CCR Groundwater Monitoring System Certification

SCRUBBER SOLIDS POND No. 3

Sherburne County (Sherco) Generating Plant
Becker, Minnesota

Prepared for:

Northern States Power Company, a Minnesota Corporation

October, 2017

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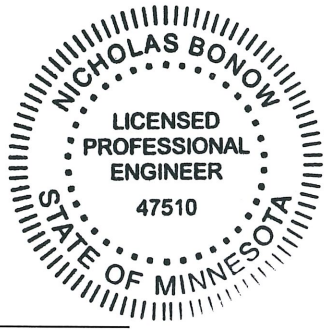
CCR GROUNDWATER MONITORING SYSTEM CERTIFICATION

Sherco Scrubber Solids Pond No. 3
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.



Signature of Preparer:

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Carlson McCain, Inc.

Date: October 16, 2017

TABLE OF CONTENTS

1. INTRODUCTION 1
1.1 Groundwater Monitoring System §257.91(a) 1
2. SITE CHARACTERIZATION 3
2.1 Compliance with §257.91(b)(2) - Geology 3
2.1.1 Shallow Alluvium 4
2.1.2 Superior Till 4
2.1.3 Deep Alluvium 5
2.1.4 Pre-Late Wisconsinan Till 5
2.1.5 Bedrock 5
2.2 Compliance with §257.91(b)(1) - Hydrogeology 6
2.2.1 Aquifer Thickness 6
2.2.2 Groundwater Elevation and Flow Direction 6
2.2.3 Groundwater Flow Gradients 6
2.2.4 Groundwater Flow Velocity 7
3. CONCEPTUAL MODEL AND MONITORING WELL LOCATIONS 8
3.1 Conceptual Model 8
3.2 Groundwater Monitoring System 8
3.2.1 Compliance with §257.91(c)(1) 9
3.2.2 Compliance with §257.91(c)(2) 9
4. GROUNDWATER MONITORING SYSTEM PERFORMANCE 10
4.1 Compliance with §257.91(e) 10
4.1.1 Compliance with §257.91(e)(1) 10
4.1.2 Compliance with §257.91(e)(2) 10
4.1.3 Ground Water Sampling Plan 10
5.0 REFERENCES 11

TABLES

Table 1 CCR Groundwater Monitoring System

FIGURES

Figure 1 Site Location Map
Figure 2 Site Layout
Figure 3 Hydrograph
Figure 4 Water Table Elevation Contours – Site-wide (2/20-23/2017)
Figure 5 Water Table Elevation Contours – Pond 3 (8/21-24/2017)
Figure 6 CCR Groundwater Monitoring System

1. INTRODUCTION

This report presents documentation and certification of the groundwater monitoring system for the Scrubber Solids Pond No. 3 (Pond 3) 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 Pond 3 location is shown on Figure 1 and an aerial photograph and Site layout map for Pond 3 are shown on Figure 2.

Pond 3 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, two closed ponds, Ponds 1 and 2, are located adjacent to the west of Pond 3. 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. 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 Pond 3 as described in Table 1 and shown in Figure 6 that complies with the standard set forth in §257.91(a). The system includes twelve 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 Pond 3 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."*

Several hydrogeologic investigations have been performed in the vicinity of Pond 3. These investigations were conducted for the purposes of permitting and compliance with Minnesota Pollution Control Agency (MPCA) rules. Pertinent reports include the following:

- Donohue, 1990. Becker RDF Ash Storage Facility, Phase II Hydrogeologic Investigation, prepared for Northern States Power Company, April, 1990;
- Xcel, 2002. SHERCO Generating Plant, Scrubber Solids Pond No. 3, Hydrogeologic Evaluation – Field Investigation, May 2002;
- Carlson McCain, 2012. Becker Ash Landfill, Phase II Hydrogeologic Investigation Report and Phase III Water Monitoring System Report Work Plan, prepared for Great River Energy, April 18, 2012;
- 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; and
- Carlson McCain, 2016a. Supplemental Phase II Hydrogeologic Investigation Report, Scrubber Pond 4, Sherco Generating Plant, prepared for Xcel Energy, March 9, 2016.

Carlson McCain has reviewed these investigation reports in detail and the data and information contained in the reports has been adapted for use in this report.

2.1 Compliance with §257.91(b)(2) - Geology

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 Pond 3 (Xcel, 2002) and Ponds 4 and 5 (Carlson McCain, 2014, 2016a) in particular discuss the geology and stratigraphy at and near Pond 3. The reports generally agree on the distinctive textural classifications of the stratigraphic units beneath Pond 3, however, Carlson McCain (2014) refined the depositional

interpretations of the stratigraphic units described at and adjacent to Pond 3. As such, the discussion in this section will reference data mainly from Xcel, 2002 and the stratigraphic units beneath Pond 3 will be discussed consistent with the stratigraphic units identified in Carlson McCain, 2014. In general, unless otherwise cited, specific data on soil types, thicknesses, spatial distribution, etc. are credited to Xcel (2002).

