Assessment of Corrective Measures Under the CCR Rule – Ash Pond Complex

Gallatin Fossil Plant
Gallatin, Tennessee

Prepared for:

Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:

AECOM
Morrisville, North Carolina

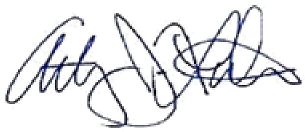
July 15, 2019

Tennessee Valley Authority
Chattanooga, Tennessee

ASSESSMENT OF CORRECTIVE MEASURES
GALLATIN FOSSIL PLANT

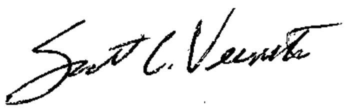
Quality information

Prepared by



Anthony J. Limke, CPG
AECOM, Principal Geologist

Prepared by



Scott C. Veenstra
AECOM, Senior Project Manager

Reviewed by

David E. Skeggs, PE
AECOM, Principal Project Manager

Table of Contents

Figures

Tables

Appendices

Acronyms

ACM	Assessment of Corrective Measures
APC	Ash Pond Complex
ASD	Alternate Source Demonstration
ATI	Agreed Temporary Injunction
bgs	Below ground surface
CARA	Corrective Action and Risk Assessment
CAO	Corrective Action Objective
CAGWMP	Corrective Action Groundwater Monitoring Program
CBR	Closure by Removal
CCR	Coal Combustion Residuals
CFR	Title 40, Code of Federal Regulations
COI	Constituent of Interest
COC	Constituent of Concern
CSM	Conceptual Site Model
CRM	Cumberland River Mile
EAR	Environmental Assessment Report
EI	Environmental Investigation
ft	Feet
GAF	Gallatin Fossil Plant
GWPS	Groundwater Protection Standards
IC	Institutional Controls
MNA	Monitored Natural Attenuation
msl	Mean sea level
mg/L	Milligram per liter
NPDES	National Pollutant Discharge Elimination System
NRL	North Rail Loop
PRB	Permeable Reactive Barrier
SSL	Statistically Significant Levels
TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority
USACE	United States Corp of Engineers
USEPA	United States Environmental Protection Agency
WSW	Water supply well

Executive Summary

On April 17, 2015, the U.S. Environmental Protection Agency (USEPA) published a rule that set forth national criteria for the management of coal combustion residuals (CCR) produced by electric utilities. The requirements can be found in Title 40, Code of Federal Regulations (40 CFR) Part 257. The rule includes requirements for monitoring groundwater and assessing corrective measures if constituents listed in Appendix IV of the rule are detected in groundwater samples collected from downgradient monitoring wells at statistically significant levels (SSL) greater than groundwater protection standards (GWPS).

In January 2019, the Tennessee Valley Authority (TVA) completed an evaluation of whether there were SSLs over established GWPS as defined in 40 CFR § 257.95(h) for one or more Appendix IV constituents in accordance with 40 CFR § 257.95(g). At the TVA Gallatin Fossil Plant (GAF) Ash Pond Complex (APC) (including Ash Pond A, Ash Pond E, Middle Pond A, and Bottom Ash Pond), assessment monitoring detected an SSL greater than the GWPS for arsenic in one well (GAF-410U), for cobalt in two wells (GAF-450C and GAF-450L), and for lithium in one well (GAF-452C). TVA has successfully demonstrated that a source other than the APC caused the SSLs above GWPS for cobalt and lithium at wells GAF-450C/-450L and GAF-452C, respectively as allowed under 40 CFR § 257.95(g)(3)(ii). At this time, TVA has not demonstrated that a source other than the APC, associated with well GAF-401U, caused the SSL of arsenic.

In accordance with 40 CFR § 257.96(a), TVA prepared this 2019 Assessment of Corrective Measures (ACM) Report for the APC, which is monitored by a multiunit groundwater monitoring well network, at GAF.

Four primary strategies have been evaluated to address groundwater exhibiting concentrations above the arsenic GWPS including the following:

- Monitored Natural Attenuation (MNA);
- In-Situ Physical/Chemical Treatment;
- Permeable Reactive Barriers (PRB); and
- Hydraulic Containment and Treatment.

This ACM Report provides an assessment of the effectiveness of potential corrective measures in achieving the criteria provided in 40 CFR § 257.96(c).

