Assessment of Corrective Measures Primary Settling Pond No. 2 Addendum No. 1 Michigan City Generating Station

Michigan City, Indiana

Prepared for:

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19 October 2022

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Subject: Assessment of Corrective Measures Report – Addendum No. 1
Primary Settling Pond No. 2, Michigan City Generating Station, Michigan City, IN
WSP Project No. 7382193341

Dear Mr. Kutch:

WSP USA Environment & Infrastructure Inc. (WSP) is pleased to provide to NiSource this Assessment of Corrective Measures Report, Addendum No. 1, prepared for the Primary Settling Pond No. 2 at the Michigan City Generating Station.

If you have any questions, please do not hesitate to contact either of the undersigned.

Sincerely,

WSP USA Environment & Infrastructure Inc.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACM	Assessment of Corrective Measures for Primary 2
CCR	coal combustion residuals
COC	constituent of concern
CSM	conceptual site model
FGD	flue gas desulphurization
GLI	Great Lakes Initiative
GWPS	Groundwater Protection Standard
IDEM	Indiana Department of Environmental Protection
MCGS	Michigan City Generating Station
mg/L	milligram per liter
MCL	Maximum Contaminant Level
MNA	monitored natural attenuation
NPDES	National Pollutant Discharge Elimination System
NIPSCO	Northern Indiana Public Service Company, LLC
POTW	publicly owned treatment works
PRB	permeable reactive barrier
Primary 2	Primary Settling Pond No. 2
RCRA	Resource Conservation and Recovery Act
redox	oxidation/reduction potential
SSL	statistically significant level
USGS	United States Geological Survey

1.0 INTRODUCTION

On July 8, 2020, NIPSCO, LLC reported that as of June 8, 2020, arsenic and thallium had been detected at statistically significant levels (SSLs) above the Groundwater Protection Standards (GWPS) of 0.017 milligrams per liter (mg/L) based on the background concentration developed for Primary Settling Pond No. 2 (Primary 2), and 0.002 mg/L based on the Maximum Contaminant Level (MCL), respectively. An Assessment of Corrective Measures (ACM) Report for Primary 2 (Wood, 2020), dated December 7, 2020, was subsequently posted to the facility record and public access site. The ACM was prepared in accordance with §257.96 to evaluate remedial alternatives for Primary 2 "to prevent further releases, to remediate any releases and to restore the affected area to original conditions" (§257.96[a]). Closure by removal of the coal combustion residuals (CCR) will "prevent further release" and is an important component of the corrective measure at Primary 2 as detailed in the closure application for surface impoundments at the Michigan City Generating Station (MCGS, or Station), which was filed with the Indiana Department of Environmental Protection (IDEM) on December 20, 2018 (Wood 2018a).

Since the ACM was filed, arsenic and thallium were consistently detected at SSLs in one or more wells until March 2022 when thallium was not detected at an SSL in any downgradient wells. New selenium SSLs were identified in two downgradient wells during the March 2022 event. On August 18, 2022, NIPSCO posted a Notice of SSL indicating that as of July 19, 2022, arsenic and selenium were detected at SSLs above the GWPS in wells downgradient of Primary 2.

The purpose of this Addendum No. 1 is to provide an update on hydrogeologic conditions and the concentrations and chemical characteristics of arsenic, selenium, and thallium in groundwater since the CCR monitoring program was initiated, and to review prior information on the remediation technologies for these three constituents of concern (COCs).

2.0 SITE BACKGROUND

The MCGS is a 469-megawatt, coal-fired steam turbine electric generating station located on the southern shore of Lake Michigan in Michigan City, LaPorte County, Indiana. The MCGS is located on an approximately 123-acre site about one-mile northwest of Michigan City, at 101 Wabash Street (**Figure 1**), at Latitude 41° 43' 15" N, Longitude 86° 54' 30" W. It is owned by Northern Indiana Public Service Company, LLC (NIPSCO). The facility is bounded on the north by Lake Michigan; Trail Creek on the east; Chicago Southshore South Bend railroad to the south; and Indiana Dunes National Park on the west (see **Figure 2**).

2.1 SITE HISTORY AND DEVELOPMENT

NIPSCO purchased the property in 1925 and started construction in 1929. Until NIPSCO purchased the property, it was utilized by the railroads as a dock for unloading cargo from ships (IDEM, 2012). The MCGS began electricity generation in February 1931 using several different power generating units that were built and decommissioned between 1931 and 2004 (Units 1, 2, and 3). The development and expansion of the MCGS by NIPSCO required the installation of sheet pile barriers along the Lake Michigan shoreline and to the east along Trail Creek (**Figure 2**). The first of these barriers was constructed starting around 1929 (AMEC, 2008). From the 1930s additional sheet pile walls were added by NIPSCO to accommodate expansion of the MCGS and to support the creation and reconfiguration of the CCR surface impoundments. The subsequent barrier structures were installed along Lake Michigan, creating a parallel series of two sheet pile walls along the shoreline, and at various locations within the MCGS site, primarily within the central and northwestern areas (AMEC, 2008).

Currently, Unit 12 is the only unit in operation and is planned for continued operation (Golder, 2018) until 2028, possibly sooner. Unit 12 is a coal-fired boiler/steam turbine that has been active since 1974 and generates three kinds of CCR material: fly ash, dry flue gas desulphurization (FGD) by-product and boiler slag. Unit 12 was upgraded in 2016 to include a FGD "scrubber" technology to reduce air emissions. The fly ash and FGD by-product is blended and transported offsite for disposal. Unit 12 was upgraded again in 2018 with the addition of a submerged flight conveyer that manages the boiler slag and associated sluice water in a closed loop system. Most of the remaining MCGS site surface area, specifically the Power Generation Area and the CCR Management Area (**Figure 2**), is paved with asphalt or covered by inert materials that include gravel and steel slag.

The CCR generated at MCGS were historically placed in five on-site surface impoundments located southwest of the generating station and have a combined surface area of approximately 11.4 acres (**Figure 2**). The five impoundments and are regulated under different federal and state programs. Two of the surface impoundments are subject to the federal CCR Rule published in 40 CFR §257 and the Indiana state CCR program promulgated in 329 IAC 10. The remaining three surface impoundments were removed from service prior to the effective date of the federal CCR Rule. Closure of these three units is regulated by an Amended Agreed Order between NIPSCO and IDEM, dated September 22, 2015, pursuant to 329 IAC 10. A summary of the surface impoundments and governing regulatory programs is presented below in **Table 1**.

Table 1: MCGS Surface Impoundments by Regulatory Program

Assessment of Corrective Measures, Michigan City Generating Station

Subject to CCR Rule and IDEM/NIPSCO, LLC Amended Agreed Order Under RCRA - 22 September 2015		Subject to IDEM/NIPSCO, LLC Amended Agreed Order Under RCRA 22 September 2015
Original Schedule for Active Ponds 15 October 2015 Rule	**Extended Schedule for Inactive Ponds 5 August 2016 Direct Final Rule**	
Boiler Slag Pond	Primary Settling Pond No. 2	Primary Settling Pond No. 1
		Secondary Settling Pond No. 1
		Secondary Settling Pond No. 2

Primary 2 was inactive at the effective date of the regulation and is subject to an extended compliance schedule approximately 18 months behind the original CCR Rule timeframe. All five impoundments are currently being addressed through closure by removal, under a single construction activity that began in Q2 of 2022.

2.2 PRIMARY 2 DESCRIPTION

Primary 2 was designed by Sargent and Lundy Engineers of Chicago, Illinois in 1972, and put into service in 1973 and has been continuously owned by NIPSCO and operated until October 2018. Primary 2 was constructed by grading a flat bottom area, with 2.5 horizontal (H) to 1.0 vertical (V) slopes (2.5H: 1V) to the top grade matching the slope of the perimeter road surrounding the surface impoundments. The above grade embankment is approximately 14 feet high on the outside and approximately 19 feet high on the inside. Primary 2 has a footprint of approximately 3.1 acres and contained an estimated 40,000 cubic yards of CCR.

Primary 2 is undergoing closure by removal at this time, with final closure expected by the end of 2022, or early 2023. The one discharge structure in Primary 2 has been removed as part of the closure activity. Since being taken out of operation the water levels have dropped significantly in Primary 2. Post-closure stormwater runoff will occasionally discharge to Lake Michigan from the Final Pond through a permitted National Pollutant Discharge Elimination System (NPDES) outfall.

2.3 PRIMARY 2 CORRECTIVE ACTION PROGRESS

Corrective action under the federal CCR Rule is triggered through a two-phase program of groundwater monitoring: detection and assessment. Primary 2 is currently in the Assessment Monitoring phase of the program (40 CFR §257.95). A statistical evaluation of groundwater monitoring data has been conducted, and as of June 2020, Primary 2 was required to enter Groundwater Corrective Action (§257.96 through §257.98) based on exceedances of the GWPS for arsenic and thallium. This addendum addresses the GWPS exceedance for selenium.

The objective of corrective action under the CCR Rule is to “attain the groundwater protection standard as specified pursuant to §257.95(h)” and “to prevent further releases, to remediate any releases, and to restore affected area to original conditions” (40 CFR §257.96(a)). As mentioned above, a closure application (Wood, 2018a) was submitted to IDEM for all five CCR impoundments. The first step in the corrective action for Primary 2 is the removal of approximately 40,000 cubic yards of CCR. A two-foot soil cover having a permeability of $1*10^{-5}$ centimeters per second, or less, will then be placed over the excavated area. The excavation and capping at Primary 2 is currently underway and is expected to be completed by the end of 2022.

A Supplemental Addendum dated February 28, 2019 (Wood 2019) was subsequently submitted to IDEM specific to the post-closure monitoring well network for all five units. The proposed network is comprised of 16 existing wells, which includes four of the eight Primary 2 CCR monitoring wells and 12 new wells. The new monitoring wells will be installed and developed within 90 days of NIPSCO’s placing a notification of completion of closure of the CCR surface impoundments in the operating record per 40 CFR §257.100(c)(3). During development of the post-closure application and in discussions with IDEM a two-year, post-closure monitoring period was proposed to evaluate the effectiveness of source removal and attenuation before selecting a final remedy and implementing groundwater corrective action. During the post-closure monitoring period additional data will also be collected to further evaluate groundwater corrective action alternatives.

3.0 UPDATED CONCEPTUAL SITE MODEL

To support the assessment of corrective measures, a detailed Conceptual Site Model (CSM) was developed for Primary 2 in the ACM. The CSM provided information on the hydrogeologic setting at the MCGS, including climate, physiography and drainage, geology, hydraulic properties of the principal groundwater flow zone, and surface water. **Figure 3** includes cross-section A-A′ from the ACM showing geologic conditions below Primary 2. The CSM also identified the specific COCs in the environment and described how each migrated in the subsurface along potential transport pathways. The following subsections provide updates on groundwater flow and quality for the three COCs that have been detected at SSLs, including arsenic, selenium, and thallium.

3.1 GROUNDWATER FLOW

Groundwater flow in the unconsolidated sediments is primarily within the sand units and flows regionally to the north and northwest, toward Lake Michigan (Scott, 2012). Groundwater at the MCGS eventually discharges to Lake Michigan and Trail Creek as indicated by the water-table contours shown in **Figure 4** from August 2018. However, as discussed in **Section 2.1** both Lake Michigan and Trail Creek at the MCGS are separated from the land by sheet pile walls, which influence the flow of groundwater. The sheet pile walls indicate a reduction in the horizontal flow and discharge to Lake Michigan and Trail Creek. Areas of reduced flow are evident where groundwater contours plot nearly perpendicular to the sheet pile walls.

The convergence of groundwater flow in the southwest portion of the property near well MW-3 is interpreted to be flow beneath the sheet pile wall in an area where the upper clay is thin or discontinuous and the sheet pile does not extend to the lower clay unit, which is deeper in this area. In the northeast portion of the property, the water-table contours indicate flow towards the sheet pile walls, and likely through seams and minor imperfections. Since discharge to Primary 2 ceased in 2018, the groundwater mound has dissipated somewhat as shown in **Figure 5** from October 2021, but the overall flow pattern described above is similar. Groundwater levels in the CCR monitoring wells around Primary 2 that are still functional, including GAMW-12, GAMW-14, GAMW-15, and GAMW-16, have declined 1.87 to 4.90 feet in the time between August 2018 and March 2022. Upgradient well GAMW-18 was dry in March 2022.

