



December 2020

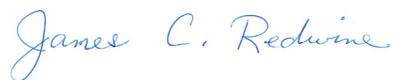


Semi-Annual Remedy Selection and Design Progress Report Plant Gadsden

Prepared for Alabama Power Company

December 2020

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James C. Redwine
Senior Reviewer
Date: December 8, 2020

Prepared for
Alabama Power Company
600 18th Street North
Birmingham, Alabama 35203



Kristi Mitchell
Originator
Date: December 8, 2020

Prepared by
Anchor QEA, LLC
600 Vestavia Parkway, Suite 121
Vestavia Hills, Alabama 35216

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ABBREVIATIONS

ACM	Assessment of Corrective Measures
ADEM	Alabama Department of Environmental Management
Alabama Power	Alabama Power Company
CCR	coal combustion residuals
CEC	cation exchange capacity
CFR	Code of Federal Regulations
CSM	conceptual site model
EGL	Environmental Geochemistry Laboratory
EPA	U.S. Environmental Protection Agency
mg/L	milligram per liter
MNA	monitored natural attenuation
SEM	scanning electron microscopy
Site	Ash Pond at Plant Gadsden
SM	Standard Method
SSE	selective sequential extraction
SSL	statistically significant level
USGS	U.S. Geological Survey
XRD	X-ray diffraction
XRF	X-ray fluorescence

1 Introduction

In accordance with the U.S. Environmental Protection Agency's (EPA's) coal combustion residuals (CCR) rule 40 Code of Federal Regulations (CFR) § 257.97(a), the Alabama Department of Environmental Management's (ADEM's) Admin. Code r. 335-13-15-.06(8)(a), and Administrative Order No. 19-104-GW, this *Semi-Annual Remedy Selection and Design Progress Report* has been prepared for the Ash Pond at Plant Gadsden (Site). Specifically, this *Semi-Annual Remedy Selection and Design Progress Report* has been prepared to describe the progress made in evaluating the selected remedy and alternative remedies and designing a remedy plan in the second semi-annual period of 2020.

In July 2020, Alabama Power Company (Alabama Power) completed an Assessment of Corrective Measures (ACM; Anchor QEA 2020) to address the occurrence of arsenic and lithium in groundwater at statistically significant levels (SSLs). In the ACM, the following remedies were considered feasible for corrective measures for groundwater:

- Monitored natural attenuation (MNA)
- Hydraulic containment
- Permeable reactive barrier walls
- Vertical barrier walls as components of other corrective measures
- Geochemical manipulation (in situ injection)
- Permeation grouting
- In situ solidification/stabilization

As required by the Administrative Order, MNA was proposed as the main groundwater corrective action remedy for the Site. Source control has already been implemented—specifically, dewatering, grading, and capping of the ash (source) and related activities.

Any data obtained during on-site investigations or to evaluate corrective action alternatives will be included in the subsequent *Semi-Annual Groundwater Monitoring and Corrective Action Reports*.

2 Summary of Work Completed

Site investigations have continued to support remedy selection and design. As discussed in the ACM (Anchor QEA 2020), completing a final long-term corrective action plan is often a multi-year process. Additional assessment work has been completed since July 2020, and field work and preliminary data analysis have been conducted to support MNA and in situ geochemical manipulation as discussed in the ACM. MNA and geochemical manipulation are both geochemically based, such that site-specific geochemical data and analyses can be applied to both technologies.

During this reporting period (July through December 2020), the following field and laboratory investigations were performed:

- Evaluated groundwater analytical data (primarily graphing) to look for evidence of natural attenuation occurring in space and time.
- Collected groundwater samples from background and impacted wells and performed a complete chemical analysis on the samples to enable groundwater geochemical modeling and the development of a geochemical conceptual site model (CSM).
- Collected attenuating solid (precipitate) samples from the bottom of monitoring wells.
- Analyzed precipitate samples by X-ray fluorescence (XRF) to determine bulk chemistry and evaluate associations among elements (e.g., arsenic with iron).

