Intended for
Dynegy Miami Fort, LLC

Date
November 30, 2020

Project No.
1940074922

CORRECTIVE MEASURES ASSESSMENT REVISION 2

MIAMI FORT POND SYSTEM

MIAMI FORT POWER STATION
11021 BROWER ROAD
NORTH BEND, OHIO

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Recipient	**Dynegy Miami Fort, LLC**
Document type	**Corrective Measures Assessment**
Revision	**2**
Date	**November 30, 2020**

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DOCUMENT REVISION RECORD

Issue No.	Date	Details of Revisions
Revision 0	September 5, 2019	Original Document (prepared by O'Brien & Gere Engineers, Inc., part of Ramboll)
Revision 1	November 12, 2020	Revised to reflect the characterization of the Miami Fort Pond System as a single multi-unit, including an Alternate Source Demonstration for statistically significant levels of arsenic and molybdenum for the Pond System
Revision 2	November 30, 2020	Revised as follows: • Section 2 – added additional geology/hydrogeology information including: cross-sections (Appendix B), groundwater contour maps (Appendix C), vertical and horizontal hydraulic gradients (Appendix D), and summary of monitoring (Table 1), plume delineation information (Table 2; Figures 3 and 4). • Section 4 – focused on application of evaluation criteria to potential corrective measures described in Section 3. Added Appendix E with independent evaluation of MNA. • Section 5 – focused on application of potential source control and groundwater corrective measures referenced in Sections 3 and 4. • Table 3 – focused on application of evaluation criteria to corrective measures referenced in Section 3.

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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 Miami Fort Pond System (Coal Combustion Residuals [CCR] Multi-Unit ID 115) located at the Miami Fort Power Station (MFS) in North Bend, Ohio. The Pond System is a CCR Multi-Unit comprised of two hydraulically connected cells (Basins A and B).

This CMA report complies with the requirements of Title 40 of the Code of Federal Regulations (40 C.F.R.) § 257, Subpart D Standards for the Disposal of Coal Combustion Residuals 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 (ASD) demonstrating that a source other than the CCR unit has caused the contamination.

As stated in the related notification for the Pond System dated August 13, 2020, SSLs for the following parameters were determined after the most recent Assessment Monitoring sampling event (A3) completed April 6 through April 7, 2020:

- Arsenic
- Cobalt
- Molybdenum

An Alternate Source Demonstration (ASD) has been completed for the arsenic and molybdenum SSLs (Appendix A), as allowed by 40 C.F.R. § 257.95(g)(3)(ii). This CMA is responsive to the 40 C.F.R. § 257.96 and § 257.97 requirements for assessing potential corrective measures to address the cobalt SSL.

This CMA is the next step in developing a long-term corrective action plan and has been prepared to evaluate applicable remedial measures to address cobalt 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 Pond System at the MFS. 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

This 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.

The 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 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; 2) design and obtain permits; and 3) 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 MFS is owned and operated by Dynegy Miami Fort, LLC. The MFS is located in the southwest corner of the State of Ohio on the north shore of the Ohio River, at the confluence with the Great Miami River, as shown in Figure 1. The facility is located within Hamilton County, Miami Township, approximately 5 miles southwest of the village of North Bend, Ohio. The state boundary with Indiana is approximately 1,900 feet to the west of MFS and the boundary with the State of Kentucky lies just offshore to the south, within the Ohio River.

The MFS has two coal-fired units, Units 7 and 8, constructed in 1975 and 1978 with a total capacity of 1,100 megawatts (MW) and four oil-fired facilities constructed in 1971 with a total capacity of 78 MW. The Pond System (Multi-unit 115) covers a total area of approximately 51 acres and is located in the southwest corner of the Miami Fort Power Station property as shown in Figure 1.

Basin A (formerly Unit 111) receives effluent from the sluice lines, which primarily transport bottom ash products as well as flue gas desulfurization (FGD) effluent and some fly ash. Basin A also receives directly discharged miscellaneous yard drainage. The material is discharged into the northern portion of the basin and through a constructed internal ditch line allowing the solids to settle and the water to decant into Basin B. Solid materials collected in Basin A are generally reclaimed for beneficial reuse or landfill placement. The Basin A normal pool level is typically between elevations of 495 and 498 ft. Basin A and Basin B are hydraulically connected with a 48-inch corrugated metal pipe (CMP) culvert slip-lined with a 40-inch high density polyethylene (HDPE) pipe that runs through the shared dike, allowing the basins to operate in series. The Basin A outfall is currently not in use and flow-through is controlled by the gate structure (AECOM, 2017).

Basin B (formerly Unit 112) was constructed between 1979 and 1981 (AECOM, 2017). The Basin B normal pool level is typically below the Basin A normal pool and between elevations of 495 and 498 ft. Basin A discharges into Basin B, which is used as a polishing pond prior to discharge to the Ohio River through the permitted outfall structure in Basin B. Miscellaneous yard drainage is currently discharged directly to Basin B (AECOM, 2017).

2.1 Geology

Geologic units present at the Site include unlithified geologic materials (alluvial deposits, glacial outwash [Uppermost Aquifer]) and Ordovician-aged bedrock.

2.1.1 Regional Setting

The Site is located adjacent to the convergence of the Great Miami River drainage basin and Ohio River, near the southern border of the Glacial Plains and the northern border of the Interior Low Plateau at the southern edge of the glacial drift deposits. The local geologic conditions within the basin area consists of an alluvial silt, clay and/or sand deposited by Ohio River floodwaters, and glacial outwash deposits consisting of fine sand, silts and clays that were mainly deposited during the Illinoian and Wisconsinan stages of the Pleistocene. The thickness of the outwash deposits is approximately 120 feet above bedrock. A thick silt cap is also present locally on top of the outwash deposits. As depicted in the attached Appendix B, geologic cross-sections were prepared illustrating the lithology beneath Basins A and B (AECOM, 2017).

The bedrock immediately underlying the glacial deposits is of sedimentary origin and belongs to the Cincinnatian series (blue-gray limestone of the Fairview and Kope formations). The dominant sediments are the Richmond shales, the Maysville limestone, and the Eden shales. These rock units average approximately 800 feet in thickness. Situated near the crest of the Cincinnati arch, these bedrock units have a regional dip of about 10 feet per mile to the west (Burgess & Niple, Limited Engineers and Architects, 1988). Depth to bedrock beneath the Site varies between approximately 110 to 120 feet bgs dependent on proximity to the edge of the valley wall north of the basins. Due to the relatively impermeable nature of the shales and limestones underlying this region, water yields in the bedrock are generally insufficient for domestic use (AECOM, 2017).

2.1.2 Site Geology

The geology of the Site was evaluated during previous investigations. Deposits include the following units:

- Alluvial Deposits - The alluvial deposits consist of clay, silt and fine sand deposited by the Ohio River floodwaters. These alluvial deposits range in depth from approximately 20 to 60 feet below the present ground surface. A silty, sandy clay layer is the primary component of the alluvial deposits. The clay ranges in elevation from 428 feet (ft) in the southwest corner of Basin B near the confluence of the Ohio River and the Great Miami River to 495 ft referenced to North American Vertical Datum of 1988, beneath the northeast corner of Basin A. The clay is thin, or absent, near the valley wall north of the Site and thickens towards the Ohio River. The clay is thickest beneath the southern half of Basin A and Basin B, ranging in thickness from 15 ft to 48 ft. A silt layer, averaging approximately 7 ft thick, overlies the clay in several areas.
- Glacial Outwash (Uppermost Aquifer) - The Uppermost Aquifer consists of glacial outwash sands and gravels deposited during the Illinoian and Wisconsin stages of the Pleistocene. The thickness of the outwash deposits beneath the Site is approximately 100 ft; the outwash deposits directly overlie bedrock. A silt and fine sand layer is present locally overlying the outwash deposits and ranges in thickness from 4 to 30 ft; however, it is not present below the entirety of the Pond System.
- Bedrock - The bedrock consists of interbedded shales and limestones belonging to the Ordovician-aged Fairview and Kope formations (AECOM, 2017). Depth to bedrock beneath the Site varies between approximately 110 to 120 ft bgs. Due to the relatively impermeable nature of the shales and limestones underlying this region, water yields in the bedrock are generally insufficient for domestic use (AECOM, 2017).

2.2 Hydrogeology

The hydrogeologic conceptual site model (CSM) is detailed in the sections below. The Miami Fort Pond System monitoring system is shown in Figure 2.

2.2.1 Uppermost Aquifer

The glacial outwash deposits (Uppermost Aquifer) underlying the Pond System are part of the Ohio River Valley Fill Aquifer; a glacial buried-valley deposit aquifer. The valley was cut into the bedrock by pre-glacial and glacial streams and subsequently backfilled with deposits of sand, gravel and other glacial drift by glacial and alluvial processes as the glaciers advanced and receded. The thickness of the deposits ranges from approximately 60 to 100 ft and covers much of the width of the terrace between the valley wall to the Great Miami River and Ohio River confluence. Buried valley aquifers such as the Uppermost Aquifer are Ohio's most productive water-bearing formations. Estimates of transmissivity are in excess of 50,000 gallons per day per foot (USGS, 1997).

Regionally, yields for high-capacity wells in the Uppermost Aquifer range from 450 gallons per minute (gpm) to 3,000 gpm with one well tested as high as 6,000 gpm. (IDNR, 2006). The majority of the water withdrawn by high capacity wells near the Site is from induced flow from the Ohio River (ODNR, undated). The Site operates four production wells east-southeast of Basin A for cooling water. Pumping rates measured at the cooling water production wells range from 1,000 to 1,500 gpm. Additionally. three production wells, located northwest of the Pond System, are operated by Veolia for process (non-potable) water.

The aquifer receives most of its recharge from infiltration of precipitation on the valley floor; however, secondary recharge also comes from bank storage from the Great Miami River and Ohio River during flood stages. Recharge to the aquifer from bank storage is periodic and short-lived.

2.2.2 Lower Limit of Aquifer

The lower confining unit underlying the Pond System is bedrock consisting of interbedded shales and limestones belonging to the Fairview and Kope formations. Depth-to-bedrock beneath the site varies between approximately 110 to 120 feet bgs dependent on proximity to the edge of the valley wall north of the Pond System. These low-yielding shale and limestone formations average around 800 feet in thickness (Burgess & Niple, Limited Engineers and Architects, 1988).

Groundwater yields from the bedrock strata in this region are quite limited. Generally, the bedrock is not tapped for water due to its low permeability. Those wells which do tap the bedrock aquifers generally draw water from the bedding planes and fracture zones. Due to the relatively impermeable nature of the shales and limestone underlying this region, water yields are generally insufficient for domestic use. Fresh water does not typically occur at depths greater than 500 feet bgs.

2.2.3 Hydraulic Conductivity

Hydraulic conductivity testing has not been conducted in the Uppermost Aquifer at the Pond System because typical aquifer testing methods, such as slug testing, are ineffective in highly transmissive aquifers. Hydraulic conductivity testing was completed at wells screened in alluvial deposits overlying the Uppermost Aquifer as part of ongoing site investigation activities completed in the fall of 2020. Testing results are in currently in review.

2.2.4 Groundwater Elevations, Flow Direction, and Velocity

Groundwater elevations vary coincidentally with the elevation of the Ohio River pool elevation. Groundwater elevations in the Uppermost Aquifer typically range from approximately 450 to 465 ft. Groundwater elevation contour maps based on groundwater measurements collected on the first day of sampling at the Pond System from December 2015 through September 2020 are included in Appendix C.

Groundwater flow in the Uppermost Aquifer is generally to the west/northwest towards the Great Miami River and Veolia’s production wells, and south towards the Ohio River as shown on Figure 3. The minimal variation in groundwater flow direction is primarily influenced by extreme flood events or long period of sustained pool-stage conditions in the Ohio River and Miami River.

Horizontal hydraulic gradients were calculated using groundwater elevations measured from September 2018 to September 2019 (Appendix D, Table 1). Across Basin A, the horizontal hydraulic gradient ranged from approximately 0.0010 to 0.0026 feet per foot (ft/ft). Across Basin B, the horizontal hydraulic gradient was between 0.0018 and 0.0028 ft/ft.

Vertical hydraulic gradient was calculated across the Uppermost Aquifer using nested well pairs MW-4/MW-14 and MW-15/MW-16 for groundwater measurements for September 2019 (Appendix D, Table 2). East of Basin A, at well pair MW-15/MW-16, the vertical hydraulic gradient was calculated as an upward gradient at -0.0020 ft/ft. South of the divider dike, at well pair MW-4/MW-14, the vertical hydraulic gradient was calculated as a downward 0.0006 ft/ft.

Site-specific hydraulic conductivity values are not available; therefore, groundwater flow velocity was not calculated.

2.3 Groundwater Quality and Plume Delineation – 257.95(g)

Detection monitoring in the Uppermost Aquifer, per 40 C.F.R. § 257.90, was initiated in October 2017; statistically significant increases (SSIs) of Appendix III parameters over background concentrations were detected in October 2017. Monitoring well locations are shown on Figure 2. 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 for the Pond System on April 9, 2018 (Table 1). Assessment Monitoring results identified statistically significant levels (SSLs) of the following Appendix IV parameters over the GWPS:

- Arsenic at wells MW-2, MW-10 and MW-13
- Cobalt at wells MW-4 and 4A
- Molybdenum at well MW-6

An ASD has been completed for the arsenic and molybdenum SSLs (Appendix A), as allowed by 40 C.F.R. § 257.95(g)(3)(ii). This CMA has been completed to comply with the 40 C.F.R. § 257.96 and § 257.97 requirements for assessing potential corrective measures to address the cobalt SSL.

SSLs for total cobalt were identified in downgradient monitoring wells MW-4 and MW-4A where concentrations ranged from 0.00503 mg/L to 0.0187 mg/L.

In accordance with the Statistical Analysis Plan for MFS (NRT, 2017), SSLs are based on based on a Lower Confidence Limit (LCL) calculated from all observed concentrations for each Appendix IV parameter at each monitoring well (2015 through the current sampling event) compared to the GWPS. Maximum LCL concentrations associated with the cobalt SSLs at MW-4 and 4A are 0.00844 milligrams per liter (mg/L) and 0.012 mg/L, respectively (Table 2).

Well locations with observed exceedances of the GWPS have been illustrated on Figure 3 along with maximum LCL concentrations from Table 2. This figure illustrates the maximum extent of cobalt exceedances of the GWPS observed during the assessment monitoring period. There are five wells with observed cobalt exceedances of the GWPS (0.006 mg/L); however, MW-4 is the only well with SSLs on a consistent basis. The other wells with cobalt exceedances were recently added plume delineation wells that have fewer sample results. Wells 4A, MW-15, and MW-16 are located east of the Pond System, wells MW-6 and MW-5 have not exceeded the GWPS for cobalt and are located between the Pond System and these three wells with cobalt exceedances. Two of those wells, MW-15 and MW-16, have not had an exceedance of the GWPS for cobalt in the latest two sampling events (September 2019 and April 2020). Further, the recently completed well MW-19, located upgradient of the Pond System, had the highest observed cobalt concentration within the monitoring network indicating there may be an alternate source of cobalt upgradient of the Pond System. Additional data is being collected on a monthly basis to evaluate potential changes to background concentrations of cobalt.

Cobalt exceedances observed at well MW-4 are bounded laterally and vertically by monitoring wells with parameter concentrations below their respective GWPSs and oftentimes below the reporting limit for the parameter. Cobalt observed at MW-4 is bounded to the south by the Ohio River, as there is not enough space to safely install a separate monitoring well between MW-4 and the river. Timeseries for cobalt is shown in Figure 4. Mann-Kendall analysis of cobalt concentrations observed in MW-4 indicate there is not a significant increasing trend in concentrations (Appendix E).

Elevated cobalt concentrations in groundwater at monitoring well MW-4, are not expected to be within the radius of pumping influence of any industrial wells. Currently, elevated cobalt concentrations in groundwater would only have a potential impact on surface water of the Ohio River. Mixing calculations showing the effect of cobalt loading on the Ohio River at low flow (i.e. baseflow at the 90th percentile of daily mean low flow) show that the cobalt concentration increase near-shore in the Ohio River due to possible groundwater loading from the east portion of the Pond System (i.e. Basin A) is 0.00000076 mg/L, which is 100 times lower than the typical cobalt laboratory detection limit of 0.000075 mg/L. An Ohio River Valley Water Sanitation Commission report from October 1998 indicates the nearest water supply intakes are located at river mile 463.2 upstream of the Pond System in the Cincinnati, Ohio metro area; and, at river mile 594.2 downstream of the Pond System in the Louisville, KY metro area. The Pond System is located near river mile 490, meaning the nearest downstream intake is over 100 river miles away.

2.4 Well Survey

Groundwater near the Miami Fort Pond System is within the radius of influence of four industrial pumping wells located to the southeast of the pond (operated by Miami Fort Station) and three industrial wells located to the northwest of the pond (operated by Veolia North America) – see Figure 2. All groundwater pumped by the production wells is non-contact water and non-potable for industrial use only. All groundwater not captured by the industrial water wells flows towards the Great Miami River to the west or the Ohio River to the south. A review of the ODNR's interactive Water Well Map was performed to identify water supply wells located within 2,500 feet of the Pond System. The nearest residence is greater than 2,500 feet northeast and upgradient of Basin A. No public water supply (PWS) wells were identified between the Great Miami River and the Ohio River within a ten-mile radius of the MFS.

3. DESCRIPTION OF CORRECTIVE MEASURES

The corrective measures described below are frequently used to mitigate impacts from contaminants. The corrective measures are identified as either potential source control or groundwater corrective measures. Each measure is summarized in Table 3, Corrective Measures Assessment Matrix.

3.1 Objectives of the Corrective Measures – § 257.96(c)

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).

Site-specific considerations regarding the Pond System, provided in Section 2, were used to evaluate potential 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 in developing a long-term corrective action plan. The corrective measures may be used independently or may be combined into specific remedial alternatives to leverage the advantages of multiple corrective measures to meet the performance standards.

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

- Potential Source Control Corrective measures
  - Closure in Place (CIP)
  - Closure by Removal (CBR) (Off-Site Landfill)
  - In-Situ Solidification/Stabilization (ISS)
- Potential Groundwater Remedial Corrective measures
  - Monitored Natural Attenuation (MNA)
  - Groundwater Cutoff Wall
  - In-Situ Chemical Treatment
  - Permeable Reactive Barrier (PRB)
  - Groundwater Extraction

3.2 Potential Source Control Corrective Measures

3.2.1 Closure in Place

CIP includes constructing a cover system in direct contact with the graded CCR. Cover systems are designed to significantly minimize water infiltration into the CCR unit and allow surface water to drain off the cover system, thus reducing generation of potentially impacted water and reducing the extent of cobalt impact in the Uppermost Aquifer.

Construction of a cover system typically includes, but is not limited to, the following primary project components:

- Removal of free water and grading the CCR to allow cover system construction.
- Relocating and/or reshaping the existing CCR and cover material within the impoundment to achieve acceptable grades for closure. Borrow soil may be used to supplement fill volume, if necessary, to reach final design grades.
- Constructing a cover system that complies with the CCR Rule, including establishment of a vegetative cover to minimize long-term erosion.
- Constructing a stormwater management system to convey runoff from the cover system to a system of perimeter drainage channels for ultimate routing and discharge to nearby surface water.
- Ongoing inspection and maintenance of the cover system; and, stormwater and property management.

3.2.2 Closure by Removal

CBR includes the following components: removal of all CCR from the CCR unit; moisture conditioning the CCR as needed to facilitate excavating, loading and transporting CCR to either an on-site or off-site landfill; and backfilling the excavation. This corrective measure would address the source of groundwater impacts by removing the CCR, but the groundwater impacts would not begin to diminish until the source is completely removed.

3.2.3 In Situ Solidification/Stabilization

ISS is a corrective measure which consists of encapsulating waste within a cured monolith having increased compressive strength and reduced hydraulic conductivity. Hazards can be reduced by both converting waste constituents into a less soluble and mobile forms and by isolating waste from groundwater, thus facilitating groundwater remediation and reducing leaching to groundwater. ISS includes solidifying all CCR from the CCR unit and encapsulating the CCR through in-place mechanical mixing with reagents in an engineered grout mixture. The grout is typically emplaced using augers, backhoes or injection grouting. ISS also improves the geotechnical stability and material strength of the CCR materials.

ISS construction technologies include vertical rotary mixed ISS, hydraulic auger mixed ISS, hydraulic mixing tool ISS, and excavator mixed ISS. ISS construction may use a combination of these technologies depending on site-specific design requirements. ISS design typically requires data on, but not limited to, the following CCR material properties: geotechnical parameters, inorganic chemical constituents, class of ash, and ash management information (*e.g.,* coal source, co-management). Due to the variability in material properties of CCR, ISS would require an extensive mix design process for assessing ISS performance. Typical design and performance parameters include but are not limited to: volume expansion (swell), leachability, permeability, and unconfined compressive strength. ISS performance may be evaluated based on both civil design and remedial performance objectives.

3.3 Potential Groundwater Corrective Measures

3.3.1 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 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 3.2.

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. Timeframes to achieve GWPS are dependent on site-specific conditions, actual timeframes would require detailed technical analysis.

Cobalt has the potential to be sorbed onto iron hydroxides or organic matter in the aquifer materials, depending on the geochemical conditions, but is typically mobile (EPRI, 2012). Physical and chemical mechanisms are available natural attenuation processes acting upon CCR constituents such as cobalt. The performance of MNA as a groundwater corrective measure 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.

3.3.2 Groundwater Extraction

Groundwater extraction is a widely used groundwater corrective measure. 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 or trenches 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.

3.3.3 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.

3.3.4 Permeable Reactive Barrier

Chemical treatment via a 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 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.

3.3.5 In-Situ Chemical Treatment

In-situ chemical treatment technologies 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 cobalt.

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. ASSESSMENT OF CORRECTIVE MEASURES

4.1 Evaluation Criteria – § 257.96(c)

The 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 for the corrective measures described in Section 3 to allow a qualitative evaluation of the ability of each corrective measure to address SSLs for cobalt 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 Source Control Corrective Measure Evaluation

As presented in Section 3, the following source control corrective measures may be viable to address SSLs in the Uppermost Aquifer:

- Potential Source Control Corrective measures
  - Closure in Place (CIP)
  - Closure by Removal (CBR) (On-Site or Off-Site Landfill)
  - In-Situ Solidification/Stabilization (ISS)

These remedial corrective measures are discussed below relative to their ability to effectively address the cobalt SSL in the Uppermost Aquifer. To attain GWPS these source control corrective measures may be combined with groundwater corrective measures, such as MNA

4.2.1 Closure in Place

CIP is an accepted corrective measure. The **performance** of CIP as a source control corrective measure can vary based on site-specific conditions and may require additional data collection or groundwater fate and transport modeling to support the design and regulatory approval. Site conditions at the Miami Fort Pond System are favorable for effective source control by CIP because the basins are underlain by low-permeability clays. CIP is a **reliable** source control measure that does not require active systems to operate and requires limited maintenance.

Implementation of CIP only requires commonly performed construction and earthwork activities as described in Section 3.2 and can typically be completed in a **timeframe** of 5 to 8 years, including design, permitting, and construction.

Cover systems control exposure to CCR by limiting potential contact with CCR material, controlling stormwater runoff and significantly reducing infiltration of water into the CCR material. During construction of the cover system there is the potential **impact** of short term exposure to CCR. During the approximately 1 to 2 year construction period there could be some increase in off-site traffic due to the increased need for on-site workers.

Controlling the primary source quickly results in lowering the total mass released, subsequently reducing the time to attain GWPS. Based on groundwater modeling of geosynthetic and soil cover systems at affiliate Dynegy Midwest Generation, LLC CCR units with similar hydrogeologic conditions (*e.g.,* Hennepin West and Hennepin East), concentrations of CCR constituents are expected to begin to decline and the extent of groundwater impacts are expected to reduce within months after cover placement. **Timeframes to achieve GWPS** are dependent on site-specific conditions which require detailed technical analysis. CIP requires **approval by OEPA** to be implemented.

4.2.2 Closure by Removal

CBR is an accepted corrective measure. CBR is a **reliable** source control measure that does not require active systems to operate and requires limited maintenance. CBR only requires commonly performed construction and earthwork activities as described in Section 3.2. However, dewatering and moisture conditioning of the CCR for transport can often be problematic to **implementation**; and site access is limited.

The **regulatory approval process** for constructing a new on-site landfill, if feasible, would take multiple levels of approval, including environmental permits and local authorization. Opposition to such projects and regulatory approvals would take years before construction could commence. However, most importantly, there is no available space (see Figure 1) at the MFS on which to site or construct an on-site landfill, requiring that only off-site landfill alternatives be considered.

Assuming 60 trucks per day (8 trucks per hour), it will take over 18 years to transport the CCR to an off-site landfill. This will result in an **impact** of 289,000 roundtrips (3.6 MCY of CCR; assuming 12.5 CY per truck load) between the MFS and the landfill.

CBR of the Pond System could be completed in the **timeframe** of approximately 20 to 24 years, including design, permitting, and construction. Delays in controlling the primary source will increase the potential for additional mass release, subsequently increasing the **time to attain GWPS**.

During that timeframe the transport of the CCR could lead to the following **impacts**: increased risk to the public, increased greenhouse gas emissions and carbon footprint, and increased potential for fugitive dust exposure.

Commercially available landfill capacity is extremely limited. Decatur Hills Landfill in Greensburg, Indiana has the most available airspace within 50 miles of the MFS but it is insufficient to accommodate the 3.6 MCY of CCR to be removed, unless they cease accepting municipal solid waste.

Due to insufficient available commercial landfill capacity, and lack of space onsite to construct a landfill, CBR is not retained as a viable corrective measure.

4.2.3 In-Situ Solidification/Stabilization (ISS)

Performance of ISS for application as a CCR source control measure is not proven, therefore the **performance and reliability are unknown**. The design of ISS as a source control corrective measure would require additional data collection. During ISS construction there would be the potential **impacts** of short-term exposure to CCR.

Implementation of ISS would require extensive pre-implementation testing, specialized equipment, and specialized contractors. ISS construction **timeframes** would be dependent on application volume. Treatment of all CCR materials may not be feasible dependent upon depth and obstructions. Targeted ISS may reduce the timeframe required; however, another source control corrective measure would be required to address remaining CCR. ISS requires **approval by the OEPA** to be implemented. The **timeframe to implement** ISS, including bench-scale and pilot-scale testing to support the detailed design and regulatory approval, would delay source control. In addition, the effects on groundwater chemistry associated with the addition of large volumes of Portland cement and other amendments to the subsurface would require detailed evaluation.

Site conditions at the Miami Fort Pond System would support implementation of ISS because the CCR material is present less than 50 feet below ground surface and underlain by low-permeability clays which are likely to provide a viable "key layer" for the stabilization of CCR material.

4.3 Potential Groundwater Corrective Measure Evaluation

Based on the corrective measure review presented in Section 3.3, the following remedial corrective measures are considered potentially viable to address the cobalt SSL in the Uppermost Aquifer:

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

These corrective measures are discussed below relative to their ability to effectively address the cobalt SSL in the Uppermost Aquifer. Additional site-specific data collection and analyses will be required to verify the feasibility of selected corrective measures and to design the corrective measure(s), consistent with 40 C.F.R. § 257.97 requirements.

4.3.1 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 E. 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 E, MNA performance is likely to achieve the 40 C.F.R. § 257.97 performance criteria based on the conclusions of the evaluation and the geochemical behavior of cobalt. 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.

4.3.2 Groundwater Extraction

Groundwater extraction is a widely accepted corrective measure for groundwater with a long track record of performance and reliability. It is routinely approved by state and federal regulators. 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.

Implementation of a groundwater extraction system presents design challenges due to the significant features controlling hydraulic head and groundwater flow in the Uppermost Aquifer (*i.e.,* Ohio River and Great Miami River). Relatively high horizontal hydraulic conductivities are anticipated to require a high pumping rate to successfully control groundwater in the vicinity of the Pond System. For a corrective measure using groundwater containment to effectively control off-site flow or to remove potentially contaminated groundwater, horizontal and vertical capture zone(s) must be created using pumping wells. Depending on the volumetric rate of extraction required, groundwater pumping wells may require high capacity well registration. Extracted groundwater would need to be managed, which may include modification to the existing NPDES permit and treatment prior to discharge, if necessary.

