RAMBOLL

ENVIRONMENT
& HEALTH

March 5, 2022

SEMIANNUAL REMEDY SELECTION PROGRESS REPORT
POND SYSTEM
MIAMI FORT POWER PLANT

In accordance with Title 40 Code of Federal Regulations (40 C.F.R.) § 257.97(a), the owner or operator of a coal combustion residuals (CCR) unit must prepare a semiannual report describing the progress in selecting and designing a remedy for statistically significant levels (SSLs) of constituents listed in Appendix IV of 40 C.F.R. § 257 over the groundwater protection standards established in accordance with 40 C.F.R. § 257.95(h).

This report is for activities occurring between September 6, 2021 and March 5, 2022 at the Pond System located at the Miami Fort Power Plant.

As stated in the March 5, 2020 Semiannual Remedy Selection Progress Report, a Corrective Measures Assessment (CMA) was completed for Basin A of the Pond System on September 5, 2019 to address SSLs for total cobalt and total molybdenum (see related notification dated February 6, 2019), as required by 40 C.F.R. § 257.96. The CMA was revised on November 12, 2020 to reflect the characterization of the Pond System as a single multi-unit comprised of Basins A and B, including an Alternate Source Demonstration for SSLs of total arsenic (identified for Basin B) and total molybdenum. The CMA was revised again on November 30, 2020 to include additional information related to site geology and hydrogeology, apply evaluation criteria to potential corrective measures, and provide an independent evaluation of monitored natural attenuation (MNA).

As stated in the September 5, 2020 Semiannual Remedy Selection Progress Report, selection of the source control measure continues to be in the feasibility study phase and will incorporate groundwater flow and transport modeling that is in development. In addition, existing groundwater and source water data were reviewed, as well as identification and collection of additional groundwater and source water samples to evaluate the feasibility of MNA. These data indicate that site-specific conditions appear favorable for implementation of MNA in combination with the source control measures considered in the CMA.

Additional activities completed during the reporting period associated with the selection of a groundwater remedy include characterization of aquifer solids and batch adsorption tests to better understand natural attenuation mechanisms, rates, and aquifer capacity. Analysis of natural attenuation mechanisms, rates, and aquifer capacity is needed to complete the tiered evaluation referenced in United States Environmental Protection Agency (USEPA) guidance, including development of a geochemical conceptual site model. These activities are necessary to understand the natural attenuation mechanisms occurring at the site and their potential ability to reduce the aqueous concentrations of total cobalt to below the applicable groundwater protection standard. The results of the bench scale testing completed to date in support of the evaluation of MNA as a potential corrective measure is provided in Attachment A to this progress report document. A numerical groundwater model (MODFLOW) has been constructed with preliminary calibration to groundwater flow. Further model refinement and transport calibration will be completed as results are obtained from ongoing investigations.

As stated in the notification letter dated February 2, 2022, SSLs for total arsenic, total cobalt, and total molybdenum were identified at the Pond System following assessment monitoring completed during the reporting period in accordance with 40 C.F.R. § 257.95, consistent with related observations during previous reporting periods.

ATTACHMENT A
TECHNICAL MEMORANDUM – MIAMI FORT POND SYSTEM CORRECTIVE MEASURES ASSESSMENT UPDATE

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TECHNICAL MEMORANDUM

Date:	March 3, 2022
To:	Brian Voelker – Vistra
Copies to:	Stu Cravens and Phil Morris – Vistra
From:	Allison Kreinberg, Ryan Fimmen – Geosyntec Consultants
Subject:	Miami Fort Pond System Corrective Measures Assessment Update

EXECUTIVE SUMMARY

Geosyntec Consultants, Inc. (Geosyntec) has prepared this technical memorandum as an addendum to the existing Corrective Measures Assessment (CMA)[1] for the Miami Fort Pond System (the Site). This memo provides an update on the ongoing remedy selection progress, including providing additional details on aspects of the groundwater corrective measures evaluation and closure design.

Topics covered in this memorandum include:

- An update on the evaluation of monitored natural attenuation (MNA) as a potential component of a selected groundwater remedy;
- Information regarding plans for dewatering the coal combustion residual (CCR) material as part of closure activities; and,
- Information regarding plans to minimize vertical and lateral infiltration of groundwater during and following closure activities.

MNA EVALUATION PROGRESS

The CMA reviewed multiple potential groundwater remedies, including MNA, to address statistically significant levels (SSLs) of cobalt above the groundwater protection standard (GWPS) at the Site.