The following investigations were begun during this reporting period but are still ongoing:

- Analysis of precipitate samples by X-ray diffraction (XRD) to determine which attenuating mineral phases are present
- Scanning electron microscopy (SEM) to directly observe attenuating mineral phases by their distinctive morphology (shape) and to determine attenuating mechanisms by spectral analysis (e.g., incorporation of arsenic into sulfide mineral phases)
- Selective sequential extraction (SSE) to determine association of arsenic and lithium with attenuating phases, and the relative strength and stability of the attenuation mechanisms
- Cation exchange capacity (CEC) to assess ion exchange as an attenuation mechanism, which is particularly relevant to lithium
- Performed preliminary geochemical modeling using the U.S. Geological Survey (USGS) computer program PHREEQC with the WATEQ4F thermodynamic database to predict which attenuating mechanisms should be occurring

2.1 Data Analysis

Existing groundwater data were used to generate concentration versus time graphs to determine if attenuation is occurring over time and to assess natural attenuation rates. Arsenic, lithium, and boron concentrations were plotted on the y-axis. Boron can be used as a conservative tracer because it is

poorly chemically attenuated but is physically attenuated by dilution and dispersion. For the concentration versus time plots, the time between sampling events (in days) was plotted on the x-axis. These plots were created for constituents and wells where concentrations exceeded the groundwater protection standard, as identified in the ACM (Anchor QEA 2020). No trends are apparent for the arsenic concentration versus time plots in wells GSD-AP-MW-2 and GSD-AP-MW-4 (Figure 1). Figures 2 and 3 show that lithium and boron concentrations are decreasing with time in well GSD-AP-MW-2, which provides evidence for natural attenuation likely due to source control (dewatering) and change in the groundwater flow direction (gradient). The latest lithium measurement in GSD-AP-MW-2 from April 2020 showed a concentration of 0.0406 milligram per liter (mg/L), which is essentially the same as the groundwater protection standard of 0.04 mg/L.

Figure 1
Arsenic Versus Time in Wells GSD-AP-MW-2 and GSD-AP-MW-4

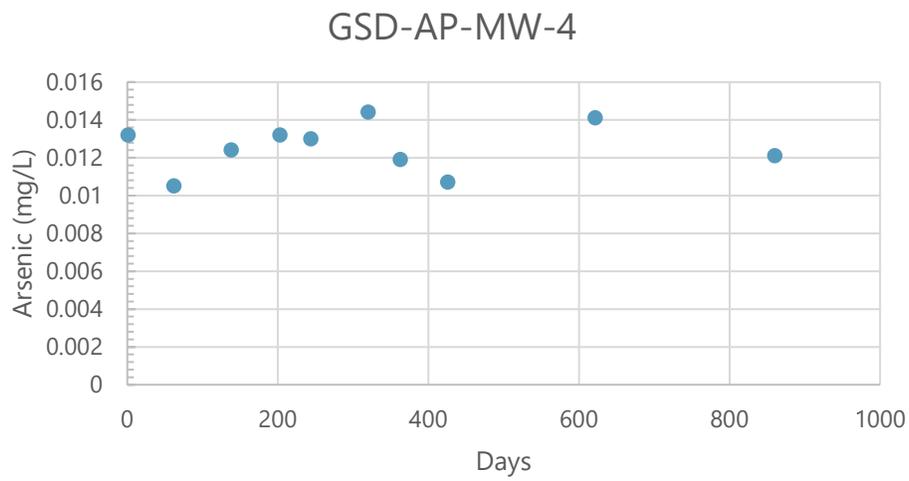
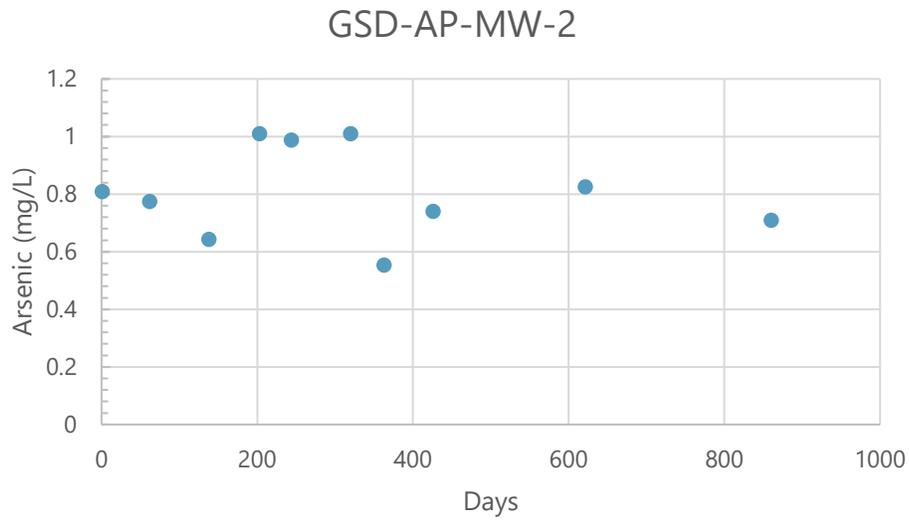


