Alabama Power

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July 11, 2019

Mr. Eric L. Sanderson, P. E., Chief
Solid Waste Branch
Alabama Department of Environmental Management
1400 Coliseum Boulevard
Montgomery, Alabama 36110-2400

Re: Assessment of Corrective Measures for the Plant Gaston Ash Pond

Dear Mr. Sanderson:

Alabama Power Company is the owner and operator of the Plant Gaston Ash Pond, located at Wilsonville, Alabama. Pursuant to 40 CFR § 257.96, rule 335-13-15-.06(7) of the regulations of the Alabama Department of Environmental Management (ADEM), and Paragraph C of ADEM Administrative Order No. 18-095-GW, please find enclosed an Assessment of Corrective Measures (ACM) for the Plant Gaston Ash Pond.

The ACM is the first step in developing a long-term corrective action plan to address exceedances of groundwater protection standards (GWPS) identified at the site. As part of the ACM, potential groundwater corrective measures were identified and evaluated based on the criteria outlined in § 257.96(c) and r. 335-13-15-.06(7)(c). The closure plan for the Plant Gaston Ash Pond, as reflected in the permit application package filed at ADEM in December 2018, was also considered because source control activities are integral to the long-term corrective action plan and will influence corrective measures performance at the site. In addition, Alabama Power will use other advanced engineering technologies beyond the minimum requirements of the CCR rule to accelerate water removal, provide additional flood protection, and seal off vertical access with an impermeable cap.

As proposed in the December permit application and the updated package to be submitted on July 15, 2019, Alabama Power plans to close the Plant Gaston Ash Pond by dewatering, excavating, consolidating, and capping the ash within an impermeable composite cover system to prevent infiltration. Dewatering will consist of removing the free liquids from the pond, which will reduce the volume of water available to potentially migrate from the ash pond during closure and minimize the hydraulic head within the pond, thereby reducing pressure to cause any migration from the pond. As part of ash consolidation, the closure plan proposes to excavate ash and move it to an area of higher elevation to create a buffer of up to 330 yards from the river. Construction will require the movement of approximately 7 million cubic yards of ash within the unit (out of a total volume of some 24 million cubic yards of material). The process will reduce the footprint of the area covered by approximately 75 acres, or by more than a fourth. Alabama Power will construct an advanced engineering feature of a reinforced dike system between the closure area and the river to increase flood protection. A drain system will be installed at the base of the excavation areas to collect any remaining leachate. The system and associated pump stations will remain post-closure for long term protection. These technologies provide robust source control. Ongoing groundwater monitoring will provide important information that will ensure the remediation goals of the long-term corrective action plan are being met.

To meet the requirements of Part C of the Administrative Order, and after a thorough consideration of available corrective measures, Alabama Power is proposing a remedial system that consists of combined source control and monitored natural attenuation at the site. The dewatering and enhanced closure design of the Plant Gaston Ash Pond are expected to reduce the source contribution to groundwater such that the attenuation may be all that is needed to achieve the GWPS in a reasonable timeframe. However, using an adaptive site management process, site conditions will be monitored and necessary adjustments will be made, leading to continuous improvements in the corrective measures performance. The closure configuration includes space between the capped area and the outer dike, should Alabama Power identify a need for further action in that area.

Thank you for your consideration. Please feel free to contact me if Alabama Power can provide additional information or answer any questions.

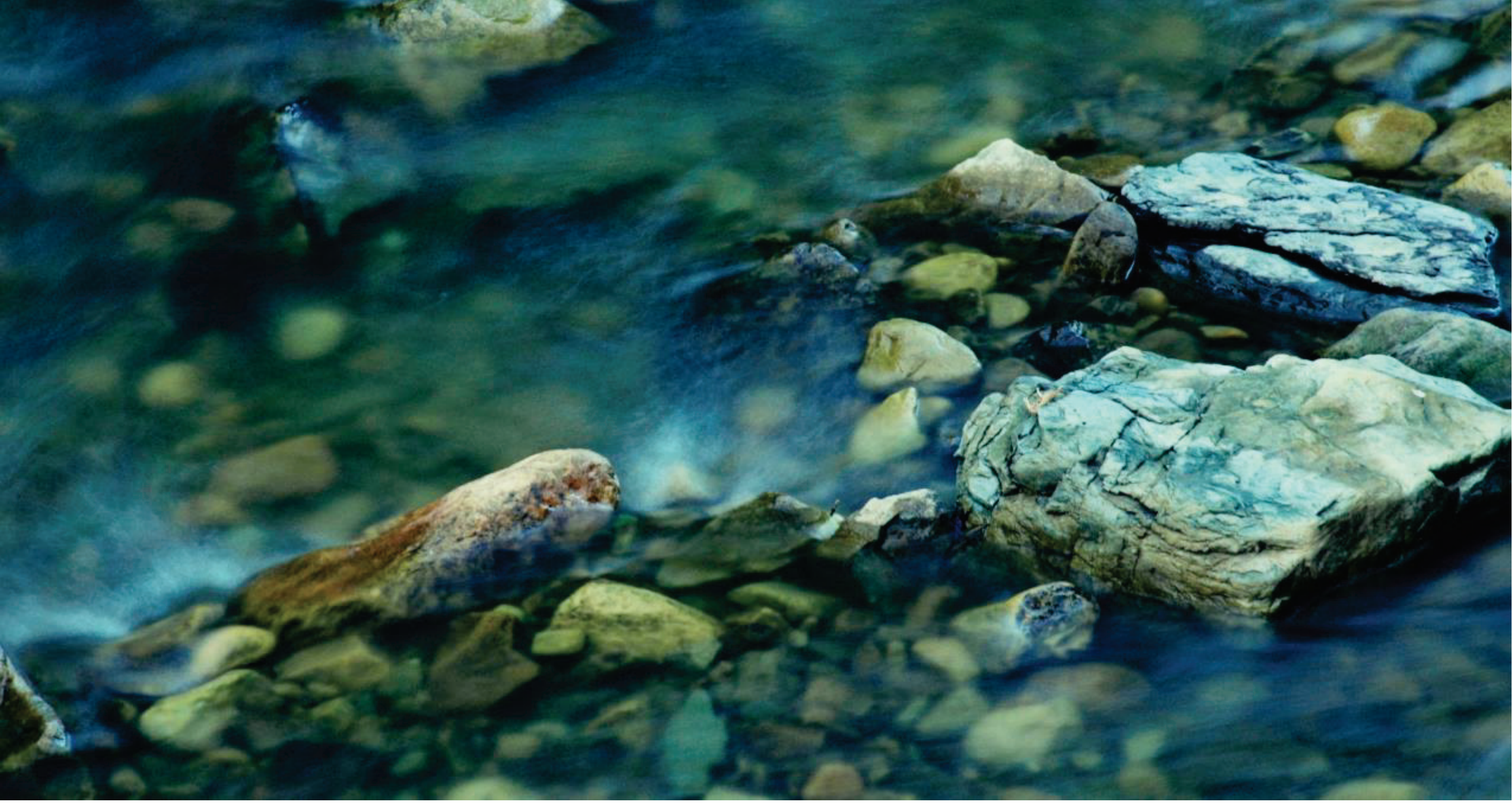
Sincerely,

Susan B. Comensky

Susan B. Comensky

Enclosures

cc w/enc.: Heather Jones
Scott Story



June 2019
Plant Gaston

Assessment of Corrective Measures
Plant Gaston

Prepared for Alabama Power Company

June 2019
Plant Gaston

Assessment of Corrective Measures
Plant Gaston

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ABBREVIATIONS

ACM	Assessment of Corrective Measures
ADEM	Alabama Department of Environmental Management
Admin. Code	Administrative Code
CCR	coal combustion residuals
CCR rule	80 Federal Register 21302 (April 17, 2015); "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities"
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act, or Superfund
CFR	Code of Federal Regulations
cm/sec	centimeters per second
CMS	Corrective Measures Study
CSM	conceptual site model
EPRI	Electric Power Research Institute
FeS_2	pyrite
GWPS	groundwater protection standard
MNA	monitored natural attenuation
MSL	mean sea level
PRB	permeable reactive barrier
RCRA	Resource Conservation and Recovery Act
RCRA FIRST Toolbox	*Resource Conservation and Recovery Act Facilities Investigation Remedy Selection Track: A Toolbox for Corrective Action*
Site	Plant Gaston
SSI	statistically significant increase
SSL	statistically significant level
USEPA	U.S. Environmental Protection Agency

1 Introduction

This Assessment of Corrective Measures (ACM) has been prepared pursuant to the U.S. Environmental Protection Agency (USEPA) coal combustion residuals (CCR) rule (40 Code of Federal Regulations [CFR] Part 257 Subpart D), Alabama Department of Environmental Management's (ADEM's) Administrative Code (Admin. Code) r. 335-13-15, and an Administrative Order issued by ADEM (AO 18-095-GW) to evaluate potential groundwater corrective measures for the occurrence of arsenic, lithium, and molybdenum in groundwater at statistically significant levels (SSLs) at Plant Gaston (Site).

Specifically, this ACM is prepared pursuant to 40 CFR 257.96, ADEM Admin. Code r. 335-13-15-.06(7), and Part C of the Administrative Order. Pursuant to the requirements of Part C of the Administrative Order, this ACM also "include(s) the remedy proposed to the Department for approval."

This ACM was initiated within 90 days of identifying the SSLs on January 13, 2019; a 60-day extension until June 12, 2019, for completion of the ACM was documented on April 12, 2019.

This ACM is the first step in developing a long-term corrective action plan to address exceedances of groundwater protection standards (GWPS) identified at the Site. Based on the results of the ACM, further evaluation will be performed, site-specific studies completed, and a final long-term corrective action plan developed and implemented pursuant to 40 CFR 257.97–98 and ADEM Admin. Code r. 335-13-15-.06(8) and (9).

In addition to the corrective measures discussed in this ACM, APC will close the Ash Pond by excavation and consolidation of the unit's CCR material into a smaller area located within the current footprint of the Ash Pond. A final cover system will be installed that is designed to minimize infiltration and erosion. A summary of the Closure Plan was published to APC's CCR compliance webpage in November 2016.