Groundwater seepage velocities were calculated in Appendix J of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report (Golder, 2018). Calculated seepage velocities ranged from approximately 16 feet per year using the lowest calculated hydraulic conductivity and lowest calculated hydraulic gradient to approximately 500 feet per year using the highest calculated hydraulic conductivity and highest calculated hydraulic gradient. The average calculated flow velocity was approximately 170 feet per year. These calculations were based on an assumed effective porosity value of 35% for well sorted sand and silt. The average Darcy flux would therefore be approximately 60 feet per year. Assuming an average saturated thickness of 30 feet over 2700 feet (approximate length of upgradient site boundary), the volumetric flux eventually discharging to Lake Michigan and Trail Creek would be 4,860,000 cubic feet per year, or approximately 70 gallons per minute.

3.2 GROUNDWATER QUALITY

Consistent with the requirements of 40 CFR §257.90 and 257.91, NIPSCO, LLC designed, constructed, and developed a groundwater monitoring system for Primary 2, with the downgradient wells installed at the waste boundary to ensure detection of groundwater contamination in the uppermost aquifer, which is fill at Primary 2. NIPSCO identified four existing monitoring wells (GAMW-05, GAMW-08, GAMW-09, and GMMW-01- installed as part of an ongoing RCRA Corrective Action groundwater program) that were appropriately located and constructed to serve as CCR Rule-compliant monitoring wells. To complete the monitoring system as per CCR Final Rule interpretations, seven wells were installed in June 2016, including GAMW-12 through GAMW-18. As shown in **Figure 6** when the monitoring well network for this CCR unit was established, it consisted of three background wells and eight downgradient wells. NIPSCO obtained certification from a qualified professional engineer stating that the groundwater monitoring system was designed and constructed to meet the requirements of 40 CFR §257.91. In recent years downgradient wells GAMW-08, GAMW-09, GAMW-13 and GAMW-17 have been decommissioned.

Groundwater at the MCGS has been monitored since 2014 as part of the ongoing RCRA Corrective Action Program, and voluntarily before 2014. Per the requirements of 40 CFR §257.94, eleven independent background groundwater samples were collected from each background and downgradient well between July 2016 and October 2018 at intervals of at least 49 days to account for both seasonal and spatial variability in groundwater quality. The first Detection Monitoring event was conducted in April 2019. Based on statistically significant increases identified during the initial Detection Monitoring event, an Assessment Monitoring Program was established for Primary 2 on October 16, 2019. The Verification Monitoring event was conducted in February 2020. At that time Primary 2 had detections of arsenic and thallium at SSLs above the GWPS. The SSLs were confirmed after the second Assessment Monitoring event of April 2020, and notification was posted on July 8, 2020, stating that as of June 8, 2020, Primary 2 had detections of arsenic and thallium at SSLs above the GWPS as prescribed in §257.95.

On September 6, 2020, NIPSCO posted notification that an assessment of corrective measures, as prescribed in §257.95(g)(3), had been initiated for Primary 2 and an ACM Report was prepared (Wood 2020). Since that time arsenic and thallium were consistently detected at SSLs in one or more wells until March 2022 when thallium was not detected as an SSL in any well. New selenium SSLs were identified in GWMW-14 and GMMW-1 during the March 2022 event. On August 18, 2022, NIPSCO, LLC posted a Notice of SSL indicating that as of July 19, 2022, arsenic and selenium were detected at SSLs above the GWPS in wells downgradient of Primary 2.

According to the United States Geological Survey (USGS; 2002), arsenic and thallium occur naturally as trace constituents in different minerals, including sedimentary pyrite, sulfide ores, and iron oxides. These trace elements can be found in sediment and leached from sediment and minerals into groundwater. In groundwater associated with these natural mineral sources, arsenic and thallium concentrations are generally below 0.003 mg/L and 0.001 mg/L, respectively. Selenium is commonly found in rocks as sulfide minerals or with silver, copper, lead, and nickel minerals (ASTDR 2003).

The history of arsenic, selenium, and thallium detections in groundwater from wells located downgradient of Primary 2 from July 2016 through March 2022 is shown in **Table 2,** including results for field duplicates. Wells GAMW-14, GAMW-15, GAMW-16 and GMMW-01 were sampled 19 times over that time. The following wells have been sampled fewer times:

- GAMW-08 and GAMW-13 were decommissioned after 18 events in November 2021
- GAMW-09 and GAMW-17 were decommissioned after 13 events in November 2019

These four wells were decommissioned in anticipation of the closure activities. Additional detail for arsenic, selenium and thallium in groundwater is provided below.

3.2.1 Arsenic

The background concentration (and GWPS) for arsenic at the Primary 2 was initially established as 0.014 mg/L in May 2019 and updated to 0.017 mg/L in July 2020, and July 2022 based on additional background data. Based on statistical evaluations performed by Golder, arsenic SSLs were determined for all eight downgradient wells at Primary 2 during the six Assessment

Monitoring events. The range of detected arsenic concentrations in groundwater collected from the downgradient wells for the period July 2016 to March 2022, are as follows:

- GMMW-01 – 0.014 to 0.043 mg/L
- GAMW-08 – 0.014 to 0.051 mg/L
- GAMW-09 – 0.0062 to 0.017 mg/L
- GAMW-13 – 0.029 to 0.049 mg/L
- GAMW-14 – 0.022 to 0.044 mg/L
- GAMW-15 – 0.013 to 0.044 mg/L
- GAMW-16 – 0.023 to 0.049 mg/L
- GAMW-17 – 0.015 to 0.060 mg/L

Arsenic is not a conservative constituent, meaning the mass of arsenic dissolved in groundwater can change significantly as the result of geochemical interactions. According to the USGS and others (Smith 1999, Hinkle and Polette 1999), arsenic mobility in groundwater is largely controlled by one of two geochemical interactions: (1) adsorption and desorption reactions and (2) precipitation and dissolution reactions. The mass of arsenic migrating in groundwater from CCR sites is primarily influenced by changes in solution chemistry, mineralogy, pH and/or reduction/oxidation (redox) conditions. Arsenic can be present within groundwater under different redox states (e.g. As(III) versus As(V)) that effect its sorption characteristics (Smith 1999, Hinkle and Polette 1999). Arsenic speciation testing on groundwater samples collected from select wells at the MCGS in support of a treatability study (**Attachment A**) has shown that some of the concentrations detected in groundwater to date are associated with the presence of arsenite (As(III)), which is typically more soluble than arsenate (As(V)) as arsenate adsorbs strongly to aluminum, manganese, and iron hydroxides over a broader range of pH values.

Under the site-specific conditions at Michigan City, which are circumneutral pH and relatively oxic, arsenic is expected to be retained on aquifer solids and relatively immobile. Sequential extraction results from the 2018 investigation (Appendix B; Golder, 2018) also support attenuation of arsenic on aquifer sediments and indicate a potential for additional arsenic attenuation in some areas, with limited additional attenuation capacity in other areas. The indication is that arsenic concentrations have the potential to decrease along a flow path where there is greater remaining attenuation capacity, and where the attenuation capacity is limited, arsenic will instead continue to migrate with decreasing concentrations attributed to dispersion and dilution.

Current areas of more reducing redox conditions in groundwater may also change post-closure to more oxic conditions favoring attenuation of arsenic on aquifer solids, which may not be immediately evident. Groundwater geochemistry will be evaluated during the post-closure period to assess changes over time that may favor arsenic removal from the dissolved phase.

3.2.2 Selenium

The GWPS for selenium at Primary 2 was established as the MCL of 0.050 mg/L. The first SSLs for selenium were identified for groundwater collected from GMMW-1 and GAMW-14 during the sixth Assessment Monitoring event. The range of detected selenium concentrations in groundwater collected from the eight wells positioned downgradient of Primary 2 for the period July 2016 to March 2022 are as follows:

- GMMW-1 – 0.0033J to 0.650 mg/L
- GAMW-08 – 0.0045J to 0.062 mg/L
- GAMW-09 – 0.00092J to 0.0073 mg/L
- GAMW-13 – 0.0011J to 0.015 mg/L
- GAMW-14 – 0.0016J to 0.130 mg/L
- GAMW-15 – 0.0033J to 0.230 mg/L
- GAMW-16 – 0.0071 to 0.260 mg/L
- GAMW-17 – 0.012 to 0.170 mg/L

Weathering of rocks and soils containing selenium can result in release of selenium into groundwater. Selenium is present in the environment in various valence states whose speciation is a function of pH, Eh, and microbial activity, as well as the presence and activity of other metals. Selenium exhibits similar chemistry to that of sulfur (Hem 1989). Selenium can exist in the -2, 0 +4, and +6 valence states (ASTDR 2003). Selenium present as selenates (Se6+ valence state) and selenites (Se4+ valence state) are water soluble. Selenium speciation testing on groundwater samples collected from select wells screened in fill at the MCGS in support of a treatability study (included as Attachment A to the ACM; Wood 2020) indicated that 94% of the selenium was in the selenate form.

As mentioned above, the CCR monitoring well system focused on the uppermost aquifer, which is comprised primarily of fill. Underlying the fill is a native sand aquifer. In 2018 nine wells were installed at depth below the fill to characterized groundwater quality in the native sand. Selenium was not detected above the reporting limit of 0.005 mg/L in groundwater from any of the nine wells screened in native sands, nor were there any estimated concentrations reported above the method detection limit of 0.00081 mg/L (Wood 2018b). The sequential extraction results for selenium were frequently non-detect supporting the lack of selenium detections in groundwater collected from the native sand.

As indicated in **Section 3.3** below, porewater data collected from temporary wellpoints in Lake Michigan and Trail Creek in 2018 indicated that attenuation mechanisms were effective at reducing selenium concentrations to levels that were not detected above 0.005 mg/L only a short distance downgradient of the Primary 2 waste boundary.

3.2.3 Thallium

The GWPS for thallium at Primary 2 was established as the MCL of 0.002 mg/L. Based on statistical evaluations performed by Golder, thallium SSLs were determined for GMMW-01 and GAMW-14 during the first, second, fourth and fifth events, and at GMMW-01 only during the third event. There were no thallium SSLs determined for the sixth event due to decreasing trends in thallium concentrations. The range of detected thallium concentrations in groundwater collected from the eight wells positioned downgradient of Primary 2 for the period July 2016 to March 2022 are as follows:

- GMMW-1 – 0.0014 to 0.0052 mg/L
- GAMW-08 - 0.000089J to 0.0032 mg/L
- GAMW-09 - 0.00022J to 0.0016 mg/L
- GAMW-13 – 0.00021J to 0.0043 mg/L
- GAMW-14 – 0.0019 to 0.0052 mg/L
- GAMW-15 - -0.0011 to 0.0037 mg/L
- GAMW-16 – 0.001 to 0.0025 mg/L
- GAMW-17 – 0.0016 to 0.0056 mg/L

Thallium (Tl) is widely distributed in natural environments but typically at low concentrations. The most common minerals containing thallium are lorandite ($TlAsS_2$) and crooksite (CuTlSe) (Alloway, 2013). Thallium occurs in the environment in two oxidation states, including the thallus ion (Tl^+) and the thallic ion (Tl^{3+}). The geochemical behavior of Tl^+ is analogous to that of potassium (K^+), and the lower oxidation state may predominate in aqueous systems (Lin and Nriagu, 1999). The proportion of Tl^{3+} increases considerably under acidic oxidizing conditions. The behavior of Tl^{3+} is somewhat like that of Al^{3+} but Tl^{3+} hydrolyzes more readily than Al^{3+}, and the insoluble oxide, $Tl_2O_{3(s)}$ forms at low pH (<2) and remains insoluble at higher pH values (>10) than Al_2O_3 (McBride 1994). Therefore, in groundwater and surface water environments Tl^{3+} is expected to be very immobile while the mobility and transport of Tl^+ is expected to be fairly high. Greater retention of thallium is found in soils containing large amounts of clay, organic matter, and iron (Fe) and manganese (Mn) oxides (Alloway, 2013).

Thallium was not detected above the reporting limit of 0.001 mg/L in groundwater from any of the nine wells screened in the native sands underlying the fill, nor were there any estimated concentrations reported above the method detection limit of 0.000063 mg/L (Wood 2018b).