Following preparation of this ACM Report, the remedy selection process will begin to select a remedy that meets the requirements of 40 CFR § 257.97(b) and § 257.97(c). A corrective measure remedy must be selected as soon as feasible. At least 30 days prior to when the final remedy is selected, a public meeting will be held with interested and affected parties to discuss the results of the corrective measures assessment in accordance with 40 CFR § 257.96(e).

Semi-Annual Reports will be prepared pursuant to 40 CFR § 257.97(a) to document progress toward remedy selection and design. TVA will continue to review new data as it becomes available and implement changes to the groundwater monitoring and corrective action program as necessary to maintain compliance with 40 CFR § 257.90 through § 257.98.

1.0 Introduction

This assessment of corrective measures (ACM) report has been prepared to meet the requirements in the United States Environmental Protection Agency (USEPA) Coal Combustion Residuals (CCR) Rule, 40 Code of Federal Regulations (CFR) § 257.96. During assessment monitoring when at least one constituent listed in Appendix IV of the CCR Rule is detected at a statistically significantly level (SSL) above a site-specific groundwater protection standard (GWPS) established pursuant to § 257.95(h), and the owner/operator has been unable to demonstrate that a source other than the CCR unit or an error caused the SSL, the owner/operator must initiate an assessment of corrective measures.

At the TVA Gallatin Fossil Plant (GAF) Ash Pond Complex (APC) (including Ash Pond A, Ash Pond E, Middle Pond A, and Bottom Ash Pond) (hereinafter collectively referred to as CCR Multiunit or APC Multiunit), assessment monitoring detected an SSL greater than the GWPS for arsenic in one well (GAF-410U), for cobalt in two wells (GAF-450C and GAF-450L), and for lithium in one well (GAF-452C). TVA has successfully demonstrated that a source other than the APC Multiunit caused the SSLs above GWPS for cobalt and lithium at wells GAF-450C/-450L and GAF-452C, respectively, as allowed under 40 CFR § 257.95(g)(3)(ii). TVA has not been able to demonstrate that a source other than the APC Multiunit caused the SSL of arsenic. Thus, TVA initiated an assessment of corrective measures on April 15, 2019. This report documents the completion of the required ACM and discusses potential corrective measures as required under the CCR Rule.

1.1 Overview of CCR Rule Requirements for Assessment of Corrective Measures in 40 CFR § 257.96

Section 257.96(a) of the CCR Rule requires that, within 90 days of determining an SSL exceeding a GWPS of an Appendix IV constituent, the owner/operator must initiate an assessment of corrective measures to prevent further releases, to remediate any releases and to restore the affected area to original conditions. The assessment of corrective measures report must be completed within 90 days of initiating the assessment of corrective measures unless the owner/operator demonstrates that an extension of no longer than 60 days is needed due to site-specific conditions or circumstances. A qualified professional engineer must certify the accuracy of the extension demonstration. The certified demonstration must be included in the annual groundwater monitoring and corrective action report required by § 257.90(e). TVA did not seek an extension for completing the assessment of corrective measures.

The CCR Rule requires that the assessment of corrective measures report under § 257.96(a) must include an analysis of the effectiveness of potential corrective measures in meeting the requirements and objectives of the remedy. More specifically, § 257.96(c) provides that:

The assessment under paragraph (a) of this section must include an analysis of the effectiveness of potential corrective measures in meeting all of the requirements and objectives of the remedy as described under §257.97 addressing at least the following:

(1) The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;

(2) The time required to begin and complete the remedy;

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

Potential corrective measures to be considered for these CCR units are generally discussed in Section 4.0 and Appendix A of this report. Using the criteria of § 257.96(c), this report also includes an analysis of these potential corrective measures based on the information known at this time (Appendix B).

1.2 Overview of CCR Rule Requirements for Remedy Selection in 40 CFR § 257.97

Once the ACM report is complete, the process for selecting a remedy will commence. The owner or operator must select a remedy that, at a minimum, meets the requirements of 40 CFR § 257.97(b) and must consider the evaluation factors set forth in 40 CFR § 257.97(c) in selecting the remedy. In addition, at least 30 days prior to the selection of the remedy, the owner/operator must discuss the results of the ACM in a public meeting required by 40 CFR § 257.96(e). The owner/operator must also provide a schedule for implementing the selected remedy that takes into account the factors set forth in 40 CFR § 257.97(d).

