Monitor Well Installation Plan

INTRODUCTION

Uranium (U) and molybdenum (Mo) are present at levels that exceed Colorado Groundwater Quality Standards (CGWQS) in groundwater beneath Lincoln Park, located north of the Cotter Corporation Canon City Milling Facility. The elevated U and Mo in groundwater beneath Lincoln Park are believed to have originated from a combination of infiltration of overland flow along Sand Creek and groundwater migration from the Milling Facility prior to construction of the SCS Dam. Groundwater monitoring locations are proposed for Lincoln Park to further characterize and delineate the extent of groundwater impacts.

Although there are numerous wells throughout Lincoln Park that are included in the current Cotter Groundwater Monitoring Program (GMP), several of those wells are privately owned and are not suitable for monitoring purposes. Access to the many of wells may be limited due to seasonal factors (winterizing) and existing plumbing and pump assemblies. The private wells are not under the control of Cotter Corporation and some of the wells are used for irrigation purposes. Many of the wells are of unknown depth and/or screened intervals. It is unclear if those wells are completed within the alluvial or bedrock aquifer. Based on these factors, Cotter proposes to replace most of the private wells currently included in the Cotter GMP with wells installed specifically as monitor wells. This document provides the plan for installation of the Lincoln Park Monitor Wells.

OBJECTIVES

The objectives of the proposed monitor well locations are to

- provide clear delineation of the extent of U and Mo in groundwater that exceeds the CGWQS of 0.03 mg/L and 0.035 mg/L, respectively,
- provide data to determine if natural attenuation is adequate to reduce levels that will meet the CGWQS, or
- if necessary, provide data to evaluate the effectiveness of any implemented remedial measures.

SITE CONDITIONS

Geologic, hydrologic and geochemical site conditions within the Lincoln Park Area were described in detail in the December 2009 *Site Conceptual Model and Proposed Corrective Measures* (HydroSolutions). A summary of key environmental conditions is provided below.

Geology

Lincoln Park is separated from the Milling Facility by a bedrock ridge that is an outcrop of the Raton Formation. A surface drainage (Sand Creek) cuts through the bedrock ridge and extends into Lincoln Park. The SCS constructed a dam for flood control in 1971 across the drainage incised into the bedrock ridge. The land north of the ridge (Lincoln Park) is characterized by surficial alluvial deposits underlain by bedrock. The alluvial deposits generally thicken to the north toward the Arkansas River.

Most of Lincoln Park rests on top of the north limb of a syncline, with geologic dip to the south-southeast. Because of this orientation, progressively older bedrock units are present directly beneath and in contact with the alluvium to the north toward the Arkansas River. The sequence of Upper Cretaceous bedrock units that directly underlie the alluvium from the SCS Dam to the Arkansas River includes the Raton Formation, Vermejo Formation, Trinidad Sandstone and the Pierre Shale. Data regarding the depth to bedrock within the Lincoln Park Area are limited, particularly further north of the SCS Dam. Most wells completed within Lincoln Park are private wells for which detailed lithologic information is not available. Near the SCS dam, however there are numerous monitoring wells and the depth to bedrock is known to range from a few feet to over 50 feet. Bedrock immediately north of the SCS dam is predominately the Vermejo Formation. Further north and northeast, the depth to bedrock can be at greater than 80 feet but then becomes very shallow again close the Arkansas River. In fact, the Pierre Shale is present as outcrop along the banks of portions of the Arkansas River.

Hydrogeology

The shallowest occurrence of groundwater beneath most of Lincoln Park is within the Arkansas River alluvium. The depth to water across the area of interest is variable, generally ranging between 20 and 40 feet below ground surface. The saturated thickness of the alluvium is also highly variable, typically between 5 to 30 feet. At Well 020, which is near the Deweese Dye Ditch, the depth to water varies from 10 to 30 feet and the saturated thickness of the alluvium is from 5 to 25 feet. The large variability of depth to water is attributed to seasonal recharge from the DeWeese Dye Ditch and associated irrigation storage ponds.

