Intended for
Dynegy Midwest Generation, LLC

Date
November 30, 2020

Project No.
1940072855

CORRECTIVE MEASURES ASSESSMENT REVISION 2

BALDWIN FLY ASH POND SYSTEM

BALDWIN ENERGY COMPLEX
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BALDWIN, ILLINOIS

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DOCUMENT REVISION RECORD

Issue No.	Date	Details of Revisions
Revision 0	September 5, 2019	• Original Document
Revision 1	November 15, 2019	Typographical edits, addition of a citation in References section, and Table 1 formatting edit as follows: • Revised first paragraph line three of Section 1.2.5 on document page 3 of 14 from "measusre" to "measure" • Revised seventh bullet line six of paragraph two in Section 2.4 on document page 6 of 14 from "Ash Pond 2" to "the Baldwin Fly Ash Pond System," • Removed last partial sentence of paragraph four in Section 3.2.1 on document page 8 of 14, "Based on MNA case histories evaluated for 24 inorganic constituents, including most Appendix III and Appendix IV constituents, in other industries," • Revised third bullet line two of paragraph two in Section 5.1 on document page 13 of 14 from "appendix IV" to "Appendix IV" • Revised lines five and six of last paragraph in Section 5.1 on document page 13 of 14 from "Ash Pond 2" to "the Baldwin Fly Ash Pond System" • Added citation for "Willman, H.B. and others. 1967. Geologic Map of Illinois. Illinois State Geological Survey. Champaign, Illinois." in References section on document page 14 of 14 • Revised Table 1 border formatting column 7 row 3
Revision 2	November 30, 2020	• Revised as follows: • Section 2 – added additional geology/hydrogeology information, including Appendices A through D, added reference to lithium SSLs, added plume delineation information, including Tables 1 and 2 and Figures 2, 3, and 4. • Section 3 – removed discussion of in-situ solidification /stabilization (ISS) because it is not applicable to bedrock as a groundwater corrective measure. Separated permeable reactive barrier and in-situ chemical treatment into separate sections for discussion • Section 4 - focused on application of evaluation criteria added to Section 1 to potential groundwater corrective measures referenced in Section 3, added Appendix E with independent evaluation of MNA • Section 5 – focused on potential groundwater corrective measures referenced in Sections 3 and 4 • Table 3 – focused on application of evaluation criteria added to Section 1 to potential groundwater corrective measures referenced in Section 3

CONTENTS

TABLES

FIGURES

APPENDICES

1. INTRODUCTION

Ramboll Americas Engineering Solutions Inc., formerly known as O'Brien & Gere Engineers, Inc (Ramboll), has prepared this revision of the Corrective Measures Assessment (CMA) for the Baldwin Fly Ash Pond System located at the Baldwin Energy Complex (BEC, the Site). This CMA report complies with the requirements of Title 40 of the Code of Federal Regulations (C.F.R.) § 257, Subpart D, Standards for the Disposal of Coal Combustion Residuals (CCR) in Landfills and Surface Impoundments (CCR Rule). Under the CCR Rule, owners and operators of existing CCR surface impoundments (SIs) must initiate a CMA, in accordance with 40 C.F.R. § 257.96, when one or more Appendix IV constituents are detected at statistically significant levels (SSLs) above groundwater protection standards (GWPS) in the Uppermost Aquifer, and the owner or operator has not completed an alternate source demonstration demonstrating that a source other than the CCR unit has caused the contamination. This CMA is responsive to the 40 C.F.R. § 257.96 requirements for assessing potential corrective measures to address the exceedance of the GWPS for lithium in the Uppermost Aquifer.

In March 2016, Dynegy Midwest Generation, LLC (DMG) submitted the Closure and Post-Closure Care Plan for the Baldwin Fly Ash Pond System (Closure Plan [AECOM, 2016]) to the Illinois Environmental Protection Agency (IEPA). The Closure Plan set forth source control measures and sought approval to close the Fly Ash Pond System by leaving CCR in place and constructing a final cover system of earthen material. The final cover system has lower permeability than the subsoils underlying the CCR, will control the potential for water infiltration into the closed CCR unit, and allows drainage of water off of, and water out of, the closed CCR unit. The Closure Plan included provisions for performing groundwater monitoring to assess natural attenuation and maintenance of the final cover system as measures to address exceedances of GWPS. The IEPA subsequently approved the Closure Plan in a letter to Dynegy Operating Company dated August 16, 2016 (IEPA, 2016). Construction of the final cover system was completed November 17, 2020.

This CMA is the next step in developing a long-term corrective action plan to address lithium SSLs in the Uppermost Aquifer. Source control measures have been completed, including pumping to remove surface water, dewatering the CCR, relocating and/or reshaping the existing CCR to achieve acceptable grades for closure, and constructing an earthen cover system (additional details are discussed in Section 2). This CMA has been prepared to evaluate applicable remedial measures to address the lithium SSLs in the Uppermost Aquifer. The results of the CMA will be used to select a remedy for the Uppermost Aquifer, consistent with 40 C.F.R. § 257.96 and § 257.97 requirements.

1.1 Corrective Measures Assessment Objectives and Methodology

The objective of this CMA is to evaluate appropriate corrective measure(s) to address impacted groundwater in the Uppermost Aquifer potentially associated with the Fly Ash Pond System at the BEC. The CMA evaluates the effectiveness of the corrective measures in meeting the requirements and objectives of the remedy, as described under 40 C.F.R. § 257.96(c), by addressing the following evaluation criteria:

- Performance
- Reliability

- Ease of implementation
- Potential impacts of appropriate potential remedies (safety impacts, cross-media impacts, and control of exposure to any residual contamination)
- Time required to begin and complete the remedy
- Institutional requirements that may substantially affect implementation of the remedy(s) (permitting, environmental or public health requirements)

The CMA provides a systematic, rational method for evaluating potential corrective measures. The assessment process documented herein: a) identifies the site-specific conditions that will influence the effectiveness of the potential corrective measures (Section 2); b) identifies applicable corrective measures (Section 3); c) assesses the corrective measures against the evaluation criteria to select potentially feasible corrective measures (Section 4); and d) summarizes the remedy selection process and future actions (Section 5).

1.2 Evaluation Criteria

The evaluation criteria are defined below to provide a common understanding and consistent application. The evaluation included qualitative and/or semi-quantitative screening of the corrective measures relative to their general performance, reliability and ease of implementation characteristics, and their potential impacts, timeframes and institutional requirements. Evaluations were at a generalized level of detail in order to screen out corrective measures that were not expected to meet 40 C.F.R. § 257.97 design criteria, while retaining corrective measures that would meet the design criteria.

This evaluation considered the elements qualitatively, applying engineering judgement with respect to known site conditions, to provide a reasoned set of corrective measures that could be used, either individually or in combination, to supplement the source control measures and achieve GWPS in the most effective and protective manner.

1.2.1 Performance

The performance of potentially applicable corrective measures was evaluated for the:

1. Potential to ensure that any environmental releases to groundwater, surface water, soil and air will be at or below relevant regulatory and health-based benchmarks for human and ecological receptors.
2. Degree to which the corrective measure isolates, removes or contains SSLs identified in the Uppermost Aquifer.
3. Ability of the corrective measure to achieve GWPS within the Uppermost Aquifer at the compliance boundaries.

1.2.2 Reliability

The reliability of the corrective measure is a description of its ability to function as designed until the GWPS are achieved in the Uppermost Aquifer at the compliance boundaries. Evaluation of the reliability included considering:

1. Type and degree of long-term management required, including monitoring, operation, and maintenance.

2. Long-term reliability of the engineering and institutional controls associated with the corrective measure.
3. Potential need for replacement of the corrective measure.

1.2.3 Ease of Implementation

The ease or difficulty of implementing a given corrective measure was evaluated by considering:

1. Degree of difficulty associated with constructing the corrective measure.
2. Expected operational reliability of the corrective measure.
3. Need to coordinate with and obtain necessary approvals and permits.
4. Availability of necessary equipment and specialists.
5. Available capacity and location of needed treatment, storage, and disposal services.

1.2.4 Potential Impacts of the Remedy

Potential impacts associated with a given corrective measure included consideration of impacts on the distribution and/or transport of contaminants, safety impacts (the short-term risks that might be posed to the community or the environment during implementation), cross-media impacts (increased traffic, noise, fugitive dust), and control of potential exposure of humans and environmental receptors to remaining wastes.

1.2.5 Time Required to Begin, Implement, and Complete the Remedy

Evaluating the time required to begin the remedy focused on the site-specific conditions that could require additional or extended timeframes to characterize, design, and/or field test a corrective measure to verify its applicability and effectiveness. The length of time that would be required to begin and implement the remedy was considered to be the total time to: 1) verify applicability and effectiveness; and 2) to complete construction of the corrective measure.

The time required to complete the remedy considered the total time after the corrective measure was implemented until GWPS would be achieved in the Uppermost Aquifer at the compliance boundaries.

1.2.6 Institutional, Environmental or Public Health Requirements

Institutional, environmental and public health requirements considered state, local, and site-specific permitting or other requirements that could substantially affect construction or implementation of a corrective measure.

2. SITE HISTORY AND CHARACTERIZATION

2.1 Site Description and History

The BEC is owned and operated by DMG, and is located in southwest Illinois in Randolph and St. Clair Counties. The Randolph County portion of the BEC is located within Sections 2, 3, 4, 9, 10, 11, 14, 15, and 16 of Township 4 South and Range 7 West. The St. Clair County portion of the property is located within Sections 33, 34, and 35 of Township 3 South and Range 7 West. The Baldwin Fly Ash Pond System is approximately one-half mile west-northwest of the Village of Baldwin (Figure 1).

The BEC is a coal-fired electrical generating plant that began operation of its first unit in 1970; two additional generating units were put into service in 1973 and 1975. The plant initially burned bituminous coal from Illinois and switched to subbituminous coal in 1999. Total plant generating capacity is approximately 1,892 megawatts.

The BEC property is bordered on the west by the Kaskaskia River; on the east by Baldwin Road, farmland, and strip mining areas; on the southeast by the village of Baldwin; on the south by the Illinois Central Gulf railroad tracks, scattered residences, and State Route 154; and on the north by farmland. The St. Clair/Randolph County Line crosses east-west at approximately the midpoint of the Baldwin Power Plant Cooling Lake. Figure 1 shows the location of the plant; Figure 2 is a site plan showing the location of the Fly Ash Pond System and groundwater monitoring system established in accordance with the requirements of 40 C.F.R. § 257.91.

The Fly Ash Pond System at the BEC is a CCR Multi-Unit consisting of three unlined SIs: the East Fly Ash Pond, Old East Fly Ash Pond, and West Fly Ash Pond, with a combined surface area of approximately 232 acres. The Fly Ash Pond System discharged to the Bottom Ash Pond, which discharged to the Secondary Pond, and in turn to the Tertiary Pond, which ultimately flows towards a tributary of the Kaskaskia River, south of the Cooling Pond intake structure. The elevation of the top of ash is lower than the surrounding berms, which provide full ash containment. The Fly Ash Pond System is estimated to contain about 10,000,000 cubic yards (CY) of CCR.

2.2 Geology and Hydrogeology

Geologic units present at the Fly Ash Pond System include fill, ash generated at BEC, and unlithified glacial deposits overlying Mississippian and Pennsylvanian bedrock. Outside of the fill material, groundwater in the unlithified deposits from the water table to the top of bedrock is monitored per Illinois EPA’s request and is referred to as the Upper Groundwater Unit. This unit includes the Cahokia Alluvium, Peoria Loess, Equality Formation, and Vandalia Till Member, as described below. The Bedrock Unit beneath the unlithified deposits constitutes the geologic formation nearest the natural ground surface that is an aquifer. Thus, per 40 C.F.R. § 257.53, the Bedrock Unit comprises the Uppermost Aquifer and is monitored in accordance with 40 C.F.R. § 257.90. Details of Site geology are also provided in cross-sections AA’ through EE’ (Appendix A).

The five principal types of unlithified materials (Upper Groundwater Unit) present above the Bedrock Unit (Uppermost Aquifer), in the vicinity of the Fly Ash Pond System, consist of the following, in descending order:

- UNLITHIFIED DEPOSITS (UPPER GROUNDWATER UNIT)
  - Fill, predominantly coal ash - (fly ash, bottom ash, and slag). Fill is within the Fly Ash Pond System, but also includes constructed berms around the ponds and constructed railroad embankment to the south.
  - Cahokia Formation - (alluvial clay, sandy clay, and clayey sand). The Cahokia Formation is the uppermost unlithified unit between the ash ponds and the Kaskaskia River, and along the south side of the western third of the Fly Ash Pond System. The Cahokia, an alluvial deposit of the Kaskaskia River and its tributaries, consists predominantly of clay with some clayey sand and sandy clay intervals.
  - Peoria Loess - (silt and silty clay). The Peoria Loess occurs in topographically higher areas and bedrock upland areas and is typically underlain by the Vandalia Till Member of the Glasford Formation. It was categorized as silt and silty clay and ranges from 2 to 23 ft. in thickness.
  - Equality Formation - (clay and sandy clay with occasional sand seams and lenses). The Equality Formation is present as the lowermost unlithified geologic layer along the southwestern portion of the Fly Ash Pond System, where it lies between the Cahokia and bedrock. It is present as the uppermost unlithified layer at the south-central portion of the Fly Ash Pond System where the Cahokia pinches out. It is also the present as the middle or uppermost unlithified layer in the central portion of the Fly Ash Pond System, where it is either the uppermost unit above the Vandalia Till Member or lies between the Vandalia Till Member and either the Peoria Loess or CCR and fill material. The Equality was deposited in a slackwater lake formed as a result of back flooding of the Kaskaskia River during flooding events of the Mississippi River. The Equality ranged in thickness from 8 to 20 ft.
  - Vandalia Till Member - (clay and sandy clay diamictons with intermittent and discontinuous sand lenses). The Vandalia Till Member of the Glasford Formation is the lowermost and oldest unlithified geologic material in the vicinity of the Fly Ash Pond System. The Vandalia Till is a diamicton and occurs beneath the Equality in the central portion of the Site as the Cahokia pinches out and as the topographic and bedrock uplands are approached. At the higher topographic elevations (*i.e.*, bedrock uplands) to the east and southeast of the ash ponds, the Vandalia Till is the principal unlithified geologic material, but may be mantled in some areas by 4 to 6 ft of the Peoria Loess. The Vandalia Till also exhibits some intermittent and discontinuous sand lenses. The lowermost portion of the Vandalia Till may become shaley within a few feet of the top of bedrock.
- BEDROCK UNIT (UPPERMOST AQUIFER)
  - Bedrock Unit (Uppermost Aquifer). - The Bedrock Unit is the Uppermost Aquifer beneath the Fly Ash Pond System. The Bedrock Unit consists of Pennsylvanian and Mississippian bedrock, mainly limestone and shale. The shallow bedrock transitions from Mississippian-age limestone and shale beneath the western portion of the Site, to Pennsylvanian-age limestone and shale toward the east (Willman, 1967). The change from Mississippian bedrock to Pennsylvanian bedrock occurs beneath the central portion of the ash ponds. The shallow bedrock is composed of interbedded and undifferentiated limestone and shale. Bedrock topography slopes generally to the west and southwest across the Fly Ash Pond System. A bedrock low is present at the southwest corner of the Site and extends

northeastward. The topographic relief of the bedrock (change in bedrock elevation beneath the site) is approximately 45 ft.

The Uppermost Aquifer is the shallow Pennsylvanian and Mississippian-aged bedrock that immediately underlies the unlithified deposits. Within the boundaries of the Site, only thin and intermittent sand lenses are present within predominantly clay deposits, thus, the unlithified materials do not represent a continuous aquifer unit. The shallow bedrock yields water through interconnected secondary porosity features (e.g. cracks, fractures, crevices, joints, bedding planes and other secondary openings). The shallow bedrock is the only water-bearing unit that is continuous across the Site. Groundwater in the Pennsylvanian and Mississippian-aged bedrock mainly occurs under semi-confined to confined conditions with the overlying unlithified unit behaving as the upper confining unit to the Uppermost Aquifer.

Groundwater flow in the unlithified glacial materials, and in the bedrock, is to the west and southwest, and ultimately flows towards the Kaskaskia River or its tributaries, which border the BEC to the west and south. The Kaskaskia River in the vicinity of the Fly Ash Pond System is a gaining stream. Groundwater flow maps completed between 2015 and 2020 are included as Appendix B. The horizontal migration of CCR constituents in groundwater is limited by the low permeability of both the unlithified deposits, and the Uppermost Aquifer.

Field measurements indicated that the horizontal hydraulic conductivity for the Upper Groundwater Unit ranged from 3.5×10^{-7} to 6.8×10^{-4} cm/s, with a geometric mean of 3.2×10^{-5} cm/s. Laboratory testing of vertical hydraulic conductivity measurements from the units that comprise the Upper Groundwater Unit have a geometric mean value of 8.6×10^{-7}. Based on field testing, the geometric mean horizontal hydraulic conductivity for the Uppermost Aquifer (Bedrock Unit) was 5.0×10^{-6} cm/s (NRT, 2014 and Appendix C).

A hydraulic conductivity of 5×10^{-6} cm/s and a median effective porosity of 30% were used to calculate bedrock groundwater velocities based on data referenced in Groundwater Quality Assessment and Phase II Hydrogeologic Investigation (NRT, 2014). Groundwater flow velocity in the vicinity of the neighboring bottom ash pond was approximately 0.0017 and 0.0009 feet per day (ft/day) as groundwater flowed from east to west across the site on March 19, 2019 and September 24, 2019, respectively. Less than 0.0008 ft/day change in groundwater velocity was observed when comparing March 19, 2019 and September 24, 2019 (Appendix C).

Recent vertical gradients determined at the site between the unlithified deposits and the bedrock Uppermost Aquifer at nested well pairs MW-150/MW-350, MW-155/MW-355, OW-156/MW-356, and MW-252/MW-352 on March 19, 2019 and September 24, 2019 are downward, with the exception of gradients at nested well pair OW-156/MW-356 (Appendix C).

2.3 Groundwater Quality and Plume Delineation

Water quality in the Uppermost Aquifer (i.e., Pennsylvanian and Mississippian-aged bedrock) decreases with increasing depth as water becomes increasingly mineralized due to naturally occurring conditions. Further, the ability of the unit to store and transmit water is dependent on the density of bedrock features that contribute to secondary porosities and whether those features are interconnected enough to yield water. Therefore, the lower limit of the uppermost aquifer is the depth at which either the groundwater is mineralized to a point that it is no longer a useable water source or the secondary porosities do not yield a sufficient volume of groundwater to produce a useable water supply.

Detection monitoring in the Uppermost Aquifer, per 40 C.F.R. § 257.90, was initiated in November 2015; statistically significant increases (SSIs) of Appendix III parameters over background concentrations were detected in October 2017. Alternate source evaluations were inconclusive for one or more of the SSIs. Therefore, in accordance with 40 C.F.R. § 257.94(e)(2), an Assessment Monitoring Program was established on April 9, 2018 (Table 1). Assessment Monitoring results identified statistically significant levels (SSLs) of the Appendix IV parameter lithium over the GWPS based on background concentrations of 0.0693 milligrams per Liter (mg/L). SSLs for lithium were identified in downgradient monitoring wells MW-375 and MW-391 (Figure 2).