After the ACM report is completed and before the remedy is selected, 40 CFR § 257.97(a) requires semi-annual reports to be prepared describing the progress in selecting and designing the remedy. The CCR Rule contemplates that more investigation and consideration may be needed to evaluate and design the remedy before making the final selection. Once a final remedy is chosen, a final report describing the remedy and how it meets the standards set forth in 40 CFR § 257.97(b) will be prepared.

2.0 Site Background and Characteristics

GAF is located at 1499 Steam Plant Road in Gallatin, Sumner County, Tennessee. The facility is located on the north bank of the Cumberland River and between Cumberland River Mile (CRM) 246 and 241.5. The Cumberland River is impounded by the Old Hickory Dam located approximately 23 miles downstream (CRM 216.2). Old Hickory Dam construction started in 1952 and was completed in 1954. Old Hickory Dam raised the Cumberland River elevation approximately 35 feet beginning in December 1956. The reservoir reached full pool elevation (445 ft msl) in January 1957 (USACE, 1959).

GAF construction began in 1953. GAF began operations in 1956 with full operation in 1959, following completion of the fourth generating unit.

The coal combustion process at GAF historically generated by-products that included fly ash and bottom ash. The fly ash and bottom ash were managed at the former Non-Registered Site (NRS) from 1956 until approximately 1970. The NRS was closed in 1997 (Arcadis, 2014) and is not subject to the CCR Rule. In approximately 1970 until 2019, CCR was managed in the APC Multiunit (which is subject to the CCR Rule) in accordance with National Pollutant Discharge Elimination System (NPDES) Permit No.TN0005428 issued by the Tennessee Department of Environment and Conservation (TDEC).

The recently-constructed scrubber system (2013-2016) produces dry CCR material. The dry CCR material is managed in the 52-acre Class II Landfill (Tennessee Solid Waste Permit IDL83-0219) called the North Rail Loop (NRL) Landfill. Cell 1 of the landfill, which includes both a soil and geosynthetic liner system and groundwater monitoring well network, has been approved by TDEC for operation and began receiving CCR in June 2016. The NRL Landfill is subject to the CCR Rule and remains in detection monitoring.

With the completion of the new Flow Management System, the APC has been removed from service. Process flows and NRL Landfill leachate have been rerouted to the Flow Management System. The Flow Management System effluent is released at Outfall 010. NRL landfill contact water and stormwater have been rerouted to Stilling Pond B and are discharged at Outfall 001.

Figure 1 shows an overview map of GAF including its facilities and CCR management areas.

2.1 CCR Unit Descriptions

CCR units subject to the CCR Rule include the APC Multiunit (consisting of Ash Pond A, Ash Pond E, Middle Pond A, and Bottom Ash Pond) and the NRL Landfill. The APC Multiunit no longer receives flows.

The APC was first used in approximately 1970, and the four ash basins (Ash Pond A, Ash Pond E, Middle Pond A, and Bottom Ash Pond) evolved in the late 1970s with the construction and subsequent raising of internal divider dikes. Beginning in 1978, pond divider dikes were constructed and subsequently raised over time to divide operational areas of the pond system. These efforts resulted in the current APC configuration.

Approximately 11,440,000 cubic yards of CCR material is currently present in the APC, with the majority present in Ash Pond A. The APC covers approximately 383 acres.

Prior to the new Flow Management System, a series of Stilling Ponds (B, C, and D) received decant water from the primary Ash Ponds A and E and provided final water treatment before discharging from Stilling Pond D to the Cumberland River at Outfall 001 in accordance with individual NPDES Permit No. TN0005428 issued by TDEC. The stilling ponds now serve as a final polishing pond for various stormwater flows and contact water from the NRL Landfill.

2.2 Overview of July 2019 Closure Plan

An updated Closure Plan is being prepared for the APC Multiunit as a result of an agreement between TVA and TDEC as noted in Section 2.2.1. This Closure Plan will be posted on TVA's CCR Rule Compliance Data and Information website in the near future.