There could be some **impacts** associated with constructing and operating a groundwater extraction system, including 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 and selected source control measures, which require detailed technical analysis. Groundwater extraction requires **approval by the OEPA** to be implemented.

The high transmissivity of the Uppermost Aquifer (see Section 2.2) and the nature, extent, and detected concentrations of cobalt in groundwater may limit the effectiveness of a pump and treat system to hydraulically contain and capture the cobalt plume in close proximity to the Ohio River, and in an Uppermost Aquifer with relatively high permeability. The proximity of the plume to the

Ohio River and existing industrial production wells presents challenges for plume capture and containment, which would require removal and treatment of high volumes of groundwater.

4.3.3 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 state and federal regulators. Cutoff walls have a long history of **reliable performance** as hydraulic barriers provided they are properly designed and constructed. **Implementation** of a cutoff wall extending to, and keyed into, the bedrock underlying the Uppermost Aquifer would present challenges due to the required depth (estimated thickness of the permeable valley fill at the MFS is approximately 120 feet). Additional site investigation would be required to verify the feasibility of a cutoff wall keyed into the bedrock below the Uppermost Aquifer, and to evaluate alternate configurations, including a shallower wall used in conjunction with groundwater extraction.

Cutoff walls are designed to act as hydraulic barriers; as a result, cutoff walls inherently alter the existing groundwater flow system. These 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 groundwater 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. Based on literature, and the high yield of the production wells, the hydraulic conductivity is expected to be high. The high horizontal conductivities in the upper aquifer suggest that a barrier wall would have the desired contrast in hydraulic conductivities which improves the **reliability** as groundwater will be unlikely to migrate through the barrier.

There could be some **impacts** associated with constructing and operating a groundwater cutoff wall, 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 3 to 4 years. **Time of implementation** is approximately 6 to 9 years, including characterization, design, permitting and construction. To attain GWPS, groundwater cutoff walls require a separate groundwater corrective measure to operate in concert with the hydraulic barriers. Groundwater cutoff walls are commonly coupled with MNA and/or groundwater extraction as groundwater corrective measures. **Timeframes to achieve GWPS** are dependent on site-specific conditions, which require detailed technical analysis. Groundwater cutoff walls require **approval by the OEPA** to be implemented.

4.3.4 Permeable Reactive Barrier

PRB application as a groundwater corrective measure for cobalt is not well established and more research is needed (EPRI, 2006), therefore, **performance** is unknown. PRB treatment of cobalt is expected to have variable **reliability** based on site-specific hydrogeologic and geochemical conditions. The capacity of the reactive media may be exceeded and require replacement or rejuvenation. Conservative estimates indicate iron-based reactive media are expected to require maintenance every 10 years (ITRC, 2005). **Implementation** of PRBs may have design challenges associated with both groundwater hydraulics and plume configuration given the location of the groundwater impacts between the Ohio River and two high capacity pumping centers.

Funnel-and-gate PRBs inherently alters the existing groundwater flow system. As mentioned above, the high horizontal conductivities in the upper aquifer suggest that the barrier portions of a funnel-and-gate system would have the desired contrast in hydraulic conductivities which improves the reliability as groundwater will be unlikely to migrate through the barrier. 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. **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 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 OEPA** to be implemented.

4.3.5 In-Situ Chemical Treatment

In-situ chemical treatment of cobalt is not well established, and more research is needed (EPRI, 2006); therefore, **performance and reliability** are unknown. Chemical treatment of cobalt is expected to have variable reliability based on site-specific geochemical conditions. The capacity of the reactive media may be exceeded and require replacement or rejuvenation. Conservative estimates indicate iron-based reactive media is expected to require maintenance every 10 years (ITRC, 2005).

Implementation of in-situ chemical treatment may have design challenges associated with groundwater hydraulics given the location of the groundwater impacts between the Ohio River and two high capacity pumping centers.

Injections of reactive media could be completed within 2 to 3 years. **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)**.

In-situ chemical treatment is not retained as a viable corrective measure to address SSLs of cobalt in the Uppermost Aquifer since its performance and reliability are unknown and the groundwater hydraulics are likely to require increased control provided by a PRB.

5. REMEDY SELECTION PROCESS

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 possible 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)

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:

- Potential Source Control Corrective measures
  - Closure in Place (CIP)
  - In-Situ Solidification/Stabilization (ISS)
- Potential Groundwater Corrective measures
  - Monitored Natural Attenuation (MNA)
  - Groundwater Extraction
  - Groundwater Cutoff Wall
  - Permeable Reactive Barrier (PRB)

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)

Using the currently available site-specific data discussed in this CMA, Closure in Place is the source control corrective measure that best fits the standards mentioned above. It is a proven, reliable technology with relatively short implementation (and therefore GWPS attainment) timelines compared to ISS.

Based on the analysis completed to-date (Appendix E), MNA combined with source control appears to be a promising groundwater remedy at the Miami Fort Pond System when reviewed 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 an analysis of the attenuation mechanism, rate, and aquifer capacity to establish multiple lines of evidence in accordance with USEPA guidance.

Additional investigation is also required to increase the density and resolution of Uppermost Aquifer data to facilitate design of a groundwater extraction system, cutoff wall, and/or PRB, if necessary, to evaluate other corrective measures. As presented in the September 5, 2020 Semiannual Remedy Selection Progress Report, groundwater flow and transport modeling is in development to support selection and design of the groundwater remedy. Bench-scale evaluation of reactive media would also be required for design of a PRB.

5.2 Future Actions

Additional investigation will be completed to support analysis of the attenuation mechanism, rate, and aquifer capacity to complete the tiered MNA evaluation recommended by USEPA guidance. Additional Uppermost Aquifer data needed for design of groundwater extraction, cutoff wall, and/or PRB will also be collected during the MNA investigation to the extent allowed by the scope of the MNA investigation.

Semiannual reports per § 257.97 will be prepared to describe the progress in selecting and designing the remedy that addresses the cobalt SSL 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. The corrective action plan will address impacts from CCR constituents in the Uppermost Aquifer.

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TABLES

TABLE 1. ASSESSMENT MONITORING PROGRAM SUMMARY
CORRECTIVE MEASURES ASSESSMENT
MIAMI FORT POND SYSTEM
MIAMI FORT POWER STATION
NORTH BEND, OHIO

Sampling Dates	Analytical Data Receipt Date	Parameters Collected	SSL(s) Appendix IV	SSL(s) Determination Date	ASD Completion Date	CMA Completion / Status
September 18-20, 2018	January 2, 2019	Appendix III	--	--	--	--
		Appendix IV Detected[1]	Cobalt (MW-4) Molybdenum (MW-6)	January 7, 2019	NA	Sept 5, 2019 (completed CMA)
			Arsenic (MW-2, MW-10)		April 8, 2019	NA
March 12-14, 2019	April 29, 2019	Appendix III	--	--	--	--
		Appendix IV	Cobalt (MW-4) Molybdenum (MW-6)	July 29, 2019	NA	ongoing
			Arsenic (MW-2, MW-10)		October 28, 2019	NA
June 12-14, 2019 (delineation event)[2]	July 1, 2019	Cobalt and Molybdenum	NA	NA	NA	NA
September 9-10, 2019	October 8, 2019	Appendix III	--	--	--	--
		Appendix IV Detected[1]	Cobalt (MW-4) Molybdenum (MW-6)	January 6, 2020	NA	Feasibility study phase of CMA; Public meeting held December 16, 2019
			Arsenic (MW-2, MW-10)		April 6, 2020	NA
April 6-7, 2020	May 4, 2020	Appendix III	--	--	--	--
		Appendix IV	Cobalt (4A, MW-4)	August 3, 2020	NA	March 5, 2020 (Semiannual remedy selection progress report)
			Molybdenum (MW-6) Arsenic (MW-2, MW-10, MW-13)		November 12, 2020	September 5, 2020 (Semiannual remedy selection progress report)
September 14-15, 2020	October 20, 2020	Appendix III	--	--	--	--
		Appendix IV Detected[1]	TBD	TBD	TBD	November 30, 2020 (revised CMA)

[O: RAB 9/11/20; C: EJT 9/16/20][U: BGH 11/18/20][U:KLT 11/24/20, C: RAB 11/24/2020]

Notes:
-- = SSL evaluation 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 12-14, 2019 samples were collected as part of a delineation event and analytical results were not statistically evaluated for SSLs. Individual monitoring well exceedances of the GWPS are presented.

TABLE 2. GROUNDWATER CONCENTRATIONS DELINEATING THE COBALT PLUME
CORRECTIVE MEASURES ASSESSMENT
MIAMI FORT POND SYSTEM
MIAMI FORT POWER STATION
NORTH BEND, OHIO

Monitoring Well ID	GWPS	9/18-20/2018		3/12-14/2019		6/12-14/2019		8/9/2019	
		Result	Comparison Value	Result	Comparison Value	Result	Comparison Value	Result	Comparison Value
4A	0.006	--	--	--	--	--	--	0.00200	0.00200
MW-1	0.006	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	NS	NS
MW-2	0.006	NS	0.00050	0.00098	0.00050	NS	NS	NS	NS
MW-3A	0.006	NS	0.00022	0.00223	0.00050	NS	NS	NS	NS
MW-4	0.006	0.01870	**0.00762**	0.00588	**0.00727**	0.0083	**0.0083**	NS	NS
MW-5	0.006	<0.0005	0.00050	<0.0005	0.00050	0.00066	0.00066	NS	NS
MW-6	0.006	0.00473	0.00255	0.00258	0.00253	0.0033	0.0033	NS	NS
MW-7	0.006	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	NS	NS
MW-8	0.006	NS	0.00050	<0.0005	0.00050	NS	NS	NS	NS
MW-9	0.006	NS	0.00050	<0.0005	0.00050	NS	NS	NS	NS
MW-10	0.006	NS	0.00116	<0.0005	0.00095	NS	NS	NS	NS
MW-11	0.006	NS	0.00211	0.00061	-0.00457	NS	NS	NS	NS
MW-12	0.006	0.00193	0.00183	0.00194	0.00183	0.0023	0.0023	NS	NS
MW-13	0.006	<0.0005	-0.01049	<0.0005	-0.01040	<0.0005	<0.0005	NS	NS
MW-14	0.006	NI	NI	NI	NI	0.00099	0.00099	NS	NS
MW-15	0.006	NI	NI	NI	NI	0.0065	**0.0065**	NS	NS
MW-16	0.006	NI	NI	NI	NI	0.00960	**0.00960**	NS	NS
MW-17	0.006	NI	NI	NI	NI	NI	NI	NI	NI
MW-18	0.006	NI	NI	NI	NI	NI	NI	NI	NI
MW-19	0.006	NI	NI	NI	NI	NI	NI	NI	NI

[O: KLT 9/1/20, C: RAB 9/2/2020][U:KLT 9/14/20, C:MGP 9/16/20, U: BGH 11/18/20][U: KLT 11/23/20, C: RAB 11/23/2020]

Notes:

Bold red highlighted concentration indicates exceedance of GWPS for parameter indicated
< = Not Detected at Reporting Limit
-- = No sample; monitoring well not part of CCR program during sampling event
GWPS = Groundwater Protection Standard
mg/L = milligrams per liter
NI = Not Installed
NS = Not Sampled
1. Negative comparison values are the result of the Lower Confidence Band around a negative slope.
2. Comparison Values are presented on plume maps.

TABLE 2. GROUNDWATER CONCENTRATIONS DELINEATING THE COBALT PLUME
CORRECTIVE MEASURES ASSESSMENT
MIAMI FORT POND SYSTEM
MIAMI FORT POWER STATION
NORTH BEND, OHIO

Monitoring Well ID	GWPS	9/9-10/2019		4/6-7/2020		6/12/2020		9/14-15/2020	
		Result	Comparison Value	Result	Comparison Value	Result	Comparison Value	Result	Comparison Value
4A	0.006	--	--	0.00908	**0.00908**	0.012	**0.012**	0.0109	TBD
MW-1	0.006	<0.0005	<0.0005	<0.002	<0.002	NS	NS	<0.002	TBD
MW-2	0.006	0.00063	0.00051	<0.002	0.00052	NS	NS	<0.002	TBD
MW-3A	0.006	<0.0005	0.00050	<0.002	0.00050	NS	NS	<0.002	TBD
MW-4	0.006	0.01710	**0.00795**	0.02240	**0.00844**	NS	NS	0.0149	TBD
MW-5	0.006	0.00052	0.00050	<0.002	0.00050	NS	NS	<0.002	TBD
MW-6	0.006	0.00296	0.00263	0.00263	0.00262	NS	NS	0.00266	TBD
MW-7	0.006	<0.0005	<0.0005	<0.002	<0.002	NS	NS	<0.002	<0.002
MW-8	0.006	<0.0005	0.00050	<0.002	0.00050	NS	NS	<0.002	TBD
MW-9	0.006	<0.0005	0.00050	<0.002	0.00050	NS	NS	<0.002	TBD
MW-10	0.006	<0.0005	-0.00599	<0.002	0.00073	NS	NS	<0.002	TBD
MW-11	0.006	0.00062	-0.00420	<0.002	-0.00382	NS	NS	<0.002	TBD
MW-12	0.006	0.00256	0.00193	0.00259	0.00193	NS	NS	0.00245	TBD
MW-13	0.006	<0.0005	-0.00836	<0.002	-0.00887	NS	NS	<0.002	TBD
MW-14	0.006	0.00069	0.00069	<0.002	<0.002	NS	NS	<0.002	TBD
MW-15	0.006	0.00360	0.00360	0.00386	0.00386	NS	NS	0.00379	TBD
MW-16	0.006	0.00267	0.00267	0.00217	0.00217	NS	NS	0.00347	TBD
MW-17	0.006	NI	NI	NI	NI	NI	NI	<0.002	<0.002
MW-18	0.006	NI	NI	NI	NI	NI	NI	NS	NS
MW-19	0.006	NI	NI	NI	NI	NI	NI	0.0145	**0.0145**

[O: KLT 9/1/20, C: RAB 9/2/2020][U:KLT 9/14/20, C:MGP 9/16/20, U: BGH 11/18/20][U: KLT 11/23/20, C: RAB 11/23/2020]

Notes:

Bold red highlighted concentration indicates exceedance of GWPS for parameter indicated
< = Not Detected at Reporting Limit
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GWPS = Groundwater Protection Standard
mg/L = milligrams per liter
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1. Negative comparison values are the result of the Lower Confidence Band around a negative slope.
2. Comparison Values are presented on plume maps.

TABLE 3. CORRECTIVE MEASURES ASSESSMENT MATRIX
CORRECTIVE MEASURES ASSESSMENT
MIAMI FORT POWER STATION
MIAMI FORT POND SYSTEM
NORTH BEND, OH

	Evaluation Factors	Performance	Reliability	Ease of Implementation	Potential Impacts of Remedy (safety impacts, cross-media impacts, control of exposure to any residual contamination)	Time Required to Begin and Implement Remedy[1]	Time to Attain Groundwater Protection Standards	Institutional Requirements (state/local permit requirements, environmental/public health requirements that affect implementation of remedy)
Source Control Corrective Measures	**Closure In Place**	Widely accepted source control method, routinely approved; variable performance based on site-specific conditions which are favorable for Miami Fort.	Reliable technology.	Commonly performed construction and earthwork.	Controls exposure to CCR. Some potential short term exposure during construction.	5 to 8 years.	CIP achieves source control in 5 to 8 years. Additional time to attain GWPS is dependent on selected groundwater remediation technology.	Requires regulatory approval processes.
	Closure By Removal	Widely accepted, good performance with regard to source control.	Reliable technology.	Commonly performed earthwork. Dewatering can be problematic. Insufficient landfill capacity available with 50 miles.	Significant impact to the community due to CCR transport; reduction in landfill airspace; increases potential for additional mass relase.	20 to 24 years.	CBR achieves source control in 20 to 24 years. Additional time to attain GWPS is dependent on selected groundwater remediation technology.	Requires regulatory approval processes.
	In-Situ Solidification /Stabilization	Not proven in CCR applications.	Unknown.	Requires extensive preimplementation testing and specialized equipment and contractors. Site specific conditions are favorable.	Some potential short term exposure during construction.	Dependent on application volume.	Dependent on selected groundwater remediation technology.	Requires regulatory approval processes.

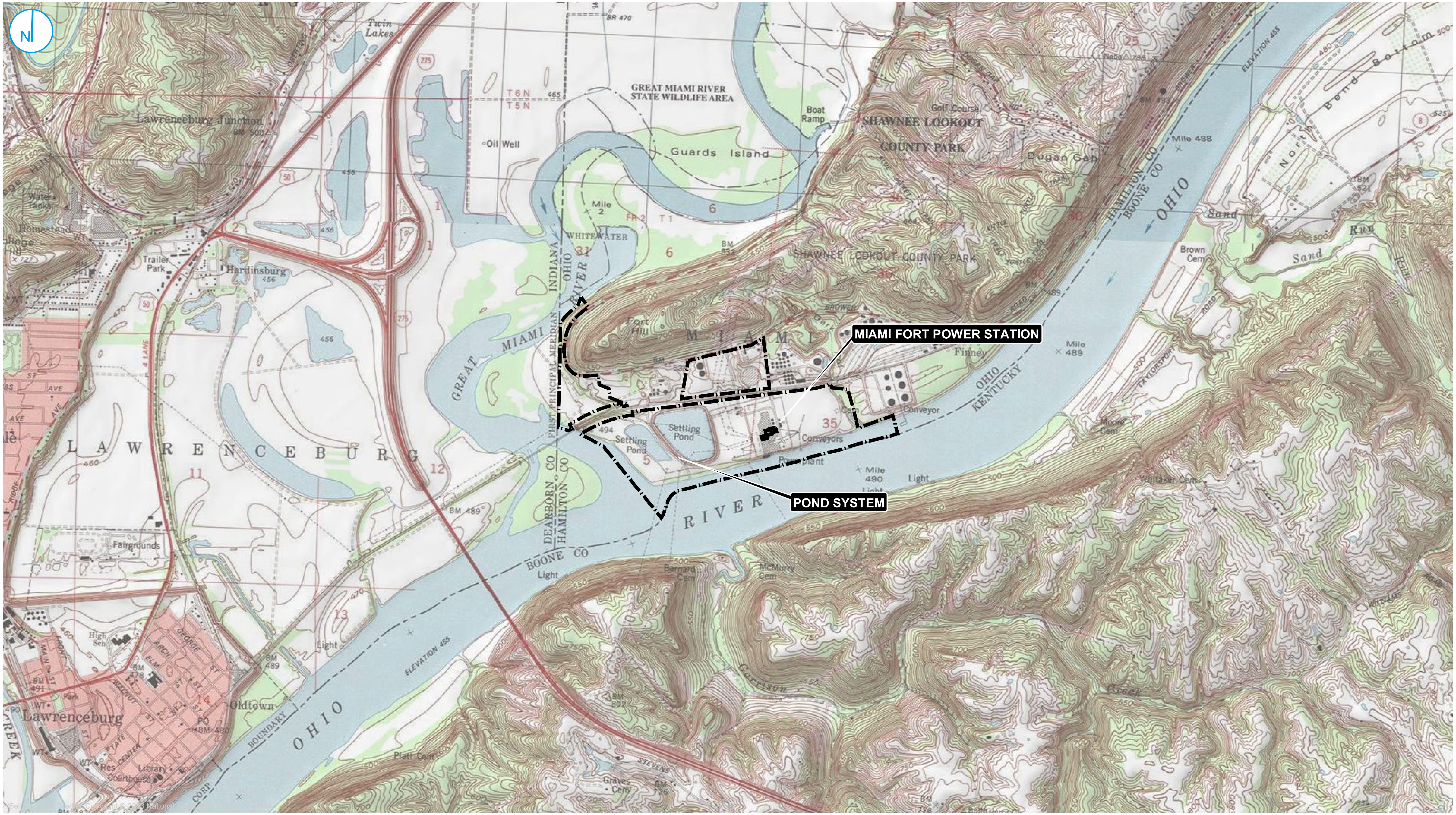
TABLE 3. CORRECTIVE MEASURES ASSESSMENT MATRIX
CORRECTIVE MEASURES ASSESSMENT
MIAMI FORT POWER STATION
MIAMI FORT POND SYSTEM
NORTH BEND, OH

	Evaluation Factors	Performance	Reliability	Ease of Implementation	Potential Impacts of Remedy (safety impacts, cross-media impacts, control of exposure to any residual contamination)	Time Required to Begin and Implement Remedy[1]	Time to Attain Groundwater Protection Standards	Institutional Requirements (state/local permit requirements, environmental/public health requirements that affect implementation of remedy)
Groundwater Remediation Corrective Measures	**MNA**	Performance appears likely to be good given existing information on the constituents of concern and site conditions.	Planned additional testing will evaluate if the attenuation mechanism has low reversability and the aquifer has sufficient capacity.	Easy - completion of tiered evaluation and long-term monitoring required, neither of which require extensive specialized equipment or contractors.	None identified.	1 year, not including source control measures.	Dependent on site-specific condtions including schedule for source controls. Planned additional testing will evaluate attenuation rate.	Requires state regulatory approval processes; additional investigation is designed to address criteria of regulatory process
	Groundwater Extraction	Widely accepted, routinely approved; variable performance based on site-specific conditions. Challenges presented by high permeability aquifer, proximity to Ohio River, and other production wells.	Reliable if properly designed, constructed and maintained.	Design challenges due to groundwater hydraulics and plume configuration. Extracted groundwater may require management of high volumes of water.	Alters groundwater flow system. Potential for some limited exposure to extracted groundwater.	3 to 4 years.	Dependent on site-specific condtions including schedule for source controls.	Extracted groundwater will require management and approval from OEPA. May require high capacity well registration.
	Groundwater Cutoff Wall	Widely accepted, routinely approved, good performance if properly designed and constructed. May not be feasible for full penetration of the Uppermost Aquifer.	Reliable if properly designed and constructed (if feasible). Hydraulic conductivity of aquifer is favorable.	Widely used, established technology. May not be feasible for full penetration of the Uppermost Aquifer.	Alters groundwater flow system.	6 to 9 years.	Needs to be combined with other remediation technology(ies). Time required to attain GWPS dependent on combined technologies and schedule for source control.	Requires regulatory approval processes.
	Permeable Reactive Barrier	Permeable Reactive Barrier treatment not well established for cobalt, therefore performance is unknown.	Variable reliability based on site-specific groundwater hydraulics and geochemical conditions. Hydraulic conductivity of aquifer is favorable.	Design challenges associated with groundwater hydraulics and plume configuration.	Alters groundwater flow system.	6 to 9 years.	Dependent on site-specific conditions including detailed analaysis of reactivity and maintenance.	Requires regulatory approval processes.
	In-Situ Chemical Treatment	In-Situ treatment not well established for cobalt, therefore performance is unknown.	Variable reliability based on site-specific geochemical conditions.	Design challenges associated with groundwater hydraulics.	Alters groundwater geochemistry.	8 to 13 years.	Dependent on site-specific conditions including detailed analaysis of reactivity.	May require Underground Injection Control approval.

Notes:
[1]Time required to begin and implement remedy includes design, permitting and construction.

FIGURES

Y:\Mapping\Projects\22\2285\MXD\Miami_Fort\CMA_Figures\Rev_201022\Figure 1_Site Location Map.mxd



APPROXIMATE PROPERTY BOUNDARY

PROJECT: 169000XXXX | DATED: 10/22/2020 | DESIGNER: STOLZSD

0 1,000 2,000 Feet

SITE LOCATION MAP

FIGURE 1

CORRECTIVE MEASURES ASSESSMENT
MIAMI FORT POND SYSTEM
MIAMI FORT POWER STATION
NORTH BEND, OHIO

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

RAMBOLL

DOWNGRADIENT CCR MONITORING WELL
BACKGROUND CCR MONITORING WELL
MONITORING WELL
MIAMI FORT PRODUCTION WELLS
VEOLIA PRODUCTION WELLS
CCR MONITORED MULTI-UNIT
BERM
RIVER FLOW DIRECTION

0 250 500 Feet

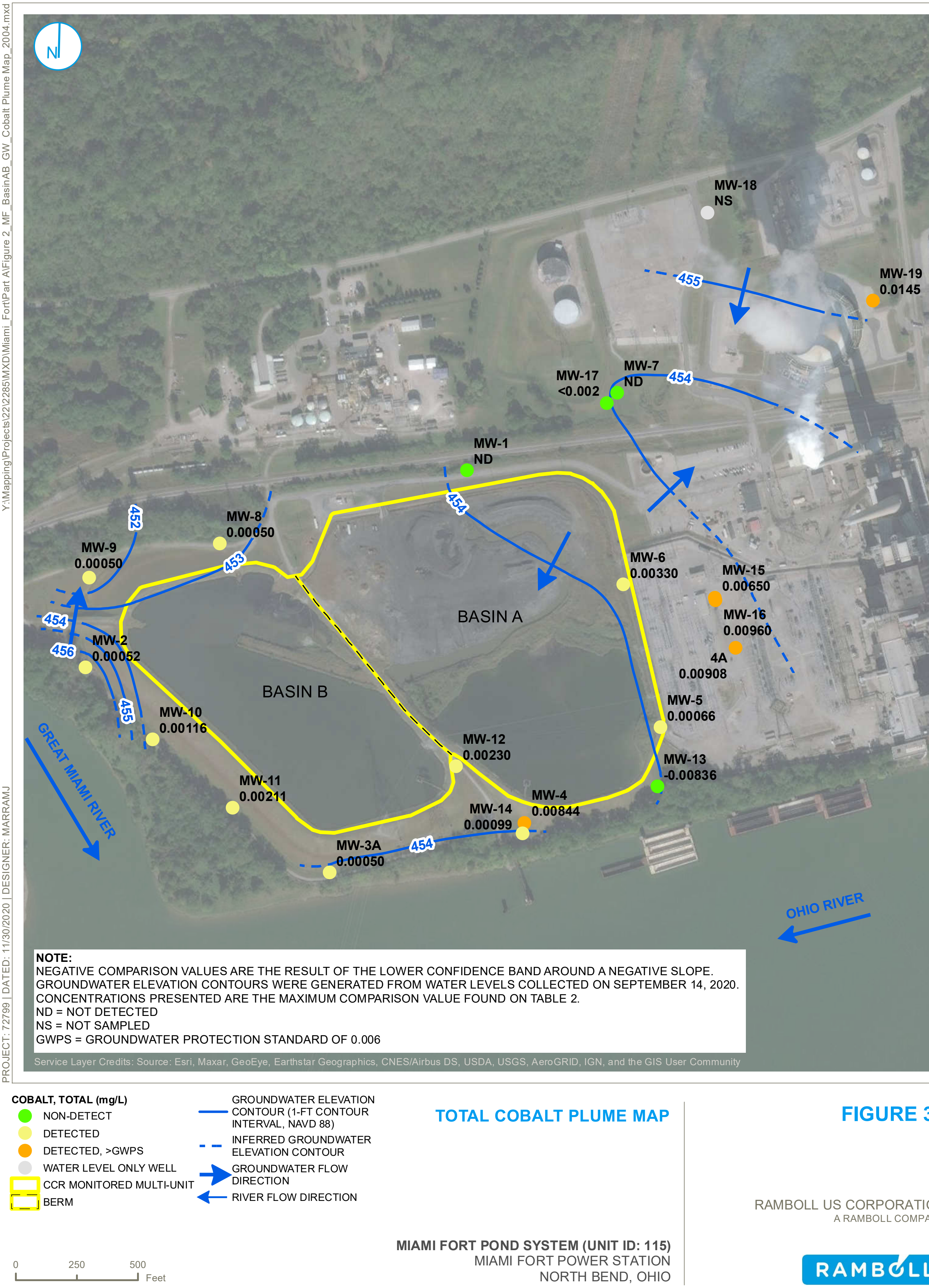
SITE AND WELL LOCATION MAP
POND SYSTEM
(MULTI-UNIT ID: 115)