A succession of unconsolidated, Quaternary-age, glacially-derived sediments overlies bedrock beneath Pond 3. The unconsolidated deposits range from 98 to 176 feet thick 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 2.1.5.

2.1.1 Shallow Alluvium

Shallow alluvium is the upper-most stratigraphic unit at the Site and 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 Wisconsinan glaciation (Carlson McCain, 2014).

Description/Classification
The shallow alluvium deposits consist of primarily of fine to medium grained, typically less than 8% fines and less than 25% gravel, and are well to poorly sorted. Soils are typically classified as SP or SP-SM under the United Soil Classification System (USCS). The sand color was primarily tan to brown in color. The texture and color of the material is fairly consistent across the Site.

Spatial Distribution
The shallow alluvium unit consists of the material between the ground surface and the top of the underlying glacial till described in Section 2.1.2. The presence of a thin layer of sandy topsoil ranging from 0 to 3.0 feet thick with underlying sand deposits ranging from 4 to 55 feet thick. The thinner deposits are associated with a borrow pit that was previously located east of Pond 2; and the thickness of the deposit typically increases from south to north. With the exception of the borrow pit area, the average thickness of the unit is approximately 23 feet across the Site.

Permeability
Using the Hazen method (Fetter, 1994) and slug testing, the average permeability for the shallow alluvium beneath Pond 3 was estimated to be 2.69×10^{-2} cm/sec. This is consistent with values obtained from slug tests reported in Carlson McCain (2014), which produced an average of 4.2×10^{-2} cm/sec. The porosity of the shallow alluvium beneath Pond 3 was estimated to be 0.30.

2.1.2 Superior Till

The next stratigraphically lower geologic unit at Pond 3 was identified as glacial till, which is interpreted to be the Superior till of Superior Lobe provenance (Carlson McCain, 2014).

Description/Classification
Superior till consists primarily of fine grained, medium-dense to very-dense silty sand with a little gravel, with USCS symbol SM. Gravel clasts typically consist of sandstone, basalt and fine- to coarse-crystalline granite. Color is typically described as brown, dark brown, reddish brown, or dark reddish gray. 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 Site, and was typically present at elevations ranging from 925 to 945 feet above mean sea level (MSL). Although it was present in the majority of the borings advanced during the Pond 3 hydrogeologic investigation, discontinuities in the till have been observed both beneath Pond 3 and within the Pond 4/5 investigation area. Where present, the till thickness ranged from 1 to 26.5 feet thick beneath Pond 3, with a mean thickness of 9 feet. The till has an undulating surface which could be the result of collapse of underlying sediments due to melting of buried ice blocks.

Permeability
Using slug testing data, it was determined the permeability for the till beneath Pond 3 ranged from 1.5 x 10^{-7} to 9.4 x 10^{-7} cm/sec.

2.1.3 Deep Alluvium

Below the glacial till, a deeper outwash sand, or 'deep alluvium', was identified to exist beneath Pond 3.

Description/Classification
The deep alluvium deposits consist of primarily of fine to medium grained sand, typically less than 8% fines and less than 25% gravel, and is well to poorly sorted. Soils are typically classified as SP or SP-SM under the USCS. The sand color is primarily light brown or brown in color. The texture and color of the material is fairly consistent across the Site.

Spatial Distribution
The deep alluvium occurs immediately beneath the Superior till, and was identified in all borings at Pond 3 deep enough to penetrate the unit. It generally extends from the bottom of the till down to the bedrock surface, or to the top of a 10 to 15-foot thick layer of silty to clayey, gravelly colluvium. Overall thickness of the deep alluvium ranges from 33 to 121 feet.

Permeability
Average permeability of the deep alluvium was estimated to be 3.7 x 10^{-2} cm/sec, while values reported in Carlson McCain (2014), ranged from 4.4 x 10^{-2} to 4.8 x 10^{-3}. The porosity of the deep alluvium was estimated to be 0.30.

2.1.4 Pre-Late Wisconsinan Till

A second, deeper till unit is present in certain locations beneath Pond 3 and the till is typically encountered on top of or within 20 feet of the bedrock surface. It is a dark brown to grayish brown silty to sandy clay till with frequent granite gravel clasts. It was likely deposited by an earlier advance of the Superior lobe.

2.1.5 Bedrock

Middle Precambrian granitic bedrock underlies the unconsolidated sediments beneath Pond 3. The depth to bedrock ranged from 98 to 176 feet or at an elevation of 786 to 868 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) - Hydrogeology

2.2.1 Aquifer Thickness

The water table beneath Pond 3 typically occurs below the top of the glacial till identified in Section 2.1.2. Therefore, the uppermost aquifer is the deep alluvium discussed in Section 2.1.3, which ranges from 33 to 121 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 six feet from a wet year to a drought year at Pond 3. The hydrograph also indicates that, from 2006 to the present, groundwater elevations at Pond 3 have ranged from approximately 923 to 935 feet MSL and are typically at or below the glacial till described in Section 2.1.2.