Completing a final long-term corrective action frequently takes several years. Therefore, corrective measures presented herein can be applied as warranted based on site conditions during closures and while implementing a long-term corrective action strategy to meet remedial objectives at the Site.

1.1 Purpose and Approach

The purpose of this ACM is to begin the process of selecting corrective measure(s). This process may be composed of multiple components to analyze the effectiveness of corrective measures and to address the potential prior migration of CCR constituents to groundwater at the Site.

The CCR rule (40 CFR 257 Subpart D), ADEM Admin. Code (r. 335-13-15), and ADEM Administrative Order No. 18-095-GW provide requirements for an ACM. In addition, the subsequent 2016 USEPA report entitled *Resource Conservation and Recovery Act Facilities Investigation Remedy Selection Track: A Toolbox for Corrective Action* (RCRA FIRST Toolbox; USEPA 2016) provides general guidance for conducting a Corrective Measures Study (CMS) at Resource Conservation and Recovery Act (RCRA) facilities. Because a CMS is equivalent to an ACM, ACM will be used in this report for consistency with the CCR rule terminology. The RCRA FIRST Toolbox (USEPA 2016) describes three approaches for assessing the need for, or performing, an ACM at RCRA facilities:

1. **No ACM:** "This is a likely outcome when interim measures are suitable for the final remedy, when post-closure will include provisions for corrective action, or when the only additional requirements are institutional controls" (USEPA 2016). Examples where an ACM is not likely to be needed include the following:
   a. Low risk facilities
   b. Excavation/removal remedies
   c. Presumptive remedies/proven effective remedies in similar cases
2. **Limited ACM:** In some cases, the final remedy may be obvious, but additional field work, bench-scale testing, or pilot testing may be required to support the final decision. The RCRA FIRST Toolbox includes a path for additional study without requiring a full ACM.
3. **Full ACM:** USEPA recommends that a full ACM be used only when more than one viable alternative exists to meet site cleanup and other criteria. USEPA discourages creating alternatives (such as No Action) for comparison purposes only.

According to the RCRA FIRST Toolbox (USEPA 2016), a full ACM is not required in every case, and determining the appropriate level of study is the first step in an ACM. Because four Appendix IV constituents (arsenic, lithium, and molybdenum) were identified at the Site and several technologies are available for addressing the constituents, a full and thorough ACM was performed for the Site.

Per USEPA (2016) guidance, corrective measures that were clearly not viable were not evaluated. Initial steps in the ACM included analyzing existing Site information and developing a conceptual site model (CSM). Closure and source control plans were also considered since those activities are integral to the long-term strategy and will influence groundwater corrective measures performance. Potential groundwater correction measures were then identified and evaluated against the applicable criteria.

Frequently used technologies that are unlikely to perform satisfactorily or reliably at the Site, or that are technically impractical to implement were not thoroughly evaluated as part of this ACM. A brief explanation is provided for each remedy not thoroughly evaluated. Though several technologies and combinations of these technologies appear viable for the Site, further evaluation of the technologies is needed to identify a remedy (or remedies) that may be implemented as part of a long-term corrective action plan.

1.2 Remedy Evaluation Criteria

Once potential remedies were identified, they were evaluated using the criteria outlined in 40 CFR 257.96 and ADEM Admin. Code r. 335-13-15-.06(7), which state that the ACM should include an analysis of the effectiveness of potential corrective measures that considers the following:

- Performance
- Reliability
- Ease of implementation
- Potential impacts of the remedy (including safety, cross-media, and exposure)
- The time required to begin and complete the remedy
- Any institutional requirements (e.g., permitting or environmental and public health requirements) that could affect implementation of the remedy

These evaluation criteria, discussed in more detail in the following sections, were considered for each potential remedy.

1.2.1 Performance

Factors taken into consideration when determining the performance of a remedy include the degree to which the remedy removes released Appendix IV constituents from the environment and the ability of the remedy to achieve GWPS at compliance boundaries.

1.2.2 Reliability

Reliability includes the type and degree of long-term management (e.g., monitoring, operations, and maintenance) of a remedy, the reliability of the engineering and institutional controls to maintain the effectiveness of the remedy, potential need for replacement, or any other operational reliability issues that may arise for the remedy that will limit its use or effectiveness in meeting the corrective action objectives.

1.2.3 Ease of Implementation

Ease of implementation includes the degree of difficulty associated with installing or constructing a remedy due to Site conditions, including the need to obtain necessary approvals and/or permits from other agencies, the availability of necessary equipment and/or specialists to implement the remedy, and the available capacity and location of treatment, storage, or disposal services, if needed.

1.2.4 Potential Impacts of the Remedy

Potential impacts of a remedy include the short-term risks that might be posed to the community or the environment during implementation of the remedy (e.g., due to excavation, transportation, disposal, or containment of CCR material), potential for exposure of humans and environmental receptors to remaining CCR material following implementation of the remedy, and cross-media impacts due to the remedy.

1.2.5 Time Required to Begin and Complete the Remedy

The time required to begin and complete a remedy considers the amount of time needed to completely design and implement (i.e., begin) the remedy as well as the time it will take the implemented remedy to achieve applicable GWPS at compliance points.

1.2.6 Institutional, Environmental, or Public Health Requirements

Institutional requirements can vary from site to site and technology to technology. Any state, local, or site-specific requirements (e.g., permits), or other environmental or public health requirements, that could substantially affect construction or implementation of the remedy are considered.

2 Site Background and Characteristics

2.1 Location

Alabama Power Company's E.C. Gaston Electric Generating Plant is located in Shelby County, Alabama, near the city of Wilsonville. The physical address is 31972 Alabama Highway 25, Wilsonville, Alabama 35186. Plant Gaston lies in Sections 21, 22, 27, 28, 29, 32, 33, and 34, Township 20 South, Range 2 East and Sections 4, 5, and 6 Township 21 South, Range 2 East. Section/Township/Range data are based on visual inspection of U.S. Geological Survey topographic quadrangle maps and GIS maps (USGS 2018a, 2018b).

The Ash Pond is located south-southwest of the main plant along the Coosa River. Figure 1 depicts the location of the Site with respect to the surrounding area. The Ash Pond was originally constructed in the early 1950s, and the area designated for ash storage and disposal currently includes about 263 acres.

2.2 Site History

The Site is an electricity generating facility that includes coal-fired and gas-fired units. The Ash Pond received and stored CCR produced during the coal-fired electricity generating process. It also served as a low-volume waste treatment pond for the plant, receiving process water and stormwater from various plant sources, sluiced ash, and decant water from the gypsum pond. As of April 15, 2019, the Ash Pond ceased receipt of all CCR and non-CCR wastestreams. Per ADEM Admin. Code r. 335-13-15-.09, Alabama Power Company submitted a closure plan for the Ash Pond to ADEM for review and approval, as part of the permitting package.

The Ash Pond was formed by excavating predetermined zones to elevations ranging from 389 feet above mean sea level (MSL) to 418 feet MSL, with much of the center zone having no excavation. Material for the embankment construction was excavated from within the ash pond area adjacent to the embankments. The dike fill material consists mainly of clay. The depth of the fill extends up to depths of approximately 50 feet at its deepest point. In the late 1980s, the impoundment was reconfigured to the arrangement that is currently used today.

2.3 Hydrogeological Conceptual Site Model and Groundwater Flow

The major components of the hydrogeological CSM include (Southern Company Services 2018a) the following:

- Geologic Unit 1 (Figures 2a and 2b)—Predominantly overburden silty or sandy, lean to fat clays that grade into gravelly clays; overburden soil thickness generally between 11 and 63 feet; vertical hydraulic conductivities ranging from 1.53×10^{-8} to 9.97×10^{-5} cm/sec and horizontal hydraulic conductivities (from slug tests) ranging from 4.27×10^{-8} to 1.37×10^{-4} cm/sec ; may provide localized upper confining or leaky confining conditions for uppermost aquifer

- Geologic Unit 2 (Uppermost Aquifer)—Known locally as the Knox Dolomite, a portion of the Valley and Ridge Aquifer System; described as fine-grained to micritic, fractured dolomites; top of bedrock elevation occurs between 388 and 401 feet MSL; located 35 to 125 feet below the ground surface; consisting of fractured dolomites of the Knox Group
- Groundwater Flow Characteristics:
  - Groundwater flow is accomplished primarily by fracture flow.
  - Sources of recharge are largely from infiltration of precipitation.
  - Groundwater flows generally towards the north, west, and east.
  - Twelve slug tests were performed to estimate the horizontal hydraulic conductivity of the uppermost aquifer. Calculated horizontal hydraulic conductivities ranged from 4.79×10^{-6} to 8.15×10^{-4} cm/sec, with an average of 1.39×10^{-4} cm/sec.
  - Calculations of groundwater flow rates range between 0.03 and 0.16 feet/day, a relatively slow rate.

Groundwater elevations fluctuate in response to rainfall infiltration. Seasonal variations of 0.25 to 14 feet are typical at the Site. Monitoring wells located along the Coosa River typically display the least variation. This is likely due to the well-maintained level of the Coosa River stabilizing groundwater water levels over time. During gauging events, wells GN-AP-MW-12, GN-AP-MW-13, and GN-AP-MW-17 consistently displayed artesian conditions. Groundwater flow direction is consistent despite seasonal fluctuations. Groundwater elevation data indicate that water levels tend to be higher in the spring and early summer and lower during the fall and winter seasons (Southern Company Services 2018a). A typical potentiometric surface map is presented in Figure 3. Table 1 provides a summary of historical groundwater elevation data for the Site.