FIGURE 2

RAMBOLL US CORPORATION
A RAMBOLL COMPANY

MIAMI FORT POND SYSTEM (UNIT ID: 115)
MIAMI FORT POWER STATION
NORTH BEND, OHIO

Y:\Mapping\Projects\22\2285\MXD\Miami_Fort\Part A\Figure 2_MF_BasinAB_GW_Cobalt Plume Map_2004.mxd



NOTE:
NEGATIVE COMPARISON VALUES ARE THE RESULT OF THE LOWER CONFIDENCE BAND AROUND A NEGATIVE SLOPE.
GROUNDWATER ELEVATION CONTOURS WERE GENERATED FROM WATER LEVELS COLLECTED ON SEPTEMBER 14, 2020.
CONCENTRATIONS PRESENTED ARE THE MAXIMUM COMPARISON VALUE FOUND ON TABLE 2.
ND = NOT DETECTED
NS = NOT SAMPLED
GWPS = GROUNDWATER PROTECTION STANDARD OF 0.006

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

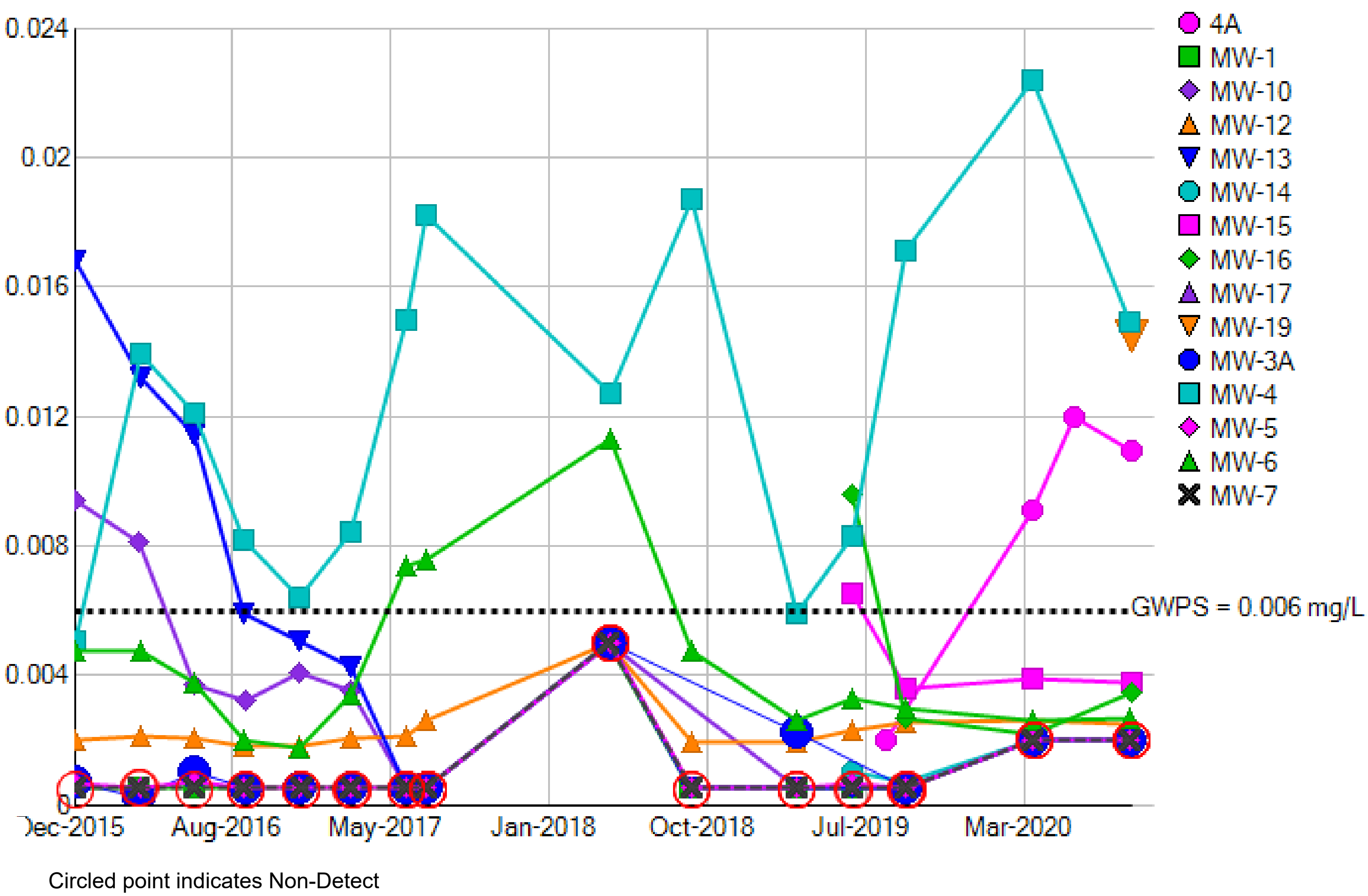
PROJECT: 72799 | DATED: 11/30/2020 | DESIGNER: MARRAMJ

TOTAL COBALT PLUME MAP

FIGURE 3

MIAMI FORT POND SYSTEM (UNIT ID: 115)
MIAMI FORT POWER STATION
NORTH BEND, OHIO

RAMBOLL US CORPORATION
A RAMBOLL COMPANY



COBALT - TIMESERIES

FIGURE 4

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

MIAMI FORT POND SYSTEM (UNIT ID: 115)
MIAMI FORT POWER STATION
NORTH BEND, OHIO

APPENDIX A
ALTERNATE SOURCE DEMONSTRATION FOR ARSENIC & MOLYBDENUM SSLS

Intended for

Dynegy Miami Fort, LLC

Date

November 12, 2020

Project No.

1940074922

40 C.F.R. § 257.95(g)(3)(ii): ALTERNATE SOURCE DEMONSTRATION

MIAMI FORT POND SYSTEM

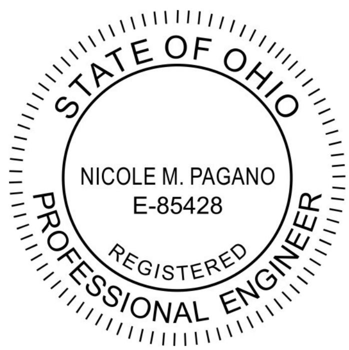
CERTIFICATIONS

I, Jacob J. Walczak, certify that the information in this report is accurate as of the date of my signature below. The content of this report is not to be used for other than its intended purpose and meaning, or for extrapolations beyond the interpretations contained herein.

Jacob J. Walczak
Senior Hydrogeologist
Ramboll Americas Engineering Solutions, Inc.,
f/k/a O'Brien & Gere Engineers, Inc.
Date: November 12, 2020

I, Nicole M. Pagano, a qualified professional engineer in good standing in the State of Ohio, certify that the information in this report is accurate as of the date of my signature below. The content of this report is not to be used for other than its intended purpose and meaning, or for extrapolations beyond the interpretations contained herein.

Nicole M. Pagano
Qualified Professional Engineer
85428
Ohio
Ramboll Americas Engineering Solutions, Inc.,
f/k/a O'Brien & Gere Engineers, Inc.
Date: November 12, 2020



CONTENTS

FIGURES (IN TEXT)

FIGURES

APPENDICES

ACRONYMS AND ABBREVIATIONS

40 C.F.R.	Title 40 of the Code of Federal Regulations
ASD	Alternate Source Demonstration
bgs	below ground surface
CCR	Coal Combustion Residuals
CMP	corrugated metal pipe
FGD	Flue Gas Desulfurization
f/k/a	formerly known as
ft	feet
GWPS	Groundwater Protection Standards
HDPE	high density polyethylene
LOEs	lines of evidence
MCD	Miami Conservancy District
μg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
NAVD88	North American Vertical Datum of 1988
NRT/OBG	Natural Resource Technology, an OBG Company
OEPA	Ohio Environmental Protection Agency
ORP	oxidation-reduction potential
Ramboll	Ramboll Americas Engineering Solutions, Inc., f/k/a O'Brien & Gere Engineers, Inc.
RCRA	Resource Conservation and Recovery Act
Site	Miami Fort Power Station
SSIs	Statistically Significant Increases
SSLs	Statistically Significant Levels
USGS	United States Geological Survey

1. INTRODUCTION

Title 40 of the Code of Federal Regulations (40 C.F.R.) § 257.95(g)(3)(ii) allows the owner or operator of a Coal Combustion Residuals (CCR) unit 90 days from the date of determination of Statistically Significant Levels (SSLs) over Groundwater Protection Standards (GWPS) of groundwater constituents listed in Appendix IV of 40 C.F.R. Part 257 to complete a written demonstration that a source other than the CCR unit being monitored caused the SSL(s), or that the SSL(s) resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality (Alternate Source Demonstration [ASD]).

This ASD has been prepared on behalf of Dynegy Miami Fort, LLC, by Ramboll Americas Engineering Solutions, Inc., formerly known as (f/k/a) O'Brien & Gere Engineers, Inc.(Ramboll), to provide pertinent information pursuant to 40 C.F.R. § 257.95(g)(3)(ii) for the Miami Fort Pond System located near North Bend, Ohio.

The most recent Assessment Monitoring sampling event (A3) was completed on April 6 through April 7, 2020 and analytical data were received on May 4, 2020. Analytical data from all sampling events, from December 2015 through A3, were evaluated in accordance with the Statistical Analysis Plan (Natural Resource Technology, an OBG Company [NRT/OBG], 2017) to determine any Statistically Significant Increases (SSIs) of Appendix III parameters over background concentrations or SSLs of Appendix IV parameters over GWPS. That evaluation identified the following SSLs at downgradient monitoring wells:

- Arsenic at wells MW-2, MW-10 and MW-13
- Cobalt at wells MW-4 and 4A
- Molybdenum at well MW-6

In accordance with the Statistical Analysis Plan, wells MW-13 and 4A were resampled on June 12, 2020 and analyzed only for arsenic and cobalt, respectively, to confirm the SSLs. Following evaluation of analytical data from the resample event, the SSLs listed above for MW-13 and 4A were confirmed.

Pursuant to 40 C.F.R. § 257.95(g)(3)(ii), the following lines of evidence (LOEs) demonstrate that sources other than the Miami Fort Pond System were the cause of the arsenic and molybdenum SSLs listed above. This ASD was completed by November 2, 2020, within 90 days of determination of the SSLs (August 3, 2020), as required by 40 C.F.R. § 257.95(g)(3)(ii). This ASD does not address cobalt SSLs at downgradient monitoring wells MW-4 and 4A which is addressed by the Corrective Measures Assessment for the Pond System.

2. BACKGROUND

2.1 Site Location and Description

Miami Fort Power Station (Site) is located in the southwest corner of Ohio (Hamilton County) adjacent to the state boundaries of Indiana (west) and Kentucky (south), and approximately 5 miles southwest of North Bend, Ohio on the north shore of the Ohio River at the confluence with the Great Miami River (Figure 1). The Miami Fort Pond System (Pond System) is bounded by the Veolia North America property and Brower Road to the north, the Great Miami River to west, the Ohio River to the south, and the Miami Fort electric switch yard to the east. The Miami Fort production wells are located east of Basin A and Veolia's production wells are located northwest of Basin B. Pond System CCR monitoring well locations, production well locations, and source water sampling locations are shown in Figure 1.

2.2 Description of the CCR Multi-Unit

The Pond System is a CCR Multi-Unit consisting of Basins A and B (CCR Multi-Unit ID 115). The Multi-Unit covers a total area of approximately 51 acres and is located in the southwest corner of the Site property as shown in Figure 1.

Basin A (formerly Unit 111) receives effluent from the sluice lines, which primarily transport bottom ash products as well as flue gas desulfurization (FGD) effluent and some fly ash. Basin A also receives directly discharged miscellaneous yard drainage. The material is discharged into the northern portion of the basin and through a constructed internal ditch line allowing the solids to settle and the water to decant into Basin B. Solid materials collected in Basin A are generally reclaimed for beneficial reuse or landfill placement. The Basin A normal pool level is typically between elevations of 495 and 498 ft. Basin A and Basin B are hydraulically connected with a 48-inch corrugated metal pipe (CMP) culvert sliplined with a 40-inch high density polyethylene (HDPE) pipe that runs through the shared dike, allowing the basins to operate in series. The Basin A outfall is currently not in use and flow-through is controlled by the gate structure (AECOM, 2017).

Basin B (formerly Unit 112) was constructed between 1979 and 1981 (AECOM, 2017). The Basin B normal pool level is typically below the Basin A normal pool and between elevations of 495 and 498 ft. Basin A discharges into Basin B, which is used as a polishing pond prior to discharge to the Ohio River through the permitted outfall structure in Basin B. Miscellaneous yard drainage is also currently discharged directly to Basin B (AECOM, 2017).

2.3 Geology and Hydrogeology

The native geologic materials present beneath the Pond System at the Site include alluvial deposits, glacial outwash (Uppermost Aquifer), and bedrock, as described below:

- Alluvial Deposits - The alluvial deposits consist of clay, silt and fine sand deposited by the Ohio River floodwaters. These alluvial deposits are present at a depth ranging from approximately 20 to 60 ft below ground surface (bgs). A silty, sandy clay layer is the primary component of the alluvial deposits. The top of clay elevation ranges from 428 ft referenced to the North American Vertical Datum of 1988 (NAVD88) in the southwest corner of Basin B near the confluence of the Ohio River and the Great Miami River to 495 ft beneath the northeast corner of Basin A. The clay is thin, or absent, near the valley wall north of the Pond System and thickens towards the Ohio River. The clay is thickest beneath the southern half of the

Pond System, ranging in thickness from 15 ft to 48 ft. A silt layer, averaging approximately 7 ft thick, overlies the clay in several areas.

- Glacial Outwash (Uppermost Aquifer) - The Uppermost Aquifer consists of glacial outwash sands and gravels deposited during the Illinoian and Wisconsin stages of the Pleistocene. The thickness of the outwash deposits beneath the Site is approximately 100 ft; the outwash deposits directly overlie bedrock. A silt and fine sand layer is present locally overlying the outwash deposits and ranges in thickness from 4 to 30 ft; however, it is not present below the entirety of the Pond System.
- Bedrock - The bedrock consists of interbedded shales and limestones belonging to the Ordovician-aged Fairview and Kope formations (AECOM, 2017). Depth to bedrock beneath the Site varies between approximately 110 to 120 ft bgs. Due to the relatively impermeable nature of the shales and limestones underlying this region, water yields in the bedrock are generally insufficient for domestic use (AECOM, 2017).

The glacial outwash deposits (Uppermost Aquifer) underlying the Pond System are part of the Ohio River Valley Fill Aquifer; a glacial buried-valley deposit aquifer. The valley was cut into the bedrock by pre-glacial and glacial streams and subsequently backfilled with deposits of sand, gravel, and other glacial drift by glacial and alluvial processes as the glaciers advanced and receded. The thickness of the deposits ranges from approximately 60 to 100 ft and covers much of the width of the terrace between the valley wall to the Great Miami River and Ohio River confluence.

Groundwater elevations across the Site ranged from approximately 456 to 460 ft during A3, coincident with an approximate Ohio River pool elevation of 461 ft. The groundwater elevation contours shown on Figure 2 are based on groundwater measurements collected on April 6, 2020, the day prior to A3 analytical sampling. Groundwater flow in the Uppermost Aquifer is generally to the west/northwest towards the Great Miami River and Veolia’s production wells, and south towards the Ohio River.

3. ALTERNATE SOURCE DEMONSTRATION: LINES OF EVIDENCE

This ASD is based on the following LOEs:

1. Median arsenic and molybdenum concentrations in the Pond System source water are lower than the median arsenic and molybdenum concentrations observed in downgradient wells with arsenic and molybdenum SSLs.
2. Arsenic and molybdenum concentrations associated with monitoring wells MW-2, MW-10 and MW-13, and MW-6, respectively, are not correlated with boron concentrations, a common indicator for CCR impacts to groundwater.
3. Naturally-occurring concentrations of arsenic are commonly found in soils and groundwater in southwestern Ohio. MW-2, MW-10 and MW-13 are located in southwestern Ohio, along the banks of the Great Miami River and Ohio River, where they are susceptible to geochemical conditions that can mobilize naturally-occurring arsenic from the soils into groundwater.

These LOEs are described and supported in greater detail below. Monitoring wells and Pond System source water sample locations are shown on Figure 1.

3.1 LOE #1: Median Arsenic and Molybdenum Concentrations in the Pond System Source Water Are Lower Than the Median Arsenic and Molybdenum Concentrations Observed in Downgradient Wells with Arsenic and Molybdenum SSLs.

Box-and-whisker plots graphically represent the range of values of a given dataset using lines to construct a box where the lower line, midline, and upper line of the box represent the values of the first quartile, median, and third quartile values, respectively. The minimum and maximum values of the dataset (excluding outliers) are illustrated by whisker lines extending beyond the first and third quartiles of (*i.e.*, below and above the box). The interquartile range (IQR) is the distance between the first and third quartiles. Outliers (values that are at least 1.5 times the IQR away from the edges of the box) are represented by single points plotted outside of the range of the whiskers. The number in parentheses below each plot is the number of observations (i.e. samples) represented in that dataset.

Figure A below provides a box-and-whisker plot of the total arsenic concentrations collected between 2015 and 2020 at Pond System monitoring wells and source water locations A-1, B-1, B-2, and B-3 (monitoring well and source water [pond] sampling locations are shown on Figure 1). Total arsenic concentrations obtained in source water samples and presented in Figure A were pooled to provide a median concentration for comparison to arsenic concentrations in monitoring wells.

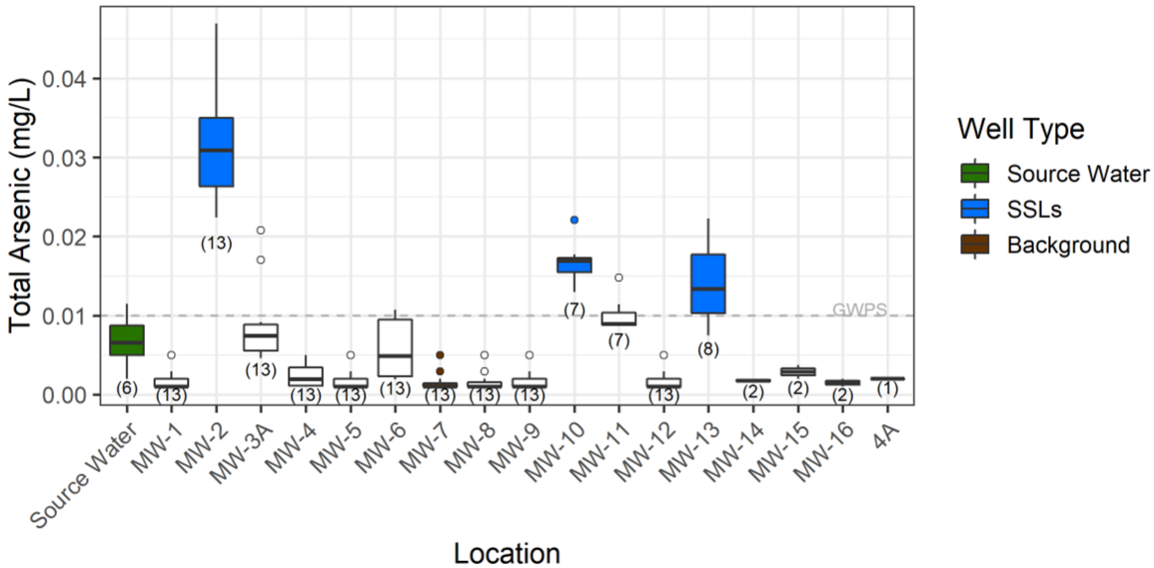


Figure A. Distribution of Arsenic Concentrations at Pond System Monitoring Wells and Source Water Locations (note: source water locations are pooled).

The box-and-whisker plot (Figure A) shows the arsenic concentrations in wells with arsenic SSLs (*i.e.*, MW-2, MW-10, and MW-13) have median arsenic concentrations greater than the median arsenic concentration observed in the source water (A-1, B-1, B-2, and B-3). If the Pond System was the source of arsenic in downgradient groundwater at wells with arsenic SSLs (*i.e.*, MW-2, MW-10, and MW-13), Pond System source water concentrations would be higher than the groundwater concentrations at those wells. Therefore, the Pond System is not the source of the arsenic in the downgradient groundwater.

Figure B below provides a box-and-whisker plot of the molybdenum concentrations collected between 2015 and 2020 at Pond System monitoring wells and source water locations A-1, B-1, B-2 and B-3 (monitoring well and source water sampling locations are shown on Figure 1).

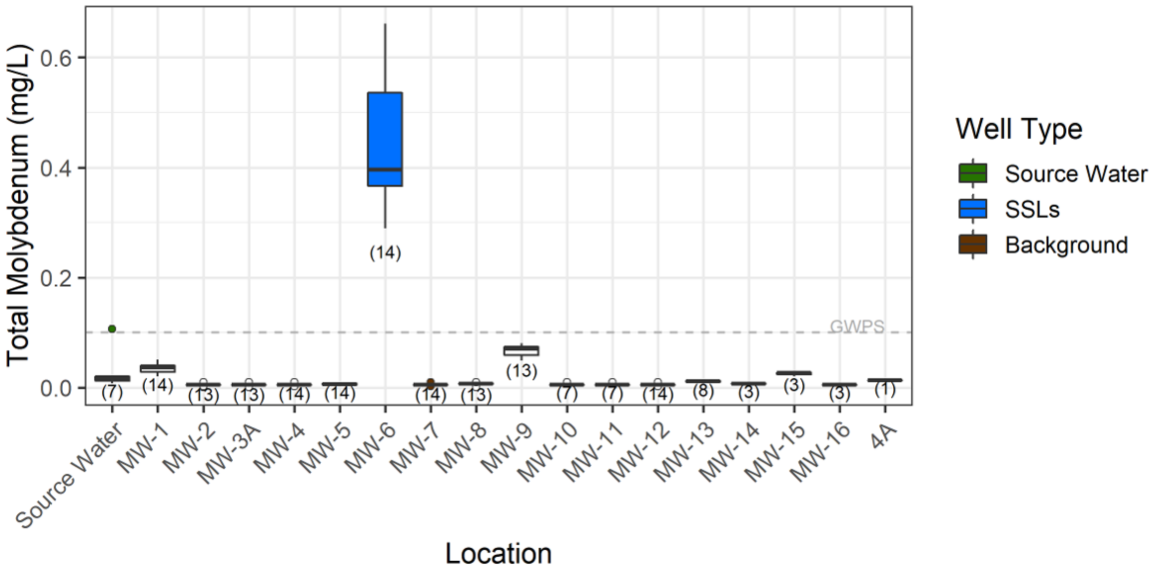


Figure B. Distribution of Molybdenum Concentrations at Pond System Monitoring Wells and Source Water Locations (note: source water locations are pooled).

The box-and-whisker plot (Figure B) shows the median molybdenum concentration in the well with a molybdenum SSL (*i.e.*, MW-6) is greater than the median molybdenum concentration observed in the source water (A-1, B-1, B-2, and B-3). If the Pond System was the source of molybdenum in downgradient groundwater at the well with a molybdenum SSL (*i.e.*, MW-6), Pond System source water concentrations would be higher than the groundwater concentrations at that well. Therefore, the Pond System is not the source of the molybdenum in the downgradient groundwater.

3.2 LOE #2: Arsenic and Molybdenum Concentrations Associated with Monitoring Wells MW-2, MW-10 and MW-13, and MW-6, respectively, are Not Correlated with Boron Concentrations, a Common Indicator for CCR Impacts to Groundwater.

Boron is a common indicator of CCR impacts to groundwater due to its leachability from CCR and mobility in groundwater. If a CCR constituent is identified as an SSL but boron is not correlated with that constituent, it is unlikely that the CCR unit is the source of the SSL.

Figure C below provides a scatter plot of arsenic versus boron concentrations (collected between 2015 and 2020) in downgradient groundwater at wells with arsenic SSLs, along with the results of a Kendall correlation test for non-parametric data. The results of the test at each well are described by the p-value and tau (Kendall’s correlation coefficient) included in each plot. Typically, a p-value greater than 0.05 is considered to be a statistically insignificant relationship. The range of tau falls between -1 and 1, with a perfect correlation equal to -1 or 1. The closer tau is to 0, the less of a correlation exists in the data.

The results of the correlation analyses indicated that groundwater concentrations of arsenic observed at monitoring wells MW 2, MW-10, and MW-13 do not correlate with concentrations of boron, a common indicator of CCR impacts to groundwater. Figure C below illustrates the lack of a relationship between arsenic concentrations and boron concentrations in groundwater at MW-2, MW-10, and MW-13, where the p-values are greater than 0.05 and tau is close to 0.

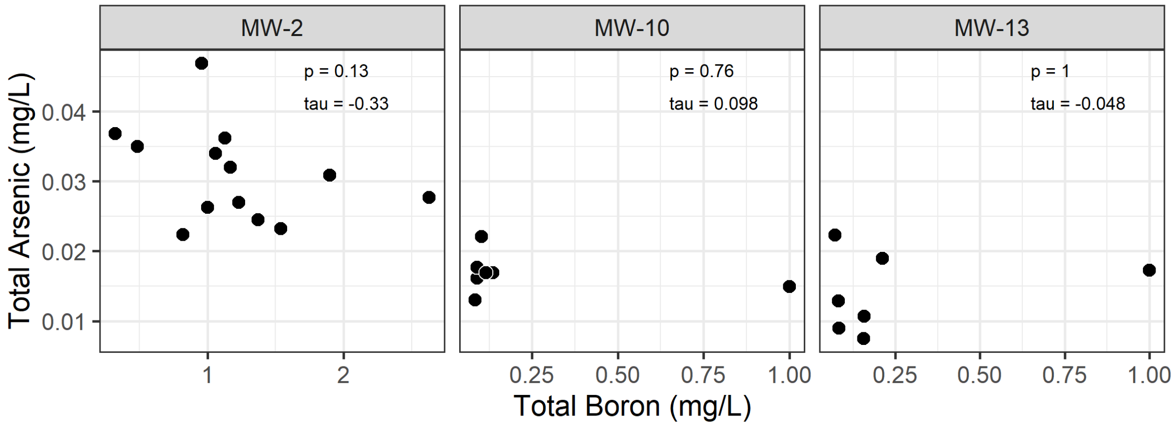


Figure C. Arsenic Concentrations Versus Boron Concentrations at Wells MW-2, MW-10, and MW-13 (2015-2020).

Figure D below provides a scatter plot of molybdenum versus boron concentrations (collected between 2015-2020) in downgradient groundwater at the only well with a molybdenum SSL, MW-6, along with the results of Kendall correlation analysis at MW-6 as described by the p-values and tau correlation coefficients included in the plot. The results of the Kendall correlation analysis indicated that groundwater molybdenum concentrations observed at monitoring well MW-6 do not correlate with concentrations of boron, a common indicator of CCR impacts to groundwater. Figure D below illustrates the lack of a relationship between molybdenum concentrations and boron concentrations in groundwater at MW-6, where the p-value is greater than 0.05 and tau is close to 0.

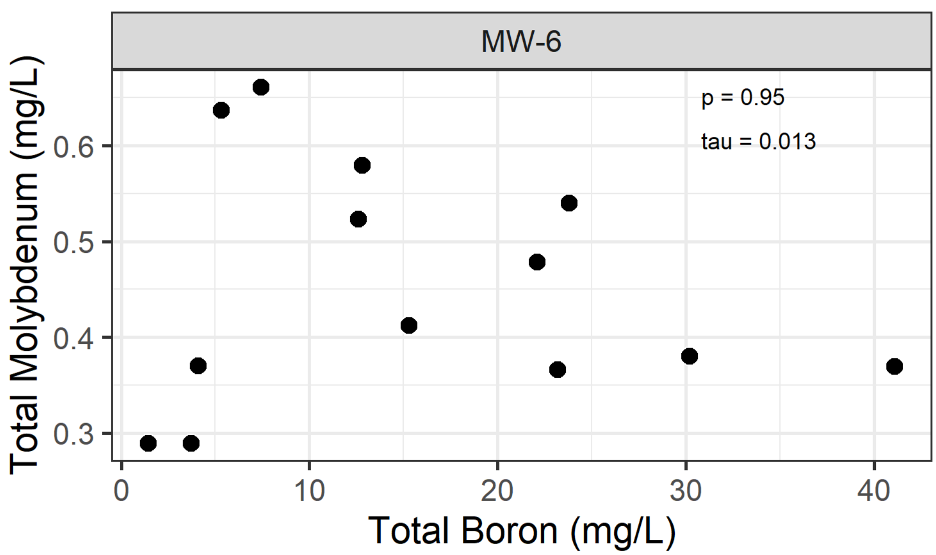


Figure D. Molybdenum Concentrations Versus Boron Concentrations at Well MW-6 (2015-2020).

