CCR Groundwater Monitoring System Certification

BOTTOM ASH POND

Sherburne County (Sherco) Generating Plant
Becker, Minnesota

Prepared for:

Northern States Power Company, a Minnesota Corporation

October, 2017

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CCR GROUNDWATER MONITORING SYSTEM CERTIFICATION

Sherco Bottom Ash Pond
Becker, Minnesota

I hereby certify that this plan, specification, or report was prepared by or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Additionally, I certify that the groundwater monitoring system identified in this report has been designed and constructed to meet the requirements of § 257.91, Groundwater monitoring systems, as included in 40 CFR Part 257, Subpart D, Disposal of Coal Combustion Residuals from Electric Utilities.

NICHOLAS BONOW
LICENSED PROFESSIONAL ENGINEER
47510
STATE OF MINNESOTA

Signature of Preparer:

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Carlson McCain, Inc.

Date: October 16, 2017

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1. INTRODUCTION

This report presents documentation and certification of the groundwater monitoring system for the Bottom Ash Pond (BAP) at the Sherburne County Generating Plant (Sherco) located in Becker, Minnesota. The Sherco plant is owned and operated by Northern States Power Company, a Minnesota Corporation (NSPM). The BAP location is shown on Figure 1 and an aerial photograph and site layout map for the BAP are shown on Figure 2.

The BAP is an existing coal combustion residuals (CCR) surface impoundment and is required to comply with provisions of the U.S. Code of Federal Regulations (CFR), Title 40, Parts 257 and 261 relating to disposal of coal combustion residuals from electric utilities. In particular, this report addresses the requirements of 40 CFR §257.91, Groundwater Monitoring Systems.

As shown in Figure 2, three ponds, Scrubber Solids Ponds 1, 2, and 3 are located adjacent to the south and east of the BAP. Ponds 1 and 2 ceased receiving CCR prior to October 19, 2015 and therefore not subject to regulation under 40 CFR §257. Pond 1 was closed in approximately 1995 and Pond 2 was closed in 2014. Pond 3's groundwater monitoring system meeting the requirements of 40 CFR Section §257.91 is described in Carlson McCain (2017). The areas adjacent to the north and east of Pond 3 have been evaluated for potential development of future ponds 4 and 5. To date, no construction has taken place and these ponds remain in the planning phase.

1.1 Groundwater Monitoring System §257.91(a)

According to §257.91(a), CCR units must comply with the following performance standard:

"The owner or operator of a CCR unit must install a groundwater monitoring system that consists of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that:

> *(1) Accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit. A determination of background quality may include sampling of wells that are not hydraulically upgradient of the CCR management area where:*
>
> > *(i) Hydrogeologic conditions do not allow the owner or operator of the CCR unit to determine what wells are hydraulically upgradient; or*
> >
> > *(ii) Sampling at other wells will provide an indication of background groundwater quality that is as representative or more representative than that provided by the upgradient wells; and*
>
> *(2) Accurately represent the quality of groundwater passing the waste boundary of the CCR unit. The down-gradient monitoring system must be installed at the waste boundary that ensures detection of groundwater contamination in the uppermost aquifer. All potential contaminant pathways must be monitored."*

Additionally, §257.91 includes specific requirements in subparts (b) through (g) relating to the development and implementation of the groundwater monitoring system, which must be satisfied in order to demonstrate compliance with the performance standard listed in subpart (a).

NSPM has installed a groundwater monitoring system at the BAP as described in Table 1 and shown in Figure 6 that complies with the standard set forth in §257.91(a). The system includes nine monitoring wells that monitor up-gradient and down-gradient locations.

The following sections describe the system in further detail, and address the requirements of subparts (b) through (g).

2. SITE CHARACTERIZATION

The hydrogeologic setting of the BAP has been characterized in accordance with §257.91(b) which states *"The number, spacing, and depths of monitoring systems shall be determined based upon site specific technical information that must include thorough characterization of*':

(1) Aquifer thickness, groundwater flow rate, groundwater flow direction including seasonal and temporal fluctuations in groundwater flow; and

(2) Saturated and unsaturated geologic units and fill materials overlying the uppermost aquifer, materials comprising the uppermost aquifer, and materials comprising the confining unit defining the lower boundary of the uppermost aquifer, including, but not limited to, thicknesses, stratigraphy, lithology, hydraulic conductivities, porosities and effective porosities."

Soil borings and monitoring wells have been constructed in the BAP area and several hydrogeologic investigations have been conducted in the vicinity of the BAP such as Scrubber Solids Pond No. 3 (Pond 3), future Scrubber Solids Ponds 4 and 5 (Ponds 4 and 5), and the Unit 3 Dry Ash Landfill (Landfill) for the purposes of permitting and compliance with Minnesota Pollution Control Agency (MPCA) rules. The soil borings/well installations and investigations have assisted in characterizing the hydrogeology beneath the BAP and the information gathered from previous work is included the following reports:

- Xcel, 2002. SHERCO Generating Plant, Scrubber Solids Pond No. 3, Hydrogeologic Investigation Report Phase II – Field Investigation, May 2002;

- Northern States Power (NSP) - Minnesota, 2008. Sherco Dry Ash Disposal Facility, Hydrogeologic Evaluation, Phase II – Field Investigation, prepared by Xcel Energy; March 2008;

- Carlson McCain, 2014. SHERCO Generating Plant, Scrubber Solids Ponds 4 & 5, Phase II Hydrogeologic Investigation Report and Phase III Water Monitoring System Report Work Plan, prepared for Xcel Energy, December 15, 2014;

- Carlson McCain, 2016a. SHERCO Generating Plant, Scrubber Pond 4, Supplemental Phase II Hydrogeologic Investigation Report, prepared for Xcel Energy, March 9, 2016; and

- Carlson McCain, 2016b. SHERCO Generating Plant, Bottom Ash Pond, Monitoring Well Installation Report, prepared for Xcel Energy, March 9, 2016.