Based on conceptual plans, and subject to the completion of all necessary environmental reviews, TVA intends to close the APC by following a closure-by-removal approach pursuant to 40 CFR § 257.102(c). Closure activities are anticipated to include pond drawdown, CCR dewatering, and CCR excavation and removal. CCR is expected to be transported and disposed of in an on-site permitted landfill and/or transported to a beneficial re-use facility for recycling and encapsulated beneficial use with the potential for some unusable CCR to be disposed of in an on-site or off-site landfill. Details of the CCR disposal options will be completed during detailed closure design, which will begin in 2019, and is subject to the completion of all necessary environmental reviews.

Consistent with the requirements of 40 CFR § 257.102(c), potentially impacted underlying material will be addressed. Post-excavation surfaces will be graded to promote positive drainage, and permanent vegetation or permanent stabilization will be established. Where needed, the APC perimeter berms may be excavated to allow the adjacent Cumberland River and/or Stilling Ponds to combine with the existing ponds.

2.2.1 Summary of State Required Investigation and Remedy Selection Process

Since 2016, TVA has been conducting an environmental investigation of CCR disposal sites at its GAF coal-fired site in Tennessee under the oversight of TDEC through an Agreed Temporary Injunction (ATI) entered by the state court on January 21, 2016, in a lawsuit brought by the State of Tennessee and TDEC against TVA pertaining to the GAF site. This ATI required TVA to conduct an Environmental Investigation (EI) at GAF, which began on July 18, 2016 and continues as of the date of this report. The APC Multiunit at GAF that is subject to the CCR Rule is included in the ATI.

Based upon an agreement between TDEC and TVA on June 13, 2019, resolving the lawsuit, the closure method for the APC Multiunit will be by removal of the CCR. The agreement requires CCR to be transported to a beneficial re-use facility for recycling and encapsulated beneficial use, transported and disposed of in an on-site permitted landfill, or transported and disposed of in an off-site permitted landfill. The agreement requires the EI to be completed and requires that TVA submit to TDEC for approval an environmental assessment report (EAR) that provides an analysis of the extent of CCR contamination, including groundwater contamination, at GAF. The EI/EAR process will be used to develop a plan for monitoring discharge locations during the removal action. Further, the agreement requires TVA to submit a Corrective Action/Risk Assessment (CARA) Plan to address groundwater contamination at the APC Multiunit.

2.3 Conceptual Site Model Summary

A hydrogeologic conceptual site model (CSM) is needed to make a decision on corrective measures. This section of the report provides a summary of the hydrogeologic conceptual site model.

2.3.1 Geology

The geology and hydrology of the GAF site have been characterized during implementation of multiple investigations, including the NRL landfill hydrogeologic investigation, the EI, CCR Rule monitoring network development, and the NRL landfill expansion hydrogeologic investigation. These investigations provide a thorough understanding of the site geology and presence of water-bearing zones in which groundwater and potential contaminants would be present and migrating.

GAF is located within the Central Basin Aquifer area of Middle Tennessee. Groundwater in Central Tennessee that occurs within the stratigraphic interval between the bottom of the Devonian age Chattanooga Shale and the top of the Cambrian-Ordovician age Knox Group is known as the Central Basin Aquifer system. This aquifer system is an important source of drinking water for Central Tennessee, as it supplies most of the rural domestic wells and many public drinking wells in the Central Basin and surrounding region (Brahana and Bradley, 1986).

Groundwater in the Central Basin Aquifer system occurs primarily in a shallow flow system of solution channels. These channels are highly irregular in their distribution throughout the solid rock mass and generally occur within 300 feet of the land surface. The solution channels are openings along joints and bedding planes that locally may be enlarged by dissolution of the limestone. These channels represent zones of secondary porosity and permeability in an otherwise nonporous and impermeable rock mass. Bedding planes are thought to be the major control in the formation of solution cavities, which have typically been found to be horizontally elongated (Brahana and Bradley, 1986).

The primary bedrock units at GAF that have developed water-bearing zones are the Carters and Lebanon Limestones, both members of the Stones River Group. Bentonite zones in the Carters Limestone play a significant role in the hydrology of the Central Basin Aquifer system. In areas where the bentonite layers are present, the downward movement of groundwater is restricted.

Where the bentonite zones are eroded or otherwise breached by open joints or intersecting stream valleys, solution openings can form in the underlying limestone. Groundwater in these openings can receive recharge from precipitation. In contrast, shale units within the formations comprising the aquifer system typically act as local confining units for groundwater (Brahana and Bradley, 1986). As noted in a Tennessee Division of Geology publication (Newcome,1958): “Practically all ground water in the Central Basin of Tennessee is confined under artesian pressure in solution channels in the limestone. …When a well penetrates the channel the confining pressure is released and the water rises in the well.”