Arsenic and molybdenum concentrations do not correlate with boron concentrations in downgradient monitoring wells with arsenic and molybdenum SSLs, indicating the Pond System is not the source of CCR constituents detected in the downgradient monitoring wells.

3.3 LOE #3: Naturally-Occurring Concentrations of Arsenic are Commonly Found in Soils and Groundwater in Southwestern Ohio. MW-2, MW-10, and MW-13 are Located in Southwestern Ohio, Along the Banks of the Great Miami River and Ohio River, Where They are Susceptible to Geochemical Conditions that can Mobilize Naturally-Occurring Arsenic from the Soils into Groundwater.

Naturally-occurring concentrations of arsenic are commonly found in nearby soils. Ten surficial soil samples (0 to 2 ft bgs) were collected by Ohio Environmental Protection Agency (OEPA), approximately 3,000 ft northeast of the Pond System (Figure 1), near Shawnee Lookout in Hamilton County Park, and analyzed for arsenic as part of a study to evaluate background soil concentrations of Resource Conservation and Recovery Act (RCRA) metals in the Cincinnati area (OEPA, 2015). Results of the analysis indicated surficial terrace soils (clay) adjacent to the Pond System have background arsenic concentrations ranging from 5.61 to 8.20 milligrams per kilogram (mg/kg).

Arsenic occurs naturally in southwestern Ohio glacial buried-valley deposit aquifers like the Uppermost Aquifer. Fifty-seven (57) groundwater samples were collected by the United States Geological Survey (USGS) in cooperation with the Miami Conservancy District (MCD) to increase understanding of arsenic occurrence in southwest Ohio (Thomas et al., 2005). The study included samples collected from carbonate bedrock, glacial buried-valley deposits and glacial till with interbedded sand and gravel aquifers within the Great Miami River drainage basin, and included samples from domestic wells in Preble, Miami, and Shelby counties. The USGS reported that 37 percent of the samples analyzed had elevated concentrations of arsenic (greater than or equal to 10 micrograms per liter [μg/L]) and elevated arsenic concentrations were found in all three aquifer types studied. Geochemical conditions were also evaluated and the USGS determined that elevated arsenic concentrations in the study area were associated with iron-reducing, sulfate-reducing, or methanic conditions, and all samples with elevated arsenic concentrations had iron concentrations that exceeded 1 milligrams per liter (mg/L), indicating the potential for the reduction of arsenic-bearing iron oxides present in soil.

Based on previous studies discussed above, naturally-occurring concentrations of arsenic are known to exist in both soils and groundwater in the same region (southwestern Ohio) and aquifer type (glacial buried-valley deposit aquifer) as the Pond System. The OEPA study showed arsenic-bearing soils were found in close proximity (approximately 3,000 ft northeast) to the Pond System. The USGS study showed that iron-reducing, sulfate-reducing, or methanic geochemical conditions needed to mobilize arsenic were common in southwestern Ohio aquifers. Reducing conditions indicating the potential for arsenic mobilization are likely to occur at the Pond System monitoring wells MW-2, MW-10, and MW-13, where arsenic SSLs were determined, as indicated by the following factors discussed below:

- Most riverbank boring logs indicate organic materials are present in the soils.
- MW-2, MW-10, and MW-13 are among the monitoring wells adjacent to the riverbank, where the lowest oxidation-reduction potential (ORP) at the Site were observed.

- Dissolved iron concentrations present in groundwater at monitoring well MW-2 correlate with dissolved arsenic concentrations.

Arsenic is naturally present in groundwater and soils at variable concentrations. The arsenic is co-precipitated with iron oxyhydroxides and incorporated into the mineral structure of the soils, and can also be adsorbed to organic matter or the iron oxyhydroxides in the aquifer. Both of these sources of arsenic can be mobilized in groundwater by dissolution or desorption under reducing geochemical conditions, where organic carbon commonly acts as the reducing agent (Thomas et al., 2005; McArthur et al., 2001). Arsenic-bearing soils are known to be present in the areas near the Pond System (OEPA, 2015); and, organic matter, a source of organic carbon and potential reducing agent, was observed in the most riverbank boring logs for monitoring wells located along the banks of the Great Miami River and Ohio River (see boring logs for wells MW-2, MW-3A, MW-4, MW-10, and MW-11 in Appendix A). The presence of organic material and arsenic-bearing soils indicates there is potential for naturally-occurring arsenic to become mobilized through reductive dissolution or desorption.

Reducing conditions sufficient to mobilize naturally-occurring arsenic have also been observed along the riverbanks of the Great Miami River and Ohio River as evidenced by the low ORP measurements observed in the groundwater at monitoring wells MW-2, MW-3A, MW-10, MW-11, MW-13 and MW-14 (presented in Figure E below; monitoring wells adjacent to the riverbank are illustrated with solid lines, upland wells are illustrated with dashed lines).

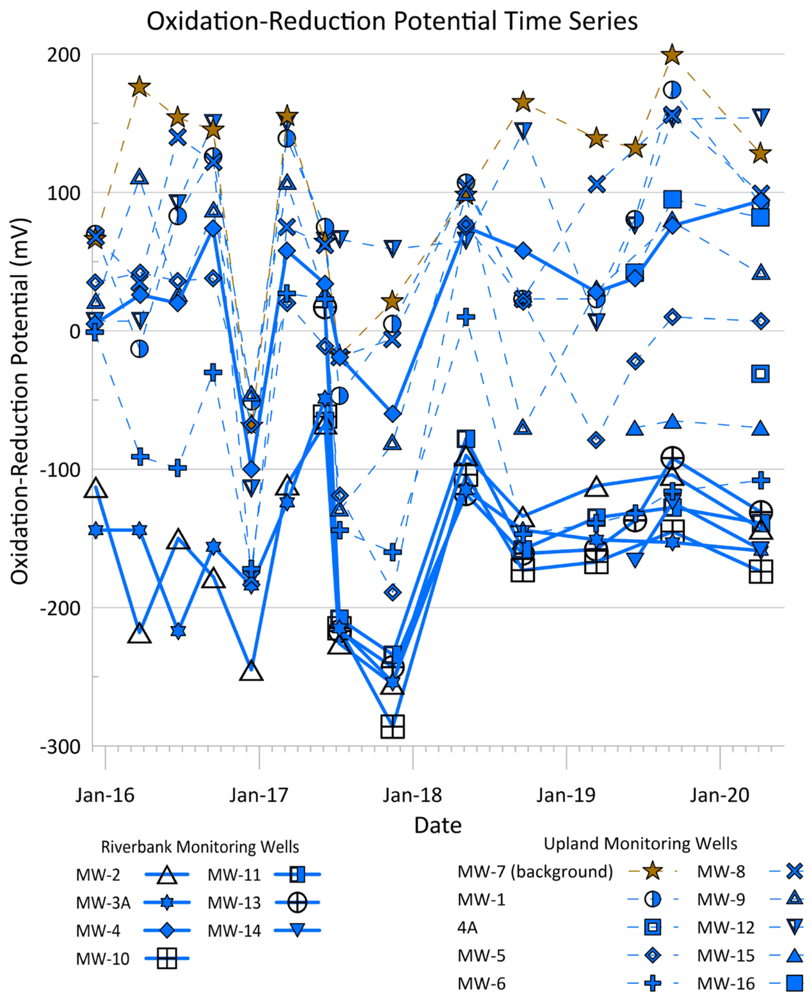


Figure E. Oxidation Reduction Potential Time-Series for Groundwater Samples (Monitoring Wells Adjacent to the Riverbank are Illustrated with Solid Lines, Upland Wells are Illustrated with Dashed Lines).

Available data indicated that concentrations of dissolved iron observed in groundwater at monitoring well MW-2 from 2008 to 2014 correlate with dissolved arsenic concentrations. Dissolved iron concentrations ranged from 11.8 to 52.1 mg/L at monitoring well MW-2 from 2008 to 2014, at least an order of magnitude greater than the 1 mg/L reported by the USGS as being indicative of iron-reducing geochemical conditions. Dissolved iron concentrations were also near or greater than 1 mg/L in A3 for MW-2, MW-10, and MW-13 at 45, 2.5 and 0.91 mg/L, respectively. Figure F below illustrates the relationship between dissolved iron concentrations and dissolved arsenic concentrations in groundwater at MW-2, where the R-squared value is 0.87, indicating a good correlation between dissolved iron and dissolved arsenic.

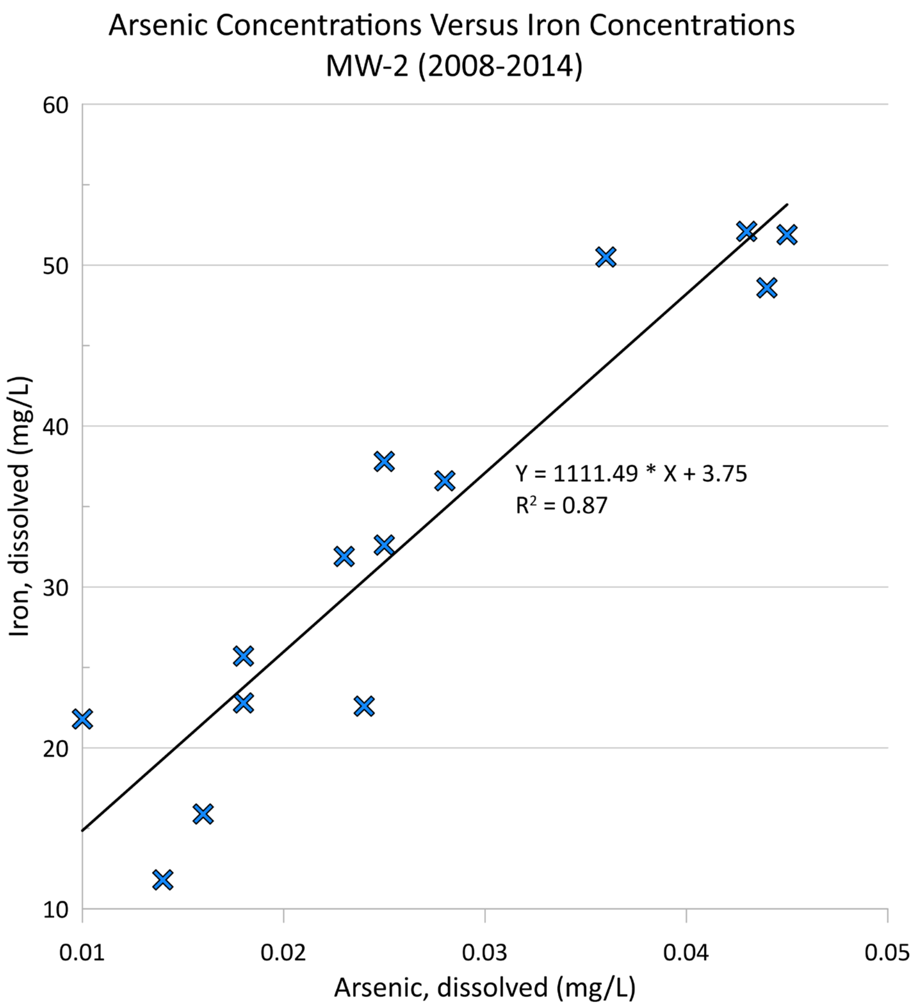


Figure F. Arsenic Concentrations Versus Iron Concentrations at Well MW-2 (2008-2014).

The presence of elevated concentrations of arsenic in background soil and groundwater in surrounding areas, as well as the presence of geochemical conditions (*i.e.*, reducing conditions) necessary to mobilize arsenic from soil to groundwater indicate that elevated concentrations of arsenic at monitoring wells MW-2, MW-10, and MW-13 are likely the result of naturally-occurring geochemical variations within the Uppermost Aquifer.

4. CONCLUSIONS

Based on the following three LOEs, it has been demonstrated that the arsenic SSLs at MW-2, MW-10, and MW-13, and the molybdenum SSL at MW-6 are not due to Miami Fort Pond System but are from a source other than the CCR unit being monitored:

1. Median arsenic and molybdenum concentrations in the Pond System source water are lower than the median arsenic and molybdenum concentrations observed in downgradient wells with arsenic and molybdenum SSLs.
2. Arsenic and molybdenum concentrations associated with monitoring wells MW-2, MW-10 and MW-13, and MW-6, respectively, are not correlated with boron concentrations, a common indicator for CCR impacts to groundwater.
3. Naturally-occurring concentrations of arsenic are commonly found in soils and groundwater in southwestern Ohio. MW-2, MW-10 and MW-13 are located in southwestern Ohio, along the banks of the Great Miami River and Ohio River, where they are susceptible to geochemical conditions that can mobilize naturally-occurring arsenic from the soils into groundwater.

This information serves as the written ASD prepared in accordance with 40 C.F.R. § 257.95(g)(3)(ii) that the SSLs for arsenic and molybdenum observed during the A3 sampling event were not due to the Pond System. Therefore, a corrective measures assessment is not required for arsenic and molybdenum at the Miami Fort Pond System.

5. REFERENCES

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McArthur, J.M., Ravenscroft, R., Safiulla, S., and Thirwall, M.F., 2001, Arsenic in groundwater—Testing pollution mechanisms for sedimentary aquifers in Bangladesh: Water Resources Research, v. 37, no. 1, p. 109–117.

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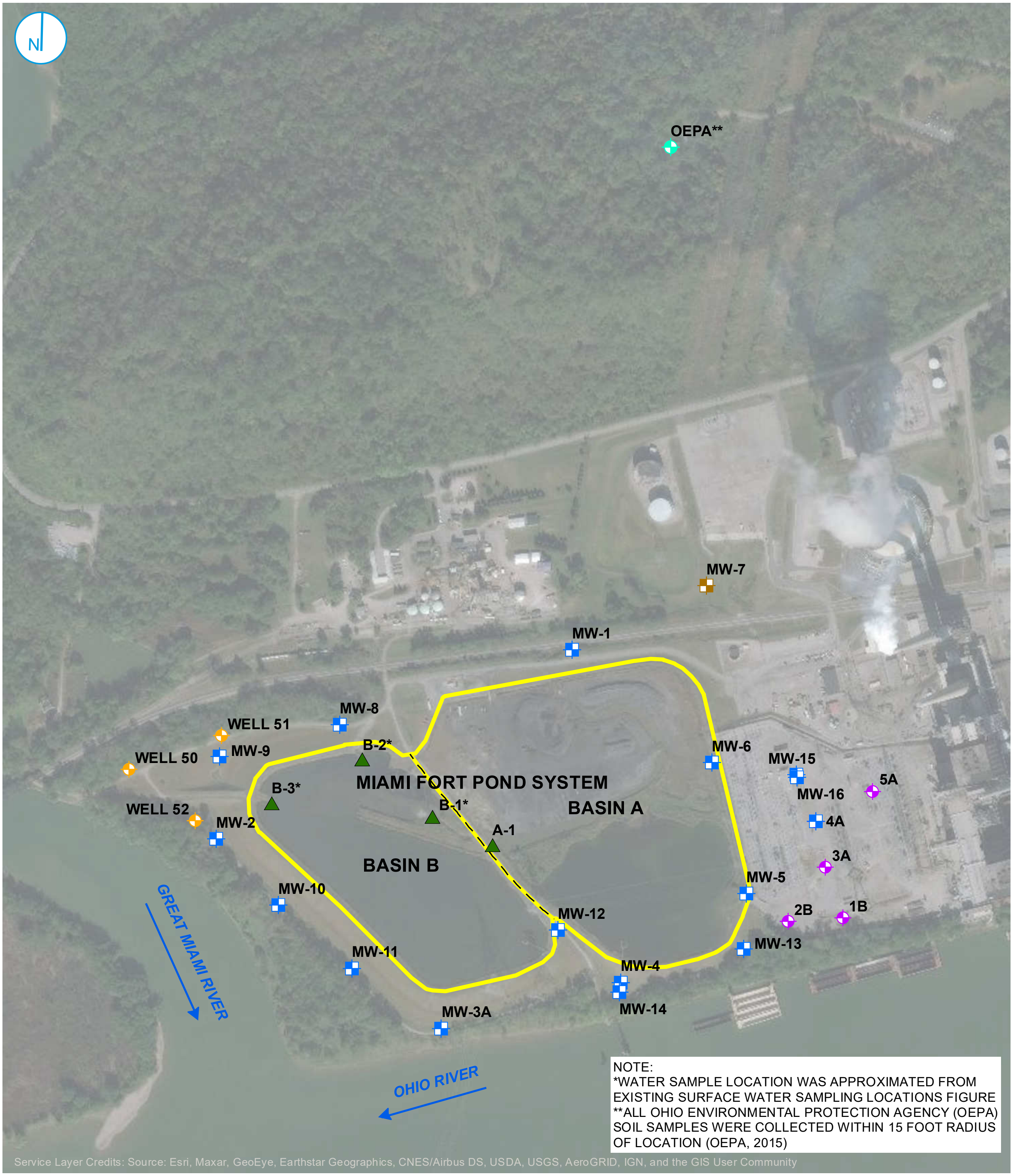
Ohio Environmental Protection Agency (OEPA), 2015, Evaluation of Background Metal Soil Concentrations in Hamilton County – Cincinnati Area, Developed in Support of the Ohio Voluntary Action Program, Summary Report, May 2015.

Thomas, M.A., Schumann, T.L., and Pletsch, B.A., 2005, Arsenic in ground water in selected parts of southwestern Ohio, 2002–03: U.S. Geological Survey Scientific Investigations Report 2005–5138, 30 p.

FIGURES



Y:\Mapping\Projects\22\2285\MXD\Miami_Fortlasd\A3\Figure 1_Monitoring Well and Sampling Locations.mxd

PROJECT: 169000XXXX | DATED: 10/20/2020 | DESIGNER: galarnmc

- DOWNGRADIENT CCR MONITORING WELL LOCATION
- BACKGROUND CCR MONITORING WELL LOCATION
- SOURCE WATER SAMPLING LOCATION
- OEPA SOIL SAMPLE LOCATION
- MIAMI FORT PRODUCTION WELL
- VEOLIA PRODUCTION WELL
- CCR MONITORED MULTI-UNIT
- BERM
- RIVER FLOW DIRECTION

0 300 600 Feet

MONITORING WELL AND SAMPLING LOCATION MAP

FIGURE 1

MIAMI FORT POND SYSTEM (UNIT ID:115)
ALTERNATE SOURCE DEMONSTRATION
VISTRA ENERGY
MIAMI FORT POWER STATION
NORTH BEND, OHIO

RAMBOLL US CORPORATION
A RAMBOLL COMPANY

RAMBOLL

Y:\Mapping\Projects\22\2285\MXD\Miami_Fort\asd\A3\Figure 2_2020_1Q_MiamiFort_GW_Contours.mxd

PROJECT: 72799 | DATED: 10/22/2020 | DESIGNER: STOLZSD

CCR MONITORING WELL LOCATION
MIAMI FORT PRODUCTION WELLS
VEOLIA PRODUCTION WELLS
CCR MONITORED MULTI-UNIT
BERM
RIVER FLOW DIRECTION
SURFACE WATER FEATURE
GROUNDWATER ELEVATION CONTOUR (1-FOOT CONTOUR INTERVAL, NAVD 88)
INFERRED GROUNDWATER ELEVATION CONTOUR
GROUNDWATER FLOW DIRECTION

0 250 500 Feet

GROUNDWATER ELEVATION CONTOUR MAP
APRIL 6, 2020

FIGURE 2

RAMBOLL US CORPORATION
A RAMBOLL COMPANY

MIAMI FORT POND SYSTEM (UNIT ID: 115)
ALTERNATE SOURCE DEMONSTRATION
MIAMI FORT POWER STATION
NORTH BEND, OHIO

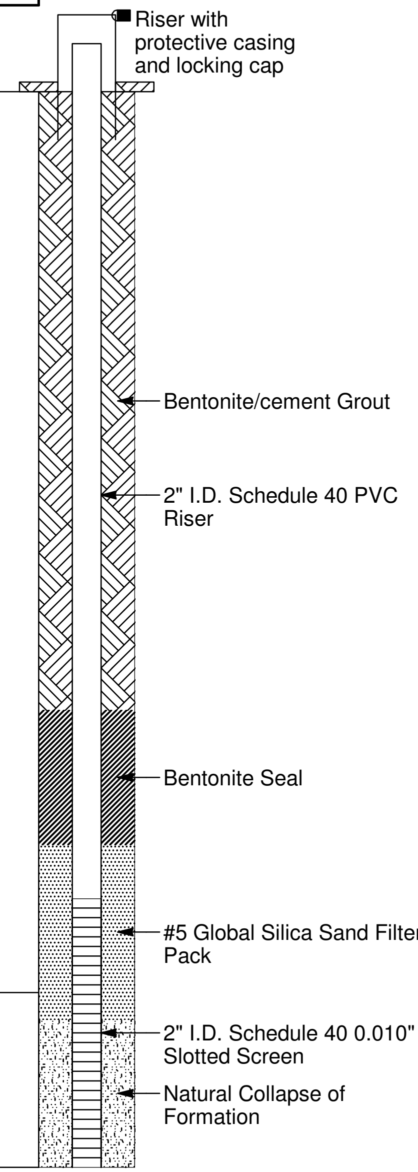
RAMBOLL

APPENDIX A
BORING LOGS FOR MONITORING WELLS MW-2, MW-3A, MW-4, MW-10, AND MW-11

Depth (Feet)	Sample Location	Percent Recovery	USCS Symbol	DESCRIPTION OF SUBSURFACE MATERIALS
0		76		Brown to dark brown sandy CLAY with silt and trace pebbles and rounded gravel, soft, plastic, moist
5		80		grades with organics grades with less sand, pebbles, and gravel, stiff, no plasticity
10		60		grades with increasing sand and pebbles, single 3" cobble grades soft, plastic, very moist grades brownish yellow to brown, without organics
15		70		grades medium stiff to stiff, very slight plasticity to no plasticity
20		100		grades with increasing fine sand, plastic, soft
25		100		grades gray to dark gray, with increasing silt and sand
30		100		grades wet
35		0		Gray fine to coarse SAND and rounded GRAVEL, very loose, poorly sorted, wet
40				

Boring terminated 40' bgs on 12/11/2007.
2" I.D. Schedule 40 PVC monitoring well installed 40' bgs with 10' 0.010" slotted screen.

WELL CONSTRUCTION DETAIL



LEGEND:

Rotosonic

bgs Below ground surface

NR Not recorded

URS

JOB NO. 14947868

Duke Energy
Miami Fort Station
11021 Brower Road
North Bend, OH

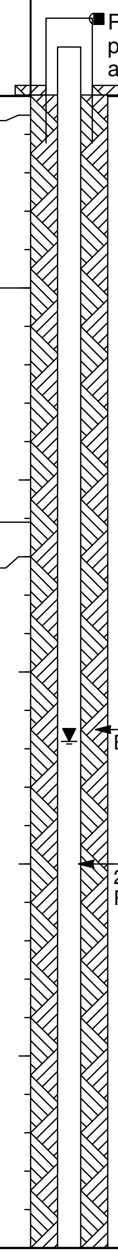
MONITORING WELL MW-2

Project: Duke Energy	**Monitoring Well MW-3A**
Project Location: Miami Fort Station	Sheet 1 of 2
Project Number: 14948624	

Date(s) Drilled	**2/25/2009**	Logged By	**K. Pritchard**	Checked By	**M. Wagner**
Drilling Method	**4.25 in. Hollow Stem Auger**	Drilling Contractor	**Belasco Drilling Services**	Total Depth of Borehole	**52.0 feet**
Drill Rig Type	**Truck-Mounted Auger**	Sampler Type	**Split Spoon**	Surface Elevation	**471.17 feet, msl**
Groundwater Elevation(s)	**456.42 ft, msl**	Hammer Weight and Drop	**140 lb, Dropped 30-inches**	Top of PVC Elevation	**473.23 feet, msl**
Diameter of Hole (inches) **8.25**	Diameter of Well (inches) **2**	Type of Well Casing	**Schedule 40 PVC**	Screen Perforation	**0.010-Inch**
Type of Sand Pack	**Natural Collapse**	Well Completion at Ground Surface	**Riser, With Locking Cap**		
Comments	**** Split spoon sampler advanced through interval under weight of hammer and rods only**				

Elevation, feet	Depth, feet	Blows per 1-foot Interval	Percent Recovery	MATERIAL DESCRIPTION
	0	12	83	Yellowish red CLAY TOPSOIL, moist
470				Gray to brownish gray clayey SILT with medium sand and organics, soft, moist to very moist
		19	100	
		6	83	grades brownish yellow with increasing clay
	5			Dark gray silty CLAY with trace fine sand and organics, plastic, very soft, moist
465		3	100	
				grades with increasing fine to medium sand, without organics, with iron staining
		3	83	grades with medium to coarse grained sand lenses, without staining
	10			grades high plasticity, very moist to wet
		3	75	
460				Yellowish brown clayey fine to coarse grained SAND, very loose, well sorted, wet
		2	100	Yellowish brown fine grained sandy to silty CLAY, very soft, high plasticity, very moist to wet
		1	100	
	15			grades wet with increasing fine sand
455		1	100	
				grades with fine grained sand lenses
		2	100	grades brown with increasing fine sand
	20	2	100	
450				
		2	100	grades with gray to reddish gray lenses, decreasing sand, without sand lenses
		**	100	grades gray, without gray to reddish gray lenses, medium plasticity
				grades high plasticity
	25			grades with increasing sand
445		3	100	
				grades with organics, sulphur odor, decreasing sand
		2	100	grades without sand, without odor
				grades with fine sand lenses, without organics
	30			

WELL CONSTRUCTION DETAILS



Project: Duke Energy
Project Location: Miami Fort Station
Project Number: 14948624

Monitoring Well MW-3A

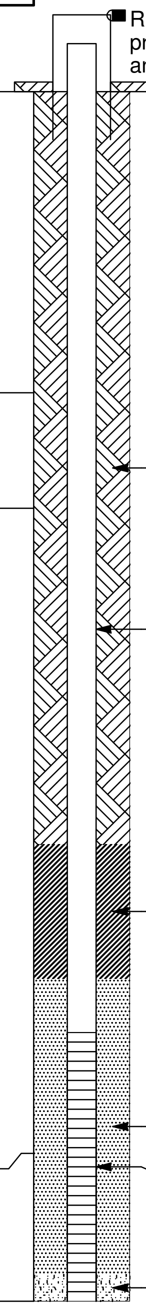
Elevation, feet	Depth, feet	SAMPLES Type	Blows per 1-foot Interval	Percent Recovery	MATERIAL DESCRIPTION	WELL CONSTRUCTION DETAILS
440	30	X	1	100	grades without sand, with trace organics	
		X	4	100	grades with sand, without organics	
		X	4	100	grades with trace fine sand and increasing silt, without sand lenses, medium plasticity	
435	35				grades with increasing sand, without organics	
		X	3	100	grades with increasing silt, trace sand, very low plasticity, stiff	Bentonite Seal
		X	6	100	grades with sand, plastic, very soft	
					grades stiff, very low plasticity, very moist	
430	40	X	4	100	grades with trace organcis, less sand, increasing silt	
		X	8	100		
		X	14	42	Gray fine to coarse grained SAND and sub-rounded to rounded GRAVEL, pebble-sized gravel with trace 1" diameter clasts, very loose, sorted, wet	
425	45	X	7	100		Natural Collapse of Formation
						2" I.D. Schedule 40 0.010" Slotted Screen
		X	22	63	grades with increasing diameter gravel	
420	50	X	13	50		
					Boring terminated 52' bgs on 2/25/2009. 2" I.D. Schedule 40 PVC monitoring well installed 52' bgs with 10' 0.010" slotted screen.	
415	55					
410	60					
405	65					
	70					

DESCRIPTION OF SUBSURFACE MATERIALS

Depth (Feet)	Sample Location	Percent Recovery	USCS Symbol	Description of Subsurface Materials
0				Dark gray fine to coarse SAND and GRAVEL FILL with clay, soft, moist
		100		
5				grades very hard to brittle (FILL) with glass piece
				grades dry, very loose with angular clasts (FILL)
		50		
10				
				Yellowish red silty CLAY with trace fine sand, medium stiff, very slightly moist to moist
		62		grades soft
15				Brownish yellow to yellowish red sandy CLAY, soft, moist (sand is very fine grained to fine grained)
		80		grades loose, with increasing sand
				grades soft
20				
		80		grades sandy clay/clayey sand (increasing sand), very moist to wet
25				grades very moist
		80		grades with less sand, with red staining and organics, medium stiff
30				grades with increasing sand
				grades with less sand
		40		
35				
				grades gray
		100		grades with increasing sand (clayey sand), very moist
				large wood piece through core sample
40				Gray medium to coarse grained SAND and rounded GRAVEL, poorly sorted, wet
		0		NO RECOVERY 40-45 feet bgs
45				

Boring terminated 45' bgs on 12/12/2007.
2" I.D. Schedule 40 PVC monitoring well installed 45' bgs with 10' 0.010" slotted screen.