The potentiometric surface of the alluvial aquifer in Lincoln Park is not well defined because of the limited number of water level measurements from wells with known screen intervals. Based on the limited water level data and the distribution of U and Mo in groundwater, the direction of groundwater flow across the Lincoln Park generally follows the orientation of Sand Creek, being north to northeast near the SCS Dam and turning more easterly closer to the Arkansas River.

The transmissivity of the alluvium determined from an aquifer test conducted in 1993 (Galloway 1994) ranges from 400 to 1400 ft^2/d. Hydraulic conductivity averaged approximately 75 ft/d. Hydraulic conductivity values determined from aquifer tests in the bedrock are orders of magnitude lower. Stephens & Associates (1993) reported that the arithmetic mean value of hydraulic conductivity in 78 tests conducted near the SCS Dam was 0.11 ft/d.

Extent of Groundwater Impacts

Uranium and Mo are present within Lincoln Park at levels that exceed the respective CGWQS for those constituents. Figure 1 shows the distribution of U in groundwater for Lincoln Park. The distribution of U where it exceeds the CGWQS has separated into two lobes. The cause of the separation appears to be leakage of irrigation supply water from the Deweese Dye Ditch and associated holding ponds. Within Lincoln Park, U levels are only marginally above the CGWQS.

The distribution of Mo in groundwater (Figure 1) shows a similar pattern to uranium although the molybdenum concentrations are generally higher. The impact of leakage from the Deweese Dye Ditch and associated irrigation ponds on the distribution of Mo does not appear as pronounced as for U, probably because of the overall lower initial concentration of U.

In general, the areal extent of U and Mo that exceed the CGWQS in Lincoln Park have decreased over time. Similarly, most wells within Lincoln Park show evidence that groundwater concentrations of uranium and molybdenum are decreasing. However, concentrations of U and Mo appear to have stabilized at levels that still exceed CGWQS at a few wells, most notably wells 006 and 129. Based on available water quality data it appears that groundwater contamination may extend through the entire saturated thickness of the alluvial aquifer to depths of 50 to 80 ft bgs. Groundwater contamination in the bedrock aquifer has not been measured within Lincoln Park. If groundwater contamination exists within the bedrock beneath Lincoln Park, it would most likely be restricted to the upper weathered portions of the bedrock.

Potential Sources of Groundwater Impacts

The elevated U and Mo in groundwater beneath Lincoln Park are believed to have originated from a combination of infiltration of overland flow along Sand Creek and groundwater migration from the Milling Facility prior to construction of the SCS Dam. Currently, surface flow from the Milling Facility is prevented from moving into Lincoln Park by several factors, including: construction of the SCS Dam in 1971, pump back of ponded water to the lined impoundment starting in 1978, and placement of a clay hydraulic barrier on the upgradient side of the Dam in 1988. Therefore surface flow is no longer a source of U and Mo in groundwater in Lincoln Park. Groundwater flow passing beneath the SCS Dam may still be contributing unknown amounts of U and Mo to the offsite area although the rate is estimated to be minimal (USGS 1987). No sources are known to exist within Lincoln Park. However, historic overland flow may have resulted in infiltration and sorption of U and Mo onto subsurface materials. Slow release (desorption) of U and Mo may be an ongoing secondary source of groundwater contamination in the Lincoln Park. Pumping of impacted water and then utilizing that water for surface irrigation may result in infiltration and sorption of U and Mo onto subsurface materials that are later desorbed and transported to the water table aquifer.

RATIONALE FOR PROPOSED LOCATIONS

As previously discussed, U and Mo are present beneath Lincoln Park in the shallow alluvial aquifer system at levels that exceed the respective CGWQS for those constituents. The location of the current

groundwater monitoring network is provided on Figure 1. The extent of U and Mo that exceed the CGWQS are provided on the figure for reference. Because many of the wells are unsuitable for monitoring purposes, Cotter proposes to install replacement wells to further characterize and delineate the extent of U and Mo that exceeds CGWQS in Lincoln Park and to provide reliable, high quality, defensible data to support any corrective actions that may be implemented, including monitored natural attenuation.