Groundwater elevations and flow direction in the vicinity of Pond 3 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 vertical 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. The flow direction is consistent with historical data from over 20 years of monitoring at the 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 or in adjacent areas to Pond 3; 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 Figures 4 and 5, the average horizontal groundwater gradient at Pond 3 was calculated at 0.0026 (units of vertical feet per horizontal foot). The horizontal gradient is fairly consistent across the entire Sherco facility and is also consistent with values previously reported for the Pond 3 area.

Using groundwater elevation data, vertical gradients were calculated from four nested well pairs near Pond 3 (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 3,500 feet west of Pond 3; the P-112 well nest is located approximately 1,600 feet south of Pond 3 at the Becker Ash Landfill; the P-152 well nest is located approximately 1,300 feet north of Pond 3; and the P-154 well nest is located approximately 900 feet east of Pond 3, 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-152A/P-152B, and 0.002 (upward) for P-154A/P-

154B. The vertical gradients are consistent with the gradients previously reported for the vicinity of Pond 3. 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 Pond 3 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 deep alluvium at the facility exhibited an average Kh value of 3.7 x 10^{-2} cm/sec and 0.30 for n_e (estimated). Section 2.2.3 indicated the value for i is 0.0026 (calculated).

The resulting groundwater velocity value at the Site is approximately 331 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 existing 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 a release of a constituent of concern (COC) from Pond 3 focuses on groundwater as the transport mechanism. As discussed in Section 2.2.2, the water table beneath Pond 3 is typically below the glacial till layer identified in Section 2.1.2. Exfiltration from Pond 3 area is anticipated to move vertically downward from the base of the pond 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. The lack of an identifiable perched zone above the till indicates that flow along the top of the till is minimal. Upon reaching the water table, a COC will likely travel mainly horizontally toward the west-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 west and south sides of Pond 3 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 Pond 3 that complies with the standard set forth in §257.91(a). The system includes twelve water table monitoring wells that include up-gradient and down-gradient wells as follows:

Up-Gradient	Down-Gradient
P-130, P-131, P-150, P-151, P-152a, P-153, P-154a	P-132, P-162, P-163, P-164, P-165

Well locations relative to Pond 3 are shown in Figure 6; and well construction data, including unique well number and installation date, are summarized in Table 1. Monitoring wells P-162, P-163 and P-164 located atop the shared embankment between Pond 3 and Pond 2. These wells are angled

downward at approximately 39 degrees from the top embankment and are screened underneath the west side of Pond 3. The remainder of the wells are traditional, vertical wells.

3.2.1 Compliance with §257.91(c)(1)

As described above in Section 3.2, seven monitoring wells are located up-gradient and five monitoring wells are located down-gradient of Pond 3. 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-162, P-163, P-164 and P-165 were installed at the facility in 2016 as described in Carlson McCain (2016b). These wells were installed to provide additional monitoring locations that are downgradient of Pond 3, but upgradient of Pond 2. Combined with the previously existing monitoring well P-132, these wells are evenly spaced along the downgradient edge of Pond 3 and are well-situated to detect a release from Pond 3. The remainder of the groundwater monitoring system wells have been located in up-gradient locations to accurately represent the background groundwater quality at the Site.

4. GROUNDWATER MONITORING SYSTEM PERFORMANCE

Pond 3 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 logs that were reviewed indicate that wells included in the monitoring network have casings that are screened and packed with sand to enable collection of groundwater samples (Carlson McCain, 2014 and 2016b). The monitoring well completion logs also indicate the annular spaces above the sand packs in the monitoring wells have been sealed to prevent contamination of samples and the groundwater. Further, previous sampling at all wells in the monitoring network have 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 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 Pond 3 (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, 2012. Becker Ash Landfill, Phase II Hydrogeologic Investigation Report and Phase III Water Monitoring System Report Work Plan, prepared for Great River Energy, April 18, 2012.

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.

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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.

Xcel, 2002. SHERCO Generating Plant, Scrubber Solids Pond No. 3, Hydrogeologic Evaluation – Field Investigation, May 2002.

