Assessment of Corrective Measures Report

Bremo Power Station, Solid Waste Permit No. 618
East Pond

Submitted to:

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EXECUTIVE SUMMARY

In accordance with Title 9, Virginia Administrative Code (VAC), Agency 20, Chapter 81-260 *et seq.* (9VAC20-81-260), and Title 40 Code of Federal Regulations (CFR) Part 257.50 *et seq.* of the Federal Disposal of Coal Combustion Residuals from Electric Utilities Rule (CCR Rule) as well as the Commonwealth of Virginia adoption of 40 CFR Part 257 Subpart D by reference [Title 9 Virginia Administrative Code (VAC) Agency 20, Chapter 81-800 *et seq.* (9VAC20-81-800)], Golder Associates Inc. (Golder) prepared this *Assessment of Corrective Measures (ACM) Report* on behalf of Virginia Electric and Power Company, doing business as Dominion Energy Virginia (Dominion Energy) for the East Pond at the Bremo Power Station in Bremo Bluff, Virginia. Dominion Energy maintains a groundwater monitoring program for the East Pond at the Bremo Power Station in Fluvanna County, Virginia, consistent with the requirements of the CCR Rule and Solid Waste Facility Permit (SWP) No. 618 issued by the Virginia Department of Environmental Quality (DEQ).

On January 5, 2020, federal CCR Rule GWPS exceedances were documented at the East Pond in samples collected from monitoring wells MW-20S (molybdenum), MW-20D (lithium, molybdenum), MW-21 (cobalt), and MW-22 (cobalt). These exceedances triggered the need for an ACM for cobalt, lithium, and molybdenum under the CCR Rule. Subsequently, on May 14, 2020, Virginia Solid Waste Permit GPS and federal CCR Rule GWPS exceedance were documented in the East Pond samples collected from monitoring wells MW-19 (boron), MW-20S (boron, cobalt, lithium, and molybdenum), MW-20D, (boron, lithium, and molybdenum), MW-21 (boron and cobalt), and MW-22 (boron and cobalt). These exceedances resulted in boron being added to the ACM triggered in January 2020. In response to these exceedances, Dominion Energy initiated an Assessment of Corrective Measures (ACM) prior to April 4, 2020, consistent with the CCR Rule requirements.

A nature and extent field investigation was completed for the Bremo Power Station East Pond between March 2020 and May 2020 to support the ACM. A report summarizing the results of the field investigation is provided under separate cover (*Nature and Extent Study*, August 2020). This ACM Report summarizes the results of the assessment of remedial alternatives for addressing the reported federal CCR Rule GWPS and Virginia Solid Waste Permit GPS exceedances based on the results of the field investigation, the site conceptual model, and a Risk Assessment.

As part of the ACM, consistent with the requirements of the Virginia Solid Waste Management Regulations (VSWMR) 9VAC20-81-260.C.3 and the CCR Rule (40 CFR Part 257.96 and 257.97), this ACM evaluated remedial alternatives for the boron, cobalt, lithium, and molybdenum groundwater impacts by identifying those remedial alternatives applicable to the contaminants-of-concern present in groundwater. The pool of remedial alternatives was then screened with a screening matrix designed to identify the remedial alternatives most applicable to the site conditions present at the Bremo East Pond. The remedial alternatives selected for additional consideration were evaluated in detail based on criteria presented in the CCR Rule and the VSWMR, as those criteria relate to the conditions at the East Pond. Based on the findings of the NES and the ACM screening matrix, the following remedial alternatives were evaluated in detail as potential remedial strategies for the Bremo East Pond.:

- Monitored Natural Attenuation/Natural Recovery (MNA)
- In-Situ Aquifer Enhancement and MNA
- Hydraulic Pumping Containment (East Pond External Pumping Wells) with Ex-Situ Water Treatment and MNA and North Pond Wastewater Treatment Plant

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- Funnel and Gate Ex-Situ Treatment and MNA and North Pond Wastewater Treatment Plant

Due to the lack of groundwater receptors, the incomplete exposure pathway at the East Pond, and the removal of historical CCR materials and subsoils from the East Pond coupled with the scheduled removal of CCR materials from the North Pond, the evaluation of remedial alternatives suggests that the MNA remedy is likely the most appropriate remedial alternative for the documented impacts associated with the East Pond.

Consistent with VSWMR 9VAC20-81-260.C.1.e a public meeting must be held to discuss the results of the ACM prior to the final selection of the remedy. Due to the coronavirus pandemic a public meeting is not feasible at this time. A public meeting and comment period will be scheduled for a future date when it is reasonable to do so.

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1.0 INTRODUCTION

Golder Associates Inc. (Golder) has prepared this *Assessment of Corrective Measures* (ACM) *Report* on behalf of Virginia Electric and Power Company, doing business as Dominion Energy Virginia (Dominion Energy). The ACM was prepared for the East Pond at the Bremo Power Station (Station) in Bremo Bluff, Virginia in response to federal and state Groundwater Protection Standard (GWPS/GPS) exceedances. The location of the Station is shown on Figure 1. Groundwater at the downgradient point of compliance for the East Pond is currently being monitored under a modified Assessment Monitoring Program (AMP). The groundwater monitoring activities are conducted pursuant to the requirements in the June 2019 Department of Environmental Quality (DEQ)-issued Solid Waste Permit No. 618, the Virginia Solid Waste Management Regulations (VSWMR), and Title 40 Code of Federal Regulations (CFR) Section 257.96 (40 CFR Part 257.96) of the Federal Disposal of Coal Combustion Residuals from Electric Utilities Rule (CCR Rule).

The ACM requirement was triggered during the second semi-annual 2019 compliance event on January 5, 2020, when federal CCR Rule GWPS exceedances were documented at the East Pond in samples collected from monitoring wells MW-20S (molybdenum), MW-20D (lithium, molybdenum), MW-21 (cobalt), and MW-22 (cobalt). Subsequently, on May 14, 2020, during the first semi-annual 2020 sampling event Virginia Solid Waste Permit GPS exceedances and federal CCR Rule GWPS exceedance were documented in the East Pond samples collected from monitoring wells MW-19 (boron), MW-20S (boron, cobalt, lithium, and molybdenum), MW-20D, (boron, lithium, and molybdenum), MW-21 (boron and cobalt), and MW-22 (boron and cobalt). These exceedances resulted in boron being added to the ACM triggered in January 2020.

The ACM is required under Title 40 Code of Federal Regulations (CFR) Section 257.96 (40 CFR Part 257.96) of the federal CCR Rule following the documentation of federal CCR Rule GWPS exceedances. Specifically, once a federal CCR Rule GWPS exceedance has been documented for an Appendix IV constituent, the CCR Rule requires the initiation of an ACM within 90 days of documenting the federal CCR Rule GWPS exceedance unless a successful Alternative Source Demonstration (ASD) is completed. Consistent with the CCR Rule, the ACM must be completed within an additional 90 days unless a demonstration for additional time based on a site-specific condition or circumstances is completed. Pursuant to Part 257.96(a) of the CCR Rule, a demonstration of need for a 60-day extension was certified by a professional engineer and placed in the Station's operating record on June 17, 2020. A copy of the extension request will be included in the East Pond's annual groundwater monitoring and corrective action report consistent with the provisions of the CCR Rule.

Similarly, when a Virginia Solid Waste Permit GPS is exceeded, the VSWMR require initiation of the ACM, to include a NES, within 90 days of documenting the Virginia Solid Waste Permit GPS exceedance unless a successful ASD is completed. Similar to the CCR Rule, the Station operator has an additional 90 days to complete the ACM under the VSWMR unless a demonstration for additional time based on a site-specific condition or circumstances is approved by the DEQ.

In response to the federal CCR Rule GWPS and Virginia Solid Waste Permit GPS exceedances, Dominion Energy completed a field investigation [Nature and Extent Study (NES)] to support the ACM. The field investigation was conducted between March 2020 and May 2020 pursuant to the requirements in Solid Waste Facility Permit No. 618 and consistent with Virginia Department of Environmental Quality (DEQ) NES and ACM guidance for solid waste facilities and is documented in a report under separate cover (Golder, 2020). This ACM Report summarizes the results of the assessment of remedial alternatives for addressing the reported federal

CCR Rule GWPS and Virginia Solid Waste Permit GPS exceedances based on the results of the field investigation.

Consistent with these requirements, this ACM investigation was performed to evaluate remedial alternatives for remediating elevated concentrations of the following constituents that have been detected in East Pond groundwater samples above the federal CCR Rule GWPS and/or Virginia Solid Waste Permit GPS as follows:

- Boron GPS in wells MW-19, MW-20S, MW-20D, MW-21, MW-22;
- Cobalt GWPS/GPS in wells MW-20S, MW-21, MW-22;
- Lithium GWPS/GPS in wells MW-20S, MW-20D; and
- Molybdenum GWPS/GPS in wells MW20S, MW-20D.

This Report summarizes the ACM process and findings.

1.1 Purpose and Report Structure

Consistent with 9VAC20-81-260 and the CCR Rule, the purpose of the East Pond ACM is to assess corrective measures that can be used to prevent future releases, to remediate any releases, and to restore affected areas to original conditions. The evaluation of remedial options should take into consideration the nature and extent of the groundwater impacts.

As previously stated, a comprehensive summary of the field investigation completed to address the nature and extent of groundwater impacts (*i.e.,* to delineate the horizontal and vertical extents of boron, cobalt, lithium, and molybdenum GPS/GWPS exceedances in the vicinity of the East Pond) is provided under separate cover in the *NES* (Golder, 2020). A summary of the work completed, and the key results of the field investigation is provided in Section 3.0. An assessment of select remedial options to address the requirements of the ACM per 9VAC20-81-260 and the CCR Rule is presented in Section 4.0. Cost estimates associated with the evaluated remedial options are presented in Section 5.0. A summary of the public meeting and associated public comment period is presented in Section 6.0. Limitations for the remedial alternative assessments are presented in Section 7.0, and conclusions are presented in Section 8.0.

2.0 STATION INFORMATION SUMMARY

Station information relevant to the ACM is summarized in the following sections.

2.1 Site Setting and Background

As shown on Figure 1, a portion of the United States Geological Survey (USGS) 7½-minute topographic map of Arvonia, Virginia, the site vicinity has moderately steep topography in the upland areas bordering the Station. The local topography is dissected by drainage swales that have developed a mix of dendritic and trellis drainage patterns reflecting an underlying structure control. Both intermittent and perennial streams characterize surface flow in the vicinity of the Station, with broad ridges and hilltops serving as topographical highs (maximum elevations of roughly 450 feet above mean sea level [AMSL] to the north of the Station). A portion of the Station, including the former generation station and the East and West Ponds, is located within the James River floodplain where topographic elevations range from 200 to 230 feet AMSL.

As presented on the aerial photograph inlay on Figure 2, the Station property consists of wooded, open, and developed land just north of the James River. The Station's northern, eastern, and western boundaries are bordered primarily by undeveloped parcels. The Station property is bordered to the south by a CSX rail line and the James River. Land use surrounding the Station is classified as "A-1 Agricultural" and consists of undeveloped wooded and agricultural properties within a rural residential setting. Other than a process water supply well that is located on the Station, there are no known water supply wells within the immediate vicinity of the Station boundary.

Power generation activities at the Station were initiated in the late 1930's. Ash from the power generation activities has historically been stored in the three on-site coal combustion residual (CCR) surface impoundments (North Pond, West Pond, and East Pond). In 2014, the Station converted from a coal-fired power plant to a natural gas-fired power plant. No newly generated CCR has been placed in these impoundments since the conversion to a gas-fired plant. The Station ceased power generation activities in 2018. Storage of existing CCR materials at the Station has been consolidated to the North Pond, with removal of CCR materials formerly stored in the West Pond to the North Pond having been completed in 2017, and removal of CCR materials and an over excavation of a minimum of 6 inches from the East Pond to the North Pond completed in early 2019. DEQ documented their approval of closure by removal records and a DEQ site inspection of the visual removal of CCR material and over-excavation of 6 inches of soil (conducted March 14, 2019) in a letter dated October 1, 2019.

2.2 Groundwater Monitoring Network

Historically, groundwater at the Station was monitored on a 5-year cycle under Virginia Pollutant Discharge Elimination System (VPDES) Permit (Permit No. VA0004138). Beginning in 2013, following installation of an updated groundwater monitoring network under VPDES Permit No. VA0004138, quarterly background sampling activities associated with VPDES monitoring at the Facility were completed between March 2013 and October 2014.

Subsequent to promulgation of the CCR Rule, background sampling activities for the East Pond under the CCR Rule were initiated in October 2017 following installation of additional monitoring wells for the unit. The East Pond background sampling activities were completed in February 2019. On June 5, 2019, Solid Waste Permit No. 618 was issued by DEQ with groundwater monitoring provisions for all three of the Ponds at the Station. The Station currently monitors groundwater downgradient from the East Pond in accordance with the Modified Assessment

Monitoring Program (AMP) as established in the Solid Waste Permit consistent with the AMP provisions in the CCR Rule.

As presented in Table 1 following, the East Pond compliance monitoring network includes three upgradient wells and six downgradient wells that are screened within the uppermost aquifer beneath the East Pond.

Table 1: East Pond Monitoring Network

Upgradient Compliance Monitoring Wells		
MW-11	MW-29S	MW-29D
Downgradient Compliance Monitoring Wells		
MW-19	MW-20S	MW-20D
MW-21	MW-22	MW-23

The monitoring wells are sampled semi-annually under the provisions of the modified AMP. The sample results from the first semi-annual 2020 compliance event were used in preparation of the NES for the East Pond.

2.3 Surface Water Monitoring Network

Under Permit Module XVIII of Bremo Power Station's Solid Waste Permit, the Station operator is required to monitor near-shore waters of the James River to assess for potential surface water impacts that may be occurring due to potential groundwater-surface water exchanges downgradient of the active and inactive impoundments. In accordance with the Surface Water Monitoring Plan (SWMP) prepared for the Station, a total of 10 surface water samples along the north shore of the James River were collected on March 13, 2020 (EnviroScience, 2020). Although this sampling was conducted independent of the ACM investigation, data generated as part of this routine surface water monitoring was evaluated as part of the NES for the East Pond. Table 2 following summarizes the surface water sampling locations. A site map showing the downgradient East and North Pond surface water monitoring locations is presented in Figure 3. Additional surface water sampling locations are shown in the *1st Quarter 2020 Surface Water Monitoring Report* completed by EnviroScience and presented in the NES (Golder, 2020).

Table 2: Surface Water Sampling Locations

NES Surface Water Sampling Locations – Upstream of the Facility	
JR-01	JR-02
NES Surface Water Sampling Locations – Downgradient of West Pond, Upstream of East Pond	
BR-01	BR-02
BR-03	BR-04

NES Surface Water Sampling Locations – Downgradient of East and North Pond	
BR-05	BR-06
BR-07	BR-08

3.0 NES SUMMARY

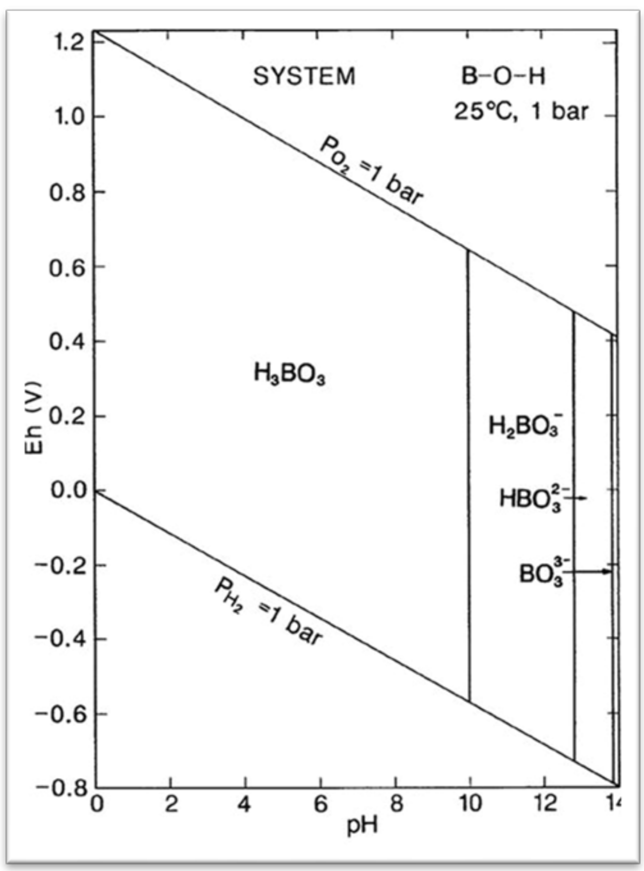
The following sections summarize the findings from the *NES* (Golder, 2020) completed to support this *ACM Report*. The field investigation focused on understanding the nature and extent of the COCs (boron, cobalt, lithium, and molybdenum) in groundwater and surface water based on the documented state and federal GPS/GWPS exceedances for boron, cobalt, lithium, and molybdenum in the Ponds' compliance wells.

3.1 Constituents of Concern

The COCs for the ACM are boron, cobalt, lithium, and molybdenum, details for which are presented in the following sections.

3.1.1 Constituent of Concern Boron

Boron is included as an Appendix III constituent in 40 CFR Part 257 because historically it has been detected at CCR disposal sites and has been identified as an inorganic parameter known to be a leading indicator of releases of contaminants associated with CCR (EPA, 2015). Boron is a naturally occurring, non-metallic element found in rocks, soil, and water. Boron has an oxidation state of +3 and does not exist as a pure element in nature. Rather, it is combined with oxygen as borate minerals and various boron compounds such as boric acid, borax, and boron oxide. Under ambient conditions the boron compounds are found in crystalline form or as granules or amorphous powders. Borate minerals and other boron compounds are ubiquitous, and are found in high concentrations in marine deposits, sedimentary rocks, coal, shale, geothermal fluids, and naturally boron-rich mineral deposits and the soils derived from those mineral deposits (EPA, 2008). Boron is widely distributed in nature at concentrations approaching 30 parts per million (ppm) in some geologic formations (Moore *et al.*, 1997). Boron concentrations in rocks range from 5 ppm in basalts to 100 ppm in shales, and the average concentration in the earth's crust is 10 ppm (Woods, 1994). Boron concentrations in freshwater normally range from <10 to 1,500 µg/L (Woods, 1994).

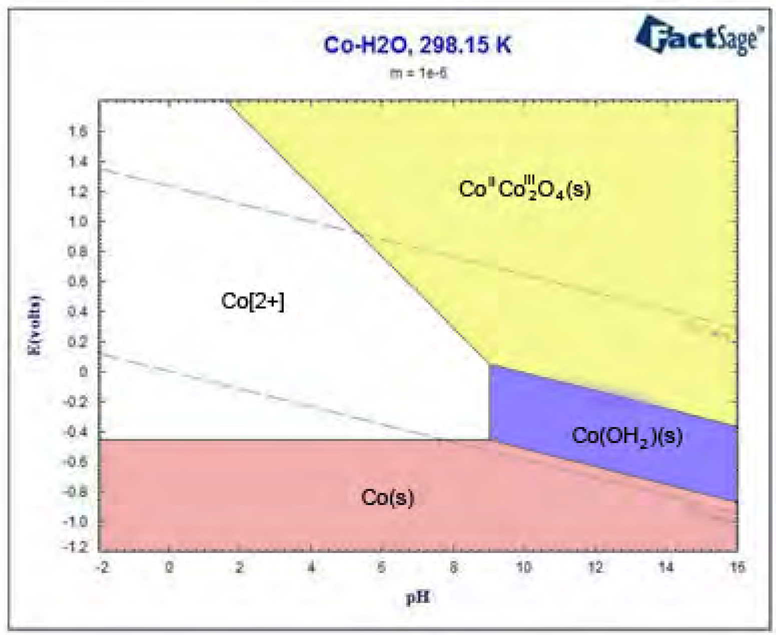


Boron may be released into the environment as a result of natural weathering of geologic formations, burning of coal in power plants, and by activities associated with chemical plants and manufacturing facilities. Fertilizers, herbicides, and industrial wastes are also among the sources of boron soil contamination (EPA, 2008). Contamination of water can come directly from industrial wastewater and municipal sewage, as well as indirectly from air deposition and soil runoff (EPA, 2008). Borates in detergents, soaps, and personal care products can also contribute to the presence of boron in the environment. Elemental boron is insoluble in water and boric acid and borax are only slightly soluble in water. Boron can be present in drinking water from both naturally occurring and man-made sources.

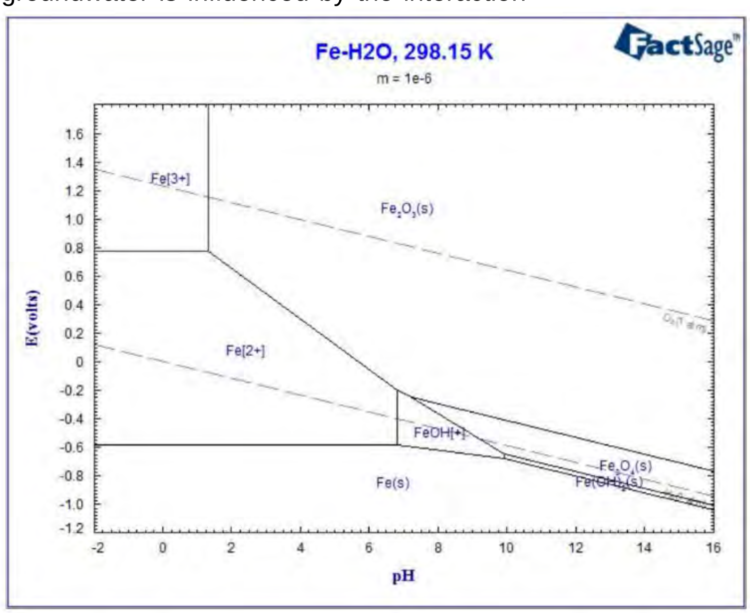
Boron speciation is controlled by acidity, with the noncharged species, boric acid, predominant at lower pH relative to the charged borate ion (Harkness, 2016). The borate ion is more likely to coprecipitate into secondary phases, and therefore, dissolved boron concentrations are lower at high pH (Harkness, 2016). As illustrated in the inset Eh-pH diagram (Brookins, 1988) under natural groundwater and surface water conditions (pH of 4 to 9 Standard Units and Eh of -0.1 to 0.4 volts) found in central Virginia, boron is found almost exclusively as boric acid in the natural environment.

3.1.2 Constituent of Concern Cobalt

Cobalt is a naturally occurring metal found in soil and rock and is commonly associated with minerals and ores that contain copper and nickel. In addition to industrial uses, the Agency for Toxic Substances and Disease Registry (ATSDR) notes in the public health statement for cobalt that cobalt is an essential vitamin for plant and animal nutrient uptake. For most humans, food is the largest source of cobalt intake. Cobalt is a part of essential vitamin B_{12} (found in meat and dairy products) which is needed to maintain human health. The average person consumes approximately 11 micrograms of cobalt a day in their diet (ATSDR, April 2004).