Carlson McCain has reviewed these reports in detail, as well as additional unpublished boring and well logs from the BAP vicinity, and the data and information contained in the reports and boring logs has been adapted for use in this report.

2.1 Compliance with §257.91(b)(2)

General notes:

1) The requirements in §257.91(b)(2) will be discussed prior to §257.91(b)(1) in Sections 2.1 and 2.2 respectively since the geology and stratigraphy requirements in §257.91(b)(2) are generally the basis for the hydrogeologic requirements in §257.91(b)(1).
2) Of the reports listed in the previous section, the reports for the BAP (Carlson McCain, 2016b), Pond 3 (Xcel, 2002) and Ponds 4 and 5 (Carlson McCain, 2014, 2016a) in particular discuss the geology and stratigraphy at and near the BAP. The reports generally agree on the distinctive textural classifications of the stratigraphic units beneath the BAP, however, Carlson McCain (2014) refined the depositional interpretations of the stratigraphic units described in the vicinity of Pond 3; and has been confirmed in Carlson McCain (2016a and 2016b). As such, the discussion in this section will reference data mainly from Xcel, 2002 and the stratigraphic units beneath the BAP will be discussed consistent with the stratigraphic units identified in Carlson McCain (2014, 2016a, and 2016b). In general, unless otherwise cited, specific data on soil types, thicknesses, spatial distribution, etc. are credited to Xcel (2002).

Previous investigations indicate that a succession of unconsolidated, Quaternary-age, glacially-derived sediments overlies bedrock beneath the BAP. The unconsolidated deposits range from approximately 76 to 140 feet thick at the site and can be further divided into distinct stratigraphic members of outwash alluvium (sand, silt and clay) and glacial till. The distinct stratigraphic members are described below in Sections 2.1.1 to 2.1.4.

2.1.1 Shallow Alluvium

The uppermost stratigraphic unit in the vicinity of the BAP is comprised of sandy deposits of Mississippi River terrace alluvium and undifferentiated glacial outwash alluvium associated with the Grantsburg sublobe and/or the Superior lobe of the Wisconsin glaciation (Carlson McCain, 2016b).

Description/Classification
The shallow alluvium consists primarily of fine to medium grained, non-cohesive poorly graded sand. Soils are typically classified as SP or SP-SM under the United Soil Classification System (USCS). The sand color was typically reported as brown, with reference to the Munsell color chart, hue was reported as YR. The texture and color of the material is fairly consistent across the Site.

Spatial Distribution
The shallow alluvium unit is present and laterally continuous across the BAP area. Thickness of the unit was, on average, reported to be 15 feet which is approximately 10 feet thinner than observations recorded at Pond 3 and Proposed Pond 4 and 5. Thinner occurrences of the shallow alluvium occurred in the borings for monitoring wells P-155 and P-156 where the unit had been removed and replaced with fill for the construction of the BAP embankment.

Permeability
Due to the consistent nature of the soil types and textures that comprise the hydrostratigraphic units across the ash pond areas, the permeability of the shallow alluvium beneath the BAP is assumed to be similar to that reported for Pond 3. As reported in Carlson McCain (2017), average hydraulic conductivity for the unit is approximately 2.69×10^{-2}. The porosity of the shallow alluvium is estimated to be 0.3.

2.1.2 Superior Till

The next stratigraphically lower geologic unit identified at the Site is glacial till, which is interpreted to be the Superior till of Superior Lobe provenance.

Description/Classification
Superior till typically consists primarily of fine grained, medium-dense to very-dense silty sand with a little gravel (SM). Gravel clasts typically consist of sandstone, basalt and fine- to coarse-crystalline granite. Color is typically described as brown or reddish brown. Occasional, thin lenses of fine to coarse grained sand, USCS symbol SP, occur within the till but are not laterally continuous within the unit.

Spatial Distribution
The Superior till is present immediately beneath the shallow alluvium over a large portion of the Sherco plant site, and was typically present at elevations ranging from 927 to 949 feet above mean sea level (MSL). Although it was present in the majority of the borings advanced in the vicinity of the BAP, discontinuities in the till have been observed beneath the BAP, Pond 3 and within the Pond 4/5 investigation areas. Where present, the till thickness ranged from less than 1 foot thick to over 10 feet thick and averaged to be 4 feet thick at the BAP. The till has an undulating surface which could be the result of collapse of underlying sediments due to melting of buried ice blocks.

Permeability
Data from Pond 3 indicates that the average permeability for the Superior till ranges from approximately 1.5×10^{-7} to 9.4×10^{-7} cm/s.

2.1.3 Deep Alluvium

Below the glacial till, deep alluvium was identified to exist beneath the BAP.

Description/Classification
The deep alluvium typically consists of fine to very coarse-grained, non-cohesive, poorly graded sand. Occasional gravelly or siltier zones were also observed within the unit. Soils were primarily classified as SP under USCS. Color was typically reported as brown, light brown, or light yellowish-born. The texture and color of the material is fairly consistent across the Sherco plant site.