Tables

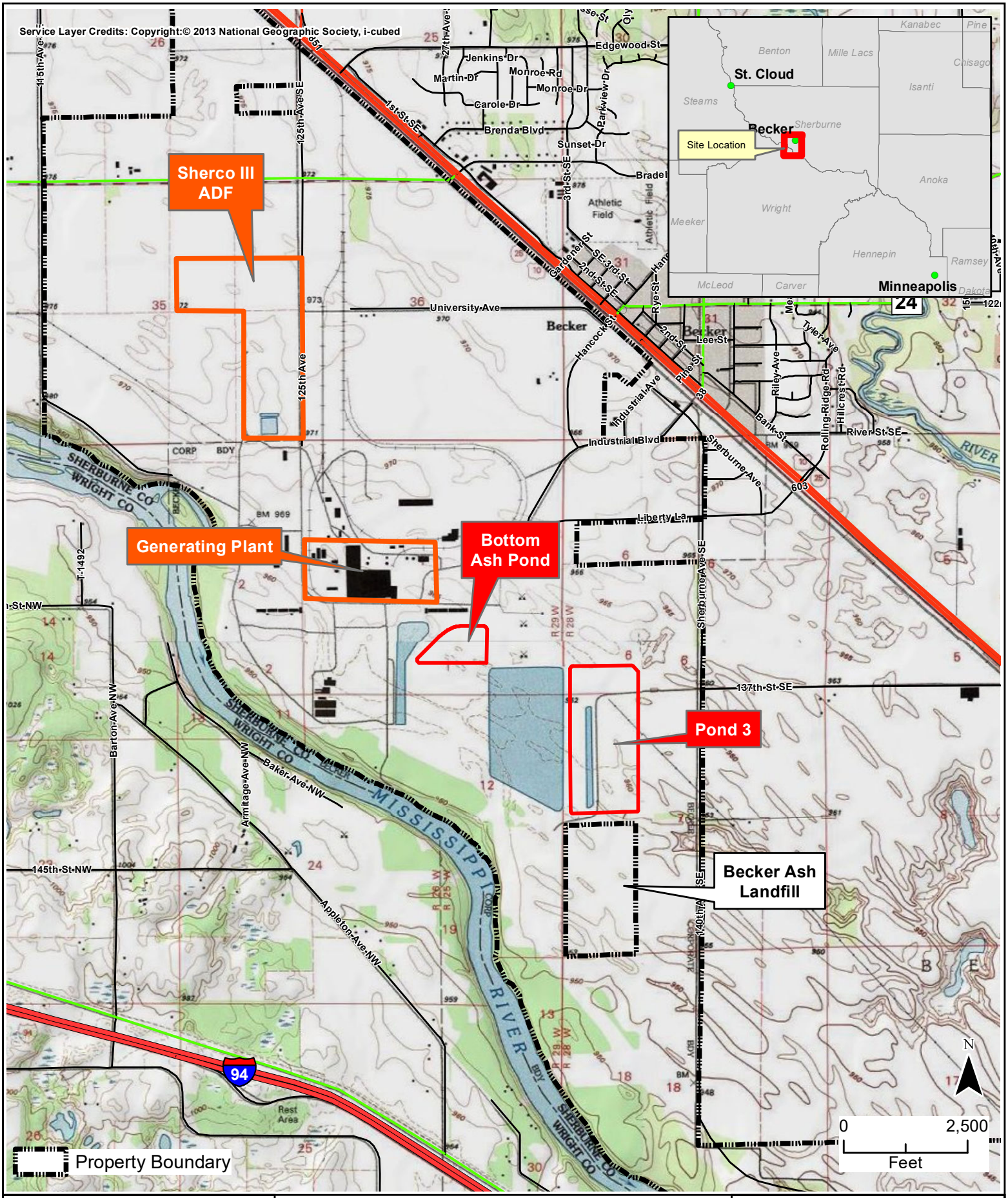
TABLE 1
CCR GROUNDWATER MONITORING SYSTEM
Scrubber Solids Pond No. 3

Well ID	Minnesota Unique Well ID	Date Installed	Location Site Coordinates (ft) Easting	Location Site Coordinates (ft) Northing	Elevation Top of Riser Pipe	Well Type	Screen Length (ft)	Elevation Top of Screen	Elevation Bottom of Screen	Monitoring Status	Hydrologic Location
P-130	722085	5/12/05	2031446.8	865871.1	965.59	Vertical	10	931	921	Routine Semi-annual	Up-gradient
P-131	722086	5/16/05	2033046.4	865133.3	966.03	Vertical	10	931	921	Routine Semi-annual	Up-gradient
P-132	722087	5/11/05	2031594.6	862211.7	955.96	Vertical	10	931	921	Routine Semi-annual	Down-Gradient
P-150	806320	10/7/14	2032983.1	867047.3	964.41	Vertical	10	938	928	Routine Semi-annual	Up-gradient
P-151	806315	10/9/14	2032644.2	865848.2	942.44	Vertical	10	932	922	Routine Semi-annual	Up-gradient
P-152A	806318	10/10/14	2031471.6	866696.4	965.87	Vertical	10	934	924	Routine Semi-annual	Up-gradient
P-153	806314	10/13/14	2032310.4	864158.5	944.94	Vertical	10	931	921	Routine Semi-annual	Up-gradient
P-154A	806316	10/15/14	2032966.3	862868.4	961.44	Vertical	10	922	912	Routine Semi-annual	Up-gradient
P-162	822156	7/25/16	2030610	864631.7	1020.9	Angled	20	929	916	Routine Semi-annual	Down-Gradient
P-163	822157	7/19/16	2030604	863992	1024.98	Angled	20	927	914	Routine Semi-annual	Down-Gradient
P-164	822158	7/14/16	2030610	863059.5	1020.49	Angled	20	928	916	Routine Semi-annual	Down-Gradient
P-165	822159	7/12/16	2030714	862215.8	957.13	Vertical	10	927	917	Routine Semi-annual	Down-Gradient

*Notes:

Elevation is feet above mean sea level

Figures



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Scrubber Solids Pond No. 3

Sherburne County Generating Plant
Becker, Minnesota

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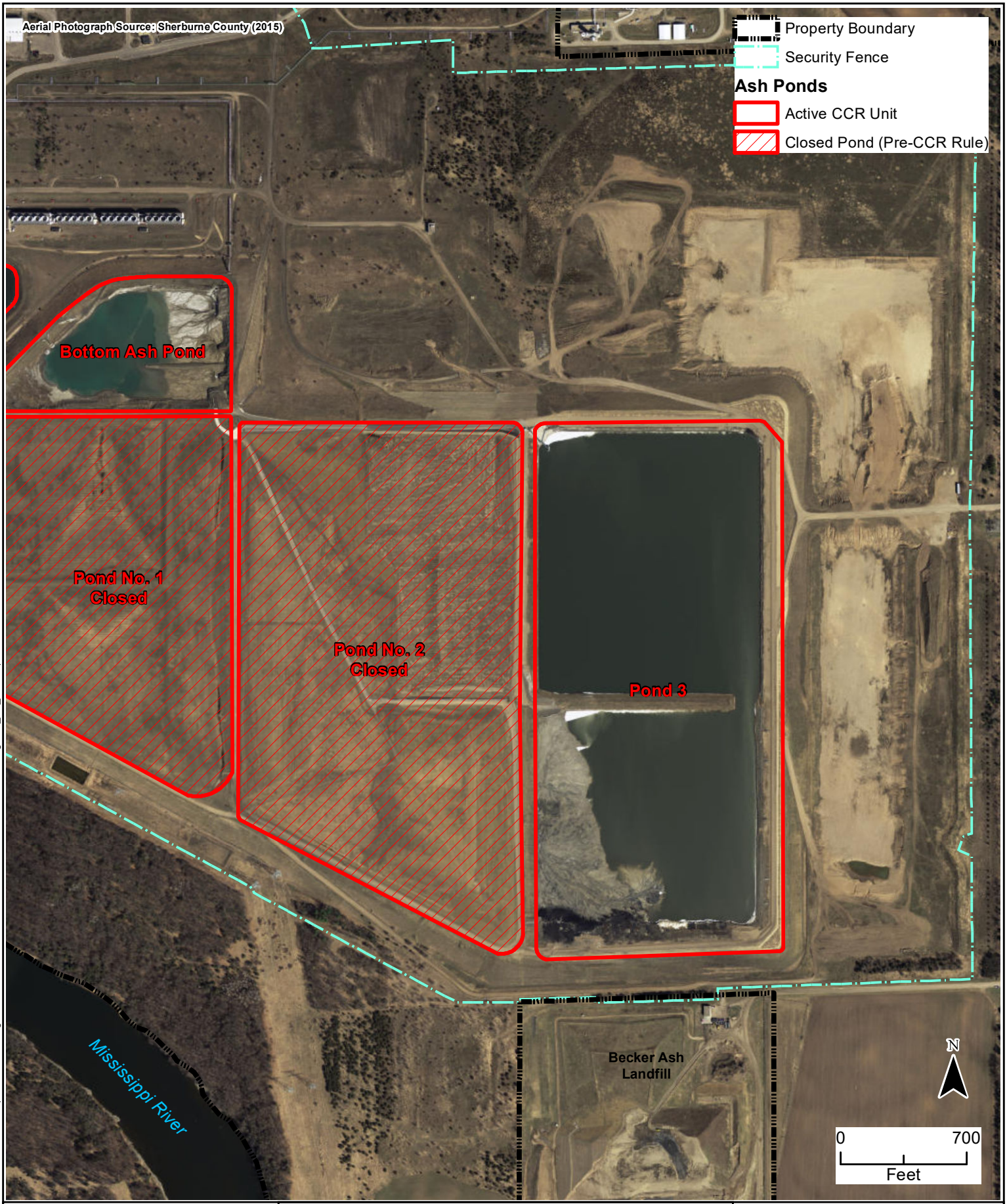
FIGURE 1