WELL CONSTRUCTION DETAIL



LEGEND:

- Rotosonic
- bgs Below ground surface
- NR Not recorded

Duke Energy - 14947868 - North Bend, OH

DUKE ENERGY MIAMI FORT STATION MIAMI FORT STATION.GPJ 2/5/08

URS

JOB NO. 14947868

Duke Energy
Miami Fort Station
11021 Brower Road
North Bend, OH

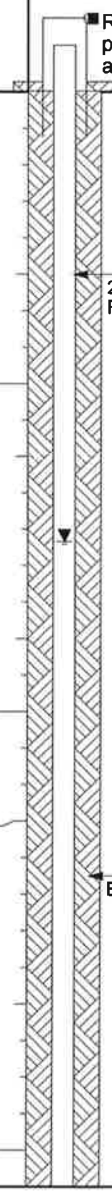
MONITORING WELL MW-4

Project: Dynegy
Project Location: Miami Fort Station
Project Number: 60442412

Monitoring Well MW-10
Sheet 1 of 2

Date(s) Drilled	4/10/2017	Logged By	J. Alten	Checked By	M. Wagner
Drilling Method	Rotosonic	Drilling Contractor	Frontz Drilling	Total Depth of Borehole	59.0 feet
Drill Rig Type	Rotosonic	Sampler Type	Sonic Sleeve	Surface Elevation	470.90 feet, msl
Depth to Groundwater	12.34 ft bgs	Seal Material	Hydrated 3/8-inch Bentonite Chips	Top of PVC Elevation	473.35 feet, msl
Diameter of Hole (inches)	6.0 / Diameter of Well (inches) 2	Type of Well Casing	Schedule 40 PVC	Screen Perforation	0.010-Inch
Type of Sand Pack	#5 Silica Sand	Well Completion at Ground Surface	Riser, With locking cap and protective casing.		
Comments					

Elevation, feet	Depth, feet	SAMPLES: Type	SAMPLES: Percent Recovery	SAMPLES: Graphic Log	MATERIAL DESCRIPTION
470	0		74		Brown SILT, with clay and fine angular to sub rounded gravel, soft, slightly moist
					Grades with more clay and gravel, medium stiff
465	5				Grades without gravel and more clay, very stiff, moist
					Brown CLAY, with silt, medium stiff, moist
460	10		48		
455	15				Brown SILT, with some clay and very fine sand, soft, moist
			93		Grades with less silt and more fine sand
450	20				Brown fine SAND, with silt and clay, loose, soft, moist
					Grades with less silt and clay
445	25				Grades gray and brown
					Grades with trace silt and without clay, few pieces of organic matter
	30		88		Gray and brown fine SAND, with trace silt, loose, moist



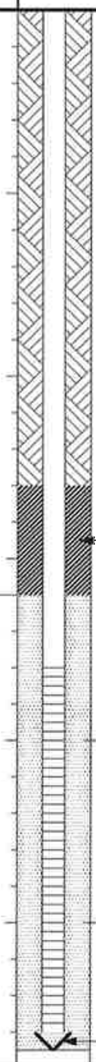
DYNEGY CCR GENERAL MIAMI FORT STATION CCR WELLS.GPJ 5/18/17

AECOM

Project: Dynegy **Project Location:** Miami Fort Station **Project Number:** 60442412	**Monitoring Well MW-10** Sheet 2 of 2

Elevation, feet	Depth, feet	SAMPLES Type	Percent Recovery	Graphic Log	MATERIAL DESCRIPTION
440	30				
435	35				Grades with some medium sand
					Grades to medium sand
			58		Grades wet
430	40				Grades with silt, more dense
425	45				Grades with fine and coarse sand
					Brown and gray fine to coarse SAND wtih fine to coarse rounded gravel, loose, wet
			88		
420	50				Brown medium SAND, loose, wet
415	55				
					End of boring at 59'
410	60				
405	65				
	70				

WELL CONSTRUCTION DETAILS



AECOM

DYNEGY CCR GENERAL MIAMI FORT STATION CCR WELLS.GPJ 5/18/17

Project: Dynegy	Monitoring Well
Project Location: Miami Fort Station	MW-11
Project Number: 60442412	Sheet 1 of 2

Date(s) Drilled	4/11/2017	Logged By	J. Alten	Checked By	M. Wagner
Drilling Method	Rotosonic	Drilling Contractor	Frontz Drilling	Total Depth of Borehole	59.0 feet
Drill Rig Type	Rotosonic	Sampler Type	Sonic Sleeve	Surface Elevation	471.81 feet, msl
Depth to Groundwater	13.25 ft bgs	Seal Material	Hydrated 3/8-inch Bentonite Chips	Top of PVC Elevation	474.45 feet, msl
Diameter of Hole (inches)	6.0 / Diameter of Well (inches) 2	Type of Well Casing	Schedule 40 PVC	Screen Perforation	0.010-Inch
Type of Sand Pack	#5 Silica Sand	Well Completion at Ground Surface	Riser, With locking cap and protective casing.		
Comments					

Elevation, feet	Depth, feet	SAMPLES: Type	SAMPLES: Percent Recovery	MATERIAL DESCRIPTION
	0		69	Gray coarse angluar limestone GRAVEL, with fines, medium dense, slightly moist (FILL)
470				Brown and tan with reddish mottled SILT with trace fine gravel, very stiff, moist
				Grades with fine sand
	5			Brown with red mottled fine SAND, soft, moist
465				Dark gray SILT with some clay, stiff, moist, trace organci matter
				Grades with more clay
				Gray and brown CLAY, with some silt, soft, moist
	10		42	
460				Gray and brown SILT, with fine sand and some clay, soft, moist
	15			
455				Grades with less clay
			56	
	20			Grades gray without clay
450				
				Gray very fine SAND with silt, soft, moist
	25			
445				
			53	
	30			Grades with dark gray and black wood fragments

WELL CONSTRUCTION DETAILS

Riser with protective casing and locking cap

2" I.D. Schedule 40 PVC Riser

Bentonite/cement Grout

DYNEGY CCR GENERAL MIAMI FORT STATION CCR WELLS.GPJ 5/18/17

AECOM

Project: Dynegy	Monitoring Well
Project Location: Miami Fort Station	MW-11
Project Number: 60442412	Sheet 2 of 2

Elevation, feet	Depth, feet	Samples: Type	Samples: Percent Recovery	Samples: Graphic Log	MATERIAL DESCRIPTION	WELL CONSTRUCTION DETAILS
	30					
440					Grades without wood fragments	
	35					
435					Grades with less silt	
			83			
	40					
					Gray fine to coarse SAND with rounded fine gravel, loose, moist	
430						
					Grades to fine sand and without gravel	
	45					
					Grades brown and gray	Bentonite Seal
425						
					Grades fine to coarse sand with rounded fine to medium gravel	
			80			
	50				Grades wet	#5 Global Silica Sand Filter Pack
420						
					Alternating reddish brown CLAY lens and fine to coarse SAND with rounded fine to coarse gravel, soft, wet	
	55					2" I.D. Schedule 40 0.010" Slotted Screen
415						
					Boring terminated at 59'	End Cap
	60					
410						
	65					
405						
	70					

DYNEGY CCR GENERAL MIAMI FORT STATION CCR WELLS.GPJ 5/18/17

AECOM

APPENDIX B
GEOLOGIC CROSS-SECTIONS

UNIT BOUNDARY

DOWNGRADIENT MONITORING WELL LOCATION

UPGRADIENT MONITORING WELL LOCATION

CROSS-SECTION LOCATION

AERIAL SOURCE: CAGIS

N

0 150 300

SCALE IN FEET

DYNEGY

Miami Fort
Hamilton County, Ohio

FIGURE 4
SITE AND GEOLOGIC
CROSS-SECTION LOCATION MAP

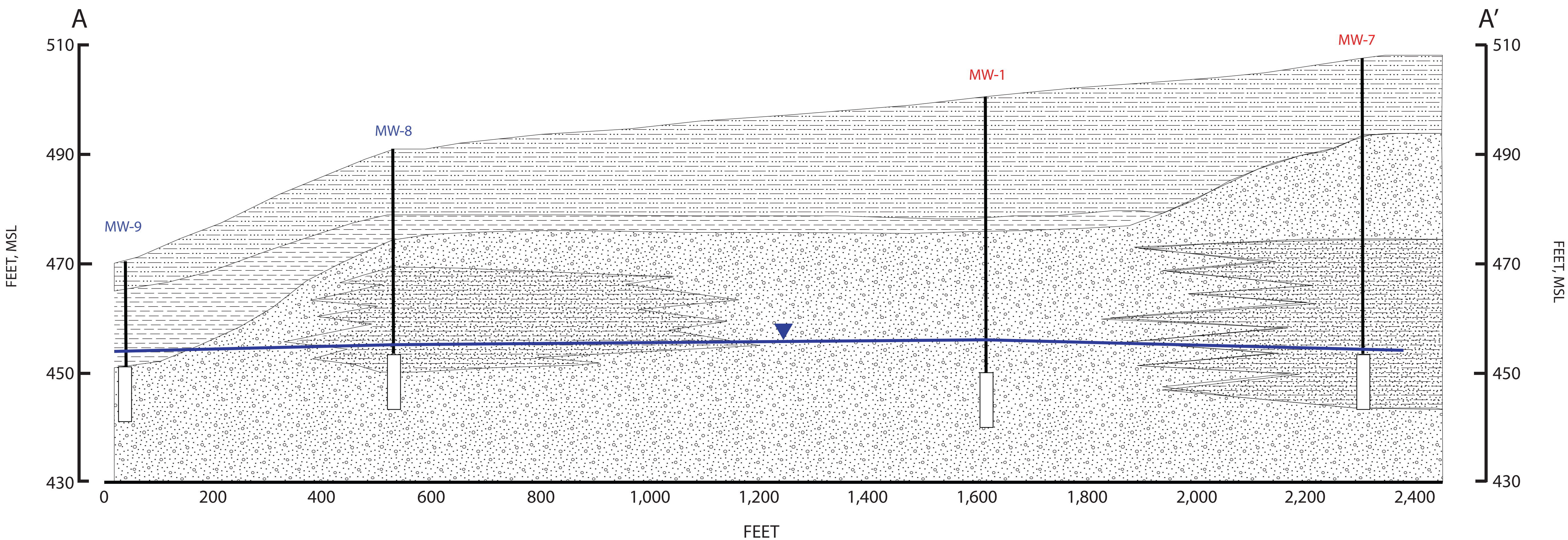
DATE	REV NO.	DWG. BY	CHKD. BY
09/28/17	0	ALW	MAW

JOB NO. 60442412

AECOM

Appendix B - Geologic Cross Sections

J:\Project\D\Dynegy\60442412 Miami Fort and Zimmer CCR 2015-2017\Data-Tech\TI\MFS\MFS HCR\Unit 111 and 112



LEGEND

SILT

SILT AND FINE SAND

CLAY / SILTY CLAY

SAND AND GRAVEL

MW-7 UPGRADIENT MONITORING WELL LOCATION

MW-8 DOWNGRADIENT MONITORING WELL LOCATION

POTENTIOMETRIC SURFACE ON 07-10-17

MONITORING WELL RISER

MONITORING WELL SCREEN

20

200

(Vertical Exaggeration in Feet = 10x)

DYNEGY

Miami Fort
Hamilton County, Ohio

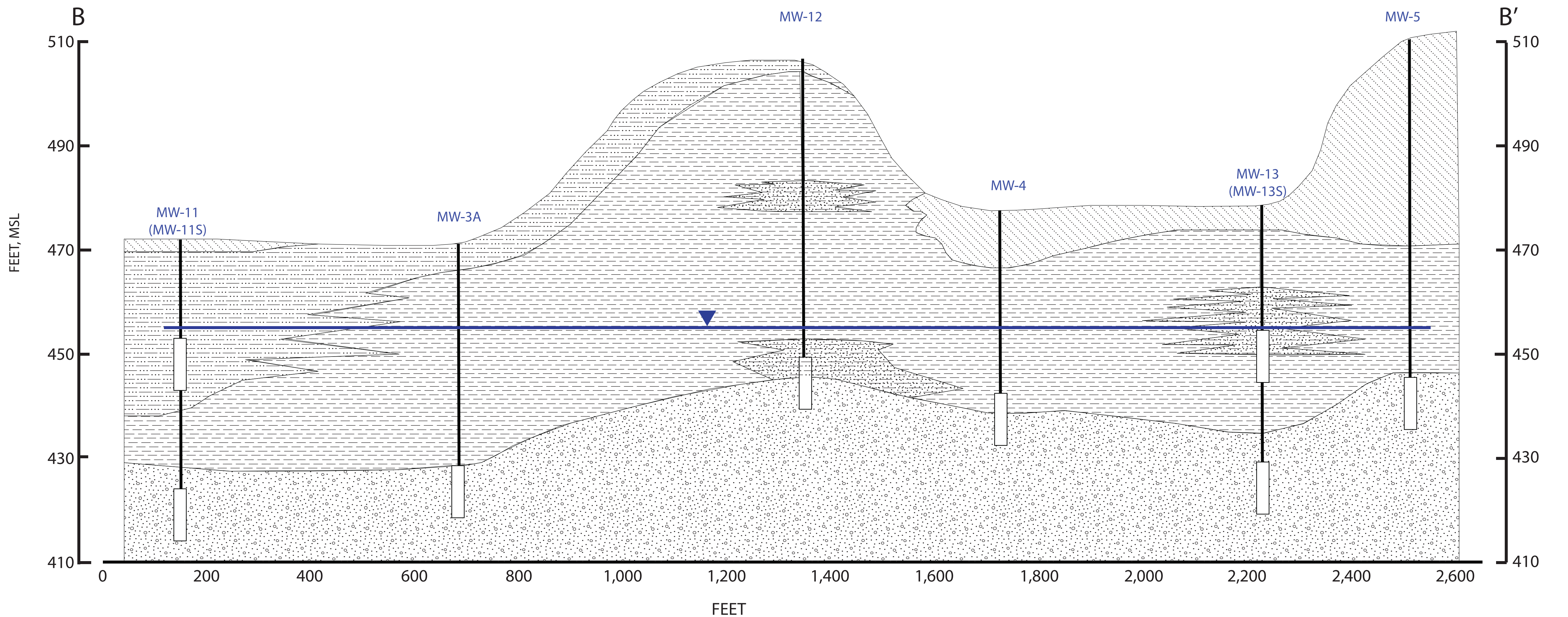
FIGURE 5
GEOLOGIC CROSS-SECTION A-A′

DATE	REV NO.	DWG. BY	CHKD. BY
08/28/17	0	JMA	MAW

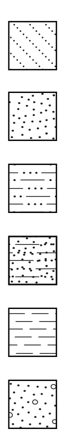
JOB NO. 60442412

AECOM

Appendix B - Geologic Cross Sections



LEGEND



GRAVEL / SAND / CLAY FILL

SAND

SILT

SILT AND FINE SAND

CLAY / SILTY CLAY

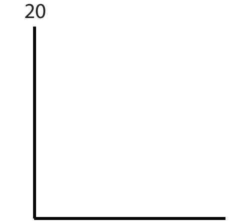
SAND AND GRAVEL

MW-11 DOWNGRADIENT MONITORING WELL LOCATION

POTENTIOMETRIC SURFACE ON 07-10-17

MONITORING WELL RISER

MONITORING WELL SCREEN



(Vertical Exaggeration in Feet = 10x)

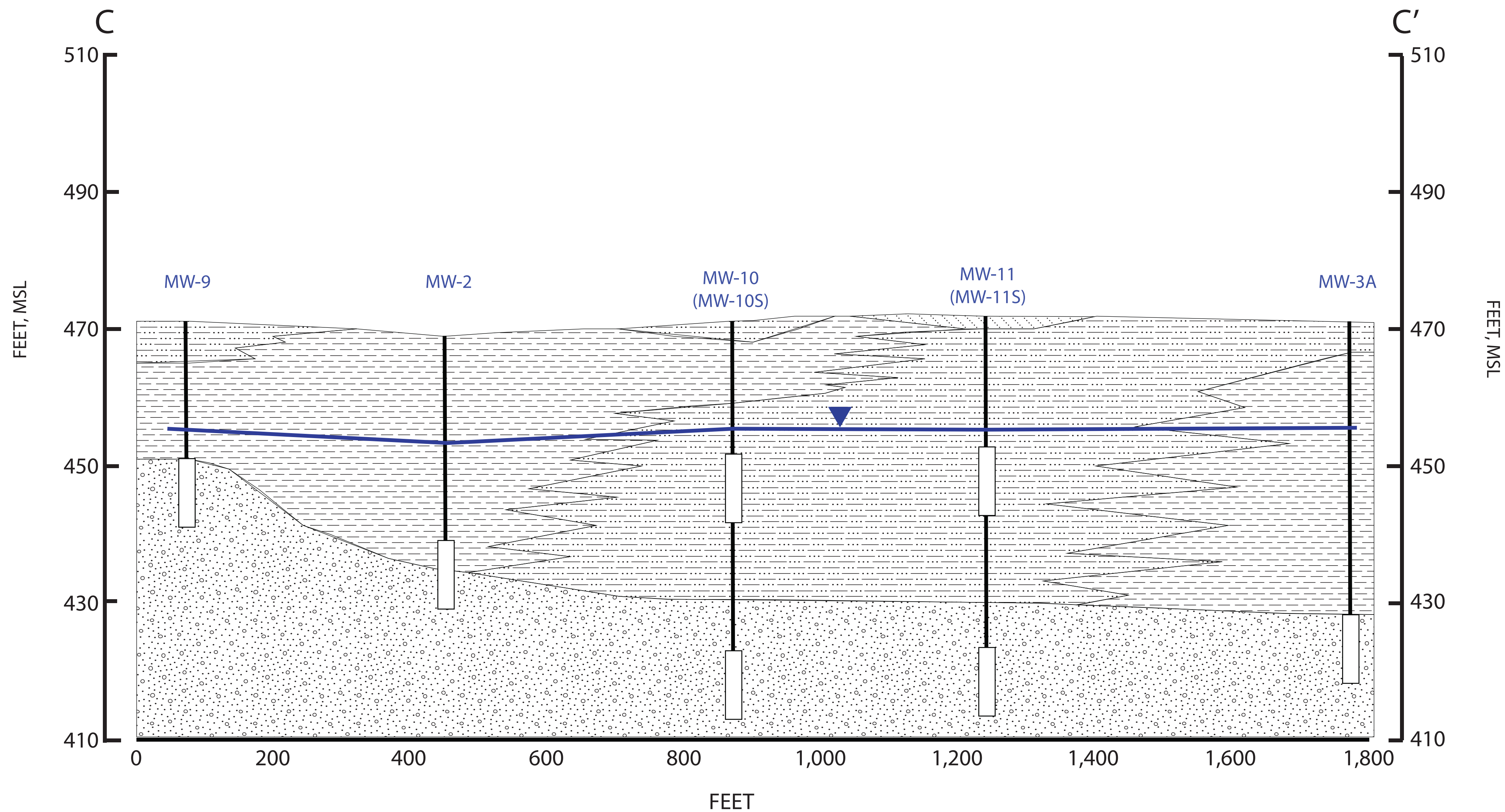
DYNEGY

Miami Fort
Hamilton County, Ohio

FIGURE 6
GEOLOGIC CROSS-SECTION B-B′

DATE	REV NO.	DWG. BY	CHKD. BY
08/28/17	0	JMA	MAW

JOB NO. 60442412 AECOM



LEGEND

GRAVEL FILL

SILT

CLAY / SILTY CLAY

SAND AND GRAVEL

MW-9 DOWNGRADIENT MONITORING WELL LOCATION

POTENTIOMETRIC SURFACE ON 07-14-17

MONITORING WELL RISER

MONITORING WELL SCREEN

20

200

(Vertical Exaggeration in Feet = 10x)

DYNEGY

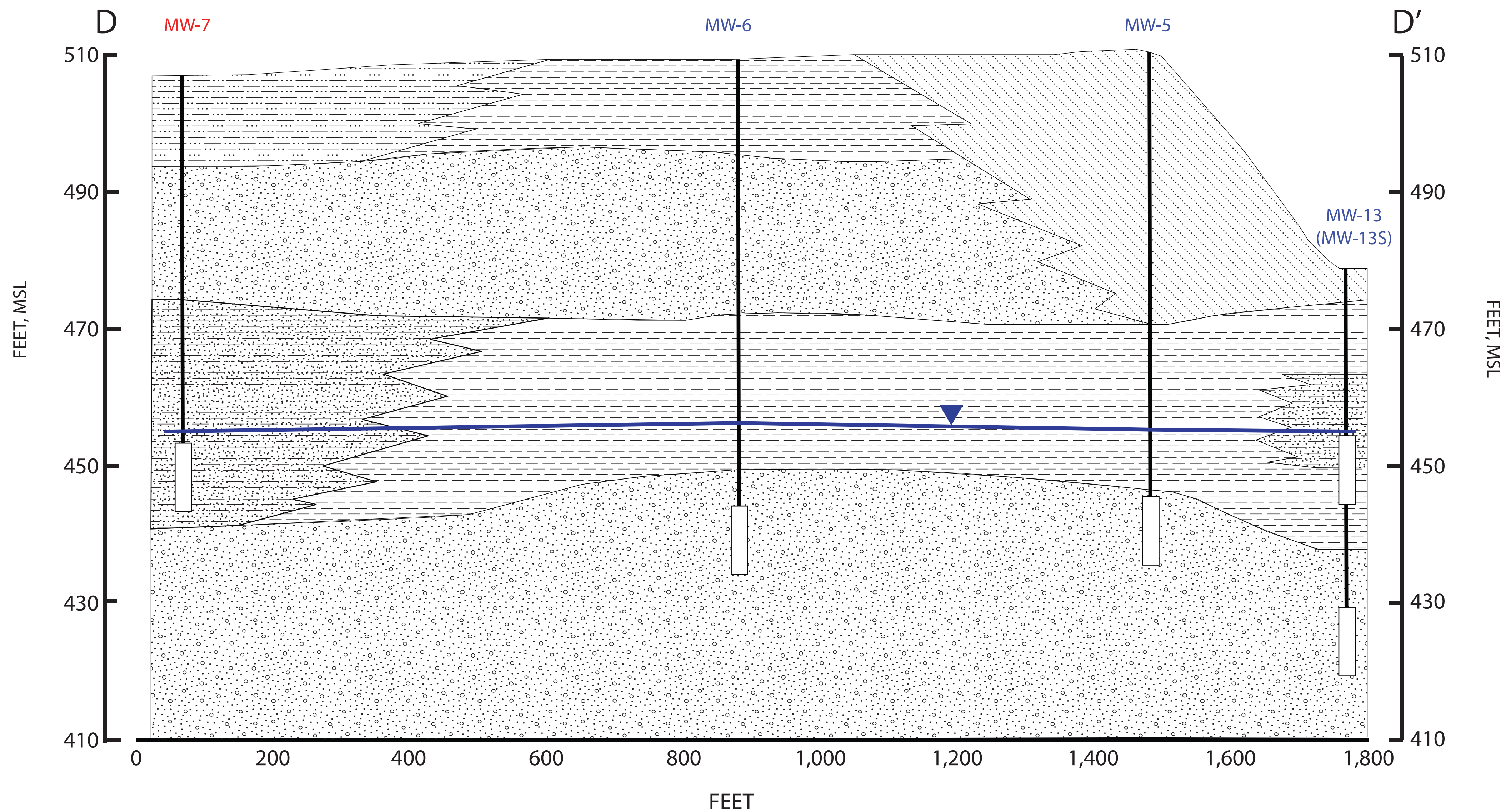
Miami Fort
Hamilton County, Ohio

FIGURE 7
GEOLOGIC CROSS-SECTION C-C′

DATE	REV NO.	DWG. BY	CHKD. BY
08/28/17	0	JMA	MAW

JOB NO. 60442412 AECOM

J:\Project\D\Dynegy\60442412 Miami Fort and Zimmer CCR 2015-2017\Data-Tech\T\MFS\MFS HCR\Unit 111 and 112



J:\Project\D\Dynegy\60442412 Miami Fort and Zimmer CCR 2015-2017\Data-Tech\T\MFS\MFS HCR\Unit 111 and 112

LEGEND

- GRAVEL FILL
- SILT
- SILT AND FINE SAND
- CLAY / SILTY CLAY
- SAND AND GRAVEL

MW-7 UPGRADIENT MONITORING WELL LOCATION

MW-6 DOWNGRADIENT MONITORING WELL LOCATION

POTENTIOMETRIC SURFACE ON 07-10-17

MONITORING WELL RISER

MONITORING WELL SCREEN

20

200

(Vertical Exaggeration in Feet = 10x)

DYNEGY

Miami Fort
Hamilton County, Ohio

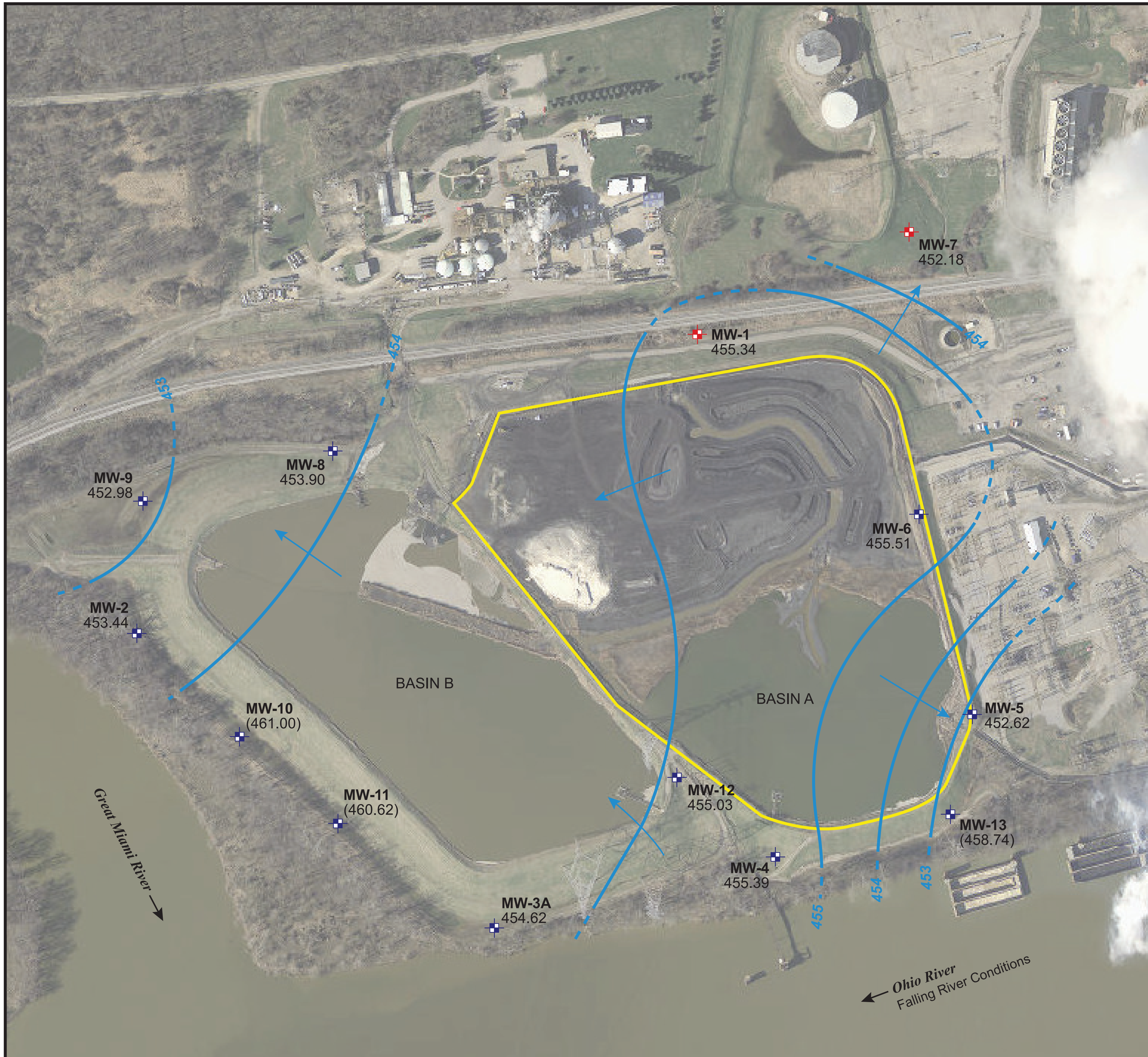
FIGURE 8
GEOLOGIC CROSS-SECTION D-D'