Spatial Distribution
The deep alluvium occurs immediately beneath the Superior till, and was identified in all previous borings at the BAP deep enough to penetrate the unit. It generally extends from the bottom of the till down to the bedrock surface. Overall thickness of the deep alluvium ranges from approximately 36 to 98 feet.

Permeability
Similar to the shallow alluvium, the permeability of the deep alluvium is estimated from values reported for Pond 3. As reported in Carlson McCain (2017), average hydraulic conductivity for the deep alluvium is approximately 3.7×10^{-2} cm/sec. The porosity of the deep alluvium was estimated to be 0.30.

2.1.4 Bedrock

Middle Precambrian granitic bedrock underlies the unconsolidated sediments beneath the BAP. The depth to bedrock ranges from approximately 76 to 140 feet or at elevations of 825 to 889 feet MSL. The upper portion of the bedrock was weathered to various degrees. Beneath the weathered veneer, bedrock is considered impermeable.

2.2 Compliance with §257.91(b)(1)

2.2.1 Aquifer Thickness

The water table beneath the BAP typically occurs below the Superior till identified in Section 2.1.2. As such, the uppermost aquifer at the BAP is the deep alluvium discussed in Section 2.1.3, which ranges from 36 to 98 feet thick.

2.2.2 Groundwater Elevation and Flow Direction

As shown in the hydrograph in Figure 3, the groundwater fluctuates between one and three feet on an annual basis and by as much as five feet from a wet year to a drought year at the BAP. The hydrograph also indicates that, from 2006 to the present, groundwater elevations at the BAP have ranged from approximately 921.5 to 931.0 feet MSL and are typically at or below the glacial till described in Section 2.1.2.

Groundwater elevations and flow direction at the BAP during February and August 2017 are shown on the water table contour elevation maps in Figures 4 and 5 respectively. The contours in Figure 4 were derived from a Sherco site-wide water level gathering effort and the contours in Figure 5 were derived from the wells included in the groundwater monitoring system described in Section 3.2. For both of the events, the flow direction was generally to the west-southwest. This flow direction is consistent with historical data from over 20 years of monitoring at the Sherco facility and is also consistent with the regional groundwater flow direction towards the Mississippi river.

Because of the relatively low permeability of the till, the potential exists for some localized perched conditions on top of the till and/or lateral flow along the water table/till contact. However, perched groundwater has not been identified beneath the BAP or in areas adjacent to the BAP; and based on the relatively uniform groundwater elevation contours it does not appear that the presence of the till significantly impacts the groundwater flow direction or gradient on a large (pond-size) scale.

2.2.3 Groundwater Flow Gradients

Based on the groundwater elevation contours shown in Figure 4, the average horizontal groundwater gradient at the BAP was calculated at 0.0012 (units of vertical feet per horizontal foot). The horizontal gradient is fairly consistent across the entire facility and is also consistent with previous values for the facility.

Using groundwater elevation data, vertical gradients were calculated from four nested well pairs near the BAP (P-50 and P-50B, P-112A and P-112B, P-152A and P-152B and P-154A and P-154B) from August 21 to 24, 2017. The P-50 well nest is located approximately 400 feet west of the BAP; the P-112 well nest is located approximately 4,800 feet southeast of the BAP at the Becker Ash Landfill; the P-152 well nest is located approximately 2,500 feet west-northwest of the BAP; and the P-154 well nest is located approximately 4,600 feet east-southeast of the BAP, as shown on Figure 5. The gradients for the four nested well pairs are small: calculated gradients for the August 2017 measurements are 0.0005 (upward) for P-50/P-50B, -0.0003 (downward) for P-112A/P-112B, 0.006 (upward) for P-112A/P-112B, and 0.002 (upward) for P-73A-1/ P-73B-1. The vertical gradients are consistent with the gradients previously reported for the vicinity of the BAP. The lower magnitude, opposing results indicate that there is no apparent vertical flow regime and vertical flow is nearly negligible at these locations. The lack of a vertical gradient is consistent with a very permeable aquifer with a discontinuous till layer.

2.2.4 Groundwater Flow Velocity

Average linear groundwater flow velocity for the BAP was calculated using Darcy's equation:

$$v = Kh \times i / n_e$$

where Kh = horizontal hydraulic conductivity (length/time)
i = horizontal gradient (dimensionless)
n_e = effective porosity

As discussed in Section 2.1.3, the average Kh value for the deep alluvium is estimated at 3.7×10^{-2} cm/sec and 0.30 for n_e (estimated). Section 2.2.3 indicated the value for i is 0.0012 (calculated).

The resulting groundwater velocity value at the BAP is approximately 153 feet per year.

3. CONCEPTUAL MODEL AND MONITORING WELL LOCATIONS

§257.91(c) states that *"The groundwater monitoring system must include the minimum number of monitoring wells necessary to meet the performance standards specified in paragraph (a) of this* section (discussed in Section 1.1 of this report), *based on the site-specific information specified in paragraph (b) of this section* (discussed in Section 2.0 of this report)."

Section 3.1 below integrates the Site data into a geologic and hydrogeologic framework, or conceptual model, for the Site. The conceptual model offers a simplified representation of the geologic media and serves as the basis for identifying the primary monitoring units.

The conceptual model also facilitates a description of the fate and transport of a hypothetical release from the proposed facility. It provides a rationale for predicting the most likely flow paths that a release might follow and provides the basis for an effective monitoring network that can intercept the likely release.