Figure 2 shows the location of proposed monitor wells that will be installed for this purpose. The rationale for the proposed Lincoln Park Monitor Well locations is provided below.

LP01 – The location provides delineation of elevated Mo and U in groundwater along the west portion of the Lincoln Park plumes. It is located near well 231 that is currently part of the Cotter GMP. Mo levels at well 231 were slightly above the CGWQS until recently. U levels have always been below the U CGWQS but recently show a slight increasing trend. Neither the depth or screen interval of well 231 are known, therefore it is unclear if this well is completed in the alluvial or bedrock aquifer. Well LP01 is proposed to replace well 231 in the GMP.

LP02 – This location provides delineation of elevated Mo in groundwater along the eastern portion of the southern lobe of the Lincoln Park plume. It is located near well 169 that is currently part of the Cotter GMP. Mo levels at well 169 have been slightly above the CGWQS but have decreased below that level over the last few years. U levels have always been below the CGWQS but are showing a recent increasing trend. Neither the depth or screen interval of well 169 are known. Well LP02 is proposed to replace well 169 in the GMP.

LP03 – The location provides delineation of elevated Mo and U in groundwater along the northwest portion of the Lincoln Park plumes. Well LP03 is located north of any currently monitored wells. Well LP03 will provide confirmation that the U and Mo plumes turn eastward and follow the Sand Creek Drainage toward the Arkansas River.

LP04 – This location provides delineation of elevated Mo and U in groundwater along the northeast portion of the Lincoln Park plumes. The location is near well 274 that is currently included in the Cotter GMP. Although U and Mo levels have always been below the respective CGWQS at well 274, no information is available on either the depth or screen interval of this well. Well LP04 will be also used to assess hydraulic and chemical aquifer conditions in the critical area near well 129 where elevated levels of Mo and U persist. Well LP04 is proposed to replace well 274 in the GMP.

LP05 – The location provides delineation of elevated Mo and U in groundwater along the eastern edge of the Lincoln Park plumes. It is located near wells 266 and 267 that are currently included in the Cotter GMP. U levels at 266 and 267 have generally been below the CGWQS and Mo levels have shown decreasing trends to levels near the CGWQS. Neither the total depth or screen intervals are known for wells 266 or 267. Well LP05 is proposed to replace wells 266 and 267 in the GMP.

LP06 – The location provides delineation of elevated Mo and U in groundwater between the north and south lobes of the east trending Lincoln Park plumes. This well would be located in an area where the plumes appear to bifurcate. Well LP06 is located upgradient (west) of well 130 that is currently included in the Cotter GMP. Well 130 has always been below the CGWQS for U and has recently decreased below the CGWQS for Mo. Well 130 is screened from 50 to 60 feet below ground surface within the alluvial aquifer. Well LP06 will also be used to assess hydraulic and chemical aquifer conditions near the well 129 area. Well LP06 is proposed to replace well 130 in the GMP.

LP07 – This location provides additional hydraulic and chemical aquifer characterization in the area of well 129 where levels of Mo and U persist above the CGWQS. The proposed location will be east of the irrigation ditch that runs near well 129 but north of Sand Creek. There are also geologic considerations as the Pierre Shale may outcrop along the Sand Creek drainage which may truncate flow in the alluvial aquifer. Well LP07 may eventually be used to replace well 129 in the GMP.

LP08 – The location provides additional hydraulic and chemical aquifer characterization in the area between well 122 and well 129 where levels of Mo and U persist above the CGWQS. Based on current water quality data, well LP08 should be located in the area where the maximum Mo and U levels exist. This well will be useful for determining if natural attenuation is sufficient to reduce Mo and U levels below the CGWQS, or to monitor the effectiveness of any proposed remedial measures.

LP09 – The location provides delineation of elevated Mo in groundwater along the southern portion of the southern lobe of the Lincoln Park plume. The location is south of well 144 which is currently included in the Cotter GMP and has been below the U CGWQS for many years. The Mo levels at well 144 have shown a decreasing trend but remain above the CGWQS. Well LP09 may eventually be used to replace well 144 in the GMP.