2.4 Delineation of Appendix IV Constituents

The groundwater monitoring network is composed of 22 monitoring wells installed around the Ash Pond (Figure 3 and Table 2): 3 upgradient and 19 downgradient. Monitoring well locations GN-AP-MW-1 through GN-AP-MW-3 serve as upgradient locations for the Ash Pond, as determined by water level monitoring and potentiometric surface maps constructed for the Site. Upgradient wells are screened within the same uppermost aquifer as downgradient locations and are representative of background groundwater quality at the Site. Monitoring well locations GN-AP-MW-4 through GN-AP-MW-22 are utilized as downgradient locations for the Ash Pond, as determined by water level monitoring and potentiometric surface maps constructed for the Site.

Background sampling occurred between March 2016 and June 2017. Compliance detection sampling began following completion of background sampling, with sampling occurring in August 2017. Statistically significant increases (SSIs) of Appendix III constituents were noted during the August 2017 compliance detection sampling event, as described in the *2017 Annual Groundwater Monitoring and Corrective Action Report* (Southern Company Services 2018b). The Appendix III SSIs triggered assessment sampling for Appendix IV constituents, with sampling events occurring in January, April, and October 2018. Appendix III and IV Maximum Contaminant Level and CCR-rule-specified GWPS values are shown in Table 3. The April and October 2018 sampling events noted Appendix IV constituents arsenic, lithium, and molybdenum above GWPS. SSLs above the GWPS for arsenic (0.01 mg/L), lithium (0.04 mg/L), molybdenum, and (0.1 mg/L) from the April and October 2018 sampling events are summarized as follows (Tables 4 and 5):

- Arsenic was reported at SSLs above the GWPS at the following monitoring well for both April and October 2018 sampling events: GN-AP-MW-17.
- Lithium was reported at SSLs above the GWPS at the following monitoring wells for both April and October 2018 sampling events: GN-AP-MW-16, GN-AP-MW-17, and GN-AP-MW-20.
- Molybdenum was reported at SSLs above the GWPS at the following monitoring wells for both April and October 2018 sampling events: GN-AP-MW-5, GN-AP-MW-16, GN-AP-MW-17, and GN-AP-MW-20.

As the above indicates, Appendix IV SSLs are generally relegated to the eastern areas of the Site with one well exhibiting a GWPS exceedance to the west of the Site. To delineate groundwater impacts in these areas, an additional delineation network consisting of five vertical delineation wells and two horizontal delineation wells installed at locations downgradient of monitoring wells where Appendix IV SSIs were observed. Additionally, one pre-existing deep piezometer was utilized for vertical delineation and two pre-existing piezometers utilized for horizontal delineation west of the Site. Vertical delineation wells were installed within the Unit 2 Knox Dolomite and off-set from locations GN-AP-MW-17 and GN-AP-MW-20 consisted of a shallow and deep vertical delineation well pair. Three vertical delineation wells were installed at the waste boundary, offset (10 to 20 feet) from select monitoring wells where SSIs were observed. Horizontal delineation wells were installed within zones of increased weathering or fracturing and potentially preferential groundwater flow. Three horizontal delineation locations were installed adjacent to the Coosa River. The remaining two horizontal delineation locations were stepped out 175 to 250 feet from the western edge of the ash pond.

To discern the nature of source, porewater samples from three locations within the ash pond were collected and analyzed for Appendix III and IV constituents.

Additionally, data derived from vertical delineation efforts to date have indicated some potential for naturally derived sources of arsenic, molybdenum, and lithium. Additional investigations are underway to further explore lines of evidence for an alternate source of these constituents and an alternate source demonstration may be performed.

2.5 Pond Closure – Source Control

Closure of the Plant Gaston Ash Pond will be accomplished by dewatering, consolidating, and capping the ash with a final cover system. Dewatering is estimated to last several years. The mechanical treatment system will be adjusted to 1) control ash pond drawdown at a rate to ensure structural integrity of the impoundment is maintained as determined by the Dam Safety Engineer; and 2) manage fluctuating site conditions due to the decrease of the ash pond volume as well as the addition of rainfall. The Plant Gaston Ash Pond will be closed by leaving CCR in place and consolidating the current site footprint of approximately 269 acres to an area of approximately 193 acres. The current closure plan estimates that dewatering, consolidating, and capping will be completed in 2030.

As part of closure, the ash will be dewatered sufficiently to remove the free liquids. Removing free liquids will reduce the volume of water available to migrate from the ash pond during closure and minimize hydraulic head within the pond, thereby reducing pressure to cause migration from the Ash Pond. CCR will be consolidated into a smaller footprint and graded to create a subgrade for the final cover system. Excavation will include removing all visible ash and over excavating into the subgrade soils.

The final cover will be constructed to control, minimize, or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and potential releases of CCR from the unit. This will be prevented by providing sufficient grades and slopes to: 1) preclude the probability of future impoundment of water, slurry, or sediment; 2) ensure slope and cover system stability; 3) minimize the need for further maintenance; and 4) be completed in the shortest amount of time consistent with recognized and generally accepted good engineering practices.

The final cover system will be designed to minimize infiltration and erosion. The final cover system, at a minimum, will be designed to meet or exceed the requirements of r. 335-13-15-.07(3)(d)3.(ii) (alternative cover system). Current design for the cover system is the synthetic ClosureTurf® cover system that utilizes a 50-mil LLDPE geomembrane overlain by an engineered synthetic turf. The synthetic turf will contain a minimum ½ inch sand infill. The permeability of the final cover system will be less than the permeability of the natural subsoils beneath the surface impoundment. Final design will ensure the disruption of the integrity of the final cover system is minimized through a design that accommodates settlement and subsidence, in addition to providing an upper component for protection from wind or water erosion.

3 Groundwater Corrective Measures Alternatives

3.1 Objectives of the Corrective Measures

Following 40 CFR 257.97(b) and ADEM Admin. Code r. 335-13-15-.06(8)(b), the following summarizes the criteria that must be met by the remedy:

- Protect human health and the environment.
- Attain applicable groundwater protection standards.
- Control the source of the release to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents to the environment.
- Remove from the environment as much of the material released from the CCR unit as is feasible, considering factors such as avoiding inappropriate disturbances of sensitive ecosystems.
- Comply with any relevant standards (i.e., all applicable RCRA requirements) for management of wastes generated by the remedial actions.

All corrective measures selected for evaluation for potential use at the Site are anticipated to satisfy the above performance criteria to varying degrees of effectiveness.

3.2 Potential Groundwater Corrective Measures

The following presents a summary of potential groundwater corrective measures evaluated as part of this ACM. Based on Site-specific information and knowledge of corrective alternatives, the following remedies—or combination of remedies—are being considered using the evaluation criteria specified in 40 CFR 257.96(c) and ADEM Admin. Code r. 335-13-15-.06(7)(c):

- Monitored natural attenuation (MNA)
- Hydraulic containment (pump-and-treat)
- Geochemical manipulation (via in situ injection)
- Permeation grouting

Three frequently considered remedies—(1) phytoremediation, (2) vertical barrier walls, and (3) permeable reactive barrier (PRB) walls—were not considered viable at the Site. Conventional phytoremediation for inorganic constituents may be effective for impacts at or near the ground surface, but Appendix IV SSLs occur in groundwater at depths from about 50 to greater than 100 feet. The TreeWell phytoremediation technology may be effective to depths of 50 feet (under proper conditions); however, SSLs at the site occur at depths greater than 50 feet, rendering the technology infeasible.

Vertical barrier and PRB walls are technically infeasible at the site. These technologies are generally limited to depths of approximately 100 feet. Here SSLs occur at depths greater than 100 feet, well below the depth at which these approaches are feasible. Additionally, the thickness of bedrock beneath the site precludes using these approaches with conventional technology. Therefore, based on depth and presence of bedrock, barrier and PRB walls are infeasible at the site.

3.2.1 Monitored Natural Attenuation

MNA has been a component of corrective action at RCRA and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) sites since the 1990s. MNA describes a range of physical and biological processes in the environment that reduce the concentration, toxicity, or mobility of constituents in groundwater. For inorganic constituents, the mechanisms of natural attenuation include biostabilization, sorption, dispersion, and precipitation (USEPA 1999, 2007a. 2007b). MNA as a remedial alternative depends on a good understanding of localized hydrogeologic conditions and may require considerable information and monitoring over an extended period of time. MNA is not an approach that will lead to rapid closure of a site and is frequently used in combination with other remedies at a site.

Where site conditions are conducive to MNA, it has the potential to provide a more sustainable, lower cost alternative to aggressive remediation technologies such as pump-and-treat. The Electric Power Research Institute (EPRI) has prepared a document describing implementation of MNA for 24 inorganic constituents, which includes most Appendix III and IV constituents (EPRI 2015a).

USEPA defines MNA as follows (USEPA 1999, 2015):

> The reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a timeframe that is reasonable compared to that offered by other more active methods. The "natural remediation processes" that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater.

When properly implemented, MNA removes constituents from groundwater and immobilizing them onto aquifer solids. Decisions to utilize MNA as a remedy or remedy component should be thoroughly supported by site-specific data and analysis (USEPA 1999, 2015).

According to USEPA (2015) guidance, a four-phase approach should be used to establish whether MNA can be successfully implemented at a given site. The phases (also referred to as "steps" or "tiers") include (USEPA 1999, 2007a):

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

Based on MNA case histories for inorganic constituents, MNA timeframes range from a few years to decades (EPRI 2015a). Since pond closure activities (consolidation and capping) at the Site are projected to take approximately 11 years, the timeframe for MNA would not be expected to extend well beyond the closure period.

Attenuation mechanisms can be placed in two broad categories, physical and chemical. Physical mechanisms include dilution, dispersion, flushing, and related processes. All constituents are subject to physical attenuation mechanisms, so physical processes should be considered in MNA evaluations. In its most recent guidance, USEPA (2015) discourages using dilution and dispersion as primary MNA mechanisms, as these mechanisms disperse contaminant mass rather than immobilize it. Further, USEPA (2015) advises that dilution and dispersion may be appropriate as a polishing step (e.g., at the boundaries of a plume, when source control is complete, an active remedy is being used at the Site, and appropriate land use and groundwater controls are in place).