As indicated in **Section 3.3** below, porewater data collected from temporary wellpoints in Lake Michigan and Trail Creek in 2018 indicated that attenuation mechanisms were effective at reducing thallium concentrations to levels that are not detected above 0.001 mg/L only a short distance downgradient of the Primary 2 waste boundary.

3.3 GROUNDWATER/SURFACE WATER INTERACTION

As documented in the RFI Report (Golder, 2018) groundwater at the MCGS flows toward Lake Michigan and Trail Creek. Shallow groundwater flows horizontally in the fill, and some seepage through the sheet pile walls is expected. Shallow groundwater also moves downward from fill into the underlying native sands. Deep groundwater in the native sands below fill eventually discharges to Lake Michigan and Trail Creek. Sampling of sediment porewater and surface water at the sediment/lake interface in Lake Michigan and Trail Creek was performed in August and November 2018. Sample locations in Lake Michigan were established as close as possible to the rip rap along the MCGS shoreline and as close as possible to the sheet pile along Trail Creek. Details of the sampling and analysis for the August 2018 event are provided in a memo dated October 2, 2018 (Haley & Aldrich and Wood, 2018). It was concluded that the surface water and porewater conditions in Lake Michigan and Trail Creek represented by the August 2018 sampling event do not pose a risk to human health or the environment. The November 2018 event employed the same sampling and analysis protocols. The maximum arsenic concentrations detected in sediment porewater from Lake Michigan and Trail Creek were 0.018 mg/L and 0.030 mg/L, respectively.

Surface water concentrations of arsenic in Lake Michigan and Trail Creek ranged from non-detect to an estimated concentration 0.00095 mg/L and from non-detect to 0.001 mg/L, respectively. These surface water concentrations of arsenic are comparable to results from the most upstream location positioned to represent background conditions in Trail Creek, where arsenic was detected in surface water from non-detect to 0.0012 mg/L. All surface water concentrations of arsenic, when detected, are approximately 10-fold lower than the MCL of 0.010 mg/L.

Selenium and thallium were not detected in sediment porewater or surface water at any sampling location in Lake Michigan or Trail Creek above the reporting limits of 0.005 mg/L and 0.001 mg/L, respectively. These reporting limits are below the GWPS (in both cases the MCL) of 0.050 mg/L for selenium and 0.002 mg/L for thallium. These data indicate that selenium and thallium concentrations detected above the GWPS at the waste boundary of Primary 2 did not persist in groundwater above detectable levels downgradient of the former impoundment.

3.4 SELENIUM PLUME DELINEATION AND MASS ESTIMATE

The distribution of selenium in groundwater around Primary 2 is shown in **Figure 7**. The concentration contours were developed using data from March 2022 for the four remaining downgradient wells and two upgradient wells (GAMW-18 was dry). To augment the March 2022 data, selenium concentrations for the four decommissioned CCR wells were used from the last sample date at each well (posted in **Figure 7**). Finally, to bound the area of contouring, additional data were used from two nearby RCRA wells and one of the downgradient Boiler Slag Pond CCR wells. Concentrations increase 100-fold from east (upgradient) to west (downgradient); therefore, contour intervals of 0.001 mg/L, 0.01, mg/L and 0.1 mg/L were used to depict the plume of selenium. Contour intervals end at the inner sheet pile wall, which significantly impedes groundwater flow and selenium transport. Groundwater originating at Primary 2 flows to the north and south, parallel to the sheet pile wall, consistent with the groundwater contours depicted in **Figures 4** and **5**. Concentrations of selenium decline significantly north and south of Primary 2.

The mass of selenium in the groundwater plume within the uppermost aquifer below and around Primary 2 is estimated at 2.6 kilograms (kg) (5.6 pounds) and 4.5 kg (9.8 pounds) for porosities of 0.20 and 0.35, respectively. These estimates are based on the following assumptions:

- The entire plume depicted in **Figure 7** was included in the mass calculation, including the entire area encompassed by the 0.001 mg/L contour.
- The detected concentrations of selenium in groundwater were assumed to be constant over the entire saturated thickness of the uppermost, fill aquifer. There is no detectable selenium in the underlying, native sand aquifer.
- The saturated thickness of the uppermost aquifer was determined by subtracting a constant clay elevation of 570 feet msl from the water-table elevations at each well. The individual saturated thicknesses were averaged for the October 2021 event (17.9 feet) and March 2022 (18.1 feet). A value of 18 feet was assumed as the saturated thickness of fill in the mass calculations.

- Contours from **Figure 7** were imported into GIS and converted to polygons to determine the areas between contour intervals.
- Average concentrations were assigned to each area between contours based on actual selenium concentrations measured in each well within the area.

A spreadsheet detailing the mass calculations are provided in **Attachment A**

4.0 POTENTIAL CORRECTIVE MEASURES FOR GROUNDWATER

The objective of corrective action under the CCR Rule is to "attain the groundwater protection standard as specified pursuant to §257.95(h)" and "to prevent further releases, to remediate any releases, and to restore affected area to original conditions" (40 CFR §257.96(a)). Removal of CCR from Primary 2, as detailed in the Closure Application (Wood, 2018a), will prevent further releases. During development of the post-closure application and in discussions with IDEM a two-year, post-closure monitoring period was proposed to evaluate the effectiveness of source removal and attenuation before selecting a final remedy and implementing groundwater corrective action. During the post-closure monitoring period additional data will also be collected to further evaluate groundwater corrective action alternatives, as needed.

4.1 SUMMARY OF PRIOR EVALUATION

The ACM documented the initial screening and evaluation of remedial technologies to address arsenic (primarily) and thallium in groundwater. Table 3 from the ACM summarized the initial screening of applicable remedial technologies and process options, and is included herein as **Attachment B**. The technology types and process options were screened for applicability at Primary 2 and either retained or not retained for further evaluation regarding effectiveness. Retained technologies were then combined into the following five remedial alternatives:

- Alternative No. 1: Monitored Natural Attenuation.
- Alternative No. 2: Groundwater Extraction and Discharge of Treated Groundwater to Surface Water.
- Alternative No. 3: Groundwater Extraction and Discharge of Treated Groundwater to a Publicly Owned Treatment Works.
- Alternative No. 4: Groundwater Extraction and Discharge of Treated Groundwater to the Subsurface.
- Alternative No. 5: Permeable Reactive Barrier (PRB).

Each alternative was further evaluated as required under §257.96(c):

1. **Effectiveness and Implementability**: The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination.

2. **Timeframe**: The time required to begin and complete the groundwater corrective action, where completion is defined by §257.98(c).

3. **Institutional Requirements**: The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy(s).

The reader is directed to the ACM (Wood 2020) for detailed descriptions of the rationale, conceptual design, and performance monitoring of the retained remedial alternatives for the treatment of primarily arsenic in groundwater at Primary 2.

The ACM concluded that due to the proposed removal of CCR as the initial step in the corrective action measure, Monitored Natural Attenuation (MNA) is a viable technology if irreversible sorption can be demonstrated. If active remediation is required, arsenic can be readily treated in-situ (e.g., using a PRB) or ex-situ following groundwater recovery. In-situ treatment using a PRB would target arsenic and is anticipated to be very successful. The literature and initial bench-scale testing is also promising for the treatment of selenium and thallium using a PRB. Groundwater recovery would be a secondary option because the extracted water would have to be treated for disposal. Multiple inorganics in the extracted groundwater, not just arsenic, selenium and thallium, would have to be treated to achieve standards for discharge to Lake Michigan, a publicly owned treatment works (POTW), or the subsurface. Some inorganics are difficult to treat with low discharge standards, making groundwater extraction, treatment, and disposal difficult to permit and implement.

4.2 ADDITIONAL CONSIDERATIONS FOR SELENIUM

The recent occurrence of selenium above the GWPS does not change or add to the five potential remedial alternatives originally put forth in the ACM because selenium was identified as a key constituent during the field program conducted from May through September 2018 (Wood, 2018b), along with arsenic, molybdenum, and thallium. Moreover, arsenic, selenium and fluoride were selected as analytes of concern for the treatability study dated February 12, 2020 (Attachment A to the ACM), before arsenic and thallium were detected at SSLs downgradient of Primary 2 in June 2020. An update for each alternative is provided in the following subsections.

4.2.1 Monitored Natural Attenuation

In a traditional CERCLA Feasibility Study, the "No Action" alternative is required to be analyzed as a baseline for comparison to other alternatives. However, in the ACM (Wood 2020), the "No Action" alternative was eliminated from consideration since it is not permitted under the federal CCR Rule once corrective action has been triggered by statistical analysis of groundwater monitoring results; however, MNA is allowed under the current CCR Rule. Note that MNA is different than groundwater monitoring only in that it is necessary to demonstrate irreversible sorption of arsenic to aquifer solids to justify MNA as a remedy.

Arsenic can be very amenable to the geochemical "sequestering" mechanisms in aquifer systems under favorable conditions. The amount of arsenic detected at Primary 2 is limited to a finite source and based on sequential extraction data, loading away from Primary 2 is still possible and may provide additional attenuation capacity. While redox conditions may change post-closure that could promote desorption, post-closure conditions are potentially likely to increase the redox potential of the system by allowing more oxygen from fresh recharge in areas that were previously inundated by stagnant impoundment water therefore increasing the attenuation capacity for arsenic. Sequential extraction testing on aquifer solids collected from native sands below fill at the MCGS indicate that arsenic has the potential to migrate away from high concentration source areas but still have the potential to attenuate away from source areas where redox and aquifer conditions may become more favorable.

Selenium and thallium are not detected in groundwater downgradient of the waste boundary at Primary 2 indicating effective natural attenuation already in progress. Under oxidizing conditions selenite and selenate oxyanions predominate and under reducing conditions selenium (Se2-valence state) reacts with metal cations to form insoluble selenides. If iron is present selenium may be coprecipitated with pyrite or form other iron minerals, or in its oxidized form adsorb onto iron oxyhydroxides (Hem 1989). Selenite salts are less soluble than selenate salts, and both are strongly adsorbed by iron and aluminum oxyhydroxides (Langmuir, et al., 2005).

Thallium is retained in soils with large amounts of clay, organic mater and Fe and Mn oxides (Alloway 2013). In addition, both Tl^{+} and Tl^{3+} containing mineral phases, Tl_2O and Tl_2O_3, respectively, have broad stability fields over a wide range of pH and Eh (Brookins 1988). Current conditions in groundwater at downgradient wells show slightly alkaline pH and slightly reducing Eh, which favors stability of the soluble Tl^{+} ion. Post-closure conditions are potentially likely to increase the redox potential of the system by allowing more oxygen from fresh recharge in areas that were previously inundated by stagnant impoundment water therefore increasing the attenuation capacity for thallium.

Studies that focus on the fate and transport of arsenic, and to a lesser extent for selenium and thallium, will be conducted during the post-closure groundwater monitoring period. These data may be used in support of an MNA demonstration, but are also necessary to refine ex-situ and in-situ treatment technologies and to better understand remediation timeframes.

4.2.2 Groundwater Extraction, Treatment and Disposal

Alternatives 2, 3 and 4 are similar in that they all include a mechanism for extracting groundwater to address downgradient migration of COCs. The two-year post-closure monitoring period will allow for optimal placement of a recovery trench or extraction wells once long-term, post-closure groundwater conditions are achieved. The distribution of selenium in groundwater would not materially affect recovery-well placement or extraction rates as the selenium and thallium plumes, as defined by concentrations greater than the GWPS of 0.050 mg/L and 0.002 mg/L, respectively, are entirely within the arsenic plume as defined by concentrations greater than the GWPS of 0.010 mg/L.

Extracted groundwater would have to be treated to levels acceptable for the method of disposal, including surface water (Alternative 2), a POTW (Alternative 3) or recharge back to groundwater (Alternative 4). Groundwater extraction can be used to accelerate the migration and removal of arsenic from the aquifer system since pore volumes are replaced by upgradient groundwater and infiltrating rainwater. However, the ability to accelerate remediation via groundwater extraction is limited by adsorption of arsenic to the aquifer soils and the slow processes of desorption and diffusion from that matrix.

Bench-scale studies were completed in 2019 to assess the effectiveness of various technologies to treat site groundwater. Details of the bench-scale study are provided in a memo dated February 12, 2020, which was included as Attachment A to the ACM (Wood 2020). The primary focus of the testing was to evaluate the ability of a pump and treat system to remove arsenic and selenium to the target treatment levels. Each technology was compared against a target treatment limit which represented the lowest of the three regulatory standards applicable to the site, including IDEM Remediation Closure Guide, Great Lakes Initiative (GLI), and MCLs).