SITE LOCATION MAP



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Scrubber Solids Pond No. 3
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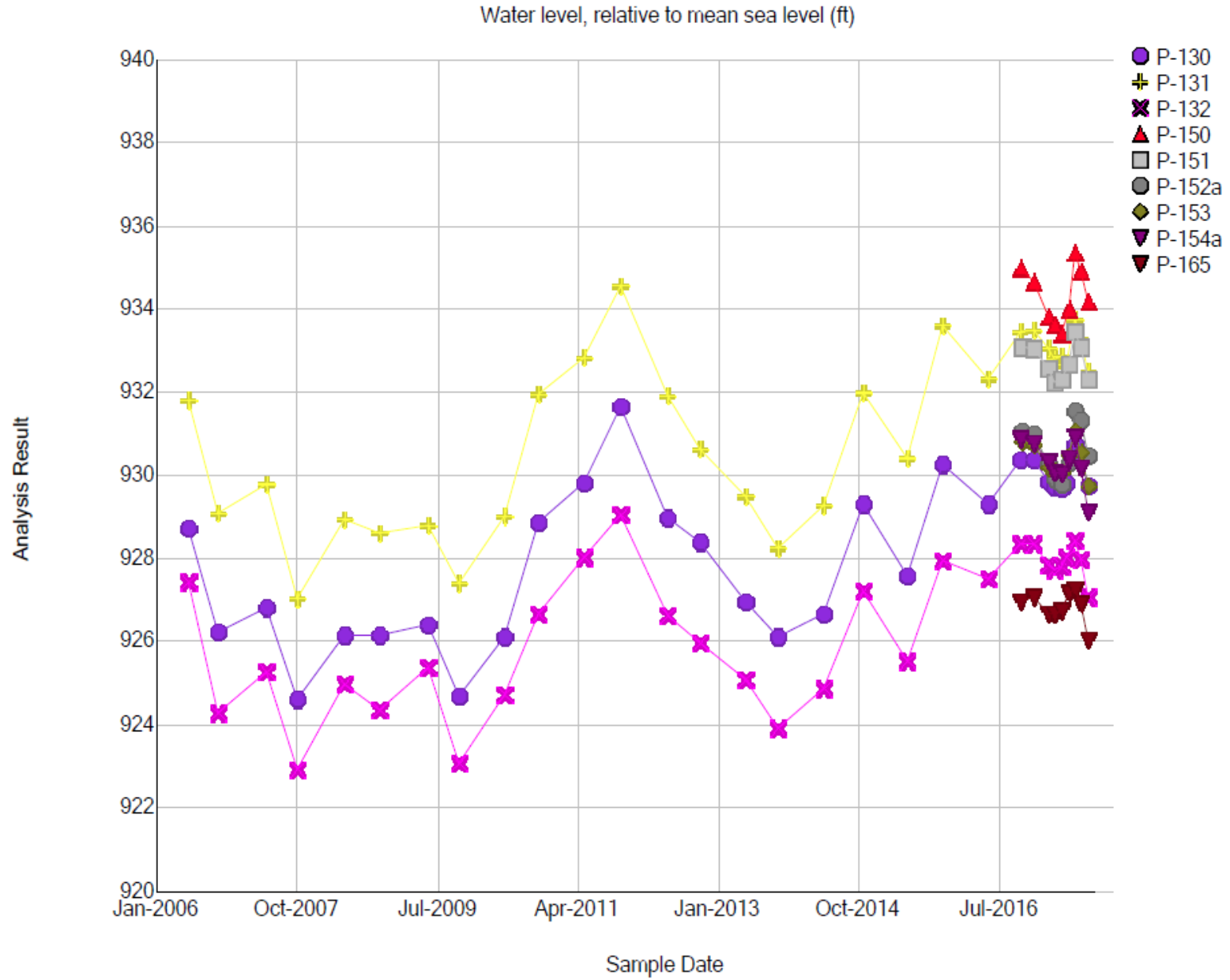
Becker, Minnesota

FIGURE 2
SITE LAYOUT



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Scrubber Solids Pond No. 3
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FIGURE 3
HYDROGRAPH
(2006 – Present)