Common chemical mechanisms of attenuation for constituents include adsorption to, or coprecipitation with, oxides and hydrous oxides (oxyhydroxides) of iron and manganese; coprecipitation with, and adsorption to, iron sulfides such as pyrite (FeS_2); and precipitation as carbonates, sulfides, sulfates, and/or phosphates (USEPA 2007b).

Arsenic, lithium, and molybdenum are subject to physical attenuation mechanisms, and arsenic, molybdenum, and possibly lithium are also chemically attenuated (e.g., by sorption to naturally occurring oxyhydroxides of iron and other metals, and by coprecipitating with common minerals such as iron sulfides). Therefore, MNA is a feasible corrective measure for groundwater at the Site.

3.2.2 Hydraulic Containment (Pump and Treat)

Hydraulic containment utilizes pumping wells (and sometimes injection wells, trenches, galleries, and/or trees) to contain and prevent the expansion of impacted groundwater. Effective hydraulic containment uses pumping wells or other subsurface hydraulic mechanisms to create a horizontal and vertical capture zone or a hydraulic barrier. Hydraulic containment is one of the most mature corrective action technologies, and it is described in *Pump-and-Treat Ground-Water Remediation: A Guide for Decision Makers and Practitioners* (USEPA 1996) and *Groundwater Contamination, Optimal Capture and Containment* (Gorelick et al. 1993). After pumping, the water may be reused in beneficial applications or treated, discharged, or reinjected.

Hydraulic containment could be implemented within the more permeable zones of Unit 2 (Knox Dolomite). Because the three constituents should be treatable by conventional technologies, pump-and-treat is a potentially viable corrective measure for groundwater at the Site.

3.2.3 Geochemical Manipulation (In Situ Injection)

Geochemical manipulation via subsurface injections is an emerging remediation technology for inorganic constituents in groundwater. Geochemical manipulation for inorganic constituents may be applied in three modes: redox manipulation; adsorption to iron or other metal oxyhydroxides under oxidizing groundwater conditions; and adsorption to, or coprecipitation with, iron or other metal sulfides under reducing conditions (sequestration in sulfides).

Redox manipulation has been applied to metals such as chromium since the 1990s, where reducing compounds are injected to chemically reduce chromium (VI) to the more benign chromium (III); (USEPA 2000; Ludwig et al. 2007). Geochemical processes such as adsorption and coprecipitation are applicable to arsenic and molybdenum, and probably lithium. In adsorption under oxidizing conditions, an iron source (such as ferrous sulfate) is injected into the subsurface and oxidizes to iron oxyhydroxides (ferrihydrite) to which contaminants adsorb (Pugh et al. 2012; Redwine et al. 2004). Due to the generally mildly reducing conditions at the Site, sequestration in sulfides may be the most viable of the geochemical manipulation technologies.

In the sequestration-in-sulfides technology, soluble sources of organic carbon, ferrous iron, and sulfate are injected into the subsurface to optimize conditions for sulfate-reducing bacteria growth (Saunders 1998). Sulfate-reducing bacteria produce sulfide minerals as a by-product of their metabolism, and constituents are removed from groundwater and immobilized by the sulfide minerals. Trace constituents substitute for other elements in the sulfide mineral structure and are adsorbed to sulfide mineral surfaces. In recent successful applications for arsenic, treatment solution containing molasses, ferrous sulfate heptahydrate, and small amounts of commercial fertilizer dissolved in unchlorinated water were injected to significantly decrease arsenic concentrations in groundwater.

The following inorganic constituents may be removed from groundwater by sulfide mineral formation: antimony, arsenic, cadmium, cobalt, copper, mercury, lead, molybdenum, nickel, selenium, thallium, and zinc, in addition to some rarer elements (Abraitis et al. 2004; EPRI 2015b). The most common sulfide minerals include the iron sulfide family (FeS, FeS_2), though many other sulfide minerals are documented.

With the possible exception of lithium, geochemical manipulation should be effective for the constituents of interest (arsenic and molybdenum). Geochemical manipulation for lithium is currently under development. However, effectiveness of the mode of sequestration (coprecipitation with sulfides, adsorption to iron oxyhydroxides, and others) may be different for the different constituents. Laboratory treatability and/or field pilot tests would be necessary to completely evaluate geochemical manipulation prior to selection as a corrective measure. Because the technology has not yet been demonstrated for large areas, its optimum application may be treatment of isolated areas (e.g., in the vicinity of a few impacted wells).

3.2.4 Permeation Grouting

Grouting is another way to construct a barrier to groundwater flow. Though there are several types of grouting, permeation grouting is likely the most applicable to groundwater corrective action at CCR settings. Permeation grouting is a method of impregnating the void space within a soil or rock mass, thereby displacing water and air from the voids and replacing it with grout and without displacing the soil particles or widening existing fractures in the rock (Wani 2015).

Permeation grouting utilizes low pressure injection to reduce the permeability and improve the strength of granular soils or fractured or solutioned (karst) rock (Keller Ground Engineering 2017). In groundwater corrective action applications, permeability (hydraulic conductivity) reduction and impeding the flow of impacted groundwater are the primary objectives. Permeation grouting can be effective in unconsolidated alluvial soils (Pearlman 1999), such as those often found at CCR settings, and in rock. In classic grouting theory in porous material such as sand and gravel, overlapping columns are constructed by grouting to create a wall. In rock, the void space to be grouted is more irregular than that in porous media, though the wall concept still applies. Grout mixtures may be particulate, chemical, or a combination of both. Particulate mixtures contain a slurry of cement and bentonite and/or other additives combined with water. Chemical grout mixtures contain a chemical base (such as sodium silicate, acrylate, and urethane), a catalyst, and solvent (typically water). Particulate grouts are generally more viscous and better suited for larger pore spaces, while chemical grouts are usually preferred for smaller voids (Pearlman 1999; USEPA 2014).

Grout barriers can be used either as stand-alone barriers to contain or control groundwater flow, or they may be used in conjunction with another type of technology. Grout may be injected at the bottom of geomembrane or PRB walls to address fracturing that may have occurred when these barriers were keyed into underlying bedrock. Grout barriers may also be installed at any angle, including horizontally, which may be beneficial at sites where there is no accessible underlying aquitard to tie into. However, maintaining continuity of the grout installation is typically more difficult for angled drilling and grouting (USEPA 1998; Pearlman 1999). Permeation grouting has been performed successfully for other applications at the Site.

3.3 Potential Remedy Evaluation

The following remedies are considered potentially feasible for corrective measures for groundwater at the Site:

- Monitored natural attenuation
- Hydraulic containment (pump and treat)
- Geochemical manipulation via injections
- Grouting

Although these technologies are potentially viable remedies, further data collection and evaluation are required to (1) verify the feasibility of each, and (2) provide sufficient information to design a corrective action system that meets the criteria specified in 40 CFR 257.97(b) and ADEM Admin. Code r. 335-13-15-.06(8)(b). Table 6 provides a summary of these technologies compared to the evaluation criteria discussed below as applied to Site conditions. Table 7 discusses advantages and disadvantages of each technology that should be considered.

3.3.1 MNA

MNA is compatible with the other groundwater corrective actions that are potentially viable for the Site. At a minimum, MNA can serve as a polishing step (USEPA 2015), which may be all that is needed at the Site due to source control and the relatively small reductions in constituent concentrations required to meet GWPS in most impacted wells.

The long-term performance of MNA requires further investigation, especially related to the identification of an attenuating mechanism, capacity of Unit 2 (Knox Dolomite) for attenuation, and time to achieve GWPS. Dewatering, consolidation, and capping of the ash pond, however, will likely reduce the source contribution to groundwater such that the attenuation capacity of Unit 2 may be sufficient to achieve GWPS in a reasonable timeframe.

Implementation of MNA at the Site will be relatively easy. Most of the wells for MNA are already in place, though a few additional wells may need to be installed to monitor progress in critical areas. Solid (e.g., aquifer) samples will need to be collected to identify attenuating mechanisms and to test capacity, permanence, and help determine the time required to achieve GWPS. Reliability of MNA will be relatively high, and potential impacts of the remedy will be negligible because MNA is non-intrusive and requires almost no operation and maintenance.

Implementation of MNA would require some geochemical studies and possibly the installation of additional wells. Because MNA does not require design and construction of infrastructure other than new monitoring wells, it can be initiated within 6 months to a year. At least 1 year of groundwater monitoring data should be collected before implementation of MNA is considered complete. The additional data would be needed for statistical analysis and to determine if additional monitoring wells need to be installed. Therefore, complete implementation of MNA would take about 18 to 24 months.

Time for MNA to achieve GWPS is currently unknown and would require additional studies. Published and unpublished case histories for arsenic, and by inference lithium and molybdenum, suggest that MNA would take 2 or more decades to achieve groundwater protection standards. However, the timeframe at the Site may be less because of the source control measures (dewatering, consolidation, and capping).

3.3.2 Hydraulic Containment (Pump-and-Treat)

Hydraulic containment via pump-and-treat has been used for groundwater corrective action for decades. When the pump-and-treat system is online, the performance is considered high: many inorganic constituents are readily treated, and if the system subsurface hydraulics are designed properly, the area of impact will stabilize or shrink. Because these systems require substantial operation and maintenance, the reliability is considered not as high as some other technologies. Pumps, piping, and the water treatment system must be maintained and will be offline occasionally for various reasons.

Similarly, hydraulic containment is not as easy to implement as some other technologies (e.g., MNA or geochemical manipulation), due to design, and installation of wells, pumps, and piping. An on-site water treatment plant would be required to accommodate both the quantity, and constituents of interest in the pumped groundwater. Since the quantity of water requiring treatment cannot be ascertained without further study, the design parameters of the treatment system would also need to be verified through additional investigations.

Hydraulic containment could be likely be designed and installed within 1 to 2 years. Time to achieve GWPS could take a decade, due to the slow desorption kinetics of inorganic constituents from aquifer solids, though both the planned source control and MNA should accelerate this process. Regulatory requirements and institutional controls may be greater for hydraulic containment than some of the other technologies. For example, permits may be required for the withdrawal and re-injection (if used) of water, and the chemistry of the effluent after treatment would need to be compatible with the National Pollutant Discharge Elimination System permit.