[1] Ramboll Americas Engineering Solutions, Inc. (Ramboll). 2020. *Corrective Measures Assessment Revision 2 – Miami Fort Pond System, Miami Fort Power Station, North Bend, Ohio*. Report to Dynegy Miami Fort, LLC., November.

A tiered evaluation is being completed in accordance with United States Environmental Protection Agency (USEPA) guidance[2] to assess whether MNA, in combination with source control, is a viable remedy based on current and potential post-closure site conditions. According to the USEPA guidance, a tiered MNA evaluation should include:

- Tier I: Demonstration that the groundwater plume is not expanding, and that sorption of the contaminant onto aquifer solids is occurring where immobilization is the predominant attenuation process;
- Tier II: Determination of the attenuation mechanism(s) and rate of the attenuation process(es);
- Tier III: Determination of aquifer capacity to attenuate the mass of contaminant within the plume and the stability of the immobilized contaminant to resist re-mobilization under current and future anticipated conditions; and
- Tier IV: Design of a performance monitoring program based on the mechanistic understanding developed for the attenuation process, and establish a contingency plan tailored to site-specific characteristics.

MNA as a potential groundwater remedy is supported by Tier II and III evaluations, which demonstrate a cobalt attenuation mechanism (i.e., adsorption). The findings of the study completed to-date and the additional data collection planned to develop multiple lines of evidence to support the evaluation of MNA in accordance with USEPA guidance are summarized below.

<u>Tier I Analysis – Initial Considerations and Source Control</u>

The uppermost aquifer at the Site is a glacial outwash consisting of sands and gravels overlain by alluvial silts and clays, as described in Section 2.1.2 of the CMA. The alluvium is likely to provide sufficient attenuation capacity via adsorption of dissolved cobalt to the slit and clay fractions to prevent off-site migration of dissolved cobalt. A monitoring well network was installed in 2017 in accordance with 40 C.F.R. § 257.91 to adequately characterize groundwater flow at the Site and accurately represent the quality of background groundwater (**Figure 1**). Cobalt impacts at MW-4 are vertically delineated via groundwater monitoring well MW-14, but there is insufficient space downgradient of MW-4 to install a lateral delineation well before reaching the Ohio River. The anticipated contribution of cobalt from groundwater to the Ohio River was calculated instead[3]. The initial evaluation suggested that the contribution of cobalt to the Ohio River did not represent a potential risk for human or ecological receptors. Results indicate suitable conditions to proceed with an MNA evaluation.

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[2] USEPA, 2007. Monitored Natural Attenuation of Inorganic Contaminants in Ground Water – Volume 1, Technical Basis for Assessment, Publication EPA/600/R-07/139. October.
[3] Geosyntec. 2020. *Monitored Natural Attenuation Evaluation Update Technical Memorandum – Miami Fort Pond System, Miami Fort Power Station, North Bend, Ohio.* Memo to Dynegy Miami Fort, LLC., November.

An initial characterization was completed to identify if attenuation can occur for cobalt under the known site conditions, with the objective of identifying the predominant attenuation mechanism(s) for cobalt. It is known that cobalt readily undergoes chemical attenuation in soils due to adsorption onto clay minerals, iron- and manganese-oxides, and organic matter[4] with minimal desorption[5]. Geochemical modeling using groundwater data and an approximation of expected mineralogy of the aquifer solids from the area of MW-4 was completed to evaluate the potential for adsorption as an attenuation mechanism. Geochemical model results indicated the potential for cobalt attenuation via adsorption, with more than 60% of aqueous cobalt predicted to sorb to aquifer solids, including iron oxides. These results indicate cumulative removal via adsorption is expected to provide substantial attenuation as cobalt migrates downgradient and sorbs to aquifer solids along the groundwater flow path.

Closure in place, closure by removal (off-site landfill), and in-situ solidification/stabilization were retained as potential source control measures based on criteria outlined in 40 C.F.R. § 257.96. It is assumed that MNA will be paired with one of the retained potential source control measures, which would decrease the input of cobalt to the groundwater system and further reduce aqueous concentrations at MW-4.

Tier II Analysis – Constituent Attenuation Mechanisms

Field investigations were completed in February 2021 to collect site materials for use in the Tier II MNA evaluation. Solid phase material (from location SB-2) was collected adjacent to MW-4 to better characterize soil mineralogy and potential reactive phases that can attenuate cobalt. These materials were analyzed to evaluate if they indicate conditions favorable for removal of cobalt from groundwater via chemical attenuation processes. Analytical techniques to characterize soil mineralogy and reactive phases included X-ray diffraction (XRD), sequential extraction procedure (SEP), analysis of total metals, and analysis of total organic carbon (TOC).