In accordance with the Statistical Analysis Plan for BEC (NRT, 2017), SSLs are based on the median of the three most recent sampling event concentrations compared to the GWPS. The highest median concentrations associated with the lithium SSLs at MW-375 and MW-391 are 0.0742 milligrams per liter (mg/L) and 0.129 mg/L, respectively (Table 2). Plume delineation well (MW-350) was added to the monitoring well network at the property line down gradient of MW-391 and sampling was initiated in June of 2019. In 2020, the background groundwater protection standard (GWPS) calculation was updated to the date range of 11/1/2017 to 3/26/20 to account for changing conditions at background wells MW-304 and MW-306 (Table 2 and Figure 3). No other parameters have been identified as having SSLs for the Fly Ash Pond System.

Lithium is present in background wells in excess of the health-based screening level of 0.04 mg/L; therefore, the GWPS is based on background concentrations (Table 2 and Figure 4). Exceedances of the GWPS in the Uppermost Aquifer are limited to the area close to the BEC's south and southwest property boundary. SSLs at MW-391 are defined by MW-375 to the south, MW-350 to the west, the secondary and tertiary ponds to the northwest, and MW-366 to the northeast (Figure 3). Due to the low permeability of the bedrock Uppermost Aquifer, MW-391 did not have a sufficient quantity of groundwater to facilitate sample collection during the March, June, August, and September 2016 sampling events, as well as those in July and November 2017. Lithium concentrations in MW-391 were initially below background concentrations. As the well equilibrated with the low permeability bedrock and water levels stabilized, lithium concentrations also stabilized near current levels (Figure 4). Mann-Kendall analysis of the last six lithium concentrations observed in MW-391 indicate there is no statistically significant trend in concentrations (Appendix D) confirming the relative stability of lithium concentrations.

2.4 Source Control: IEPA-Approved Closure in Place (Soil Cover System) and MNA

Construction of source control measures is complete and included pumping to remove surface water, dewatering the CCR, relocating and/or reshaping the existing CCR to achieve acceptable grades for closure, and constructing an earthen cover system. The earthen cover system complies with applicable design requirements of the CCR Rule, including establishment of a vegetative cover to minimize long-term erosion. The new cover system will significantly minimize water infiltration into the closed CCR unit (the primary source of CCR constituents in groundwater) and improve surface water drainage off the cover system, thus reducing generation of potentially impacted water, and ultimately reducing the extent of lithium impacts in the Uppermost Aquifer.

Natural attenuation processes will constitute a "finishing step" after effective source control. Ongoing groundwater monitoring will document the attenuation and long-term effectiveness of the source control. The IEPA-Approved source control measures include, but are not limited to, the following primary components:

- Pumping to remove surface water.
- Dewatering the CCR to allow cover system construction.
- Relocating and/or reshaping the existing CCR to achieve acceptable grades for closure. Plant-generated CCR may be placed in the Baldwin Fly Ash Pond System as beneficial reuse.
- Constructing an earthen cover system that complies with the CCR Rule, including establishment of a vegetative cover to minimize long-term erosion. The soil cover system consists of a minimum 18-inch infiltration layer of compacted earthen material, with a permeability less than 1 x 10^{-5} cm/sec, which is less than the permeability of the subsoils present below the CCR to allow water in the pore space of the CCR to drain into the foundation soils and not accumulate in the closed impoundment.
- Constructing a stormwater management system to convey runoff from the final cover system into a system of interior collection channels for routing through two new stormwater detention ponds and ultimately discharging through the existing Secondary Pond and Tertiary Pond prior to discharge through the BEC's existing NPDES permitted Outfall.
- An operational sewage lagoon with a geomembrane liner is located in the northernmost end of the Baldwin Fly Ash Pond System. The sewage lagoon was constructed on top of CCR, in the northeast corner of the Baldwin Fly Ash Pond System; and, will remain open and operational after the closure of the Baldwin Fly Ash Pond System. The area surrounding this sewage lagoon will be closed in place with a final cover system, in compliance with the CCR Rule, and the final cover system will tie into the lagoon perimeter berm.
- Monitoring attenuation processes in groundwater of the Upper Groundwater Unit and the Uppermost Aquifer, to demonstrate that the extent of groundwater impact is decreasing in size and concentration following closure. In accordance with the IEPA-approved Groundwater Monitoring Plan (NRT, 2016), if a statistically significant increasing trend is observed to continue over a period of two or more years, and a subsequent hydrogeologic site investigation demonstrates that such exceedances are due to a release from the Baldwin Fly Ash Pond System, and corrective actions are necessary and appropriate to mitigate the release, a corrective action plan will be proposed as a modification to the Post-Closure Care Plan.
- Ongoing inspection and maintenance of the cover system and stormwater and property management, per the approved Post-Closure Care Plan.

3. DESCRIPTION OF CORRECTIVE MEASURES

3.1 Objectives of the Corrective Measures

The following performance standards, per 40 C.F.R. § 257.97, must be met by the selected corrective measures:

- Be protective of human health and the environment
- Attain the groundwater protection standards per 40 C.F.R. § 257.95(h)
- Provide source control to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents
- Remove from the environment as much of the contaminated material as feasible
- Comply with waste management standards, per 40 C.F.R. § 257.98(d)

3.2 Potential Groundwater Corrective Measures

Site-specific considerations regarding the Fly Ash Pond System provided in Section 2 were used to evaluate potential groundwater corrective measures. Each of the corrective measures evaluated may be capable of satisfying the performance standards listed above to varying degrees of effectiveness. The corrective measure review process yields a set of applicable corrective measures that can be used to supplement the source control activities described in Section 2. The corrective measures may be used independently or may be combined into specific remedial alternatives to leverage the advantages of multiple corrective measures to attain GWPS in the Uppermost Aquifer.

The following potential corrective measures are commonly used to mitigate groundwater impacts and were considered as a part of the CMA process:

- Monitored Natural Attenuation (MNA)
- Groundwater Extraction
- Groundwater Cutoff Wall
- Permeable Reactive Barrier
- In-Situ Chemical Treatment

3.2.1 Monitored Natural Attenuation

Both federal and state regulators have long recognized that MNA can be an acceptable component of a remedial action when it can achieve remedial action objectives in a reasonable timeframe. In 1999, the USEPA published a final policy directive (USEPA, 1999) for use of MNA for groundwater remediation and described the process as follows:

- The reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods. The 'natural attenuation processes' that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants.

The USEPA has stated that source control (like the completed IEPA-approved earthen cover system) is the most effective means of ensuring the timely attainment of remediation objectives (USEPA, 1999). Natural attenuation processes may be appropriate as a "finishing step" after effective source control implementation, if there are no risks to receptors and/or the contaminant plume is not expanding. Thus, MNA would be used in conjunction with source control measures described in Section 2.

The 1999 USEPA MNA document was focused on organic compounds in groundwater. However, in a 2015 companion document, the USEPA addressed the use of MNA for inorganic compounds in groundwater. The USEPA noted that the use of MNA to address inorganic contaminants: (1) is not intended to constitute a treatment process for inorganic contaminants; (2) when appropriately implemented, can help to restore an aquifer to beneficial uses by immobilizing contaminants onto aquifer solids and providing the primary means for attenuation of contaminants in groundwater; and (3) is not intended to be a "do nothing" response (USEPA, 2015). Rather, documenting the applicability of MNA for groundwater remediation should be thoroughly and adequately supported with site-specific characterization data and analysis in accordance with the USEPA's tiered approach to MNA (USEPA 1999, 2007, and 2015):

1. Demonstrate that the area of groundwater impacts is not expanding.
2. Determine the mechanisms and rates of attenuation.
3. Determine that the capacity of the aquifer is sufficient to attenuate the mass of constituents in groundwater and that the immobilized constituents are stable and will not remobilize.
4. Design a performance monitoring program based on the mechanisms of attenuation and establish contingency remedies (tailored to site-specific conditions) should MNA not perform adequately.

Both physical and chemical attenuation processes can contribute to the reduction in mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. Physical attenuation processes applicable to CCR include dilution, dispersion and flushing. Chemical attenuation processes applicable to CCR include precipitation and coprecipitation (*i.e.*, incorporation into sulfide minerals), sorption (*i.e*., to iron, manganese, aluminum, or other metal oxides or oxyhydroxides, or to sulfide minerals or organic matter), and ion exchange.

All inorganic compounds are subject to physical attenuation processes. Physical mechanisms may be the primary natural attenuation processes acting upon CCR constituents, such as boron, chloride and lithium, that are relatively mobile (poorly chemically attenuated). The performance of MNA as a groundwater remedy varies based on site-specific conditions. Additional data collection and analysis may be required to support the USEPA's tiered approach to MNA (USEPA, 2015) and obtain regulatory approval.

3.2.2 Groundwater Extraction

Groundwater extraction is one of the most widely used groundwater corrective measures and has a long history of performance. This corrective measure includes installation of one or more groundwater pumping wells or trenches to control and extract impacted groundwater.

Groundwater extraction captures and contains impacted groundwater and can limit plume expansion and/or off-site migration. Construction of a groundwater extraction system typically includes, but is not limited to, the following primary components:

- Designing and constructing a groundwater extraction system consisting of one or more extraction wells and operating at a rate to allow capture of CCR impacted groundwater within the Uppermost Aquifer.
- Management of extracted groundwater, which may include modification to the existing NPDES permit, including treatment prior to discharge, if necessary.
- Ongoing inspection and maintenance of the groundwater extraction system.

Remediation of inorganics by groundwater extraction can be effective, but systems do not always perform as expected. A combination of factors, including geologic heterogeneities, difficulty in flushing low permeability zones, and rates of contaminant desorption from aquifer solids can limit effectiveness. Groundwater extraction systems require ongoing operation and maintenance to ensure optimal performance and the extracted groundwater must be managed, either by ex-situ treatment or disposal.

3.2.3 Groundwater Cutoff Wall

Since the late 1970s and early 1980s, vertical cutoff walls have been used to control and/or isolate impacted groundwater. Low-permeability cutoff walls can be used to prevent horizontal off-site migration of potentially impacted groundwater. Cutoff walls act as barriers to transport of impacted groundwater and can isolate soils that have been impacted by CCR to prevent contact with unimpacted groundwater. Cutoff walls are often used in conjunction with an interior pumping system to establish a reverse gradient within the cutoff wall. The reverse gradient imparted by the pumping system maintains an inward flow through the wall, keeping it from acting as a groundwater dam and controlling potential end-around or breakout flow of contaminated groundwater.

A commonly used cutoff wall construction technology is the slurry trench method, which consists of excavating a trench and backfilling it with a soil-bentonite mixture, often created with the soils excavated from the trench. The trench is temporarily supported with bentonite slurry that is pumped into the trench as it is excavated (D'Appolonia & Ryan, 1979). Excavation for cutoff walls is conducted with conventional hydraulic excavators, hydraulic excavators equipped with specialized booms to extend their reach (*i.e.*, long-stick excavators), or chisels and clamshells, depending upon the depth of the trench and the material to be excavated. Constructing the cutoff wall such that it intersects a low-permeability material at its base, referred to as "keying", can greatly increase its effectiveness, depending on the objectives of the barrier.

Cutoff walls could be used in combination with groundwater extraction or as part of a permeable reactive barrier system (as the "funnel" in a funnel-and-gate system; Section 3.2.4). The strength of the bedrock and the required cutoff wall design depth are not known; verifying whether a cutoff wall could be constructed in the bedrock Uppermost Aquifer would be necessary.

3.2.4 Permeable Reactive Barrier

Chemical treatment via a Permeable Reactive Barrier (PRB) is defined as an emplacement of reactive materials in the subsurface designed to intercept a contaminant plume, provide a flow path through the reactive media, and transform or otherwise render the contaminant(s) into environmentally acceptable forms to attain remediation concentration goals downgradient of the barrier (EPRI, 2006).

As groundwater passes through the PRB under natural gradients, dissolved constituents in the groundwater react with the media and are transformed or immobilized. A variety of media have been used or proposed for use in PRBs. Zero-valent iron has been shown to effectively immobilize some CCR constituents, including arsenic, chromium, cobalt, molybdenum, selenium, and sulfate. Zero-valent iron has not been proven effective for boron, antimony, or lithium (EPRI, 2006).

System configurations include continuous PRBs, in which the reactive media extends across the entire path of the contaminant plume; and funnel-and-gate systems, where low-permeability barriers are installed to control groundwater flow through a permeable gate containing the reactive media. Continuous PRBs intersect the entire contaminant plume and do not materially impact the groundwater flow system. Design may or may not include keying the PRB into a low-permeability unit at depth. Funnel-and-gate systems utilize a system of barriers to groundwater flow (funnels) to direct the contaminant plume through the reactive gate. The barriers, typically some form of cutoff wall, are keyed into a low-permeability unit at depth to prevent short circuiting of the plume. Funnel-and-gate design must consider the residence time to allow chemical reactions to occur. Directing the contaminant plume through the reactive gate can significantly increase the flow velocity, thus reducing residence time.

Design of PRB systems requires rigorous site investigation to characterize the site hydrogeology and to delineate the contaminant plume. A thorough understanding of the geochemical and redox characteristics of the plume is critical to assess the feasibility of the process and select appropriate reactive media. Laboratory studies, including batch studies and column studies using samples of site groundwater, are needed to determine the effectiveness of the selected reactive media at the site (EPRI, 2006). The main considerations in selecting reactive media are as follows (EPRI, 2006):

- Reactivity - The media should be of adequate reactivity to immobilize a contaminant within the residence time of the design.
- Hydraulic performance - The media should provide adequate flow through the barrier, meaning a greater particle size than the surrounding aquifer materials. Alternatively, gravel beds have been emplaced in front of barriers to direct flow through the barrier.
- Stability - The media should remain reactive for an amount of time that makes its use economically advantageous over other technologies.
- Environmentally compatible by-products - Any by-products of media reaction should be environmentally acceptable. For example, iron released by zero-valent iron corrosion should not occur at levels exceeding regulatory acceptance levels.
- Availability and price: The media should be easy to obtain in large quantities at a price that does not negate the economic feasibility of using a PRB.

3.2.5 In-Situ Chemical Treatment

In-situ chemical treatment for inorganics are being tested and applied with increasing frequency (Evanko and Dzombak, 1997). In-situ chemical treatment includes the targeted injection of reactive media into the subsurface to mitigate groundwater impacts. Inorganic contaminants are typically remediated through immobilization by reduction or oxidation followed by precipitation or adsorption (EPRI, 2006). Chemical reactants that have been applied or are in development for application in treating inorganic contaminants include ferrous sulfate, nanoscale zero-valent iron, organo-phosphorus nutrient mixture (PrecipiPHOS™) and sodium dithionite (EPRI, 2006). Zero-valent iron has been shown to effectively immobilize some CCR constituents, including arsenic, chromium, cobalt, molybdenum, selenium, and sulfate. However, the CCR constituent detected in the Uppermost Aquifer, lithium, has not been proven to be amenable to transformation or immobilization using reactive media.

In-situ chemical treatment design considerations include the following (EPRI, 2006):

- Source location and dimensions
- Source contaminant mass
- The ability to comingle the contaminants and reactants in the subsurface
- Competing subsurface reactions (that consume added reactants)
- Hydrologic characteristics of the source and subsurface vicinity
- Delivery options for the cleanup procedure(s)
- Capture of any contaminants mobilized by the procedures
- Long-term stability of any immobilized contaminants

4. EVALUATION OF POTENTIAL CORRECTIVE MEASURES

4.1 Evaluation Criteria

The potential groundwater corrective measures described in the previous section were evaluated relative to the criteria presented in Section 1.2 and reiterated below:

- Performance
- Reliability
- Ease of implementation
- Potential impacts of appropriate potential remedies (safety impacts, cross-media impacts, and control of exposure to any residual contamination)
- Time required to begin and complete the remedy
- Institutional requirements that may substantially affect implementation of the remedy(s) (permitting, environmental or public health requirements)

These factors are presented in Table 3 to allow a qualitative evaluation of the ability of each potential corrective measure to address SSLs for lithium in the Uppermost Aquifer. The goal is to understand which potential corrective measures could be used, either independently or in combination, to attain the GWPS, as discussed in the following sections.

Discussion of potential groundwater corrective measures is provided below with content pertaining to each evaluation criteria provided above highlighted in **bold** text.

4.2 Potential Groundwater Corrective Measure Evaluation

As presented in the previous section, the following groundwater corrective measures are potentially viable to address SSLs for lithium in the Uppermost Aquifer:

- MNA
- Groundwater Extraction
- Groundwater Cutoff Wall
- Permeable Reactive Barrier
- In-Situ Chemical Treatment

These potential corrective measures are discussed below relative to their ability to effectively address the SSLs for lithium in the Uppermost Aquifer.

4.2.1 Monitored Natural Attenuation

MNA is an in-situ remedial technology which relies on source control and natural processes occurring in aquifers to attenuated dissolved constituents and thereby reduce their concentrations in groundwater. MNA is most effective at sites where the source is controlled, the contaminant plume is stable or shrinking, contaminant concentrations are low, and potential receptors are not exposed to concentrations greater than health-based values. The **performance** of MNA as a groundwater remedy can vary based on site-specific conditions; these conditions should be evaluated in accordance with USEPA's tiered approach to MNA (USEPA 1999, 2007, and 2015).

The results of an in-progress independent evaluation regarding the potential feasibility of MNA as a groundwater remedy are provided as Attachment D. This evaluation considered whether site-specific conditions appear favorable for **implementation** of MNA. As part of this evaluation, the likely ability of MNA, in combination with source control, to meet the criteria provided in 40 C.F.R. § 257.96(c) was completed; these results are also summarized in Table 3. As discussed in the independent evaluation in Attachment D, MNA performance is likely to achieve the 40 C.F.R. § 257.97 performance criteria based on the conclusions of the evaluation. Additional efforts will be completed to gather information to complete the tiered evaluation in accordance with USEPA guidance which will support the selection of MNA, in combination with source control, as a groundwater remedy. The MNA evaluation is currently underway at the Miami Fort Pond System and will be completed in 2021.

4.2.2 Groundwater Extraction

Groundwater extraction is a widely accepted groundwater corrective measure with a long track record of performance and reliability. It is routinely approved by the IEPA. The **performance** of a groundwater extraction system is dependent on site-specific hydrogeologic conditions and would require additional data collection (aquifer testing) and possibly groundwater fate and transport modeling to support the design and regulatory approval. Groundwater extraction systems are proven **reliable** when properly designed and maintained. The low-permeability and heterogeneous lithology of the bedrock Uppermost Aquifer could present difficulties for designing an effective system. The Uppermost Aquifer bedrock has a mean horizontal hydraulic conductivity of 5.0×10^{-6} cm/s and groundwater flow velocity was recently estimated in the upper aquifer at approximately 0.0017 (ft/day). For a corrective measure using groundwater extraction to effectively control off-site flow or to remove potentially contaminated groundwater, horizontal and vertical capture zone(s) must be created using pumping wells. However, the low permeability Uppermost Aquifer would restrict the ability to pump at rates high enough to establish the required capture zone(s) or require a high density of wells. Cutoff walls (Section 4.2.3) could also be used in conjunction with a pumping system to control groundwater movement. Source control measures (Section 2) will reduce the mass loading to the Uppermost Aquifer, thus reducing the total contaminant mass that would need to be captured to attain GWPS.