Figure 2
Lithium Versus Time in Well GSD-AP-MW-2

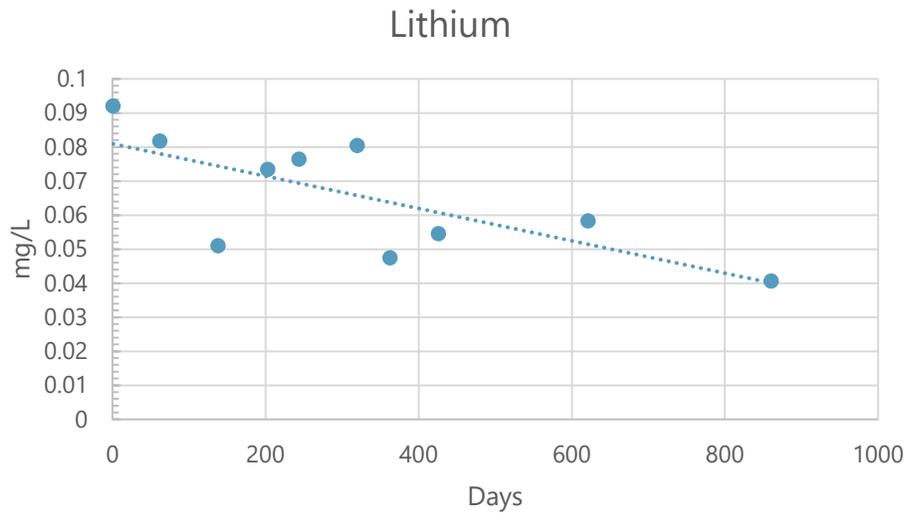
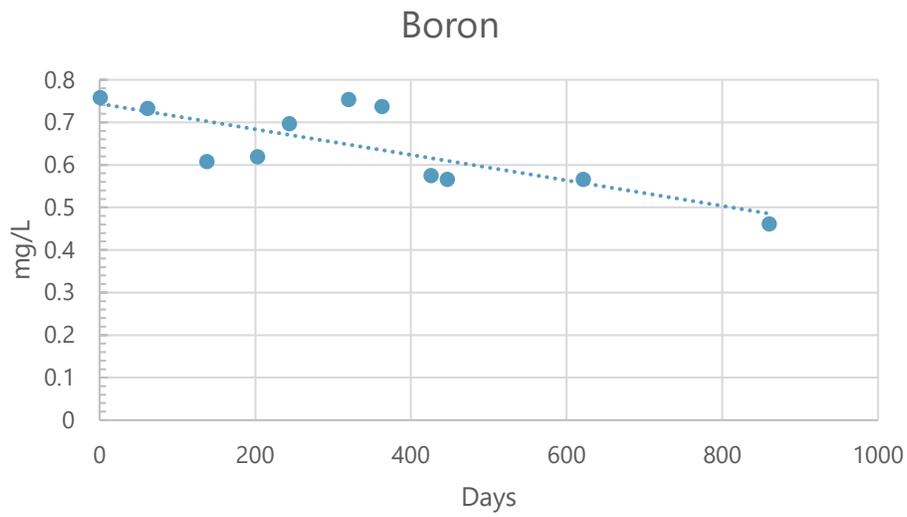


Figure 3
Boron Versus Time in Well GSD-AP-MW-2



2.2 Remedy Selection Data Collection

Activities completed during the second semi-annual reporting period in 2020 have focused on:

1) sampling delineation wells to define the horizontal and vertical extent of arsenic and lithium SSLs; and 2) collecting and analyzing groundwater and solids samples from wells to support MNA and geochemical manipulation. Additional hydrogeologic and geochemical data collected during delineation investigations are being used to refine the CSM and to further evaluate the feasibility of each proposed corrective measure. When feasible, data needed to refine the CSM will be collected concurrent with the routine assessment monitoring events.