XRD analyses provide mineralogical characterization, whereas SEP testing can provide insight into the attenuation mechanism, capacity, and reversibility under different aqueous conditions. Results from the XRD analysis identified the presence of clays and iron oxides, including hematite, at MW-4 (**Table 1**). The SEP analysis found that the highest levels of cobalt were associated with the amorphous and crystalline iron and manganese oxide phases downgradient of the Pond System (**Table 2**). Cobalt was also identified during the acid-extractable phase, which represents more recalcitrant minerals such as sulfides. Both the XRD and SEP data align with the conceptual site model that cobalt is associated with iron-bearing minerals in the aquifer solids via adsorption.

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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

Chemical attenuation of cobalt via interactions with oxide minerals and sulfide phases therefore appears to be present at the Site.

Batch attenuation testing was performed in 2021 to further evaluate the Tier I/II findings that cobalt undergoes chemical attenuation as predicted by the geochemical model and Site characterization data analyses. The goal of the batch attenuation testing was to develop a Site-specific partition coefficient for cobalt, which represents the relative propensity for cobalt to be associated with the solid versus the aqueous phase.

Groundwater from MW-4 was spiked to achieve an elevated starting target concentration and then mixed with aquifer solids collected adjacent to MW-4 at five different solid-to-liquid ratios. Data obtained from the test was used to construct a 5-point attenuation isotherm for cobalt. Mathematical fitting was used to calculate a linear (K_d) adsorption distribution coefficient. The relatively high K_d value of 1575 L/kg for cobalt derived from the batch attenuation test was selected as being most representative of Site conditions. The linear transformation resulted in a high correlation coefficient (R^2=0.93), indicating a good fit to the model data (**Figure 2**). The selected cobalt K_d value of 1575 L/kg is comparable to those observed at other sites with sands, gravels, and alluvial silts and clays[6]. Further, the calculated K_d value is consistent with the geochemical modeling, which predicted low cobalt mobility in the groundwater system due to adsorption to iron-oxide surfaces. The results of the batch attenuation testing are favorable for the selection of MNA as a component of the groundwater corrective action, as they provide evidence for the removal of cobalt from the environment via chemical attenuation of cobalt.

<u>Tier III – Evaluation of Attenuation Stability</u>

Batch desorption testing was completed in 2021 to support the Tier III evaluation, which aims to understand the reversibility of the cobalt attenuation processes occurring at the Site. Changes in cobalt concentrations or in ambient geochemical conditions (e.g., pH, ORP) could reduce the occurrence or stability of the attenuated cobalt, thereby resulting in potential subsequent releases to the environment. These conditions were evaluated through batch desorption testing. While variable redox conditions were evaluated, the pH conditions of the microcosms were not adjusted because the pH at the background location is comparable to current downgradient pH conditions, and therefore pH conditions are not anticipated to change under future use scenarios.

The mass of cobalt desorbed averaged 3.1% across all three desorption treatments, with the greatest desorption under reducing conditions (8.2%) and the lowest under oxidizing conditions (0.2%). The relatively low extent of desorption indicates high stability of attenuated complexes between cobalt and the soil matrix, which is consistent with the relatively high Site-specific partition coefficient (K_d) that was determined for cobalt. Further, the consistently low desorption indicates that cobalt associated with the soil solids at the Site will remain largely immobilized. Tier II/III

[6] USEPA. 2005. Partition coefficients for metals in surface water, soil, and waste. Rep. EPA/600/R-05, 74. July.

results demonstrate that cobalt immobilization (via adsorption) is in effect and that the process is highly stable. Natural chemical attenuation can therefore remove from the environmental as much of the released mass of cobalt as is feasible (per 40 C.F.R. § 257.97(b)(4)) and is protective of human health and the environment (per 40 C.F.R. 257.97(b)(1)).

Tier IV – Long-term Monitoring and Remedy Evaluation

If MNA is selected as a component of the groundwater corrective action, then a long-term monitoring (LTM) plan and contingency plan will be developed as part of Tier IV of the MNA evaluation. The LTM plan is required to design a monitoring program that will evaluate the performance of the MNA remedy and the progress of the natural attenuation processes at the Site, following completion of source control measures.

Tier IV of the MNA evaluation also calls for a consideration of the contingency plan if the observed declines in groundwater concentrations of cobalt are not consistent with the groundwater fate and transport model predictions. Alternatively, the contingency plan may need to be considered if Site conditions which are identified as key for MNA performance are no longer present. The contingency plan may specify a technology that is different from MNA, or it may call for modifications to the selected MNA remedy depending on observed changes in Site conditions or performance.