Implementation of a groundwater extraction system presents design challenges due to the low permeability and heterogeneous lithology of the Uppermost Aquifer. Details of the bedrock bedding planes, fracture distribution and density, as well as the contaminant distribution within the fracture system, would be needed to effectively design the extraction system. Extracted groundwater would need to be managed, which may include modification to the existing NPDES permit and treatment prior to discharge, if necessary. Trenches would likely not be feasible due to the depth and lithified character of the Uppermost Aquifer.

There could be some **impacts** associated with constructing and operating a groundwater extraction system, including some limited exposure to extracted groundwater. Additional data collection and analyses would be required to design an extraction system. Construction could be completed within 1 year. **Time of implementation** is approximately 3 to 4 years, including characterization, design, permitting and construction. **Timeframes to achieve GWPS** are dependent on site-specific conditions, which require detailed technical analysis. Groundwater extraction requires **approval by the IEPA** to be implemented.

4.2.3 Groundwater Cutoff Wall

Groundwater cutoff walls are a widely accepted corrective measure used to control and/or isolate impacted groundwater and are routinely approved by the IEPA. Cutoff walls have a long history of **reliable performance** as hydraulic barriers provided they are properly designed and constructed. Construction of a cutoff wall extending into the Uppermost Aquifer would be difficult, if it is technical feasible, because the aquifer is in bedrock. **Implementation** of a groundwater cutoff wall presents design challenges due to the lithified nature of the Uppermost Aquifer. Cutoff walls are generally constructed in unconsolidated soil deposits and keyed into low permeability materials such as bedrock. Additional site investigation would be required to verify the feasibility of a cutoff wall in the bedrock Uppermost Aquifer.

Cutoff walls are designed to act as hydraulic barriers, as a result, cutoff walls inherently alter the existing groundwater flow system. Changes to the existing groundwater flow system may need to be controlled to maximize the effectiveness of the remedy, for example, groundwater extraction may be required to control build-up of hydraulic head upgradient and around the cutoff walls. The effectiveness and **performance** of a cutoff wall as a hydraulic barrier also relies on the contrast between the hydraulic conductivity of the aquifer and the cutoff wall. The most effective barriers have hydraulic conductivity values that are several orders of magnitude lower than the aquifer that it is in contact with. A cutoff wall designed with hydraulic conductivity of 1x10-7 cm/sec would be less than two orders of magnitude lower than the aquifer with a mean conductivity of 5x10-6 cm/sec, which may adversely affect **reliability** as groundwater may migrate through the barrier under certain conditions.

There could be some **impacts** associated with constructing and operating a groundwater cutoff wall in bedrock, including changes to the groundwater flow system that have to be considered for effective groundwater corrective action. Additional data collection and analyses would be required to design a cutoff wall. Construction could be completed within 2 to 3 years. **Time of implementation** is approximately 5 to 8 years, including characterization, design, permitting and construction. To attain GWPS, cutoff walls require a separate groundwater corrective measure to operate in concert with the hydraulic barriers. Cutoff walls are commonly coupled with MNA and/or groundwater extraction as groundwater corrective measures. The **time to attain GWPS** is dependent on the selected groundwater corrective measure or measures that are coupled with the cutoff walls. Cutoff walls require **approval by the IEPA** to be implemented.

The Uppermost Aquifer is a bedrock unit consisting mainly of limestone and shale overlain by tens of feet of unlithified, fine grained soil deposits. Constructing an effective cutoff wall, with sufficient contrast between the hydraulic conductivity of the aquifer and the cutoff wall would be difficult and may not be possible; and, groundwater treatment requires a separate groundwater corrective measure. Therefore, groundwater cutoff wall was not retained as a viable corrective measure to address SSLs of lithium in the Uppermost Aquifer.

4.2.4 Permeable Reactive Barrier

PRB application as a groundwater corrective measure for lithium is not well established and more research is needed (EPRI, 2006), therefore, **performance and reliability** are unknown.

Implementation of PRBs may have design challenges associated with both groundwater hydraulics and plume configuration. The Uppermost Aquifer is a bedrock unit consisting mainly of limestone and shale overlain by tens of feet of unlithified, fine-grained soil deposits. Constructing an effective PRB system, including emplacement of reactive media, within the bedrock of the Uppermost Aquifer would be difficult, and may not be possible.

Funnel-and-gate PRBs inherently alters the existing groundwater flow system. These changes to the existing groundwater flow system may need to be controlled to reduce potential **impacts** of the remedy. Construction of PRBs could be completed within 2 to 3 years, if possible. **Time of implementation** is approximately 6 to 9 years, including characterization, design, permitting and construction. **Timeframes to achieve GWPS** are dependent on site-specific conditions, including reactivity, which is unproven, and maintenance (replacement or rejuvenation requirements) which require detailed technical analysis. PRBs and potentially associated groundwater cutoff walls (funnel-and-gate system) require **approval by the IEPA** to be implemented.

The Uppermost Aquifer is located in bedrock and the CCR constituent detected in the Uppermost Aquifer, lithium, has not been proven to be amenable to transformation or immobilization using reactive media. Therefore, PRB was not retained as a viable corrective measure to address SSLs of lithium in the Uppermost Aquifer.

4.2.5 In-Situ Chemical Treatment

In-situ chemical treatment of lithium is not well established and more research is needed (EPRI, 2006); therefore, **performance and reliability** are unknown.

Implementation of in-situ chemical treatment may have chemical delivery challenges due to the low permeability and heterogeneous lithology of the Uppermost Aquifer. Details of the bedrock bedding planes, fracture distribution and density, as well as the contaminant distribution within the fracture system, would be needed to effectively design an injection system.

Injections of reactive media will alter the geochemistry of the flow system and could be completed within 2 to 3 years, if feasible. **Time of implementation** is approximately 8 to 13 years, including characterization, design, permitting and injections. Chemical treatment alters groundwater geochemical conditions, which may result in potential **impacts** associated with implementation of the remedy. **Timeframes to achieve GWPS** are dependent on site-specific conditions, including reactivity and maintenance (replacement or rejuvenation requirements) which require detailed technical analysis. Since in-situ chemical treatment alters groundwater geochemistry implementation of the remedy **may require Underground Injection Control approval (UIC)**.

The Uppermost Aquifer is located in bedrock and the CCR constituent detected in the Uppermost Aquifer, lithium, has not been proven to be amenable to transformation or immobilization using reactive media. Therefore, in-situ chemical treatment was not retained as a viable corrective measure to address SSLs of lithium in the Uppermost Aquifer.

5. REMEDY SELECTION PROCESS

5.1 Retained Corrective Measures

This CMA was prepared to address the requirements of 40 C.F.R. § 257.96. The following potentially viable corrective measures were identified based upon site-specific conditions:

- MNA
- Groundwater Extraction

Per 40 C.F.R. § 257.97, a remedy must be selected to address the SSLs in the Uppermost Aquifer, based on the results of the CMA. The remedy should be selected as soon as feasible and must meet the following standards:

- Be protective of human health and the environment
- Attain the groundwater protection standard as specified pursuant to § 257.95(h)
- Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV to this part into the environment
- Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems
- Comply with standards for management of wastes as specified in § 257.98(d)

Source control measures completed will significantly minimize water infiltration into the closed CCR unit and allow surface water to drain off the cover system, thus reducing the generation of potentially impacted water and reducing the extent of groundwater impacts by natural attenuation, both in the unlithified deposits above bedrock and in the bedrock Uppermost Aquifer.

Based on the analysis completed to date (Attachment D), MNA combined with source control appears to be a promising groundwater remedy at the Baldwin FAP when evaluated against the requirements in 40 C.F.R. § 257.96(c). Further investigation will be completed in 2021 to collect sufficient evidence to support the tiered MNA evaluation, which will include a better understanding of site hydrogeology and conditions after closure to develop multiple lines of evidence in accordance with USEPA guidance.

Additional aquifer testing and capture zone evaluation is also required to facilitate design of a groundwater extraction system, if necessary.

The Post-Closure Care Plan includes on-going groundwater monitoring to demonstrate that the extent of groundwater impact is decreasing in size and concentration in the Uppermost Aquifer following closure. In accordance with the IEPA-approved Groundwater Monitoring Plan (NRT, 2016), if a statistically significant increasing trend is observed to continue over a period of two or more years, and a subsequent hydrogeologic site investigation demonstrates that such exceedances are due to a release from the Baldwin Fly Ash Pond System, and corrective actions are necessary and appropriate to mitigate the release, a corrective action plan will be proposed as a modification to the Post-Closure Care Plan. The corrective action plan may incorporate one or more of the corrective measures identified in this CMA to address impacts from CCR constituents in the Uppermost Aquifer.

5.2 Future Actions

Source control by IEPA-Approved closure in place was completed November 17, 2020. MNA will be implemented as part of the approved Closure Plan, including monitoring of the Uppermost Aquifer. Further investigation will be completed in 2021 to collect sufficient evidence to support the tiered MNA evaluation.

Semiannual reports per § 257.97 will continue to be prepared to describe the progress in selecting and designing the remedy that addresses SSLs for lithium in the Uppermost Aquifer. A final report describing the selected remedy and how it meets the standards listed above will also be prepared, per § 257.97.

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TABLES

Table 1 - Assessment Monitoring Program Summary, Baldwin Fly Ash Pond System

Sampling Dates	Analytical Data Receipt Date	Parameters Collected	SSL(s) Appendix IV	SSL(s) Determination Date	ASD Completion Date	CMA Completion / Status
September 25-26, 2018	November 6, 2018	Appendix III	--	--	--	--
		Appendix IV Detected[1]	Lithium (MW-375, MW-391)	January 7, 2019	NA	September 5, 2019 (completed CMA)
March 19-20, 2019	April 30, 2019	Appendix III	--	--	--	--
		Appendix IV	Lithium (MW-375, MW-391)	July 29, 2019	NA	ongoing
June 25, 2019 (delineation)[2]	July 10, 2019	Lithium	NA	NA	NA	NA
September 24-25, 2019	October 24, 2019	Appendix III	--	--	--	--
		Appendix IV Detected[1]	Lithium (MW-375, MW-391)	January 22, 2020	NA	Feasibility study phase of CMA; Public meeting held December 2, 2019
March 24-26, 2020	April 15, 2020	Appendix III	--	--	--	March 5, 2020 (Semiannual remedy selection progress report)
		Appendix IV	Lithium (MW-391)	July 30, 2020	NA	September 5, 2020 (Semiannual remedy selection progress report)
September 15-17, 2020	October 16, 2020	Appendix III	--	--	--	--
		Appendix IV Detected[1]	TBD	TBD	TBD	TBD

[O:KLT 11/23/20, C: RAB 11/24/2020]

Notes:
-- = SSL evaluation does not apply to Appendix III parameters
ASD = Alternate Source Demonstration
CMA = Corrective Measures Assessment
NA = Not Applicable
SSL = Statistically Significant Level
TBD = To Be Determined
1. Groundwater sample analysis was limited to Appendix IV parameters detected in previous events in accordance with 40 C.F.R. Part 257.95(d)(1).
2. June 25, 2019 sample was collected as part of a delineation event and the analytical result was not statistically evaluated for an SSL. Individual monitoring well exceedance of the GWPS is presented on Table 2

RAMBOLL

Table 2 - Groundwater Concentrations Delineating The Lithium Plume, Baldwin Fly Ash Pond System

Monitoring Well ID	Parameter:	Lithium (mg/L)							C
	Date:	9/25-26/2018		3/19-20/2019		6/25/2019		9/24-25/	
	GWPS	Result	Comparison Value[1]	Result	Comparison Value[1]	Result	Comparison Value[1]	Result	C
MW-304	0.0693	0.0958	0.0958	0.0833	0.0833	NS	NS	0.0836	
MW-306	0.0693	0.0132	0.0132	0.0143	0.0143	NS	NS	0.0133	
MW-350[3]	0.0693	--	--	--	--	0.0788	**0.0788**	--	
MW-366	0.0693	0.0171	0.0171	0.0101	0.0115	NS	NS	0.0177	
MW-375	0.0693	0.0707	0.0666	0.0744	0.0687	NS	NS	0.0831	
MW-377	0.0693	0.0584	0.0573	0.0603	0.0597	NS	NS	0.0671	
MW-383	0.0693	0.0354	0.0350	0.0387	0.0373	NS	NS	0.0421	
MW-384	0.0693	0.0392	0.0428	0.0433	0.0449	NS	NS	0.0451	
MW-390	0.0693	0.0146	0.0219	0.0153	0.0145	NS	NS	0.0249	
MW-391	0.0693	0.135	**0.0996**	0.128	**0.126**	NS	NS	0.124	

Notes:

Bold red highlighted concentration indicates exceedance of GWPS for parameter indicated

-- = No sample; monitoring well not part of CCR program during sampling event

GWPS = Groundwater Protection Standard

mg/L = milligrams per liter

NS = Not Sampled

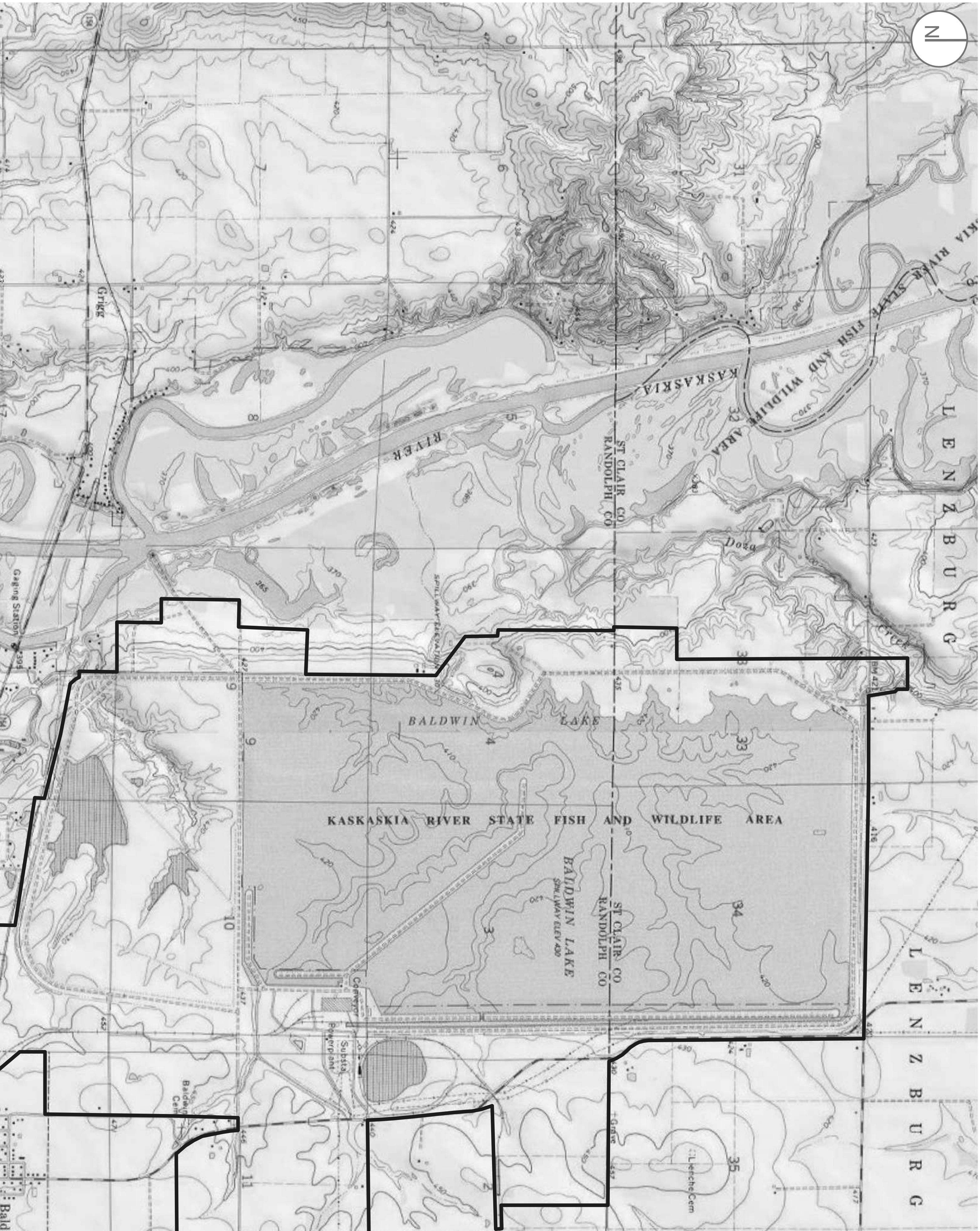
TBD = To Be Determined

1. Comparison Values are presented on plume maps.
2. Background GWPS calculation was updated to the date range of 11/1/2017-3/26/2020 to account for changing conditions in background wells MW-304 and MW-306. The
3. MW-350 was added to the monitoring network during 1st quarter 2020.