The transport of metals, like cobalt, in groundwater is influenced by the interaction of several factors including complexation reactions in water, redox-related processes, pH, adsorption, and precipitation. Mineral surfaces generally strongly adsorb metal ions, although this adsorption is highly dependent upon the mineral assemblage of the soil and the composition of the groundwater. The transport of metals in groundwater can increase when metals are complexed with binding ligands, either naturally present or introduced as contamination (Herbert *et al*., 1993).



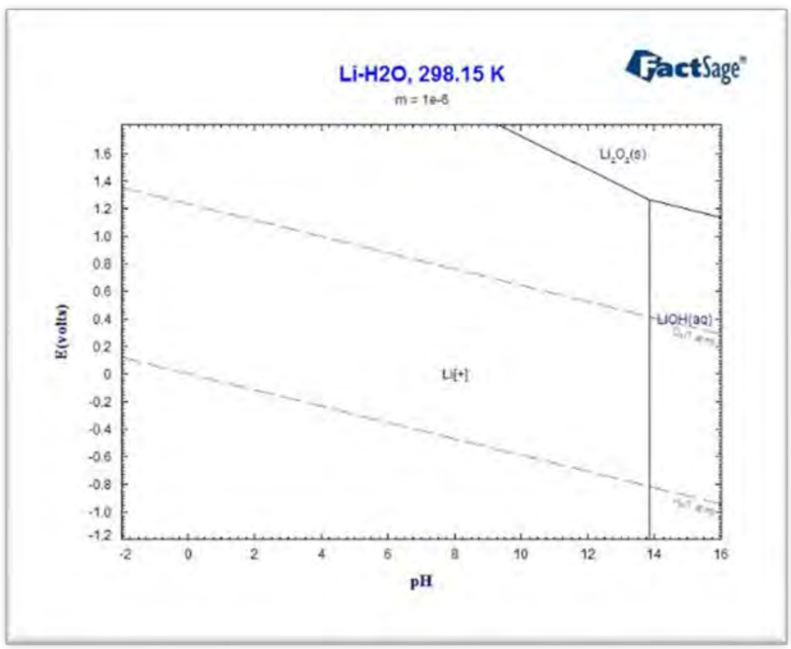
As illustrated in the inset Eh-pH diagram from FactSage™ for cobalt, under natural groundwater and surface water conditions found in Virginia (*i.e.,* pH of 4 to 9 Standard

Units and Eh of -0.1 to 0.4 volts), cobalt is typically found almost exclusively in its divalent free ionic form in the natural environment. However, cobalt (and other divalent metals) is known to strongly absorb to iron oxyhydroxide minerals that are naturally present in sedimentary aquifers, such as the alluvium and saprolite aquifers observed in the vicinity of the East Pond. As illustrated in the inset Eh-pH diagram from FactSage™ for iron, groundwater in central Virginia typically falls near the Ferrous and Ferric iron transition boundary. As such, even *de minimis* changes in groundwater quality (pH and Eh) associated with land-use changes or other activities can result in the dissolution (and corresponding release of absorbed cations) or precipitation (and corresponding absorption of divalent cations) of iron oxyhydroxide minerals. As described in Section 1.0, the East Pond underwent significant disturbance during removal of CCR materials (initiated around March 2017) and subsequent reconstruction of the pond (substantially complete in November 2019).

3.1.3 Constituent of Concern Lithium

Lithium is an alkali metal found naturally in the Earth's crust. Lithium in nature occurs predominantly in silicate minerals, and is a common accessory element in feldspar, biotite mica, amphibole, and clay minerals (Reeder, 2006). The abundance of lithium in soil can vary considerably; lithium content of a soil is influenced more by the conditions under which the soil was formed than by the content of the original parent rock (Yalamanchali, 2012). Lithium is used in batteries, glass and ceramic production, in lubricants used in high-temperature environments, and in pharmaceuticals (Yalamanchali, 2012).

As illustrated in the inset Eh-pH diagram from FactSage™ under natural groundwater and surface water conditions (pH of 4 to 9 Standard Units and Eh of -0.1 to 0.4 volts) found in central Virginia, lithium is found almost exclusively in its univalent free ionic form in the natural environment. When not dissolved in the water column, it is considered relatively immobile because its fluoride, carbonate, and phosphate compounds (*i.e.*, minerals) generally have low solubilities. Chemical and physical weathering of these minerals from igneous rocks and from secondary clay minerals, especially at low pH levels (Lyons and Welsh, 1997) will release the lithium ion into solution. As a result, lithium is found naturally occurring in groundwater (VDH, 2011).



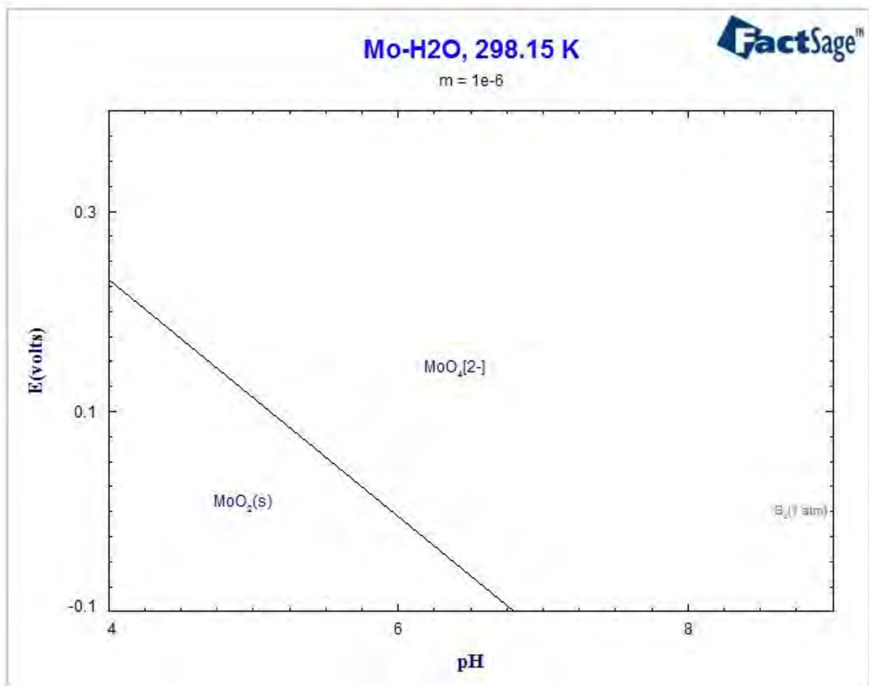
Lithium is included as an Appendix IV constituent in 40 CFR Part 257 because it has historically been detected at CCR disposal sites at concentrations exceeding the United States Environmental Protection Agency (EPA) Regional Screening Level (RSL) for soil to groundwater, and because lithium has the potential to be toxic if consumed with certain drug types (EPA, 2015).

3.1.4 Constituent of Concern Molybdenum

Molybdenum is included as an Appendix IV constituent in 40 CFR Part 257 as historically it has been detected at CCR disposal sites and is relevant to risk assessment and damage cases (EPA, 2015). Molybdenum is a naturally occurring metal found in the Earth's crust. It is found in minerals, rocks and soils as well as in aqueous form, however it does not occur naturally as a free metal. Estimates of crustal abundance have been put at around 0.6 - 1.5 milligram per kilogram (mg/kg; Hu, *et al*., 2008; Taylor, 1964). Within Virginia the USGS reported an average molybdenum concentration in Virginia soils (based on 16 samples) of less than 3 mg/kg (Shacklette, 1984). More recent studies (Smith *et al*., 2013) identified a mean concentration of 1.03 mg/kg for soils in Virginia based on analysis of 132 samples. Overall, this is consistent with the limited evaluation of site soils adjacent to North Pond at the Station (*i.e.,* immediately upgradient of the East Pond), where concentrations of molybdenum ranged from below the MDL (<0.12 mg/kg) to 0.76 mg/kg (Golder, 2019).

Molybdenum is released into soil and water as a result of industrial activity and natural environmental conditions due to anthropogenic and geologic sources. Contamination of water through geologic sources includes degradation of organic matter and natural weathering processes. Anthropogenic sources of molybdenum include impacts from metal sulfide mining, the combustion of fossil fuels, and discharges from industrial operations (Smedley, *et al.*, 2017)

As illustrated in the inset Eh-pH diagram from FactSage™ (Bale *et al.*, 2016) under natural groundwater and surface water conditions (pH of 4 to 9 Standard Units and Eh of -0.1 to 0.4 volts) found in central Virginia, molybdenum is found almost exclusively as the stable molybdate ion in the natural environment. Molybdenum is a redox-sensitive element that forms highly insoluble minerals under certain reducing conditions. Under most oxidizing conditions (typical pH greater than 6), the molybdate ion is expected to be the dominant solution species (Smedley, *et al.*, 2017). Molybdate transport in groundwater is retarded by sorption, depending on the pH, adsorbent contents (including clay, iron, aluminum oxides, iron sulfide, manganese oxides, and organic matter) of soils, and the influence of the competitive adsorption of other anions (Xu, *et al.*, 2013).



3.2 Summary of Field Program

To fulfill the requirements in Solid Waste Permit 618 and its reference to 9VAC20-81 *et seq*., and the CCR Rule as modified to be consistent with DEQ NES guidance for solid waste facilities, a field investigation was conducted to characterize the nature and extent of the release in the vicinity of the East Pond and to identify site conditions that could affect the remedy. To meet these requirements Golder completed a field investigation that included the following tasks:

- Collection, analysis, and evaluation of a comprehensive round of groundwater elevation measurements on May 7, 2020.
- Collection, analysis, and evaluation of groundwater samples from the routine compliance monitoring network as part of the first semi-annual 2020 compliance groundwater event in March 2020.
- Collection, analysis, and evaluation of groundwater samples from three existing observations wells (MW-40, MW-22D, and MW-VPDES) in the vicinity of the East Pond were sampled on May 7, 2020.
- Evaluation of surface water samples from the routine surface water monitoring event as part of the first semi-annual 2020 compliance surface water event on March 13, 2020, completed by EnviroScience.
- Incorporation and evaluation of available historical cation and anion data from an October 2019 sampling event for groundwater and North Pond pore water.
- An assessment and evaluation of potential and actual risks to human health using default exposure scenarios and actual conditions using the DEQ Virginia Unified Risk Assessment Model.

Detailed descriptions of sampling methods, analytical parameters, and analysis methodology are provided in the *NES* (Golder, 2020).

3.3 Summary of NES Results

A groundwater surface contour map for the East Pond is presented as Figure 4. As presented the direction of the interpreted groundwater flow beneath and downgradient from the East Pond is consistent with historical interpretations.

As presented in Figures 5, 6, 7, and 8, the NES delineated the inferred vertical and horizontal extents of boron, cobalt, lithium, and molybdenum concentrations in groundwater which exceed the Virginia Solid Waste Permit GPS and federal CCR Rule GWPS as summarized in Table 3 following.

Table 3: Summary of NES GPS/GWPS Exceedance Results

Constituent	GPS/GWPS Concentration (µg/L)	Assessment Monitoring Well	Concentration (µg/L)
Boron	250 (Solid Waste Permit GPS)	MW-19	710
		MW-20S	2,400
		MW-20D	2,100
		MW-21	360
		MW-22	360
		MW-22D	290
		MW-34	1,200

Constituent	GPS/GWPS Concentration (µg/L)	Assessment Monitoring Well	Concentration (µg/L)
Boron	250 (Solid Waste Permit GPS)	MW-35	430
		MW-40	480
		MW-VPDES	620
Cobalt	7.83 (Solid Waste Permit and Federal GPS/GWPS)	MW-20S	13.0
		MW-21	18.3
		MW-22	27.2
		MW-24	12.1
Lithium	25 (Solid Waste Permit GPS) / 40 (Federal GWPS)	MW-20S	330
		MW-20D	121
Molybdenum	16.4 (Solid Waste Permit GPS) / 100 (Federal GWPS)	MW-20S	137
		MW-20D	114

Based on the information evaluated during the NES, the inferred extent of the federal CCR Rule GWPS and Virginia Solid Waste Permit GPS exceeding lithium concentrations in groundwater were delineated around the two compliance monitoring wells, MW-20S and MW-20D. The lithium concentrations observed at MW-20S and MW-20D are thought to be related to a natural geological soil source. Concentrations of lithium have decreased relative to maximum concentrations detected in 2018 during the excavation of CCR materials from the East Pond. The observed decrease in lithium concentrations is believed to be associated with transient geochemical conditions in the aquifer due to Station completed site work, including source removal from the East Pond and conversion of the pond to a stormwater management system.

The inferred extent of the federal CCR Rule GWPS and Virginia Solid Waste Permit GPS exceeding molybdenum concentrations in groundwater were delineated around two compliance monitoring wells, MW-20S and MW-20D. While some of the molybdenum detected in groundwater at these wells may be related to a natural source, geochemical considerations indicate that there may be an additional source associated with the CCR material that was formerly in the East Pond or the CCR material that is currently in the North Pond. Overall, concentrations of molybdenum have decreased relative to maximum concentrations detected in 2018 during the excavation of CCR materials from the East Pond.

The inferred extent of the federal CCR Rule GWPS and Virginia Solid Waste Permit GPS exceeding cobalt concentrations generally extend along the southern berm of the East Pond from MW-20S to MW-22. The cobalt impacts among these wells appear localized along the berm within the near-surface aquifer. A natural vadose zone geological source combined with transient geochemical conditions resulting in the dissolution of iron oxyhydroxide minerals is likely contributing to cobalt concentrations in the vicinity of the East Pond. With the exception of MW-20S, wells with on-going cobalt federal CCR Rule GWPS and Virginia Solid Waste Permit GPS exceedances have reported decreases in cobalt concentrations since maximum concentrations were detected in 2018. The decreasing trends are expected to continue subsequent to the removal of the CCR materials from the

East Pond as geochemical conditions revert to conditions that are conducive for iron oxyhydroxide mineral formation resulting in the removal of dissolved cobalt from the groundwater via a sorption attenuation mechanism.

The inferred extent of Virginia Solid Waste Permit GPS exceeding boron concentrations extends along the southern berm of the East Pond from MW-19 to MW-22, with the highest concentrations centered on the MW-20S/MW-20D couplet. Boron impacts from the East Pond area appear to extend northward and may overlap with impacts associated with the North Pond. Although a natural geologic source may be contributing to concentrations of boron detected in groundwater at the East Pond, based on a geochemical evaluation and historical monitoring results from North Pond source area pumping wells, North Pond CCR material pore water and/or former East Pond CCR material pore water may have contributed to the relatively higher groundwater concentrations observed at MW-20S and MW-20D.

Assessment of the risk related to Virginia Solid Waste Permit GPS and federal CCR Rule GWPS exceedances in the vicinity of the East Pond identified potential non-cancer risk associated with current groundwater concentrations of cobalt, lithium, and molybdenum for either adults and children, or children only (molybdenum). However, access to the Station and downgradient (railroad) property is restricted to the public, and groundwater at the Station is not used as a potable water source. Because exposure pathways associated with groundwater are not complete at the East Pond, no actual unacceptable risk associated with Virginia Solid Waste Permit GPS and federal CCR Rule GWPS exceedances is present. It is noted that although boron concentrations in the vicinity of the East Pond exceed the Virginia Solid Waste Permit GPS of 250 µg/L, neither current nor historical concentrations of boron exceed the risk-based United States EPA RSL for boron in drinking water of 4,000 µg/L, which is based on the conservative default exposure scenario for drinking water consumption and exposure. The Station's Virginia Solid Waste Permit GPS for boron of 250 µg/L is not a risk-based concentration but is rather based on a laboratory quantitation limit (QL) concentration that is not reflective of actual risk.

Surface water samples collected from along the north shore of the James River (located 200 to 400 feet downgradient of East Pond and thought to be the point of exchange for groundwater flowing southwest across the Station) reported no detections of the constituents of concern (boron, cobalt, lithium, and molybdenum). These results indicate that impacted groundwater is not reaching surface water at concentrations that could pose a risk to human health or the environment.

4.0 REMEDIAL TECHNOLOGIES

In accordance with the Station's Solid Waste Permit, and the CCR Rule, the owner/operator of a CCR impoundment with federal CCR GWPS exceedances must complete an assessment of potential corrective measures that could be implemented to remediate impacted groundwater. The ACM must include an analysis of the effectiveness of potential corrective measures in meeting the requirements of §257.97 and 9VAC20-81-260.C.3 of the VSWMR, including performance, reliability, ease of implementation, potential remedy impacts, residual contamination controls, time required to initiate and complete the remedy, and the institutional controls that may be required that could impact the remedy implementation. The evaluation criteria in §257.97 and 9VAC20-81-260.C.3. are comprised of some 37 "evaluation elements" that Golder has grouped into seven "evaluation categories" as follows:

- Remedy Constructability
- Remedy Institutional Controls
- Remedy Performance
- Remedy Timeframes
- Remedy Concerns
- Remedy Operations and Maintenance
- Remedy Risks

The evaluation elements in each category are summarized in Table 4 (attached) along with the relevant CCR Rule citation. Within each category, the evaluation elements were assigned a mean probability of success. These mean values were assigned based on Golder's experience with similar remediation and construction activities and the following site-specific conditions, remedial option considerations, and regulatory requirements:

- Site Conceptual Model (Geology/Hydrogeology)
- CCR Impoundment Design
- Site Geometry
- Site Geographic Location
- Contaminant Risk (Human and Environmental)
- Source Removal Regulatory Requirement
- Aquifer Geochemistry
- Constituents of Concern (Contaminants)
- Contaminant Fate and Transport Considerations
- Treatment Technology Efficacy
- Site-Specific Data Gaps

To minimize bias for one remedial option versus another, the mean probability of success for each element was limited to one of four success probability options (20%, 40%, 60%, or 80%) with each option assigned a 15% standard deviation. In general, the higher the probability of success, the more likely the remedy is to satisfy the individual ACM evaluation criterion in the CCR Rule. Some of the ACM evaluation criteria are ranked in an inverse manner (*e.g.*, the potential need for remedy replacement: a lower probability for this element correlates with a higher probability of success) and the assigned probabilities for these criteria have been accounted for in the model. Similarly, timeframe criteria are evaluated in terms of years, with short timeframes generally considered more successful. The timeframes are translated in the model to probability of success using linear regression.

To account for expected bias in the extreme tails of the assigned probability, a beta distribution was assumed for each evaluation element (with exception of the Occupational Safety and Health Administration [OSHA] compliance criterion and the Virginia Standards compliance criterion, which were assigned a uniform distribution that assumed 100% compliance for every remedy). The beta distribution follows a normal distribution for a 50% rating with an increasingly positive skewness for mean success ratings that exceed 50% and an increasingly negative skewness for mean success ratings that are less than 50%. Table 4 summarizes the assigned success probabilities for the 37 ACM evaluation elements for each potential remedial option evaluated.

The ACM evaluation elements within each category were weighted evenly such that the maximum success probability for any one category was 80%, with the minimum being 20%. The ACM categories (collections of evaluation elements) were weighted based on Golder's interpreted significance as presented in the VSWMR, the CCR Rule, the CCR Rule Preamble, and our experience with working on similar solid waste remediation projects. The assigned category weightings used for this evaluation are presented in Table 5 following.

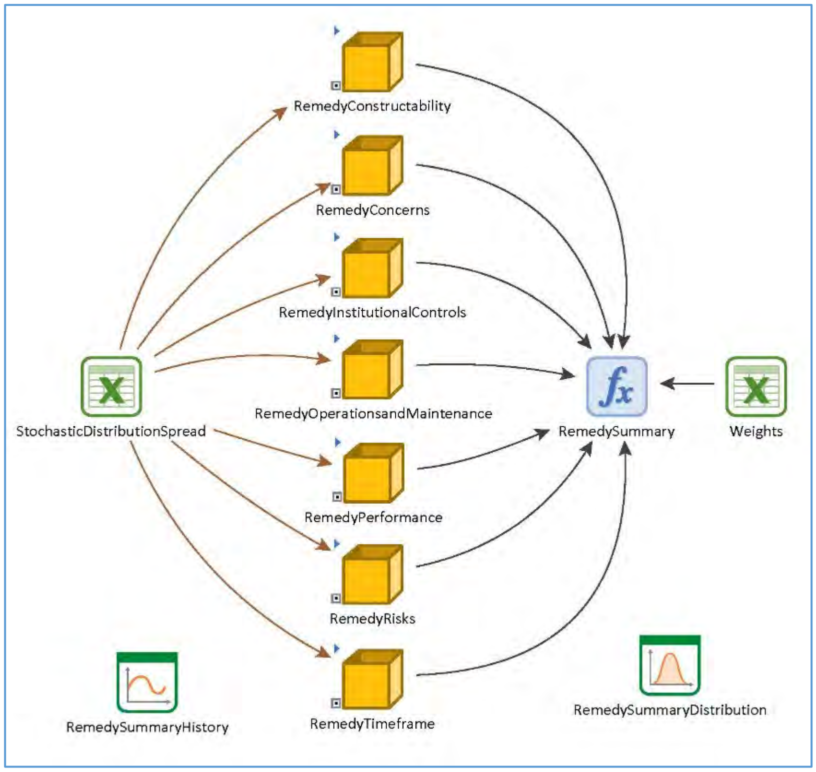
Table 5: Remedy Evaluation – Model Categories and Weights

Category	Weighting
Remedy Constructability	10%
Remedy Concerns	10%
Remedy Institutional Controls	5%
Remedy Operations and Maintenance	5%
Remedy Performance	20%
Remedy Risk	30%
Remedy Timeframe	20%
Sum of Weights:	**100%**

As presented in Table 5, the category weightings sum to 100%, such that a remedial option with a 80% probability of success in all seven categories would yield an average weighted overall probability of success score of 80%.

The assigned groupings, probabilities, distributions, and weightings for the ACM evaluation categories and evaluation elements were subsequently evaluated using an analytical model constructed within the commercially available GoldSim® Monte Carlo simulation software that is managed and maintained by the GoldSim Technology Group LLC.

After constructing the model (see inset illustration) and assigning the probabilities and distributions to the model elements within each category, the GoldSim® software was used to simulate the probability of success for each remedial option using 1,000 simulations over the expected remedial option-specific timeframe.



Golder believes the natural recovery of groundwater beneath and downgradient from the East Pond is influenced by the natural recovery of the groundwater beneath the North Pond. Based on this belief and in consideration of the existing groundwater impact extent from over 30 years of pond operation, it is expected that source removal from the East and North Ponds will significantly expedite the remediation of documented groundwater impacts. Therefore, this ACM considered the following remedial alternatives, with an on-site and off-site disposal option for the North Pond for each:

- Monitored Natural Attenuation/Natural Recovery (MNA) - Option 1
- In-Situ Aquifer Enhancement and MNA – Option 2
- Hydraulic Pumping Containment (East Pond External Pumping Wells) with Ex-Situ Water Treatment and MNA and North Pond Wastewater Treatment Plant - Option 3
- Funnel and Gate Ex-Situ Treatment and MNA and North Pond Wastewater Treatment Plant – Option 4

A summary of the remedial alternatives evaluated as part of the ACM is presented in the following sections. Details regarding the consideration of the 37 evaluation elements in the VSWMR and CCR rule for each potential remedy are presented in Table 4. As noted above, each of these alternatives assumes that the North Pond will be excavated, with either disposal of the ash at an off-site third-party permitted municipal solid waste or industrial facility, or disposal of the ash in a new Dominion-owned landfill to be sited, permitted, and constructed in the immediate vicinity of the Bremo Power Station.