Laboratory analysis of groundwater and precipitates (attenuating solids) was conducted to support MNA and geochemical manipulation (sometimes referred to as enhanced natural attenuation). The major rationale for these investigations includes the following:

- Identifying attenuating mechanisms
- Gaining an understanding of the permanence of the attenuating mechanisms
- Identifying potential geochemical manipulation approaches for arsenic and lithium based on site geochemical conditions and attenuation processes already occurring naturally

Analytical results generated during these studies will be included in subsequent semi-annual groundwater monitoring reports.

2.2.1 Groundwater Sampling and Analysis

Groundwater samples were collected by Anchor QEA and analyzed by the Alabama Power General Test Laboratory to evaluate MNA and geochemical manipulation. Groundwater was collected from monitoring wells included in Table 1 and was analyzed for major cations, anions, and parameters influencing the chemical behavior of arsenic and lithium. Analyzed constituents and their associated laboratory analysis methods are summarized in Table 2.

Table 1
Groundwater Sampling Locations

Well ID	
GSD-AP-MW-2	GSD-AP-MW-14
GSD-AP-MW-2VA	GSD-AP-MW-16
GSD-AP-MW-3	GSD-AP-MW-17
GSD-AP-MW-4	GSD-AP-MW-19H
GSD-AP-MW-4V	GSD-AP-MW-20H

Table 2
Analyzed Constituents and Laboratory Analytical Methods

Constituent	Analytical Method	Constituent	Analytical Method
Alkalinity (Total as CaCO ₃)	SM 2320 B	Lead (Dissolved)	EPA 200.8
Aluminum (Dissolved)	EPA 200.8	Iron (Total)	EPA 200.7
Aluminum (Total)	EPA 200.8	Lead (Total)	EPA 200.8
Antimony (Dissolved)	EPA 200.8	Lithium (Total)	EPA 200.7
Antimony (Total)	EPA 200.8	Magnesium (Total)	EPA 200.7
Arsenic (Dissolved)	EPA 200.8	Manganese (Dissolved)	EPA 200.8
Arsenic (Total)	EPA 200.8	Manganese (Total)	EPA 200.8
Barium (Total)	EPA 200.8	Molybdenum (Dissolved)	EPA 200.8
Beryllium (Dissolved)	EPA 200.8	Molybdenum (Total)	EPA 200.8
Beryllium (Total)	EPA 200.8	Nitrogen Nitrate (Calculated)	EPA 353.2
Bicarbonate Alkalinity (Calculated)	SM 4500CO2 D	Nitrogen Nitrate/Nitrite	EPA 353.2
Boron (Total)	EPA 200.7	Nitrogen Nitrite	EPA 353.2
Cadmium (Dissolved)	EPA 200.8	Ortho Phosphate	SM 4500PF-OP
Cadmium (Total)	EPA 200.8	Potassium (Total)	EPA 200.8
Calcium (Total)	EPA 200.7	Selenium (Dissolved)	EPA 200.8
Carbonate Alkalinity (Calculated)	SM 4500CO2 D	Selenium (Total)	EPA 200.8
Chloride	SM4500CI E	Silica (Total; Calculated)	EPA 200.7
Chromium (Dissolved)	EPA 200.8	Silicon (Total)	EPA 200.7
Chromium (Total)	EPA 200.8	Sodium (Total)	EPA 200.7
Cobalt (Dissolved)	EPA 200.8	Sulfate	SM 4500SO4 E 2011
Cobalt (Total)	EPA 200.8	Thallium (Dissolved)	EPA 200.8
Fluoride	SM 4500F G 2017	Thallium (Total)	EPA 200.8
Iron (Dissolved)	EPA 200.7	Total Organic Carbon	SM 5310 B

Prior to collecting groundwater samples, depth to water was measured from all wells included in Table 1. Each depth-to-water level was recorded to the nearest hundredth of a foot relative to the top of casing.

Groundwater samples were collected from monitoring wells included in Table 1 using the dedicated pump installed in each well. Wells were purged at a low flow rate to minimize drawdown and sampled using low-flow sampling techniques in accordance with 40 CFR § 257.93(a) and ADEM Admin. Code r. 335-13-15-.06(4)(a). Prior to sampling, each monitoring well was purged until field parameters (pH, temperature, specific conductance, dissolved oxygen, and oxidation-reduction potential) stabilized. Turbidity was measured during sampling but was not used as a stabilization criterion.