TABLE 3. CORRECTIVE MEASURES ASSESSMENT MATRIX
CORRECTIVE MEASURES ASSESSMENT
BALDWIN ENERGY COMPLEX
BALDWIN FLY ASH POND SYSTEM
BALDWIN, IL
11/30/2020

Evaluation Factors	**Performance**	**Reliability**	**Ease of Implementation**	**Potential Impacts of Remedy** (safety impacts, cross-media impacts, control of exposure to any residual contamination)	**Time Require Implemen**
MNA	Performs best paired with source control, completed at the site in 2020. Performance appears likely to be good given existing information including the stable trend for lithium prior to completion of source control	Planned additional testing will evaluate if hydrogeology is favorable for lithium dilution/dispersion	Easy - completion of tiered evaluation and long-term monitoring required, neither of which require extensive specialized equipment or contractors	None identified.	1
Groundwater Extraction	Widely accepted, routinely approved; variable performance based on site-specific conditions. May be limited by low permeability bedrock Uppermost Aquifer.	Reliable if properly designed, constructed, and maintained.	Design challenges due to hydraulic conditions of bedrock aquifer and plume configuration. Extracted groundwater would require management.	Alters groundwater flow system. Potential for some limited exposure to extracted groundwater.	3 to 4
Groundwater Cutoff Wall	Widely accepted, routinely approved, good performance if properly designed and constructed. May not be feasible for the bedrock Uppermost Aquifer.	Reliable if properly designed and constructed (if feasible).	Widely used, established technology. May not be feasible in bedrock Uppermost Aquifer.	Alters groundwater flow system.	5 to 8
Permeable Reactive Barrier	In-Situ treatment not well established for lithium, therefore performance is unknown.	Variable reliability based on site-specific groundwater hydraulics and geochemical conditions. May not be feasible in bedrock Uppermost Aquifer. Unkown reliability for lithium.	Design challenges associated with groundwater hydraulics. May not be feasible in bedrock Uppermost Aquifer.	Alters groundwater flow system.	6 to 8

FIGURES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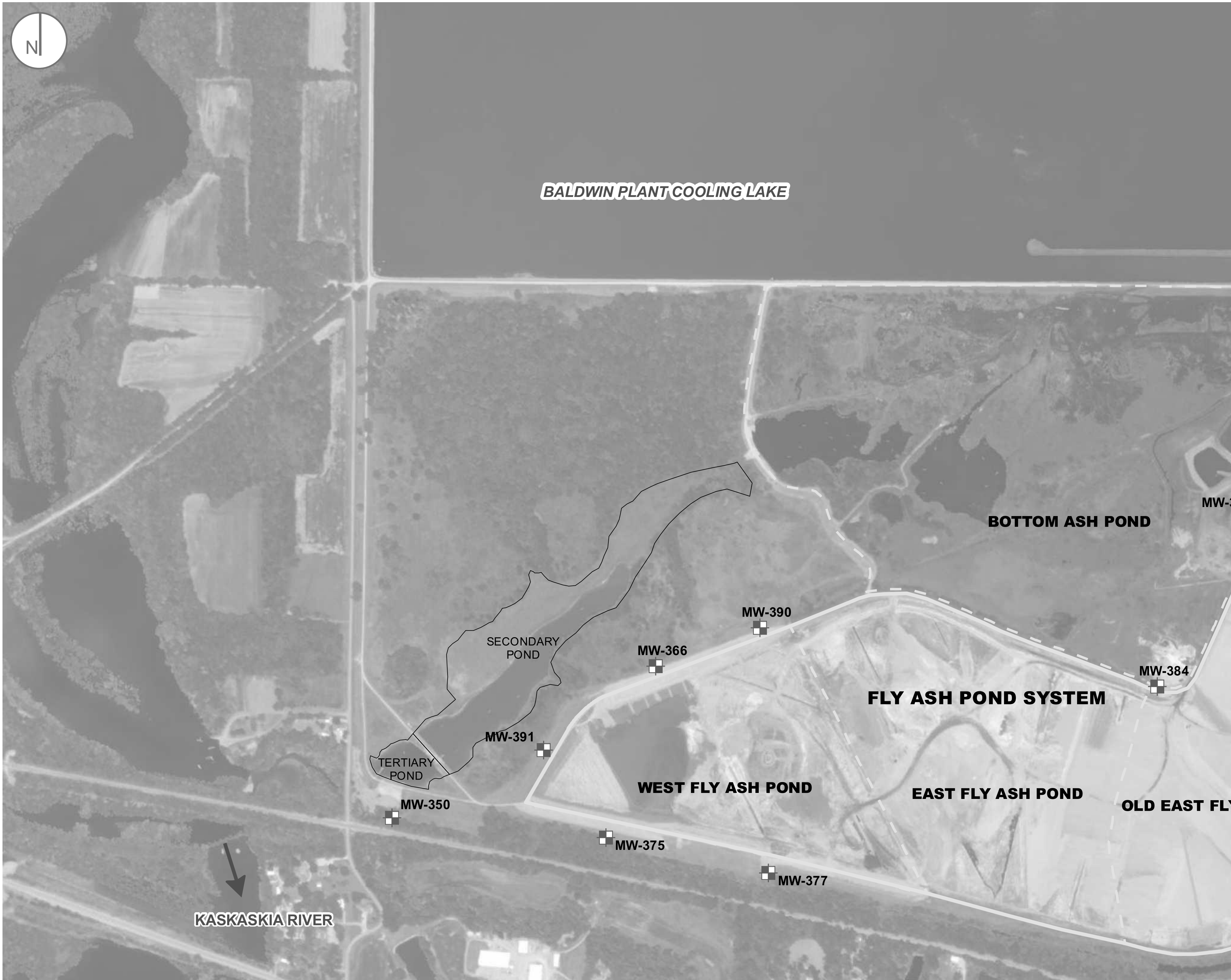
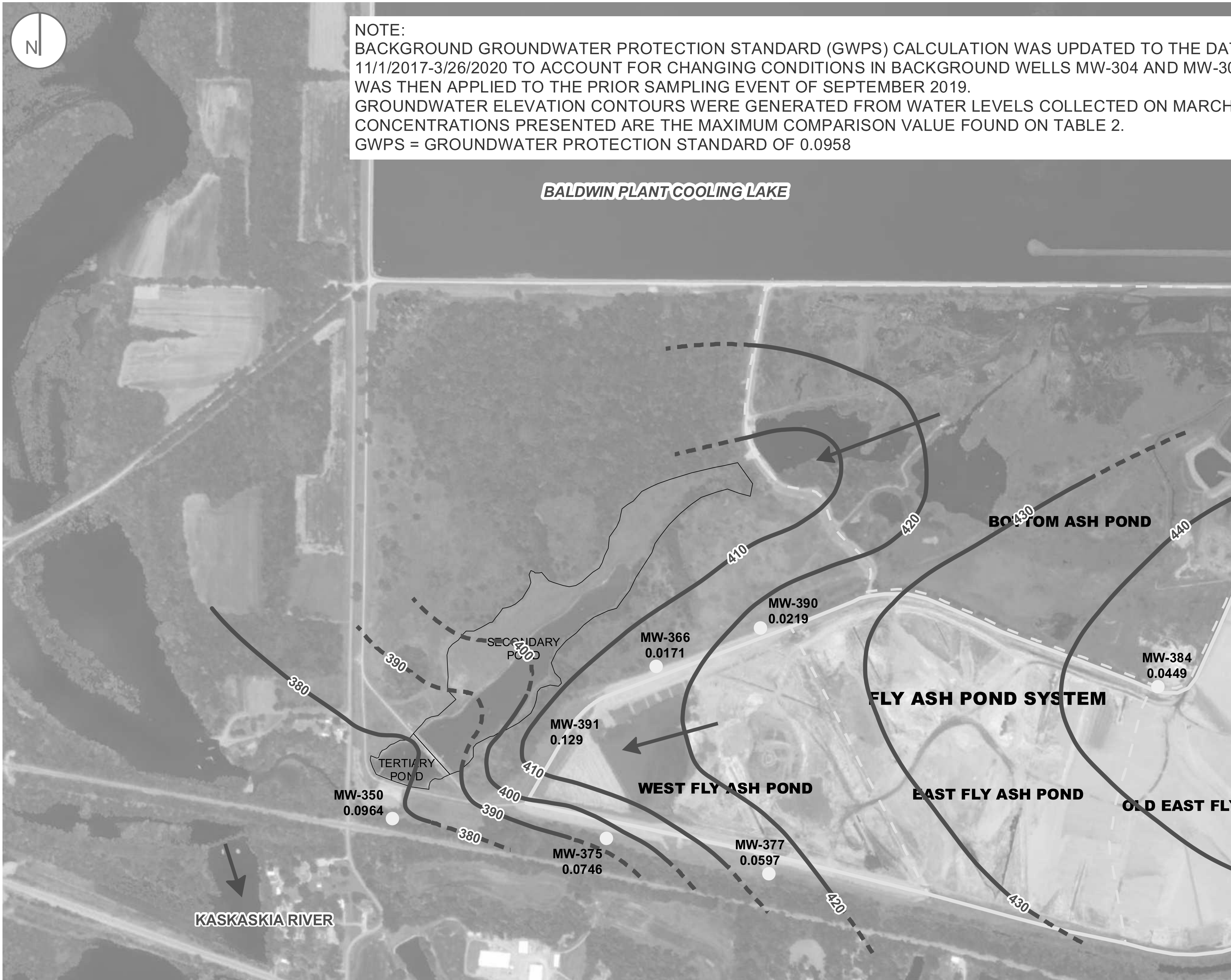
KASKASKIA RIVER STATE FISH AND WILDLIFE AREA
BALDWIN LAKE
SPILLWAY ELEV 430
ST CLAIR CO
RANDOLPH CO
KASKASKIA
RIVER
LENZBURG
Doza
Creek
Gaging Station
Grigg
Conveyor
Powerplant
Substa
Baldwin Cem
Lienche Cem
Grove
SPILLWAY ELEVATION
BM 421



Y:\Mapping\Projects\22\2285_Baldwin\MXD\Part A\Figure 1_Baldwin_Site and Well Location Map.mxd

XX | DATED: 11/25/2020 | DESIGNER: MARRAMJ

NOTE:
BACKGROUND GROUNDWATER PROTECTION STANDARD (GWPS) CALCULATION WAS UPDATED TO THE DAT
11/1/2017-3/26/2020 TO ACCOUNT FOR CHANGING CONDITIONS IN BACKGROUND WELLS MW-304 AND MW-30
WAS THEN APPLIED TO THE PRIOR SAMPLING EVENT OF SEPTEMBER 2019.
GROUNDWATER ELEVATION CONTOURS WERE GENERATED FROM WATER LEVELS COLLECTED ON MARCH
CONCENTRATIONS PRESENTED ARE THE MAXIMUM COMPARISON VALUE FOUND ON TABLE 2.
GWPS = GROUNDWATER PROTECTION STANDARD OF 0.0958



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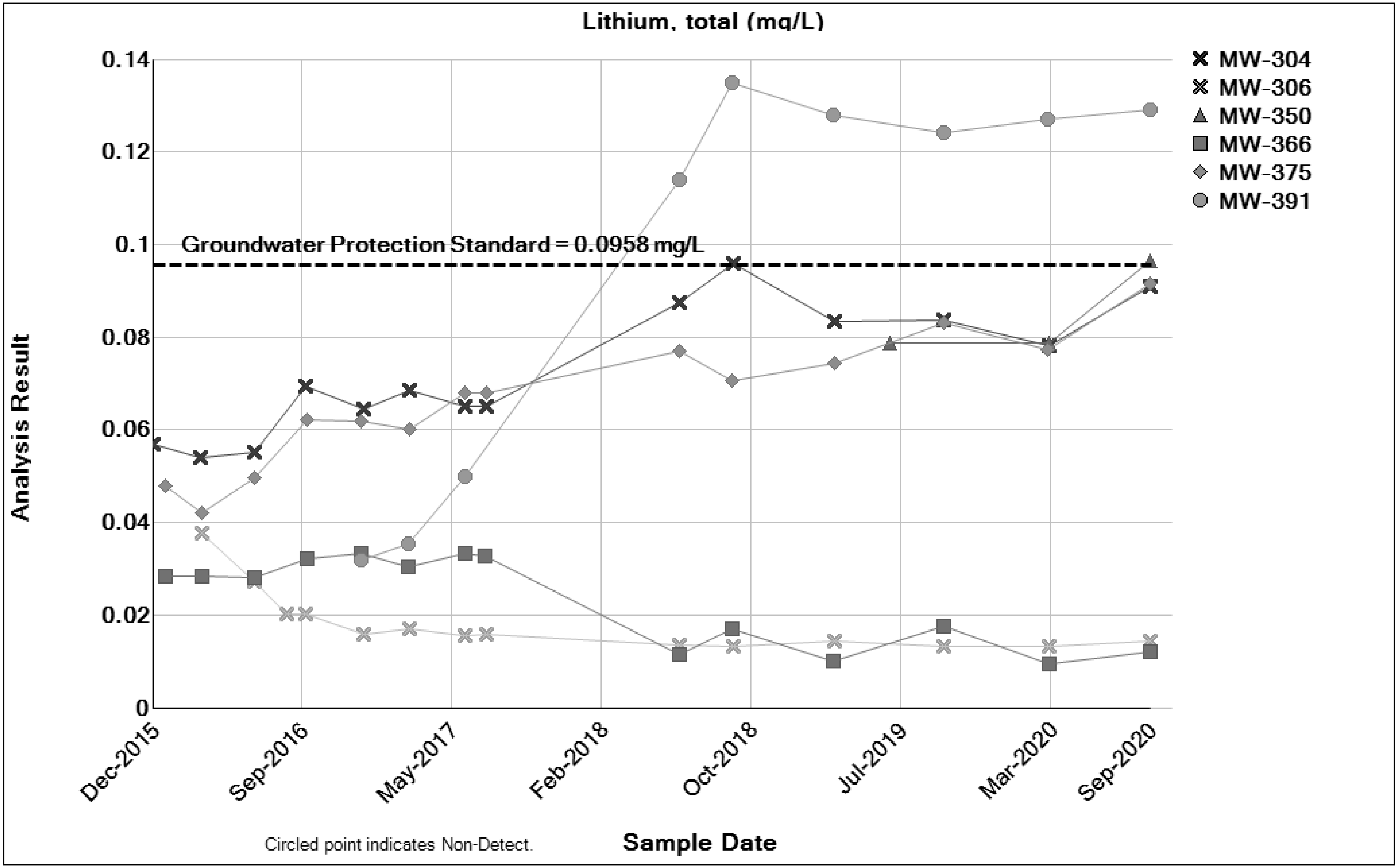


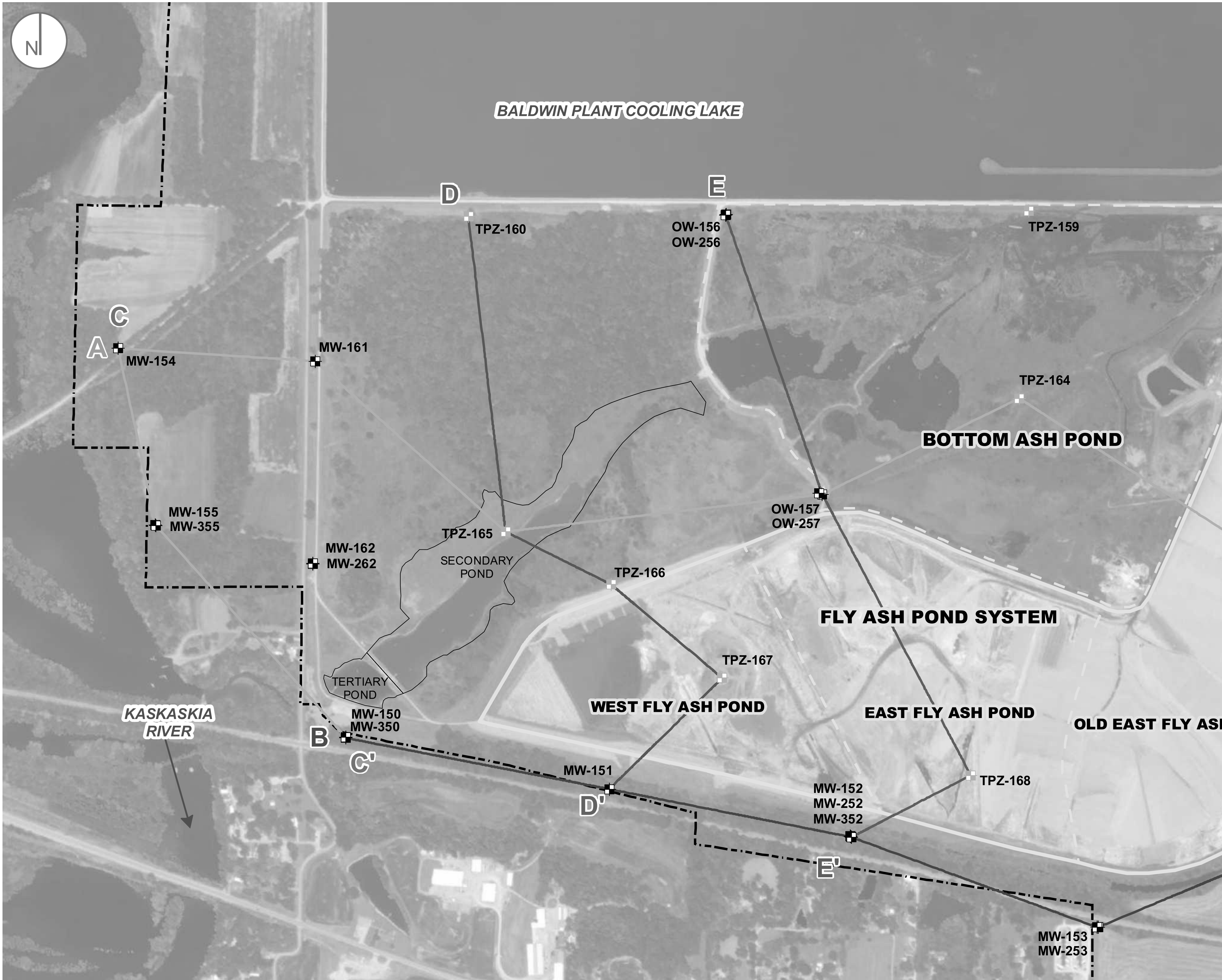
LITHIUM - TIMESERIES

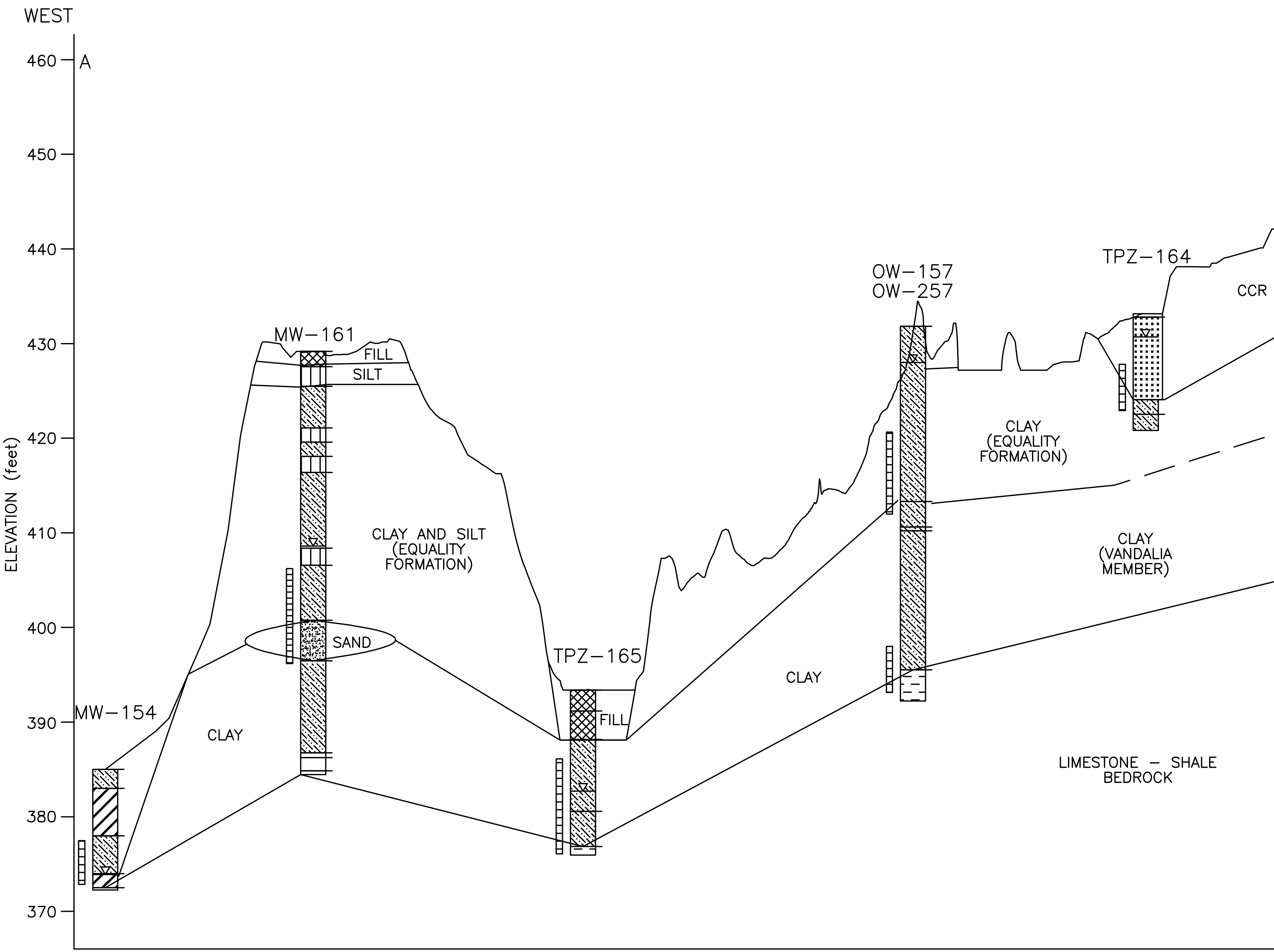
FIGURE 4

BALDWIN FLY ASH POND SYSTEM (UNIT ID: 605)
BALDWIN ENERGY COMPLEX
BALDWIN, ILLINOIS

O'BRIEN & GERE ENGINEERS, INC.
A RAMBOLL COMPANY

APPENDIX A
GEOLOGIC CROSS-SECTIONS


BALDWIN PLANT COOLING LAKE
BOTTOM ASH POND
FLY ASH POND SYSTEM
WEST FLY ASH POND
EAST FLY ASH POND
OLD EAST FLY ASH
SECONDARY POND
TERTIARY POND
KASKASKIA RIVER
A
B
C
C'
D
D'
E
E'
N
MW-154
MW-161
MW-155
MW-355
MW-162
MW-262
MW-150
MW-350
MW-151
MW-152
MW-252
MW-352
MW-153
MW-253
TPZ-160
TPZ-159
TPZ-164
TPZ-165
TPZ-166
TPZ-167
TPZ-168
OW-156
OW-256
OW-157
OW-257