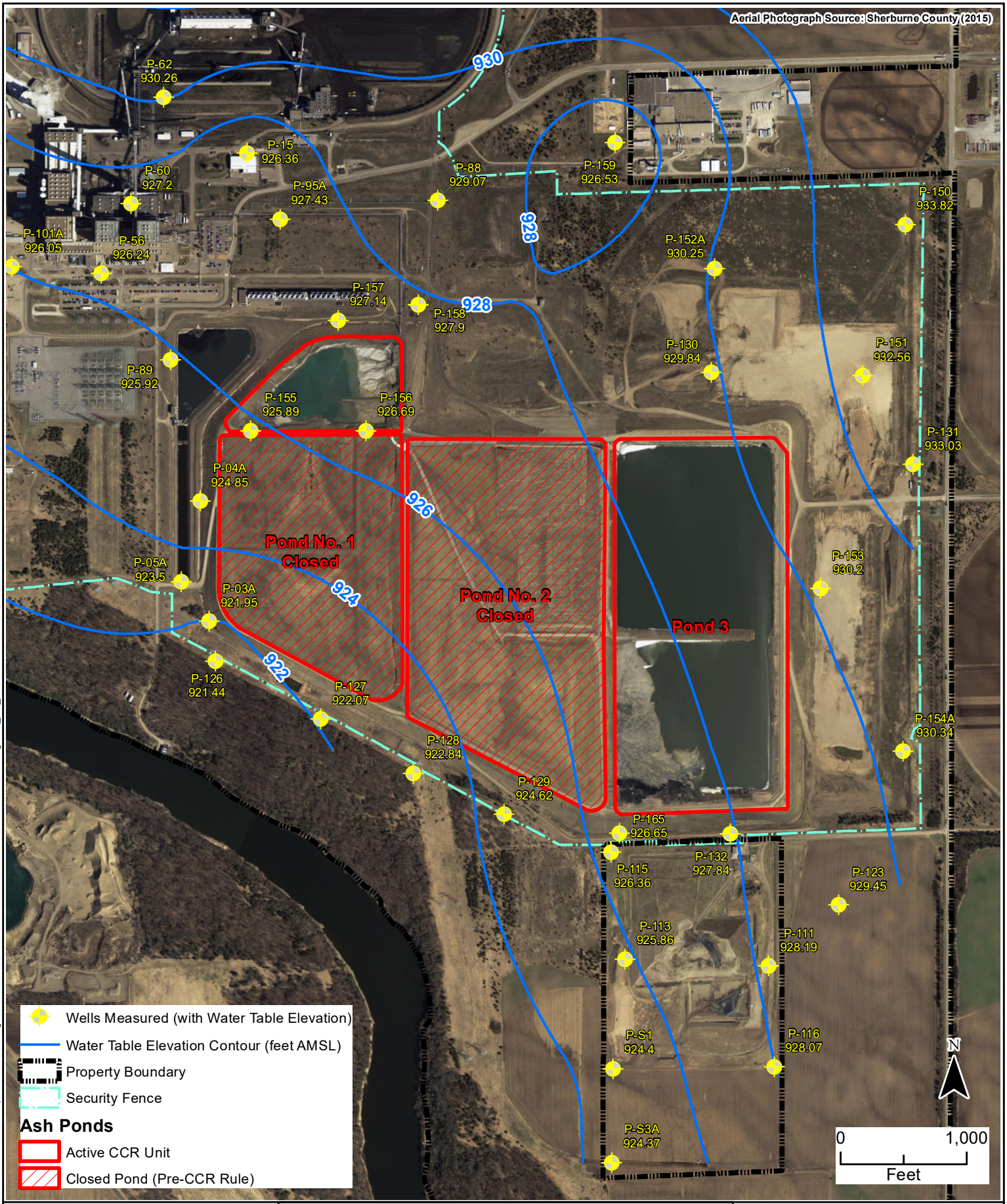

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FIGURE 4
WATER TABLE ELEVATION CONTOUR MAP (2/20-23/2017)