4.1 Monitored Natural Attenuation/Natural Recovery (MNA)

Options 1 and 2 are comprised of excavation of the East (completed) and North Ponds (with on- or off-site disposal) followed by natural recovery of the groundwater system. Specifically, based on available data, Golder believes that natural hydrogeological processes based on diffusion, dispersion, sorption, dilution, and mineralization (potential carbonate mineralization) will attenuate the above federal CCR Rule GWPS and Virginia Solid Waste Permit GPS concentrations of boron, cobalt, lithium, and molybdenum being detected in East Pond compliance wells to concentrations that are less than the applicable standard within approximately 25 years following removal of the CCR materials (including the North Pond materials). Off-site disposal for the North Pond is expected to require 15 years to complete the CCR removal activities and on-site disposal for the North Pond is expected to require 12 years to complete the removal activities, including the front-loaded permitting timeframe.

Future studies prior to formal remedy selection may be necessary to validate natural recovery mechanisms and timeframes.

4.1.1 Method Description

Natural attenuation requires minimal resources and relies on physical processes such as diffusion, dispersion, sorption, and mineralization (potential carbonate and iron oxyhydroxide mineralization) to remediate contaminants in groundwater. To be the sole method of remediation, three tiers of evidence documenting bioremediation are typically required, as follows:

1. Historical groundwater data that demonstrate a clear and meaningful trend of decreasing contaminant mass and/or concentration over time at appropriate monitoring points.
2. Hydrogeologic and geochemical data that can be used to demonstrate indirectly the type of natural attenuation processes active at the site, and the rate at which such processes will reduce contaminant concentrations to required levels.
3. Data from field or microcosm studies, which directly demonstrate the occurrence of a particular natural attenuation process at the site and its ability to degrade the contaminants of concern.

MNA consists of monitoring natural attenuation processes (both biological and physical) and is a proven remedial alternative for sites where biological processes are documented and a more aggressive remedy is not required (*i.e.*, the impacts do not pose an immediate or substantial risk). The physical attenuation processes (dispersion, dilution, adsorption, vaporization, abiotic degradation, *etc*.) are important parts of MNA; however, it is only viable if the source of contamination has been removed or isolated allowing natural processes to remove the remaining, smaller concentrations of contaminants.

Under an MNA remedial alternative, a site is monitored at regular intervals to demonstrate that contaminants are attenuating at a rate sufficient to prevent potential exposures, and that the dissolved-phase contaminants are not migrating to a receptor. It may also include measurements of contaminant concentrations in soil, groundwater, or soil gas.

There is substantial guidance from the EPA concerning MNA, including the appropriateness of the remedy and cleanup levels. When restoration of groundwater is not practicable, EPA "expects to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction" (EPA, 1999). Cleanup levels appropriate for the expected beneficial use "should generally be attained throughout the contaminated plume, or at and beyond the edge of the waste management area when waste is left in place" (EPA, 1999). The objectives for a natural attenuation groundwater remedy include the following:

- Demonstrate that natural attenuation is occurring;
- Be protective of human health and the environment;
- Monitor natural attenuation and environmental impact; and
- Restore groundwater to below state and federal GPS/GWPS.

Acceptance of this option requires a conceptual model of the site, a quantification of attenuation, and establishment of a long-term monitoring program. A conceptual model was proposed in the NES (Golder, 2020). The model described the groundwater flow system and characterized and delineated the boron, cobalt, lithium, and molybdenum plumes.

The demonstration and documentation of measurable MNA processes are key in the application of minimizing risk. Typically, MNA programs indicate the status of the groundwater plume at different locations in the plume (stable, shrinking, or expanding), enable estimation of remediation rates, and warn of potential impact on sensitive receptors. Primary evidence of natural attenuation includes demonstration of a stable or shrinking plume, or a plume expanding more slowly than groundwater movement adjusted for retardation.

Downgradient wells, located within and parallel to the groundwater flow path, would be sampled periodically for measurable changes in contaminant concentrations. The monitoring frequency for MNA depends on the plume status, water table fluctuations and seasonal variability, groundwater velocity, and distance from the plume to a sensitive receptor.

4.1.2 Remedy Performance

MNA performance differs at every site and is dependent on-site conditions. Therefore, performance of MNA is typically determined by long-term monitoring for the COCs. Adsorption to sediments with negative charge sites (boron, cobalt, lithium, and molybdenum dioxide) or positive charge sites (borate and molybdate) and dilution are expected to be the most significant mechanisms that will influence the fate of COCs in water (Rai *et al*., 1986). It is possible that a steady state condition may not be confirmed within the first few years of the MNA process but with time sorption and dilution should be able to reduce contaminant concentrations to acceptable levels.

4.1.3 Remedy Reliability

MNA is a proven remedial alternative, which has been used at Resource Conservation and Recovery Act (RCRA), Underground Storage Tank (UST), Superfund, Voluntary Remediation Program (VRP), and Brownfield sites to treat both impacted groundwater and soils. MNA alone is adequate when there is no identified risk, or when proactive remediation is no more effective than MNA.

4.1.4 Remedy Implementation Ease

Implementation of MNA requires a Corrective Action Monitoring Program (CAMP). Per the OSWER Directive (EPA, April 1999), “Performance monitoring to evaluate remedy effectiveness and to ensure protection of human health and the environment is a critical element of all response actions.” The CAMP should be designed to accomplish the following:

- Demonstrate that natural attenuation is occurring;
- Detect changes in environmental conditions that may reduce the efficacy of any of the natural attenuation processes;
- Identify any potentially toxic and/or mobile transformation products;
- Verify that the plume(s) is not expanding;
- Verify no unacceptable impact to downgradient receptors;
- Detect new releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy;
- Demonstrate that institutional controls that were put in place to protect potential receptors are performing as desired; and

- Verify attainment of remediation objectives.

Dominion Energy would implement the CAMP program through a Corrective Action Plan (CAP) submitted to DEQ upon approval of the ACM.

4.1.5 Remedy Impacts

There are no major remediation related impacts expected with MNA. Specifically, MNA does not require any intrusive activities that could impact the unit and the COCs are attenuated via destruction, sorption, or precipitation within the uppermost aquifer beneath the unit. Minor operational impacts may include the generation of contaminated purge water, which would have to be disposed of appropriately. Potential safety impacts for commercial and industrial workers via contamination exposure would also be present on site.

4.1.6 Remedy Exposure Control

Dominion Energy has removed the CCR material from the East Pond, however, the CCR material has been consolidated into the North Pond. Porewater from the North Pond is believed to commingle with groundwater flowing beneath the pond, which then flows beneath the East Pond. Therefore, exposure to CCR materials (COCs) could occur during excavation of the North Pond. However, upon completion of excavation activities, no potential for future COC exposure under the MNA remedy is expected, with the exception of potential exposure during well installation and groundwater sampling activities. Provided site personnel are appropriately trained in the hazards of the COCs and that they use appropriate personal protection equipment (PPE) for onsite activities, the exposures to hazards associated with the MNA remedy can be minimized.

4.1.7 Remediation Time to Completion

Based on preliminary 1-dimensional analytical modeling Golder believes that natural hydrogeological processes based on diffusion, dispersion, sorption, dilution, and mineralization (potential carbonate mineralization) will attenuate the above federal CCR Rule GWPS and Virginia Solid Waste Permit GPS concentrations of boron, cobalt, lithium, and molybdenum to concentrations that are less than the applicable GWPS and GPS within approximately 20 to 30 years following removal of the CCR materials from the North Pond. Off-site disposal of the CCR materials is expected to require 15 years to complete and on-site disposal of the CCR materials is expected to require 12 years to complete, including the front-loaded permitting timeframe. Future studies prior to formal remedy selection may be necessary to validate natural recovery mechanisms and timeframes.

4.1.8 Remedy Institutional Requirements

No significant institutional requirements for implementation of the MNA remedy are required other than DEQ permitting of the remedial alternative, which will include incorporating a CAP as a permit amendment.

4.2 *In-Situ* Aquifer Enhancement and MNA

Options 2 and 3 are comprised of excavation of the East (completed) and North Ponds (with on- or off-site disposal) with concurrent *in-situ* aquifer enhancement treatment for the East Pond followed by natural recovery of the groundwater system. Golder believes the natural recovery of groundwater beneath and downgradient from the East Pond is influenced by the natural recovery of the groundwater beneath the North Pond, therefore the above federal CCR Rule GWPS and Virginia Solid Waste Permit GPS concentrations of boron, cobalt, lithium, and molybdenum being detected in East Pond compliance wells will likely not attenuate to concentrations that are less than the applicable standard until after the removal of the CCR materials (including the North Pond materials) is complete. Following removal of the CCR materials, attenuation to concentrations that are less than the applicable standard is expected to occur within approximately 20 years. Off-site disposal for the North Pond is expected to require 15 years to complete the CCR removal activities and on-site disposal for the North Pond is expected to require 12 years to complete the removal activities, including the front-loaded permitting timeframe. Future studies prior to formal remedy selection may be necessary to validate in-situ aquifer enhancement technologies, natural recovery mechanisms and timeframes.

4.2.1 Method Description

A variety of *in-situ* aquifer enhancement technologies exist; however, based on the site conceptual model nano-iron injection coupled with air sparging (oxygen injection) is currently the most viable option for the East Pond.

In-situ zero-valent iron nano-remediation is the application of reactive nano materials for transformation and removal of COCs in the water column in the aquifer with no groundwater removal required for *ex-situ* treatment (Otto *et al.*, 2008). The nanomaterials are injected into the aquifer via an injection well, and then the nanoparticles are transported via groundwater flow to the contamination. Upon contact, the nanoparticles can bind the COCs through redox reactions, immobilize them, or attenuate them to below the GPS/GWPS (Karn *et al.*, 2009).

Air sparging is an *in-situ* remediation technology used to enhance the rate of mass removal from a COC plume through injecting air into the saturated subsurface to treat contaminated soil and groundwater (USACE, 2013). Air sparging can be used as air stripping to remove volatile contaminants by partitioning them from the aqueous phase to the vapor phase for their transfer and removal from the unsaturated zone. Air sparging can also be used as biosparging to enhance aerobic microbial degradation of contaminants in the saturated zone. Air sparging is also used to immobilize contaminants through chemical changes as proposed in this situation. Aeration increases dissolved oxygen which causes an increase in oxidation-reduction potential which can immobilize unwanted inorganic compounds or heavy metals (Marley *et al.*, 1996).

Using a combination of nano-iron injection with air sparging, the goal will be to increase the amount of iron oxyhydroxide mineralization within the aquifer matrix, which is expected to result in a combination of co-precipitation of cationic metals and sorption of cationic metals. The increased oxidation reduction potential from the air sparging may also result in metal oxide formation for immobilization of the cationic metals. This chemical immobilization remedy is unlikely to significantly impact the boron concentrations due to its oxyanion form, however, dilution as part of the natural recovery aspect of the remedy will attenuate the boron concentrations which are well below risk-based concentrations.

4.2.2 Remedy Performance

Nano-remediation performance is dependent upon site-specific conditions, the COCs at the site, and the nanomaterials chosen for the application. The current three leading nanomaterials are nanoscale zero-valent iron (nZVI), bimetallic nanoscale particles (BNP), and emulsified zero-valent iron (EZVI) which all perform differently under different conditions. Nano-remediation has proven successful in reducing COC concentrations of volatile organice compounds (VOCs), semi-volatile organic compounds (SVOCs), and heavy metals; however, specific-site performance of the selected nanoparticle would require a pilot study (EPA, 2004) to confirm the efficacy of the remedial design.

Air sparging performance is also dependent upon site-specific conditions and has not been researched fully in the removal of contaminants other than volatile contaminants. A site-specific pilot study would be required for further performance details to determine the final design of the supplemental oxygen addition system for the nano-remediation system.

4.2.3 Remedy Reliability

Nano-remediation is a more recent remedy with many remediation projects using nanoparticles just beginning or are currently ongoing, therefore performance data is limited. Scheduled injections of the appropriate nanomaterial should remain reliable though.

Air sparging can raise the redox potential to immobilize or precipitate out heavy metals; however, this technique has not yet been known to have been applied in field studies (Miller, 1996). In this case, the air sparging is proposed as a supplemental oxygen delivery mechanism for the primary nano-remediation program and therefore, the creation of metal oxides for the COCs is not the primary goal, rather the creation of iron oxyhydroxide mineralization is the primary goal.

4.2.4 Remedy Implementation Ease

The *In-situ* aquifer enhancement remedy using a combination of air sparging and nano-remediation will require significant design and pilot testing activities including bench scale testing to verify the efficacy of the design prior to a pilot test and full system deployment. Additional permitting may also be required for the injection of nanoparticles into the aquifer.

4.2.5 Remedy Impacts

There are no major remediation related impacts expected with *in-situ* aquifer enhancement; however, the technology is more recent and potential risks are less understood than other remedies. Continued use of nanoparticles in environmental remediation could possibly lead to a release of the nanoparticles into the environment (Nowack, 2008). Minor operational impacts may include the generation of contaminated purge water and possible chemical handling associated with nanoparticle injection. Potential safety impacts for commercial and industrial workers via contamination exposure would also be present on site. Under the proposed alternative, zero-valent iron nanomaterials are not expected to present any significant health risks since immobilization via oxidation is expected to occur quickly upon injection into the aquifer matrix.

4.2.6 Remedy Exposure Control

Dominion Energy has removed the CCR material from the East Pond; however, the CCR material has been consolidated into the North Pond. Porewater from the North Pond is believed to commingle with groundwater flowing beneath the pond, which then flows beneath the East Pond. Therefore, exposure to CCR materials (COCs) could occur during excavation of the North Pond. However, upon completion of excavation activities, no potential for future COC exposure under the *in-situ* aquifer enhancement remedy is expected, with the exception of potential exposure during well installation and groundwater sampling activities. Provided site personnel are appropriately trained in the hazards of the COCs and that they use appropriate personal protection equipment (PPE) for onsite activities, the exposures to hazards associated with the remedy can be minimized.

4.2.7 Remediation Time to Completion

Based on preliminary 1-dimensional analytical modeling Golder believes that *in-situ* aquifer enhancement and MNA will attenuate the above federal CCR Rule GWPS and Virginia Solid Waste Permit GPS concentrations of boron, cobalt, lithium, and molybdenum to concentrations that are less than the applicable GWPS and GPS within approximately 20 to 30 years following removal of the CCR materials from the North Pond. Future studies prior to formal remedy selection may be necessary to validate in-situ aquifer enhancement technologies, natural recovery mechanisms and timeframes. Off-site disposal of the CCR materials is expected to require 15 years to complete and on-site disposal of the CCR materials is expected to require 12 years to complete, including the front-loaded permitting timeframe.

4.2.8 Remedy Institutional Requirements

Possible Underground Injection Control (UIC) permits may be required from the DEQ for the injection of the aquifer treatment remedy. Additionally, DEQ permitting of the remedial alternative will be required, which will include incorporating a CAP as a permit amendment.

4.3 Hydraulic Pumping Containment (East Pond External Pumping Wells) with Ex-Situ Water Treatment and MNA and North Pond Wastewater Treatment Plant

Options 4 and 5 are comprised of excavation of the East (completed) and North Ponds (with on- or off-site disposal) with concurrent hydraulic pumping through pumping wells with an *ex-situ* water treatment at the North Pond wastewater treatment plant followed by natural recovery of the groundwater system. Golder believes the natural recovery of groundwater beneath and downgradient from the East Pond is influenced by the natural recovery of the groundwater beneath the North Pond, therefore the above federal CCR Rule GWPS and Virginia Solid Waste Permit GPS concentrations of boron, cobalt, lithium, and molybdenum being detected in East Pond compliance wells are not likely attenuate to concentrations that are less than the applicable standard until the removal of the CCR materials is complete (including the North Pond materials). Following removal of the CCR materials, attenuation to concentrations that are less than the applicable standard is expected to occur within approximately 20 years. Off-site disposal for the North Pond is expected to require 15 years to complete the CCR removal activities and on-site disposal for the North Pond is expected to require 12 years to complete the removal activities, including the front-loaded permitting timeframe. During the North Pond CCR removal and natural recovery phase of the remedy, hydraulic containment of the COC-impacted groundwater using a series of dewatering wells/trenches installed along the downgradient boundary of the East Pond would be used to control downgradient impacts. Future studies prior to formal remedy selection may be necessary to validate the design of the proposed system.

4.3.1 Method Description

Pump and treat remedies have been used for decades at contaminated sites. Pump and treat remedies are used primarily for hydraulic containment to prevent the continued expansion of the plume and for treatment to reduce the contaminant concentrations in groundwater. Groundwater pump and treat systems combine a groundwater extraction system with a treatment system to remove contaminants from the subsurface and/or to control contaminant migration. The groundwater extraction system can consist of a well field, trenches, or a pumping system which are used to capture the contaminated water. Groundwater removed from the aquifer is treated for the COC and either re-injected on-site or discharged to a surface water body on-site assuring that the effluent meets the VPDES levels. Pump and treat remedies involve pumping contaminated groundwater to the surface for treatment.

Additional site characterization activities may need to be completed to determine the effectiveness of a pump and treat remedy (EPA, 1996). Suggested site characterization activities may include:

- Contaminant conditions: physical phases, quantification of distribution between phases, extent of contamination
- Aquifer and soil conditions: particle-size distribution, sorption characteristics, and hydraulic conductivity; and
- Pumping conditions: Volume of water to be withdrawn, treatment and handling of extracted groundwater.

Groundwater monitoring would still be required to demonstrate the effectiveness of the remedy. Downgradient wells, located within and parallel to the groundwater flow path, would be sampled periodically for measurable changes in contaminant concentrations. The monitoring frequency depends on the pumping rates, plume status, water table fluctuations and seasonal variability, groundwater velocity, and distance from the plume to a sensitive receptor.

4.3.2 Remedy Performance

Success of a pump and treat remedy is not only dependent upon source and groundwater plume removal but also upon the contaminants being treated. Cobalt, lithium, and molybdenum are relatively easier to treat than boron. As most boron minerals are soluble in water, it is unlikely that mineral equilibria will control the fate of boron in water (Rai *et al.*, 1986). Boron has not been found to be significantly removed during conventional wastewater treatment (Matthijs *et al.*, 1999; Pahl *et al.*, 2001; Waggott, 1969). Reverse osmosis is currently the leading treatment for the removal of boron. However, reverse osmosis is energy intensive and requires back flushing of the membrane which can generate concentrated brines that require management for disposal. It is possible that newer innovative technologies exist, but they will require bench scale and pilot studies; therefore, the pump and treat remedy is likely to be less successful than alternative remedies in remedy performance. However, the boron Virginia Solid Waste Permit GPS of 250 µg/L is not a risk-based GPS and could possibly be considered to be of less of an immediate treatment concern than cobalt, lithium, and molybdenum. Cobalt, lithium, and molybdenum could be treated with an anionic resins or aluminum oxide media, which removes ions from the aqueous phase by the exchange of cations between the COCs and the resin and the sorption to the aluminum oxide media. Resins will require backwash and will create a concentrated waste that will need to be managed and aluminum media require periodic replacement.

4.3.3 Remedy Reliability

Pump and treat remedies are one of the most widely used groundwater remediation techniques with about three quarters of Superfund sites and most sites where cleanup is required by RCRA using the remedy (NRC, 1994). When a pump and treat system is online, the reliability is high with the COC plume stabilizing or shrinking after the removal of the source. These remedies require substantial operation and maintenance, and therefore the reliability of the remedy is not as high as other alternative remedies.

4.3.4 Remedy Implementation Ease

Pump and treat remedies are not as simple to implement as other alternative remedies due to design, installation of wells, pumps, and piping. The construction of a specialized on-site water treatment plant may also be required due to the COCs if the North Pond Wastewater Treatment Plant cannot treat the COCs. This evaluation assumes that the treatment system being designed for the dewatering of the North Pond CCR material has sufficient capacity and design elements to remove the COCs from the wastewater stream to concentrations that are acceptable for discharge to the environment.

4.3.5 Remedy Impacts

Other than the management of treated water and possible backflush water from a reverse osmosis system, there are no major remediation related impacts expected with a pump and treat remedy. Minor impacts would include the generation of contaminated purge water and possible chemical handling or cleaning associated with the water treatment plant. There are possible safety impacts during the construction phase of the pump and treat remedy associated with the installation of wells, pumps, piping, and the construction of an on-site water treatment plant.

4.3.6 Remedy Exposure Control

Dominion Energy has removed the CCR material from the East Pond, however, the CCR material has been consolidated into the North Pond. Porewater from the North Pond is believed to commingle with groundwater flowing beneath the pond, which then flows beneath the East Pond. Therefore, exposure to CCR materials (COCs) could occur during excavation of the North Pond. However, upon completion of excavation activities, no significant potential for future COC exposure is expected. There is a greater risk of potential exposure compared to alternative remedies due to the continual pumping of groundwater during the period of treatment, as well as during construction activities, well installation, and groundwater sampling activities. Provided site personnel are appropriately trained in the hazards of the COCs and that they use appropriate PPE for onsite activities, the exposures to hazards associated with the remedy can be minimized.

4.3.7 Remediation Time to Completion

Based on preliminary 1-dimensional analytical modeling Golder believes that hydraulic containment with *ex-situ* treatment of captured groundwater and natural recovery of the groundwater following removal of the North Pond CCR material will attenuate the above federal CCR Rule GWPS and Virginia Solid Waste Permit GPS concentrations of boron, cobalt, lithium, and molybdenum to concentrations that are less than the applicable GWPS and GPS within approximately 20 to 30 years. Off-site disposal of the CCR materials is expected to require 15 years to complete and on-site disposal of the CCR materials is expected to require 12 years to complete, including the front-loaded permitting timeframe.

4.3.8 Remedy Institutional Requirements

Construction permits will likely be required for the construction of the treatment plant, as well as possible UIC and/or VPDES permits for the re-injection (if used) of treated water, or the surface discharge of treated water depending on the final design of the system. Additionally, DEQ permitting of the remedial alternative will be required, which will include incorporating a CAP as a permit amendment.

4.4 Funnel and Gate Ex-Situ Treatment and MNA and North Pond Wastewater Treatment Plant

Options 6 and 7 are comprised of excavation of the East (completed) and North Ponds (with on- or off-site disposal) with concurrent funnel and gate *ex-situ* treatment for the East Pond followed by natural recovery of the groundwater system. Golder believes the natural recovery of groundwater beneath and downgradient from the East Pond is influenced by the natural recovery of the groundwater beneath the North Pond, therefore the above federal CCR Rule GWPS and Virginia Solid Waste Permit GPS concentrations of boron, cobalt, lithium, and molybdenum being detected in East Pond compliance wells will likely not attenuate to concentrations that are less than the applicable standard until the removal of the CCR materials (including the North Pond materials). Following removal of the CCR materials, attenuation to concentrations that are less than the applicable standard will likely occur within approximately 20 years. Off-site disposal for the North Pond is expected to require

15 years to complete the CCR removal activities and on-site disposal for the North Pond is expected to require 12 years to complete the removal activities, including the front-loaded permitting timeframe. Future studies prior to formal remedy selection may be necessary to validate the remedy design, the natural recovery mechanisms, and the remedial timeframes.