DATE	REV NO.	DWG. BY	CHKD. BY
08/28/17	0	JMA	MAW

JOB NO. 60442412

AECOM

APPENDIX C
GROUNDWATER ELEVATION CONTOUR MAPS, 2015-2020



UNIT BOUNDARY

DOWNGRADIENT MONITORING WELL LOCATION

UPGRADIENT MONITORING WELL LOCATION

WATER TABLE CONTOUR (INFERRED FROM AVAILABLE MONITORING DATA)

GROUNDWATER FLOW DIRECTION

455.51 GROUNDWATER ELEVATION (FEET, MSL), MEASURED DECEMBER 8, 2015

(458.74) GROUNDWATER ELEVATION (FEET, MSL) NOT USED IN CONTOUR INTERPOLATION, MEASURED DECEMBER 8, 2015

AERIAL SOURCE: CAGIS

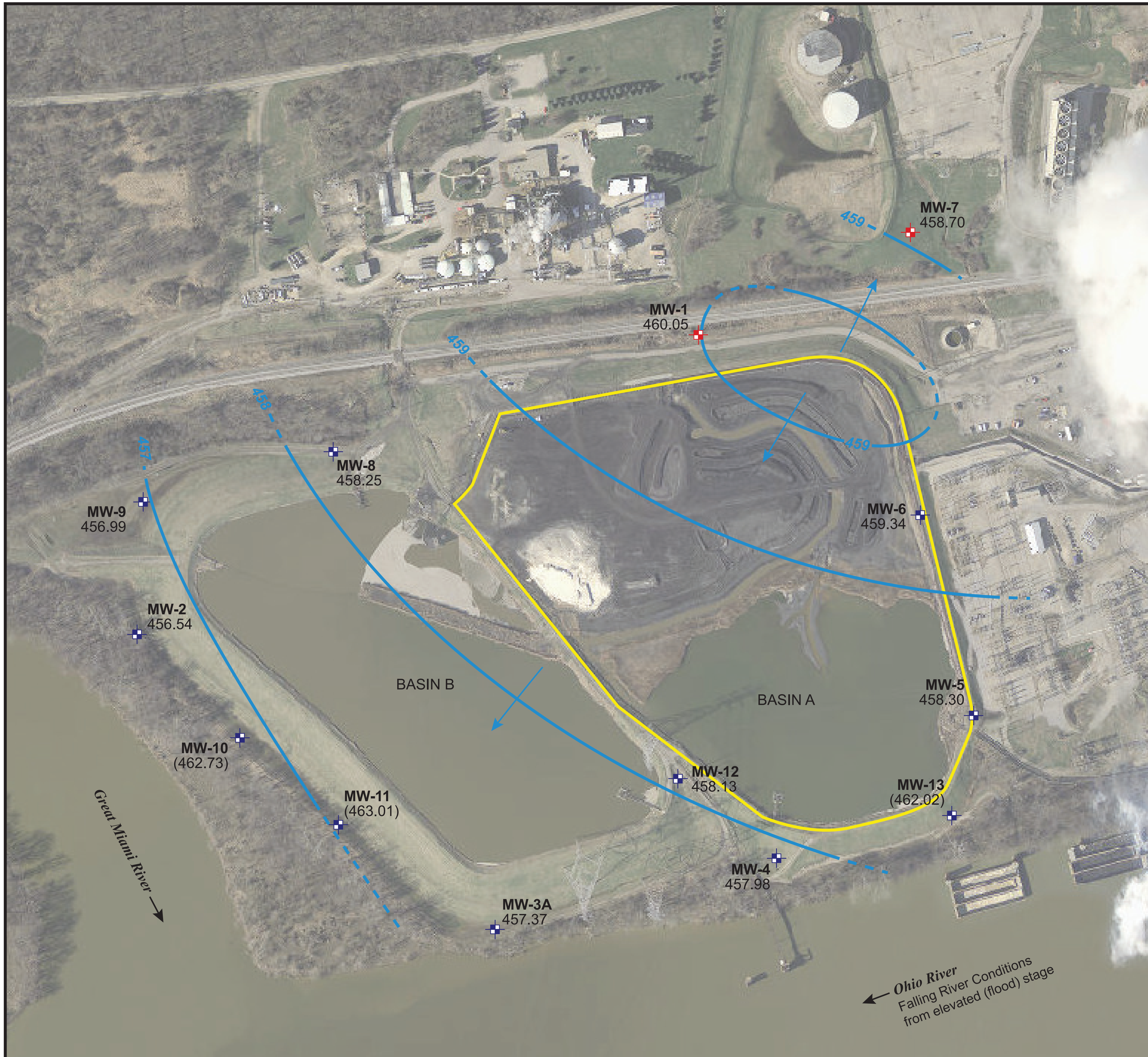
N

0 150 300

SCALE IN FEET

Certified By:	DYNEGY	Miami Fort Station Hamilton County, Ohio		
	FIGURE 1 GROUNDWATER SURFACE MAP- DECEMBER 8, 2015 BASIN A (UNIT ID: 111) CCR SAMPLING AND ANALYSIS PLAN			
	DATE	REV NO.	DWG. BY	CHKD. BY
SIGNATURE	12/28/16	0	ALW	MAW
DATE	JOB NO. 60442412			AECOM

J:\Project\D\Dynegy\60442412 Miami Fort and Zimmer CCR 2015-2017\Data-Tech\TI\MFS PIEZ\basin a fig1_12-15.ai



UNIT BOUNDARY

DOWNGRADIENT MONITORING WELL LOCATION

UPGRADIENT MONITORING WELL LOCATION

WATER TABLE CONTOUR
(INFERRED FROM AVAILABLE MONITORING DATA)

GROUNDWATER FLOW DIRECTION

458.70 GROUNDWATER ELEVATION (FEET, MSL), MEASURED MARCH 21, 2016

(462.02) GROUNDWATER ELEVATION (FEET, MSL) NOT USED IN CONTOUR INTERPOLATION, MEASURED MARCH 21, 2016

AERIAL SOURCE: CAGIS

N

0 150 300
SCALE IN FEET

J:\Project\D\Dynegy\60442412 Miami Fort and Zimmer CCR 2015-2017\Data-Tech\TI\MFS\MFS PIEZ\basin a fig1_3-16.ai

Certified By:

SIGNATURE ______

DATE ______

DYNEGY

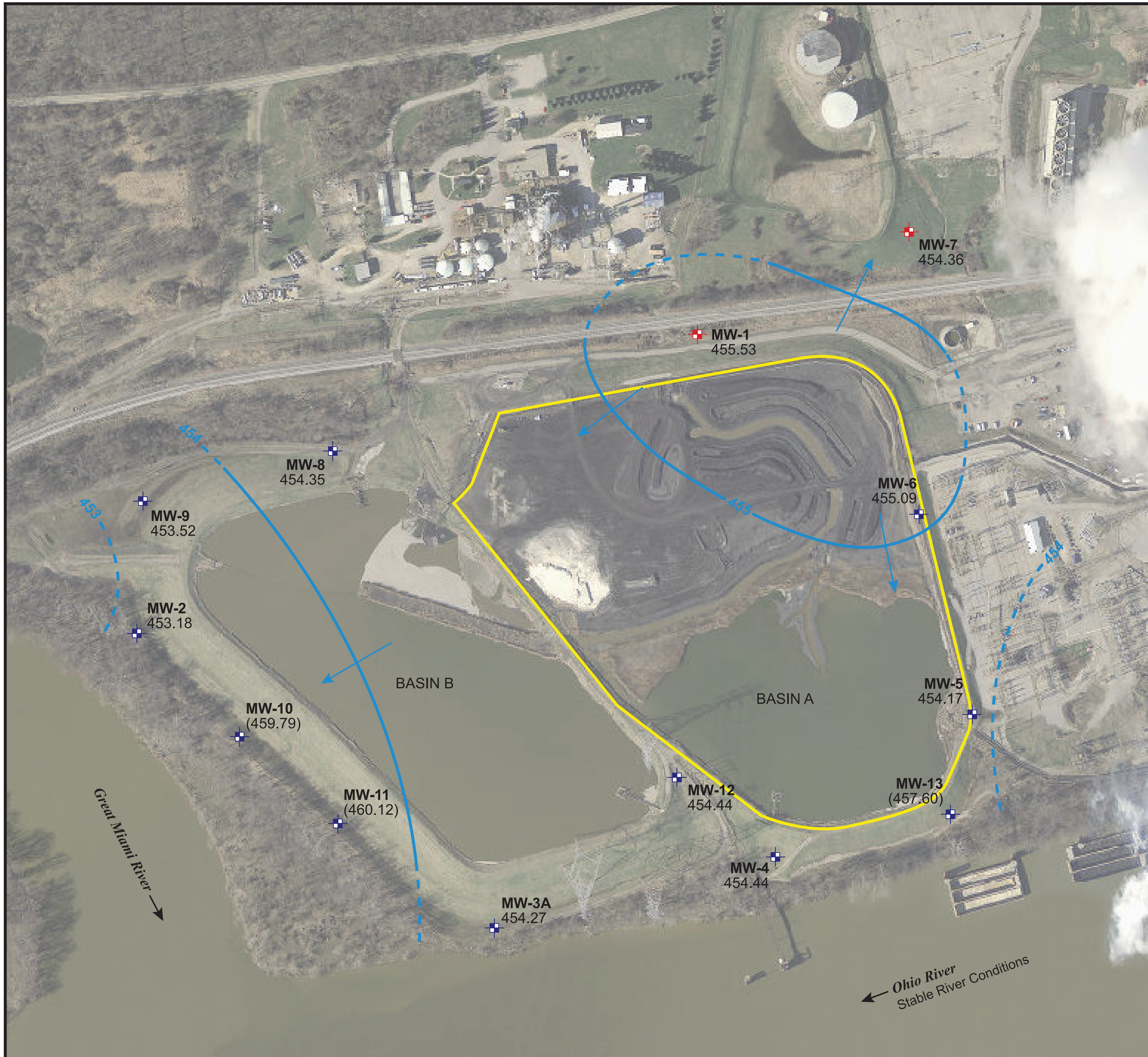
Miami Fort Station
Hamilton County, Ohio

FIGURE 1
GROUNDWATER SURFACE MAP-
MARCH 21, 2016
BASIN A (UNIT ID: 111)
CCR SAMPLING AND ANALYSIS PLAN

DATE	REV NO.	DWG. BY	CHKD. BY
12/28/16	0	ALW	MAW

JOB NO. 60442412

AECOM



UNIT BOUNDARY

DOWNGRADIENT MONITORING WELL LOCATION

UPGRADIENT MONITORING WELL LOCATION

WATER TABLE CONTOUR (INFERRED FROM AVAILABLE MONITORING DATA)

GROUNDWATER FLOW DIRECTION

454.36 GROUNDWATER ELEVATION (FEET, MSL), MEASURED JUNE 20, 2016

(457.60) GROUNDWATER ELEVATION (FEET, MSL) NOT USED IN CONTOUR INTERPOLATION, MEASURED JUNE 20, 2016

AERIAL SOURCE: CAGIS

N

0 150 300

SCALE IN FEET

Certified By:

SIGNATURE ______________________

DATE ______________________

DYNEGY

Miami Fort Station
Hamilton County, Ohio

FIGURE 1
GROUNDWATER SURFACE MAP-
JUNE 20, 2016
BASIN A (UNIT ID: 111)
CCR SAMPLING AND ANALYSIS PLAN

DATE	REV NO.	DWG. BY	CHKD. BY
12/28/16	0	ALW	MAW

JOB NO. 60442412

AECOM

J:\Projects\D\Dynegy\60442412 Miami Fort and Zimmer CCR 2015-2017\Data-Tech\T\MFS\MFS PIEZ\basin a fig1_6-16.ai

J:\Project\D\Dynegy\60442412 Miami Fort and Zimmer CCR 2015-2017\Data-Tech\MFS\MFS PIEZ\basin a fig1_9-16.ai

UNIT BOUNDARY

DOWNGRADIENT MONITORING WELL LOCATION

UPGRADIENT MONITORING WELL LOCATION

WATER TABLE CONTOUR
(INFERRED FROM AVAILABLE MONITORING DATA)

GROUNDWATER FLOW DIRECTION

453.46 GROUNDWATER ELEVATION (FEET, MSL),
MEASURED SEPTEMBER 12, 2016

(459.64) GROUNDWATER ELEVATION (FEET, MSL)
NOT USED IN CONTOUR INTERPOLATION,
MEASURED SEPTEMBER 12, 2016

AERIAL SOURCE: CAGIS

N

0 150 300
SCALE IN FEET

Certified By:

SIGNATURE ____________________

DATE ____________________

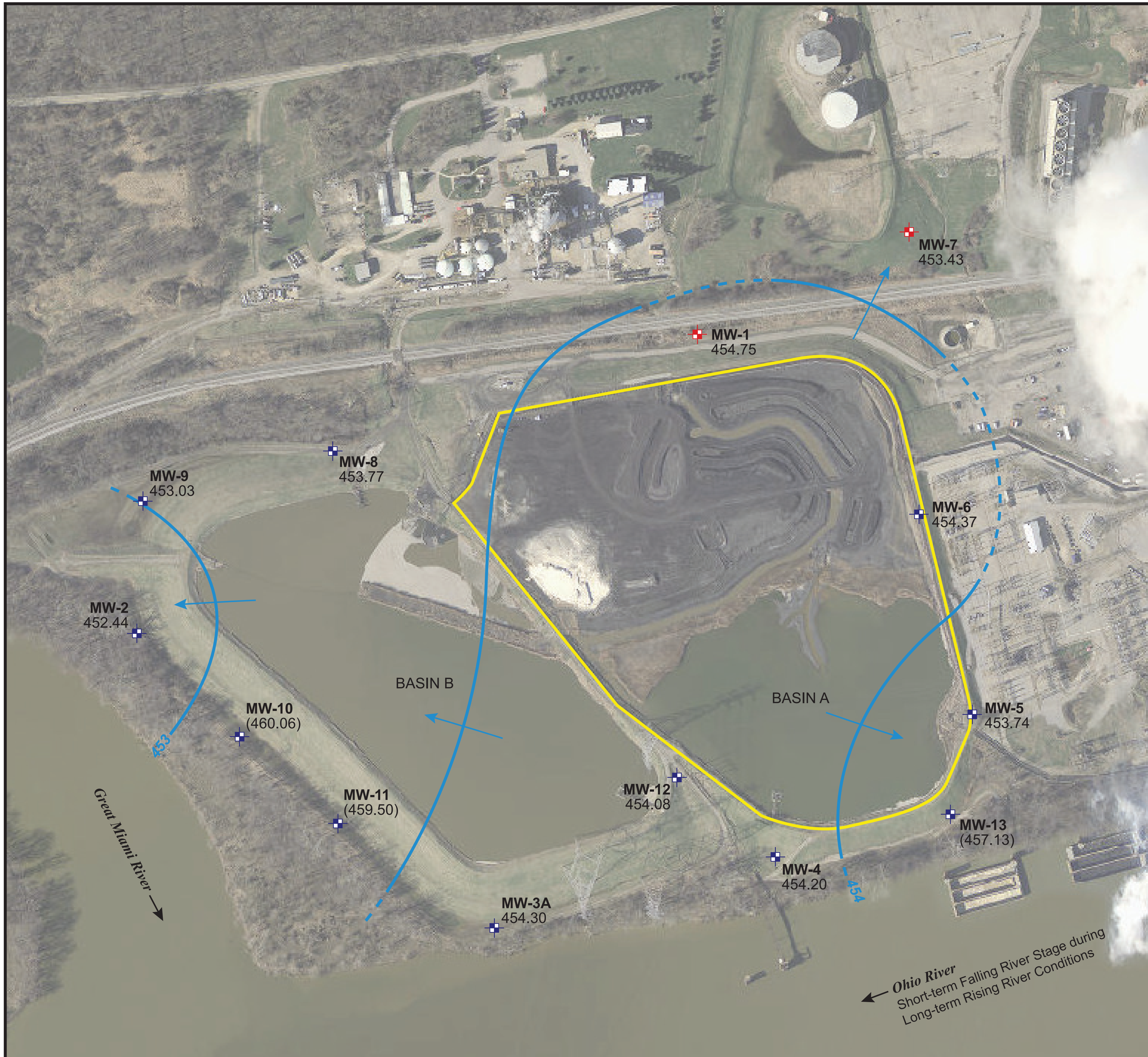
DYNEGY

Miami Fort Station
Hamilton County, Ohio

FIGURE 1
GROUNDWATER SURFACE MAP-
SEPTEMBER 12, 2016
BASIN A (UNIT ID: 111)
CCR SAMPLING AND ANALYSIS PLAN

DATE	REV NO.	DWG. BY	CHKD. BY
12/28/16	0	ALW	MAW
JOB NO. 60442412			AECOM

J:\Projects\Dynegy\60442412 Miami Fort and Zimmer CCR 2015-2017\Data-Tech\TI\MFS\MFS PIEZ\basin a fig1_12-16.ai



UNIT BOUNDARY

DOWNGRADIENT MONITORING WELL LOCATION

UPGRADIENT MONITORING WELL LOCATION

WATER TABLE CONTOUR
(INFERRED FROM AVAILABLE MONITORING DATA)

GROUNDWATER FLOW DIRECTION

453.43 GROUNDWATER ELEVATION (FEET, MSL), MEASURED DECEMBER 12, 2016

(459.50) GROUNDWATER ELEVATION (FEET, MSL) NOT USED IN CONTOUR INTERPOLATION, MEASURED DECEMBER 12, 2016

AERIAL SOURCE: CAGIS

N

0 150 300
SCALE IN FEET

Certified By:

SIGNATURE

DATE

DYNEGY

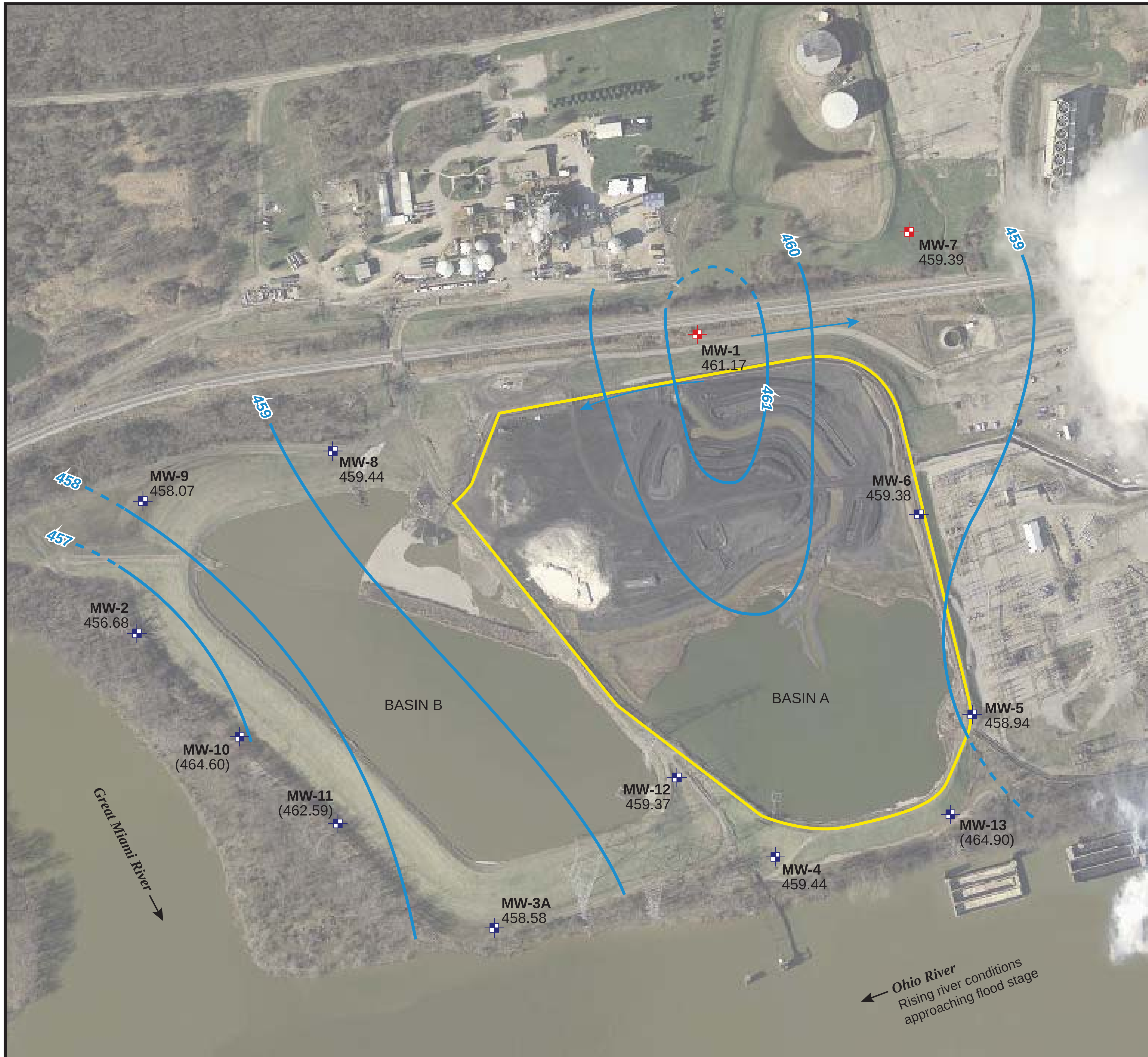
Miami Fort Station
Hamilton County, Ohio

FIGURE 1
GROUNDWATER SURFACE MAP-
DECEMBER 12, 2016
BASIN A (UNIT ID: 111)
CCR SAMPLING AND ANALYSIS PLAN

DATE	REV NO.	DWG. BY	CHKD. BY
01/05/16	0	ALW	MAW

JOB NO. 60442412

AECOM



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UNIT BOUNDARY

DOWNGRADIENT MONITORING WELL LOCATION

UPGRADIENT MONITORING WELL LOCATION

WATER TABLE CONTOUR
(INFERRED FROM AVAILABLE MONITORING DATA)

GROUNDWATER FLOW DIRECTION

459.38 GROUNDWATER ELEVATION (FEET, MSL),
MEASURED MARCH 7, 2017

(464.90) GROUNDWATER ELEVATION (FEET, MSL)
NOT USED IN CONTOUR INTERPOLATION,
MEASURED MARCH 7, 2017

AERIAL SOURCE: CAGIS

N

0 150 300
SCALE IN FEET

Certified By:

SIGNATURE

DATE

DYNEGY

Miami Fort Station
Hamilton County, Ohio

FIGURE 1
GROUNDWATER SURFACE MAP-
MARCH 7, 2017
BASIN A (UNIT ID: 111)
CCR SAMPLING AND ANALYSIS PLAN

DATE	REV NO.	DWG. BY	CHKD. BY
09/09/17	0	ALW	MAW
JOB NO. 60442412			AECOM

UNIT BOUNDARY

DOWNGRADIENT MONITORING WELL LOCATION

UPGRADIENT MONITORING WELL LOCATION

WATER TABLE CONTOUR (INFERRED FROM AVAILABLE MONITORING DATA)

GROUNDWATER FLOW DIRECTION

455.94 GROUNDWATER ELEVATION (FEET, MSL), MEASURED JUNE 5, 2017

AERIAL SOURCE: CAGIS

N

0 150 300

SCALE IN FEET

J:\Projects\Dynegy\60442412 Miami Fort and Zimmer CCR 2015-2017\Data-Tech\T\MFS\MFS PIEZ\basin a fig1_6-17.ai

Certified By:

SIGNATURE ______________

DATE ______________

DYNEGY

Miami Fort Station
Hamilton County, Ohio

FIGURE 1
GROUNDWATER SURFACE MAP-
JUNE 5, 2017
BASIN A (UNIT ID: 111)
CCR SAMPLING AND ANALYSIS PLAN

DATE	REV NO.	DWG. BY	CHKD. BY
09/06/17	0	ALW	MAW

JOB NO. 60442412

AECOM

UNIT BOUNDARY

DOWNGRADIENT MONITORING WELL LOCATION

UPGRADIENT MONITORING WELL LOCATION

WATER TABLE CONTOUR (INFERRED FROM AVAILABLE MONITORING DATA)

GROUNDWATER FLOW DIRECTION

455.14 GROUNDWATER ELEVATION (FEET, MSL), MEASURED JULY 10, 2017

AERIAL SOURCE: CAGIS

N

0 150 300
SCALE IN FEET

Certified By:

SIGNATURE ____________

DATE ____________

DYNEGY

Miami Fort Station
Hamilton County, Ohio

FIGURE 1
GROUNDWATER SURFACE MAP-
JULY 10, 2017
BASIN A (UNIT ID: 111)
CCR SAMPLING AND ANALYSIS PLAN

DATE	REV NO.	DWG. BY	CHKD. BY
09/06/17	0	ALW	MAW
JOB NO. 60442412			AECOM

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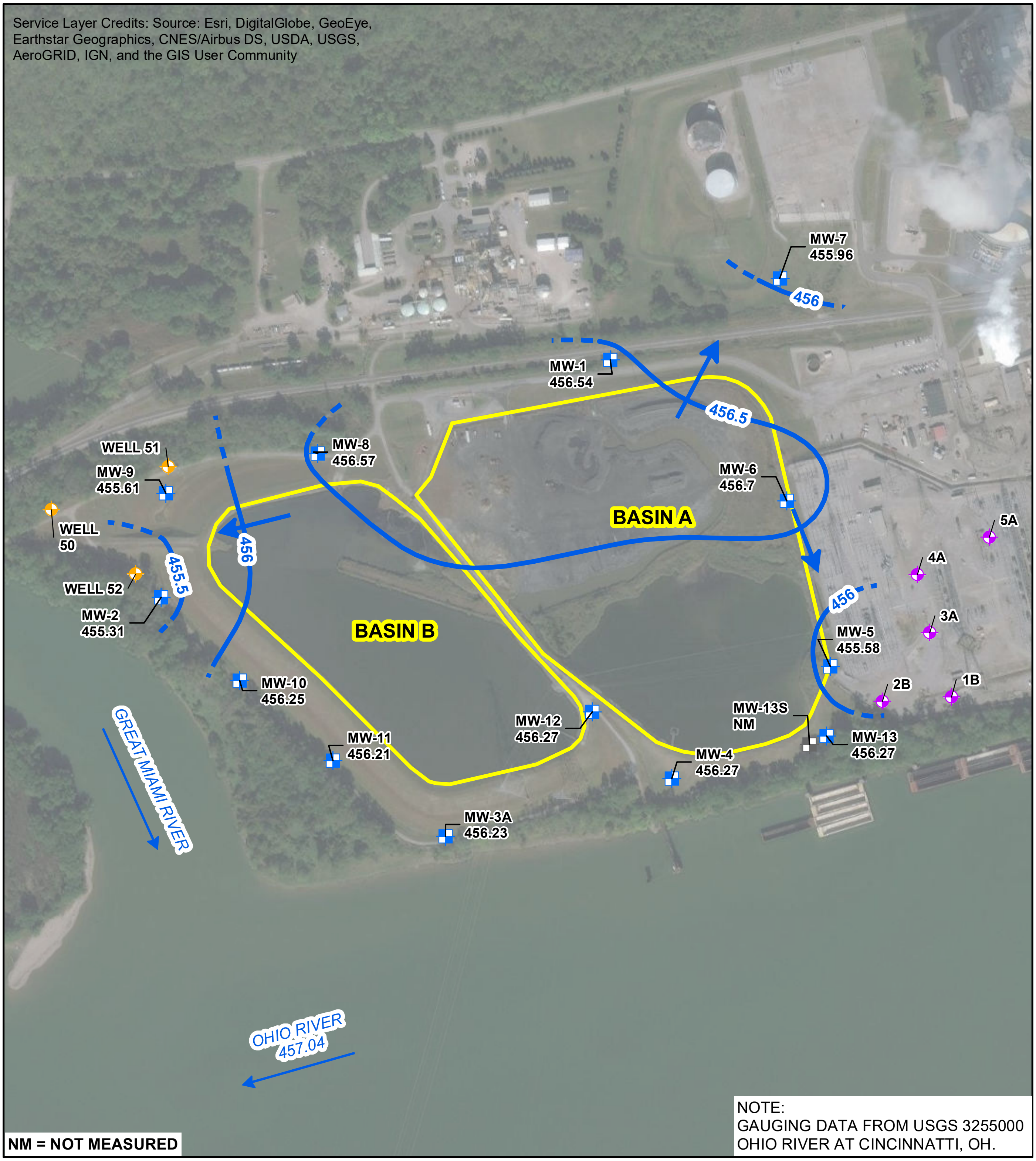