LEGEND

WELL SCREEN INTERVAL   FILL   CLAY CL   CLAY CH

NOTE: This profile was developed by interpol

\\server27-01\Y Drive\Mapping\Projects\7\74914\300\Figure 5A_Cross Section A-A.dwg

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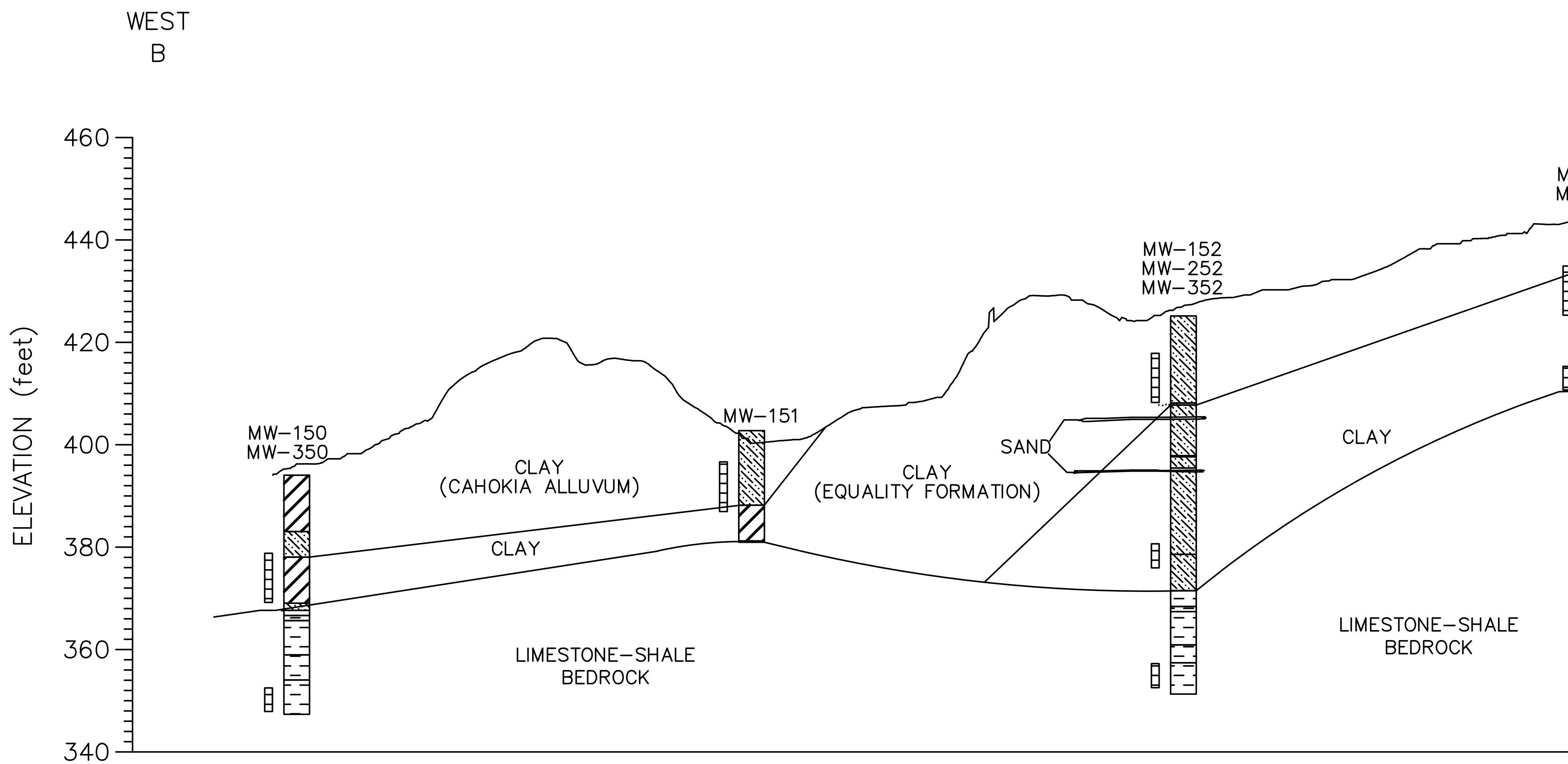
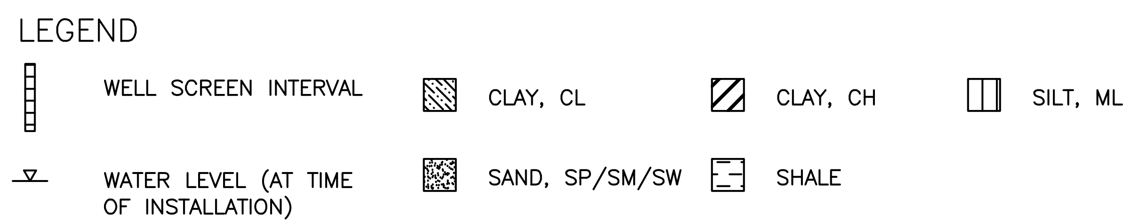
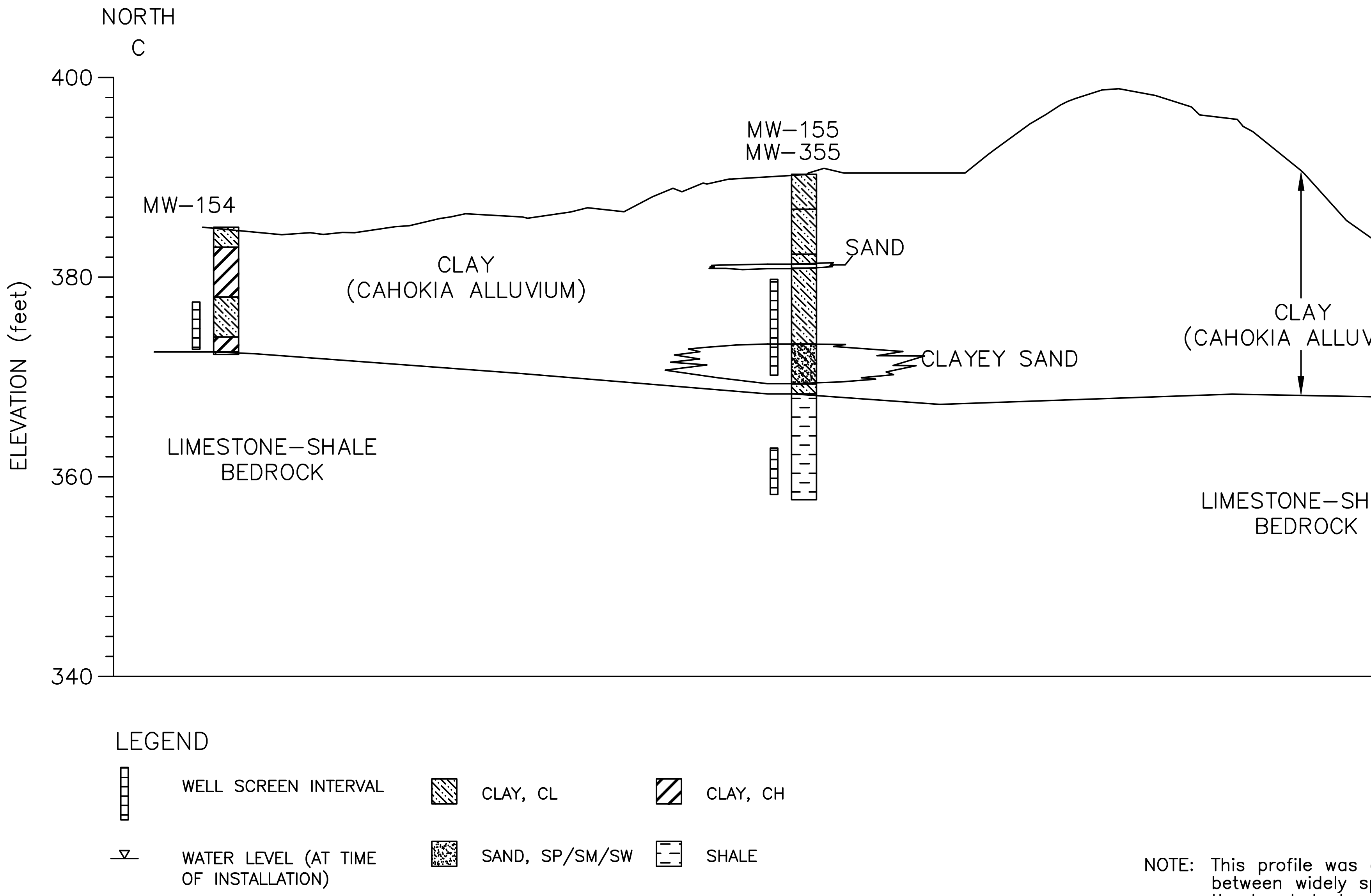




NOTE: This profile was developed by interpolation between widely spaced boreholes. Only at the borehole location should it be consider[...] as an approximately accurate representatio[...] and then only to the degree implied by th[...] notes on the borehole logs.



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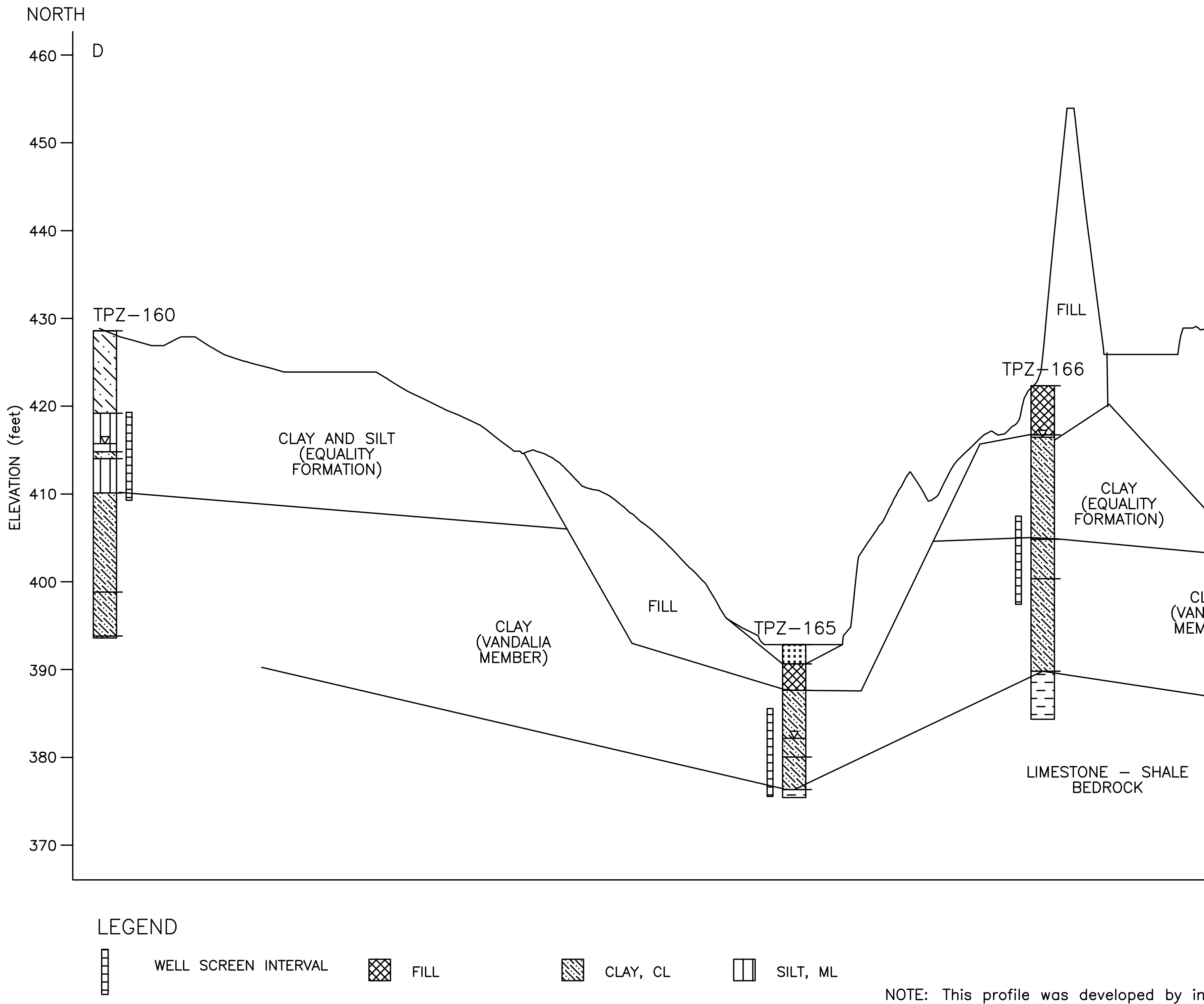

NOTE: This profile was developed by in

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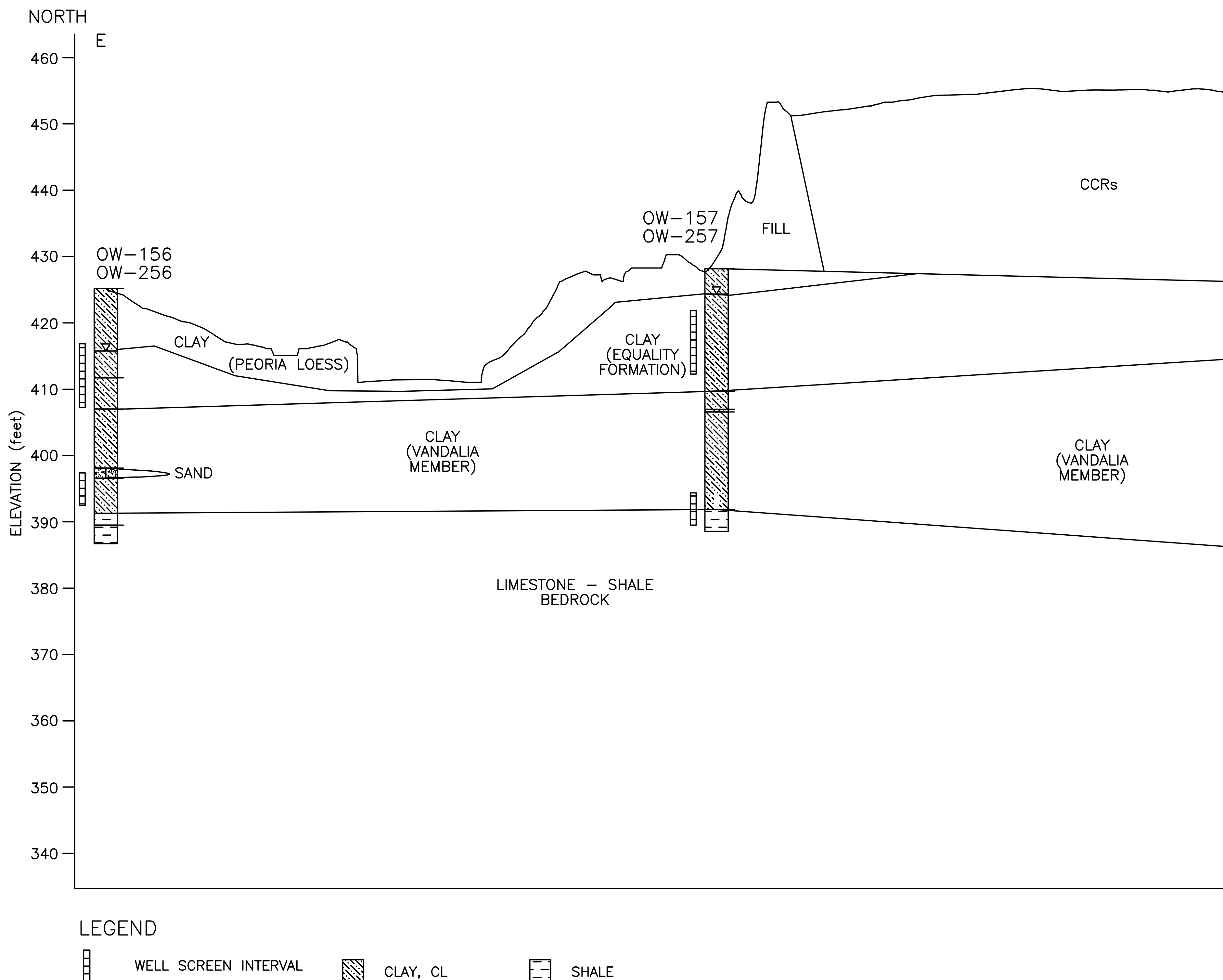

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\\server27-01\Y Drive\Mapping\Projects\7\74914\300\Figure 5E_Cross Section E-E.dwg

APPENDIX B
GROUNDWATER ELEVATION CONTOUR MAPS, 2015-2020

OPERATING RECORD
REVISION 1

TITLE 40 CFR PART 257 SECTION 257.91

GROUNDWATER ELEVATION CONTOUR MAPS
MONITORING PERIOD 2015 - QUARTER 1, 2020

LOCATION: BALDWIN ENERGY COMPLEX
LEGAL ENTITY: DYNEGY MIDWEST GENERATION, LLC
UNIT IDENTIFICATION NUMBER: 605
UNIT NAME: BALDWIN FLY ASH POND SYSTEM

und_01\R1_BaldwinFAPS_GW_Contours.mxd Author: stolzsd; Date/Time: 10/2/2017, 12:46:56 PM