As an indication of the potential NPDES discharge standards for a future pump and treat system, IDEM issued a letter to NIPSCO dated 4 May 2021 approving the temporary discharge of dewatering fluids under the facility's NPDES Permit No. IN0000116. The approval assumes that dewatering for impoundment closures will not last more than 12 months. The letter included a summary of the proposed handling of dewatering fluids

> "In addition, NIPSCO states that this construction water will be collected in sumps or pumped from wells to be treated, as necessary, prior to being discharged into the Final Pond. Anticipated treatment systems include pH adjustment, precipitation of inorganics, and final polishing with polymers/media. Non-contact stormwater will be collected and discharged directly to the Final Pond. Water in the Final Pond is recycled into the cooler tower system, evaporated, or discharged to Outfall 001 via an overflow structure (Outfall 301)."

This summary describes treatment and discharge during normal operating conditions, with associated discharge standards to be achieved at Outfall 001. Periodically, there are planned outages where the discharge standards at Outfall 001 are more stringent. For example, during periods of outage the discharge standard for arsenic is 0.110 mg/L and for selenium is 0.0037 mg/L. The arsenic standard should not be difficult to achieve; however, the selenium standard is below the GLI value of 0.0046 mg/l, which was proven to be a difficult standard to achieve in the treatability study. The letter did not include any standards for thallium; however, it did include other inorganics that have not been identified above SSLs at Primary 2 but have discharge standards that would have to be met once groundwater is extracted. Moreover, different standards might be imposed on a long-term pump and treat system. Finally, once the facility is decommissioned, the Final Pond would no longer function in the same capacity as a point of discharge for the treated water as it does currently. Additional information on treatment efficiency is provided below for each COC at Primary 2.

Arsenic - The speciated results indicated that most of the arsenic, 73%, was in the arsenite form when the sample was collected in the field and changed significantly after shipping with most of the samples tested being in the arsenate form, 99% (i.e., arsenite readily oxidizes to arsenate). Removal of arsenate is easier than arsenite. Bench-scale testing demonstrated that arsenic in the arsenate form can be effectively removed by iron reduction and co-precipitation, media adsorption, or media adsorption following iron reduction and co-precipitation. In fact, all the treatment scenarios had a 99% rate of removal for arsenic as compared to the baseline samples and achieved effluent concentrations well below the target treatment limit.

Thallium – The thallium SSL was detected at Primary 2 after the treatability study was performed in 2018. A literature review was completed, and the prior treatability testing was re-evaluated for possible effectiveness of thallium removal. Findings were presented in a memo dated August 4, 2020, which was also included as Attachment A to the ACM (Wood, 2020). Based on the literature review, conventional technologies that are commonly used for metal removal can also remove thallium; however, they are not typically effective for removal of thallium to below the MCL of 0.002 mg/L. Additional testing for the removal of low-level thallium using a pump and treat system would be required if it were determined that influent concentrations of thallium were high enough to require treatment prior to discharge. It is also quite possible that thallium would not be detected above the discharge standard, or not at all, because of the potential dilution caused by the radial contribution of groundwater to the extraction well(s) from zones where thallium may not be detected.

Selenium - The speciated results indicated that most of the selenium, 94%, was in the selenate form when the sample was collected in the field and the proportion did not significantly change after shipping. Selenium, in the selenite form, was partially removed by using reduction processes followed by adsorption media with 37% to 53% selenium removal. However, none of the tested technologies achieved the target treatment limit for selenium. Given historic concentrations of arsenic and selenium in groundwater the treatment system for the strictest discharge limits for surface water might consist of the following in-series components based in part on the treatability study findings:

1. chemical oxidation of arsenic by permanganate followed by co-precipitation;
2. clarification and filtering for precipitants and solids removal;
3. polishing followed by pH adjustment; and
4. filtration and reverse osmosis followed by a bioreactor for selenium removal.

It is unknown if a long-term (i.e., 30 years) NPDES permit would be issued, or what would be the associated standards for long-term discharge. Finally, the MCGS is slated for closure in 2028, with an unknown site configuration after that time. For these reasons, a long-term pump and treat alternative seems unlikely.

4.2.3 Permeable Reactive Barrier

As noted above, selenium and thallium do not persist in groundwater downgradient of Primary 2 at detectable concentrations; therefore, arsenic removal would be the primary focus of this in-situ treatment technology.

Based only on the treatability testing completed in 2019, a PRB system using inorganic media is expected to meet the discharge target for arsenic (in the arsenate form) and a PRB system using organic media is expected to meet the discharge target for selenium. The inorganic media may not perform as well under reducing groundwater conditions where arsenic may be present as arsenite, which sorbs less strongly to iron hydroxide at neutral to alkaline pH. NIPSCO may consider using two- or multiple-stage PRBs to achieve the treatment goals.

5.0 SUMMARY AND NEXT STEPS

It is anticipated that Primary 2 closure (removal of CCR) will be completed in 2022 or early 2023. Source removal will reduce future contributions of arsenic, selenium, and thallium to the subsurface. Following closure, additional data will be collected to further evaluate the effectiveness of the impoundment closures on groundwater quality improvements. During this time, NIPSCO will continue to evaluate the alternatives described in Section 4, collecting field data as necessary to support the most promising corrective measure alternatives, and the eventual selected remedy.

Once CCR is removed from Primary 2, MNA may be a viable technology if irreversible sorption of arsenic can be demonstrated. If active remediation is required, arsenic can be readily treated in-situ (e.g., using a PRB) or ex-situ following groundwater recovery. In-situ treatment would target arsenic and is anticipated to be very successful, and the literature and initial bench-scale testing is promising for the treatment of selenium and thallium, if needed. Groundwater recovery would be a secondary option because the extracted water would have to be treated for disposal. Multiple inorganics in the extracted groundwater would have to be treated to achieve standards for discharge to Lake Michigan, the POTW, or the subsurface. Some inorganics are difficult to treat with low discharge standards, making groundwater extraction, treatment, and disposal potentially difficult.

Twelve new monitoring wells will be installed and developed within 90 days of NIPSCO's placing a notification of completion of closure of the CCR surface impoundments in the operating record per 40 CFR §257.100(c)(3).

As soon as feasible, NIPSCO will select a remedy that meets the requirements of §257.97(b), and as required by §257.96(e) NIPSCO LLC, will discuss the results of the corrective measures assessment in a public meeting 30 days prior to selecting the final remedy.

6.0 REFERENCES

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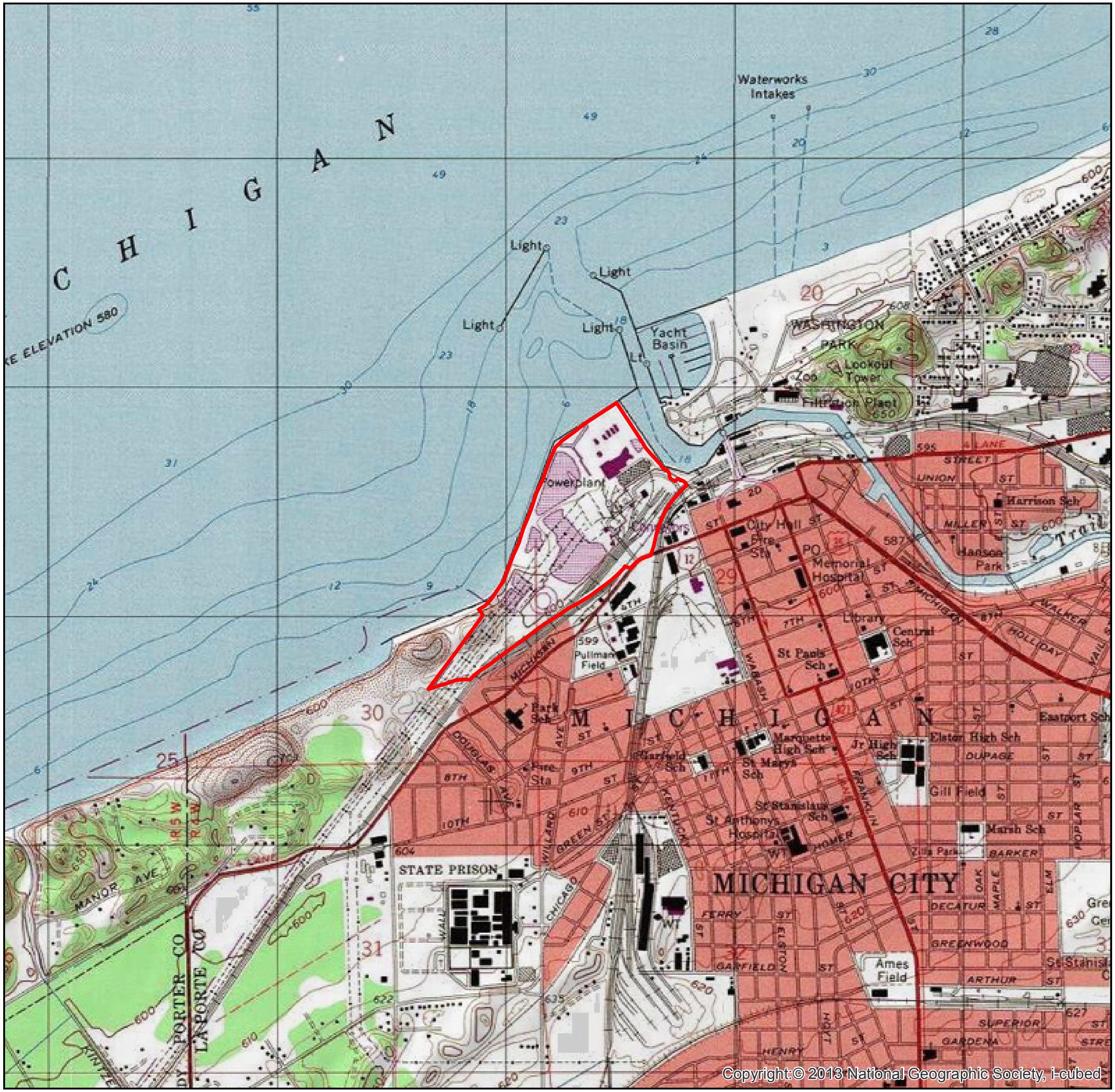
Figures