4.4.1 Method Description

Funnel and gate systems are a passive remediation technology which uses vertical barriers (the funnel) to modify flow patterns so that groundwater flows primarily through the higher conductivity gaps (the gates). The barriers are typically walls constructed using deep trenching equipment that mix a bentonite/cement slurry to create an impermeable wall. When possible, the walls are keyed into the low-permeability soil or bedrock located at the bottom of the aquifer to control seepage under the wall. The gate typically contains a reactive substance to treat the contaminated groundwater. Due to groundwater flow in bedrock at the site, a completely stable funnel and gate system is not feasible and pumping around the East Pond would still be required in conjunction with *ex-situ* treatment of the extracted groundwater.

4.4.2 Remedy Performance

Remedy performance is dependent upon the COCs, the treatment chosen for the gate, and the treatment chosen for the wastewater treatment plant. As discussed in section 4.3 above, boron is a difficult constituent to remove from the contaminated groundwater; however, cobalt, lithium, and molybdenum could be treated with an anionic resin or other readily accessible and proven technologies including activated carbon and reverse osmosis.

4.4.3 Remedy Reliability

If funnel and gate systems are constructed correctly (*i.e.* keyed into a low conductivity unit), with enough residence time in the reactive portion of the wall and a correct reactive substance to treat the contaminated groundwater, then funnel and gate systems are relatively reliable and stable. For the East Pond, with the groundwater flow also in bedrock, it is difficult to reliably control the groundwater flow path without creating a pumping low pressure to induce the upward flow of groundwater. With sufficient site characterization activities to identify the preferential flow pathways in the lower fractured bedrock, a combination of funnel and gate technology with limited pumping can be an effective remediation approach.

4.4.4 Remedy Implementation Ease

Funnel and gate systems require detailed knowledge of the groundwater flow path for construction. In addition to construction of the barriers and *in-situ* treatment this remedy also requires the design, installation of wells, pumps, and piping for *ex-situ* treatment of extracted groundwater. The construction of a specialized on-site water treatment plant may also be required due to the COCs if the North Pond Wastewater Treatment Plant cannot treat the COCs.

4.4.5 Remedy Impacts

Other than management of treated water and potential back-flush wastewater from a reverse osmosis system, there are no major remediation related impacts expected with a funnel and gate system coupled with pump and treat technology. Minor impacts would include the generation of contaminated purge water and possible chemical handling or cleaning associated with the water treatment plant. There are possible safety impacts during the construction phase of the funnel and gate system and the pump and treat remedy associated with the installation of wells, pumps, piping and the construction of an on-site water treatment plant.

4.4.6 Remedy Exposure Control

Dominion Energy has removed the CCR material from the East Pond; however, the CCR material has been consolidated into the North Pond. Porewater from the North Pond is believed to commingle with groundwater flowing beneath the pond, which then flows beneath the East Pond. Therefore, exposure to CCR materials (COCs) could occur during excavation of the North Pond. However, upon completion of excavation activities, no potential for future COC exposure is expected. There is a greater risk of potential exposure compared to alternative remedies due to the continual pumping of groundwater during the period of treatment, as well as during construction activities, funnel and gate installation, well installation, and groundwater sampling activities. Provided site personnel are appropriately trained in the hazards of the COCs and that they use appropriate PPE for onsite activities, the exposures to hazards associated with the remedy can be minimized.

4.4.7 Remediation Time to Completion

Based on preliminary 1-dimensional analytical modeling Golder believes that the funnel and gate with *ex-situ* treatment will attenuate the above federal CCR Rule GWPS and Virginia Solid Waste Permit GPS concentrations of boron, cobalt, lithium, and molybdenum to concentrations that are less than the applicable GWPS and GPS within approximately 20 to 30 years following removal of the CCR materials from the North Pond. Off-site disposal of the CCR materials is expected to require 15 years to complete and on-site disposal of the CCR materials is expected to require 12 years to complete, including the front-loaded permitting timeframe.

4.4.8 Remedy Institutional Requirements

Construction permits will be required for the construction of the funnel and gate system and of the treatment plant, as well as possible UIC or VPDES permits for the re-injection (if used) of treated water or the discharge of treated water to the surface. Additionally, DEQ permitting of the remedial alternative will be required, which will include incorporating a CAP as a permit amendment.

5.0 COST ESTIMATES

In accordance with 9VAC20-81-260.C.3.a(3) of the VSWMR an assessment of the costs of remedy implementation was completed. These costs are important for viability assessment and planning purposes. As with the ACM evaluation criteria, Golder developed probabilistic cost estimates (AACE International [formerly the Association for Advancement of Cost Engineering] Class IV type – study/feasibility level) for each viable remedial option over the remedy's expected remedial timeframe. These costs estimates include costs associated with the design and permitting, construction, operations, post-construction monitoring, and termination of the remedy once the remedial action goals are achieved. The cost estimates for the hauling efforts associated with the excavation of the East and North Ponds was not included as this activity is a regulatory required activity regardless of the selected groundwater remedy. The probabilistic costs estimates were then evaluated using 1,000 simulations of the remedy-specific analytical cost model with the GoldSim® software to generate probabilistic ranges for the remedy costs. The evaluations indicated that the upper 95% probable future value costs for the alternatives considered, based on an average inflation rate of 2.5% over the estimated remedial timeframe could range from $15 million USD for Option 2 to $800 million USD for Option 7.

Using the estimated costs for remediation, the alternatives from the probability-of-success evaluation were normalized for costs to generate a relative method for comparing the cost-benefit of the remedial options. The evaluation was completed by dividing the upper 95% probability of success for each remedial option by the mean cost estimate (in $100's of million USD) for the remedy. The relative cost-benefit factor was then normalized by dividing each option by the highest percentage. Table 6 below summarizes estimated remedial timeframes, mean probabilities of success, future remedy costs, and the relative cost-benefit factor for each remedial option. The evaluation indicates that the highest cost-benefit is obtained with Option 2.

Table 6: Summary of Cost Evaluation

Remedial Option		Estimated Remedial Timeframe (years)	Upper 95% Probability of Success Score (%)	Mean Future Value Remedy Cost (100,000,000's USD)	Normalized Relative Cost -Benefit Factor
1	Excavation with off-site disposal and Monitored Natural Attenuation (MNA)	40	72.9%	$0.14	89%
2	Excavation with on-site disposal and MNA	37	71.0%	$0.12	100%
3	Excavation with off-site Disposal and *In-Situ* Aquifer Enhancement and MNA	40	68.4%	$3.15	4%
4	Excavation with on-site Disposal and *In-Situ* Aquifer Enhancement and MNA	37	67.1%	$2.56	5%

Remedial Option		Estimated Remedial Timeframe (years)	Upper 95% Probability of Success Score (%)	Mean Future Value Remedy Cost (100,000,000's USD)	Normalized Relative Cost -Benefit Factor
5	Excavation with off-site Disposal and Hydraulic Pumping Containment (EP External Pumping Wells) with *Ex-Situ* Water Treatment, MNA, and North Pond Wastewater Treatment Plant (NP WWTP)	40	67.0%	$3.52	3%
6	Excavation with on-site Disposal and Hydraulic Pumping Containment (EP External Pumping Wells) with *Ex-Situ* Water Treatment, MNA, and NP WWTP	37	67.6%	$2.92	4%
7	Excavation with off-site Disposal and Funnel and Gate *Ex-Situ* Treatment, MNA, and NP WWTP	40	66.0%	$6.62	2%
8	Excavation with on-Site Disposal and Funnel and Gate *Ex-Situ* Treatment, MNA, and NP WWTP	37	66.6%	$5.43	2%

6.0 PUBLIC COMMENTS

Consistent with VSWMR 9VAC20-81-260.C.1.e a public meeting must be held to discuss the results of the ACM process prior to the final selection of the remedy. Due to the coronavirus pandemic a public meeting is not feasible at this time. A public meeting and comment period will be scheduled for a future date when it is reasonable to do so.

7.0 LIMITATIONS

The assessment and evaluation activities presented here were performed based on limited data, the impacts of which could have a substantial bearing on the evaluation outcomes presented herein. These limitations include the following assumptions and data gaps:

- Limited understanding of the hydraulic properties of the saprolite and underlying bedrock due to known heterogeneous rock composition, geometry, and differential weathering;
- Limited understanding of the depth to competent bedrock in the vicinity of the East Pond;
- Limited understanding of the nature and extent of the existing groundwater plume that will remain following ash removal;
- Current groundwater monitoring data from existing site monitoring wells accurately reflects the nature and extent of GPS/GWPS exceedances on the study area;
- Normal and expected construction costs for routine construction activities have been assumed for the cost estimates;
- High level estimates of non-routine specialty construction costs; and
- Source removal over a 15-year or less timeframe.

8.0 CONCLUSIONS

Consistent with 9VAC20-81-260 of the VSWMR, the CCR Rule, and based on the results presented in the *NES* (Golder, 2020), Golder identified potential remedial options to address the state and federal GPS/GWPS exceedances for boron, cobalt, lithium, and molybdenum in the vicinity of the East Pond. Each of these alternatives assumes that the North Pond (located upgradient from the previously excavated East Pond) will be excavated, with either disposal of the ash at an off-site third-party permitted municipal solid waste or industrial facility, or disposal of the ash in a new Dominion-owned landfill to be sited, permitted, and constructed in the immediate vicinity of the Bremo Power Station, consistent with closure by removal requirements.

Using a robust analytical model Golder evaluated the remedial options against 9VAC20-81-260 and the CCR Rule to develop a probabilistic ranking of remedial options. Additionally, Golder developed probabilistic cost estimates for each of the remedial options over the remedy's expected remedial timeframe. These cost estimates include costs associated with design and permitting, construction, operations, post-construction monitoring, and termination of the remedy once the remedial action goals are achieved.

The success probabilities for each remedial option considered were normalized with the remedy-specific mean costs estimate to provide an overall scaled relative efficacy/cost evaluation of the remedial options. These evaluations suggest that excavation with on-site disposal followed by 25 years of natural recovery monitoring would prove to be the most effective remedy option under the CCR Rule ACM evaluation criteria for mitigating the currently observed groundwater impacts. Future studies prior to formal remedy selection may be necessary to validate natural recovery mechanisms and timeframes.

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10.0 SIGNATURE SECTION

This document was prepared by qualified groundwater scientists and engineers who have received baccalaureate and/or post-graduate degrees in the natural sciences or engineering and who have sufficient training and experience in groundwater hydrology, engineering, and related fields as demonstrated by state professional registrations and completion of an accredited university program that enables sound professional judgments consistent with the industry standard of care for groundwater monitoring, contaminant fate and transport, environmental corrective actions, and cost estimate development.

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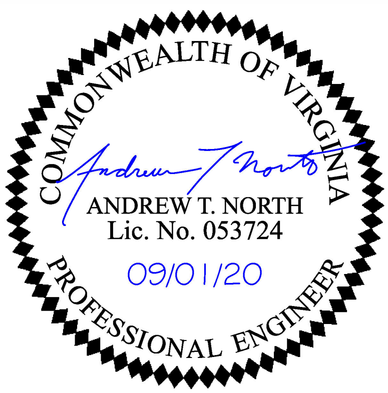

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TABLES

Table 4
Assessment of Corrective Measures Evaluation Criteria
Bremo Power Station, Solid Waste Permit No. 618
East Pond

Class		Remedy Performance									Remedy Constructability (Ease of Implementation)				Remedy Concerns			
GoldSim Model Element		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Regulatory Citation (VSWMR)		9VAC20-81-260.D.1.a(1)	9VAC20-81-260.C.3.a(1)	9VAC20-81-260.D.1.a(2b)	9VAC20-81-260.D.1.a(1)	9VAC20-81-260.C.3.c(1b)	9VAC20-81-260.D.1.a(2); 9VAC20-81-260.D.1.a(2a); 9VAC20-81-260.C.3.c(1c)	--	9VAC20-81-260.C.3.a(4); 9VAC20-81-260.D.1.a(3c)	9VAC20-81-260.D.1.a(1h)	9VAC20-81-260.D.1.a(3a)	9VAC20-81-260.D.1.a(3b)	9VAC20-81-260.D.1.a(3d)	9VAC20-81-260.D.1.a(3e)	9VAC20-81-260.C.3.a(1)	9VAC20-81-260.C.3.a(1)	9VAC20-81-260.C.3.a(1)	9VAC20-81-260.D.1.a(6)
Regulatory Citation (CCR)		§257.96(c)(1); §257.97(c)(1); §257.97(c)(2)(i)	§257.96(c)(1); §257.97(c)(1); §257.97(c)(1)(vii); §257.97(c)(3)(ii)	§257.97(c)(2)(ii)	§257.96(c)(1)	§257.97(b)(2)	§257.96(c)(1); §257.97(b)(3)	§257.96(c)(1); §257.97(b)(4)	§257.97(c)(1)(ii)	§257.96(c)(1); §257.97(c)(1)(viii)	§257.96(c)(1)	§257.97(c)(3)(i)	§257.97(c)(3)(iv)	§257.97(c)(3)(v)	§257.96(c)(1)	§257.96(c)(1)	§257.96(c)(1)	§257.97(c)(4)
Percent Success		0% = minimal; 100% = substantial longterm effectiveness	0% = minimal; 100% = substantial longterm reliability	0% = lot of tech use; 100% = no tech use	0% = minimal; 100% = substantial shortterm effectiveness	0% = low; 100% = high ability to obtain GPS at POC	0% = minimal reduction; 100% = elimination of further releases	0% = minimal recovery; 100% = full recovery, or none required	0% = low potential for preventing; 100% = high potential for preventing future	0% = high remedy replacement potential; 100% = low remedy replacement potential	0% = hard to build; 100% = easy to build	0% = not available; 100% = available	0% = not available; 100% = available	0% = not available; 100% = available	0% = high potential safety impact; 100% = low safety impacts	0% = high cross media impact; 100% = low cross media impacts	0% = no residual contamination control; 100% = control	0% = does not address; 100% = addresses all concerns
Criteria		Long-Term Effectiveness of Remedy (%)	Long-Term Reliability of Remedy (%)	Treatment Tech Use Extent (%)	Short-Term Effectiveness (%)	Ability to Obtain the GPS at Point of Compliance (%)	Source Control to Reduce or Eliminate Further Releases (%)	Fugitive Material Recovery (%)	Potential for Future Material Releases (%)	Potential Need for Remedy Replacement (%)	Constructability (%)	Technology Availability/ Reliability (%)	Resource & Knowledge Availability (%)	Available Treatment, Storage, and Disposal Resources (%)	Potential Safety Impacts (%)	Potential Cross-Media Impacts (%)	Residual Contamination Exposure Control (%)	Community Concerns (%)
Option 1: Excavation with Off-Site Disposal and Monitored Natural Attenuation (MNA)	Mean	60	60	80	20	60	80	80	80	20	80	80	80	60	60	60	60	60
	Assignment Notes (Relative evaluation across crierion)	Source removal coupled with limited sorption and dilution. Considering current groundwater impacts, sould be effective in controlling the release	Source removal, Natural Recovery based on sorption and dilution for COCs	No tech required, just physical controls, sorption, and dilution	May require up to 15 years for complete source removal and full remedy effectiveness	With time, soprtion and dilution will attain goal	Source removal coupled with gradient reduction and Natural Recovery for contaminated water.	Fugitive materials recovered under parallel program	Source Removal over 15 years	May not be sufficent as a stand alone remedy to prevent off-site impacts above risk-based concentrations due to property line proximity	normal exercise of excavation	relatively available for this scale and type of work	experience gained every day by active providers	Need space in existing Municipal Solid Waste or Industrial Landfill or new Industrial landfill	heavy equipment, source removal via over the road or rail traffic	Potential exist, 15-year removal effort, contaminated groundwater could discharge to surface water. Contaminated groundwater flux reduces after source removal.	Source removal, contaminated groundwater. Potential for exposure at groundwater-surface water interface.	Source removal to off-site location, no active groundwater treatment
Option 2: Excavation with On-Site Disposal and MNA	Mean	60	60	80	20	60	80	80	80	20	80	80	80	60	80	60	60	40
	Assignment Notes (Relative evaluation across crierion)	Source removal coupled with limited sorption and dilution. Considering current groundwater impacts, sould be effective in controlling the release	Source removal, Natural Recovery based on sorption and dilution for COCs	No tech required, just physical controls, sorption, and dilution	May require up to 12 years for complete source removal and full remedy effectiveness	With time, soprtion and dilution will attain goal	Source removal coupled with gradient reduction and Natural Recovery for contaminated water.	Fugitive materials recovered under parallel program	Source Removal over 12 years	May not be sufficent as a stand alone remedy to prevent off-site impacts above risk-based concentrations due to property line proximity	normal exercise of excavation	relatively available for this scale and type of work	experience gained every day by active providers	Need space in existing Municipal Solid Waste or Industrial Landfill or new Industrial landfill	heavy equipment, source removal via on-site haul roads	Potential exist, 12-year removal effort, contaminated groundwater could discharge to surface water. Contaminated groundwater flux reduces after source removal.	Source removal, contaminated groundwater. Potential for exposure at groundwater-surface water interface.	Source removal to an on-site location, no active groundwater treatment
Option 3: Excavation with Off-Site Disposal and In-Situ Aquifer Enhancement and MNA	Mean	60	60	20	40	60	80	80	80	40	40	60	60	60	40	60	60	60
	Assignment Notes (Relative evaluation across crierion)	At least as effective as removal with MNA only, no effective injectants identified for COCs	At least as effective as source removal and MNA alone; no appropriate media/injectate identified to treat COC suite, so the system as a whole is not reliable for treatment	Technology intensive remedy on top of source removal and MNA	May require up to 15 years for complete source removal and full remedy effectiveness. Short term effectiveness could be enhanced with appropriate injectant, nano-carbon or other immoblizing agents	At least equal to MNA alone	Source removal coupled with gradient reduction and MNA for contaminated water.	Fugitive materials recovered under parallel program	Source Removal over 15 years	May not be sufficent with MNA to prevent off-site impacts above risk-based concentrations due to property line proximity	technology exists; proven; somewhat complex due to varying geology, need to find the right injectant and delivery method	injection-type providers available	some in situ work for metals done	Need space in existing MSW or Industrial Landfill or new Industrial landfill	heavy equipment, source removal via over the road or rail traffic, injection safety	Potential exist, 15-year removal effort, contaminated groundwater could discharge to surface water	Source removal, contaminated groundwater. Potential for exposure at groundwater-surface water interface.	Source removal to off-site location with treatment
Option 4: Excavation with On-Site Disposal and In-Situ Aquifer Enhancement and MNA	Mean	60	60	20	40	60	80	80	80	40	40	60	60	60	60	60	60	60
	Assignment Notes (Relative evaluation across crierion)	At least as effective as removal with MNA only, no effective injectants identified for COCs	At least as effective as source removal and MNA alone; no appropriate media/injectate identified to treat COC suite, so the system as a whole is not reliable for treatment	Technology intensive remedy on top of source removal and MNA	May require up to 12 years for complete source removal and full remedy effectiveness. Short term effectiveness could be enhaced with appropriate injectant, nano-carbon or other immoblizing agents	At least equal to MNA alone	Source removal coupled with gradient reduction and MNA for contaminated water.	Fugitive materials recovered under parallel program	Source Removal over 12 years	May not be sufficent with MNA to prevent off-site impacts above risk-based concentrations due to property line proximity	technology exists; proven; somewhat complex due to varying geology, need to find the right injectant and delivery method	injection-type providers available	some in situ work for metals done	Need space in existing MSW or Industrial Landfill or new Industrial landfill	heavy equipment, source removal via over the road or rail traffic	Potential exist, 12-year removal effort, contaminated groundwater could discharge to surface water	Source removal, contaminated groundwater. Potential for exposure at groundwater-surface water interface.	Source removal to off-site location with treatment

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Assessment of Corrective Measures Evaluation Criteria
Bremo Power Station, Solid Waste Permit No. 618
East Pond