Site-wide geology consists of a series of relatively flat-lying units comprised of the following materials, from the surface downward: unconsolidated units including fill, alluvium, and residuum; and underlying bedrock units consisting of various limestone formations. The presence and distribution of the unconsolidated units is largely controlled by surface topography, historical regional erosional processes, and development activities by TVA.

Unconsolidated Units

Unconsolidated units at the site consist of fill related to TVA’s development of the peninsula, alluvial soils associated with the Cumberland River floodplain, and residuum soils associated with in-place weathering of bedrock at or near the surface.

Disturbed and filled areas of the site primarily include areas around the main plant and dikes surrounding the current and former ash disposal areas. Fill material is generally lean silty clay (CL) and is comprised of reworked native material.

Alluvial soils are primarily lean silty clay (CL) with isolated zones of higher permeability materials ranging from silty sand (SM) to sandy gravel (GP). Alluvial deposits are largely positioned along the south and west edges of the peninsula as a result of floodplain deposits from the adjacent river. Alluvial deposits are up to approximately 50 feet in thickness near the river and thin away from the river.

Residual soils are primarily lean clay (CL), with lesser amounts of silty clay (CL), clayey silt (ML), high-plasticity clay (CH), and silty sand (SM). These soils are derived from in-place weathering of limestone. The soils range in thickness from less than 1 foot to approximately 30 feet. Generally, soils are less than 15 feet thick, but may be highly variable over a short distance. This is likely a result of a pinnacle and cutter bedrock surface, typical of weathering in karstic environments. These surfaces that represent contact between bedrock and unconsolidated units are very irregular due to the natural preferential dissolution of rock along planar features such as bedding, joints, and fractures. The bottom of the soil transitions abruptly from materials with low to moderate standard penetration test blow counts to auger refusal and weathered rock. Numerous rock outcrops occur across the GAF site. Notably, these outcrops cluster north of the stilling ponds, where soils are thin.

Bedrock Units

Bedrock beneath the GAF site consists of limestone of the Nashville Group (Bigby-Cannon and Hermitage) and the Stones River Group (Carters, Lebanon, and Ridley). The bedrock stratigraphy, from youngest to oldest and in the order that the units are encountered, is shown in **Figure 2**.

The Bigby-Cannon Limestone was encountered in limited borings at the site, those typically at the highest elevations on the GAF site. It was also observed in an outcrop at the top of the hill in the center of the peninsula and along Steam Plant Road. The formation is a medium- to dark-gray, microcrystalline to medium-grained, fossiliferous limestone with shaly and fossil-hash beds.

The Hermitage Formation has been observed in numerous borings on the higher elevations of the peninsula, in borings north of the APC, and in outcrops along Steam Plant Road. The formation is a medium- to dark-gray, slightly fossiliferous, very fine-grained argillaceous limestone that is laminated to thinly bedded.

The Carters Limestone was encountered in borings throughout the peninsula, except in the far south and southwest portions of the peninsula, where the formation is completely eroded. The formation consists of two units (designated Upper Carters and Lower Carters) separated by a distinctive and continuous layer of bentonite. The Upper Carters is a gray to dark-gray, microcrystalline to medium-grained, thinly bedded, fossiliferous limestone with shaly laminations and trace fossils. A formation thickness of approximately 31 feet was logged from geophysical logs of borings that intersected the base of the overlying Hermitage Formation and the underlying bentonite layer. The bentonite layer is consistent with the T-3 bentonite as described by Hanchar (1988) and Wilson (1991). The thickness of the bentonite deposit varied slightly across the site but was present in every boring intersecting the Upper and Lower Carters Limestone. The average thickness of the bentonite deposit was 1 to 3 inches; however, up to 5-inches has been noted. The Lower Carters is lithologically distinctive from the Upper Carters by its more massive and thicker beds that contain chert, and having clean beds with stylolites near the bottom of the unit. Formation thickness is approximately 64 feet based on site drilling information.

The Lebanon Limestone was encountered across the entire site, and it is a medium-gray to olive-gray, very fine- to medium-grained, fossiliferous limestone with thin shaly beds. The unit is similar in appearance to the Lower Carters Limestone but contains slightly more clay content.