LP10 – This location provides additional hydraulic and chemical aquifer characterization in the area of well 129 where levels of Mo and U persist above the CGWQS. The proposed location will be south and of the irrigation ditch that runs near well 129 and south of Sand Creek. As with proposed location LP07, there are geologic considerations as the Pierre Shale may outcrop along the Sand Creek drainage which may truncate flow in the alluvial aquifer. Well LP10 may eventually be used to replace well 129 in the GMP.

It is also proposed that once these new wells have been installed and sampled for four quarters, that all of the wells with unknown depths and/or screen intervals be removed from the routine groundwater monitoring program and only be sampled as part of the 5-Year Lincoln Park Water Use Survey sampling. Some of the other wells with known completion intervals, such as wells 122 and 129, will continue to be sampled until the investigation into the cause of persistent elevated U and Mo is completed.

DRILLING SPECIFICATIONS

Cotter Corporation will seek the services of a qualified drilling company that has capabilities in monitor well installation, completion and development and soil boring and coring. The specifications for the proposed drilling are as follows.

Drilling will be conducted under the direction and supervision of a designated Cotter site geologist. Cotter Corporation will perform site utility clearance for all potential drilling locations prior to beginning drilling activities.

Boreholes will be drilled at each of the proposed locations (Figure 2) with the intent of installing a monitor well completed within the alluvial aquifer. Each boring will be drilling at least 15 feet deeper than the first occurrence of water or until reaching bedrock. Each of the borings will be cored from surface to total depth using continuous coring methods, to the extent possible. Contact with bedrock will be determined by the site geologist. All drilling personnel will have appropriate training for drilling environmental drilling and sampling.

Drilling/Coring

The project will involve drilling ten (10) borings to depths estimated between 30 and 100 feet. The borings will be drilled using a hollow stem auger with a 10-inch outside diameter (OD) auger. A smaller diameter auger can be used during coring but the borehole must then be over-drilled using the 10 in OD auger in order to construct the monitor well.

Each of the boreholes will be sampled using a continuous core sampler from surface to total depth. The samples will be stored in waxed cardboard boxes and submitted to Cotter personnel at the end of each work day. The boreholes will be logged during drilling by observation and description of the core samples, or, in instances where core cannot be recovered, by drill cuttings. The core will be appropriately stored and marked to allow for identification of the recovered interval for subsequent observation and or testing purposes.

Monitor Well Installation

Borings will be completed as monitor wells. The wells will be installed with four (4)-inch PVC casing and well screens. The screens will be placed from the alluvium bedrock contact to at least two feet above the first occurrence of groundwater. The site geologist will determine the appropriate screen interval. The screens will be four (4)-inch schedule forty (40) PVC with 0.020 inch slots. Colorado Silica Sand 10/20 will be used as the gravel pack and will extend approximately two (2) feet above the top of the screen. The monitor wells will be constructed to allow for a two (2) foot stick up above ground surface of the PVC casing. Wells will be constructed in accordance and compliance with Colorado State Engineer's requirements. Centralizers with spacing not to exceed 50 feet are required in the monitor wells. A five (5) foot bentonite pellet seal will be placed above the gravel pack. Cement bentonite grout (3% bentonite) will be placed using positive displacement through a tremie pipe up to ground surface. Well pads will be constructed around the monitor wells with dimensions of approximately five (5) ft by five (5) ft.

Monitor Well Development

All monitor wells will be developed after installation using appropriate methods. Methods of development may include surge block, bailing or use of submersible pumps. Temperature, pH and conductivity will be measured periodically during well development as an indicator of well stabilization. Water will be removed from the well until visibly clear of sediment. The volume of water removed and the values of the stabilization parameters will be recorded. The discretion of the site geologist will determine when development is complete.

Borehole Abandonment

Any borings that are not converted to monitor wells will be plugged and abandoned using appropriate methods as required by the Colorado State Engineer.

Equipment Decontamination

All downhole drilling equipment will be decontaminated between drilling of boreholes and development of monitoring wells.