SITE LOCATION MAP

Michigan City Generating Station

Northern Indiana
Public Service Company
Michigan City, Indiana

Legend

Site Boundary

Location of Site

Notes & Sources

0 2,000
Feet

N

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FIGURE
1

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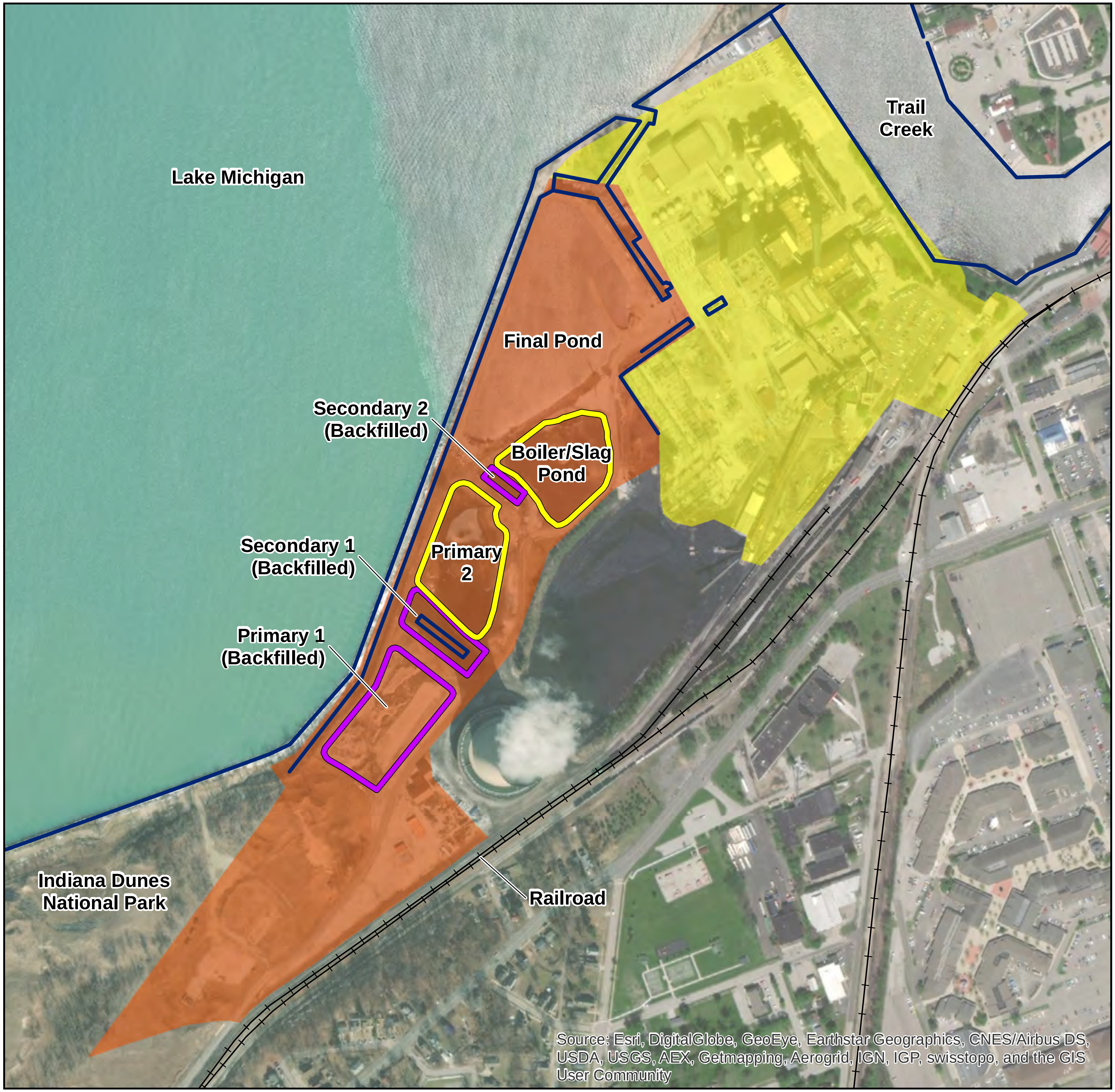

LOCATION OF CCR UNITS AND PONDS

Michigan City Generating Station

Northern Indiana
Public Service Company
Michigan City, Indiana

Legend

- CCR Rule Impoundment
- RCRA Amended Agreed Order Impoundment
- Power Generation Area
- CCR Management Area
- Existing Sheet Piles
- Railroad

Location of Site

Notes & Sources

0 550 Feet

N

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Chelmsford, MA 01824
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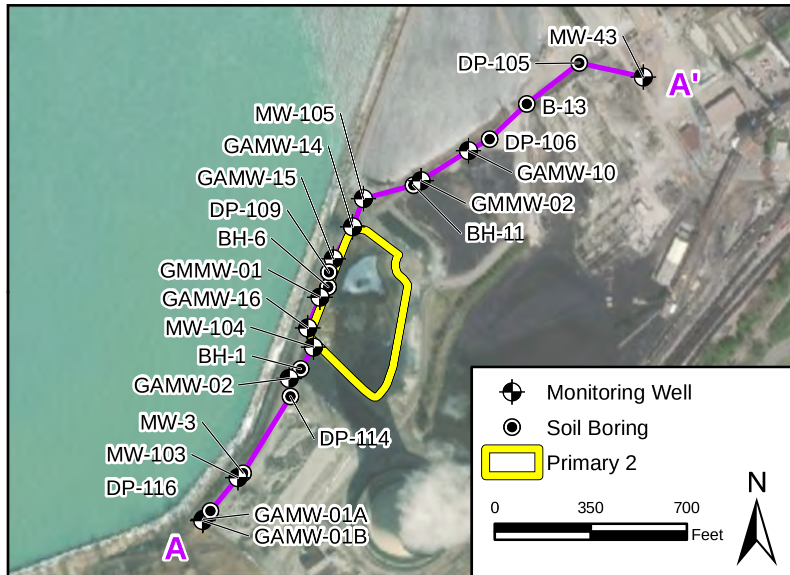
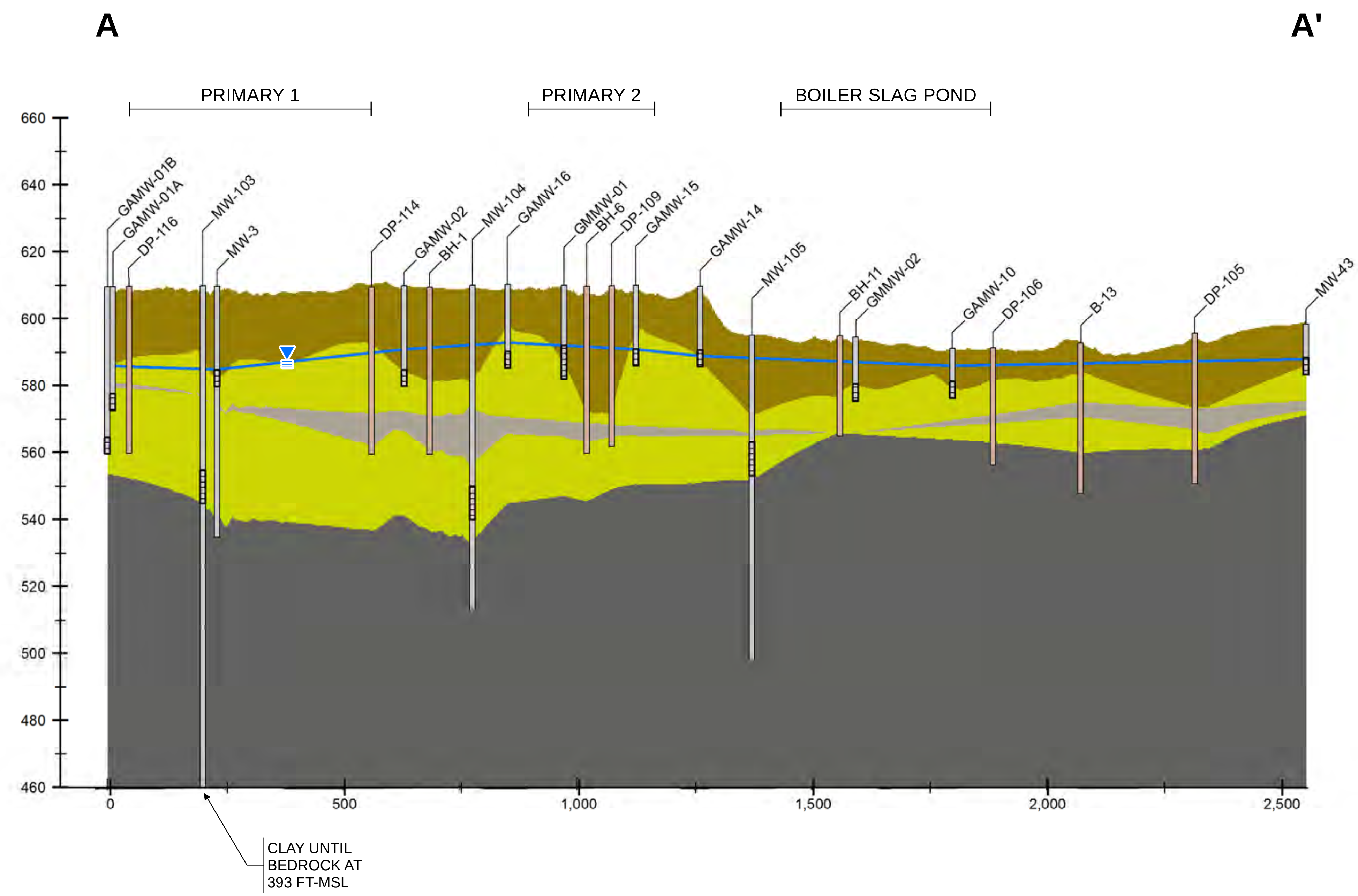
FIGURE 2





CONCEPTUAL CROSS SECTION A - A'

Michigan City Generating Station

Northern Indiana
Public Service Company
Michigan City, Indiana

Legend

- Soil Boring
- Existing Monitoring Well
- Screened Interval of Monitoring Well
- Water Table

Soil Type

- Fill
- Sand
- Upper Clay
- Lower Clay

Notes & Sources

Vertical Scale: 1 inch = 40 feet

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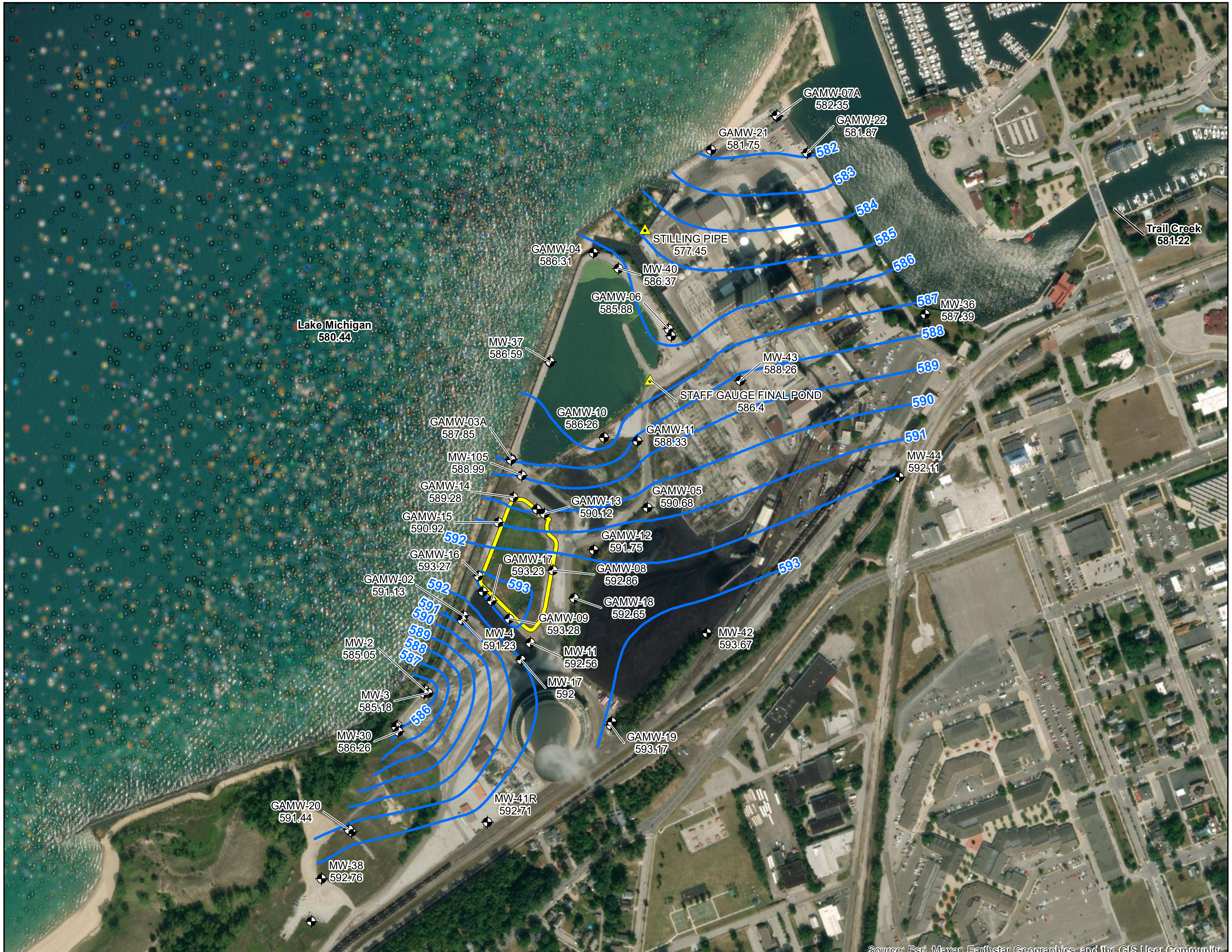
FIGURE
3



FACILITY WATER TABLE CONTOUR PLAN
August 6, 2018

Michigan City Generating Station

Northern Indiana
Public Service Company
Michigan City, Indiana

Legend

- Monitoring Well with Water Table Elevation (Feet)
- Staff Gauge with Surface Water Elevation (Feet)
- Groundwater Contour
- Primary 2