2.2.2 Well Solids Sampling and Analysis

Precipitation and coprecipitation may be major mechanisms for natural attenuation. Soil and aquifer media can also sorb arsenic and lithium, and their geochemistry can indicate if natural attenuation is occurring or has the potential to occur. If precipitates are forming and incorporating arsenic and lithium, then natural attenuation is occurring. Similarly, if precipitates are forming and incorporating arsenic and lithium, this suggests attenuation mechanisms that can be enhanced by geochemical manipulation under existing site conditions. Solids were collected from monitoring wells included in Table 3. A subset of precipitates collected is shown in Figure 4. The solids may be precipitates forming in the aquifer or may be part of the mineralogy of the aquifer. Regardless, depending upon their chemistry and mineralogy, the solids may have the ability to attenuate arsenic and lithium.

Table 3
Well Solids Sampling Locations

Well ID			
GSD-AP-MW-01	GSD-AP-MW-05	GSD-AP-MW-11	GSD-AP-MW-19H
GSD-AP-MW-02	GSD-AP-MW-06	GSD-AP-MW-12	GSD-AP-MW-20H
GSD-AP-MW-02VA	GSD-AP-MW-07	GSD-AP-MW-14	GSD-AP-PZ-01
GSD-AP-MW-03	GSD-AP-MW-08	GSD-AP-MW-16	GSD-AP-PZ-02
GSD-AP-MW-04	GSD-AP-MW-09	GSD-AP-MW-17	GSD-AP-PZ-05
GSD-AP-MW-04V	GSD-AP-MW-10	GSD-AP-MW-18H	GSD-AP-PZ-06

Figure 4
Well Solids



Well solids samples were collected as follows:

- If present, groundwater-solid slurry samples were collected from the bottom of the monitoring well.
- The slurry was pumped through an inline filter (to reduce sample exposure to oxygen) with a 0.45-micrometer filter membrane until the filter clogged or the water ran clear.
- Each filter was placed in a petri dish. Each petri dish was placed in a Mylar bag with an oxygen-absorbent packet to retain the in situ geochemical conditions and prevent oxidation during transport.
- Samples were stored on ice and shipped under chain of custody to Anchor QEA's Environmental Geochemistry Laboratory (EGL) in Portland, Oregon, for analysis.

Upon arrival at EGL, samples were inspected and checked against the chain of custody. Samples were then stored under refrigeration until processing. To maintain in situ geochemical conditions, precipitates were removed from the filters under a nitrogen atmosphere in an aerobic glove box for analysis and geochemical characterization. Sediment retained on the sample filters was scraped and rinsed into centrifuge tubes. This mixture was then centrifuged, and the solids were transferred into a pre-weighed glass jar. The solids were then placed into the incubator portion of the glove box at 38°C for 24 to 72 hours until dry.

The well solids were analyzed by XRF. Elemental analysis by XRF is used to determine the chemical composition of the matrix and presence of constituents heavier than sodium. XRF is unable to analyze for lithium, due to its light weight (low mass).

All well solids samples with sufficient volume were analyzed by XRF. After drying, processed samples were loaded and sealed in plastic sample containers for elemental analysis by XRF. XRF testing was performed by EGL staff using a Niton XL3t GOLDD+ XRF Analyzer rented from Thermo Fisher Scientific. Individual samples were analyzed by XRF by a custom program based on a mining profile that includes most elements heavier than sodium.

The following investigations were begun during this reporting period but are still ongoing: geochemical modeling, XRD, SEM, SSE, and CEC. A select number of samples will be chosen and analyzed by XRD to determine predominant mineralogy. Samples will be selected by looking at a variety of data, including, but not limited to, XRF data, field parameters, sample location, chemical analysis, and recovered sample mass. After XRD analysis, samples for SSE analysis will be selected using the criteria above and the results of the XRD analysis. SSE targets a series of operationally defined mineral fractions. SEM and associated elemental mapping will be conducted on select samples to confirm mineral phases and attenuating mechanisms. Finally, select samples with suspected clay content will be submitted for CEC testing.

2.3 Groundwater Geochemical Equilibrium Modeling

The investigations described above and geochemical equilibrium modeling will be used to develop a geochemical CSM. The geochemical CSM will include probable attenuating mechanisms for arsenic and lithium, and the relative permanence of those mechanisms. Geochemical equilibrium modeling will be performed to help determine what is controlling the mobility and attenuation of arsenic and lithium, as well as the behavior of other species (such as iron and manganese) that influence the behavior of arsenic and lithium. Geochemical modeling will be performed using PHREEQC with the WATEQ4F thermodynamic database to evaluate charge balance, calculate aqueous speciation, and determine the saturation indices for minerals for groundwater samples collected. Saturation index calculations can be useful in determining potential solid phase controls on water chemistry and reactivity of an aqueous solution toward specific mineral phases. In addition, the Geochemist's Workbench software will be used to plot Eh-pH data on Pourbaix stability diagrams to assess geochemical stability of controlling phases as needed.