Bedrock Fractures

The bedrock underlying the peninsula tends to be locally, but not extensively, fractured. Most fractures are nearly horizontal, parallel to bedding. These fractures are generally developed along bedding planes, shaly layers, or other natural weaknesses in the rock. Within the Hermitage, Carters, and Lebanon formations, these fractures are generally tight, although they may show slight to moderate weathering at shallow depths or at prominent fracture zones.

There is no apparent correlation of fractures with stratigraphic intervals in the Hermitage or Carters formations between boreholes. However, fractures in the Lebanon Limestone do appear to have some stratigraphic correlations. Based on gamma response, there are two zones relatively enriched in clay content in the Lebanon Limestone, approximately 30 feet and 70 feet into the Lebanon Limestone. In each interval, a fracture zone is present that is commonly water-bearing. The upper fracture zone (L1) occurs approximately 26 to 42 feet below the top of the Lebanon Limestone, and the lower fracture zone (L2) occurs approximately 67 to 75 feet below the top of the Lebanon Limestone. Fractures within these zones have been identified at numerous boreholes across the site.

While the L1 and L2 fracture zones may be correlated between numerous boreholes, they are not interpreted to be single continuous fractures. Rather, they each represent a 10 to 15-foot thick section of the Lebanon Limestone that may contain one or more fractures. The lateral extent of individual fractures within the zones is not known; the fractures may be highly localized or could extend tens or hundreds of feet. The interconnection of fractures is not known, but it appears to be sufficient to allow lateral groundwater flow, and for the zone to be described as an aquifer.

2.3.2 Hydrogeology

Three water-bearing units are described below as they pertain to the APC and the requirements for the ACM.

Unconsolidated

Based on the EI and previous subsurface site investigations, the extent of groundwater present in unconsolidated materials is shown on **Figure 3**. The unconsolidated materials are primarily alluvium, but water is also locally present in residuum, such as at Well 23. The alluvium generally has a high percentage of fines (silts and clays) and many wells have very poor yield. The alluvium was deposited by the Cumberland River on the south and southwest portions of the site, so its extent is limited to these areas.

Within the clay alluvium, occasional lenses of sandy, more permeable materials are encountered (e.g., well S3, GAF-410U). Drilling data indicates the sand does not occur as a simple, laterally continuous sand lens, but rather that it is encountered sporadically and not at predictable depths or horizons. Where groundwater is present in these sand lenses within the clay alluvium, it is generally confined by the overlying and underlying clays.

Lower Carters Limestone

Beneath the APC and adjacent areas to the north and west, groundwater is present in fractures within the Carters Limestone. Although the Carters Limestone is present over a large area of the site, it is not necessarily water-bearing throughout this extent. Where the T-3 bentonite is present, it appears that the bentonite and overlying Hermitage Formation have limited the vertical infiltration of water and thus limited the development of solution-enhanced water-bearing zones in the Carters Limestone. Therefore, the groundwater is generally present in the Lower Carters Limestone only where the T-3 bentonite is absent and the Lower Carters is exposed near the ground surface.

Groundwater within the Lower Carters Limestone flows through secondary porosity consisting of a network of water-bearing fracture zones that have been developed and enhanced by dissolution of the limestone. The majority of these are developed parallel to nearly flat-lying bedding planes. The shallowest water-bearing zones in the Lower Carters Limestone were encountered at elevations between approximately 441 and 463 ft msl, and the deepest is at elevation 388 ft msl. Groundwater in these zones is generally under confined or semi-confined conditions. In the vicinity of sinkholes and swallow holes where recharge occurs, Lower Carters Limestone groundwater may be locally unconfined.

Water levels and calculated hydraulic heads for wells screened in the Lower Carters Limestone are shown on **Figure 4** for the December 2018 measurement event. The area of low hydraulic head north of the APC is a dominant feature shown on the groundwater contour map. The low head of approximately 444.5 ft msl occurs in wells close to the Cumberland River (well 24) and as far away as GAF-414C, approximately 5,000 linear feet from the Cumberland River. This is a large area with a low hydraulic head and a virtually flat gradient that suggests relatively high permeability and interconnectivity of water-bearing zones through this area.