Waste Management

Drill cuttings will be managed to allow for collection and transport back to Cotter facility at the end of the drilling program. All water recovered during well development, equipment decontamination and sampling activities will also be collected and containerized for return to the Cotter facility for disposal.

MONITOR WELL MEASUREMENT AND SAMPLING

Groundwater samples will be collected from each of the newly installed monitoring wells using Cotter's standard water quality sampling protocols established in the Remedial Action Plan, Radiological Program Plan Procedures and the Quality Assurance Program Plan. Specifically, sampling will follow the procedures EV-040, EV-041 and EV-042 for sampling the monitor wells. Decontamination methods described in EV-044 will be followed during all sampling events. The newly installed wells will be included in the routine quarterly sampling of Lincoln Park wells.

Water levels will be measured at each new monitor well using RAP procedure EV-043. The newly installed wells will be included in the routine quarterly water level measurement of Lincoln Park wells.

HEALTH and SAFETY

A daily safety meeting will be held each morning prior to beginning drilling operations with the management and oversight personnel and the drilling crew to discuss objectives for the day, potential site hazards, and hazard mitigation. Daily safety meeting forms will be prepared during each meeting. It is not anticipated that any drilling activities will occur within the Restricted Area. In the event that such

activities are necessary, all involved personnel will be required to complete the Cotter Corporation onsite safety training prior to entering the Restricted Area.

STATE PERMITTING REQUIREMENTS

Notice of Intent to Drill Monitor Holes

Notices of Intent to construct monitoring holes (Form GWS-51 from the Colorado Office of the State Engineer) will be prepared and submitted to the Colorado Division of Water Resources prior to the start of field operations. A notice of Intent will be prepared for each ¼ ¼ Section where drilling activities are to take place.

Monitor/ Observation Water Well Application Permits

Monitoring Well Permit Applications (Form GWS-46 from the Colorado Office of the State Engineer) will be prepared for each well that has an intended use of monitoring water levels and or water quality sampling. The Monitoring Well Permit and the appropriate filing fee will be submitted to the Colorado Division of Water Resources.

Well Construction and Test Reports

Well Construction and Test Reports (Form GWS-31 from the Colorado Office of the State Engineer) will be prepared and submitted to the Colorado Division of Water Resources for each monitor well that is constructed.

Well Abandonment Reports

A Well Abandonment Report (Form GWS-9 from the Colorado Office of the State Engineer) will be submitted to the Colorado Division of Water Resources for any boring that is not completed as a monitor well. The report documents the procedures used in plugging and abandonment of the boring.

DRILLING OVERSIGHT AND DAILY REPORTING

Cotter will designate a site geologist to provide supervision and oversight during all drilling and sampling activities. The site geologist will be responsible for documenting all drilling, coring, well installation, well development and well sampling activities. The site geologist will prepare daily drilling summary reports, core logs, well construction logs and well sampling logs. The site geologist will also prepare and submit necessary forms to the Colorado Division of Water Resources including the Notice of Intent to Drill, Monitor Well Permit Application, Well Construction and Test Report and the Well Abandonment Report (if necessary). A Summary Report will be prepared at the completion of the drilling program that will include a description of all field activities and copies of core logs, well construction logs, Well Permit Applications, Well Construction and Test Reports and Well Abandonment Reports.

SITE ACCESS

Cotter Corporation will obtain site access for all potential drilling locations prior to beginning drilling activities.

SCHEDULE

The schedule for installation of the monitor wells is contingent on obtaining access to the proposed locations. Cotter is currently in the process of identifying the property owners at each of the proposed locations and will request access agreements with those owners. In the event that access agreements cannot be obtained at any of the proposed locations, alternate locations that satisfy the objectives and rationale proposed in this plan will be selected. The CDPHE will be notified of any such modifications to the locations proposed in this plan.