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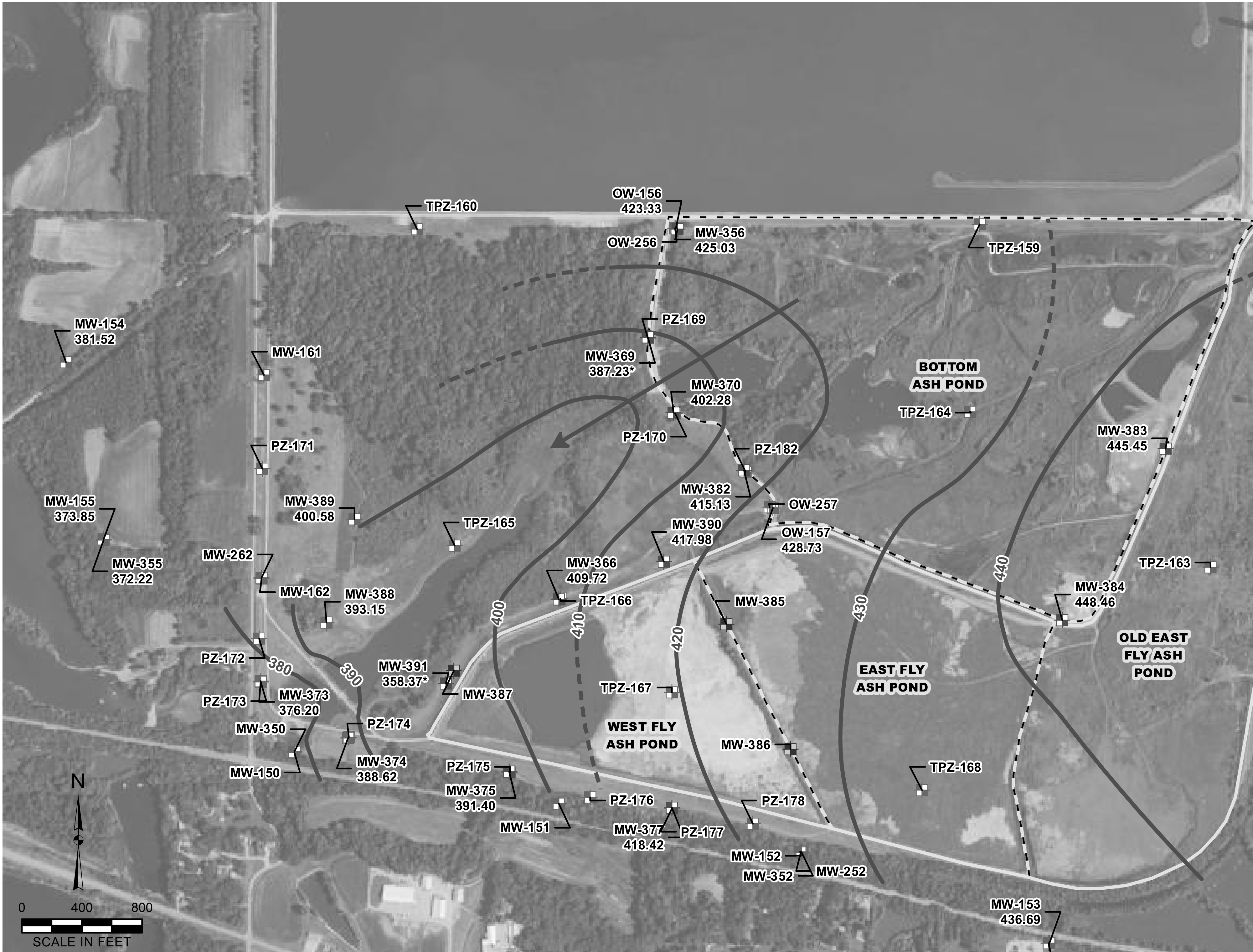

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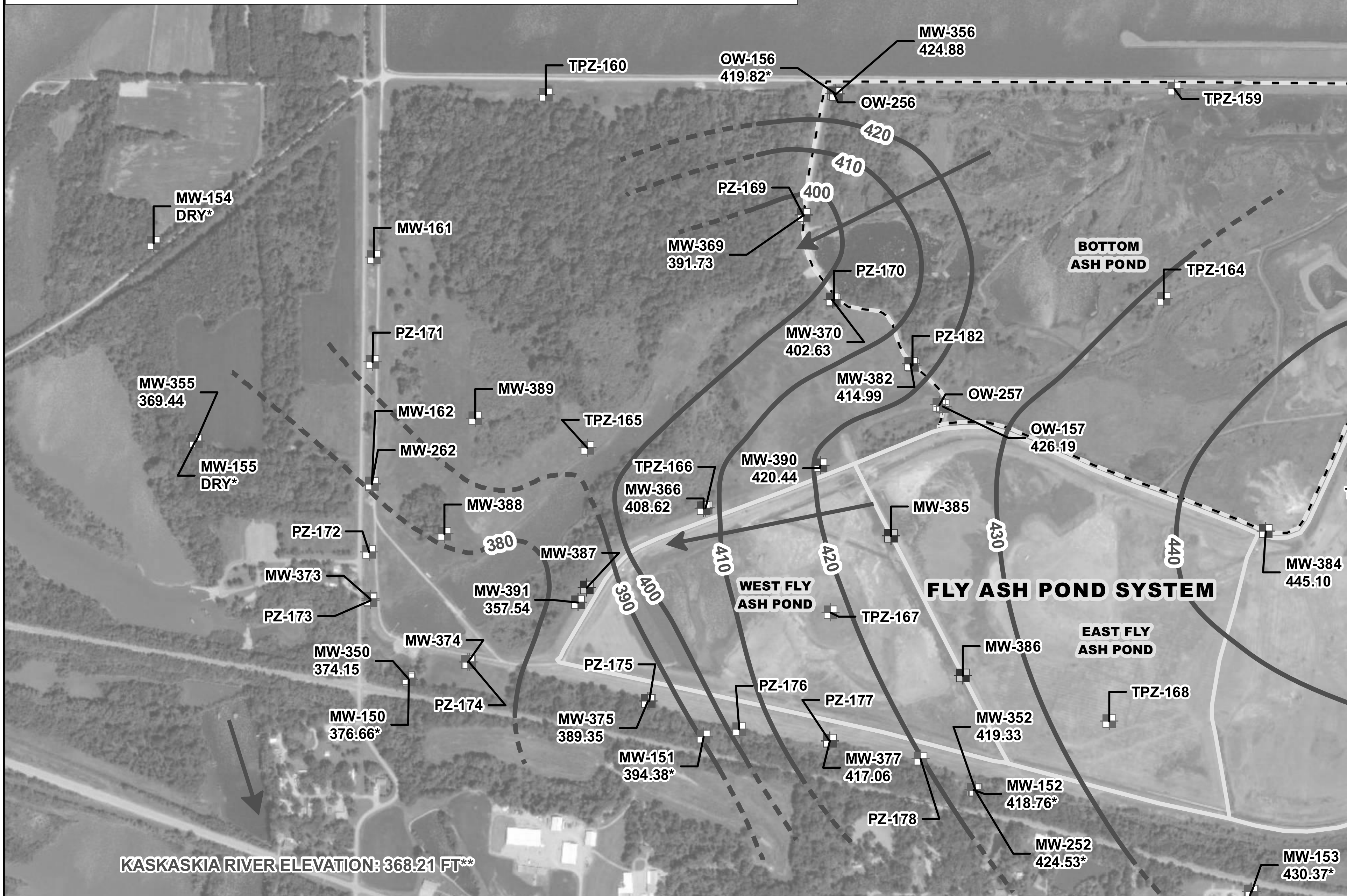
TPZ-160
OW-156
423.70
OW-256
MW-356
425.20
TPZ-159
MW-154
376.76
MW-161
PZ-169
MW-369
397.02*
420
BOTTOM
ASH
POND
TPZ-164
PZ-170
MW-370
402.81
410
MW-382
415.29
MW-383
443.72
PZ-171
400
PZ-182
OW-157
426.79
OW-257
MW-389
402.06
MW-155
376.60
TPZ-165
MW-390
418.72
TPZ-163
MW-355
372.39
MW-262
MW-162
MW-366
410.51
440
MW-385
MW-388
394.29
TPZ-166
OLD EAST
FLY ASH
POND
MW-384
447.78
PZ-172
390
380
MW-373
377.49
PZ-173
MW-391
358.88*
MW-387
WEST FLY
ASH POND
TPZ-167
EAST FLY
ASH POND
MW-350
375.52
PZ-174
MW-374
389.17
MW-386
TPZ-168
MW-150
377.35
MW-375
392.08
PZ-175
PZ-176
PZ-177
PZ-178
MW-151
MW-377
418.18
MW-152
419.59
MW-252
425.05
MW-352
419.86
MW-253
433.85
N
0
400
800
SCALE IN FEET

und_08\R8_Baldwin_GW_Contours.mxd Author: stolzsd; Date/Time: 9/1/2017, 4:35:46 PM

NOTE: MONITORING WELL OW-156 AND OW-157 IDENTIFIED AS MW-156 AND MW-157S, RESPECTIVELY, ON NPDES PERMIT NO. IL0000043 SPECIAL CONDITION 17.
* = MONITORING WELL GROUNDWATER ELEVATION NOT USED FOR CONTOURING
**RIVER ELEVATION OBTAINED FROM UNITED STATES GEOLOGICAL SURVEY KASKASKIA RIVER NEAR RED BUD, IL GAUGING STATION (05595240). ELEVATION WAS REPORTED IN NGVD29 THEN CONVERTED TO NAVD88. AT THE TIME OF THIS DRAWING, THE DATA WAS PRELIMINARY AND SUBJECT TO CHANGE
NON-CCR RULE WELLS WERE NOT MONITORED FOR ELEVATION. AVAILABLE ELEVATION DATA IS PROVIDED.



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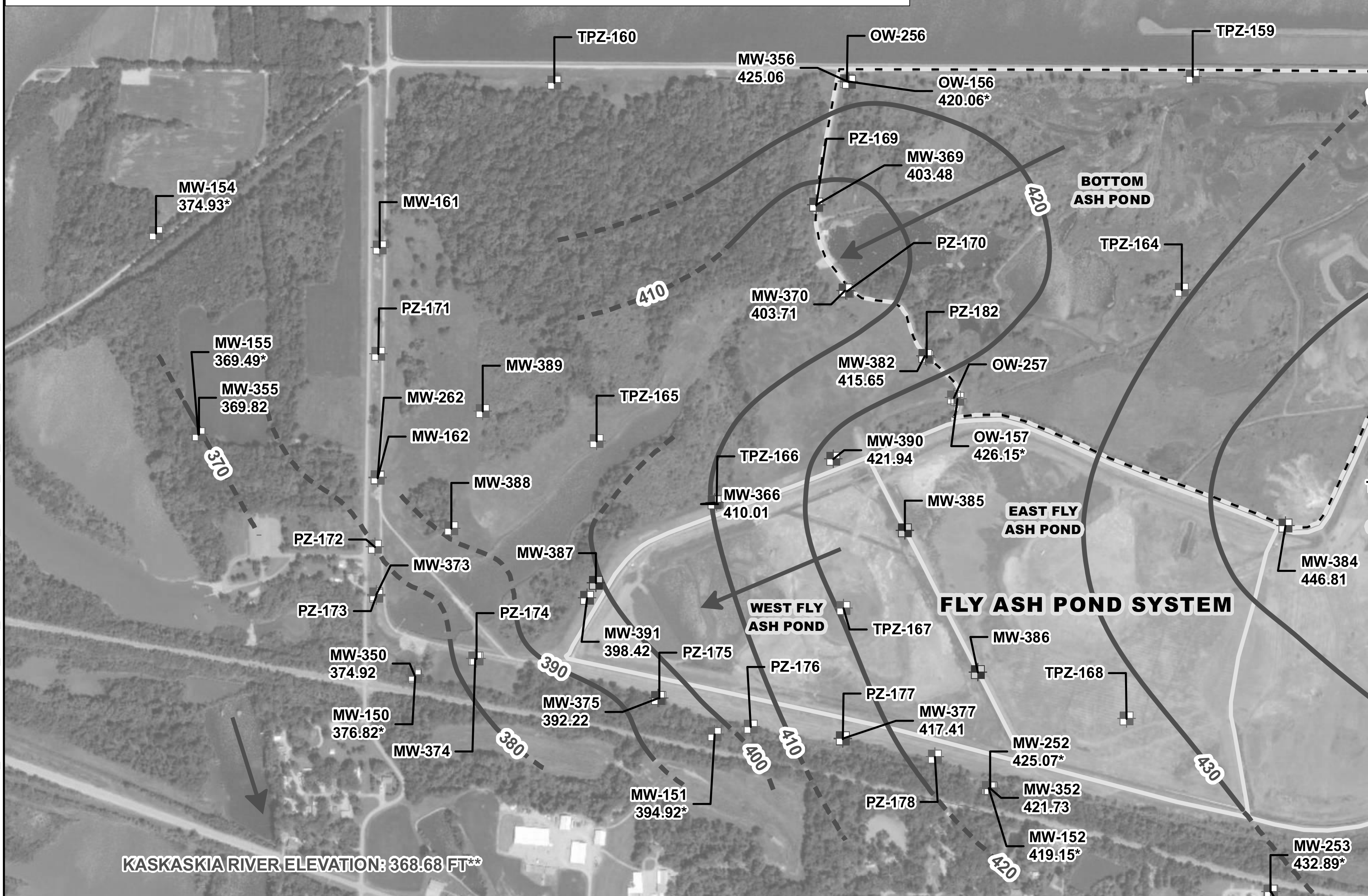
ELEVATION WAS REPORTED IN NGVD29 THEN CONVERTED TO NAVD88.
AT THE TIME OF THIS DRAWING, THE DATA WAS PRELIMINARY AND SUBJECT TO CHANGE.
NON-CCR RULE WELLS WERE NOT MONITORED FOR ELEVATION. AVAILABLE ELEVATION DATA IS PROVIDED.



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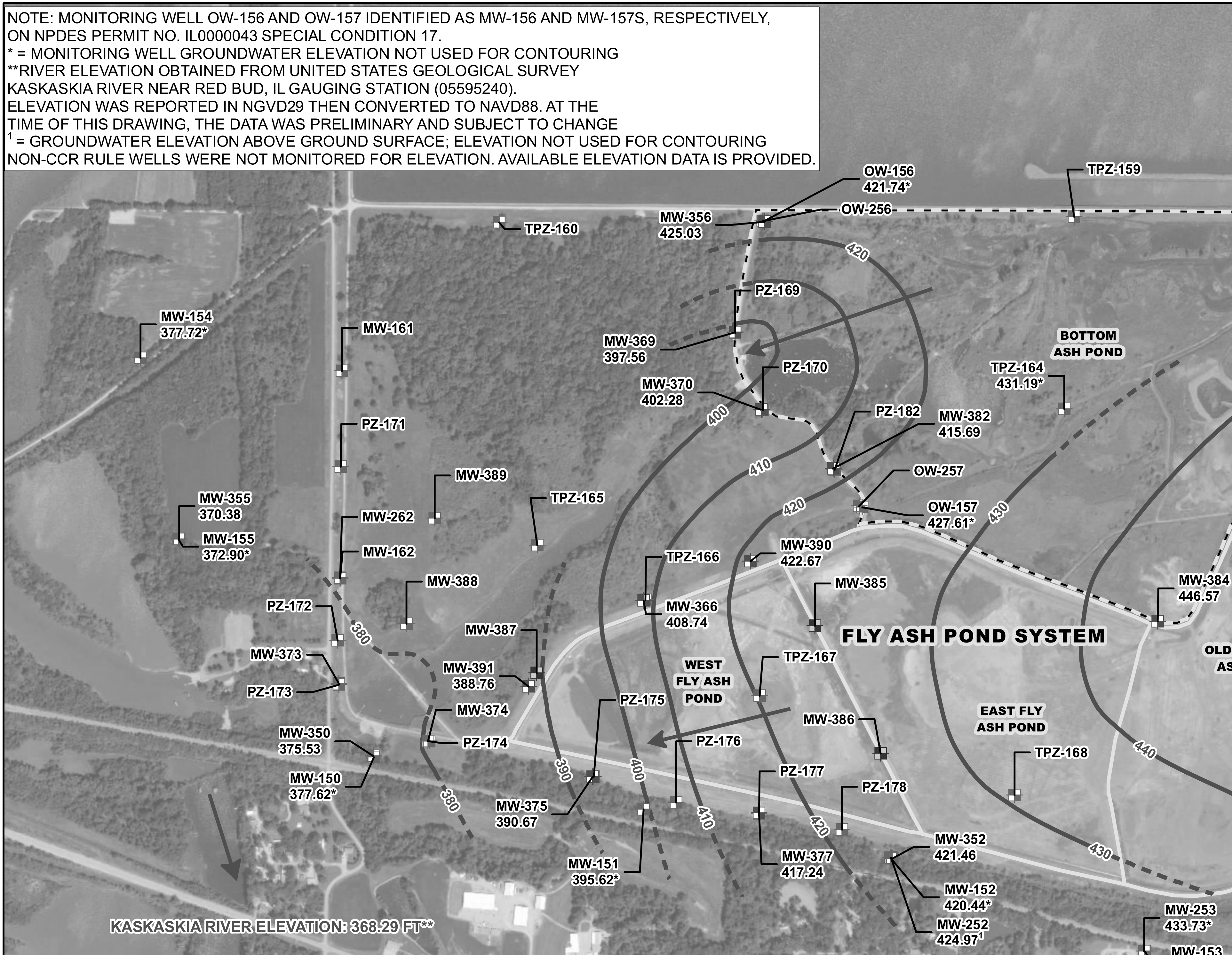

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[1] = GROUNDWATER ELEVATION ABOVE GROUND SURFACE; ELEVATION NOT USED FOR CONTOURING
NON-CCR RULE WELLS WERE NOT MONITORED FOR ELEVATION. AVAILABLE ELEVATION DATA IS PROVIDED.

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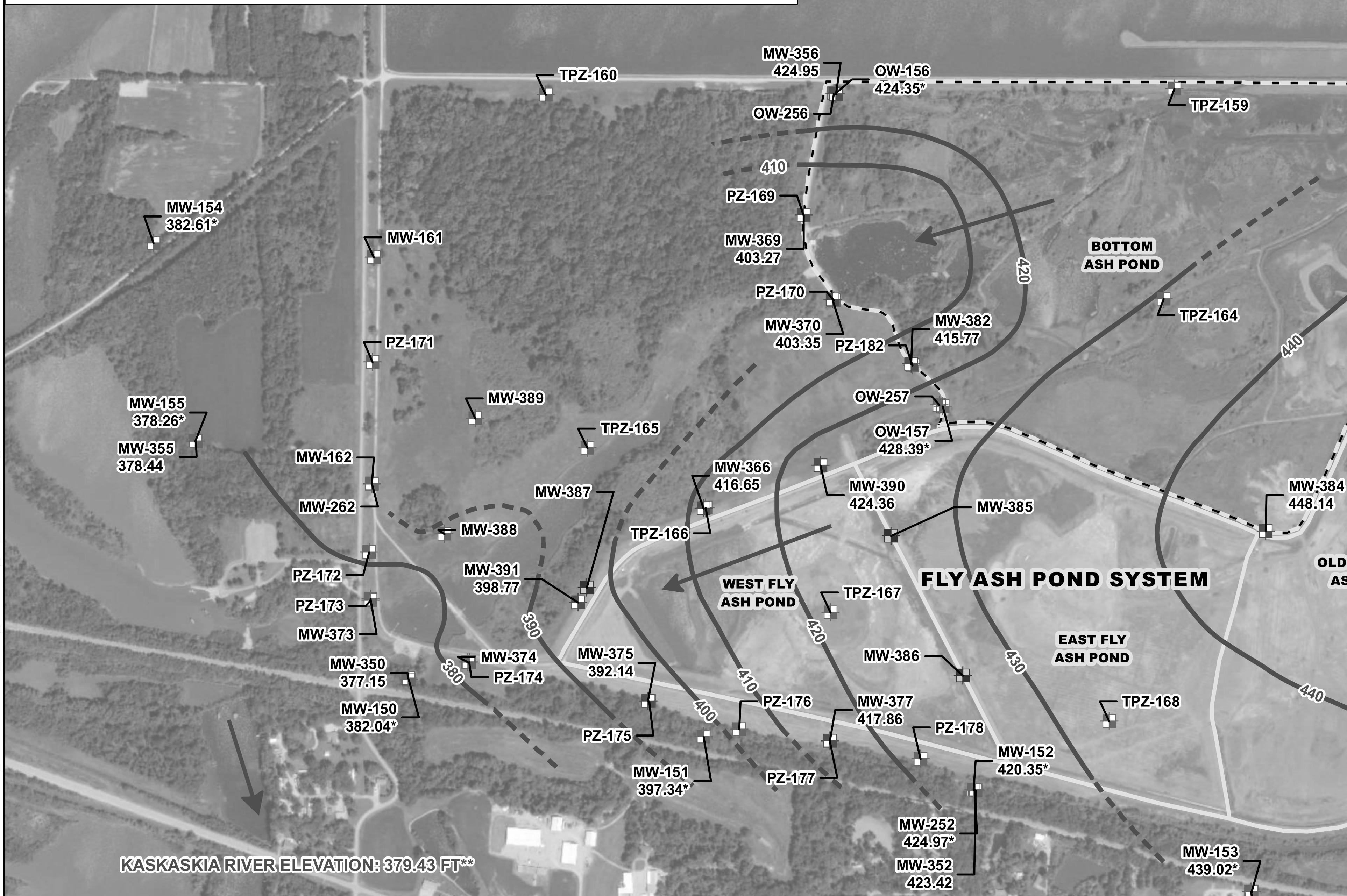
NON-CCR RULE WELLS WERE NOT MONITORED FOR ELEVATION. AVAILABLE ELEVATION DATA IS PROVIDED.