Ongoing Efforts

To establish whether the attenuation rates identified are sufficient for attaining the GWPS, Ramboll is developing a groundwater fate and transport model to predict how groundwater concentrations of cobalt will decline following completion of source control measures. Modeling efforts began in 2020. In combination with the model being developed by Ramboll, which will predict the decline in aqueous cobalt concentrations due to physical attenuation mechanisms, the results of the batch attenuation testing described in the Tier II analysis will be used to understand rates of chemical attenuation mechanisms.

A review of the chemical attenuation capacity for the aquifer will be completed to understand if sufficient capacity is available in the downgradient aquifer to attenuate cobalt via chemical attenuation processes (i.e., adsorption). The Site-specific partition coefficient calculated from the batch attenuation test will be used to estimate the chemical attenuation capacity of the aquifer downgradient of the Site. The potential total mass flux for cobalt will be calculated using the estimated mass of cobalt migrating toward the Ohio River predicted by the groundwater fate and transport model. The total estimated discharged mass will include both historical and future post-closure periods. The chemical attenuation capacity will then be compared to the estimated mass flux of cobalt to (1) evaluate whether sufficient capacity is available to reduce groundwater concentrations to below the GWPS, and (2) predict timeframes to reduce aqueous cobalt concentrations to below the GWPS.

MNA Evaluation Preliminary Conclusions

A tiered MNA evaluation is being developed to assess if Site conditions are favorable for the implementation of MNA as a groundwater corrective measure in combination with source control measures. The evaluation completed thus far found that chemical attenuation of cobalt is expected based on the results of site characterization and batch attenuation testing efforts, demonstrating that immobilization via adsorption occurs and is relatively irreversible. Further analysis is ongoing to determine if there is sufficient capacity in the aquifer system through chemical attenuation alone to attenuate the predicted future contaminant mass flux of cobalt, or whether MNA of cobalt would be achieved through a combination of both physical and chemical mechanisms. If MNA is selected as a component of the groundwater corrective action, then a LTM plan and contingency plan will be developed.

While MNA combined with source control appears to be a promising groundwater remedy at the Miami Fort Pond System, additional investigation is required to increase the density and resolution of the Uppermost Aquifer data to facilitate design of a groundwater extraction system, cutoff wall, and/or permeable reactive barrier, if necessary, to evaluate other corrective measures. Groundwater flow and transport modeling is in development to support selection and design of the groundwater remedy. The groundwater remedy will be selected following completion of the groundwater flow and transport model and evaluation of all potential corrective measures.

FREE LIQUID REMOVAL DURING CLOSURE

As described in Section 5 of the CMA, closure in place (CIP), either alone or potentially with in-situ solidification/stabilization (ISS), were selected as potential source control corrective measures. Prior to installing a final cover system, free liquids will be eliminated by either removing liquid wastes or by removing liquid wastes and solidifying the remaining wastes and waste residues.

If CIP without ISS was selected as the source control corrective measure, prior to installing a final cover system, free liquids would be eliminated by removing liquid waste by using engineering measures to remove liquids that are readily separable under ambient temperature and pressure are being evaluated.

If ISS was utilized with CIP, the final product of the ISS process is a relatively impermeable material that acts as a hydraulic barrier to groundwater flow and does not have liquids that are readily separable under ambient temperature and pressure. Free liquids outside of areas improved by ISS would still be eliminated by removing liquids waste with engineering measures designed to remove liquids that are readily separable under ambient temperature and pressure.

MINIMIZATION OF POST-CLOSURE INFILTRATION

Source control via CIP, potentially with ISS, will, to the maximum extent feasible, minimize the post-closure vertical infiltration of liquids into the retained CCR through the installation of a final cover system. While design of the final cover system will depend on the selected corrective measure, it is likely to contain the following features:

- An LLDPE geomembrane low-permeability layer which would be placed on a prepared subgrade to control and minimize vertical infiltration into the surface impoundment. The geomembrane will be constructed on a subgrade that is free of sharp rocks or other debris and will be protected from damage by installing a geotextile cushion layer and a total of two feet of cover soil and topsoil over the top of the membrane.
- Surface stormwater will be routed off of the top of the final cover by the construction of a free-draining post-closure stormwater management system, including channels and letdown structures. The stormwater management system will drain by gravity and preclude water impoundment on top of the final cover system, thereby minimizing vertical post-closure infiltration into the CCR.

Groundwater modeling will be completed as part of the corrective measures selection process. The modeling will assess the potential for lateral migration of water into and out of the remaining CCR material; this potential would be considered as part of the selection of groundwater corrective measures.