Class		Remedy Institutional Controls							Remedy Risks						Remedy Operations and Maintenance			
GoldSim Model Element		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Regulatory Citation (VSWMR)		9VAC20-81-260.C.3.a(4); 9VAC20-81-260.D.1.a(3c)	9VAC20-81-260.C.3.a(4); 9VAC20-81-260.D.1.a(3c)	9VAC20-81-260.C.3.a(4); 9VAC20-81-260.D.1.a(3c)	9VAC20-81-260.D.1.a(5b)	9VAC20-81-260.C.3.c(1d)	--	9VAC20-81-260.D.1.a(1g)	9VAC20-81-260.D.1.a(1d); 9VAC20-81-260.D.1.a(1f)	--	9VAC20-81-260.D.1.a(1); 9VAC20-81-260.D.1.a(5a); 9VAC20-81-260.D.1.a(1f); 9VAC20-81-260.C.3.c(1a)	9VAC20-81-260.D.1.a(1); 9VAC20-81-260.D.1.a(5a); 9VAC20-81-260.D.1.a(1f); 9VAC20-81-260.C.3.c(1a)	9VAC20-81-260.D.1.a(1a) 9VAC20-81-260.D.1.a(2c)	9VAC20-81-260.D.1.a(1b)	9VAC20-81-260.D.1.a(1c)	9VAC20-81-260.D.1.a(1c)	9VAC20-81-260.D.1.a(1c)	9VAC20-81-260.D.1.a(1c)
Regulatory Citation (CCR)		§257.96(c)(3); §257.97(c)(3)(iii)	§257.96(c)(3); §257.97(c)(3)(iii)	§257.96(c)(3); §257.97(c)(3)(iii)	§257.97(a)	§257.97(b)(5)	§257.96(c)(3); §257.97(c)(3)(iii)	§257.96(c)(1); §257.97(c)(1)(vii)	§257.97(c)(1)(iv)	§257.97(c)(1)(iv)	§257.97(b)(1); §257.97(c)(1)(vi)	§257.97(b)(1); §257.97(c)(1)(vi)	§257.97(c)(1)(i)	§257.97(c)(1)(ii)	§257.97(c)(1)(iii)	§257.97(c)(1)(iii)	§257.97(c)(1)(iii)	§257.97(c)(1)(iii)
Percent Success		0% = Hard to get Fed Permit Required; 100% = No Fed Permit Required	0% = Hard to get State Permit Required; 100% = No State Permit Required	0% = Hard to get Local Permit Required; 100% = No Local Permit Required	0% = Out of Compliance; 100% = in compliance	0% = not in compliance; 100% = always in compliance	0% = Deed Restriction Required; 100% = Not Required	0% = Not reliable; 100% = always reliable	0% = significant community risks; 100% = no community risk	0% = significant Eco risks; 100% = no Eco risk	0% = less protective; 100% = most protective	0% = less protective; 100% = most protective	0% = little to no risk reduction; 100% = major risk reduction	0% = little to no risk reduction; 100% = major risk reduction	0% = High Management; 100% = Low Management	0% = High Monitoring; 100% = Low Monitoring	0% = High Operational; 100% = Low Operational	0% = High Maintenance; 100% = Low Maintenance
Criteria		Federal Permit Need (%)	State Permit Need (%)	Local Permit Need (%)	Compliance With OSHA, Federal, and Virginia Standards - 100% Compliance Assumed (%)	Waste Management Compliance (%)	Deed Restrictions (%)	Long Term Reliability of Controls (%)	Community Implementation Risks (transporation & disposal) (%)	Ecological Implementation Risks	Remedy Human Health Protectiveness & Waste Exposure	Remedy Environment Protectiveness & Waste Exposure	Magnitude of Existing Health Risk Reduction	Magnitude of Residual Risk for Further Releases	Relative Management Requirement (%)	Relative Monitoring Requirement (%)	Relative Operational Requirements (%)	Relative Maintenance Requirements (%)
Option 1: Excavation with Off-Site Disposal and Monitored Natural Attenuation (MNA)	Mean	80	40	80	100	80	80	80	40	80	60	60	80	80	60	60	80	80
	Assignment Notes (Relative evaluation across crierion)	None	Solid Waste permit for closure via removal	no local permit known	In compliance	low risk for out of compliance conditions	Waste Removed, no deed restriction required for waste.	Once constructed, at steady state Natural Recovery is reliable after source removal	Significant over the road or rail transport for construction of remedy	low risk	With source removal steady state remedy is protective provided no media transfer to surface water	With source removal steady state remedy is protective provided no media transfer to surface water	With source removal should ultimately achieve GPS, health risk reduction is goal	Source removal	Intensive management during construction, passive management after construction	High level of monitoring during construction and moderate level of monitoring after construction is complete	High during construction, low after construction	Minimal after construction is complete
Option 2: Excavation with On-Site Disposal and MNA	Mean	60	20	40	100	80	80	80	60	40	60	60	80	80	60	60	80	80
	Assignment Notes (Relative evaluation across crierion)	May require 404 Wetland permitting	Solid Waste permit for closure via removal and may require 401 wetland permitting; Solid Waste Permit for new landfill	Conditional Use Permit may be required	In compliance	low risk for out of compliance conditions	Waste Removed, no deed restriction required for waste.	Once constructed, at steady state Natural Recovery is reliable after source removal	Assumes little to no public transportation corridor transport	Will likely result in wetland impacts	With source removal steady state remedy is protective provided no media transfer to surface water	With source removal steady state remedy is protective provided no media transfer to surface water	With source removal should ultimately achieve GPS, health risk reduction is goal	Source removal	Intensive management during construction, passive management after construction	High level of monitoring during construction and moderate level of monitoring after construction is complete	High during construction, low after construction	Minimal after construction is complete
Option 3: Excavation with Off-Site Disposal and In-Situ Aquifer Enhancement and MNA	Mean	40	40	80	100	80	80	80	40	80	60	60	80	80	20	40	40	40
	Assignment Notes (Relative evaluation across crierion)	May require a Federal Underground Injection Control permit	Solid Waste permit for closure via removal	no local permit known	In compliance	low risk for out of compliance conditions	Waste Removed, no deed restriction required for waste.	Reliability of injectant for imobilizing COCs is unclear. At least as reliable as MNA alone	Significant over the road or rail transport for construction of remedy	Low risk	With source removal steady state remedy is protective provided no media transfer to surface water	With source removal steady state remedy is protective provided no media transfer to surface water	With source removal should ultimately achieve GPS, health risk reduction is goal	Source removal	Intensive management during construction, moderate active management after construction	High level of monitoring during construction and moderate level of monitoring after construction is complete	High during construction, moderate if passive enplacement option selected	Minimal after construction is complete, may require follow-up enhancement applications to the aquifer system
Option 4: Excavation with On-Site Disposal and In-Situ Aquifer Enhancement and MNA	Mean	40	20	40	100	80	80	80	60	40	60	60	80	80	20	40	40	40
	Assignment Notes (Relative evaluation across crierion)	May require a Federal Underground Injection Control permit	Solid Waste permit for closure via removal and may require 401 wetland permitting; Solid Waste Permit for new landfill	Conditional Use Permit may be required	In compliance	low risk for out of compliance conditions	Waste Removed, no deed restriction required for waste.	Reliability of injectant for imobilizing COCs is unclear. At least as reliable as MNA alone	Significant over the road or rail transport for construction of remedy	Will likely result in wetland impacts	With source removal steady state remedy is protective provided no media transfer to surface water	With source removal steady state remedy is protective provided no media transfer to surface water	With source removal should ultimately achieve GPS, health risk reduction is goal	Source removal	Intensive management during construction, moderate active management after construction	High level of monitoring during construction and moderate level of monitoring after construction is complete	High during construction, moderate if passive enplacement option selected	Minimal after construction is complete, may require follow-up enhancement applications to the aquifer system

Table 4
Assessment of Corrective Measures Evaluation Criteria
Bremo Power Station, Solid Waste Permit No. 618
East Pond

Class		Remedy Timeframes			Remedy Cost			Upper 95% Probability of Success Score (%)	Relative Cost-Benefit Factor (% per USD)
GoldSim Model Element		35	36	37	38	39	40		
Regulatory Citation (VSWMR)		9VAC20-81-260.C.3.a(2)	9VAC20-81-260.C.3.a(2)	9VAC20-81-260.D.1.a(1e) 9VAC20-81-260.D.1.a(2d)	9VAC20-81-260.C.3.a(3); 9VAC20-81-260.D.1.a(4)	9VAC20-81-260.C.3.a(3); 9VAC20-81-260.D.1.a(4)	9VAC20-81-260.C.3.a(3); 9VAC20-81-260.D.1.a(4)		
Regulatory Citation (CCR)		§257.96(c)(2)	§257.96(c)(2)	§257.96(c)(2); §257.97(c)(1)(v)	--	--	--		
Percent Success		Enter Years	Enter Years	Enter Years	Enter Costs	Enter Costs	Enter Costs		
Criteria		Time Required to Initiate Remedy (yrs)	Time Required to Complete Remedy Construction (yrs)	Time to Full Protection (less than GPS at Point of Compliance; yrs)	Engineering/Design Cost (USD)	Construction Cost & Construction Period O&M (USD)	Annual Post-Construction O&M Cost (USD)		
Option 1: Excavation with Off-Site Disposal and Monitored Natural Attenuation (MNA)	Mean	1	15	40	$ 103,500.0	$ 83,201,100.0	$ 195,800.0	72.9%	50.5%
	Assignment Notes (Relative evaluation across crierion)	Award contract and start hauling	waste removal	estimate based on groundwater flow velocity, pore space flushing, and remedy construction timeframe					
Option 2: Excavation with On-Site Disposal and MNA	Mean	3	12	37	$ 705,000.0	$ 66,123,800.0	$ 195,800.0	71.0%	56.8%
	Assignment Notes (Relative evaluation across crierion)	Permitting for new facility, construction, then move materials	waste removal	estimate based on groundwater flow velocity, pore space flushing, and remedy construction timeframe					
Option 3: Excavation with Off-Site Disposal and In-Situ Aquifer Enhancement and MNA	Mean	1	15	40	$ 156,000.0	$ 91,292,600.0	$ 261,800.0	68.4%	2.2%
	Assignment Notes (Relative evaluation across crierion)	Award contract and start hauling	waste removal, delivery system construction	estimate based on groundwater flow velocity, pore space flushing, and remedy construction timeframe					
Option 4: Excavation with On-Site Disposal and In-Situ Aquifer Enhancement and MNA	Mean	3	12	37	$ 1,560,000.0	$ 79,968,800.0	$ 261,800.0	67.1%	2.6%
	Assignment Notes (Relative evaluation across crierion)	Permitting for new facility, construction, then move materials	waste removal, delivery system construction	estimate based on groundwater flow velocity, pore space flushing, and remedy construction timeframe					

Table 4
Assessment of Corrective Measures Evaluation Criteria
Bremo Power Station, Solid Waste Permit No. 618
East Pond

Class		Remedy Performance									Remedy Constructability (Ease of Implementation)				Remedy Concerns			
GoldSim Model Element		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Regulatory Citation (VSWMR)		9VAC20-81-260.D.1.a(1)	9VAC20-81-260.C.3.a(1)	9VAC20-81-260.D.1.a(2b)	9VAC20-81-260.D.1.a(1)	9VAC20-81-260.C.3.c(1b)	9VAC20-81-260.D.1.a(2); 9VAC20-81-260.D.1.a(2a); 9VAC20-81-260.C.3.c(1c)	--	9VAC20-81-260.C.3.a(4); 9VAC20-81-260.D.1.a(3c)	9VAC20-81-260.D.1.a(1h)	9VAC20-81-260.D.1.a(3a)	9VAC20-81-260.D.1.a(3b)	9VAC20-81-260.D.1.a(3d)	9VAC20-81-260.D.1.a(3e)	9VAC20-81-260.C.3.a(1)	9VAC20-81-260.C.3.a(1)	9VAC20-81-260.C.3.a(1)	9VAC20-81-260.D.1.a(6)
Regulatory Citation (CCR)		§257.96(c)(1); §257.97(c)(1); §257.97(c)(2)(i)	§257.96(c)(1); §257.97(c)(1); §257.97(c)(1)(vii); §257.97(c)(3)(ii)	§257.97(c)(2)(ii)	§257.96(c)(1)	§257.97(b)(2)	§257.96(c)(1); §257.97(b)(3)	§257.96(c)(1); §257.97(b)(4)	§257.97(c)(1)(ii)	§257.96(c)(1); §257.97(c)(1)(viii)	§257.96(c)(1)	§257.97(c)(3)(i)	§257.97(c)(3)(iv)	§257.97(c)(3)(v)	§257.96(c)(1)	§257.96(c)(1)	§257.96(c)(1)	§257.97(c)(4)
Percent Success		0% = minimal; 100% = substantial longterm effectiveness	0% = minimal; 100% = substantial longterm reliability	0% = lot of tech use; 100% = no tech use	0% = minimal; 100% = substantial shortterm effectiveness	0% = low; 100% = high ability to obtain GPS at POC	0% = minimal reduction; 100% = elimination of further releases	0% = minimal recovery; 100% = full recovery, or none required	0% = low potential for preventing; 100% = high potential for preventing future	0% = high remedy replacement potential; 100% = low remedy replacement potential	0% = hard to build; 100% = easy to build	0% = not available; 100% = available	0% = not available; 100% = available	0% = not available; 100% = available	0% = high potential safety impact; 100% = low safety impacts	0% = high cross media impact; 100% = low cross media impacts	0% = no residual contamination control; 100% = control	0% = does not address; 100% = addresses all concerns
Criteria		Long-Term Effectiveness of Remedy (%)	Long-Term Reliability of Remedy (%)	Treatment Tech Use Extent (%)	Short-Term Effectiveness (%)	Ability to Obtain the GPS at Point of Compliance (%)	Source Control to Reduce or Eliminate Further Releases (%)	Fugitive Material Recovery (%)	Potential for Future Material Releases (%)	Potential Need for Remedy Replacement (%)	Constructability (%)	Technology Availability/ Reliability (%)	Resource & Knowledge Availability (%)	Available Treatment, Storage, and Disposal Resources (%)	Potential Safety Impacts (%)	Potential Cross-Media Impacts (%)	Residual Contamination Exposure Control (%)	Community Concerns (%)
Option 5: Excavation with Off-Site Disposal and Hydraulic Pumping Containment (EP External Pumping Wells) with Ex-Situ Water Treatment and MNA and North Pond Wastewater Treatment Plant (NP WWTP)	Mean	80	80	20	60	80	80	80	80	80	80	80	80	60	60	40	20	80
	Assignment Notes (Relative evaluation across crierion)	More effective than removal and MNA alone, active treatment	At least as effective as source removal and MNA alone; relatively o/m needy, and power dependent, but reliably during working conditions; reliable treatment	Technology intensive remedy on top of source removal and MNA	May require up to 15 years for complete source removal and full remedy effectiveness. Short term effectiveness enhanced via traditional P&T installation in less than 15 years	Expected to obtain GPS goal at point of compliance faster than MNA alone	Source removal coupled with gradient reduction and MNA for contaminated water.	Fugitive materials recovered under parallel program	Source Removal over 15 years	Should be sufficent with MNA to prevent off-site impacts above risk-based concentrations	technology is common; some drilling challenges expected; added wells may be expected	lots of drillers; will need a good rig and crew for the setting	lots of resources	Need space in existing MSW or Industrial Landfill or new Industrial landfill	heavy equipment, source removal via over the road or rail traffic	Potential exist, 15-year removal effort, contaminated groundwater could discharge to surface water, source control for contaminated groundwater flux implemented quickly	Source removal, contaminated groundwater. Potential for exposure at groundwater-surface water interface and via O&M and treatment	Source removal to off-site location with active treatment
Option 6: Excavation with On-Site Disposal and Hydraulic Pumping Containment (EP External Pumping Wells) with Ex-Situ Water Treatment and MNA and NP WWTP	Mean	80	80	20	60	80	80	80	80	80	80	80	80	60	80	40	20	80
	Assignment Notes (Relative evaluation across crierion)	More effective than removal and MNA alone, active treatment	At least as effective as source removal and MNA alone; relatively o/m needy, and power dependent, but reliably during working conditions; reliable treatment	Technology intensive remedy on top of source removal and MNA	May require up to 12 years for complete source removal and full remedy effectiveness. Short term effectiveness enhanced via traditional P&T installation in less than 15 years	Expected to obtain GPS goal at point of compliance faster than MNA alone	Source removal coupled with gradient reduction and MNA for contaminated water.	Fugitive materials recovered under parallel program	Source Removal over 12 years	Should be sufficent with MNA to prevent off-site impacts above risk-based concentrations	technology is common; some drilling challenges expected; added wells may be expected	lots of drillers; will need a good rig and crew for the setting	lots of resources	Need space in existing MSW or Industrial Landfill or new Industrial landfill	heavy equipment, source removal via over the road or rail traffic	Potential exist, 12-year removal effort, contaminated groundwater could discharge to surface water, source control for contaminated groundwater flux implemented quickly	Source removal, contaminated groundwater. Potential for exposure at groundwater-surface water interface and via O&M and treatment	Source removal to off-site location with active treatment

Table 4
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Class		Remedy Institutional Controls							Remedy Risks						Remedy Operations and Maintenance			
GoldSim Model Element		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Regulatory Citation (VSWMR)		9VAC20-81-260.C.3.a(4); 9VAC20-81-260.D.1.a(3c)	9VAC20-81-260.C.3.a(4); 9VAC20-81-260.D.1.a(3c)	9VAC20-81-260.C.3.a(4); 9VAC20-81-260.D.1.a(3c)	9VAC20-81-260.D.1.a(5b)	9VAC20-81-260.C.3.c(1d)	--	9VAC20-81-260.D.1.a(1g)	9VAC20-81-260.D.1.a(1d); 9VAC20-81-260.D.1.a(1f)	--	9VAC20-81-260.D.1.a(1); 9VAC20-81-260.D.1.a(5a); 9VAC20-81-260.D.1.a(1f); 9VAC20-81-260.C.3.c(1a)	9VAC20-81-260.D.1.a(1); 9VAC20-81-260.D.1.a(5a); 9VAC20-81-260.D.1.a(1f); 9VAC20-81-260.C.3.c(1a)	9VAC20-81-260.D.1.a(1a) 9VAC20-81-260.D.1.a(2c)	9VAC20-81-260.D.1.a(1b)	9VAC20-81-260.D.1.a(1c)	9VAC20-81-260.D.1.a(1c)	9VAC20-81-260.D.1.a(1c)	9VAC20-81-260.D.1.a(1c)
Regulatory Citation (CCR)		§257.96(c)(3); §257.97(c)(3)(iii)	§257.96(c)(3); §257.97(c)(3)(iii)	§257.96(c)(3); §257.97(c)(3)(iii)	§257.97(a)	§257.97(b)(5)	§257.96(c)(3); §257.97(c)(3)(iii)	§257.96(c)(1); §257.97(c)(1)(vii)	§257.97(c)(1)(iv)	§257.97(c)(1)(iv)	§257.97(b)(1); §257.97(c)(1)(vi)	§257.97(b)(1); §257.97(c)(1)(vi)	§257.97(c)(1)(i)	§257.97(c)(1)(ii)	§257.97(c)(1)(iii)	§257.97(c)(1)(iii)	§257.97(c)(1)(iii)	§257.97(c)(1)(iii)
Percent Success		0% = Hard to get Fed Permit Required; 100% = No Fed Permit Required	0% = Hard to get State Permit Required; 100% = No State Permit Required	0% = Hard to get Local Permit Required; 100% = No Local Permit Required	0% = Out of Compliance; 100% = in compliance	0% = not in compliance; 100% = always in compliance	0% = Deed Restriction Required; 100% = Not Required	0% = Not reliable; 100% = always reliable	0% = significant community risks; 100% = no community risk	0% = significant Eco risks; 100% = no Eco risk	0% = less protective; 100% = most protective	0% = less protective; 100% = most protective	0% = little to no risk reduction; 100% = major risk reduction	0% = little to no risk reduction; 100% = major risk reduction	0% = High Management; 100% = Low Management	0% = High Monitoring; 100% = Low Monitoring	0% = High Operational; 100% = Low Operational	0% = High Maintenance; 100% = Low Maintenance
Criteria		Federal Permit Need (%)	State Permit Need (%)	Local Permit Need (%)	Compliance With OSHA, Federal, and Virginia Standards - 100% Compliance Assumed (%)	Waste Management Compliance (%)	Deed Restrictions (%)	Long Term Reliability of Controls (%)	Community Implementation Risks (transporation & disposal) (%)	Ecological Implementation Risks	Remedy Human Health Protectiveness & Waste Exposure	Remedy Environment Protectiveness & Waste Exposure	Magnitude of Existing Health Risk Reduction	Magnitude of Residual Risk for Further Releases	Relative Management Requirement (%)	Relative Monitoring Requirement (%)	Relative Operational Requirements (%)	Relative Maintenance Requirements (%)
Option 5: Excavation with Off-Site Disposal and Hydraulic Pumping Containment (EP External Pumping Wells) with Ex-Situ Water Treatment and MNA and North Pond Wastewater Treatment Plant (NP WWTP)	Mean	40	40	80	100	60	80	80	40	40	40	60	80	80	20	20	20	20
	Assignment Notes (Relative evaluation across crierion)	May require a Federal Underground Injection Control permit	Solid Waste permit for closure via removal	no local permit known	In compliance	low risk for out of compliance conditions; treatment process will generate a waste stream	Waste Removed, no deed restriction required for waste.	High	Significant over the road or rail transport for construction of remedy	moderate-high, coupled with water treatment system and permitted discharge	With source removal steady state remedy is protective provided no media transfer to surface water; some potential exposure associated with O&M of the system; exsposure potential with water treatment and discharge	With source removal steady state remedy is protective provided no media transfer to surface water; potential for impact associated with treated water discharge	With source removal should ultimately achieve GPS, health risk reduction is goal	Source removal	Intensive management during construction, significant active management after construction	High level of monitoring during construction and high level of monitoring after construction is complete	High during construction, moderate to high after with P&T and water treatment, discharge monitoring	High after construction is complete, routine O&M on the treatment system
Option 6: Excavation with On-Site Disposal and Hydraulic Pumping Containment (EP External Pumping Wells) with Ex-Situ Water Treatment and MNA and NP WWTP	Mean	40	20	40	100	60	80	80	60	40	40	60	80	80	20	20	20	20
	Assignment Notes (Relative evaluation across crierion)	May require a Federal Underground Injection Control permit	Solid Waste permit for closure via removal and may require 401 wetland permitting; Solid Waste Permit for new landfill	Conditional Use Permit may be required	In compliance	low risk for out of compliance conditions; treatment process will generate a waste stream	Waste Removed, no deed restriction required for waste.	High	Significant over the road or rail transport for construction of remedy	moderate-high, coupled with water treatment system and permitted discharge	With source removal steady state remedy is protective provided no media transfer to surface water; some potential exposure associated with O&M of the system; exsposure potential with water treatment and discharge	With source removal steady state remedy is protective provided no media transfer to surface water; potential for impact associated with treated water discharge	With source removal should ultimately achieve GPS, health risk reduction is goal	Source removal	Intensive management during construction, significant active management after construction	High level of monitoring during construction and high level of monitoring after construction is complete	High during construction, moderate to high after with P&T and water treatment, discharge monitoring	High after construction is complete, routine O&M on the treatment system

Table 4
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Bremo Power Station, Solid Waste Permit No. 618
East Pond

Class		Remedy Timeframes			Remedy Cost			Upper 95% Probability of Success Score (%)	Relative Cost-Benefit Factor (% per USD)
GoldSim Model Element		35	36	37	38	39	40		
Regulatory Citation (VSWMR)		9VAC20-81-260.C.3.a(2)	9VAC20-81-260.C.3.a(2)	9VAC20-81-260.D.1.a(1e) 9VAC20-81-260.D.1.a(2d)	9VAC20-81-260.C.3.a(3); 9VAC20-81-260.D.1.a(4)	9VAC20-81-260.C.3.a(3); 9VAC20-81-260.D.1.a(4)	9VAC20-81-260.C.3.a(3); 9VAC20-81-260.D.1.a(4)		
Regulatory Citation (CCR)		§257.96(c)(2)	§257.96(c)(2)	§257.96(c)(2); §257.97(c)(1)(v)	--	--	--		
Percent Success		Enter Years	Enter Years	Enter Years	Enter Costs	Enter Costs	Enter Costs		
Criteria		Time Required to Initiate Remedy (yrs)	Time Required to Complete Remedy Construction (yrs)	Time to Full Protection (less than GPS at Point of Compliance; yrs)	Engineering/Design Cost (USD)	Construction Cost & Construction Period O&M (USD)	Annual Post-Construction O&M Cost (USD)		
Option 5: Excavation with Off-Site Disposal and Hydraulic Pumping Containment (EP External Pumping Wells) with Ex-Situ Water Treatment and MNA and North Pond Wastewater Treatment Plant (NP WWTP)	Mean	1	15	40					
	Assignment Notes (Relative evaluation across crierion)	Award contract and start hauling	waste removal, wells and systems; water treatment	estimate based on groundwater flow velocity, pore space flushing, and remedy construction timeframe	$ 93,000.0	$ 83,100,800.0	$ 776,600.0	67.0%	1.9%
Option 6: Excavation with On-Site Disposal and Hydraulic Pumping Containment (EP External Pumping Wells) with Ex-Situ Water Treatment and MNA and NP WWTP	Mean	3	12	37					
	Assignment Notes (Relative evaluation across crierion)	Permitting for new facility, construction, then move materials	waste removal, wells and systems; water treatment	estimate based on groundwater flow velocity, pore space flushing, and remedy construction timeframe	$ 930,000.0	$ 70,614,800.0	$ 776,600.0	67.6%	2.3%