3 Planned Activities and Anticipated Schedule

The following activities are planned in the near term (January to February 2021) to complete the initial evaluation of MNA and geochemical manipulation:

- Installing vertical delineation wells
- Complete geochemical modeling, XRD, SSE, SEM, and CEC work
- Integrate the XRD, SEM, SSE, CEC, and geochemical modeling results into a geochemical CSM; perform additional geochemical modeling if needed

The SSE will determine the associations of arsenic and lithium with various mineral phases to help determine attenuating minerals and their stability. XRD, SEM, SSE, CEC, and geochemical modeling will be integrated to develop a geochemical CSM, i.e., to determine probable attenuation phases and their stability (permanence). As new groundwater monitoring data become available, concentration versus distance and concentration versus time graphs will be updated to identify decreasing concentration trends that indicate natural attenuation. Geochemical data and other site-specific information will be used to determine effective compositions of injected treatment solutions and where injection treatment might be applied.

Section 2 describes evidence for the occurrence of natural attenuation at the Site. The EPA's four phases (or tiers) of an MNA demonstration (EPA 2015) are as follows:

- Phase 1 – Demonstrate area of impacts (plume) is stable or shrinking
- Phase 2 – Determine mechanisms and rates of attenuation
- Phase 3 – Determine system capacity and stability
- Phase 4 – Design performance monitoring program and identify alternative remedies

Based on the May 2020 *Groundwater Investigation Report* (SCS 2020), impacts appear stable or diminishing, and limited to the areas around GSD-AP-MW-2 and GSD-AP-MW-4. The decreasing trends for lithium and boron in GSD-AP-MW-2 support this conclusion. Though indications of natural attenuation are present at the Site, natural attenuation is expected to increase with time following dewatering, capping, and closure.

The MNA work performed at the Site to date focuses on Phase 2 (specifically mechanisms) of attenuation, though some data will inform all four phases. To advance MNA at the Site, additional work needs to be performed with respect to rate, aquifer capacity, and stability (permanence) of MNA.

The longer-term schedule for advancing corrective action at the Site is as follows:

- Perform a conceptual-level feasibility study of potentially viable corrective actions (January to June 2021)

- Show where the viable corrective actions could be applied on Site maps and on geologic sections
- Compare site-specific corrective actions to the evaluation criteria in the CCR Rule, with emphasis on deficiencies that could eliminate a corrective action from further consideration
- Determine data gaps and develop plans to collect additional data as needed
- Develop plans for laboratory treatability and field pilot tests as needed (January to June 2021)
- Collect additional soil samples and perform associated laboratory work to determine MNA capacity, rates, and stability (fourth quarter 2021 and first quarter 2022)
- Collect additional soil samples for ISS treatability studies
- Perform laboratory treatability studies and implement field pilot tests (second and third quarter 2022)
- Develop a detailed groundwater remedy plan (fourth quarter 2022)

During the next reporting period, other potential remedies identified in the ACM will continue to be evaluated with respect to technical feasibility, ability to attain target standards, and ease of implementation. Based on the site-specific evaluation, additional studies may be implemented.

Pursuant to 40 CFR 257.97(a) and ADEM Admin. Code r. 335-13-15-.06(8)(a), semi-annual status progress reports will continue to be finalized in June and December until a final remedy plan is developed. Upon developing a final remedy plan, the Remedy Selection Report will be prepared describing the remedy plan and how it demonstrably meets the requirements of § 257.97 and r. 335-13-15-.06(8). Details regarding adaptive management triggers and criteria will be included in the Corrective Action Groundwater Monitoring Program.

Alabama Power will continue groundwater monitoring at the Site and will submit the next *Semi-Annual Remedy Selection and Design Progress Report* by June 12, 2021.

4 References

Anchor QEA (Anchor QEA, LLC), 2020. *Assessment of Corrective Measures: Plant Gadsden Ash Pond*. Prepared for Alabama Power Company. July 2020.

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