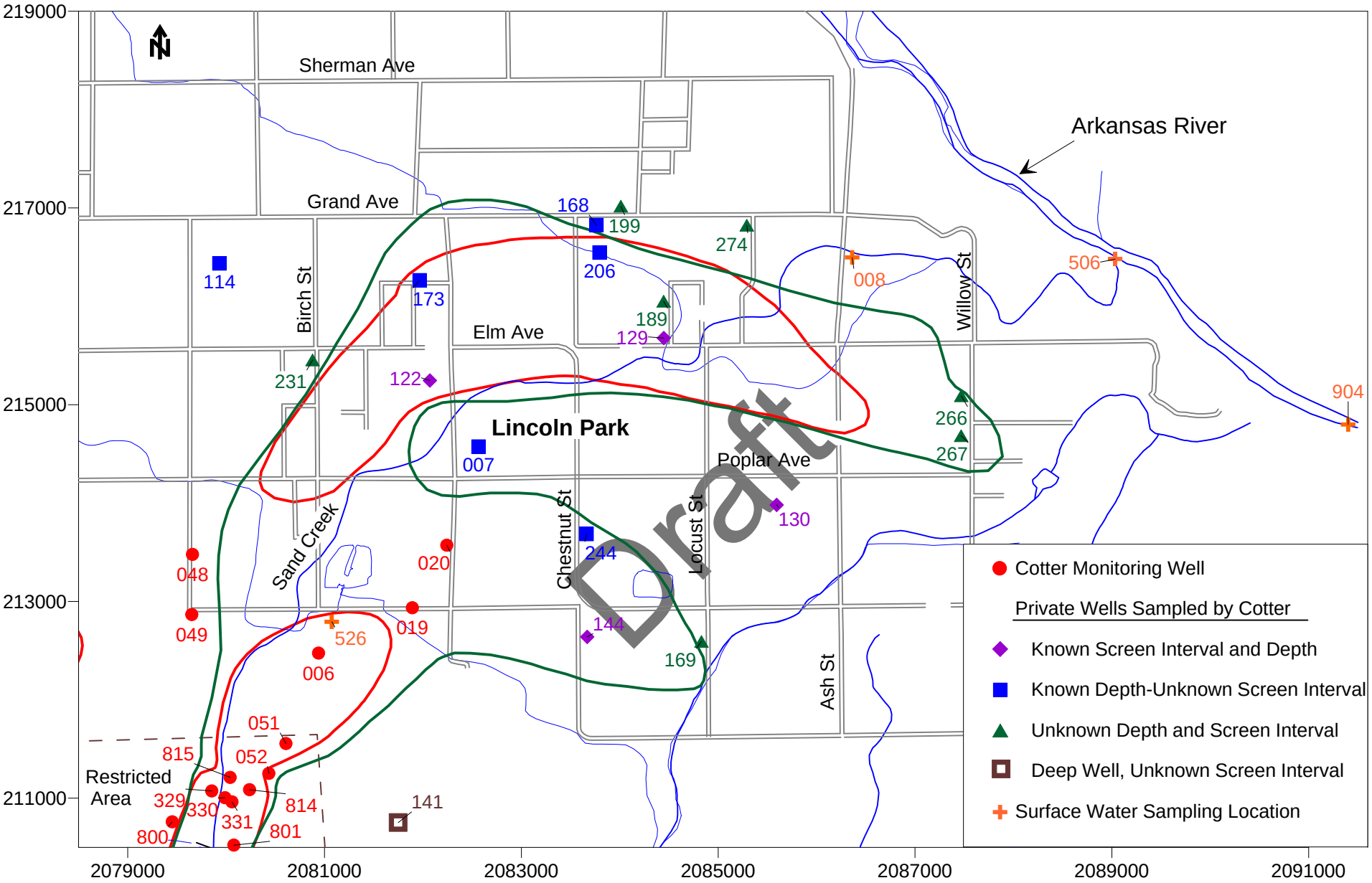

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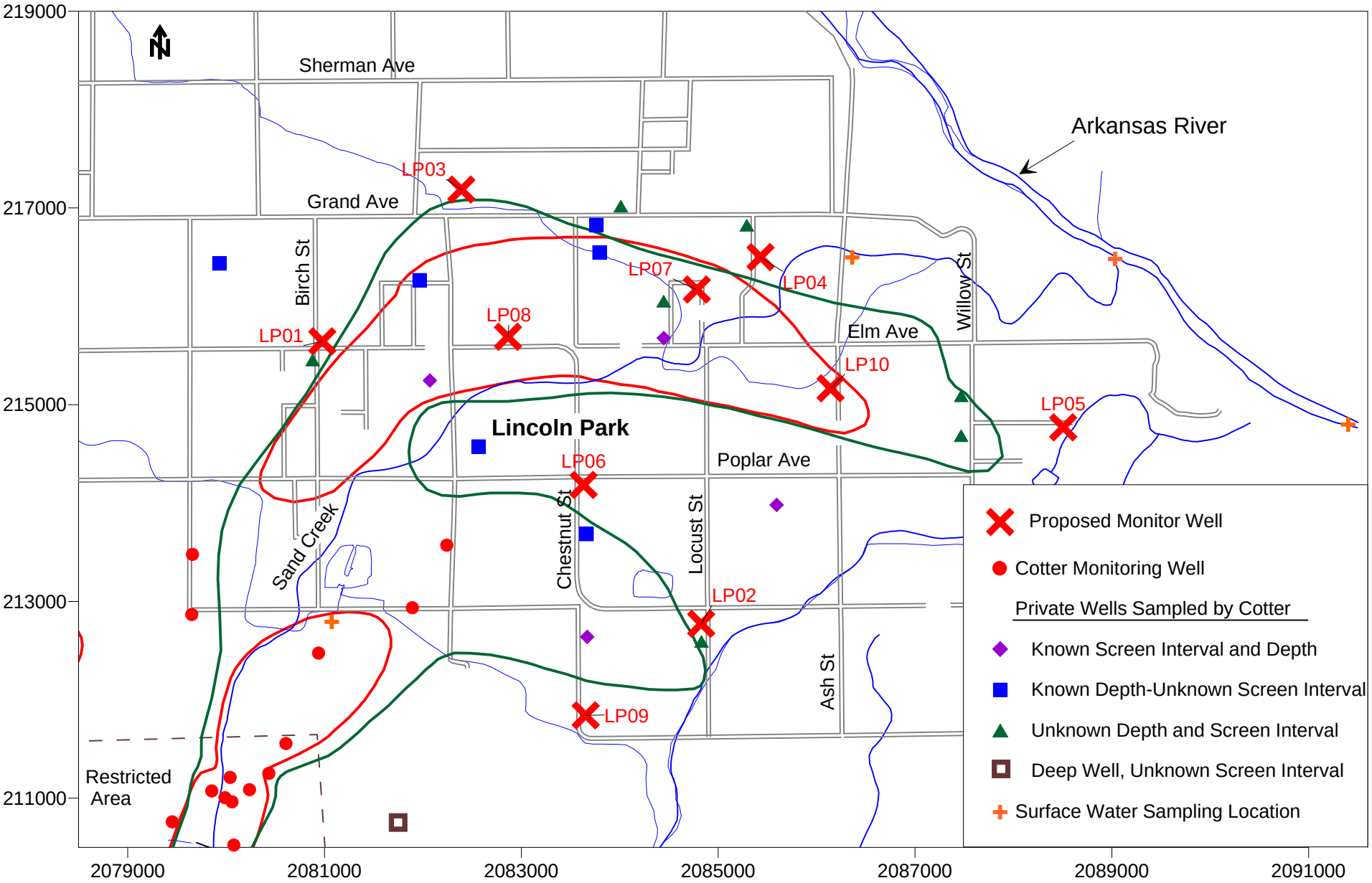
Figure 1. Lincoln Park Groundwater Monitoring Locations

By: EPL Checked: JC File ID:fig1LPGWMP.srf Date: 5/5/11



U - 0.030 mg/L Isocontour

Mo 0.035 mg/L Isocontour

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Figure 2. Lincoln Park
Proposed Monitoring Locations
(Revised 7/6/11)

By: EPL Checked: JC File ID:fig2LPGWMP.srf Date: 7/6/11