Table 4
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Bremo Power Station, Solid Waste Permit No. 618
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Class		Remedy Performance									Remedy Constructability (Ease of Implementation)				Remedy Concerns			
GoldSim Model Element		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Regulatory Citation (VSWMR)		9VAC20-81-260.D.1.a(1)	9VAC20-81-260.C.3.a(1)	9VAC20-81-260.D.1.a(2b)	9VAC20-81-260.D.1.a(1)	9VAC20-81-260.C.3.c(1b)	9VAC20-81-260.D.1.a(2); 9VAC20-81-260.D.1.a(2a); 9VAC20-81-260.C.3.c(1c)	--	9VAC20-81-260.C.3.a(4); 9VAC20-81-260.D.1.a(3c)	9VAC20-81-260.D.1.a(1h)	9VAC20-81-260.D.1.a(3a)	9VAC20-81-260.D.1.a(3b)	9VAC20-81-260.D.1.a(3d)	9VAC20-81-260.D.1.a(3e)	9VAC20-81-260.C.3.a(1)	9VAC20-81-260.C.3.a(1)	9VAC20-81-260.C.3.a(1)	9VAC20-81-260.D.1.a(6)
Regulatory Citation (CCR)		§257.96(c)(1); §257.97(c)(1); §257.97(c)(2)(i)	§257.96(c)(1); §257.97(c)(1); §257.97(c)(1)(vii); §257.97(c)(3)(ii)	§257.97(c)(2)(ii)	§257.96(c)(1)	§257.97(b)(2)	§257.96(c)(1); §257.97(b)(3)	§257.96(c)(1); §257.97(b)(4)	§257.97(c)(1)(ii)	§257.96(c)(1); §257.97(c)(1)(viii)	§257.96(c)(1)	§257.97(c)(3)(i)	§257.97(c)(3)(iv)	§257.97(c)(3)(v)	§257.96(c)(1)	§257.96(c)(1)	§257.96(c)(1)	§257.97(c)(4)
Percent Success		0% = minimal; 100% = substantial longterm effectiveness	0% = minimal; 100% = substantial longterm reliability	0% = lot of tech use; 100% = no tech use	0% = minimal; 100% = substantial shortterm effectiveness	0% = low; 100% = high ability to obtain GPS at POC	0% = minimal reduction; 100% = elimination of further releases	0% = minimal recovery; 100% = full recovery, or none required	0% = low potential for preventing; 100% = high potential for preventing future	0% = high remedy replacement potential; 100% = low remedy replacement potential	0% = hard to build; 100% = easy to build	0% = not available; 100% = available	0% = not available; 100% = available	0% = not available; 100% = available	0% = high potential safety impact; 100% = low safety impacts	0% = high cross media impact; 100% = low cross media impacts	0% = no residual contamination control; 100% = control	0% = does not address; 100% = addresses all concerns
Criteria		Long-Term Effectiveness of Remedy (%)	Long-Term Reliability of Remedy (%)	Treatment Tech Use Extent (%)	Short-Term Effectiveness (%)	Ability to Obtain the GPS at Point of Compliance (%)	Source Control to Reduce or Eliminate Further Releases (%)	Fugitive Material Recovery (%)	Potential for Future Material Releases (%)	Potential Need for Remedy Replacement (%)	Constructability (%)	Technology Availability/ Reliability (%)	Resource & Knowledge Availability (%)	Available Treatment, Storage, and Disposal Resources (%)	Potential Safety Impacts (%)	Potential Cross-Media Impacts (%)	Residual Contamination Exposure Control (%)	Community Concerns (%)
Option 7: Excavation with Off-Site Disposal and Funnel and Gate Ex-Situ Treatment and MNA and NP WWTP	Mean	80	80	20	60	80	80	80	80	80	60	80	60	60	60	40	20	80
	Assignment Notes (Relative evaluation across crierion)	More effective than removal and MNA alone, in-situ collection of water and ex-situ treatment: good access to medium and change-out ability; long term effectiveness may be high	At least as effective as source removal and MNA alone; reliable, simple water collection; o&M needy, reliable treatment due to ex-situ ability to change media and monitor conditions and flow	Technology intensive remedy on top of source removal and MNA	May require up to 15 years for complete source removal and full remedy effectiveness. Short term effectiveness enhanced via F&G with P&T installation in less than 15 years	Expected to obtain GPS goal at point of compliance faster than MNA alone	Source removal coupled with gradient reduction and MNA for contaminated water.	Fugitive materials recovered under parallel program	Source Removal over 15 years	Should be sufficent with MNA to prevent off-site impacts above risk-based concentrations	technology exists; proven; somewhat complex due to varying geology	limited providers, but available	some in PRBs for metals done	Need space in existing MSW or Industrial Landfill or new Industrial landfill	heavy equipment, source removal via over the road or rail traffic	Potential exist, 15-year removal effort, contaminated groundwater could discharge to surface water, source control for contaminated groundwater flux implemented quickly	Source removal, contaminated groundwater. Potential for exposure at groundwater-surface water interface and via O&M and treatment	Source removal to off-site location with active treatment
Option 8: Excavation with On-Site Disposal and Funnel and Gate Ex-Situ Treatment and MNA and NP WWTP	Mean	80	80	20	60	80	80	80	80	80	60	80	60	60	80	40	20	80
	Assignment Notes (Relative evaluation across crierion)	More effective than removal and MNA alone, in-situ collection of water and ex-situ treatment: good access to medium and change-out ability; long term effectiveness may be high	At least as effective as source removal and MNA alone; reliable, simple water collection; o&M needy, reliable treatment due to ex-situ ability to change media and monitor conditions and flow	Technology intensive remedy on top of source removal and MNA	May require up to 12 years for complete source removal and full remedy effectiveness. Short term effectiveness enhanced via F&G with P&T installation in less than 15 years	Expected to obtain GPS goal at point of compliance faster than MNA alone	Source removal coupled with gradient reduction and MNA for contaminated water.	Fugitive materials recovered under parallel program	Source Removal over 12 years	Should be sufficent with MNA to prevent off-site impacts above risk-based concentrations	technology exists; proven; somewhat complex due to varying geology	limited providers, but available	some in PRBs for metals done	Need space in existing MSW or Industrial Landfill or new Industrial landfill	heavy equipment, source removal via over the road or rail traffic	Potential exist, 12-year removal effort, contaminated groundwater could discharge to surface water, source control for contaminated groundwater flux implemented quickly	Source removal, contaminated groundwater. Potential for exposure at groundwater-surface water interface and via O&M and treatment	Source removal to off-site location with active treatment

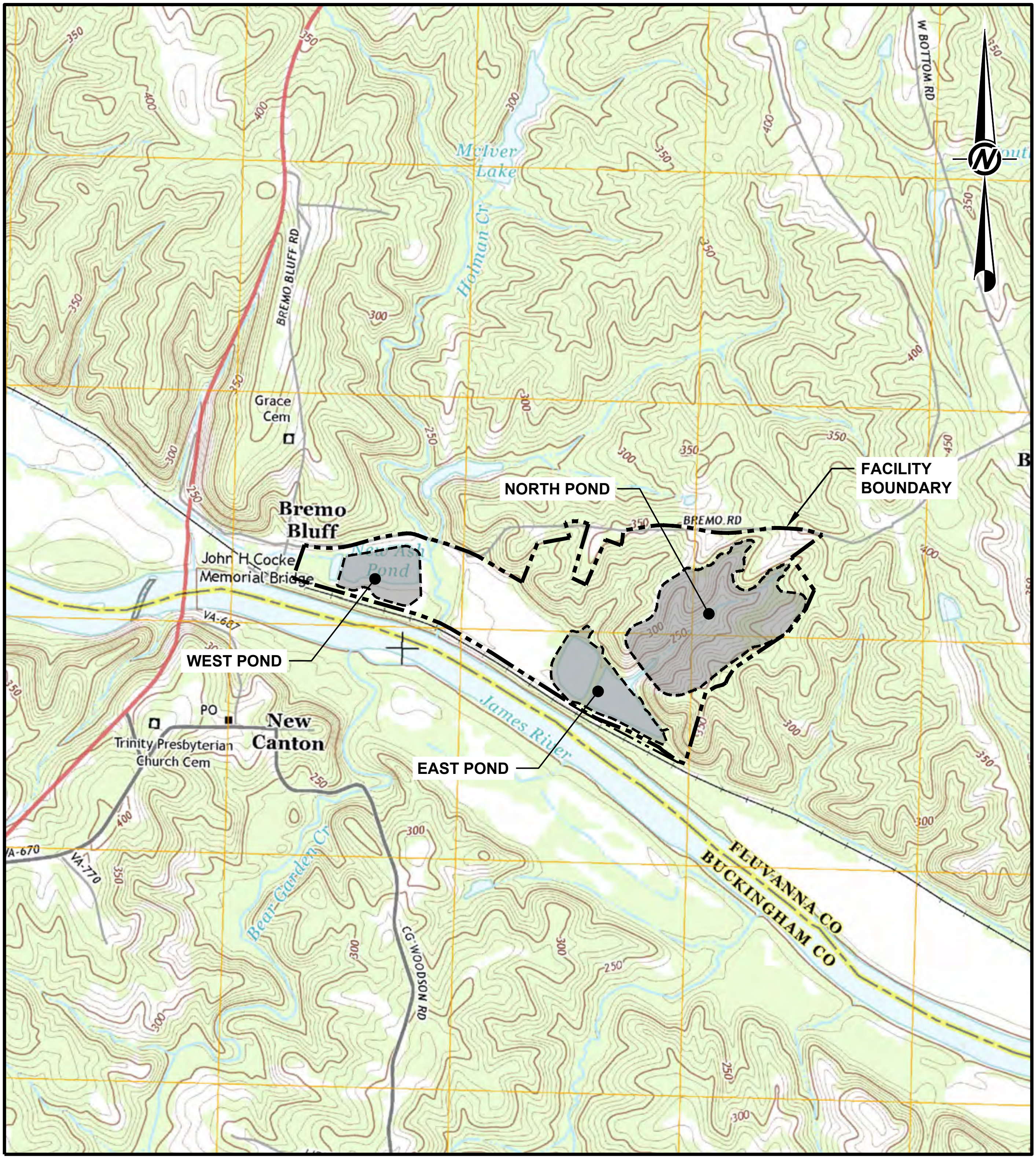
Table 4
Assessment of Corrective Measures Evaluation Criteria
Bremo Power Station, Solid Waste Permit No. 618
East Pond

Class		Remedy Institutional Controls							Remedy Risks						Remedy Operations and Maintenance			
GoldSim Model Element		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Regulatory Citation (VSWMR)		9VAC20-81-260.C.3.a(4); 9VAC20-81-260.D.1.a(3c)	9VAC20-81-260.C.3.a(4); 9VAC20-81-260.D.1.a(3c)	9VAC20-81-260.C.3.a(4); 9VAC20-81-260.D.1.a(3c)	9VAC20-81-260.D.1.a(5b)	9VAC20-81-260.C.3.c(1d)	--	9VAC20-81-260.D.1.a(1g)	9VAC20-81-260.D.1.a(1d); 9VAC20-81-260.D.1.a(1f)	--	9VAC20-81-260.D.1.a(1); 9VAC20-81-260.D.1.a(5a); 9VAC20-81-260.D.1.a(1f); 9VAC20-81-260.C.3.c(1a)	9VAC20-81-260.D.1.a(1); 9VAC20-81-260.D.1.a(5a); 9VAC20-81-260.D.1.a(1f); 9VAC20-81-260.C.3.c(1a)	9VAC20-81-260.D.1.a(1a) 9VAC20-81-260.D.1.a(2c)	9VAC20-81-260.D.1.a(1b)	9VAC20-81-260.D.1.a(1c)	9VAC20-81-260.D.1.a(1c)	9VAC20-81-260.D.1.a(1c)	9VAC20-81-260.D.1.a(1c)
Regulatory Citation (CCR)		§257.96(c)(3); §257.97(c)(3)(iii)	§257.96(c)(3); §257.97(c)(3)(iii)	§257.96(c)(3); §257.97(c)(3)(iii)	§257.97(a)	§257.97(b)(5)	§257.96(c)(3); §257.97(c)(3)(iii)	§257.96(c)(1); §257.97(c)(1)(vii)	§257.97(c)(1)(iv)	§257.97(c)(1)(iv)	§257.97(b)(1); §257.97(c)(1)(vi)	§257.97(b)(1); §257.97(c)(1)(vi)	§257.97(c)(1)(i)	§257.97(c)(1)(ii)	§257.97(c)(1)(iii)	§257.97(c)(1)(iii)	§257.97(c)(1)(iii)	§257.97(c)(1)(iii)
Percent Success		0% = Hard to get Fed Permit Required; 100% = No Fed Permit Required	0% = Hard to get State Permit Required; 100% = No State Permit Required	0% = Hard to get Local Permit Required; 100% = No Local Permit Required	0% = Out of Compliance; 100% = in compliance	0% = not in compliance; 100% = always in compliance	0% = Deed Restriction Required; 100% = Not Required	0% = Not reliable; 100% = always reliable	0% = significant community risks; 100% = no community risk	0% = significant Eco risks; 100% = no Eco risk	0% = less protective; 100% = most protective	0% = less protective; 100% = most protective	0% = little to no risk reduction; 100% = major risk reduction	0% = little to no risk reduction; 100% = major risk reduction	0% = High Management; 100% = Low Management	0% = High Monitoring; 100% = Low Monitoring	0% = High Operational; 100% = Low Operational	0% = High Maintenance; 100% = Low Maintenance
Criteria		Federal Permit Need (%)	State Permit Need (%)	Local Permit Need (%)	Compliance With OSHA, Federal, and Virginia Standards - 100% Compliance Assumed (%)	Waste Management Compliance (%)	Deed Restrictions (%)	Long Term Reliability of Controls (%)	Community Implementation Risks (transporation & disposal) (%)	Ecological Implementation Risks	Remedy Human Health Protectiveness & Waste Exposure	Remedy Environment Protectiveness & Waste Exposure	Magnitude of Existing Health Risk Reduction	Magnitude of Residual Risk for Further Releases	Relative Management Requirement (%)	Relative Monitoring Requirement (%)	Relative Operational Requirements (%)	Relative Maintenance Requirements (%)
Option 7: Excavation with Off-Site Disposal and Funnel and Gate Ex-Situ Treatment and MNA and NP WWTP	Mean	40	40	80	100	60	80	80	40	40	40	60	80	80	20	20	20	20
	Assignment Notes (Relative evaluation across crierion)	May require a Federal Underground Injection Control permit	Solid Waste permit for closure via removal	no local permit known	In compliance	low risk for out of compliance conditions; treatment process will generate a waste stream	Waste Removed, no deed restriction required for waste.	High	Significant over the road or rail transport for construction of remedy	moderate-high, coupled with water treatment system and permitted discharge	With source removal steady state remedy is protective provided no media transfer to surface water; some potential exposure associated with O&M of the system; expsoure associated with water treatment and discharge	With source removal steady state remedy is protective provided no media transfer to surface water; potential for impact associated with treated water discharge	With source removal should ultimately achieve GPS, health risk reduction is goal	Source removal	Intensive management during construction, significant active management after construction	High level of monitoring during construction and high level of monitoring after construction is complete	High during construction, moderate to high after with P&T and water treatment, discharge monitoring	High after construction is complete, routine O&M on the treatment system
Option 8: Excavation with On-Site Disposal and Funnel and Gate Ex-Situ Treatment and MNA and NP WWTP	Mean	40	20	40	100	60	80	80	60	40	40	60	80	80	20	20	20	20
	Assignment Notes (Relative evaluation across crierion)	May require a Federal Underground Injection Control permit	Solid Waste permit for closure via removal and may require 401 wetland permitting; Solid Waste Permit for new landfill	Conditional Use Permit may be required	In compliance	low risk for out of compliance conditions; treatment process will generate a waste stream	Waste Removed, no deed restriction required for waste.	High	Significant over the road or rail transport for construction of remedy	moderate-high, coupled with water treatment system and permitted discharge	With source removal steady state remedy is protective provided no media transfer to surface water; some potential exposure associated with O&M of the system; expsoure associated with water treatment and discharge	With source removal steady state remedy is protective provided no media transfer to surface water; potential for impact associated with treated water discharge	With source removal should ultimately achieve GPS, health risk reduction is goal	Source removal	Intensive management during construction, significant active management after construction	High level of monitoring during construction and high level of monitoring after construction is complete	High during construction, moderate to high after with P&T and water treatment, discharge monitoring	High after construction is complete, routine O&M on the treatment system

Table 4
Assessment of Corrective Measures Evaluation Criteria
Bremo Power Station, Solid Waste Permit No. 618
East Pond

Class		Remedy Timeframes			Remedy Cost			Upper 95% Probability of Success Score (%)	Relative Cost-Benefit Factor (% per USD)
GoldSim Model Element		35	36	37	38	39	40		
Regulatory Citation (VSWMR)		9VAC20-81-260.C.3.a(2)	9VAC20-81-260.C.3.a(2)	9VAC20-81-260.D.1.a(1e) 9VAC20-81-260.D.1.a(2d)	9VAC20-81-260.C.3.a(3); 9VAC20-81-260.D.1.a(4)	9VAC20-81-260.C.3.a(3); 9VAC20-81-260.D.1.a(4)	9VAC20-81-260.C.3.a(3); 9VAC20-81-260.D.1.a(4)		
Regulatory Citation (CCR)		§257.96(c)(2)	§257.96(c)(2)	§257.96(c)(2); §257.97(c)(1)(v)	--	--	--		
Percent Success		Enter Years	Enter Years	Enter Years	Enter Costs	Enter Costs	Enter Costs		
Criteria		Time Required to Initiate Remedy (yrs)	Time Required to Complete Remedy Construction (yrs)	Time to Full Protection (less than GPS at Point of Compliance; yrs)	Engineering/Design Cost (USD)	Construction Cost & Construction Period O&M (USD)	Annual Post-Construction O&M Cost (USD)		
Option 7: Excavation with Off-Site Disposal and Funnel and Gate Ex-Situ Treatment and MNA and NP WWTP	Mean	1	15	40	$ 273,000.0	$ 107,448,800.0	$ 776,600.0	66.0%	1.0%
	Assignment Notes (Relative evaluation across crierion)	Award contract and start hauling	waste removal, F&G installation, Collection System and water treatment	estimate based on groundwater flow velocity, pore space flushing, and remedy construction timeframe					
Option 8: Excavation with On-Site Disposal and Funnel and Gate Ex-Situ Treatment and MNA and NP WWTP	Mean	3	12	37	$ 2,730,000.0	$ 98,094,800.0	$ 776,600.0	66.6%	1.2%
	Assignment Notes (Relative evaluation across crierion)	Permitting for new facility, construction, then move materials	waste removal, F&G installation, Collection System and water treatment	estimate based on groundwater flow velocity, pore space flushing, and remedy construction timeframe					

FIGURES



REFERENCE

BASE MAP CONSISTS OF 7.5-MINUTE USGS TOPOGRAPHIC QUADRANGLE NAMED ARVONIA, VIRGINIA, DATED 2013.

2000 0 2000

SCALE FEET

CLIENT
DOMINION ENERGY

PROJECT
BREMO POWER STATION
FLUVANNA COUNTY, VIRGINIA

CONSULTANT

GOLDER

YYYY-MM-DD	2020-07-15
DESIGNED	HDE
PREPARED	SIB
REVIEWED	MGW
APPROVED	MGW

TITLE
SITE LOCATION MAP

PROJECT NO.	REV.	FIGURE
20-140438	0	1

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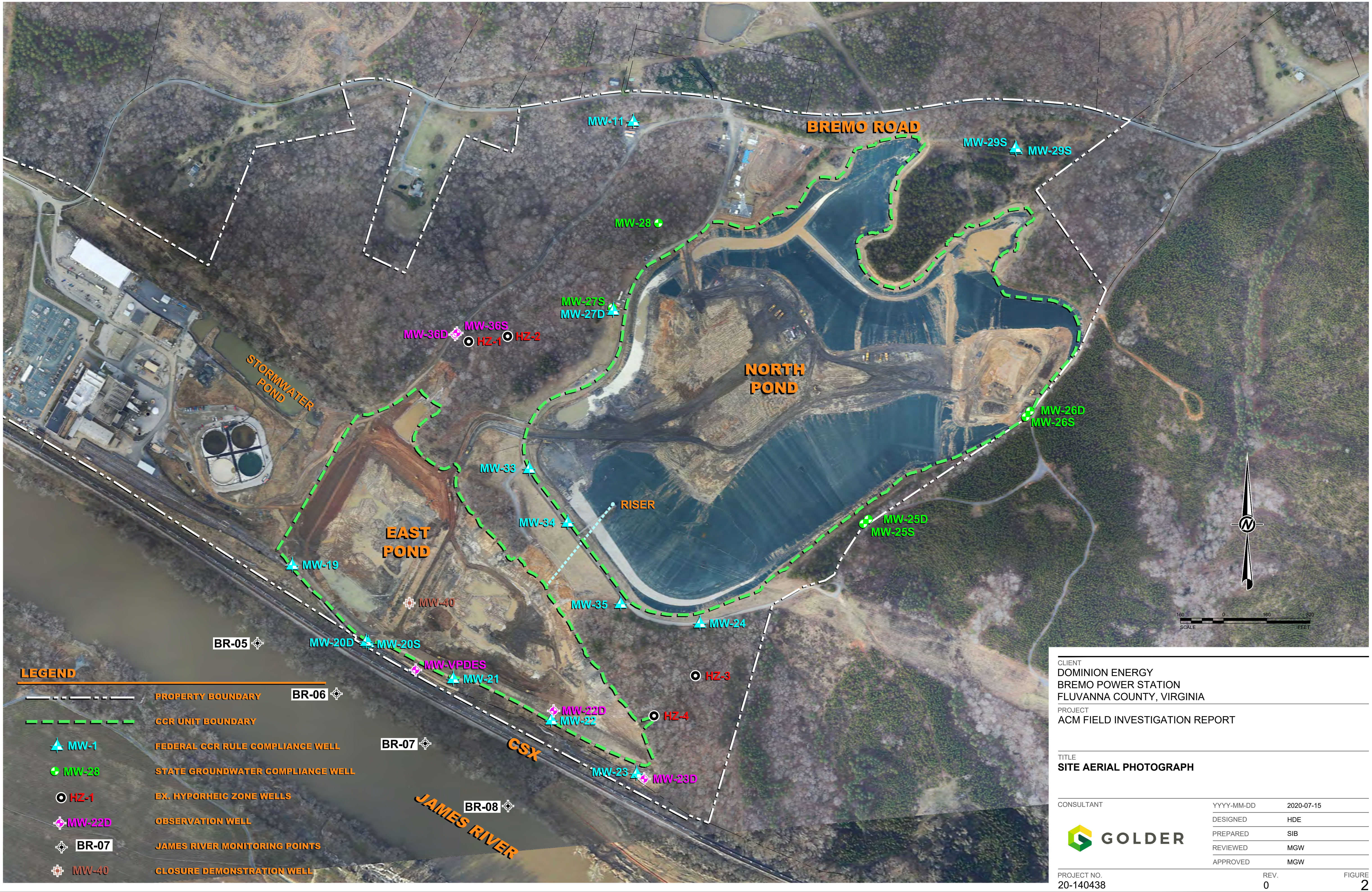