The hydraulic conductivity values for water-bearing zones in the Carters Limestone were calculated using data from injection packer tests in open boreholes and from slug testing of screened wells. The lowest conductivities are associated with unfractured, unweathered limestone, which may yield little or no water at all, and these values are on the order of 1x10-6 ft/min. The highest calculated hydraulic conductivities range between 3.4x10-3 and 1.2 x 10-2 ft/min.

Groundwater in the Lower Carters Limestone discharges to the Cumberland River through a network of secondary porosity features (e.g., fractures, solution-enlarged bedding planes, etc.). A likely location for a primary pathway is where the low hydraulic heads are present north of the ash ponds (e.g. hydraulic trough). The relatively low hydraulic head and flat gradient in this area indicate high permeability and relative ease of draining.

Lebanon Limestone

The Lebanon Limestone is present beneath the entire peninsula and the area to the north. Where groundwater is encountered within the Lebanon Limestone, it is most commonly in the L1 and/or L2 fracture zones, although these zones are not always water-bearing. Throughout much of the peninsula, the water-bearing zones within the Lebanon Limestone are confined, with overlying limestone acting as a confining unit. However, in the northwest portion of the site, the Lower Carters Limestone has been eroded or is thin. In this area, the Lebanon Limestone is closer to the ground surface and connected with the Lower Carters aquifer, and the fracture zone may be locally unconfined.

The depth to the primary Lebanon Limestone water-bearing fracture zone (L1) ranges from approximately 40 feet bgs in the northwest corner of the plant, where the Lebanon is near the ground surface to approximately 190 feet bgs beneath the NRL Landfill and other high areas on site. There are also locations where the L1 fracture zone has been shown not to be water-bearing based on packer or slug testing.

Water levels and hydraulic heads in wells screened in the Lebanon Limestone were used to construct potentiometric surface maps of the Lebanon Limestone aquifer for December 2018 (**Figure 5**). Hydraulic heads in the Lebanon Limestone, depicted on the figure, are highest in areas that also had high heads in the Lower Carters (GAF-405L, over 470 ft msl). Hydraulic heads are also relatively high in wells on the southeast side of the APC (GAF-433L and GAF-437L, over 460 ft msl). From these highs, the hydraulic heads decrease roughly radially to the east, south and west toward the Cumberland River, and to the north beneath the APC. North of the APC, hydraulic heads in several wells are low, similar to the Cumberland River level and the low heads in the Lower Carters Limestone in this area. Thus, the extensive area of low hydraulic head that is present in the Lower Carters Limestone is also present in the Lebanon Limestone, although its extent appears to be smaller.

Groundwater monitoring data was used to evaluate vertical gradients between the Lebanon Limestone and overlying Lower Carters Limestone. At most of the well pairs located adjacent to the Cumberland River and the hydraulic trough in the north, hydraulic heads indicate a vertically upward gradient, which would be expected given the plant's location adjacent to and surrounded by the Cumberland River; a regional location of groundwater discharge. To further examine vertical gradients, **Figure 6** shows a generalized geologic cross-section with potentiometric (hydraulic head) contour lines added. The cross-section extends roughly north-south through the hydraulic trough area and the APC. There is a vertical component of flow downward in the south (e.g., GAF-405C/L), and upward north of the ponds (e.g., in the trough area), and there is therefore a transition from downward to upward vertical gradients between these two areas. The water levels in Ash Pond A are also shown on the hydrographs for wells GAF-458C and GAF-437L (**Figure 6**). The differences between the pond water levels and all the groundwater levels, both in the head values and the patterns of change in the heads, demonstrate poor hydraulic communication between the pond and the groundwater. The pond is maintained at a relatively stable water level (approximately 464.5 ft msl); groundwater hydraulic heads vary over time based on factors such as the Cumberland River level and rainfall.

In summary, the hydraulic head differences between water-bearing units are generally as expected, with downward gradients at locations away from the Cumberland River and where groundwater is perched, and upward gradients close to the Cumberland River and near the hydraulic trough north of the APC.

The hydraulic conductivity of the L1 fracture zone was calculated using injection packer tests in open boreholes and slug testing of screened wells. Many of the tested intervals have very low hydraulic conductivities, and yield little or no water at all. The highest calculated hydraulic conductivities for the L1 fracture zone range between 3.2x10-3 and 1.9x10-2 ft/min.