TABLES

Table 1: X-Ray Diffraction Results
Miami Fort Power Station

Site Material		SB-2		
Sample Depth (ft bgs)				
Mineral	**Mineral Composition**	**36-37'**	**42-43'**	**43-44'**
Quartz	SiO_2	55	71	74
Calcite	$CaCO_3$	--	--	--
Albite	$NaAlSi_3O_8$	7.80	10.30	12.50
Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$	17.50	7.10	4.00
Dolomite	$CaMg(CO_3)_2$	--	--	--
Microcline	$KAlSi_3O_8$	4.10	5.70	4.50
Ankerite	$CaFe(CO_3)_2$	--	--	--
Rhodochrosite	$MnCO_3$	--	--	--
Chlorite	$(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)_8$	4.7	1.9	2.3
Hematite	Fe_2O_3	0.6	0.8	0.7
Kaolinite	$Al_2Si_2O_5(OH)_4$	10.3	3.5	2.4

Notes:

All samples represented as weight percent normalized to a sum of 100%. A quantity of amorphous material has not been determined.

-- - not detected

Table 2: Sequential Extraction Procedure Results
Miami Fort Power Station

Analyte	Fraction	SB-2
Cobalt	Exchangeable	0.79
	Carbonate	0.59
	Amorphous Fe/Mn Oxides	1.4
	Crystalline Fe/Mn Oxides	4.1
	Organic-Bound	ND
	Acid/Sulfide	2.7
	Residual	0.9
	Total	8.7

Notes:

All results are reported in mg of constituent/kg of total sample mass.

ND - not detected

FIGURES

Legend

- 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

Notes

- Figure originally from "Corrective Measures Assessment - Miami Fort Pond System" (Ramboll, 2020)

500 250 0 500 Feet

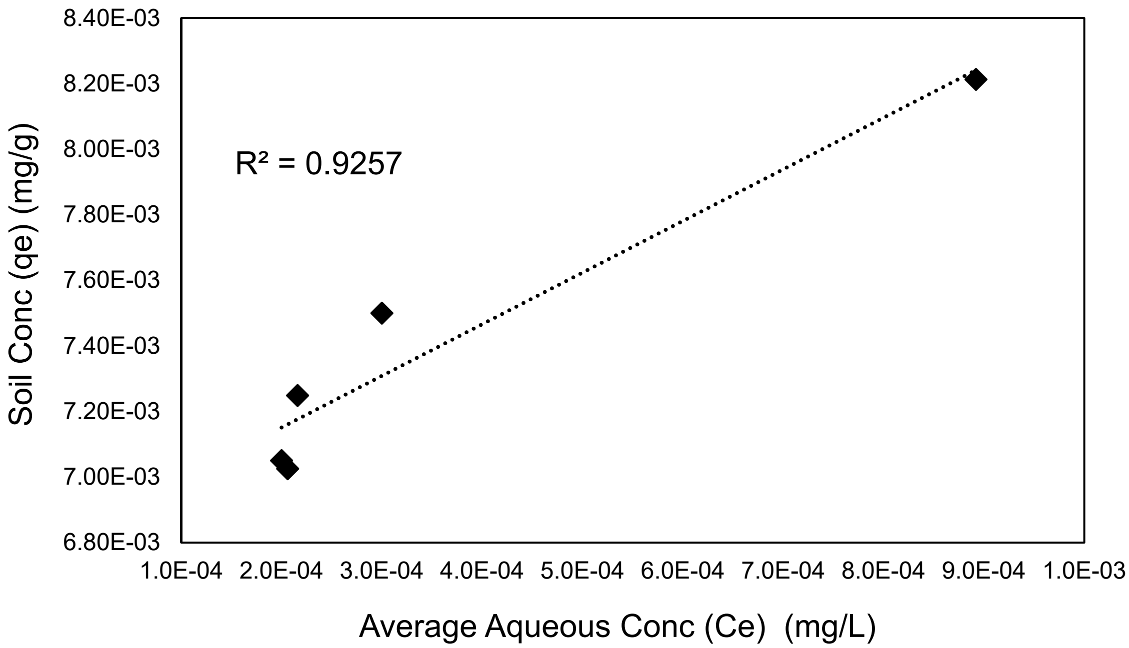
Site and Well Location Map

Miami Fort Power Station
North Bend, Ohio

Geosyntec consultants

Figure 1

Columbus, Ohio | January 2022



Notes: Linear isotherm of cobalt at the Miami Fort Pond System. Each data point represents a different soil:water ratio, increasing from 2:1 to 1:20 moving left to right.

Linear Isotherm of Cobalt

Geosyntec consultants

Columbus, Ohio | February 2022

Figure 2