Sections 3.2 and 3.3 below discuss the selection of monitoring well locations based on the rule requirements and the conceptual model for the Site.

3.1 Conceptual Model

The conceptual model for the release of a constituent of concern (COC) from the BAP focuses on groundwater as the transport mechanism. As discussed above, the water table beneath the BAP typically occurs below the Superior till identified in Section 2.1.2. Exfiltration from BAP area is anticipated to move vertically downward from the base until it reaches the water table and/or till contact. If the exfiltration first contacts the till, it may flow through the till in the downgradient direction, but may also flow locally along the till contact to a zone of higher permeability within the till or a discontinuity of the till until it reaches the water table. Upon reaching the water table, the COC will likely travel mainly horizontally toward the south and/or southwest and to the Mississippi River.

Based on this conceptual model, the groundwater monitoring network should target the water table as the primary monitoring zone; and down-gradient wells should be located on the south and/or west sides of the pond in order to detect a potential release.

3.2 Groundwater Monitoring System

As discussed in Section 1.1, NSPM has installed a groundwater monitoring system at the BAP that complies with the standard set forth in §257.91(a). The system includes nine water table monitoring wells that include up-gradient and down-gradient wells as follows:

Up-Gradient	Down-Gradient
P-17, P-23, P-152a, P-157, P-158	P–01A-1, P-22, P-155, P-156

Well locations relative to the BAP are shown in Figure 6; and well construction data, including unique well number and installation date, are summarized in Table 1.

3.2.1 Compliance with §257.91(c)(1)

As described above in Section 3.2, five monitoring wells are located up-gradient and four monitoring wells are located down-gradient of the BAP. This exceeds the minimums of one up-gradient and three down-gradient monitoring wells required in §257.91(c)(1).

3.2.2 Compliance with §257.91(c)(2)

Based on the rule requirements and the conceptual model for the Site, monitoring wells P-155, P-156, P-157 and P-158 were installed at the facility in 2015 as described in Carlson McCain (2016b). These wells were installed to provide additional monitoring locations that are down-gradient and up-gradient of the BAP. Wells P-155 and P-156, combined with the previously existing down-gradient monitoring wells P-01A-1 and P-22, are evenly spaced along the downgradient edge of the BAP and are well-situated to detect a potential release from the BAP. The remainder of the groundwater monitoring system wells have been located in up-gradient locations to accurately represent the background groundwater quality at the BAP.

4. GROUNDWATER MONITORING SYSTEM PERFORMANCE

The BAP is not a multi-unit facility and, therefore, compliance with §257.91(d) is not required. Given that, Section 4.1 below discusses compliance with §257.91(e) which states that *"Monitoring wells must be cased in a manner that maintains the integrity of the monitoring well borehole. This casing must be screened or perforated and packed with gravel or sand, where necessary, to enable collection of groundwater samples. The annular space (i.e., the space between the borehole and well casing) above the sampling depth must be sealed to prevent contamination of samples and the groundwater."*

4.1 Compliance with §257.91(e)

Monitoring well completion information for each of the wells in the monitoring system indicates that the wells have casings that are screened and packed with sand to enable collection of groundwater samples. Additionally, monitoring well completion logs indicate that in six of the nine wells the annular space above the sand pack in the monitoring wells has been sealed with grout or cement. Monitoring well completion logs for P-17, P-22, and P-23 indicate that the annular space in these wells were filled with coarse to fine sand backfill, as opposed to being sealed with grout or cement. Although this is inconsistent with the wording of §257.91(e) regarding sealing of the annular space, the well's integrity and ability to provide representative groundwater samples are not compromised by this type of construction because of the highly permeable nature of the sand which comprises unsaturated zone. Due to the similarity of the annular backfill material to the surrounding formation, it is akin to allowing the borehole to naturally cave in around the well casing, and does not provide a preferential pathway from the surface to the well screen, as would be the case with a similarly constructed well in a lower-permeability formation. As such, the wells are acceptable for use in the monitoring system, and previous sampling at all of the monitoring system wells has proven that the wells are sampleable and provide acceptable and consistent results.

4.1.1 Compliance with §257.91(e)(1)

As required in §257.91(e)(1):

1. The design, installation, development and decommissioning of any monitoring wells, piezometers, and any other measurement, sampling and analytical devices that are part of groundwater monitoring system will be kept as part of the operating record;
2. The operating record for the facility consists of electronic reports found on the NSPM's data network; and
3. Access to the operating record was provided for the completion of this groundwater monitoring system certification.

4.1.2 Compliance with §257.91(e)(2)

As required in §257.91(e)(2), monitoring wells, piezometers, and any other measurement, sampling and analytical devices that are part of the groundwater monitoring system will be operated and maintained so that they perform to the design specifications throughout the life of the monitoring program.

4.1.3 Ground Water Sampling Plan

A Ground Water Sampling Plan (GWSP) and Statistical Methods Certification have been completed for the wells in the CCR groundwater monitoring network at the BAP (NSPM, 2017). The GWSP provides the methods and procedures that will be used to collect, ship, analyze, and report groundwater monitoring data from the facility is intended to comply the requirements of §257.93.

5.0 REFERENCES

Carlson McCain, 2014. Phase II Hydrogeologic Investigation Report and Phase III Water Monitoring System Report Work Plan, Scrubber Solids Ponds 4 & 5, Sherco Generating Plant, prepared for Xcel Energy, December 15, 2014.