Active technologies such as hydraulic containment (pump-and-treat) may offer few or no advantages over MNA. For example, pump-and-treat for inorganic constituents (such as arsenic, cobalt, lithium, and radium) may reach a point of diminishing returns relatively quickly (few months to a few years) as the concentration gets lower and the subsequent reduction in concentration changes very little through time (EPRI 2018). The diminishing rate of concentration reduction is likely due to slow desorption kinetics from aquifer solids (Bethke and Brady 2000; USEPA 2000). Pump-and-treat may take a decade or more to achieve GWPS, such that it offers no time advantage over MNA (EPRI 2018).

3.3.3 Geochemical Manipulation (In Situ Injection)

Geochemical manipulation via injection is an emerging technology for inorganic constituents. The permanence of geochemical manipulation has not yet been demonstrated, due to its short history of application; therefore, performance is not considered high at present. Similarly, reliability is considered medium or moderate because Site geochemical conditions should not change beyond the tolerance of the treatment. The most effective use of this technology at the Site is probably for smaller isolated areas, where performance can be readily monitored and re-treatment applied if needed.

Geochemical manipulation is relatively easy to moderate to implement, particularly in small areas. The main infrastructure required are injection wells, though the treatment solution may be injected through direct-push drill rigs. Even though infrastructure requirements are minimal, some laboratory and/or field pilot test work will need to be done, and a state underground injection control permit may be required, so geochemical manipulation is estimated to require a few years to implement. Because the longevity of this technology has not yet been demonstrated and multiple injections may be required, up to a decade or more may be needed to achieve GWPS.

3.3.4 Permeation Grouting

Permeation grouting has been performed successfully in rock at the Site for geotechnical applications. Performance is considered high because grouting is a conventional and proven technology. Reliability is considered medium because some fractures or solution-widened fractures may be missed in the grouting process. Implementation is considered moderate because some of the rock at the Site is likely poor quality (weathered and/or solutioned), which creates challenging conditions for grouting. As with impermeable barrier walls, grouting will change groundwater flow (subsurface hydraulics), and the changes should be considered when evaluating this option. Grouting is estimated to take 24 to 36 months at the Site, based on grouting programs in similar terrain. Length and depth of the grout curtain (wall), spacings of grout holes (borings), and volume and composition of the mixture would need to be established through a test grouting program. Though grouting would stop the flow of impacted water, natural attenuation or other corrective measures would be required to meet GWPS in impacted water, so time to achieve GWPS is estimated to be 10 to greater than 25 years.

4 Remedy Selection Process

Pursuant to 40 CFR 257.97 and ADEM Admin. Code r. 335-13-15-.06(8), after completing this ACM, the Site must select a remedy as soon as feasible. In contrast, Part C of the Administrative Order states that this ACM must include the remedy proposed to the Department for approval.

To meet the requirement of Part C, the Site remedy is proposed to consist of:

1. Source control by dewatering the Ash Pond, consolidating the CCR material, and capping it with a low-permeability cover system to prevent infiltration

2. MNA and with routine evaluation of system performance to assure that remediation goals are being met

3. Adaptive site management and remediation system enhancement, or modification, to ensure that remediation performance goals are met

40 CFR 257.97(b) and ADEM Admin. Code r. 335-13-15-.06(8)(b), specify the following criteria that must be met by the remedy:

- Protect human health and the environment.
- Attain applicable groundwater protection standards.
- Control the source of the release so as to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents to the environment.
- Remove from the environment as much of the material released from the CCR unit as is feasible, considering factors such as avoiding inappropriate disturbances of sensitive ecosystems.
- Comply with any relevant standards (i.e., all applicable RCRA requirements) for management of wastes generated by the remedial actions.

Combined closure/source control and MNA are anticipated to meet the requirements of 40 CFR 257.97(b) and ADEM Admin. Code r. 335-13-15-.06(8)(b). In an adaptive site management process, system performance is monitored and one or more technologies identified in this ACM used to supplement the remedy as soon as feasible if the system is not performing as intended or corrective action goals not met.

Using adaptive site management, a remedial approach will be implemented, conditions monitored, and results interpreted. The framework for future decision-making is as follows. Based on monitoring data, adjustments will be made to the corrective measures as necessary, leading to continuous improvements in Site knowledge and corrective measures performance. Specifically, potential changes in Site conditions associated with pond closure may require periodic changes to the corrective measure system. Moreover, Site conditions may require the implementation of more than one corrective measure technology to meet remediation goals over the life of the project.

At the Site, Appendix IV SSLs have been identified and pond closure is underway but not complete. As soon as practical, MNA will be implemented to address the SSLs based on the current Site conditions. Using an adaptive site management approach, a remediation approach will be used whereby (1) the corrective measures system will be implemented to address current conditions; (2) the performance of the system will be monitored and evaluated semi-annually; (3) the site conceptual model updated as more data is collected; and (4) adjustment and augmentation made to the corrective action system to ensure that performance criteria are met.

4.1 Additional Data Needs

Additional data and analysis will be required to perform a thorough site-specific evaluation supplement the design of groundwater corrective actions for the Site. The following provides a summary of typical additional data needed to evaluate and select a remedy system.

- Geochemical studies of groundwater and aquifer media and geochemical modeling as needed
- Subsurface hydraulic calculations or models
- Laboratory treatability studies on groundwater, aquifer media, reactive media, and potential treatment solutions for injection
- Field pilot studies based on results of laboratory treatability studies
- Design and implementation of a test grouting program

4.2 Schedule

Table 8 provides a generalized conceptual schedule for evaluating additional information and selecting a remedy to potentially supplement the proposed corrective action.

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Tables

Table 1
Historical Groundwater Elevations Summary

Well ID	Average GW Elevation (feet MSL)	Highest GW Elevation (feet MSL)	Lowest GW Elevation (feet MSL)	GW Elevation Variation (feet)
GN-AP-MW-1	431.43	432.63	429.35	3.28
GN-AP-MW-2	432.97	433.79	432.16	1.63
GN-AP-MW-3	432.27	433.27	429.73	3.54
GN-AP-MW-4	428.80	435.66	423.27	12.39
GN-AP-MW-5	420.27	425.56	416.08	9.48
GN-AP-MW-6	417.66	422.98	415.39	7.59
GN-AP-MW-7	413.23	416.66	407.55	9.11
GN-AP-MW-8	414.62	419.70	405.81	13.89
GN-AP-MW-9	418.60	420.21	414.77	5.44
GN-AP-MW-10	419.55	421.17	417.24	3.93
GN-AP-MW-11	420.58	422.27	419.10	3.17
GN-AP-MW-12	424.45	424.85	422.77	2.08
GN-AP-MW-13	423.75	424.04	423.26	0.78
GN-AP-MW-14	399.82	401.55	399.07	2.48
GN-AP-MW-15	403.16	403.59	402.82	0.77
GN-AP-MW-16	402.79	403.22	402.38	0.84
GN-AP-MW-17	407.65	407.75	407.50	0.25
GN-AP-MW-18	395.95	396.37	395.80	0.57
GN-AP-MW-19	412.31	413.96	407.91	6.05
GN-AP-MW-20	398.29	398.95	397.79	1.16
GN-AP-MW-21	417.39	419.16	415.60	3.56
GN-AP-MW-22	418.46	421.65	415.59	6.06

Notes:

Source: Southern Company Services, 2019. *Plant Gaston Ash Pond, 2018 Annual Groundwater Monitoring and Corrective Action Report.*

GW: groundwater

MSL: mean sea level

Table 2
Groundwater Monitoring Network Details

Well Name	Installation Date	Northing	Easting	Ground Elevation	Top of Casing Elevation (feet MSL)	Top of Screen Elevation (feet MSL)	Bottom of Screen Elevation (feet MSL)	Purpose
GN-AP-MW-1	12/3/2015	1176920.740	2283196.280	457.72	460.54	271.420	261.420	Upgradient
GN-AP-MW-2	10/7/2015	1176581.400	2282345.820	442.81	445.67	329.640	319.640	Upgradient
GN-AP-MW-3	09/30/2015	1176143.900	2282060.220	444.34	447.14	375.540	365.540	Upgradient
GN-AP-MW-4	11/6/2015	1175062.070	2281020.140	437.86	440.57	354.470	344.470	Upgradient
GN-AP-MW-5	09/17/2015	1177490.120	2284846.070	428.06	431.30	378.250	368.250	Downgradient
GN-AP-MW-6	09/21/2015	1177492.160	2284847.540	424.61	427.85	387.450	377.450	Downgradient
GN-AP-MW-7	09/23/2015	1177496.740	2284850.770	416.80	420.02	365.35	355.35	Downgradient
GN-AP-MW-8	10/14/2015	1177568.420	2284736.100	426.87	429.63	355.530	345.530	Downgradient
GN-AP-MW-9	11/12/2015	1178554.490	2281365.540	422.16	424.85	299.160	289.160	Downgradient
GN-AP-MW-10	09/4/2015	1178850.570	2282040.740	422.69	425.69	353.090	343.090	Downgradient
GN-AP-MW-11	10/9/2015	1179132.610	2282666.850	422.62	425.39	357.950	347.950	Downgradient
GN-AP-MW-12	09/9/2015	1179430.100	2283330.460	422.43	425.22	345.720	335.720	Downgradient
GN-AP-MW-13	09/1/2015	1179697.950	2283988.800	421.21	424.04	368.620	358.620	Downgradient
GN-AP-MW-14	12/10/2015	1180209.360	2284813.200	424.54	427.20	340.150	330.150	Downgradient
GN-AP-MW-15	06/2/2016	1179719.070	2286000.590	440.35	442.60	377.360	367.360	Downgradient
GN-AP-MW-16	09/16/2015	1178734.930	2285724.010	419.08	422.30	381.950	371.950	Downgradient
GN-AP-MW-17	10/13/2015	1178159.490	2285347.910	404.86	407.75	350.330	340.330	Downgradient
GN-AP-MW-18	09/11/2015	1177498.200	2284989.040	413.22	416.13	365.240	355.240	Downgradient
GN-AP-MW-19	11/3/2015	1176692.670	2284143.510	413.75	416.16	334.26	324.26	Downgradient
GN-AP-MW-20	12/1/2015	1176964.090	2284730.290	403.89	406.65	328.350	318.350	Downgradient
GN-AP-MW-21	06/9/2016	1176379.270	2280690.660	425.25	428.25	403.650	393.650	Downgradient
GN-AP-MW-22	06/8/2016	1176073.130	2280698.610	424.11	427.11	407.110	397.110	Downgradient