Notes & Sources

0 225 450
Feet

N

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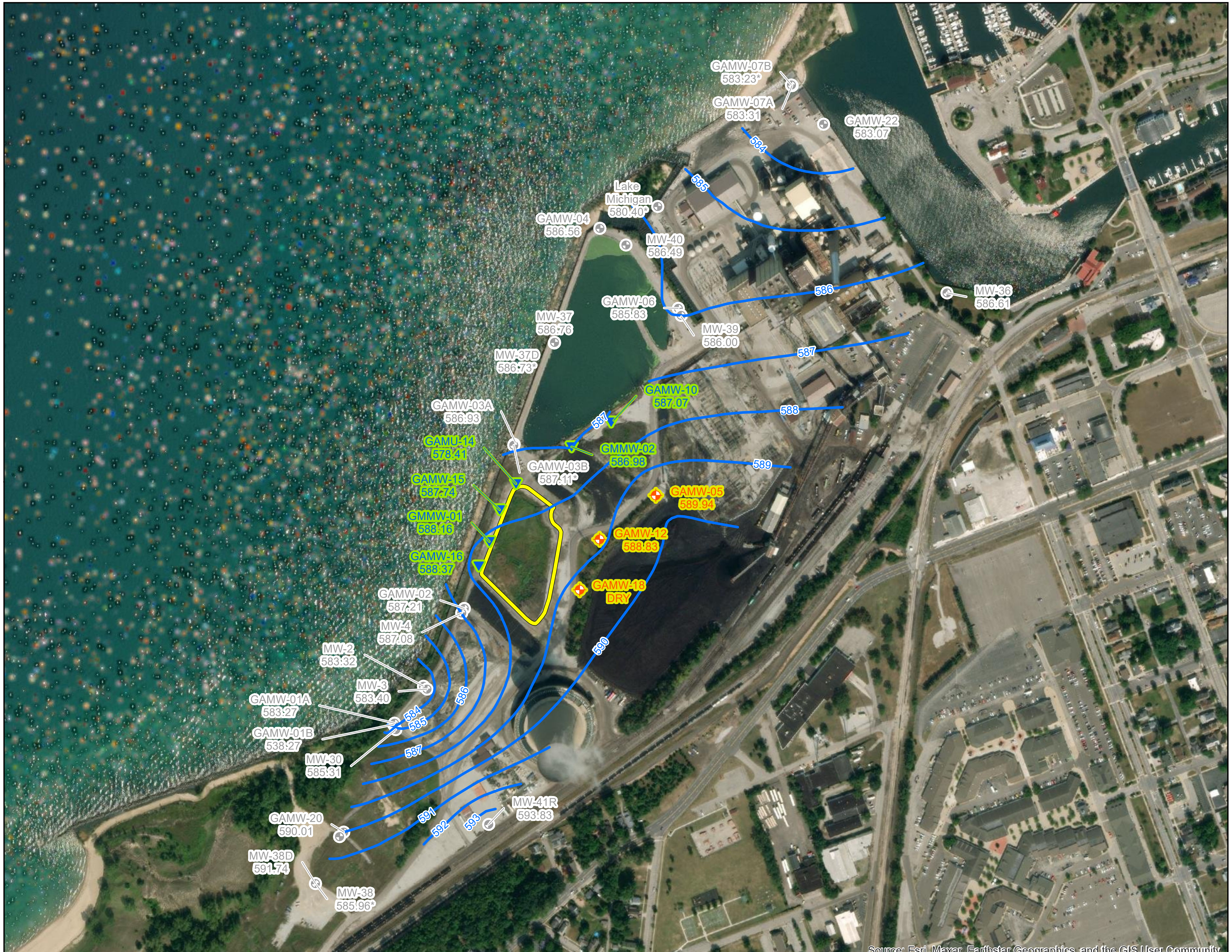
FIGURE
4

H:\NiSource\MichiganCity\Task10\MXD\Fig6_FacilityGroundwaterContours.mxd September 21, 2022 DWN: jenna.mello CHKD: RAJ



GROUNDWATER CONTOUR PLAN March 2022

Michigan City Generating Station

Michigan City, Indiana

Legend

- CCR Background Groundwater Monitroing Well
- CCR Downgradient Groundwater Monitoring Well
- Non-CCR Well
- March 2022 Groundwater Elevation Contour (ft NAVD88)
- CCR Unit

Notes & Sources

Source: Figure 4 WSP Golder, 2021-2022 AnnualGroundwater Monitoring and CorrectiveAction Report - Primary 2,NIPSCO LLC Michigan City Generating Station, August 2022.

* = Value not used for contour generation

0 215 430 Feet

N

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FIGURE 5

H:\NiSource\MichiganCity\Task8\MXD\Fig5_GroundwaterContours_March.mxd September 21, 2022 DWN: jenna.mello CHKD: AKN

PRIMARY 2 GROUNDWATER MONITORING NETWORK

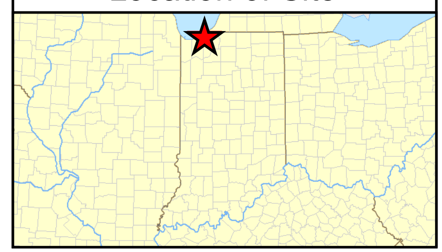
Michigan City Generating Station

Northern Indiana
Public Service Company
Michigan City, Indiana

Legend

- Background Groundwater Monitoring Well
- Downgradient Groundwater Monitoring Well
- Existing Sheet Piles
- Primary 2

Location of Site



Notes & Sources

0 120 Feet

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FIGURE 6

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SELENIUM PLUME

Michigan City Generating Station

Michigan City, Indiana

Legend

- Selenium Concentration Contour
- CCR Background Groundwater Monitoring Well
- CCR Downgradient Groundwater Monitoring Well
- Decommissioned Monitoring Well
- CCR Unit

0 55 110 Feet

N

Notes & Sources

Selenium Concentration (mg/L)

Value provided for March 2022 or last date sampled if dry or decomissioned

U = not detected above reporting limit
J = estimated concentration

GWMW-02 - Boiler Slag Pond
GAMW-02 and MW-4 - RCRA RFI

Source: Figure 2, WSP Golder, 2021-2022 Annual Groundwater Monitoring and Corrective Action Report - Primary 2, NIPSCO LLC Michigan City Generating Station, August 2022.

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FIGURE 7

H:\NiSource\MichiganCity\Task8\MXD\SeleniumContours.mxd September 21, 2022 DWN: jenna.mello CHKD: AKN

Tables

Table 2 - History of Arsenic, Seleniuim and Thallium Detections
Primary Settling Pond No. 2 Downgradient Wells
Assessment of Corrective Measures - Addemdum #1
Michigan City Generating Station

WELL	SAMPLE DATE	SAMPLE TYPE	UNITS	Arsenic	Selenium	Thallium
GAMW-08	7/19/2016	N	mg/L	0.021	0.0021 J	0.000089 J
GAMW-08	9/13/2016	N	mg/L	0.025	0.0032 J	0.001 U
GAMW-08	11/16/2016	N	mg/L	0.025	0.0031 J	0.001 U
GAMW-08	1/17/2017	N	mg/L	0.021	0.0019 J	0.001 U
GAMW-08	1/17/2017	FD	mg/L	0.021	0.002 J	0.001 U
GAMW-08	3/8/2017	N	mg/L	0.014	0.0024 J	0.001 U
GAMW-08	5/2/2017	N	mg/L	0.016	0.004 J	0.001 U
GAMW-08	7/5/2017	FD	mg/L	0.018	0.0045 J	0.001 U
GAMW-08	7/5/2017	N	mg/L	0.018	0.0037 J	0.001 U
GAMW-08	8/29/2017	N	mg/L	0.021	0.0019 J	0.001 U
GAMW-08	4/17/2018	N	mg/L	0.02	0.0026 J	0.00044 J
GAMW-08	5/8/2018	FD	mg/L	0.021	0.0025 J	0.00039 J
GAMW-08	5/8/2018	N	mg/L	0.02	0.0024 J	0.00044 J
GAMW-08	10/3/2018	N	mg/L	0.03	0.0012 J	0.001
GAMW-08	4/4/2019	FD	mg/L	0.036	0.013	0.0058
GAMW-08	4/4/2019	N	mg/L	0.038	0.012	0.0058
GAMW-08	10/23/2019	N	mg/L	0.042	0.062	0.0032
GAMW-08	2/25/2020	N	mg/L	0.044	0.05	0.0011
GAMW-08	4/1/2020	N	mg/L	0.039	0.028	0.0011
GAMW-08	10/1/2020	N	mg/L	0.051	0.044	0.001 U
GAMW-08	5/5/2021	N	mg/L	0.047	0.041	0.0012
GAMW-08	10/12/2021	N	mg/L	0.051	0.027	0.001 U
GAMW-09	7/19/2016	N	mg/L	0.0084	0.0032 J	0.0006 J
GAMW-09	9/13/2016	N	mg/L	0.01	0.0013 J	0.00061 J
GAMW-09	11/16/2016	N	mg/L	0.013	0.0009 J	0.0006 J
GAMW-09	1/17/2017	N	mg/L	0.013	0.0016 J	0.00033 J
GAMW-09	1/17/2017	FD	mg/L	0.013	0.0019 J	0.00034 J
GAMW-09	3/8/2017	N	mg/L	0.0088	0.0032 J	0.001 U
GAMW-09	3/8/2017	FD	mg/L	0.009	0.003 J	0.001 U
GAMW-09	5/2/2017	N	mg/L	0.0087	0.0044 J	0.00022 J
GAMW-09	7/5/2017	N	mg/L	0.0086	0.0046 J	0.00037 J
GAMW-09	8/29/2017	FD	mg/L	0.0087	0.007	0.00065 J
GAMW-09	8/29/2017	N	mg/L	0.0085	0.0073	0.00063 J
GAMW-09	4/17/2018	N	mg/L	0.0067	0.006	0.0014
GAMW-09	5/8/2018	N	mg/L	0.0062	0.0038 J	0.0014
GAMW-09	10/3/2018	N	mg/L	0.0083	0.0034 J	0.0015
GAMW-09	4/4/2019	N	mg/L	0.013	0.0041 J	0.0014
GAMW-09	10/23/2019	N	mg/L	0.017	0.018	0.0016
GAMW-09	10/23/2019	FD	mg/L	0.016	0.018	0.0016

Table 2 - History of Arsenic, Seleniuim and Thallium Detections
Primary Settling Pond No. 2 Downgradient Wells
Assessment of Corrective Measures - Addemdum #1
Michigan City Generating Station

WELL	SAMPLE DATE	SAMPLE TYPE	UNITS	Arsenic	Selenium	Thallium
GAMW-13	7/18/2016	N	mg/L	0.029	0.005	0.0042
GAMW-13	9/13/2016	N	mg/L	0.034	0.0056	0.0043
GAMW-13	11/16/2016	N	mg/L	0.03	0.018	0.0043
GAMW-13	1/17/2017	N	mg/L	0.036	0.0049 J	0.0025
GAMW-13	3/8/2017	N	mg/L	0.031	0.005	0.0024
GAMW-13	5/2/2017	N	mg/L	0.038	0.0051	0.0018
GAMW-13	7/5/2017	N	mg/L	0.049	0.0011 J	0.0014
GAMW-13	8/29/2017	N	mg/L	0.043	0.012	0.002
GAMW-13	4/16/2018	N	mg/L	0.039	0.0085	0.0018
GAMW-13	5/7/2018	N	mg/L	0.04	0.0081	0.0018
GAMW-13	10/2/2018	FD	mg/L	0.039	0.0043 J	0.0023
GAMW-13	10/2/2018	N	mg/L	0.038	0.0045 J	0.0023
GAMW-13	4/4/2019	N	mg/L	0.035	0.0091	0.00083 J
GAMW-13	10/22/2019	N	mg/L	0.038	0.005	0.00021 J
GAMW-13	2/25/2020	N	mg/L	0.03	0.015	0.001 U
GAMW-13	4/1/2020	N	mg/L	0.026	0.0051	0.0013
GAMW-13	9/30/2020	N	mg/L	0.032	0.0036	0.001 U
GAMW-13	5/4/2021	N	mg/L	0.03	0.015	0.001 U
GAMW-13	10/14/2021	N	mg/L	0.037	0.0088	0.001 U
GAMW-14	7/18/2016	N	mg/L	0.03	0.021	0.0026
GAMW-14	9/12/2016	N	mg/L	0.044	0.056	0.0025
GAMW-14	11/16/2016	N	mg/L	0.032	0.019	0.0034
GAMW-14	1/17/2017	N	mg/L	0.032	0.021	0.0022
GAMW-14	3/8/2017	N	mg/L	0.027	0.026	0.0023
GAMW-14	5/2/2017	N	mg/L	0.03	0.027	0.0019
GAMW-14	7/5/2017	N	mg/L	0.031	0.034	0.002
GAMW-14	8/29/2017	N	mg/L	0.025	0.014	0.0024
GAMW-14	4/16/2018	N	mg/L	0.022	0.0021 J	0.0049
GAMW-14	5/7/2018	N	mg/L	0.022	0.0016 J	0.0052
GAMW-14	10/2/2018	N	mg/L	0.028	0.041	0.0029
GAMW-14	4/3/2019	N	mg/L	0.034	0.023	0.003
GAMW-14	10/22/2019	N	mg/L	0.033	0.086	0.0041
GAMW-14	2/25/2020	N	mg/L	0.032	0.064	0.0021
GAMW-14	4/1/2020	N	mg/L	0.03	0.084	0.0021
GAMW-14	4/1/2020	FD	mg/L	0.03	0.082	0.0022
GAMW-14	9/30/2020	N	mg/L	0.036	0.065	0.0019
GAMW-14	5/4/2021	N	mg/L	0.035	0.11	0.0028
GAMW-14	10/14/2021	N	mg/L	0.031	0.11	0.0023
GAMW-14	3/11/2022	N	mg/L	0.029	0.13	0.0019