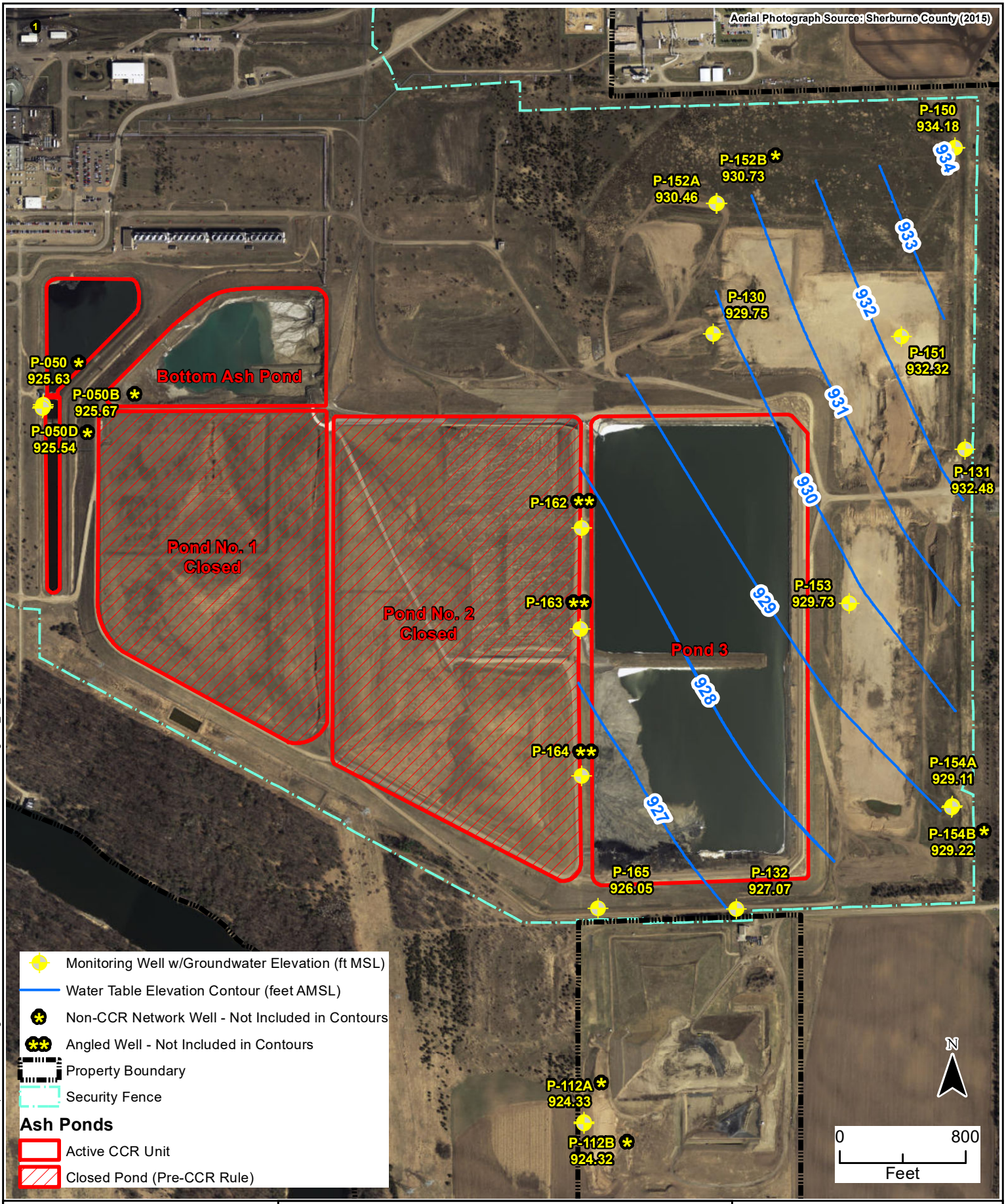

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FIGURE 5
WATER TABLE ELEVATION CONTOUR MAP (8/21-24/2017)

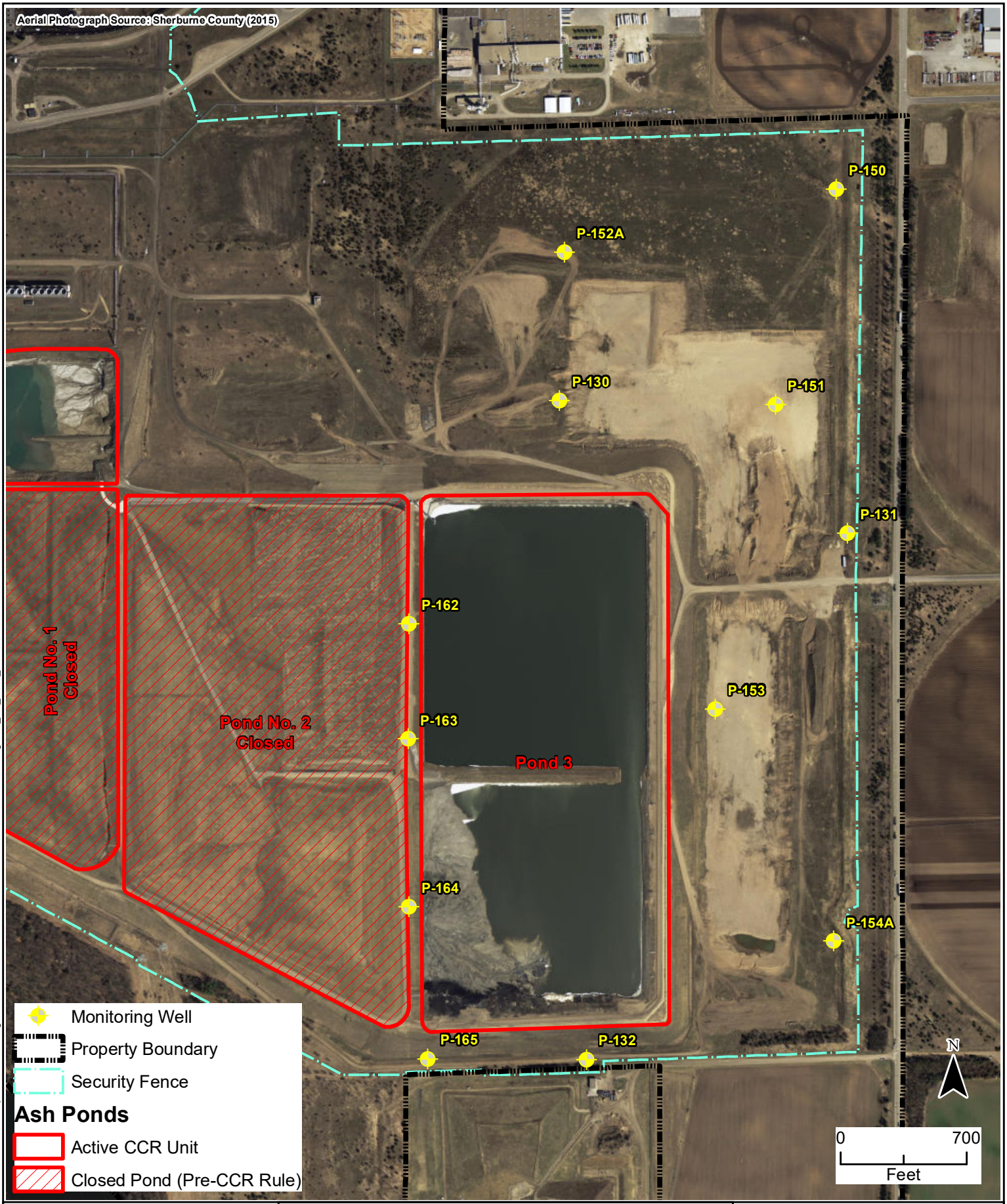

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FIGURE 6

CCR GROUNDWATER MONITORING SYSTEM