CLIENT
DOMINION ENERGY
BREMO POWER STATION
FLUVANNA COUNTY, VIRGINIA

PROJECT
ACM FIELD INVESTIGATION REPORT

TITLE
SITE AERIAL PHOTOGRAPH

CONSULTANT

GOLDER

YYYY-MM-DD	2020-07-15
DESIGNED	HDE
PREPARED	SIB
REVIEWED	MGW
APPROVED	MGW

PROJECT NO.	REV.	FIGURE
20-140438	0	2

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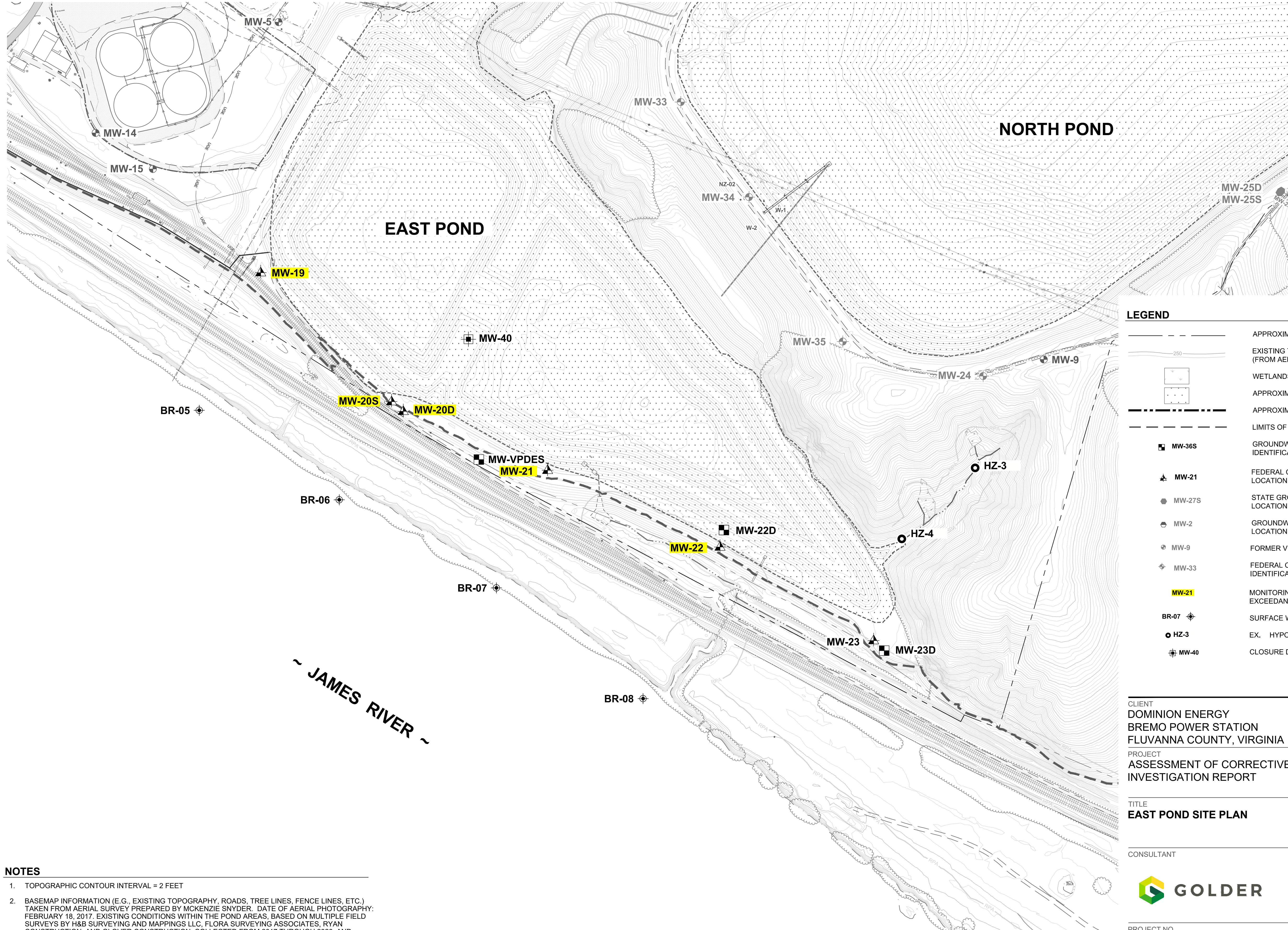


LEGEND

	APPROXIMATE PROPERTY BOUNDARY
250	EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS) (FROM AERIAL SURVEY - SEE NOTE 6)
	WETLANDS
	APPROXIMATE LIMITS OF EXISTING ASH PONDS
	APPROXIMATE LIMITS OF NORTH ASH POND FILL
	LIMITS OF 100-YR FLOOD PLAIN
MW-36S	GROUNDWATER OBSERVATION WELL LOCATION AND IDENTIFICATION
MW-21	FEDERAL CCR RULE COMPLIANCE WELL LOCATION AND IDENTIFICATION - EAST POND
MW-27S	STATE GROUNDWATER COMPLIANCE WELL LOCATION AND IDENTIFICATION
MW-2	GROUNDWATER OBSERVATION WELL LOCATION AND IDENTIFICATION
MW-9	FORMER VPDES MONITORING WELL
MW-33	FEDERAL CCR RULE COMPLIANCE WELL LOCATION AND IDENTIFICATION - NORTH POND
MW-21	MONITORING WELL WITH FEDERAL GWPS OR VIRGINIA GPS EXCEEDANCE
BR-07	SURFACE WATER MONITORING LOCATION
HZ-3	EX. HYPORHEIC ZONE WELL
MW-40	CLOSURE DEMONSTRATION WELL

NOTES

1. TOPOGRAPHIC CONTOUR INTERVAL = 2 FEET
2. BASEMAP INFORMATION (E.G., EXISTING TOPOGRAPHY, ROADS, TREE LINES, FENCE LINES, ETC.) TAKEN FROM AERIAL SURVEY PREPARED BY MCKENZIE SNYDER. DATE OF AERIAL PHOTOGRAPHY: FEBRUARY 18, 2017. EXISTING CONDITIONS WITHIN THE POND AREAS, BASED ON MULTIPLE FIELD SURVEYS BY H&B SURVEYING AND MAPPINGS LLC, FLORA SURVEYING ASSOCIATES, RYAN CONSTRUCTION, AND GLOVER CONSTRUCTION, COLLECTED FROM 2017 THROUGH 2020, AND COMPILED BY GOLDER ASSOCIATES.

CLIENT
DOMINION ENERGY
BREMO POWER STATION
FLUVANNA COUNTY, VIRGINIA

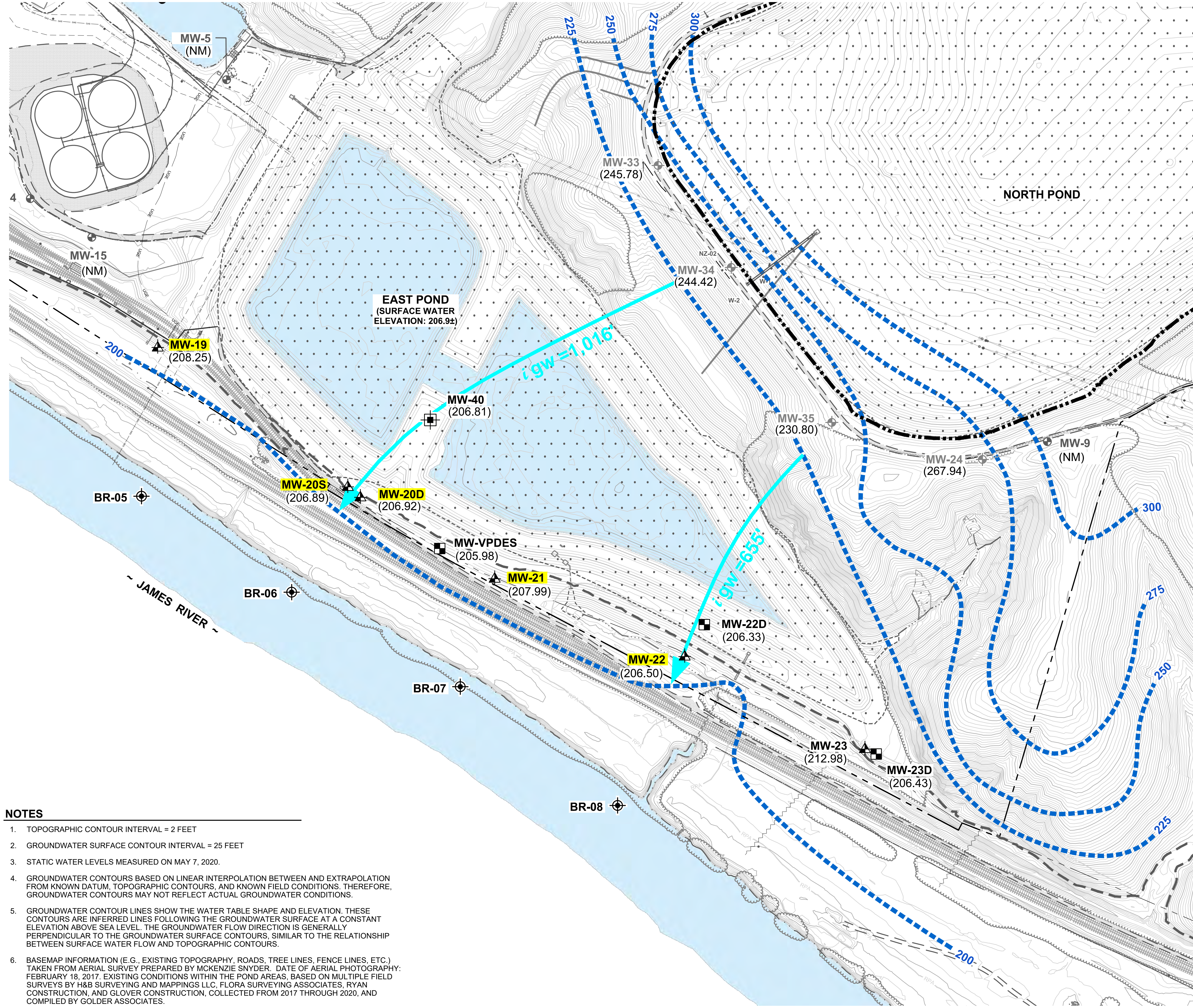
PROJECT
ASSESSMENT OF CORRECTIVE MEASURES
INVESTIGATION REPORT

TITLE
EAST POND SITE PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2020-07-15
DESIGNED	HDE
PREPARED	SIB
REVIEWED	MGW
APPROVED	MGW

PROJECT NO.	REV.	FIGURE
20-140438	0	3



LEGEND

	APPROXIMATE PROPERTY BOUNDARY
250	EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS) (FROM AERIAL SURVEY - SEE NOTE 6)
	WETLANDS
	APPROXIMATE LIMITS OF EXISTING ASH PONDS
	APPROXIMATE LIMITS OF NORTH ASH POND FILL
	LIMITS OF 100-YR FLOOD PLAIN
MW-36S	GROUNDWATER OBSERVATION WELL LOCATION AND IDENTIFICATION
(275.15)	STATIC GROUNDWATER ELEVATION (FEET ABOVE MEAN SEA LEVEL)
(NM)	NOT MEASURED
MW-21	FEDERAL CCR RULE COMPLIANCE WELL LOCATION AND IDENTIFICATION - EAST POND
MW-27S	STATE GROUNDWATER COMPLIANCE WELL LOCATION AND IDENTIFICATION
MW-2	GROUNDWATER OBSERVATION WELL LOCATION AND IDENTIFICATION
MW-9	FORMER VPDES MONITORING WELL
MW-33	FEDERAL CCR RULE COMPLIANCE WELL LOCATION AND IDENTIFICATION - NORTH POND
300	POTENTIOMETRIC SURFACE CONTOURS
	APPROXIMATE GROUNDWATER FLOW LINE
MW-21	MONITORING WELL WITH FEDERAL GWPS OR VIRGINIA GPS EXCEEDANCE
BR-07	SURFACE WATER MONITORING LOCATION
MW-40	CLOSURE DEMONSTRATION WELL

NOTES

1. TOPOGRAPHIC CONTOUR INTERVAL = 2 FEET
2. GROUNDWATER SURFACE CONTOUR INTERVAL = 25 FEET
3. STATIC WATER LEVELS MEASURED ON MAY 7, 2020.
4. GROUNDWATER CONTOURS BASED ON LINEAR INTERPOLATION BETWEEN AND EXTRAPOLATION FROM KNOWN DATUM, TOPOGRAPHIC CONTOURS, AND KNOWN FIELD CONDITIONS. THEREFORE, GROUNDWATER CONTOURS MAY NOT REFLECT ACTUAL GROUNDWATER CONDITIONS.
5. GROUNDWATER CONTOUR LINES SHOW THE WATER TABLE SHAPE AND ELEVATION. THESE CONTOURS ARE INFERRED LINES FOLLOWING THE GROUNDWATER SURFACE AT A CONSTANT ELEVATION ABOVE SEA LEVEL. THE GROUNDWATER FLOW DIRECTION IS GENERALLY PERPENDICULAR TO THE GROUNDWATER SURFACE CONTOURS, SIMILAR TO THE RELATIONSHIP BETWEEN SURFACE WATER FLOW AND TOPOGRAPHIC CONTOURS.
6. BASEMAP INFORMATION (E.G., EXISTING TOPOGRAPHY, ROADS, TREE LINES, FENCE LINES, ETC.) TAKEN FROM AERIAL SURVEY PREPARED BY MCKENZIE SNYDER. DATE OF AERIAL PHOTOGRAPHY: FEBRUARY 18, 2017. EXISTING CONDITIONS WITHIN THE POND AREAS, BASED ON MULTIPLE FIELD SURVEYS BY H&B SURVEYING AND MAPPINGS LLC, FLORA SURVEYING ASSOCIATES, RYAN CONSTRUCTION, AND GLOVER CONSTRUCTION, COLLECTED FROM 2017 THROUGH 2020, AND COMPILED BY GOLDER ASSOCIATES.

CLIENT
DOMINION ENERGY
BREMO POWER STATION
FLUVANNA COUNTY, VIRGINIA

PROJECT
ACM FIELD INVESTIGATION REPORT

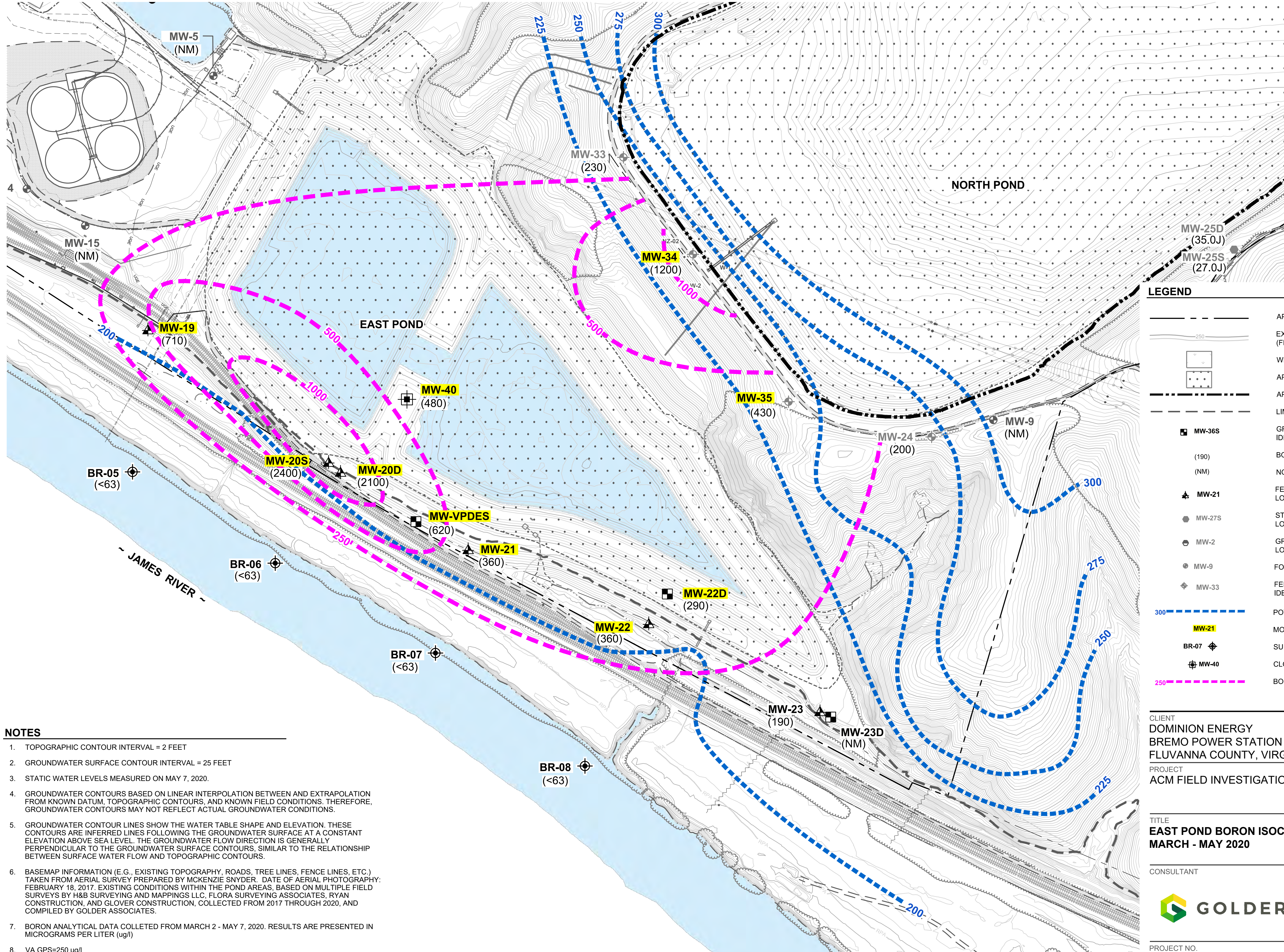
TITLE
EAST POND POTENTIOMETRIC SURFACE PLAN
MAY 7, 2020

CONSULTANT
GOLDER

YYYY-MM-DD	2020-07-15
DESIGNED	HDE
PREPARED	SIB
REVIEWED	MGW
APPROVED	MGW

PROJECT NO.	REV.	FIGURE
20-140438	0	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D



LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS) (FROM AERIAL SURVEY - SEE NOTE 6)
- WETLANDS
- APPROXIMATE LIMITS OF EXISTING ASH PONDS
- APPROXIMATE LIMITS OF NORTH ASH POND FILL
- LIMITS OF 100-YR FLOOD PLAIN
- MW-36S — GROUNDWATER OBSERVATION WELL LOCATION AND IDENTIFICATION
- (190) — BORON CONCENTRATION (ug/l)
- (NM) — NOT MEASURED
- MW-21 — FEDERAL CCR RULE COMPLIANCE WELL LOCATION AND IDENTIFICATION - EAST POND
- MW-27S — STATE GROUNDWATER COMPLIANCE WELL LOCATION AND IDENTIFICATION
- MW-2 — GROUNDWATER OBSERVATION WELL LOCATION AND IDENTIFICATION
- MW-9 — FORMER VPDES MONITORING WELL
- MW-33 — FEDERAL CCR RULE COMPLIANCE WELL LOCATION AND IDENTIFICATION - NORTH POND
- 300 — POTENTIOMETRIC SURFACE CONTOURS
- MW-21 — MONITORING WELL WITH BORON GPS EXCEEDENCE
- BR-07 — SURFACE WATER MONITORING LOCATION
- MW-40 — CLOSURE DEMONSTRATION WELL
- 250 — BORON ISOCONCENTRATION CONTOUR

NOTES

1. TOPOGRAPHIC CONTOUR INTERVAL = 2 FEET
2. GROUNDWATER SURFACE CONTOUR INTERVAL = 25 FEET
3. STATIC WATER LEVELS MEASURED ON MAY 7, 2020.
4. GROUNDWATER CONTOURS BASED ON LINEAR INTERPOLATION BETWEEN AND EXTRAPOLATION FROM KNOWN DATUM, TOPOGRAPHIC CONTOURS, AND KNOWN FIELD CONDITIONS. THEREFORE, GROUNDWATER CONTOURS MAY NOT REFLECT ACTUAL GROUNDWATER CONDITIONS.
5. GROUNDWATER CONTOUR LINES SHOW THE WATER TABLE SHAPE AND ELEVATION. THESE CONTOURS ARE INFERRED LINES FOLLOWING THE GROUNDWATER SURFACE AT A CONSTANT ELEVATION ABOVE SEA LEVEL. THE GROUNDWATER FLOW DIRECTION IS GENERALLY PERPENDICULAR TO THE GROUNDWATER SURFACE CONTOURS, SIMILAR TO THE RELATIONSHIP BETWEEN SURFACE WATER FLOW AND TOPOGRAPHIC CONTOURS.
6. BASEMAP INFORMATION (E.G., EXISTING TOPOGRAPHY, ROADS, TREE LINES, FENCE LINES, ETC.) TAKEN FROM AERIAL SURVEY PREPARED BY MCKENZIE SNYDER. DATE OF AERIAL PHOTOGRAPHY: FEBRUARY 18, 2017. EXISTING CONDITIONS WITHIN THE POND AREAS, BASED ON MULTIPLE FIELD SURVEYS BY H&B SURVEYING AND MAPPINGS LLC, FLORA SURVEYING ASSOCIATES, RYAN CONSTRUCTION, AND GLOVER CONSTRUCTION, COLLECTED FROM 2017 THROUGH 2020, AND COMPILED BY GOLDER ASSOCIATES.
7. BORON ANALYTICAL DATA COLLETED FROM MARCH 2 - MAY 7, 2020. RESULTS ARE PRESENTED IN MICROGRAMS PER LITER (ug/l)
8. VA GPS=250 ug/l

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CLIENT
DOMINION ENERGY
BREMO POWER STATION
FLUVANNA COUNTY, VIRGINIA