Carlson McCain, 2016a. Supplemental Phase II Hydrogeologic Investigation Report, Scrubber Pond 4, Sherco Generating Plant, prepared for Xcel Energy, March 9, 2016.

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EPA, 2015. 40 CFR Parts 257 and 261; Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities; Final Rule, Federal Register vol. 80, no. 74. Environmental Protection Agency. April 17, 2015.

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Tables

TABLE 1
CCR GROUNDWATER MONITORING SYSTEM
Bottom Ash Pond

Well ID	Minnesota Unique Well ID	Date Installed	Location Site Coordinates (ft)		Elevation Top of Riser Pipe	Screen Length (ft)	Elevation Top of Screen	Elevation Bottom of Screen	Monitoring Status	Hydrologic Location
			Easting	Northing						
P-01A-1	NA	1/4/78	2028267.7	865408.3	1002.8	2	924	922	Routine Semi-annual	Down-Gradient
P-17	NA	8/26/81	2030284.1	866284.1	964.34	20	923	903	Routine Semi-annual	Up-Gradient
P-22	NA	8/27/81	2027386.3	865147.1	964.33	20	922.2	902.2	Routine Semi-annual	Down-Gradient
P-23	NA	8/28/81	2028068.1	866241.6	967.26	30	926	896	Routine Semi-annual	Up-Gradient
P-152A	806318	10/10/14	2031471.6	866696.4	965.87	10	934	924	Routine Semi-annual	Up-Gradient
P-155	812964	9/22/15	2027791	865410	1002.72	10	927	917	Routine Semi-annual	Down-Gradient
P-156	812965	9/22/15	2028707	865410	1002.39	10	927	917	Routine Semi-annual	Down-Gradient
P-157	812966	9/22/15	2028485	866287	968.17	10	929	919	Routine Semi-annual	Up-Gradient
P-158	812967	9/23/15	2029122	866410	966.55	10	927	917	Routine Semi-annual	Up-Gradient