Notes:
1. Northing and easting are in feet relative to the State Plane Alabama West North America Datum of 1983.
2. Elevations are in feet relative to the North American Vertical Datum of 1988 (ft MSL).
Source: Southern Company Services, 2019. *Plant Gaston Ash Pond, 2018 Annual Groundwater Monitoring and Corrective Action Report.*

Table 3
Plant Gaston GWPS

Constituent Name	Units	Ash Pond GWPS	Gypsum Pond GWPS	Reference
Antimony	mg/L	0.006	0.006	MCL
Arsenic	mg/L	0.01	0.01	MCL
Barium	mg/L	2	2	MCL
Beryllium	mg/L	0.004	0.004	MCL
Cadmium	mg/L	0.005	0.005	MCL
Chromium	mg/L	0.1	0.1	MCL
Cobalt	mg/L	0.006	0.006	Rule
Fluoride	mg/L	4	4	MCL
Lead	mg/L	0.015	0.015	Rule
Lithium	mg/L	0.04	0.276	Rule
Mercury	mg/L	0.002	0.002	MCL
Molybdenum	mg/L	0.1	0.1	Rule
Selenium	mg/L	0.05	0.05	MCL
Thallium	mg/L	0.002	0.002	MCL

Note:
Source: Southern Company Services, 2019. *Plant Gaston Ash Pond, 2018 Annual Groundwater Monitoring and Corrective Action Report.*

Table 4
April 2018 Assessment Sampling Results

Well ID	Purpose	Sample Date	Arsenic[1] (mg/L)	Lithium[2] (mg/L)	Molybdenum[3] (mg/L)	Combined Radium 226+228[2] (pCi/L)
GN-AP-MW-1	Upgradient	4/17/2018	0.00762	ND	0.0124	0.467
GN-AP-MW-2	Upgradient	4/17/2018	ND	ND	ND	-0.125
GN-AP-MW-3	Upgradient	4/19/2018	ND	ND	0.00659 J	0.171
GN-AP-MW-4	Upgradient	4/19/2018	ND	ND	ND	0.39
GN-AP-MW-5	Downgradient	4/17/2018	ND	0.0319 J	0.135	0.641
GN-AP-MW-6	Downgradient	4/17/2018	ND	ND	0.0146	0.719
GN-AP-MW-7	Downgradient	4/17/2018	ND	ND	ND	0.623
GN-AP-MW-8	Downgradient	4/17/2018	0.00219 J	ND	ND	-0.237
GN-AP-MW-9	Downgradient	4/17/2018	0.00174 J	ND	ND	0.293
GN-AP-MW-10	Downgradient	4/16/2018	ND	ND	ND	0.0363
GN-AP-MW-11	Downgradient	4/16/2018	ND	ND	ND	0.437
GN-AP-MW-12	Downgradient	4/16/2018	0.00754	ND	ND	0.769
GN-AP-MW-13	Downgradient	4/19/2018	ND	ND	ND	0.546
GN-AP-MW-14	Downgradient	4/19/2018	0.00113 J	ND	ND	-0.42
GN-AP-MW-15R	Downgradient	4/19/2018	ND	0.0793	0.141	0.438
GN-AP-MW-16	Downgradient	4/19/2018	0.00484 J	0.0752	0.275	3.32
GN-AP-MW-17	Downgradient	4/19/2018	0.0125	0.591	1.87	1.31
GN-AP-MW-18	Downgradient	4/19/2018	0.00259	0.0358 J	0.0186	0.981
GN-AP-MW-19	Downgradient	4/19/2018	0.00298 J	ND	0.0111	0.316
GN-AP-MW-20	Downgradient	4/19/2018	0.00374 J	0.106	0.689	11.6
GN-AP-MW-21	Downgradient	4/17/2018	0.00195 J	ND	0.00623 J	0.367
GN-AP-MW-22	Downgradient	4/17/2018	ND	ND	0.0638	0.185

Notes:
1. Groundwater protection standard for arsenic is 0.01 mg/L.
2. Groundwater protection standard for lithium is 0.04 mg/L.
3. Groundwater protection standard for molybdenum is 0.1 mg/L.
4. Groundwater protection standard for combined radium 226+228 is 5 mg/L.

J: Estimated value; value may not be accurate. Spike recovery or relative percent difference outside of criteria.
mg/L: milligrams per liter
ND: non-detect

Table 5
November 2018 Assessment Sampling Results

Well ID	Purpose	Sample Date	Arsenic[1] (mg/L)	Lithium[2] (mg/L)	Molybdenum[3] (mg/L)	Combined Radium 226+228[2] (pCi/L)
GN-AP-MW-1	Upgradient	10/1/2018	0.00529	ND	0.0131	0.864
GN-AP-MW-2	Upgradient	10/3/2018	ND	ND	ND	0.364
GN-AP-MW-3	Upgradient	10/3/2018	ND	ND	0.00669 J	0.433 U
GN-AP-MW-4	Upgradient	10/3/2018	ND	ND	ND	1.23
GN-AP-MW-5	Downgradient	10/1/2018	ND	0.0482	0.294	0.651
GN-AP-MW-6	Downgradient	10/4/2018	ND	ND	0.0101	0.558
GN-AP-MW-7	Downgradient	10/4/2018	ND	ND	ND	0.971
GN-AP-MW-8	Downgradient	10/1/2018	0.00188 J	ND	ND	0.601
GN-AP-MW-9	Downgradient	10/1/2018	0.00275 J	ND	ND	1.07
GN-AP-MW-10	Downgradient	10/2/2018	ND	ND	ND	0.613
GN-AP-MW-11	Downgradient	10/4/2018	ND	ND	ND	0.703
GN-AP-MW-12	Downgradient	10/4/2018	0.0081	ND	ND	1.50
GN-AP-MW-13	Downgradient	10/5/2018	ND	ND	ND	1.04
GN-AP-MW-14	Downgradient	10/5/2018	ND	ND	ND	0.955
GN-AP-MW-15R	Downgradient	10/5/2018	0.00150 J	0.113	0.214	1.47
GN-AP-MW-16	Downgradient	10/1/2018	0.00466 J	0.0760	0.267	2.91
GN-AP-MW-17	Downgradient	10/1/2018	0.0118	0.628	1.95	0.793
GN-AP-MW-18	Downgradient	10/1/2018	0.00288 J	0.0386	0.0192	1.54
GN-AP-MW-19	Downgradient	10/2/2018	0.00361 J	ND	0.0113	0.854
GN-AP-MW-20	Downgradient	10/1/2018	0.00372 J	0.110	0.775	15.7
GN-AP-MW-21	Downgradient	10/4/2018	0.00309 J	ND	0.0159	1.05
GN-AP-MW-22	Downgradient	10/4/2018	ND	ND	0.0698	0.568

Notes:
1. Groundwater protection standard for arsenic is 0.01 mg/L.
2. Groundwater protection standard for lithium is 0.04 mg/L.
3. Groundwater protection standard for molybdenum is 0.1 mg/L.
4. Groundwater protection standard for combined radium 226+228 is 5 mg/L.

J: Estimated value; value may not be accurate. Spike recovery or relative percent difference outside of criteria.
mg/L: milligrams per liter
ND: non-detect
U: Result is less than the sample detection limit

Table 6
Groundwater Corrective Action Evaluation Summary

Technology	Evaluation Criteria						
	Performance	Reliability	Ease or Difficulty of Implementation	Potential Impacts of Remedy	Time to Implement Remedy (Influenced by Regulatory Approval Process)	Time to Achieve Groundwater Protection Standard at the Waste Boundary	Institutional Requirements
Monitored Natural Attenuation[2]	Medium because processes may be primarily physical (i.e. less chemical attenuating potential for rock fractures)	High due to little operation and maintenance and other potential repair needs	Easy due to minimal infrastructure (e.g., monitoring wells) needed to implement remedy	None	18-24 months	Estimated > 25 years[1]	None identified
Hydraulic Containment (pump-and-treat)	High; reduces constituents to compliance levels when online	Medium; system offline at times for maintenance	Moderate due to design and installation of pump-and-treat system	Pumping could impact water supply wells, if present	12-24 months	Estimated > 25 years[1]	Needs to be compatible with Site NPDES permit; would potentially need to permit withdrawals from Unit 3 aquifer
Geochemical Manipulation (in situ injection, spot treatment)	Medium	Medium; site geochemical conditions need to be maintained to prevent rebound	Easy to moderate due to minimal infrastructure (e.g., injection wells)	Constituents may be mobilized initially upon injection before ultimate immobilization	12-24 months	Estimated 10 years (for small, localized areas)	State Underground Injection Control permit may be required
Grout Curtain (permeation grouting)	High because grouting is a conventional and proven technology	Medium, some fractures and/or solution-widened fractures may be missed	Moderate due to difficulty grouting poor quality rock, such as weathered and solution-widened zones	Will alter groundwater flow hydraulics beneath and adjacent to the Site	24-36 months	Estimated 10 to greater than 25 years[2]	None identified

Notes:

1. Timeframes shown are estimated based on case histories of MNA and hydraulic containment of arsenic-impacted sites. Detailed estimate of time requires further investigation.
2. Monitored Natural Attenuation or other technologies may be required to remediate groundwater beyond the grout curtain. Detailed estimate of time requires further investigation.