Table 2 - History of Arsenic, Seleniuim and Thallium Detections
Primary Settling Pond No. 2 Downgradient Wells
Assessment of Corrective Measures - Addemdum #1
Michigan City Generating Station

WELL	SAMPLE DATE	SAMPLE TYPE	UNITS	Arsenic	Selenium	Thallium
GAMW-15	7/18/2016	N	mg/L	0.022	0.0084	0.0025
GAMW-15	9/12/2016	N	mg/L	0.028	0.011	0.0028
GAMW-15	11/16/2016	N	mg/L	0.031	0.031	0.0037
GAMW-15	1/17/2017	N	mg/L	0.029	0.0087	0.002
GAMW-15	3/8/2017	N	mg/L	0.021	0.013	0.0018
GAMW-15	5/2/2017	FD	mg/L	0.022	0.014	0.0011
GAMW-15	5/2/2017	N	mg/L	0.022	0.014	0.0011
GAMW-15	7/5/2017	N	mg/L	0.025	0.0068	0.0012
GAMW-15	8/29/2017	N	mg/L	0.022	0.012	0.0028
GAMW-15	4/16/2018	N	mg/L	0.017	0.0051	0.0011
GAMW-15	5/7/2018	N	mg/L	0.013	0.0033 J	0.0012
GAMW-15	10/2/2018	N	mg/L	0.027	0.012	0.0021
GAMW-15	4/3/2019	N	mg/L	0.036	0.0036 J	0.0034
GAMW-15	10/18/2019	N	mg/L	0.044	0.024	0.0028
GAMW-15	2/25/2020	N	mg/L	0.033	0.056	0.0022
GAMW-15	3/31/2020	N	mg/L	0.028	0.081	0.0024
GAMW-15	9/30/2020	N	mg/L	0.033	0.23	0.0022
GAMW-15	5/4/2021	N	mg/L	0.025	0.16	0.0017
GAMW-15	10/13/2021	N	mg/L	0.025	0.14	0.0015
GAMW-15	3/11/2022	N	mg/L	0.024	0.076	0.0016
GAMW-16	7/18/2016	FD	mg/L	0.041	0.0085	0.001 U
GAMW-16	7/18/2016	N	mg/L	0.039	0.0075	0.001 U
GAMW-16	9/13/2016	N	mg/L	0.042	0.012	0.0013
GAMW-16	9/13/2016	FD	mg/L	0.045	0.012	0.0013
GAMW-16	11/16/2016	N	mg/L	0.045	0.0074	0.0012
GAMW-16	11/16/2016	FD	mg/L	0.044	0.0072	0.0012
GAMW-16	1/17/2017	N	mg/L	0.049	0.0089	0.0013
GAMW-16	3/7/2017	N	mg/L	0.035	0.0071	0.0014
GAMW-16	5/2/2017	FD	mg/L	0.031	0.008	0.0015
GAMW-16	5/2/2017	N	mg/L	0.03	0.0076	0.0015
GAMW-16	7/5/2017	N	mg/L	0.023	0.011	0.0014
GAMW-16	8/29/2017	N	mg/L	0.026	0.011	0.0025
GAMW-16	4/17/2018	N	mg/L	0.03	0.082	0.0017
GAMW-16	5/8/2018	N	mg/L	0.034	0.031	0.0013
GAMW-16	10/2/2018	N	mg/L	0.029	0.023	0.0014
GAMW-16	4/4/2019	N	mg/L	0.031	0.034	0.0019
GAMW-16	10/23/2019	N	mg/L	0.044	0.017	0.0013
GAMW-16	2/26/2020	N	mg/L	0.029	0.03	0.001
GAMW-16	2/26/2020	FD	mg/L	0.03	0.029	0.001 U
GAMW-16	3/31/2020	N	mg/L	0.024	0.044	0.0012
GAMW-16	10/1/2020	N	mg/L	0.027	0.067	0.001 U
GAMW-16	10/1/2020	FD	mg/L	0.027	0.066	0.001 U
GAMW-16	5/4/2021	N	mg/L	0.03	0.098	0.0011
GAMW-16	5/4/2021	FD	mg/L	0.03	0.095	0.0011
GAMW-16	10/12/2021	N	mg/L	0.033	0.063	0.001 U
GAMW-16	3/11/2022	N	mg/L	0.029	0.26	0.0012

Table 2 - History of Arsenic, Seleniuim and Thallium Detections
Primary Settling Pond No. 2 Downgradient Wells
Assessment of Corrective Measures - Addemdum #1
Michigan City Generating Station

WELL	SAMPLE DATE	SAMPLE TYPE	UNITS	Arsenic	Selenium	Thallium
GAMW-17	7/18/2016	N	mg/L	0.015	0.012	0.0025
GAMW-17	9/13/2016	N	mg/L	0.027	0.085	0.0042
GAMW-17	11/16/2016	N	mg/L	0.028	0.024	0.0039
GAMW-17	1/17/2017	N	mg/L	0.036	0.023	0.0023
GAMW-17	3/7/2017	N	mg/L	0.034	0.059	0.002
GAMW-17	5/2/2017	N	mg/L	0.045	0.11	0.0019
GAMW-17	7/5/2017	N	mg/L	0.048	0.1	0.0042
GAMW-17	8/29/2017	N	mg/L	0.058	0.17	0.0056
GAMW-17	4/17/2018	FD	mg/L	0.032	0.018	0.0048
GAMW-17	4/17/2018	N	mg/L	0.032	0.019	0.0047
GAMW-17	5/8/2018	N	mg/L	0.03	0.012	0.0043
GAMW-17	10/3/2018	N	mg/L	0.036	0.029	0.0035
GAMW-17	4/4/2019	N	mg/L	0.044	0.014	0.0015
GAMW-17	10/23/2019	N	mg/L	0.06	0.043	0.0016
GMMW-01	7/19/2016	N	mg/L	0.016	0.016	0.0036
GMMW-01	9/13/2016	N	mg/L	0.026	0.057	0.0046
GMMW-01	11/17/2016	N	mg/L	0.028	0.075	0.0052
GMMW-01	1/17/2017	N	mg/L	0.043	0.0058	0.0023
GMMW-01	3/7/2017	N	mg/L	0.03	0.044	0.0027
GMMW-01	5/3/2017	N	mg/L	0.027	0.047	0.0014
GMMW-01	7/5/2017	N	mg/L	0.019	0.0033 J	0.0014
GMMW-01	8/29/2017	N	mg/L	0.038	0.02	0.0043
GMMW-01	4/17/2018	N	mg/L	0.017	0.0073	0.0032
GMMW-01	5/7/2018	N	mg/L	0.014	0.0045 J	0.0029
GMMW-01	10/2/2018	N	mg/L	0.019	0.035	0.0024
GMMW-01	4/4/2019	N	mg/L	0.028	0.023	0.0034
GMMW-01	10/15/2019	N	mg/L	0.022	0.13	0.0029
GMMW-01	2/26/2020	N	mg/L	0.023	0.32	0.0024
GMMW-01	3/31/2020	N	mg/L	0.023	0.34	0.0024
GMMW-01	10/1/2020	N	mg/L	0.021	0.33	0.002
GMMW-01	5/5/2021	N	mg/L	0.027	0.4	0.0017
GMMW-01	10/12/2021	N	mg/L	0.033	0.65	0.002
GMMW-01	3/11/2022	N	mg/L	0.023	0.53	0.0015

Notes:
mg/L - milligrams per liter
N - normal, or primary sample
FD - field duplicate sample
J - estimated value below the reporting limit
U - not detected above the reporting limit

Prepared by: AKN 9/19/22
Reviewed by: RAJ 09/26/22

Attachment A

Estimated Mass of Selenium in Groundwater

Attachment A
Estimated Mass of Selenium in Groundwater
Assessment of Corrective Measures, Primary Settling Pond No. 2 - Addendum No. 1
Michigan City Generating Station

Selenium Contour Values	Area (ft^2)	Saturated Thickness (ft)	Aquifer Volume (ft^3)	Porosity	Aquifer Water Volume ft^3	Gallons	Liters	Average Selenium Concentration (mg/L)	Selenium Mass (mg)
0.001 to 0.01	1.8E+05	18	3.2E+06	0.35	1.1E+06	8.4E+06	3.2E+07	0.0053	1.7E+05
0.01 to 0.1	1.8E+05	18	3.2E+06	0.35	1.1E+06	8.4E+06	3.2E+07	0.041	1.3E+06
>0.1	5.4E+04	18	9.7E+05	0.35	3.4E+05	2.5E+06	9.7E+06	0.31	3.0E+06
									4.5E+06

4.5 kgs
9.8 Pounds

Selenium Contour Values	Area (ft^2)	Saturated Thickness (ft)	Aquifer Volume (ft^3)	Porosity	Aquifer Water Volume ft^3	Gallons	Liters	Average Selenium Concentration (mg/L)	Selenium Mass (mg)
0.001 to 0.01	1.8E+05	18	3.2E+06	0.20	6.4E+05	4.8E+06	1.8E+07	0.0053	9.7E+04
0.01 to 0.1	1.8E+05	18	3.2E+06	0.20	6.4E+05	4.8E+06	1.8E+07	0.041	7.5E+05
>0.1	5.4E+04	18	9.7E+05	0.20	1.9E+05	1.5E+06	5.5E+06	0.31	1.7E+06
									2.6E+06

2.6 kgs
5.6 Pounds

Prepared by: RAJ 9/21/22
Checked by: JMM 9/21/22

From Golder RFI, p. 40: The first calculation is based on an assumed effective porosity value of 35% for well sorted sand and silt (Fetter, 1988).
From Wood 2018, p. 6-6: The second calculation is based on an assumed effective porosity of 0.2 for sand.