*Notes:
Elevation is feet above mean sea level

Figures

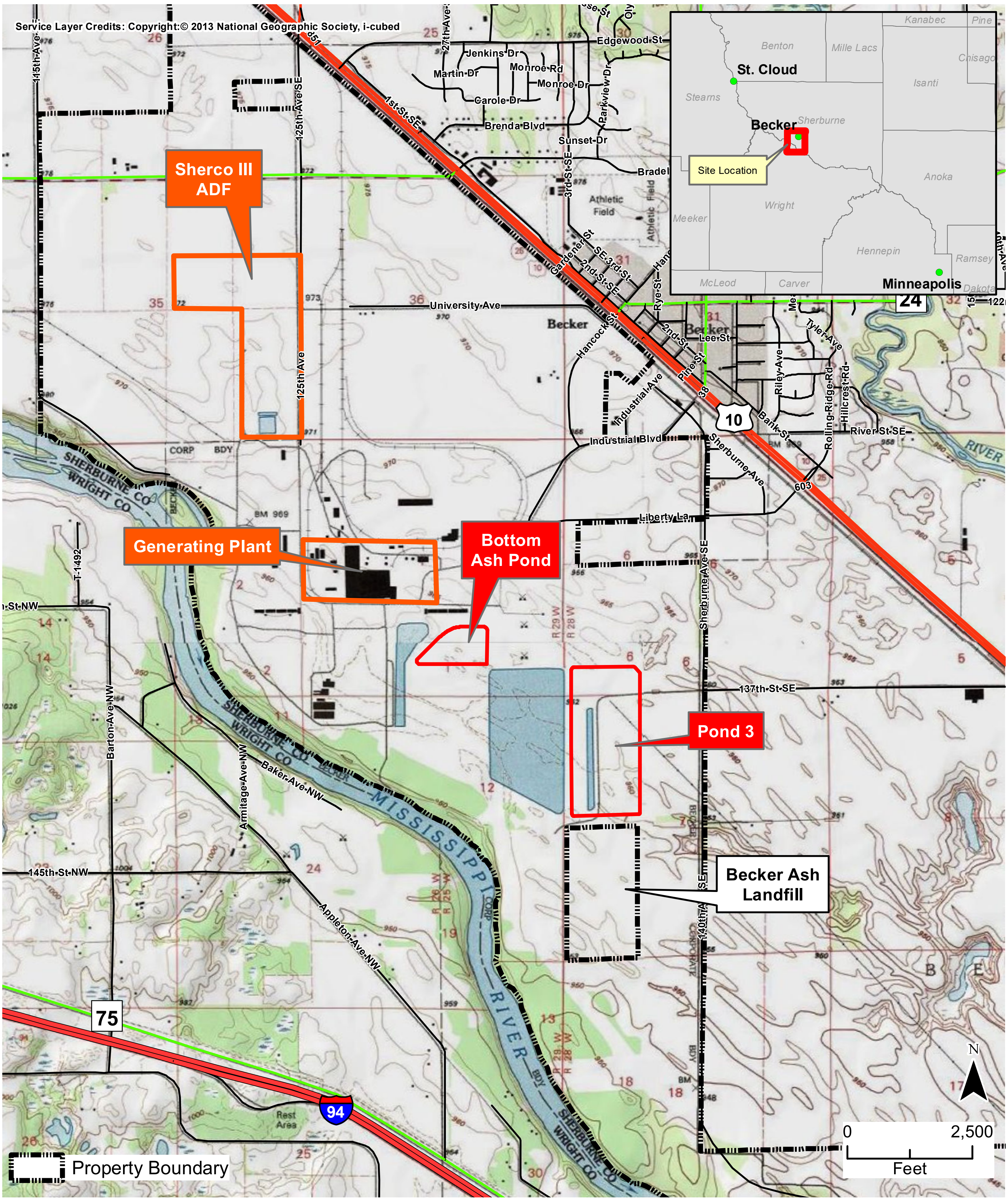

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FIGURE 1

SITE LOCATION MAP

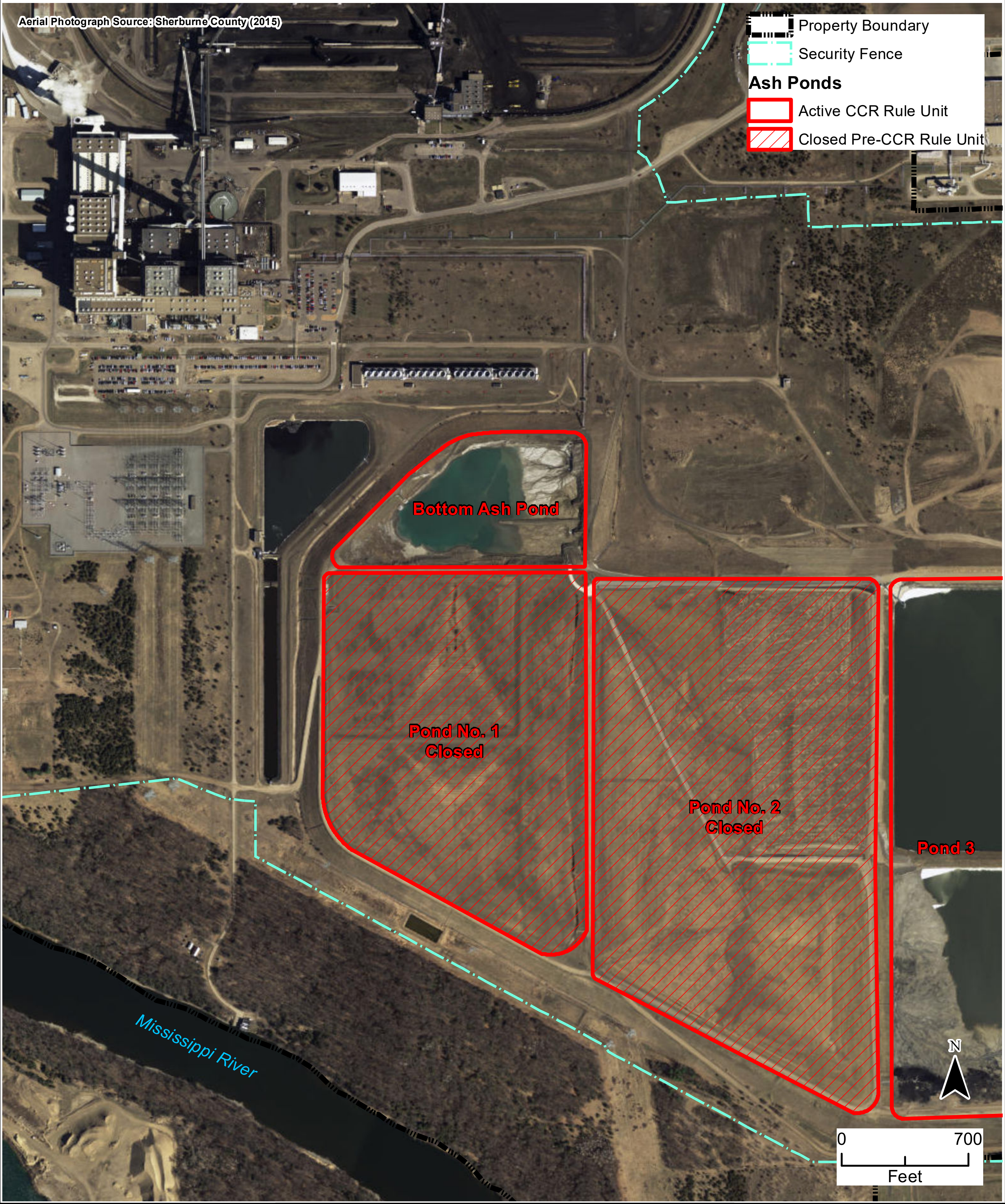

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FIGURE 2