- CCR MONITORING WELL LOCATION
- NON-CCR UNIT MONITORING WELL LOCATION
- MIAMI FORT PRODUCTION WELLS
- VEOLIA PRODUCTION WELLS
- GROUNDWATER ELEVATION CONTOUR (0.5-FOOT CONTOUR INTERVAL, NAVD 88)
- INFERRED GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION
- CCR MONITORED UNIT

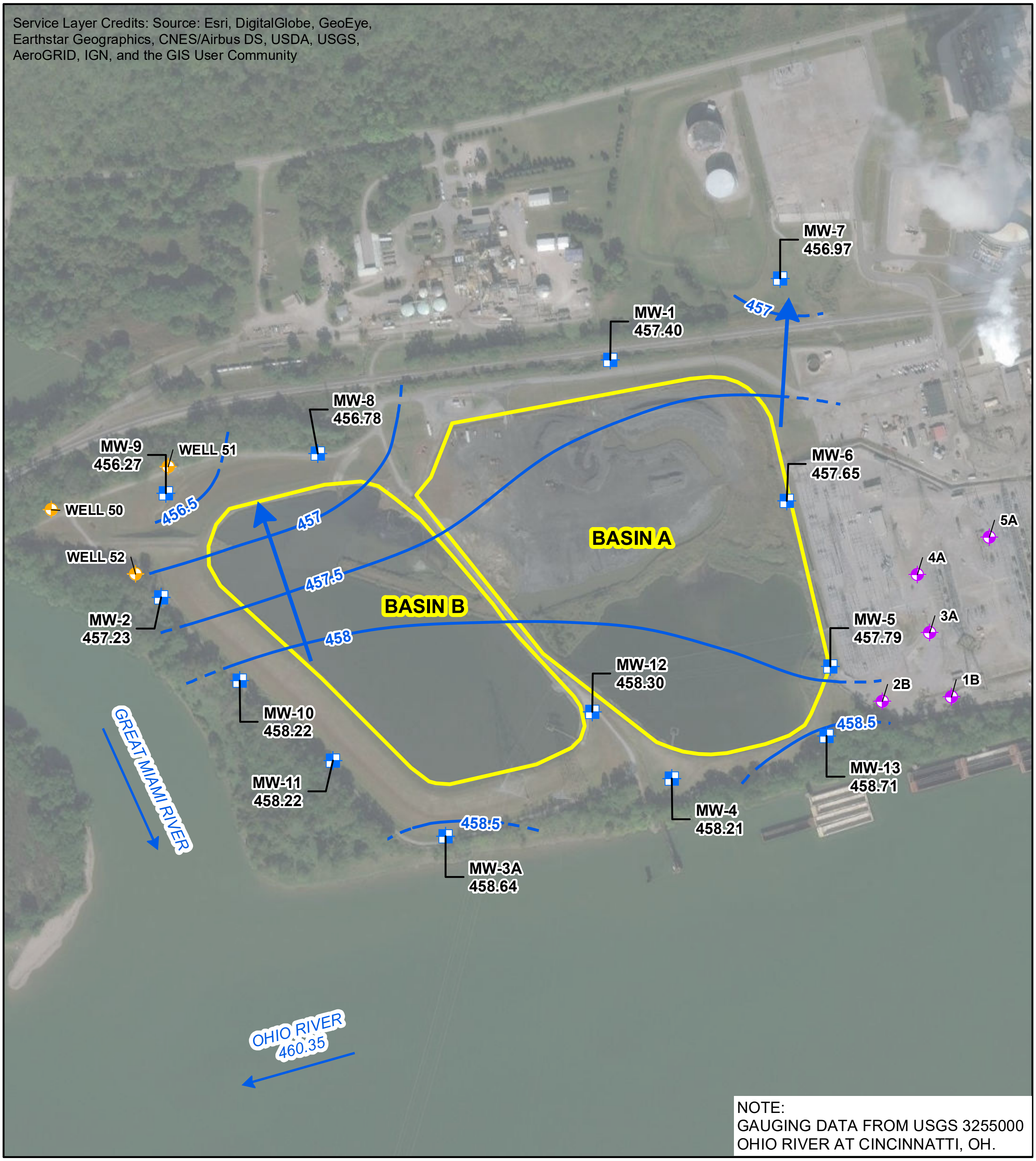
MIAMI FORT BASIN A (UNIT ID: 111)
AND MIAMI FORT BASIN B (UNIT ID: 112)
GROUNDWATER ELEVATION CONTOUR MAP
NOVEMBER 14-15, 2017

CCR RULE GROUNDWATER MONITORING
MIAMI FORT POWER STATION
NORTH BEND, OHIO

0 125 250 500
Feet

N

Y:\Mapping\Projects\22\2285\MXD\GW_Contours\Round_09\R9_MiamiFt_BasinAB_GW_Contours.mxd



NOTE:
GAUGING DATA FROM USGS 3255000
OHIO RIVER AT CINCINNATTI, OH.

CCR MONITORING WELL LOCATION
MIAMI FORT PRODUCTION WELLS
VEOLIA PRODUCTION WELLS
GROUNDWATER ELEVATION CONTOUR (0.5-FOOT CONTOUR INTERVAL. NAVD 88)
INFERRED GROUNDWATER ELEVATION CONTOUR
GROUNDWATER FLOW DIRECTION
CCR MONITORED UNIT

MIAMI FORT BASIN A (UNIT ID: 111)
AND MIAMI FORT BASIN B (UNIT ID: 112)
GROUNDWATER ELEVATION CONTOUR MAP
MAY 7, 2018

CCR RULE GROUNDWATER MONITORING
MIAMI FORT POWER STATION
NORTH BEND, OHIO

N

0 125 250 500
Feet

4/6/2020 12:01:28 PM

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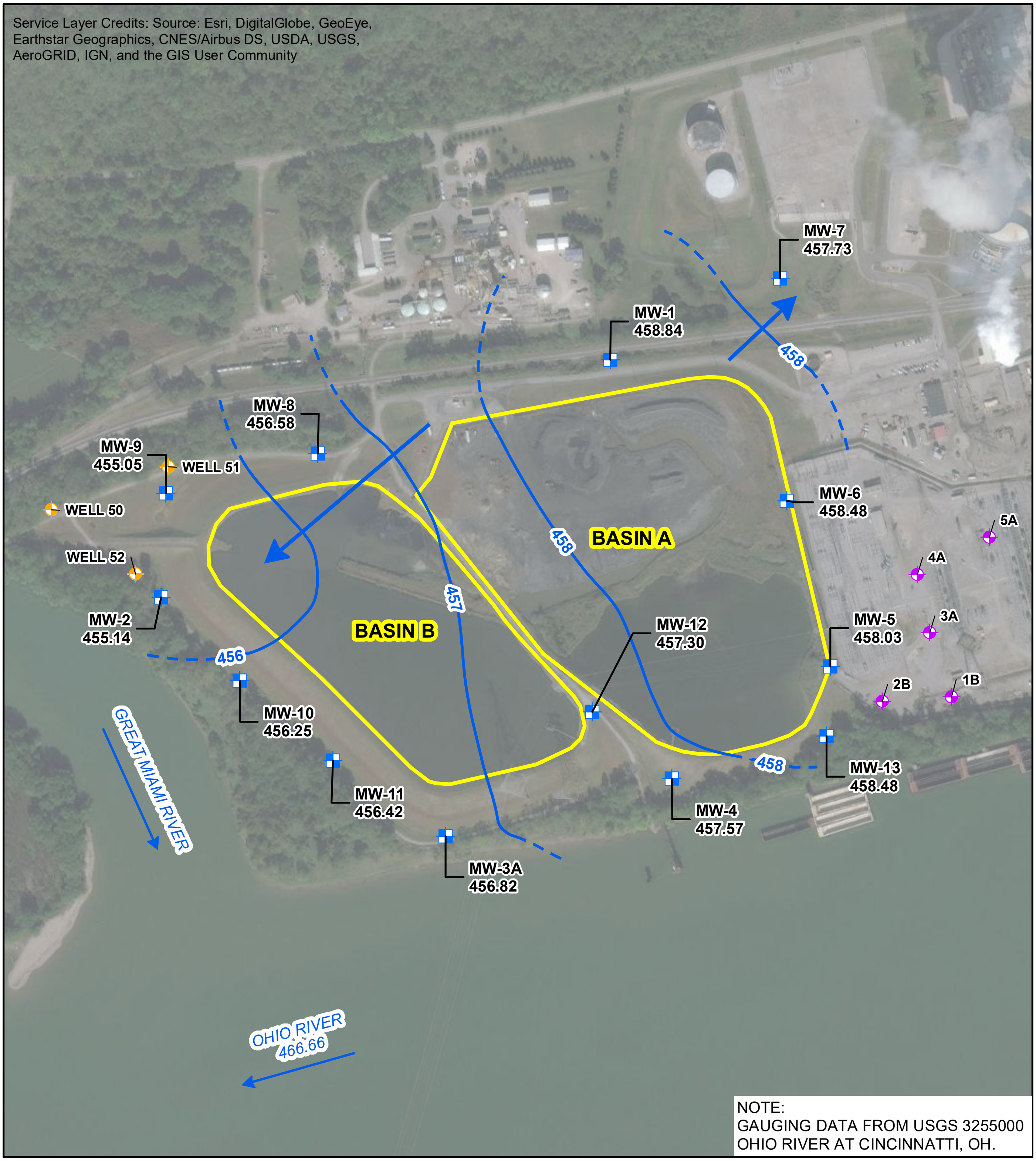


CCR MONITORING WELL LOCATION
MIAMI FORT PRODUCTION WELLS
VEOLIA PRODUCTION
GROUNDWATER ELEVATION CONTOUR (1-FOOT CONTOUR INTERVAL, NAVD 88)
INFERRED GROUNDWATER ELEVATION CONTOUR
GROUNDWATER FLOW DIRECTION
CCR MONITORED UNIT

MIAMI FORT BASIN A (UNIT ID: 111)
AND MIAMI FORT BASIN B (UNIT ID: 112)
GROUNDWATER ELEVATION CONTOUR MAP
SEPTEMBER 18, 2018

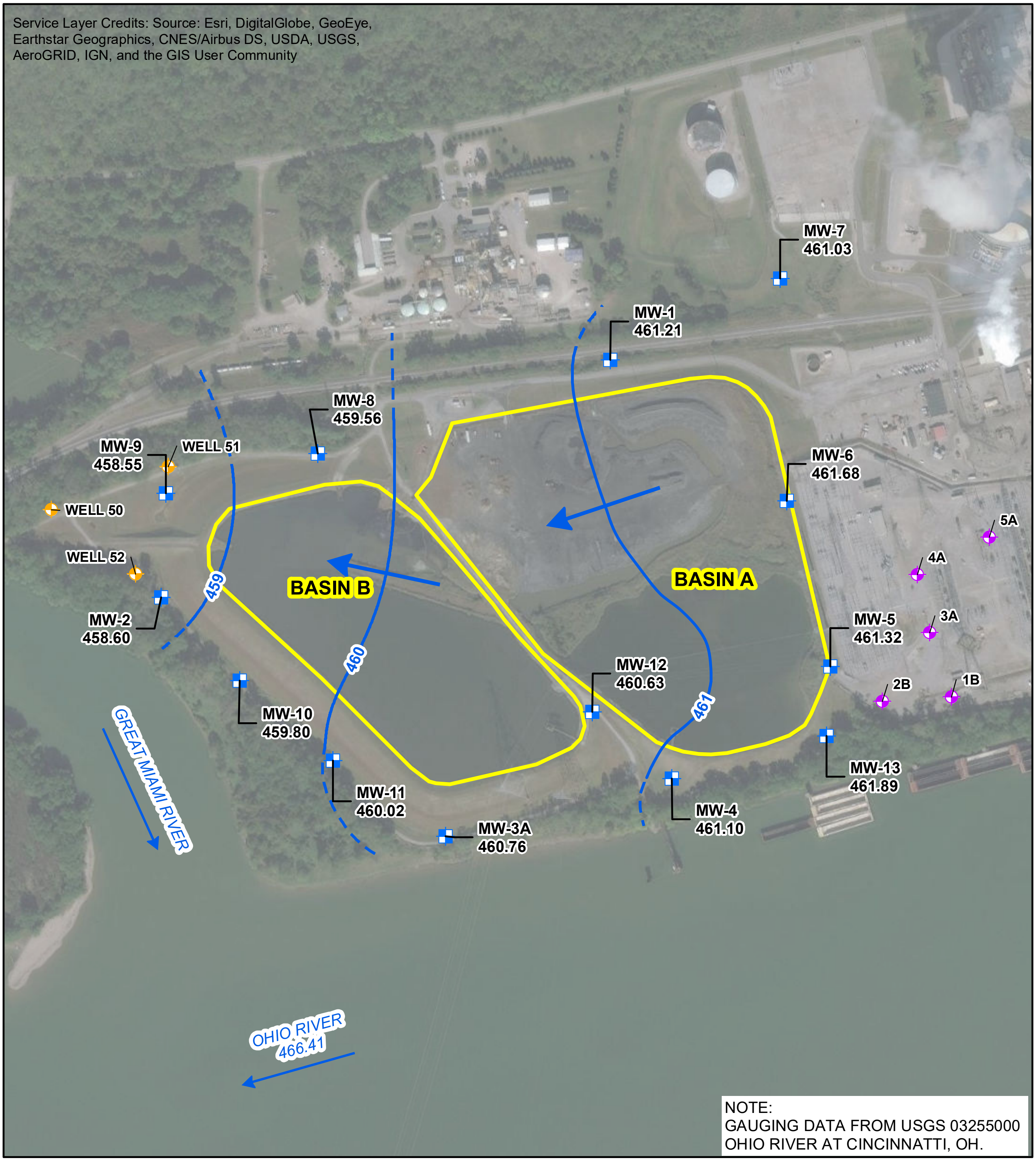
CCR RULE GROUNDWATER MONITORING
MIAMI FORT POWER STATION
NORTH BEND, OHIO

N

0 125 250 500
Feet

Y:\Mapping\Projects\22\2285\MXD\GW_Contours\Round_2018_3Q\R2018_3Q_MiamiFort_BasinAB_GW_Contours.mxd

O'BRIEN & GERE ENGINEERS, INC.



LEGEND

- CCR MONITORING WELL LOCATION
- MIAMI FORT PRODUCTION WELLS
- VEOLIA PRODUCTION WELLS
- GROUNDWATER ELEVATION CONTOUR (1-FOOT CONTOUR INTERVAL, NAVD 88)
- INFERRED GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION
- CCR MONITORED UNIT

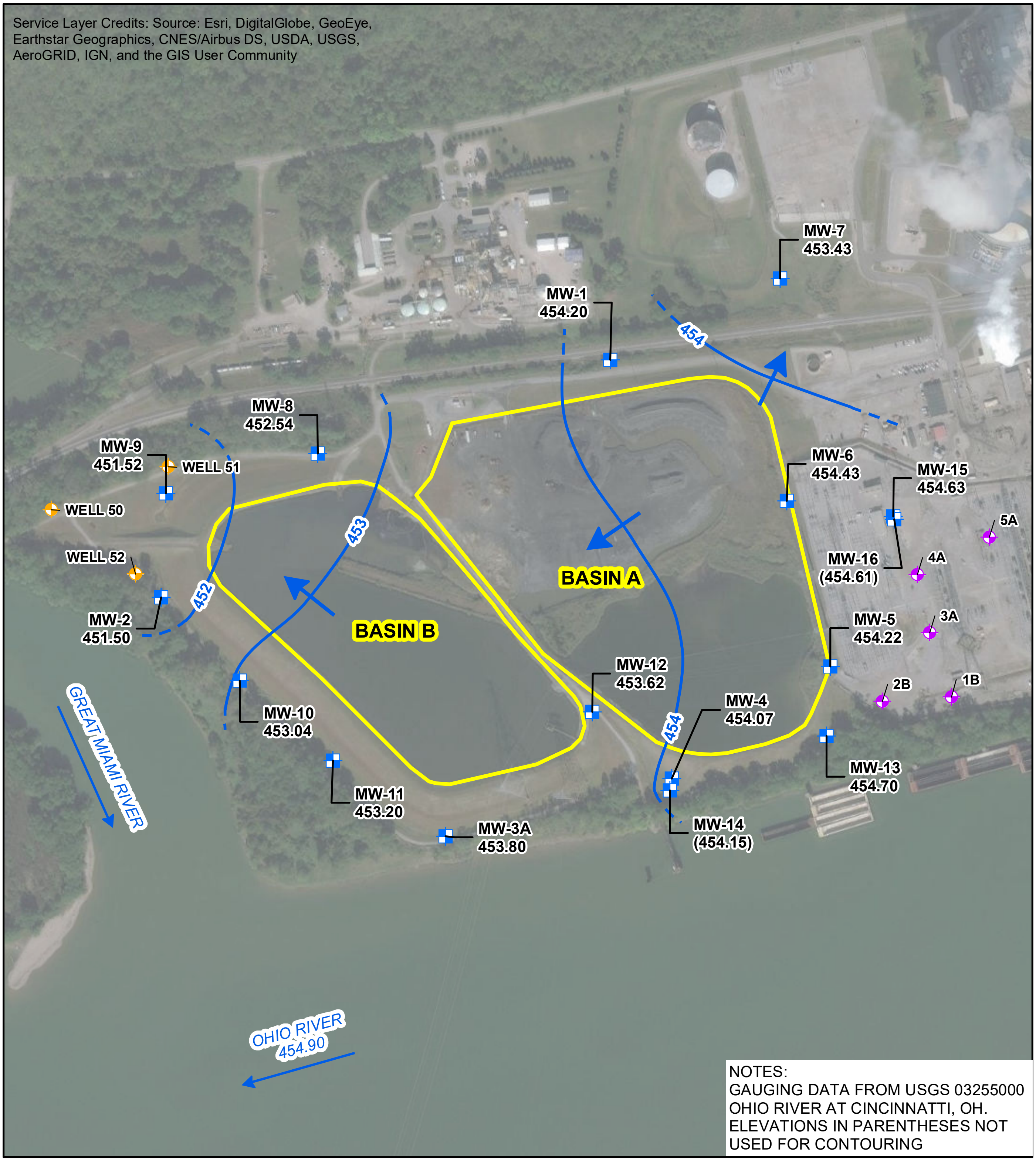
MIAMI FORT BASIN A (UNIT ID: 111)
AND MIAMI FORT BASIN B (UNIT ID: 112)
GROUNDWATER ELEVATION CONTOUR MAP
MARCH 11, 2019

CCR RULE GROUNDWATER MONITORING
MIAMI FORT POWER STATION
NORTH BEND, OHIO

0 125 250 500
Feet

N

O'BRIEN & GERE ENGINEERS, INC.



LEGEND

- CCR MONITORING WELL LOCATION
- MIAMI FORT PRODUCTION WELLS
- VEOLIA PRODUCTION WELLS
- GROUNDWATER ELEVATION CONTOUR (1-FOOT CONTOUR INTERVAL, NAVD 88)
- INFERRED GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION
- CCR MONITORED UNIT

MIAMI FORT BASIN A (UNIT ID: 111)
AND MIAMI FORT BASIN B (UNIT ID: 112)
GROUNDWATER ELEVATION CONTOUR MAP
SEPTEMBER 9, 2019

CCR RULE GROUNDWATER MONITORING
MIAMI FORT POWER STATION
NORTH BEND, OHIO

0 125 250 500
Feet

N

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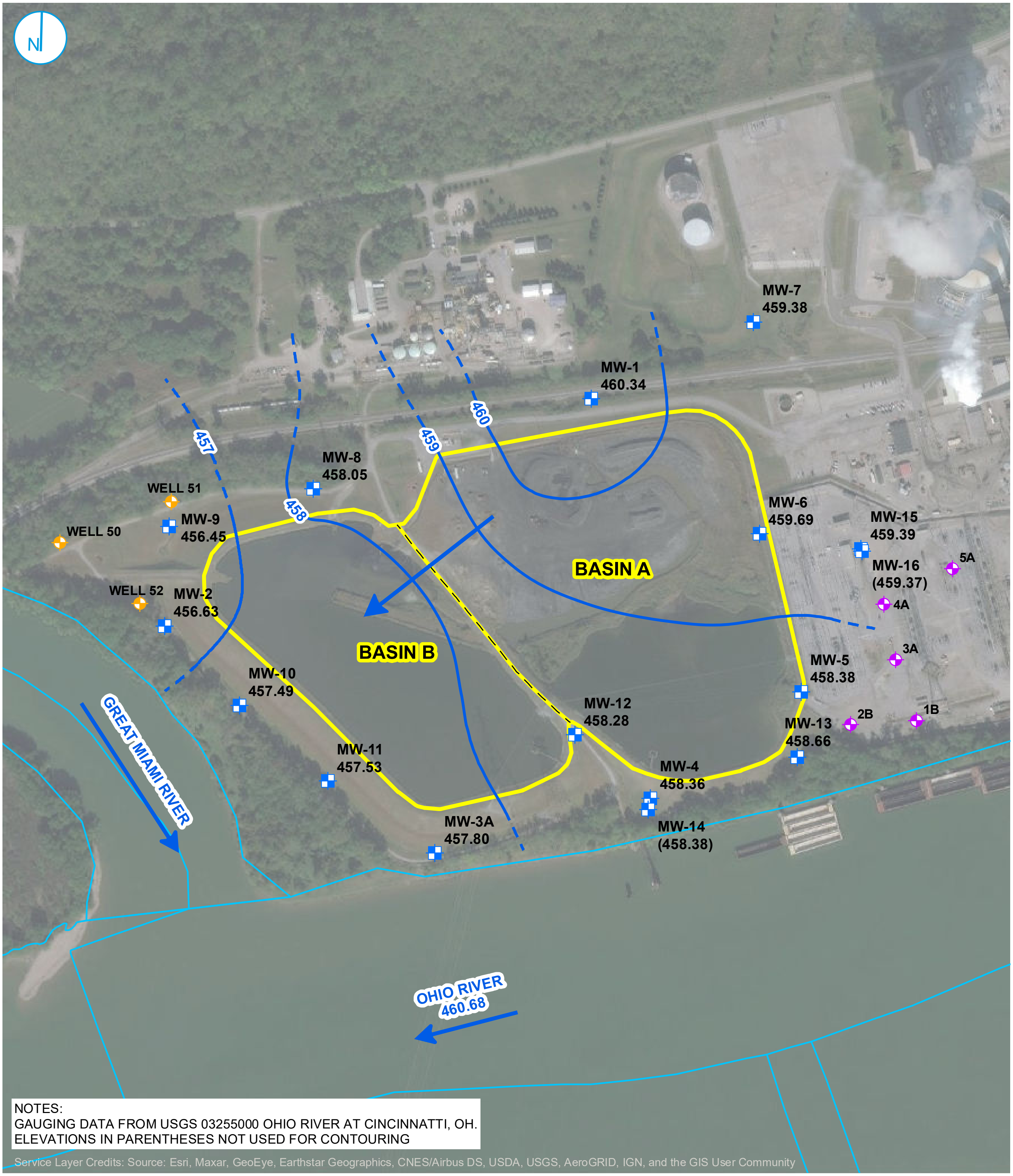
O'BRIEN & GERE ENGINEERS, INC.



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PROJECT: 72799 | DATED: 8/31/2020 | DESIGNER: STOLZSD

- CCR MONITORING WELL LOCATION
- MIAMI FORT PRODUCTION WELLS
- VEOLIA PRODUCTION WELLS
- CCR MONITORED MULTI-UNIT
- CCR UNIT
- RIVER FLOW DIRECTION
- SURFACE WATER FEATURE
- GROUNDWATER ELEVATION CONTOUR (1-FOOT CONTOUR INTERVAL, NAVD 88)
- INFERRED GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

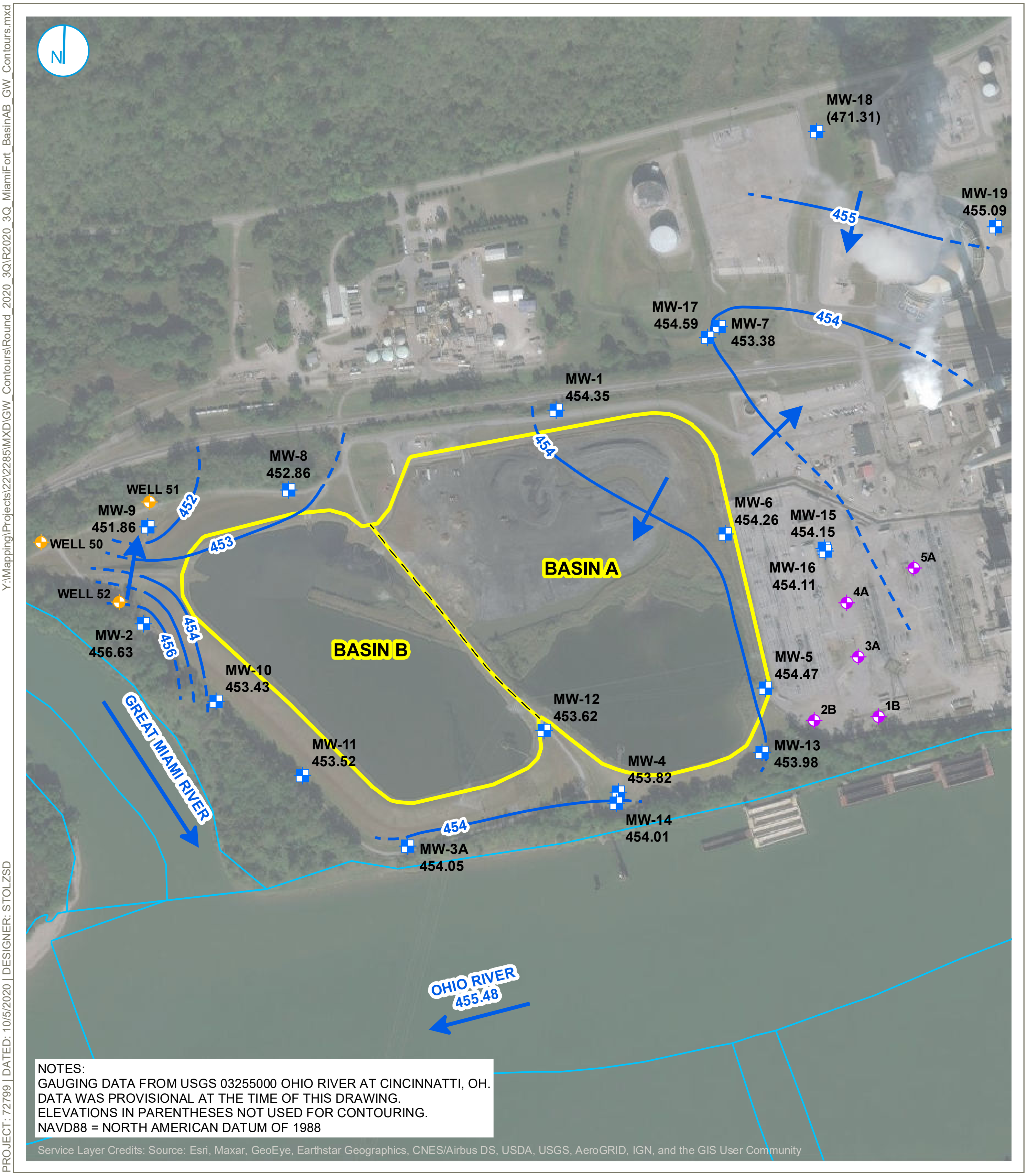
0 250 500 Feet

GROUNDWATER ELEVATION CONTOUR MAP
APRIL 6, 2020

RAMBOLL US CORPORATION
A RAMBOLL COMPANY

MIAMI FORT POND SYSTEM (UNIT ID: 115)
MIAMI FORT POWER STATION
NORTH BEND, OHIO

RAMBOLL



PROJECT: 72799 | DATED: 10/5/2020 | DESIGNER: STOLZSD

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CCR MONITORING WELL LOCATION

MIAMI FORT PRODUCTION WELLS

VEOLIA PRODUCTION WELLS

CCR MONITORED MULTI-UNIT

CCR UNIT

RIVER FLOW DIRECTION

SURFACE WATER FEATURE

GROUNDWATER ELEVATION CONTOUR (1-FOOT CONTOUR INTERVAL, NAVD88)

INFERRED GROUNDWATER ELEVATION CONTOUR

GROUNDWATER FLOW DIRECTION

0 250 500 Feet

GROUNDWATER ELEVATION CONTOUR MAP

SEPTEMBER 14, 2020

MIAMI FORT POND SYSTEM (UNIT ID: 115)
MIAMI FORT POWER STATION
NORTH BEND, OHIO

RAMBOLL US CORPORATION
A RAMBOLL COMPANY

APPENDIX D
VERTICAL AND HORIZONTAL HYDRAULIC GRADIENTS

TABLE 1.