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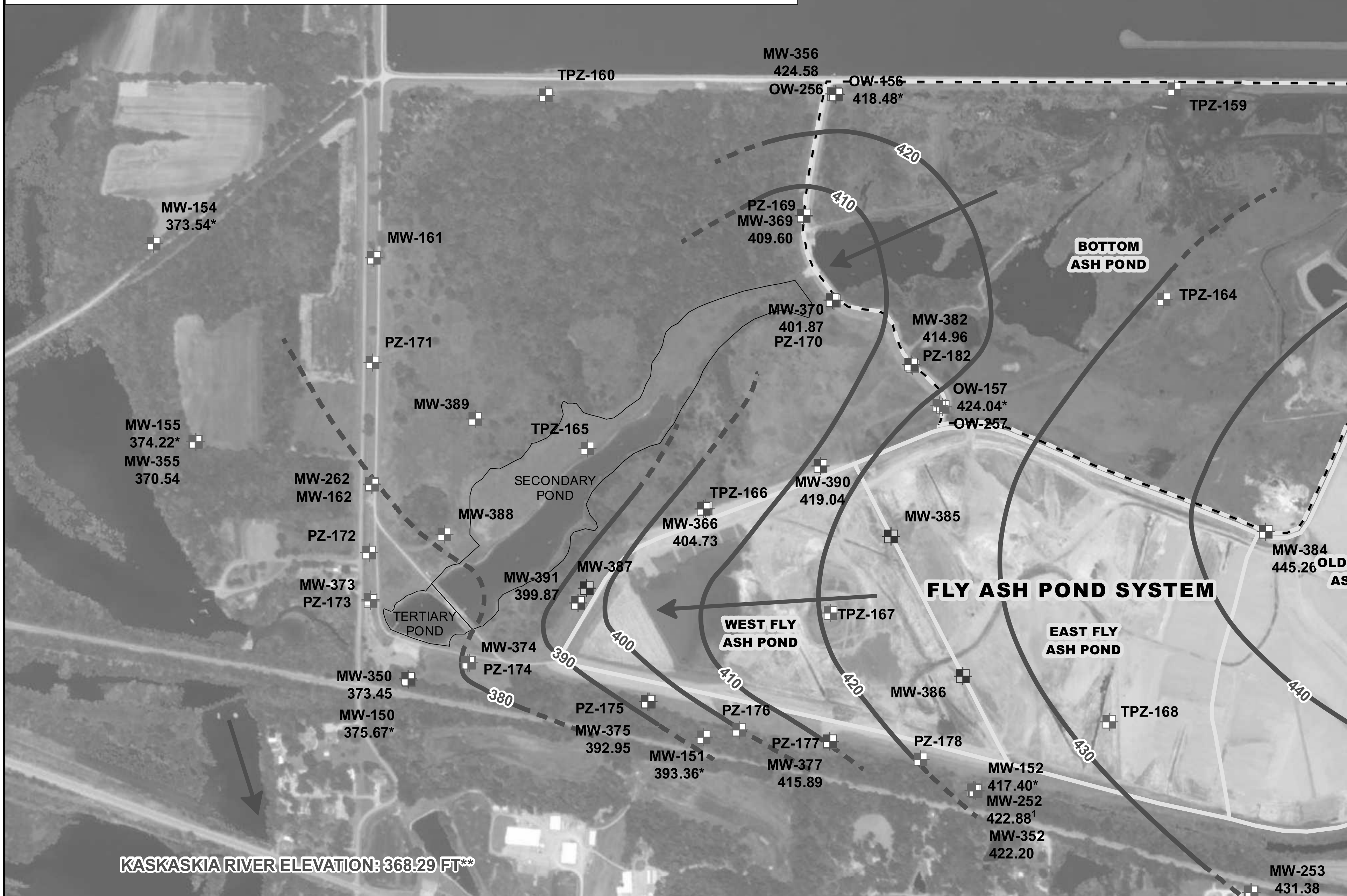
ELEVATION WAS REPORTED IN NGVD29 THEN CONVERTED TO NAVD88. AT THE TIME OF THIS DRAWING, THE DATA WAS PRELIMINARY AND SUBJECT TO CHANGE
NON-CCR RULE WELLS WERE NOT MONITORED FOR ELEVATION. AVAILABLE ELEVATION DATA IS PROVIDED.



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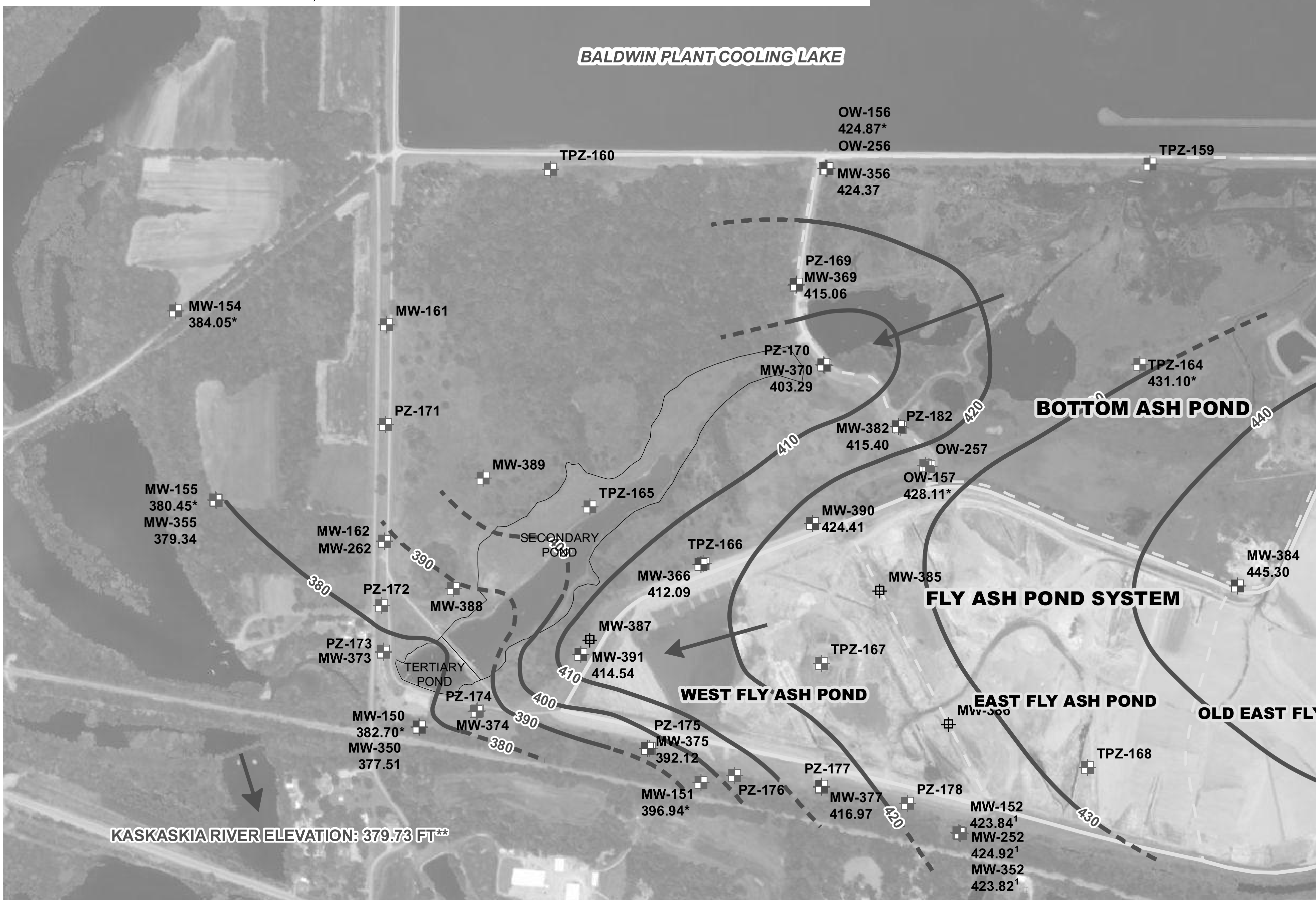
NON-CCR RULE WELLS WERE NOT MONITORED FOR ELEVATION. AVAILABLE ELEVATION DATA IS PROVIDED.
1 = WATER LEVEL ABOVE GROUND SURFACE, MONITORING WELL GROUNDWATER ELEVATION NOT USED FOR CONTOURING



APPENDIX C
VERTICAL AND HORIZONTAL GRADIENTS

TABLE C1
SUMMARY OF HORIZONTAL AND VERTICAL PERMEABILITY TEST RESULTS
BALDWIN ASH POND SYSTEM (UNIT ID: 605)
BALDWIN ENERGY COMPLEX
BALDWIN, ILLINOIS

Horizontal Hydraulic Conductivity: Field Test Results					
Monitoring Well Number	**Depth Interval Tested (feet)**	**Analysis Method**	**Lithologic Layer**	**Primary Lithologies within Screened Well Interval**	**Horizontal Hydraulic Conductivity (cm/s)**
Hydrogeologic Unit 2: Unlithified Deposits					
MW-104DR	23.2 - 28.2	Bouwer-Rice	Vandalia Till Member	Sand (fine-medium), Sandy Clay, and Silty Clay	6.8E-04
MW-151	6.1 - 15.8	Bouwer-Rice	Cahokia Formation	Sandy Clay, Silty Clay and Clay	1.1E-05
MW-152	7.5 - 16.7	Bouwer-Rice	Equality Formation	Clay	7.0E-05
OW-156	7.9 - 17.2	Bouwer-Rice	Equality Formation	Clay and Silty Clay	4.3E-05
OW-157	7.8 - 17.1	Bouwer-Rice	Equality Formation	Clay and Silty Clay	1.3E-04
MW-161	23.3 - 32.8	Bouwer-Rice	Equality Formation	Silty Clay, Sand with Silt	8.1E-05
TPZ-166	15.3 - 24.7	Bouwer-Rice	Vandalia Till Member	Silty Clay	1.9E-05
MW-252	44.4 - 49.0	Bouwer-Rice	Vandalia Till Member	Clay	1.9E-06
MW-253	29.9 - 34.5	Bouwer-Rice	Vandalia Till Member	Clay, shaley	3.5E-07
OW-256	28.0 - 32.5	Bouwer-Rice	Vandalia Till Member	Silty Clay, Sand (fine-medium)	2.2E-04
OW-257	34.0 - 38.5	Bouwer-Rice / KGS Model	Vandalia Till Member	Silty Clay	3.3E-06
MW-262	42.1 - 46.6	Bouwer-Rice	Vandalia Till Member	Sand with Silt, Sand, Silty Clay	6.0E-04
				Geometric Mean Hydraulic Conductivity	**3.2E-05**
Hydrogeologic Unit 3: Upper Bedrock					
MW-350	41.6 - 46.2	Bouwer-Rice	Mississippian Bedrock	Limestone, massive, hard to very hard; RQD = 96% (Excellent)	2.1E-06
MW-352	67.9 - 72.5	Bouwer-Rice	Pennsylvanian or Mississippian Bedrock	Limestone, medium hard to hard; RQD = 57% (Fair)	1.7E-06
MW-355	27.4 - 32.0	Bouwer-Rice	Mississippian Bedrock	Limestone, medium soft, fossiliferous; RQD = 57% (Fair)	3.5E-05
				Geometric Mean Hydraulic Conductivity	**5.0E-06**

Vertical Hydraulic Conductivity: Laboratory Test Results					
Monitoring Well Number	**Depth Interval Tested (feet)**	**Analysis Method**	**Lithologic Layer**	**Primary Lithologies within Screened Well Interval**	**Horizontal Hydraulic Conductivity (cm/s)**
Hydrogeologic Unit 1: Fill Unit					
TPZ-163	1.5 - 3.5	Geotechnology (2013)	Ash Pond System: Fly Ash / Bottom Ash	Ash (USCS classification: Silty Sand, fine grained)	2.5E-04
TPZ-164	3.0 - 5.0	Geotechnology (2013)	Ash Pond System: Bottom Ash	Ash (USCS classification: Sandy Silt, fine grained sand)	6.5E-04
TPZ-167	29.0 - 30.0	Geotechnology (2013)	Ash Pond System: Fly Ash	Ash (USCS classification: Silt)	9.7E-06
TPZ-168	3.0 - 5.0	Geotechnology (2013)	Ash Pond System: Fly Ash	Ash (USCS classification: Sandy Silt, fine-medium grained sand)	4.2E-04
				Geometric Mean Hydraulic Conductivity	**1.6E-04**
Hydrogeologic Unit 2: Unlithified Deposits					
MW-154	8.0 - 9.2	Shively Geotechnical (2010)	Cahokia Formation	Sandy Clay with gravel	7.8E-06
MW-350	18.0 - 20.0	Shively Geotechnical (2010)	Cahokia Formation	Clay	3.4E-07
TPZ-164	10.0 - 12.0	Geotechnology (2013)	Equality Formation	Clay	1.3E-06
MW-252	44.0 - 46.0	Shively Geotechnical (2010)	Vandalia Member	Clay	6.3E-09
MW-262	33.5 - 35.5	Geotechnology (2013)	Vandalia Member	Clay	9.9E-09
TPZ-163	28.0 - 30.0	Geotechnology (2013)	Vandalia Member	Clay, trace fine sand	4.2E-04
TPZ-165	8.0 - 10.0	Geotechnology (2013)	Vandalia Member	Clay, trace sand	5.3E-06
TPZ-167	32.0 - 34.0	Geotechnology (2013)	Vandalia Member	Clay with sand	6.2E-07
				Geometric Mean Hydraulic Conductivity	**8.6E-07**

Notes:
cm/s = centimeters per second

Reference:
Bouwer-Rice = Bouwer and Rice Analytical Method for Unconfined Aquifers, 1976. (note: also used for Confined Aquifers)
KGS Model = KGS overdamped slug test analysis model (Hyder et al., 1994)
Shively Geotechnical (2010): see Appendix D of NRT, June 11, 2014. Groundwater Quality Assessment and Phase II Hydrogeologic Investigation, Baldwin Ash Pond System
Geotechnology (2013): see Appendix D of NRT, June 11, 2014. Groundwater Quality Assessment and Phase II Hydrogeologic Investigation, Baldwin Ash Pond System
Data source was the Groundwater Quality Assessment and Phase II Hydrogeologic Investigation (NRT, June 11, 2014)

TABLE C2

GROUNDWATER HORIZONTAL HYDRAULIC GRADIENTS AND FLOW VELOCITIES

BALDWIN ASH POND SYSTEM (UNIT ID: 605)

BALDWIN ENERGY COMPLEX

BALDWIN, ILLINOIS

March 19, 2019					
Area	**Approximate Flow Direction**	**Average Hydraulic Conductivity (cm/s)**	**Horizontal Hydraulic Gradient**	**Effective Porosity**	**Velocity (ft/day)**
Baldwin Bottom Ash Pond - West	W	5E-06	0.04	0.30	0.0017
Baldwin Fly Ash Pond System - West	SW	5E-06	0.02	0.30	0.0008
September 24, 2019					
Area	**Approximate Flow Direction**	**Average Hydraulic Conductivity (cm/s)**	**Horizontal Hydraulic Gradient**	**Effective Porosity**	**Velocity (ft/day)**
Baldwin Bottom Ash Pond - West	SW	5E-06	0.02	0.30	0.0009
Baldwin Fly Ash Pond System - West	W	5E-06	0.01	0.30	0.0007

Note:

cm/s = centimeters per second

ft/day = feet per day

SW = southwest

W = west

1) cm/s x 2,835 = ft/day

2) Source of hydraulic conductivity values was the Groundwater Quality Assessment and Phase II Hydrogeologic Investigation (NRT, June 11, 2014)

TABLE C3
VERTICAL HYDRAULIC GRADIENTS
BALDWIN ASH POND SYSTEM (UNIT ID: 605)
BALDWIN ENERGY COMPLEX
BALDWIN, ILLINOIS

Monitoring Wells for Gradient Calculations across Screened Hydrogeologic Units		Screen Midpoint Elevations (feet)		Groundwater Level Measurements (Elevation in Feet)			
				3/19/2019		9/24/2019	
Shallow	**Deep**	**Shallow**	**Deep**	**Shallow**	**Deep**	**Shallow**	**Deep**
MW-104SR	MW-104DR	442.83	428.47	447.54	447.59	443.29	443.30
MW-153	MW-253	427.60	410.53	439.02	437.82	429.90	431.38
MW-152	MW-252	410.29	375.56	420.35	424.97	417.40	422.88
MW-252	MW-352	375.56	352.15	424.97	423.42	422.88	422.20
MW-150	MW-350	374.00	350.21	382.04	377.15	375.67	373.45
MW-155	MW-355	375.50	361.11	378.26	378.44	374.22	370.54
OW-156	OW-356	412.60	364.20	424.35	424.95	418.48	424.58

Monitoring Wells for Gradient Calculations Across Screened Hydrogeologic Units		Monitored Geologic Unit**		Hydrogeologic Unit***		Vertical Groundwater Gradient Between Designated Units (feet/foot)		Average Groundwater Gradient (feet/foot)
Shallow	**Deep**	**Shallow**	**Deep**	**Shallow**	**Deep**	**3/19/2019**	**9/24/2019**	
MW-104SR	MW-104DR	Vandalia	Vandalia	2	2	**-0.003**	**-0.001**	**-0.002**
MW-153	MW-253	Vandalia	Vandalia	2	2	0.070	**-0.087**	**-0.008**
MW-152	MW-252	Equality	Vandalia	2	2	**-0.133**	**-0.158**	**-0.145**
MW-252	MW-352	Vandalia	Bedrock	2	3	0.066	0.029	0.048
MW-150	MW-350	Cahokia	Bedrock	2	3	0.206	0.093	0.149
MW-155	MW-355	Cahokia	Bedrock	2	3	**-0.013**	0.281	0.134
OW-156	OW-356	Equality	Bedrock	2	3	**-0.012**	**-0.126**	**-0.069**

Notes:

-0.02 Vertical gradient is upwards between the screened well intervals and formations indicated.
0.04 Vertical gradient is downwards between the screened well intervals and formations indicated.
* Water level in shallow well was below top of screen. Midpoint elevation calculated based on water level elevation and bottom of screen.
- - No data collected on date, water level not static, or incorrectly measured/transcribed.
- - - Deep wells OW-256 and OW-257 not constructed until August 2014.
Data source was the Groundwater Quality Assessment and Phase II Hydrogeologic Investigation (NRT, June 11, 2014)

APPENDIX D
TECHNICAL MEMORANDUM – BALDWIN FLY ASH POND MONITORED NATURAL ATTENUATION (MNA) EVALUATION

Geosyntec consultants

941 Chatham Lane, Suite 103
Columbus, Ohio 43221
PH 614.468.0415
FAX 614.468.0416
www.geosyntec.com

TECHNICAL MEMORANDUM

Date:	November 30, 2020
To:	Brian Voelker - Vistra
Copies to:	Stu Cravens and Phil Morris - Vistra
From:	Allison Kreinberg, Bob Glazier, and Nathan Higgerson - Geosyntec Consultants
Subject:	Baldwin Fly Ash Pond Monitored Natural Attenuation (MNA) Evaluation Update

Geosyntec is evaluating the feasibility of monitored natural attenuation (MNA), in combination with coal combustion residual (CCR) unit source control measures, as a groundwater remedy for statistically significant levels (SSLs) of lithium above the groundwater protection standard (GWPS) at the Baldwin Fly Ash Pond (FAP) unit. As discussed in Section 2.3 of the Corrective Measures Assessment (CMA), an SSL of lithium was identified at downgradient monitoring well MW-391. The tiered evaluation is being completed in accordance with USEPA guidance[1,2] to assess whether MNA, in combination with source control, is likely to be the viable remedy based on site conditions. The findings of the study completed to-date and the additional data collection required to develop multiple lines of evidence to support the evaluation of MNA in accordance with USEPA guidance are summarized below.