SITE LAYOUT

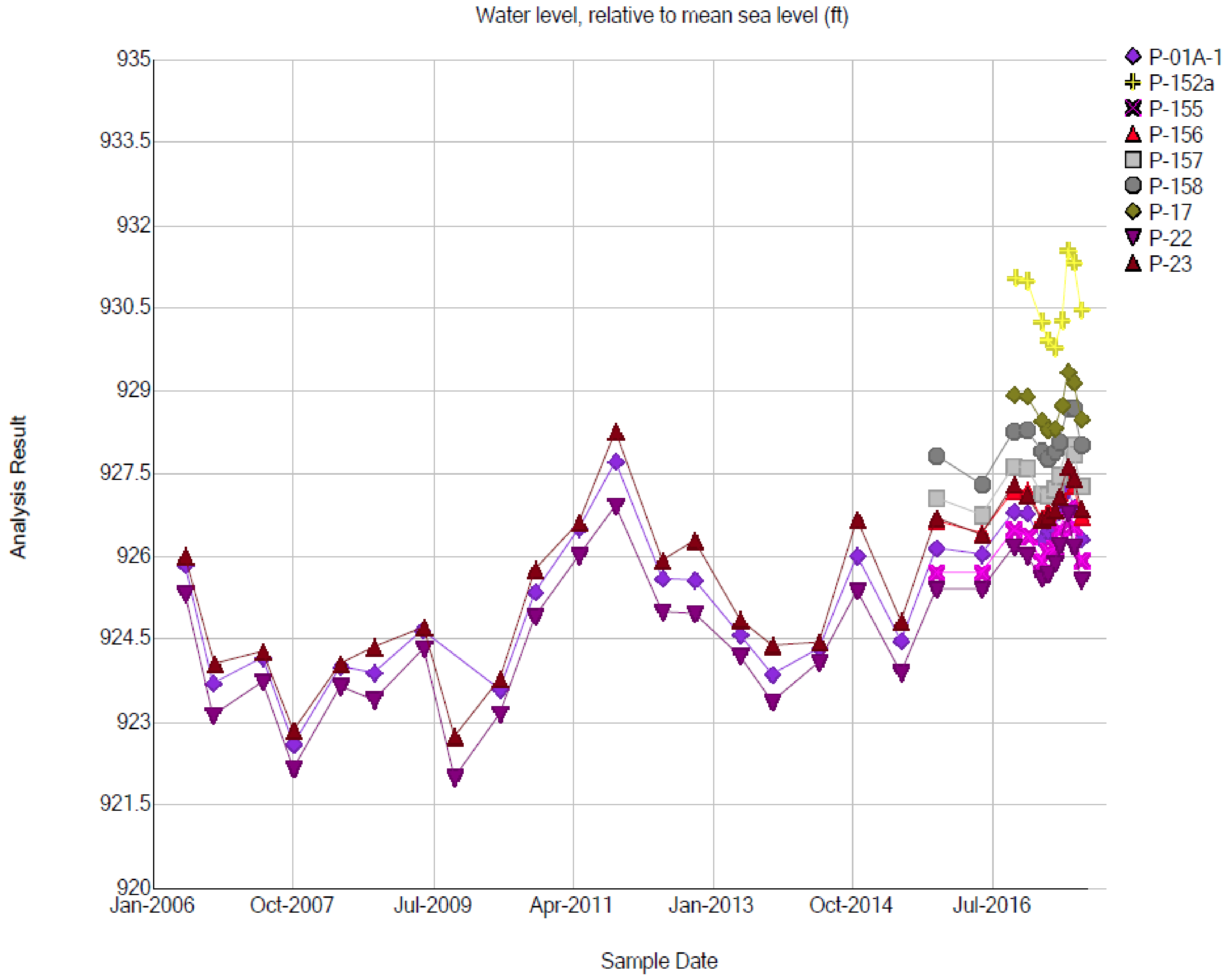

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FIGURE 3
HYDROGRAPH
(2006 – Present)

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FIGURE 4
WATER TABLE ELEVATION CONTOUR MAP (2/20-23/2017)