GROUNDWATER HORIZONTAL HYDRAULIC GRADIENTS

HYDROGEOLOGIC MONITORING PLAN

VISTRA CCR RULE GROUNDWATER MONITORING

MIAMI FORT POND SYSTEM (MULTI-UNIT ID: 115)

NORTH BEND, OHIO

September 18, 2018		
Area	**Approximate Flow Direction**	**Horizontal Hydraulic Gradient (ft/ft)**
Miami Fort - Basin A	West	0.0026
Miami Fort - Basin B	West/Southwest	0.0024
March 11, 2019		
Area	**Approximate Flow Direction**	**Horizontal Hydraulic Gradient (ft/ft)**
Miami Fort - Basin A	West	0.0011
Miami Fort - Basin B	West/Northwest	0.0018
September 9, 2019		
Area	**Approximate Flow Direction**	**Horizontal Hydraulic Gradient (ft/ft)**
Miami Fort - Basin A	West/Southwest	0.0010
Miami Fort - Basin B	Northwest	0.0028

[O: KLT 5/6/20, C:JJW 5/7/20]

Notes:

ft/ft = feet per foot

1. Horizontal hydraulic gradient calculated using groundwater elevation contour maps generated for each sampling event.

TABLE 2.

GROUNDWATER VERTICAL HYDRAULIC GRADIENTS

HYDROGEOLOGIC MONITORING PLAN

VISTRA CCR RULE GROUNDWATER MONITORING

MIAMI FORT POND SYSTEM (MULTI-UNIT ID: 115)

NORTH BEND, OHIO

Relative Position	Well ID	Screened Interval Lithology	Hydrogeologic Unit	Screen Midpoint (ft NAVD88)	Groundwater Elevation (ft NAVD88)		
					9/18/2018	3/11/2019	9/9/2019
Shallow	MW-4	Sand and Gravel, Sandy Clay	Uppermost Aquifer	436.49	457.57	461.10	454.07
Deep	MW-14	Sand with Gravel	Uppermost Aquifer	396.80	Not Installed [1]	Not Installed [1]	454.15
				Vertical Groundwater Gradient (ft/ft)	--	--	-0.0020
				Groundwater Flow Direction	--	--	Upward
Shallow	MW-15	Sand with Gravel	Uppermost Aquifer	424.30	Not Installed [1]	Not Installed [1]	454.63
Deep	MW-16	Sand with Gravel	Uppermost Aquifer	389.10	Not Installed [1]	Not Installed [1]	454.61
				Vertical Groundwater Gradient (ft/ft)	--	--	0.0006
				Groundwater Flow Direction	--	--	Downward

[O: KLT 5/6/20, C: 5/7/20]

Notes:

-- = No vertical gradient calculated

ft = feet

ft/ft = feet per foot

NAVD88 = North American Vertical Datum of 1988

1. Wells MW-14, MW-15, and MW-16 were installed in August 2019.

APPENDIX E
TECHNICAL MEMORANDUM – MIAMI FORT POND SYSTEM MONITORED NATURAL ATTENUATION (MNA) EVALUATION

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TECHNICAL MEMORANDUM

Date: November 30, 2020

To: Brian Voelker - Vistra

Copies to: Stu Cravens and Phil Morris - Vistra

From: Allison Kreinberg, Bob Glazier, Nathan Higgerson - Geosyntec Consultants

Subject: Miami Fort Pond System 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 cobalt above the groundwater protection standard (GWPS) at the Miami Fort Pond System. As discussed in Section 2.3 of the Corrective Measures Assessment (CMA), an SSL of cobalt was identified at downgradient monitoring well MW-4. 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 current and potential post-closure 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 Miami Fort Pond System will be based upon (i) source control to mitigate further loading of cobalt mass to groundwater; (ii) delineation of the nature and extent of cobalt impacts in groundwater; and (iii); a successful evaluation of favorable site conditions that result in the attenuation of cobalt in groundwater leading to stable or declining trends of cobalt in groundwater following source control implementation.

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[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 at the site is a glacial outwash consisting of sands and gravels overlain by alluvial silts and clays. These alluvial sediments are likely to provide sufficient attenuation capacity. Thus, the geologic and hydrogeologic conditions at the site are favorable for reliable performance monitoring.

Cobalt Delineation

As discussed in Section 2.3 of the CMA, the cobalt impacts at MW-4 are vertically delineated via groundwater monitoring well MW-14. There is insufficient space downgradient of MW-4 to install another delineation well before reaching the Ohio River. In lieu of using downgradient groundwater monitoring wells for delineation, the anticipated contribution of cobalt from groundwater to the Ohio River was calculated.

The current average concentration of cobalt at MW-4 is 12.3 micrograms per liter (µg/L), with a maximum reported value of 22.4 µg/L. Even without surface water dilution, the concentrations observed at MW-4 are below the Ohio Environmental Protection Agency (OEPA) aquatic life risk screening level established in OAC 3745-1[3]. OEPA does not currently have a human exposure surface water screening level for cobalt. Calculations completed by Ramboll (provided as Appendix A and included as an attachment to the Risk Mitigation Plan submitted with the Part A extension application) show that, with mixing during low flow conditions of the Ohio River, contributions of cobalt to the Ohio River will result in a negligible increase of 0.00076 µg/L in surface water concentrations in the Ohio River. USEPA guidance states that MNA should not be used at sites where concentrations result in "impacts to environmental resources that would be unacceptable to the overseeing regulatory authority". However, the initial evaluation suggests that the contribution of cobalt to the Ohio River do not represent a potential risk for human or ecological receptors. Thus, delineation is sufficient to proceed with an MNA evaluation. An additional evaluation of the surface water-groundwater interface will be completed in 2021 after protocols and methodologies specific to the site have been established.

Source Control

Source control measures will be implemented in the future. Per Section 5.1 of the CMA, closure in place, closure by removal (off-site landfill), and in-situ solidification/stabilization were

[3] Ohio Administrative Code (OAC). 2018. 3745-1. State of Ohio Water Quality Standards. Rev. May 2018.

retained as potential source control measures. It is assumed that MNA will be paired with one of the retained potential source control measures, which will result in a decrease in the input of cobalt to the groundwater system and a subsequent reduction in concentration at MW-4.

Cobalt Attenuation

According to USEPA guidance, the groundwater plume should be stable or decreasing. While there is variability in cobalt concentrations at MW-4 (Figure 1), Mann-Kendall analysis shows that there is not a significant increasing trend (Appendix B).

Cobalt readily undergoes attenuation in soils due to favorable adsorption onto clay minerals, iron and manganese oxides, and organic matter[4]. Amorphous iron oxides were found to readily remove cobalt from the aqueous phase, with minimal subsequent desorption observed[5]. Cobalt adsorption onto soils increases with increasing pH with a marked increase above pH 7. Oxidation-reduction (redox) conditions in groundwater do not appear to directly affect cobalt sorption behavior below pH 9.5; however, changes in redox conditions can affect the stability of iron oxides to which cobalt is attenuated.

A review of geochemical conditions at the Pond System suggests that cobalt is likely attenuated via interactions with iron-containing solid phases. Groundwater samples collected during the April 2020 event were analyzed for total and dissolved iron. For locations where cobalt was detected, there appears to be a correlation between cobalt and total iron, with higher iron associated with higher cobalt concentrations (Figure 2). A reduction potential (Eh)-pH diagram was developed to model iron speciation in groundwater at MW-4 (Figure 3). The ORP values measured during groundwater sampling at MW-4 were converted to Eh[6] (shown in volts [V]) and plotted against the measured pH values to show the predominant iron species in groundwater during each event. Groundwater samples with higher cobalt concentrations (shown with orange symbology on Figure 3) are typically associated with lower pH values and somewhat with lower Eh values. Under these conditions, a greater percentage of iron is present in its more mobile Fe^{2+} form and could result in the dissolution of iron oxides. These results suggest that cobalt attenuation at the site is influenced by the stability of iron-containing solid phases.

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

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[4] Borggaard, O. K. 1987. Influence of iron oxides on cobalt adsorption by soils. *J. Soil Sci.*, **38**, 229-238.

[5] McLaren, R. G., Lawson, D.M., Swift, R. S. 1986. Sorption and Desorption of Cobalt by Soils and Soil Components. *J. Soil Sci.*, **37**, 413-426.

[6] Field ORP measurements are typically recorded using an Ag/AgCl electrode (or similar), whereas Eh is defined as the voltage reading compared to the Standard Hydrogen Electrode (SHE). A conversion between the Ag/AgCl electrode and the SHE can be made by adding an offset voltage to the measured ORP value. Thus, Eh = ORP + 0.2V.

ADDITIONAL EVALUATION

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

- Tier 2 (Demonstrate the attenuation mechanism and rate): Solid phase material will be collected adjacent to MW-4 to better characterize the reactive phases which are present and can attenuate cobalt. Potential analytical techniques to characterize the reactive phase include X-ray diffraction (XRD), sequential phase extraction (SEP), analysis of total metals, and analysis of total organic carbon (TOC). Rates are described in Tier 3 below.
- Tier 3 (Demonstrate that the aquifer capacity is sufficient for attenuation and the mechanism is sufficiently irreversible): Bench-scale adsorption isotherm and/or column tests will be run to evaluate the attenuation capacity and rate of the aquifer system. Groundwater with elevated cobalt concentrations should be exposed to unimpacted aquifer solids collected from an upgradient location in these tests. Desorption isotherm tests and/or column flushing tests should be run to evaluate the stability of the attenuation mechanism. For these tests, unimpacted site groundwater should be mixed with aquifer solids that have attenuated cobalt. Additional design considerations will be determined based on the results of the Tier 2 analyses.
- Tier 4 (Long-Term Monitoring): Based on the results of the Tier 2 and Tier 3 tests, 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

Based on the initial evaluation described herein and cobalt's geochemical behavior, MNA performance at the Pond System is likely to achieve the performance criteria outlined in 40 C.F.R. § 257.97. Completion of the tiered evaluation and assessment of cobalt concentrations under closure conditions, and stability of the attenuated cobalt, 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. As discussed above, it appears that cobalt attenuation at the site is controlled by iron-containing solid phases. This iron-cobalt relationship is well documented in academic literature cited above. Additional evaluation is required to understand the site-specific attenuation mechanism, capacity, and rate, all 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 remedies 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. Conservative calculations indicate that there are currently no exceedances of the relevant regulatory criteria in the Ohio River; this will be further assessed in the groundwater-surface water interface evaluation.

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”[7]. When considering a reasonable time frame, USEPA recommends consideration of factors such as contaminant properties, exposure risk, classification of the protected resource, and potential for plume stability. As discussed above, delineation of impacts is complete and there is no current calculated exceedance of human or aquatic risk-based criteria for potential receptors in the Ohio River. Cobalt, which is known to attenuate via interactions with aquifer solids, appears to be present in stable concentrations at MW-4.

Additional efforts are planned to complete the tiered MNA evaluation and assess the attenuation capacity of the aquifer to predict future stability. The collection of this additional information does not require specialized contractors and can be completed within one year. The time required to attain the groundwater protection standard at MW-4 can be estimated once additional information is developed regarding the attenuation rate and likely decline in concentrations after

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

implementation of source control. 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 and within the guidance provided by USEPA.

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

MNA requires approval by OEPA to be implemented. Existing OEPA guidance relies on the same principals as the USEPA guidance, which are being followed in this evaluation[8]. OEPA notes that "A monitored natural attenuation plan requires a study of the processes (based on extensive monitoring) to establish that natural attenuation is already occurring and the rate of attenuation of contaminants of concern"[9]. The tiered investigation described herein is designed to address these criteria; thus, state permitting is not expected to substantially affect MNA implementation.

CONCLUSIONS

Based on the analysis completed to-date, MNA combined with source control appears to be a promising groundwater remedy at the Miami Fort Pond System when reviewed 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 an analysis of the attenuation mechanism, rate, and aquifer capacity to establish multiple lines of evidence in accordance with USEPA guidance.

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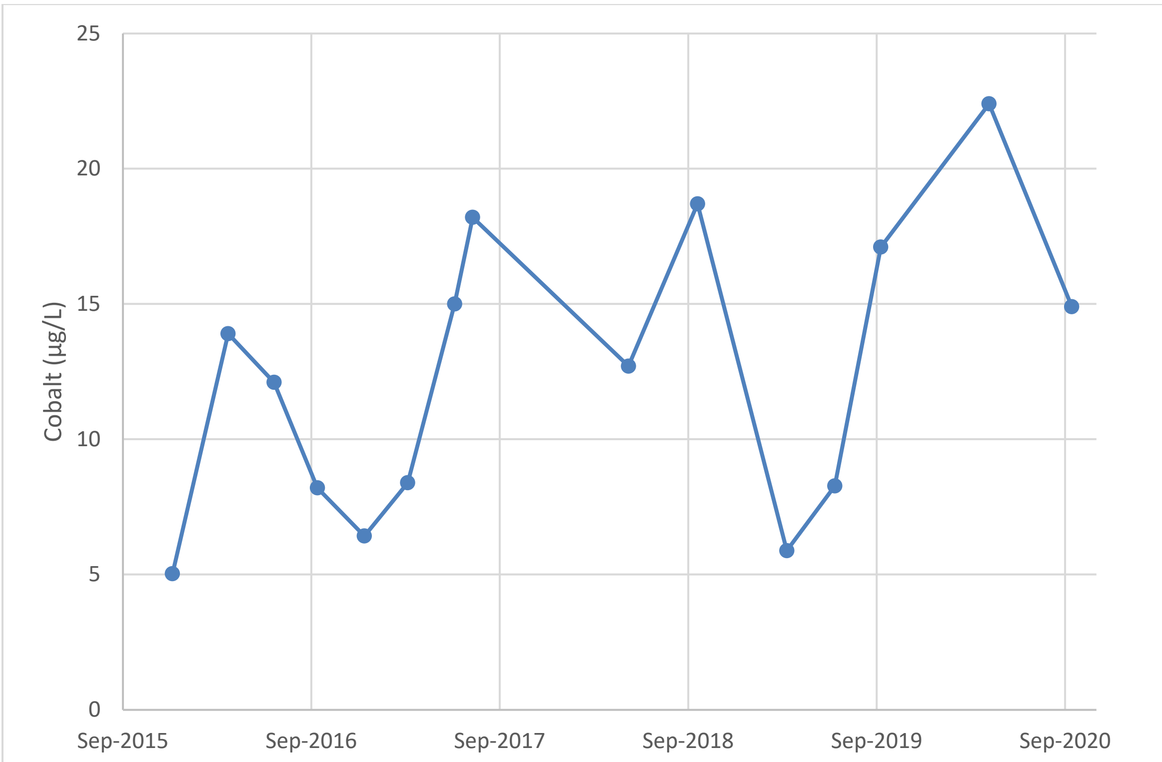
[8] OEPA. 2001. Remediation Using Monitored Natural Attenuation – Division of Environmental Response and Revitalization Remedial Response Program Fact Sheet. January.
[9] OEPA. 2002. Distinction Between Monitored Natural Attenuation and Enhanced Monitoring at DERR Remedial Sites – Technical Decision Compendium. October.

FIGURES



Notes: Cobalt concentrations are shown as micrograms per liter (µg/L).

MW-4 Cobalt Time Series Graph

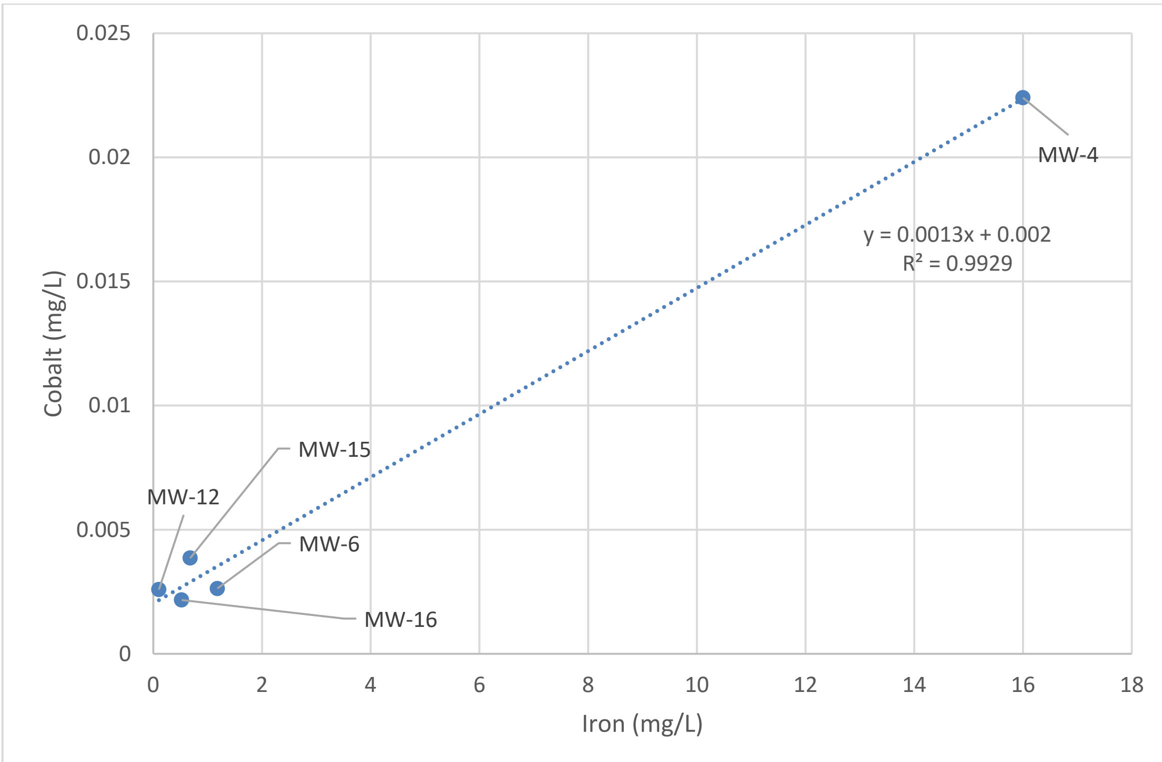
Miami Fort Pond System
North Bend, Ohio

Geosyntec consultants

Figure 1

Columbus, OH | 2020/11/23

internal info: path, date revised, author



Notes: April 2020 data are shown. Only locations where cobalt was detected are shown. Cobalt and iron concentrations are shown as milligrams per liter (mg/L).

Iron v. Cobalt Scatter Plot

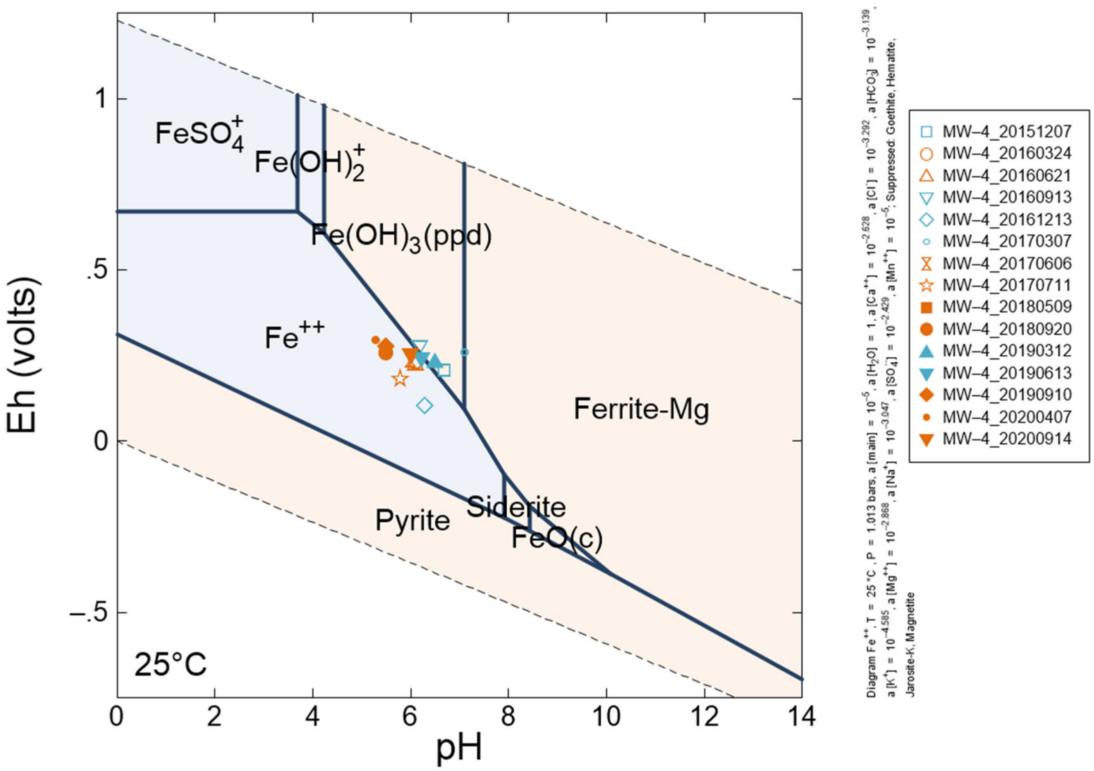
Miami Fort Pond System
North Bend, Ohio

Geosyntec consultants

Figure 2

Columbus, OH | 2020/11/30

internal info: path, date revised, author



Notes: Average groundwater concentrations for major solutes at MW-4 and an assumed iron activity of 10^{-5} molal were used as input parameters. Groundwater field measurements at MW-4 are shown in the scatter plot. Events which had a reported cobalt concentration greater than 0.01 mg/L are shown in orange.

MW-4 Iron Eh-pH Diagram

Miami Fort Pond System
North Bend, Ohio

Geosyntec consultants

Figure **3**

Columbus, OH | 2020/11/24

internal info: path, date revised, author

APPENDIX A

Ohio River Mixing Calculation

Mixing Calculation Showing Effect of Cobalt Loading on Ohio River Quality at Low Flow

Baseflow (90th percentile daily mean low flow)		22,697	cfs	Source[1]: ORSANCO, calculated as the 90th percentile low
	=	5.6E+10	L/day	of estimated daily mean discharge rates (11/1986-2/2016) at
				river mile 483.5 provided by U.S. Army Corps' CASCADE model
Cobalt loading rate				
Maximum Cobalt Concentration in Groundwater		0.0187	mg/L	Maximum Concentration Well MW-4 - 9/2018
Maximum Hydraulic Conductivity (Uppermost Aquifer)		0.123	cm/s	Source[2]: USGS, maximum hydraulic conductivity (350 ft/d)
				based on area aquifer tests conducted in alluvial deposits
Hydraulic Gradient		0.0008		Calculated based on June 2019 groundwater elevations
Basin A Discharge Zone Thickness		64	ft	Estimated maximum depth of impacts in Uppermost Aquifer[3]
Basin A Discharge Zone Length		890	ft	Estimated maximum length of impacts in Uppermost Aquifer[4]
Q = KIA				
K = Max Hydraulic Conductivity		0.0041	ft/s	
I = Hydraulic Gradient		0.0008		
A = Cross-Sectional Area		56,960	ft^2	
Q (per second)		0.17	cfs	
Q (per day)		423,400	L/day	
Loading Rate (L)		7,900	mg/day	$= C_{max} * Q$
	L =	0.02	lb/day	
Cobalt concentration increase in Ohio River at low flow due to loading from Basin A				
	d_B =	0.00000014	mg/L	$= L/Q_{90th\ low}$
Cobalt concentration increase near-shore in Ohio River at low flow due to loading from the Basin A				
Assumes loading distributed within 328 feet (100 meters) of shoreline		0.00000076	mg/L	River is approximately 1750 ft wide
Typical Cobalt laboratory detection limit		0.000075	mg/L	Source: Test America Report for 9/2018 Sampling Event

Conclusion:
The calculated cobalt concentration increase in the Ohio River at ***low flow*** due to groundwater loading from the Basin A is less than the typical cobalt detection limit, indicating that increases due to impacted discharge would not be detectable. These calculations indicate that the effects of cobalt loading in groundwater discharge to the Ohio River are negligible.

Notes
[1]Ohio River Valley Water Sanitation Commission (ORSANCO), 2019. Historical Flow Data. Prepared by U.S. Army Corps of Engineers. Accessed August 28, 2019. http://www.orsanco.org/data/flow/
[2]United States Geological Survey (USGS), 1999. Hydrogeology and Simulation of Ground-Water Flows in the Ohio River Alluvial Aquifer Near Carrollton, Kentucky, Report 98-4215. Prepared by M.D. Unkthank, in cooperation with the Carrol County Water-Supply Board.1999.
[3]Upper limit estimated as average June 2019 groundwater elevations from MW-12, MW-4 and MW-13 . Lower limit estimated as base of MW-14 well screen elevation.
[4]Estimated as linear distance from MW-12 to MW-4 to MW-13.

APPENDIX B

Mann-Kendall Analysis - Cobalt Concentrations at MW-4

Mann-Kendall Trend Test Analysis

User Selected Options	
Date/Time of Computation	ProUCL 5.111/25/2020 12:32:20
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	0.99
Level of Significance	0.01

MF-MW-4_Co

General Statistics

Number or Reported Events Not Used	0
Number of Generated Events	15
Number Values Reported (n)	15
Minimum	0.00503
Maximum	0.0224
Mean	0.0125
Geometric Mean	0.0114
Median	0.0127
Standard Deviation	0.00531
Coefficient of Variation	0.425

Mann-Kendall Test

M-K Test Value (S)	37
Tabulated p-value	0.037
Standard Deviation of S	20.21
Standardized Value of S	1.782
Approximate p-value	0.0374

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