MNA EVALUATION

The selection of MNA, with source control, as a remedy for groundwater constituents will be based on a multiple lines of evidence approach, as outlined in the USEPA guidance. The multiple lines of evidence approach for the Baldwin FAP will be based upon (i) source control to mitigate further loading of lithium mass to groundwater; (ii) delineation of the nature and extent of lithium impacts in groundwater; and (iii); a successful evaluation of favorable site conditions that result in the attenuation of lithium in groundwater leading to stable or declining trends of lithium in groundwater following source control implementation.

[1] USEPA. 2007. Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Volume I – Technical Basis for Assessment. EPA/600/R-07/139. October.
[2] USEPA. 2015. Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites. Directive No. 9283.1-36. August.

KEY CONDITIONS

The status of key conditions which will support the selection of MNA, in combination with source control, as a groundwater remedy is summarized below. These conditions were assessed as Tier 1 of the evaluation.

Site Geology and Hydrogeology

As noted in Section 2.2 of the CMA, the uppermost aquifer beneath the FAP is the Bedrock Unit, which consists of Pennsylvanian and Mississippian bedrock, mainly limestone and shale. The Bedrock Unit is overlain by unlithified alluvial and glacial deposits of clay, silty clay, silt, sandy clay, and clayey sand with occasional intermittent and discontinuous sand lenses. Groundwater flow in the unlithified glacial materials, and in the bedrock, is to the west and southwest, and ultimately flows towards the Kaskaskia River or its tributaries, which border the Baldwin Energy Complex to the west and south, as shown in the potentiometric map provided in Appendix A.

Source Control

Illinois Environmental Protection Agency (IEPA) approved the closure and post-closure plan on August 16, 2016, which consisted of dewatering the unit and constructing an earthen cover system with a permeability less than 1 x 10^{-5} centimeters per second (cm/sec). A stormwater management system will convey runoff from the final cover system into a system of interior collection channels before routing to stormwater detention ponds. Closure construction activities at the FAP associated with the approved closure plan were completed in November 2020. These closure measures act as improved source control and are designed to prevent future releases onsite.

Delineation of Groundwater Exceedances

As discussed in Section 2.3 of the CMA, the lithium SSL at MW-391 appears to be delineated via downgradient well MW-350. Lateral delineation is provided by wells MW-366, MW-375 and the secondary and tertiary surface water features. The potentiometric map provided as Figure 3 of the CMA and provided herein as Attachment A illustrates these results. On-going review of groundwater hydrology under all site conditions, including post-closure, is being conducted to further evaluate the completeness of delineation.

Lithium Attenuation

Lithium is a conservative constituent which is not readily attenuated by precipitation or adsorption processes. Instead, the primary attenuation mechanism is likely dilution and dispersion during groundwater transport downgradient. USEPA guidance notes that “Dilution and dispersion generally are not appropriate as primary MNA mechanisms because they reduce concentrations through dispersal of contaminant mass rather than destruction or immobilization of contaminant mass. Dilution and dispersion may be appropriate as a “polishing step” for distal portions of a plume when an active remedy is being used at a site, source control is complete, and appropriate land use and groundwater use controls are in place." Source control is in place via the closure efforts completed in November 2020.

As described in Section 2.3 of the CMA, MW-391 did not have sufficient groundwater to permit sampling during monitoring events in 2016 and 2017. After groundwater elevations stabilized, the lithium concentration also stabilized (as shown in the time series graph provided in Figure 1), with no statistically significant trend identified for the recent monitoring events at MW-391 (Appendix B). Additional monitoring is required to evaluate lithium concentrations post-closure. Given the current and anticipated future land use, there is likely limited risk of lithium exposure to the public.

These findings adequately meet the requirements of Tier 1 of the MNA evaluation in accordance with USEPA guidance. However, additional efforts are planned for 2021 to sufficiently develop all lines of evidence and complete a full tiered evaluation.

ADDITIONAL EVALUATION

As part of the tiered evaluation, additional efforts will be completed in 2021 to support the existing findings that MNA, in combination with source control, may be an appropriate groundwater remedy at the FAP. For each tier of the remaining evaluation, the following scope of work is planned to collect sufficient additional information:

- <u>Tier 2 (Demonstration the attenuation mechanism and rate)</u>: Groundwater hydrogeology will be reviewed to assess if dilution and dispersion will sufficiently reduce downgradient concentrations below the regulatory criteria, including after completion of closure activities. Evaluation of the decay of source flux to groundwater, including additional sampling and possible additional modeling, may be required. Evaluation of lithium attenuation mechanism and rate is not necessary because, in addition to source control, only dilution and dispersion are being considered and attenuation of lithium by reaction with aquifer solids is not likely to be occurring.

- <u>Tier 3 (Demonstration that the aquifer capacity is sufficient for attenuation)</u>: Additional modeling of groundwater hydrogeology may be required depending on the results of the Tier 2 analysis.

- <u>Tier 4 (Long-Term Monitoring)</u>: Based on the results of the Tier 2 and Tier 3 evaluations, a performance monitoring plan will be developed to evaluate the efficacy of MNA at the site. The performance monitoring plan will also include potential supplemental remedies, if needed. These other potential remedies will be evaluated in parallel with the tiered evaluation in accordance with 40 C.F.R. § 257.97 in the performance monitoring plan.

EVALUATION CRITERIA

MNA was evaluated to assess whether it will likely meet the criteria outlined in 40 C.F.R. § 257.96(c) as a potential corrective action. This evaluation is summarized below and in Table 3 of the CMA.

MNA Performance

MNA performance is best when paired with source control measures, which were completed at the site in November 2020. For lithium, the stable concentrations at MW-391 combined with source control suggest that MNA performance at the FAP is likely to achieve the performance criteria outlined in 40 C.F.R. § 257.97. Completion of the tiered evaluation and assessment of lithium concentrations under closure conditions are required to fully assess MNA performance relative to the performance criteria.

Reliability of MNA

The reliability of MNA is dependent on site-specific conditions. A review of site hydrogeology under post-closure conditions to confirm downgradient delineation is required. Additional evaluation may be required to understand the site-specific dilution and dispersion capacity and rate, both of which will provide more information on the reliability of MNA.

Ease of implementation of MNA

MNA is relatively easy to implement compared to other potential corrective actions which require construction, earthwork, or engineering design. Additional efforts required to implement MNA include completion of the tiered investigation and implementation of the performance monitoring plan. These efforts do not require specialized equipment or contractors.

Potential impacts (including safety impacts, cross-media impacts, and control of exposure to any residual contamination)

Potential impacts are not anticipated with MNA. MNA relies on processes that are naturally occurring in the aquifer; therefore, cross-media impacts are unlikely. Large scale handling of impacted materials (such as during groundwater extraction) is not required, reducing the potential for exposure to residuals during implementation.

Time required to begin and complete MNA

USEPA guidance states that "natural attenuation should achieve site-specific objections within a time frame that is reasonable compared to that offered by more active methods"[3]. When considering a reasonable time frame, USEPA recommends consideration of factors such as

[3] USEPA. 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. OSWER Directive 9200.4-17P. April.

contaminant properties, exposure risk, classification of the protected resource, and potential for plume stability. As discussed above, source control is complete and lithium concentrations at MW-391 already exhibit stable behavior.

Additional information is required to complete the tiered MNA evaluation and develop a performance monitoring plan. This evaluation can be completed within one year. The time required to attain the groundwater protection standard at MW-391 can be estimated once additional information is developed regarding the attenuation rate and continued stability or decline in concentrations after source control implementation was completed in November of 2020. Because the time to completion will depend on the source decay rate, it is anticipated that MNA would have a similar cleanup time as other potential corrective actions, such as groundwater extraction. It is anticipated that the timeframe is reasonable within the guidance provided by USEPA.

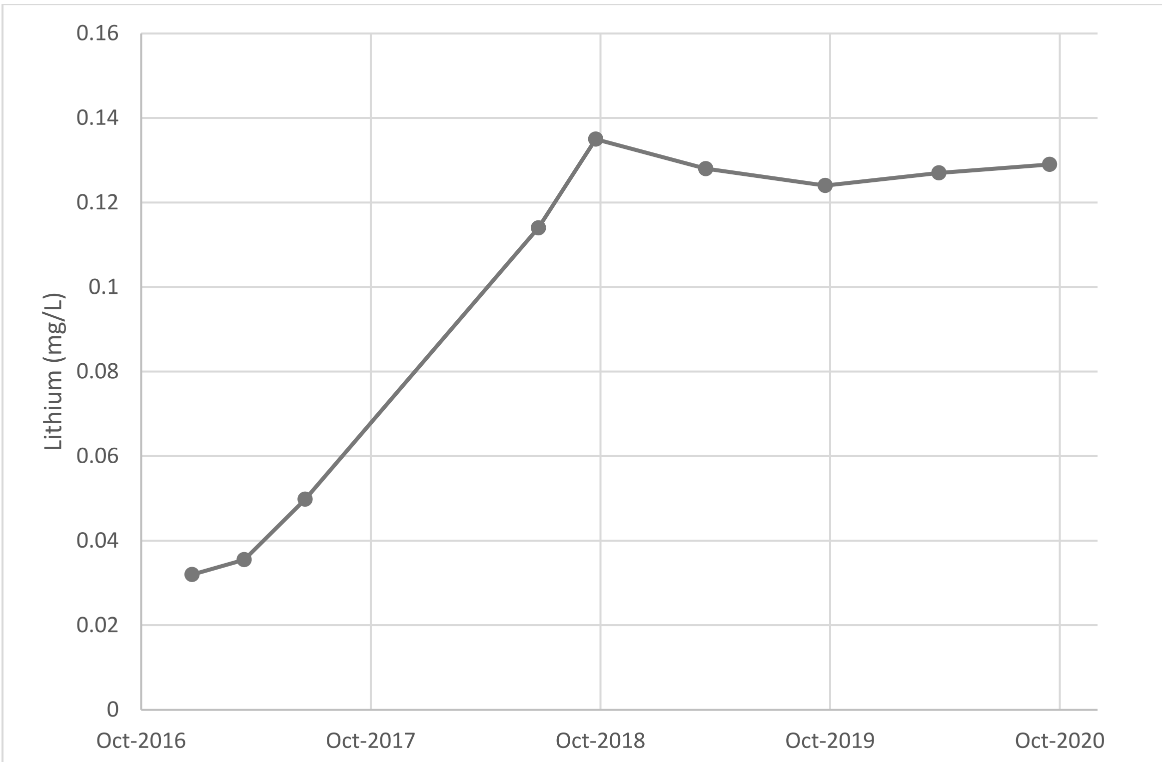
Institutional requirements, such as state or local permit requirements, that may substantially affect implementation of MNA

No institutional requirements are anticipated which would substantially affect implementation of MNA.

CONCLUSIONS

Based on the analysis completed to date, MNA combined with source control appears to be a promising groundwater remedy at the Baldwin FAP when evaluated against the requirements in 40 C.F.R. § 257.96(c). Further investigation will be completed in 2021 to collect sufficient evidence to support the tiered MNA evaluation, which will include a better understanding of site hydrogeology and conditions after closure to develop multiple lines of evidence in accordance with USEPA guidance.

FIGURES



Notes: Lithium values are shown as milligrams per liter (mg/L).

MW-391 Lithium Time Series Graph

Baldwin

Baldwin, Illinois

Geosyntec consultants

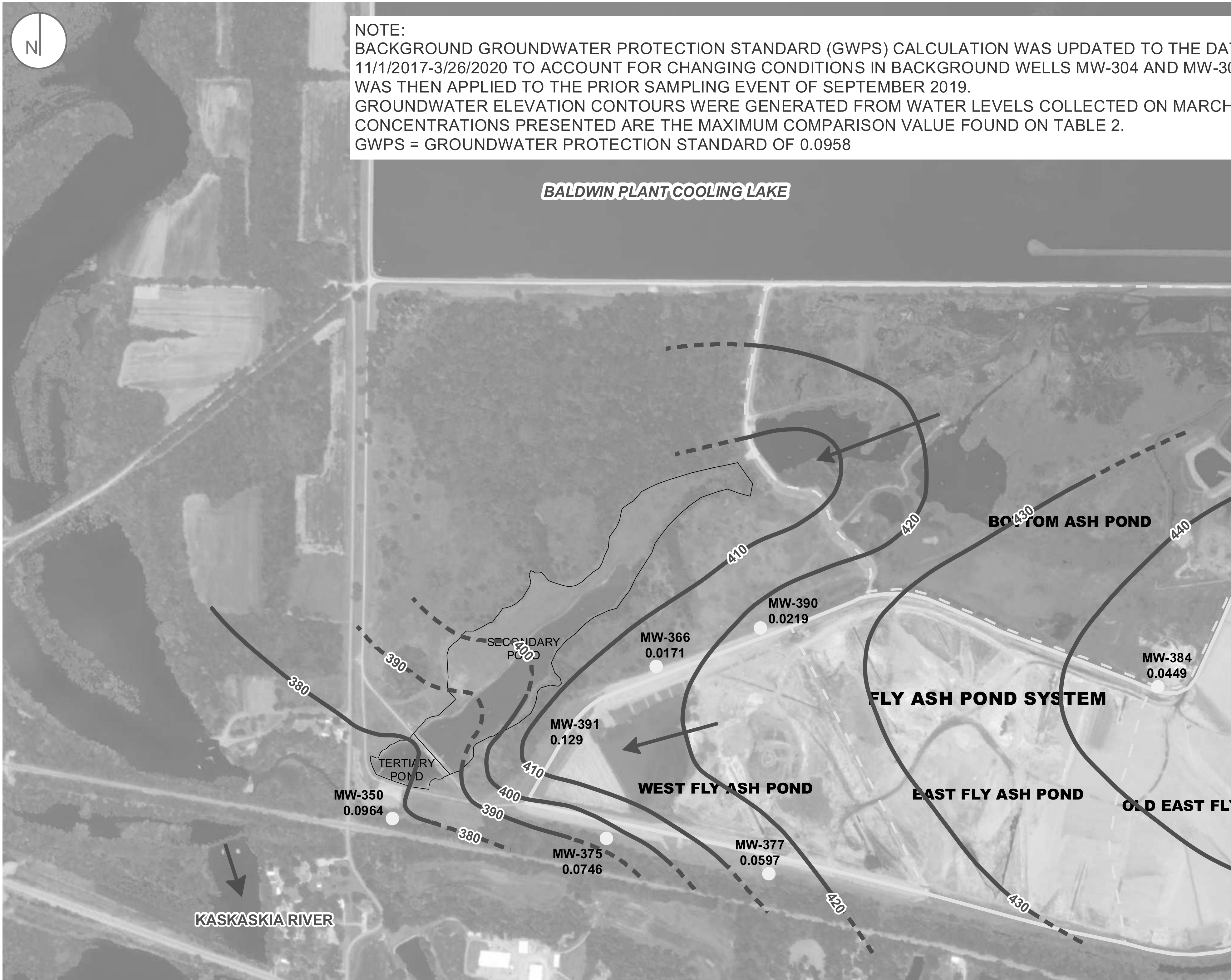
Figure 1

Columbus, OH

2020/11/27

APPENDIX A

Lithium Plume Map


NOTE:
BACKGROUND GROUNDWATER PROTECTION STANDARD (GWPS) CALCULATION WAS UPDATED TO THE DAT
11/1/2017-3/26/2020 TO ACCOUNT FOR CHANGING CONDITIONS IN BACKGROUND WELLS MW-304 AND MW-30
WAS THEN APPLIED TO THE PRIOR SAMPLING EVENT OF SEPTEMBER 2019.
GROUNDWATER ELEVATION CONTOURS WERE GENERATED FROM WATER LEVELS COLLECTED ON MARCH
CONCENTRATIONS PRESENTED ARE THE MAXIMUM COMPARISON VALUE FOUND ON TABLE 2.
GWPS = GROUNDWATER PROTECTION STANDARD OF 0.0958
N
BALDWIN PLANT COOLING LAKE
BOTTOM ASH POND
FLY ASH POND SYSTEM
WEST FLY ASH POND
EAST FLY ASH POND
OLD EAST FLY
SECONDARY POND
TERTIARY POND
KASKASKIA RIVER
MW-390
0.0219
MW-366
0.0171
MW-384
0.0449
MW-391
0.129
MW-350
0.0964
MW-375
0.0746
MW-377
0.0597
380
390
400
410
420
430
440

APPENDIX B

Mann-Kendall Analysis - Lithium Concentrations at MW-391

Mann-Kendall Trend Test Analysis

User Selected Options	Only includes data from 6/26/2018 onward
Date/Time of Computation	ProUCL 5.111/27/2020 9:36:22
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	0.99
Level of Significance	0.01

MW-391 Lithium (recent data)

General Statistics

Number or Reported Events Not Used	0
Number of Generated Events	6
Number Values Reported (n)	6
Minimum	0.114
Maximum	0.135
Mean	0.126
Geometric Mean	0.126
Median	0.128
Standard Deviation	0.00697
Coefficient of Variation	0.0552

Mann-Kendall Test

M-K Test Value (S)	3
Tabulated p-value	0.36
Standard Deviation of S	5.323
Standardized Value of S	0.376
Approximate p-value	0.354

Insufficient evidence to identify a significant trend at the specified level of significance.