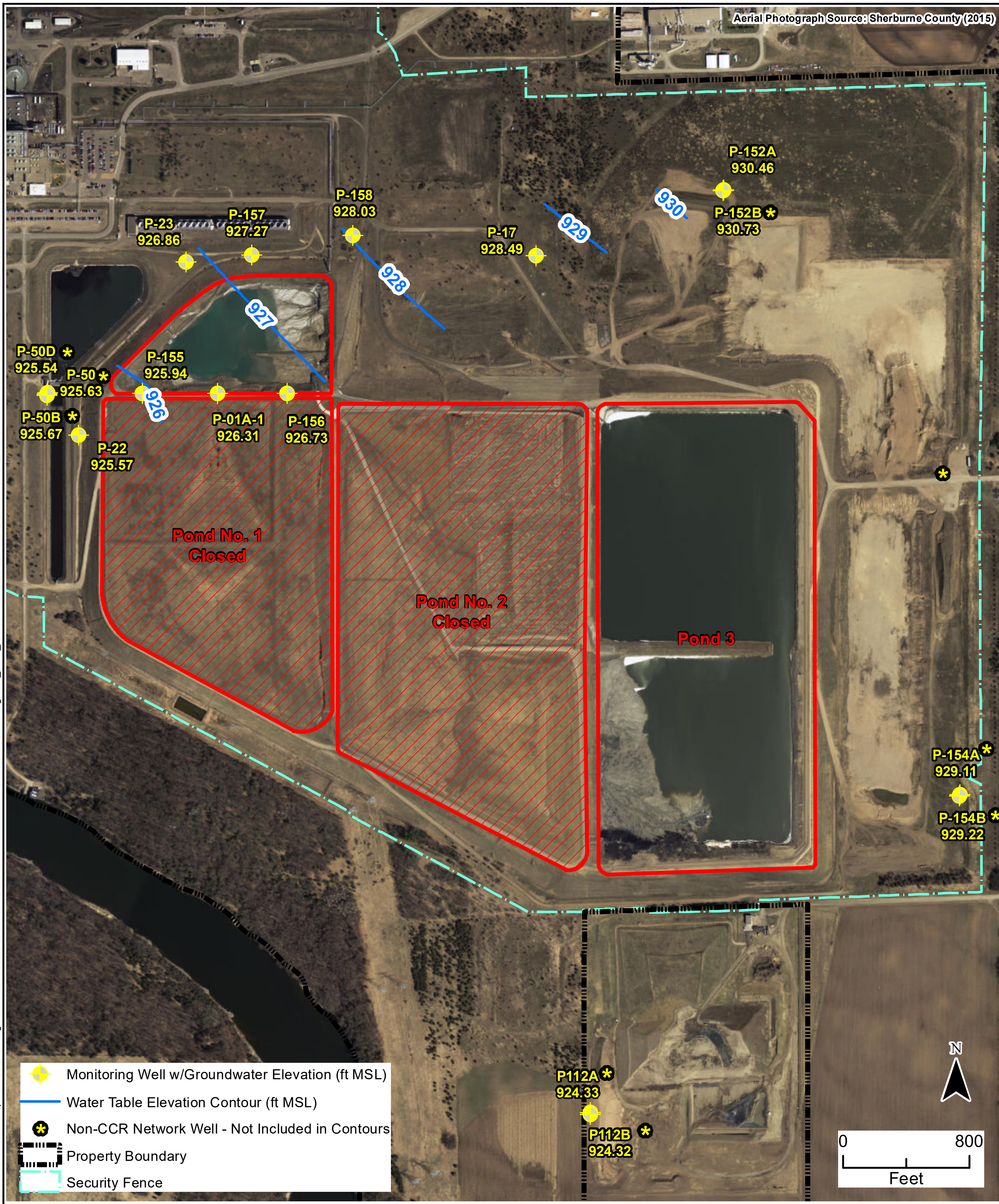

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FIGURE 5
WATER TABLE ELEVATION CONTOUR MAP (8/21-24/2017)

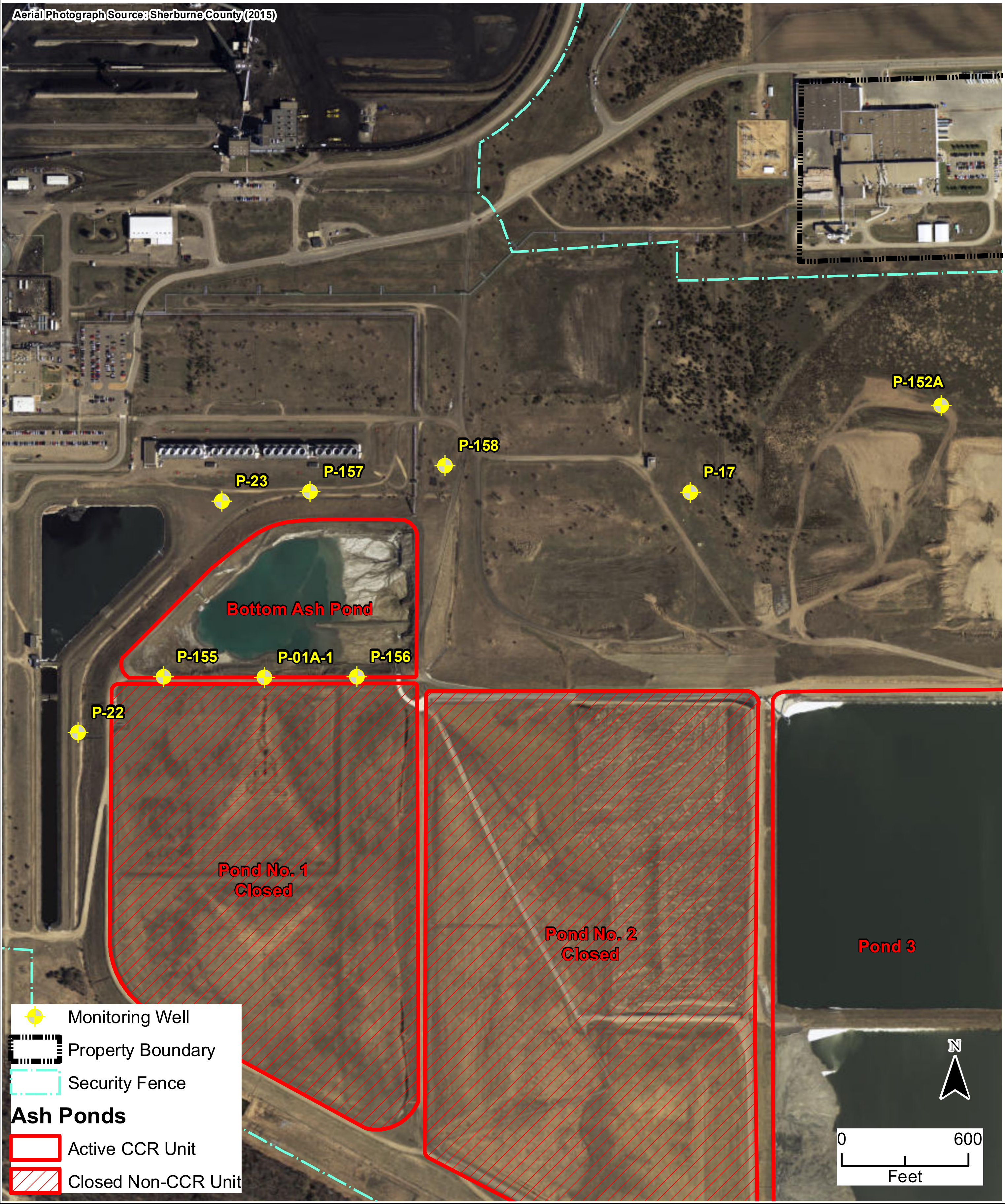

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FIGURE 6
CCR GROUNDWATER MONITORING SYSTEM