PROJECT
ACM FIELD INVESTIGATION REPORT

TITLE
EAST POND BORON ISOCONCENTRATION CONTOURS
MARCH - MAY 2020

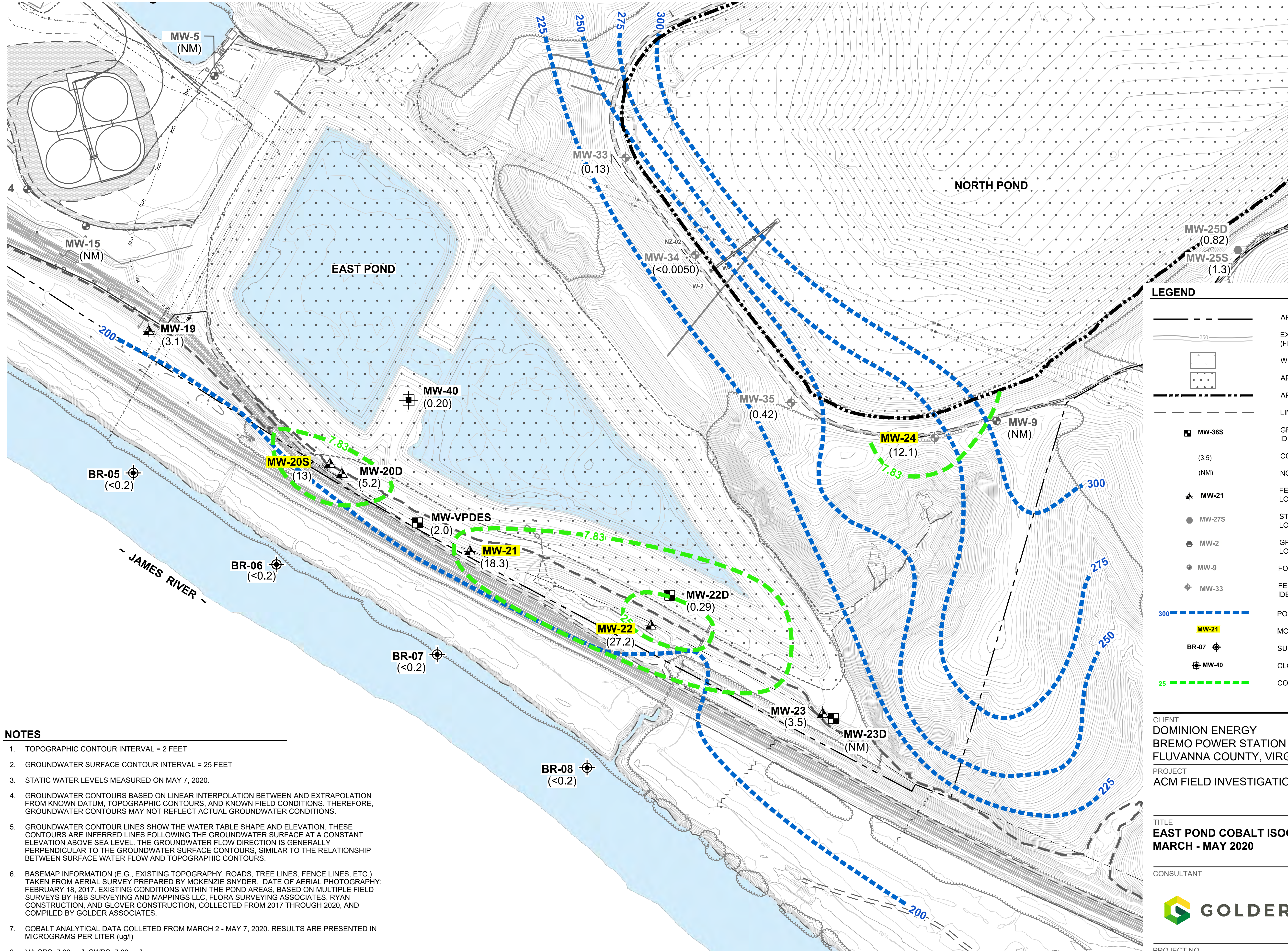
CONSULTANT

GOLDER

YYYY-MM-DD	2020-07-15
DESIGNED	HDE
PREPARED	SIB
REVIEWED	MGW
APPROVED	MGW

PROJECT NO.	REV.	FIGURE
20-140438	0	5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D



LEGEND

	APPROXIMATE PROPERTY BOUNDARY
250	EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS) (FROM AERIAL SURVEY - SEE NOTE 6)
	WETLANDS
	APPROXIMATE LIMITS OF EXISTING ASH PONDS
	APPROXIMATE LIMITS OF NORTH ASH POND FILL
	LIMITS OF 100-YR FLOOD PLAIN
MW-36S	GROUNDWATER OBSERVATION WELL LOCATION AND IDENTIFICATION
(3.5)	COBALT CONCENTRATION (ug/l)
(NM)	NOT MEASURED
MW-21	FEDERAL CCR RULE COMPLIANCE WELL LOCATION AND IDENTIFICATION - EAST POND
MW-27S	STATE GROUNDWATER COMPLIANCE WELL LOCATION AND IDENTIFICATION
MW-2	GROUNDWATER OBSERVATION WELL LOCATION AND IDENTIFICATION
MW-9	FORMER VPDES MONITORING WELL
MW-33	FEDERAL CCR RULE COMPLIANCE WELL LOCATION AND IDENTIFICATION - NORTH POND
300	POTENTIOMETRIC SURFACE CONTOURS
MW-21	MONITORING WELL WITH COBALT GPS EXCEEDENCE
BR-07	SURFACE WATER MONITORING LOCATION
MW-40	CLOSURE DEMONSTRATION WELL
25	COBALT ISOCONCENTRATION CONTOUR

NOTES

1. TOPOGRAPHIC CONTOUR INTERVAL = 2 FEET
2. GROUNDWATER SURFACE CONTOUR INTERVAL = 25 FEET
3. STATIC WATER LEVELS MEASURED ON MAY 7, 2020.
4. GROUNDWATER CONTOURS BASED ON LINEAR INTERPOLATION BETWEEN AND EXTRAPOLATION FROM KNOWN DATUM, TOPOGRAPHIC CONTOURS, AND KNOWN FIELD CONDITIONS. THEREFORE, GROUNDWATER CONTOURS MAY NOT REFLECT ACTUAL GROUNDWATER CONDITIONS.
5. GROUNDWATER CONTOUR LINES SHOW THE WATER TABLE SHAPE AND ELEVATION. THESE CONTOURS ARE INFERRED LINES FOLLOWING THE GROUNDWATER SURFACE AT A CONSTANT ELEVATION ABOVE SEA LEVEL. THE GROUNDWATER FLOW DIRECTION IS GENERALLY PERPENDICULAR TO THE GROUNDWATER SURFACE CONTOURS, SIMILAR TO THE RELATIONSHIP BETWEEN SURFACE WATER FLOW AND TOPOGRAPHIC CONTOURS.
6. BASEMAP INFORMATION (E.G., EXISTING TOPOGRAPHY, ROADS, TREE LINES, FENCE LINES, ETC.) TAKEN FROM AERIAL SURVEY PREPARED BY MCKENZIE SNYDER. DATE OF AERIAL PHOTOGRAPHY: FEBRUARY 18, 2017. EXISTING CONDITIONS WITHIN THE POND AREAS, BASED ON MULTIPLE FIELD SURVEYS BY H&B SURVEYING AND MAPPINGS LLC, FLORA SURVEYING ASSOCIATES, RYAN CONSTRUCTION, AND GLOVER CONSTRUCTION, COLLECTED FROM 2017 THROUGH 2020, AND COMPILED BY GOLDER ASSOCIATES.
7. COBALT ANALYTICAL DATA COLLETED FROM MARCH 2 - MAY 7, 2020. RESULTS ARE PRESENTED IN MICROGRAMS PER LITER (ug/l)
8. VA GPS=7.83 ug/l; GWPS=7.83 ug/l

CLIENT
DOMINION ENERGY
BREMO POWER STATION
FLUVANNA COUNTY, VIRGINIA

PROJECT
ACM FIELD INVESTIGATION REPORT

TITLE
EAST POND COBALT ISOCONCENTRATION CONTOURS
MARCH - MAY 2020

CONSULTANT
GOLDER

YYYY-MM-DD	2020-07-15
DESIGNED	HDE
PREPARED	SIB
REVIEWED	MGW
APPROVED	MGW

PROJECT NO.	REV.	FIGURE
20-140438	0	6

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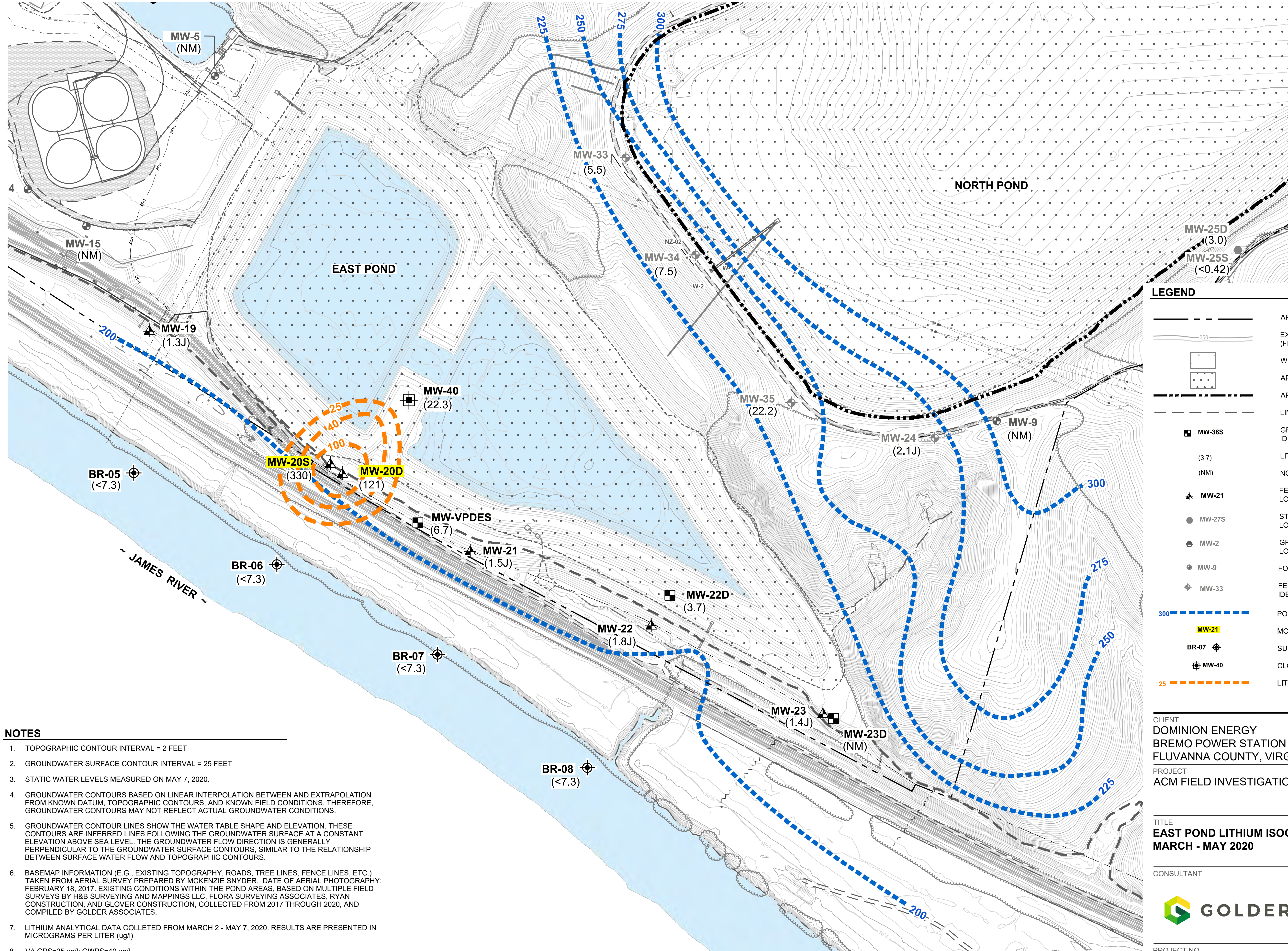
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D



NOTES

1. TOPOGRAPHIC CONTOUR INTERVAL = 2 FEET
2. GROUNDWATER SURFACE CONTOUR INTERVAL = 25 FEET
3. STATIC WATER LEVELS MEASURED ON MAY 7, 2020.
4. GROUNDWATER CONTOURS BASED ON LINEAR INTERPOLATION BETWEEN AND EXTRAPOLATION FROM KNOWN DATUM, TOPOGRAPHIC CONTOURS, AND KNOWN FIELD CONDITIONS. THEREFORE, GROUNDWATER CONTOURS MAY NOT REFLECT ACTUAL GROUNDWATER CONDITIONS.
5. GROUNDWATER CONTOUR LINES SHOW THE WATER TABLE SHAPE AND ELEVATION. THESE CONTOURS ARE INFERRED LINES FOLLOWING THE GROUNDWATER SURFACE AT A CONSTANT ELEVATION ABOVE SEA LEVEL. THE GROUNDWATER FLOW DIRECTION IS GENERALLY PERPENDICULAR TO THE GROUNDWATER SURFACE CONTOURS, SIMILAR TO THE RELATIONSHIP BETWEEN SURFACE WATER FLOW AND TOPOGRAPHIC CONTOURS.
6. BASEMAP INFORMATION (E.G., EXISTING TOPOGRAPHY, ROADS, TREE LINES, FENCE LINES, ETC.) TAKEN FROM AERIAL SURVEY PREPARED BY MCKENZIE SNYDER. DATE OF AERIAL PHOTOGRAPHY: FEBRUARY 18, 2017. EXISTING CONDITIONS WITHIN THE POND AREAS, BASED ON MULTIPLE FIELD SURVEYS BY H&B SURVEYING AND MAPPINGS LLC, FLORA SURVEYING ASSOCIATES, RYAN CONSTRUCTION, AND GLOVER CONSTRUCTION, COLLECTED FROM 2017 THROUGH 2020, AND COMPILED BY GOLDER ASSOCIATES.
7. LITHIUM ANALYTICAL DATA COLLETED FROM MARCH 2 - MAY 7, 2020. RESULTS ARE PRESENTED IN MICROGRAMS PER LITER (ug/l)
8. VA GPS=25 ug/l; GWPS=40 ug/l

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LEGEND

	APPROXIMATE PROPERTY BOUNDARY
250	EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS) (FROM AERIAL SURVEY - SEE NOTE 6)
	WETLANDS
	APPROXIMATE LIMITS OF EXISTING ASH PONDS
	APPROXIMATE LIMITS OF NORTH ASH POND FILL
	LIMITS OF 100-YR FLOOD PLAIN
MW-36S	GROUNDWATER OBSERVATION WELL LOCATION AND IDENTIFICATION
(3.7)	LITHIUM CONCENTRATION (ug/l)
(NM)	NOT MEASURED
MW-21	FEDERAL CCR RULE COMPLIANCE WELL LOCATION AND IDENTIFICATION - EAST POND
MW-27S	STATE GROUNDWATER COMPLIANCE WELL LOCATION AND IDENTIFICATION
MW-2	GROUNDWATER OBSERVATION WELL LOCATION AND IDENTIFICATION
MW-9	FORMER VPDES MONITORING WELL
MW-33	FEDERAL CCR RULE COMPLIANCE WELL LOCATION AND IDENTIFICATION - NORTH POND
300	POTENTIOMETRIC SURFACE CONTOURS
MW-21	MONITORING WELL WITH LITHIUM GPS EXCEEDENCE
BR-07	SURFACE WATER MONITORING LOCATION
MW-40	CLOSURE DEMONSTRATION WELL
25	LITHIUM ISOCONCENTRATION CONTOUR

CLIENT
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BREMO POWER STATION
FLUVANNA COUNTY, VIRGINIA

PROJECT
ACM FIELD INVESTIGATION REPORT

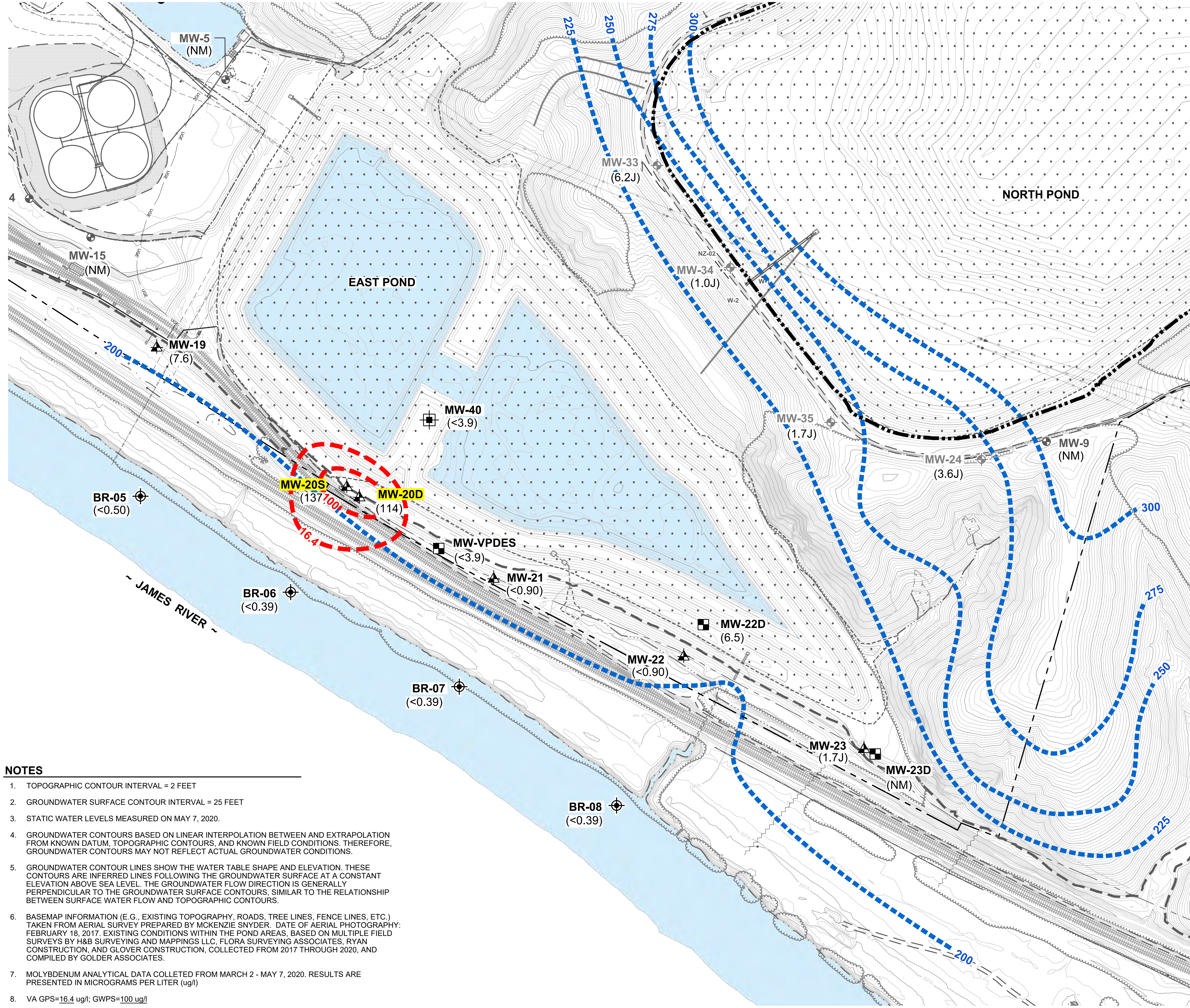
TITLE
EAST POND LITHIUM ISOCONCENTRATION CONTOURS
MARCH - MAY 2020

CONSULTANT
GOLDER

YYYY-MM-DD	2020-07-15
DESIGNED	HDE
PREPARED	SIB
REVIEWED	MGW
APPROVED	MGW

PROJECT NO.	REV.	FIGURE
20-140438	0	7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D



SCALE 120 0 120 240 FEET

LEGEND

	APPROXIMATE PROPERTY BOUNDARY
250	EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS) (FROM AERIAL SURVEY - SEE NOTE 6)
	WETLANDS
	APPROXIMATE LIMITS OF EXISTING ASH PONDS
	APPROXIMATE LIMITS OF NORTH ASH POND FILL
	LIMITS OF 100-YR FLOOD PLAIN
MW-36S	GROUNDWATER OBSERVATION WELL LOCATION AND IDENTIFICATION
(114)	MOLYBDENUM CONCENTRATION (ug/l)
(NM)	NOT MEASURED
MW-21	FEDERAL CCR RULE COMPLIANCE WELL LOCATION AND IDENTIFICATION - EAST POND
MW-27S	STATE GROUNDWATER COMPLIANCE WELL LOCATION AND IDENTIFICATION
MW-2	GROUNDWATER OBSERVATION WELL LOCATION AND IDENTIFICATION
MW-9	FORMER VPDES MONITORING WELL
MW-33	FEDERAL CCR RULE COMPLIANCE WELL LOCATION AND IDENTIFICATION - NORTH POND
300	POTENTIOMETRIC SURFACE CONTOURS
MW-21	MONITORING WELL WITH MOLYBDENUM GPS EXCEEDENCE
BR-07	SURFACE WATER MONITORING LOCATION
MW-40	CLOSURE DEMONSTRATION WELL
100	MOLYBDENUM ISOCONCENTRATION CONTOUR

NOTES

1. TOPOGRAPHIC CONTOUR INTERVAL = 2 FEET
2. GROUNDWATER SURFACE CONTOUR INTERVAL = 25 FEET
3. STATIC WATER LEVELS MEASURED ON MAY 7, 2020.
4. GROUNDWATER CONTOURS BASED ON LINEAR INTERPOLATION BETWEEN AND EXTRAPOLATION FROM KNOWN DATUM, TOPOGRAPHIC CONTOURS, AND KNOWN FIELD CONDITIONS. THEREFORE, GROUNDWATER CONTOURS MAY NOT REFLECT ACTUAL GROUNDWATER CONDITIONS.
5. GROUNDWATER CONTOUR LINES SHOW THE WATER TABLE SHAPE AND ELEVATION. THESE CONTOURS ARE INFERRED LINES FOLLOWING THE GROUNDWATER SURFACE AT A CONSTANT ELEVATION ABOVE SEA LEVEL. THE GROUNDWATER FLOW DIRECTION IS GENERALLY PERPENDICULAR TO THE GROUNDWATER SURFACE CONTOURS, SIMILAR TO THE RELATIONSHIP BETWEEN SURFACE WATER FLOW AND TOPOGRAPHIC CONTOURS.
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7. MOLYBDENUM ANALYTICAL DATA COLLETED FROM MARCH 2 - MAY 7, 2020. RESULTS ARE PRESENTED IN MICROGRAMS PER LITER (ug/l)
8. VA GPS=16.4 ug/l; GWPS=100 ug/l

CLIENT
DOMINION ENERGY
BREMO POWER STATION
FLUVANNA COUNTY, VIRGINIA

PROJECT
ACM FIELD INVESTIGATION REPORT

TITLE
EAST POND MOLYBDENUM ISOCONCENTRATION CONTOURS MARCH - MAY 2020

CONSULTANT
GOLDER

YYYY-MM-DD	2020-07-15
DESIGNED	HDE
PREPARED	SIB
REVIEWED	MGW
APPROVED	MGW

PROJECT NO. 20-140438 | REV. 0 | FIGURE 8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

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GOLDER

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