Table 7
Technology Advantages and Disadvantages

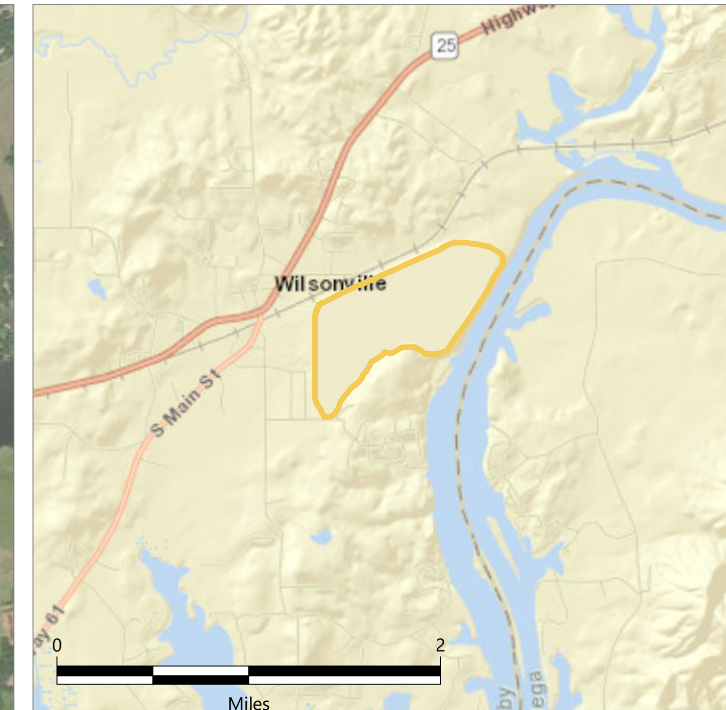
Technology	Advantages (After EPRI 2015)	Disadvantages (After EPRI 2015)
MNA	• Minimal site disruption • Sustainable • Applicable in congested, sensitive or less accessible areas where other technologies may not be feasible	• Other treatment technologies may be required
Hydraulic Containment (pump-and-treat)	• Existing on-site water treatment plant • Pump-and-treat systems are very effective at hydraulically containing impacted groundwater • Systems can be installed as deep as typical well drilling technology allows • Systems can be modified over time to increase or decrease extraction rates or modify the system to adapt changing site conditions	• More labor, O&M required than other technologies • Constituent levels can rebound if treatment is halted • System may reach a point of diminishing returns where concentrations stabilize above regulatory standards for inorganic constituents
Grout Curtain (permeation grouting)	• Reliable and widely accepted technology • Ability to be emplaced to greater depths than other methods (e.g. conventional barrier walls) • Applicable to fractured and solutioned rock	• Heterogeneity of the subsurface can impact the ability to emplace the grout curtain • Time to completion difficult to estimate due to dependence on subsurface conditions
Geochemical Manipulation (in situ injection, spot treatment)	• Ability to treat small, localized areas • Minimal site disruption • Applicable in congested, sensitive or less accessible areas where other technologies may not be feasible	• Emerging technology; permanence for inorganic constituents being demonstrated • Not proven for large-scale corrective action

Notes:
EPRI: Electric Power Research Institute
MNA: monitored natural attenuation
O&M: operation and maintenance

Table 8
Schedule

Number	Task	Estimated Completion Date
1	Field Studies and Data Collection	June 2019 – May 2020
2	Groundwater Flow and Geochemical Modeling	June 2019 – May 2020
3	Bench Testing and Pilot Studies	October 2019 – September 2020
4	Preliminary Conceptual Design	October 2020 – March 2021

Figures



LEGEND:

Ash Pond Boundary

0
3,000
Feet

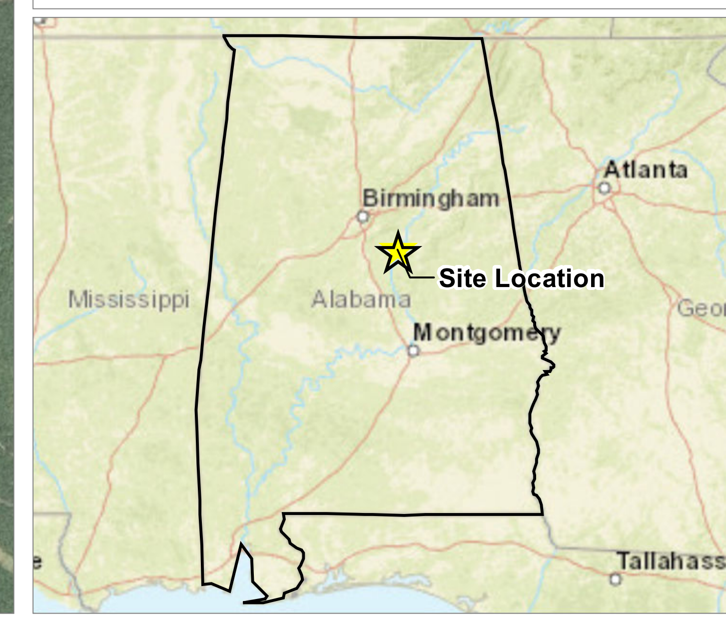


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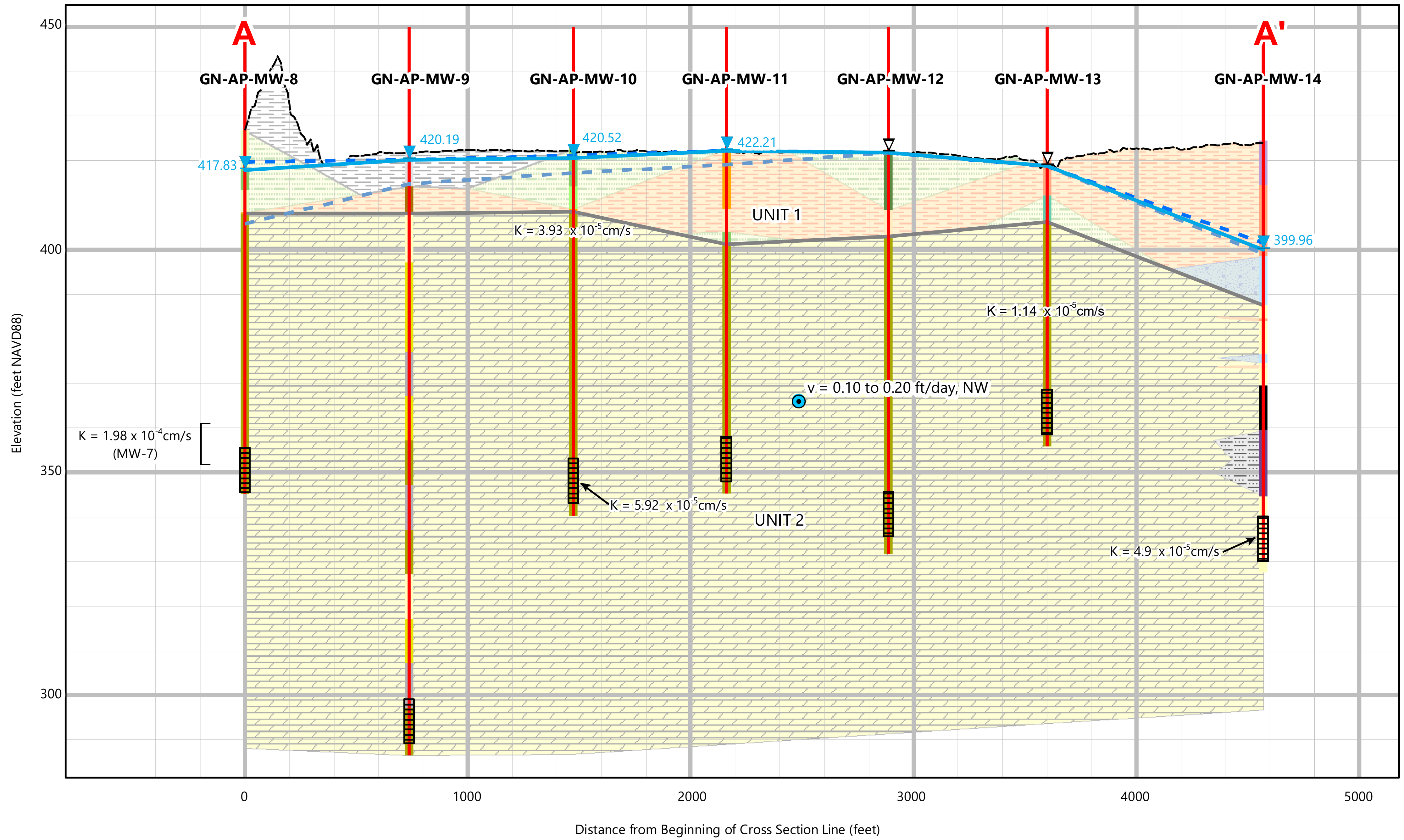
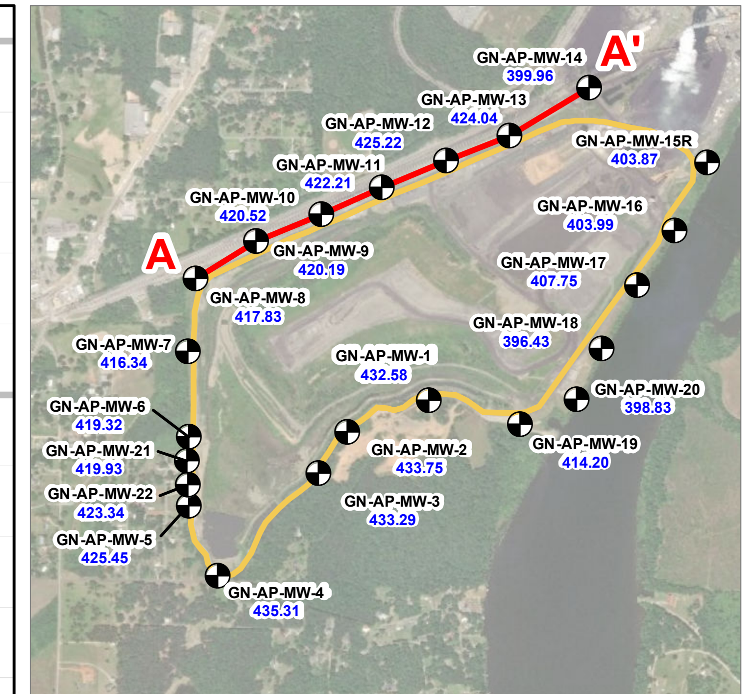
Figure 1
Site Location Map
Assessment of Corrective Measures
Alabama Power Company - Plant Gaston