Attachment B

Table 3 – Screening and Evaluation of Remedial Technologies for Groundwater Corrective Measures (from Wood 2020)

Table 3
Screening and Evaluation of Remedial Technologies for Groundwater Corrective Measures
Based on Closure by Removal at the Primary 2 Pond
Michigan City Generating Station, Michigan City, IN

General Response Action	Remedial Action Technology Type	Process Option and Description	Relative Performance/ Reliability/ Ease of Implementation (Low-Medium-High)	Relative Time Required to Begin and Complete Remedy (Short-Medium-Long)	Institutional Requirements that May Affect Implementation (Few-Some-Many)	Result of Screening
LIMITED ACTION Physical or administrative restrictions designed to prevent access to groundwater.	**Institutional Controls**	Legal and administrative restrictions designed to reduce or eliminate access to groundwater.	**High/High/High** Availability of public water supply limits impact of groundwater restrictions.	**Short/Short** Lowest time requirements, as remedy is effective as soon as restrictions are implemented.	**Few** Requires restrictive environmental covenant to limit access to groundwater.	**Not Retained**: Easily implemented but not consistent with requirements of federal Coal Combustion Residual (CCR) Rule. Unlikely to receive regulatory approval.
	Monitored Natural Attenuation (MNA)	Allowing ongoing, naturally occurring processes to remove dissolved arsenic and thallium from groundwater through irreversible sorption to aquifer solids. Includes long-term monitoring to document decline in constituent concentrations.	**Low-Med/Medium/High** Both effectiveness and reliability (permanence) dependent upon site-specific geochemical interactions between arsenic/thallium and aquifer solids.	**Short/Long** Easy to implement. Time to complete depends upon rate of groundwater flow and available recharge to replace impacted groundwater. Sorption/ desorption dynamics could extend timeframe to reach Groundwater Protection Standards (GWPS).	**Few** Ongoing monitoring and reporting would be required.	**Retained**: Easily implemented, additional studies of groundwater geochemistry, aquifer solid characteristics and post-closure oxidation/reduction conditions would be required to understand attenuation mechanisms. Serves as baseline for other remedial actions.
IN-SITU CONTAINMENT Restricts movement of arsenic and creates a barrier to prevent access to groundwater. <u>Compliments cap included as part of closure by removal.</u>	**Vertical Barrier**	Sheet-pile wall or slurry wall to fully encircle affected groundwater and keyed into native clay below Primary 2.	**High/High/Low** Sheet-pile wall or slurry wall requires exacting construction to assure complete encapsulation. Placement must consider above- and below-ground structures. Sheet-pile installation may be prevented by overhead transmission lines. Most effective in combination with capping and impermeable base.	**Medium/Long** Up to a year may be required for construction. Will require long-term monitoring to assure continued integrity.	**Few** Ongoing monitoring and reporting would be required.	**Not Retained**. In-situ containment methods must be managed in perpetuity to ensure arsenic and thallium do not migrate and may require hydraulic control within the containment area (i.e., groundwater extraction and treatment). Unlikely to receive regulatory approval.
	Impermeable Base	In-situ stabilization (ISS) beneath contaminated groundwater to prevent vertical migration if native clay not continuous below Primary 2.	**High/High/Low** ISS barrier is difficult to construct, but effective once in place in combination with capping and vertical barrier.	**Medium/Long** Up to a year may be required for construction. Will require long-term monitoring to assure continued integrity.		

Table 3
Screening and Evaluation of Remedial Technologies for Groundwater Corrective Measures
Based on Closure by Removal at the Primary 2 Pond
Michigan City Generating Station, Michigan City, IN

General Response Action	Remedial Action Technology Type	Process Option and Description	Relative Performance/ Reliability/ Ease of Implementation (Low-Medium-High)	Relative Time Required to Begin and Complete Remedy (Short-Medium-Long)	Institutional Requirements that May Affect Implementation (Few-Some-Many)	Result of Screening
REMOVAL AND CONTAINMENT Physical removal of groundwater from the aquifer through various approaches. Hydraulic containment may be possible depending upon approach.	**Extraction Wells**	Removes contaminated groundwater and provides hydraulic containment to limit plume migration.	**Med-High/Med-High/High** Mechanical system needs basic operation, maintenance and monitoring (OM&M). Addition of new wells or revision of extraction well field commonly required where duration is extended.	**Short/Long** Capture is effective soon after system is installed and started up. Corrective Action Objectives (CAOs) are met once arsenic and thallium concentrations upgradient of wells are below GWPS. Modeling needed to evaluate effectiveness of design.	**Few** Ongoing monitoring and reporting would be required.	**Retained**. Must be implemented in conjunction with ex-situ treatment. Can meet CAOs eventually but may require many years. Easily expandable to address other potential groundwater treatment areas. Will require OM&M for duration.
	Extraction Trench	Intercepts contaminated groundwater. Effectiveness of containment depends on design of extraction trench and groundwater extraction rate.	**High/Med-High/Medium** Placement must consider above- and below-ground structures. Extraction system will require OM&M for many years.	**Short/Long** Capture is effective soon after system is installed and started up. CAOs are met once arsenic and thallium concentrations up-gradient of the trench are below GWPS. Modeling needed to evaluate effectiveness of design.	**Few** Ongoing monitoring and reporting would be required.	**Retained**. Must be implemented in conjunction with ex-situ treatment. Can meet CAOs eventually but may require many years. Will require OM&M for duration.
EX-SITU TREATMENT Treatment to reduce concentrations of inorganics in extracted groundwater.	**Groundwater Treatment Technologies**	**Multiple Process Options** Multiple process options are available for treatment of extracted groundwater, including settling, pH adjustment, flocculants, clarification, carbon adsorption, oxidation, adsorption, and filtration.	**Variable/Variable/Med-Low** Once extracted, must meet discharge standards for multiple inorganics, not just arsenic and thallium. Some inorganics easy to remove (e.g., arsenic), whereas others are more resistant to treatment (e.g., selenium).	**Medium/Long** Treatment is required for as long as extraction is required. OM&M required for duration of operation.	**Few** Ongoing monitoring and reporting would be required.	**Retained**. A treatability study has been completed to evaluate effective technologies for treating arsenic and other inorganic constituents. Routine discharge monitoring required. All treatment options generate waste requiring offsite disposal.
IN-SITU TREATMENT Treatment to reduce concentrations of arsenic in groundwater without extraction.	**Chemical Addition/ Treatment**	Inject chemicals or additives into the aquifer to treat arsenic and thallium in groundwater.	**Unknown/Unknown/Low** A treatability study would be required to determine the appropriate treatment reagents and to ensure permanence. Reagent introduction is feasible but spacing to ensure proper distribution can be difficult.	**Medium/Med-Long** Injections can take months to complete. Treatment can be completed soon after final injection, or multiple injections may be required.	**Few** Underground Injection Control (UIC) permit required.	**Not Retained**: Even if appropriate treatment reagents are identified, requires effective distribution of reagents across a large area around and within the Primary 2 footprint (i.e., through the two-foot soil cap).
	Permeable Reactive Barrier (PRB)	Install PRB along downgradient boundary of the BSP.	**High/High/Medium** Very effective at removing arsenic and somewhat effective at removing thallium; however, thallium treatment may not be required because natural attenuation appears to be effective. Trench placement would have to consider below-ground structures.	**Medium/Med-Long** Groundwater downgradient of the PRB would be improved relatively quickly. Time for groundwater improvement upgradient of the barrier would be similar to MNA.	**Few** Ongoing monitoring and reporting would be required.	**Retained**: Careful construction techniques and testing required to ensure uniform distribution of barrier. Reagent in the PRB may become spent after years of operation. Monitoring required to determine if additional reagent is required.

Table 3
Screening and Evaluation of Remedial Technologies for Groundwater Corrective Measures
Based on Closure by Removal at the Primary 2 Pond
Michigan City Generating Station, Michigan City, IN

General Response Action	Remedial Action Technology Type	Process Option and Description	Relative Performance/ Reliability/ Ease of Implementation (Low-Medium-High)	Relative Time Required to Begin and Complete Remedy (Short-Medium-Long)	Institutional Requirements that May Affect Implementation (Few-Some-Many)	Result of Screening
IN-SITU TREATMENT Treatment to reduce concentrations of arsenic in groundwater without extraction (continued).	**Funnel and Gate System**	Use sheet pile to direct groundwater to treatment zone.	**High/High/Low** Very effective at removing arsenic and somewhat effective at removing thallium; however, thallium treatment may not be required because natural attenuation appears to be effective. Sheet pile installation would have to consider below-ground structures and may be hindered or prevented by overhead transmission lines.	**Medium/Med-Long** Groundwater downgradient of the treatment zone would be improved relatively quickly. Time for groundwater improvement upgradient of the treatment zone would be similar to MNA.	**Few** Ongoing monitoring and reporting would be required.	**Retained**: Technology reduces size of reactive zone for treatment. Reagent in the treatment zone may become spent after years of operation. Monitoring required to determine if additional reagent is required. Careful construction techniques and testing required to ensure effective flow management.
	Stabilization/ Solidification	A solidifying agent is mixed into the subsurface to fix arsenic and thallium onto aquifer solids and significantly reduce leaching of both into groundwater.	**High/High/Very Low** Extremely effective with the right solidification agent. Large area would require solidification. Process disruptive to above- and below-ground structures and may be hindered or prevented by overhead transmission lines.	**Med-Long/Med-Long** ISS can take months to complete. Treatment can be completed soon after solidification/ stabilization.	**Few** UIC permit required.	**Not Retained**: Solidifying a large area can significantly alter groundwater flow patterns. Modeling required to assess unintended consequences.
	Biological Treatment	Microbial Induced Calcite Precipitation: a biological process for catalyzing native soil bacteria such that it cements together particles, increases compressibility and shear strength, and reduces pore space, thereby reducing the soil's solubility and mobility (leach capacity).	**Medium/High/Very Low** Effective when bacteria and substrate can contact the impacted groundwater. Maintaining biological activity can be challenging if preferential flow paths develop as calcite precipitates. Multiple injections may be required to achieve treatment across impacted zones.	**Unknown/Unknown** Injections can take months to complete. Treatment can be completed soon after final injection, or multiple injections may be required.	**Few** UIC permit required.	**Not Retained**: Extensive geo-chemical testing and pilot scale tests would be required. Unknown if conditions are favorable.
DISPOSAL On-site (treated) or offsite (untreated) disposal of extracted groundwater.	**On-Site Discharge**	Discharge to Lake Michigan	**High/High/Low-Med** Effective, but requires National Pollutant Discharge Elimination System (NPDES) permit for long-term discharge.	**Short-Med/Long** Time to begin discharge will be governed by time required to obtain NPDES permit. Discharge will be required throughout life of remedy.	**Some** NPDES permit required; direct discharge permits to Lake Michigan take a significant time to obtain due to review process. Permit may not be issued for long-term discharge (i.e., 30 years).	**Retained**: Even though permitting may be a lengthy process, direct discharge is a reliable and an easy-to-maintain disposal option and may be worth additional studies and agency interaction.
		Discharge to local Publicly-Owned Treatment Works (POTW)	**High/High/Med** Effective and reliable, may present difficulty to construct discharge pipeline to appropriate point in sewer system due to underground utilities and limitations to conveyance system leading to the POTW.	**Medium/Long** Up to a year may be required for construction. Discharge to POTW will be required throughout life of remedy.	**Some** POTW industrial pretreatment permit will be required. Usually easier to obtain than a direct-discharge (NPDES) permit.	**Retained**: Discharge to POTW usually has less stringent limitations than direct discharge to Lake Michigan since additional treatment occurs at POTW.

Table 3
Screening and Evaluation of Remedial Technologies for Groundwater Corrective Measures
Based on Closure by Removal at the Primary 2 Pond
Michigan City Generating Station, Michigan City, IN

General Response Action	Remedial Action Technology Type	Process Option and Description	Relative Performance/ Reliability/ Ease of Implementation (Low-Medium-High)	Relative Time Required to Begin and Complete Remedy (Short-Medium-Long)	Institutional Requirements that May Affect Implementation (Few-Some-Many)	Result of Screening
DISPOSAL On-site (treated) or offsite (untreated) disposal of extracted groundwater (continued).	**On-Site Discharge** (continued)	Reinjection of treated groundwater to the subsurface within the MCGS property boundaries.	**High/High/Low-Med** Effective throughout life of the remedy and will accelerate arsenic and thallium removal through enhanced flushing; placement must consider above- and below-ground structures.	**Medium/Long** Up to a year may be required for construction. Reinjection will be required throughout life of remedy.	**Few** UIC permit required.	**Retained**: Modeling required to determine impacts to groundwater flow/quality. Will require routine OM&M to prevent fouling. Long-term reduction in aquifer permeability possible. Retained because discharge of treated water to Lake Michigan or POTW may not be allowed.
	Off-Site Disposal	Transport contaminated groundwater to an off-site permitted treatment and disposal facility.	**High/High/Low** Effective, but requires continuous traffic at the site to transport extracted groundwater throughout life of the remedy.	**Short/Long** Relatively easy to construct holding tank and schedule disposal. Required throughout the life of the remedy.	**Some** Identification of disposal facility is required.	**Not Retained**: Volume of water needed for extraction likely to make offsite disposal infeasible. Truck traffic creates air pollution and inconvenience to community.