Legend

- Monitoring Well
- Cross Section Line
- Ash Pond Boundary

0 2,000
Feet

Cross-Section Legend

- Approximate Groundwater Elevation
- Artesian Well
- Approximate Groundwater Elevation
- Maximum Groundwater Elevation
- Minimum Groundwater Elevation
- Represents GW flow directly toward reader
- Screen Interval
- Ground Surface Elevation
- Monitoring Well Location
- Unit Boundary
- No Recovery
- Hydro-excavation
- Cavity
- Fill
- Fat Clay
- Lean Clay
- Silty Clay
- Gravelly Lean Clay
- Low Plastic Organic Silt or Clay
- Silt
- Elastic Silt
- Sandy Silt
- Gravelly Elastic Silt
- Clayey Gravel
- Shale
- Limestone
- Dolomitic Limestone
- Dolostone
- Fill
- Clays
- Silts
- Shale
- Sands
- Gravels
- Dolostone
- Cavity

NOTES:
1. Source of ground surface elevation data: Lidar
2. NAVD88 indicates North American Vertical Datum of 1988.
3. Approximate groundwater elevation data was collected on April 16, 2018.
4. Maximum and minimum groundwater elevation data were derived from the highest and lowest groundwater elevation values recorded during events spanning March 28, 2016 to April 16, 2018.
5. Some recent maps show GN-AP-MW-19 and GN-AP-MW-20 locations switched.
6. "v" indicates groundwater flow velocity
7. Cross-section data from *Plant Gaston Ash Pond Facility Plan for Groundwater Investigation*, Southern Company Services, October 2018.

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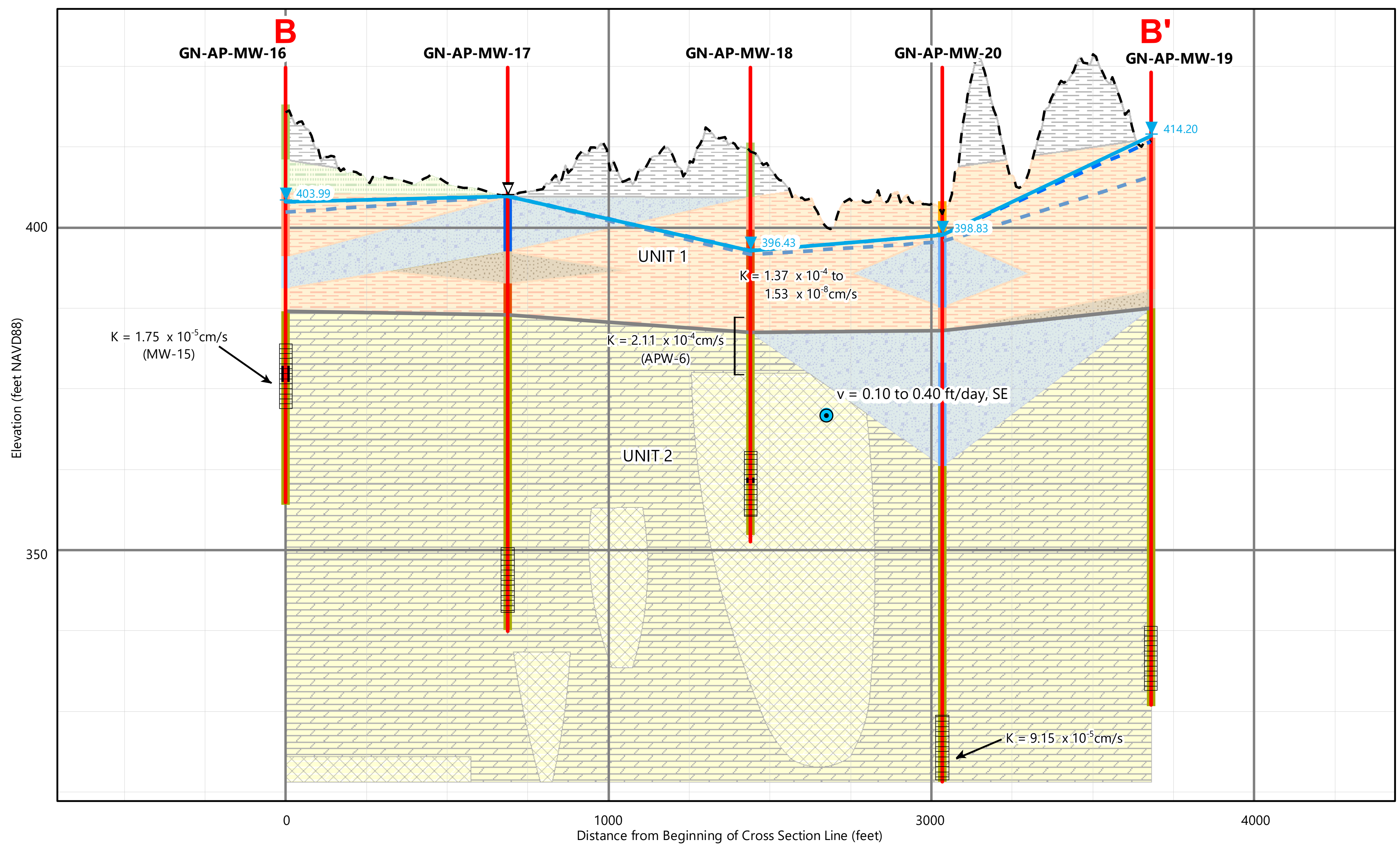
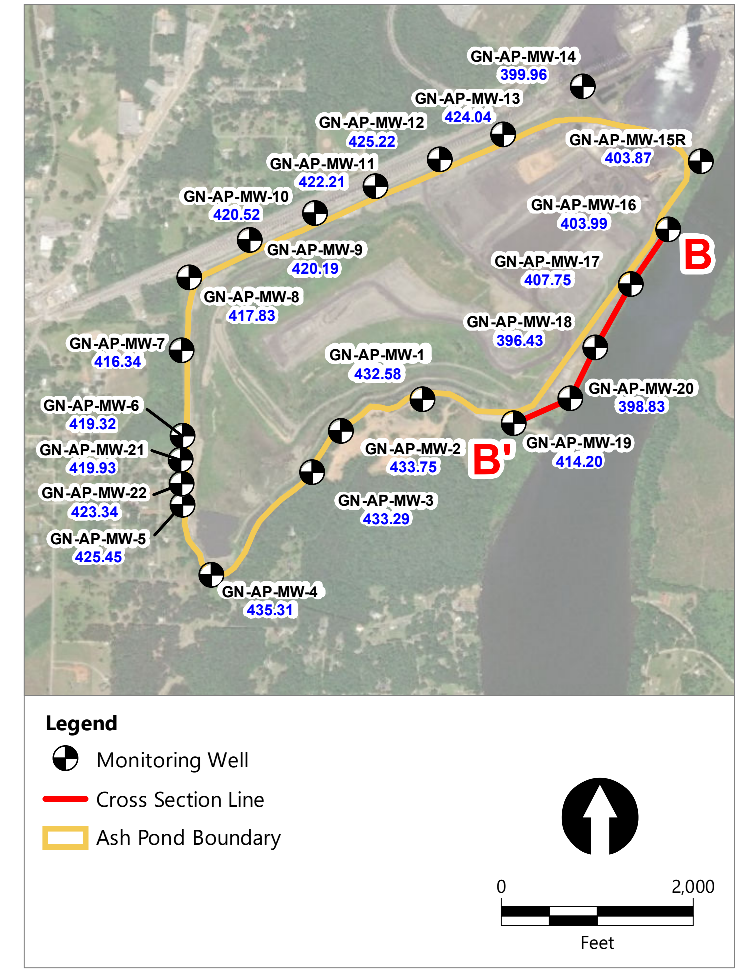
Figure 2a
Geologic Cross-Section A – A'
Assessment of Corrective Measures
Alabama Power Company - Plant Gaston





Cross-Section Legend

- Approximate Groundwater Elevation
- Artesian Well
- Approximate Groundwater Elevation
- Maximum Groundwater Elevation
- Minimum Groundwater Elevation
- Represents GW flow directly toward reader
- Screen Interval
- Ground Surface Elevation
- Monitoring Well Location
- Unit Boundary
- Topsoil
- Fat Clay
- Lean Clay
- Lean Clay with Silty Gravel
- Silty Clay
- Silt
- Clayey Sand
- Clayey Gravel
- Clayey Gravel with Lean Clay
- Well-graded Gravel with Clay
- Dolostone
- Cavity
- Fill
- Clays
- Silts
- Sands
- Gravels
- Dolostone
- Weathered or More Fractured Zone
- Cavity

NOTES:

1. Source of ground surface elevation data: Lidar
2. NAVD88 indicates North American Vertical Datum of 1988.
3. Approximate groundwater elevation data was collected on April 16, 2018.
4. Maximum and minimum groundwater elevation data were derived from the highest and lowest groundwater elevation values recorded during events spanning March 28, 2016 to April 16, 2018.
5. Some recent maps show GN-AP-MW-19 and GN-AP-MW-20 locations switched.
6. "v" indicates groundwater flow velocity
7. Cross-section data from *Plant Gaston Ash Pond Facility Plan for Groundwater Investigation*, Southern Company Services, October 2018.

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Figure 2b

Geologic Cross-Section B – B'

Assessment of Corrective Measures

Alabama Power Company - Plant Gaston

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Figure 3
Potentiometric Surface Map
Assessment of Corrective Measures
Alabama Power Company - Plant Gaston