2.3.3 Groundwater Flow Direction

The predominant groundwater flow direction at GAF is to the Cumberland River. Generalized hydraulic gradients for the Carters aquifer are presented in **Figure 7**. Generalized hydraulic gradients for the Lebanon aquifer are presented in **Figure 8**. Due to the potentiometric surface data and horizontal hydraulic gradient, it is generally expected that the groundwater at the site flows to the Cumberland River.

2.3.4 Potential Receptor Review

The following section provides a summary of the CSM for potential groundwater receptors.

Drinking Water

As part of the EI, TVA conducted a Water Supply Well (WSW) Survey and sampling activities at properties within one mile of the GAF northern property line in November 2016. The purpose of the WSW Survey was to identify usable water wells within the survey area.

The survey activities included the following tasks:

- Visit 235 target properties within the survey area;
- Complete survey form with the property owner;

- If a well is present on the property, request access to collect groundwater samples at a later date; and
- Evaluate and report the findings of the survey activities.

Of the 235 target properties, 38 were found vacant or without a dwelling, 10 of the owners solicited for a survey were unwilling to participate, 25 owners of target properties could not be reached or had not responded. Of the 162 properties that were surveyed, 24 properties were identified as having one or more wells present. A total of 28 wells were identified, as several properties have more than one well present. **Figure 9** shows the locations of the respondents and the identified wells.

Samples were collected from 11 wells and the results indicated none of the constituents detected in WSW samples were reported at concentrations above federal or state primary drinking water standards.

3.0 Groundwater Assessment Monitoring Program

Groundwater assessment monitoring for the APC has been conducted at GAF in accordance with 40 CFR § 257.95. This section of the report summarizes the results of the groundwater assessment monitoring program for the APC.

3.1 Groundwater Monitoring Network

In compliance with 40 CFR § 257.91, the APC multiunit groundwater monitoring well system contains 23 monitoring wells: 7 background monitoring wells and 16 downgradient monitoring wells. The monitoring well locations are shown on **Figure 10**.

The primary target of monitoring is the Carters Limestone, with 10 wells located along the downgradient waste boundary of the unit. At least one well in the Lebanon Limestone on each downgradient side of the unit was also included in the network, typically paired with Carters wells, or where the first water-bearing zones were encountered in the Lebanon. Groundwater is typically not encountered in overburden in the area of the APC, but the network includes one overburden well where groundwater was locally encountered.

The background monitoring wells (GAF-412C, GAF-412L, GAF-414L, GAF-426C, GAF-426L, GAF-427C, and GAF-427L) represent conditions unaffected by CCR (40 CFR § 257.91(a)(1) and (c)(1)). Four of the wells monitor groundwater conditions in the Lebanon Limestone, and three wells monitor groundwater in the shallower Carters Limestone. These background wells are not located directly upgradient from the APC. Per the CCR Rule § 257.91(a)(1), establishing background water quality may include the sampling of wells that are not hydraulically upgradient of the CCR management unit. In the case of the APC, for the Carters Limestone, there is no groundwater present in the formation on the upgradient (south) side of the unit; for the Lebanon Limestone, flow is generally away from the ponds in all directions, so there is not an upgradient direction available for monitoring. As a result, it is necessary to use wells that are not directly hydraulically upgradient to establish background conditions. The background wells are hydraulically separated from the APC by an area of low hydraulic head, so they represent conditions unaffected by CCR.

The downgradient monitoring wells (24, GAF-402C, GAF-402L, GAF-405C, GAF-406L, GAF-410U, GAF-416C, GAF-422C, GAF-446C, GAF-449L, GAF-450C, GAF-450L, GAF-451C, GAF-452C, GAF-452L, and GAF-453C) monitor groundwater downgradient near the waste boundary (40 CFR 257.91(a)(2) and (c)(1)). There are 10 downgradient monitoring wells completed in the Carters Limestone, five monitoring wells in the Lebanon Limestone, and one monitoring well screened in alluvium/unconsolidated materials.

The certification of the groundwater monitoring system required under 40 CFR § 257.91(f) is included in the facility operating record and on the facility CCR website: https://www.tva.gov/Environment/Environmental-Stewardship/Coal-Combustion-Residuals/Gallatin

3.2 Groundwater Assessment

Groundwater assessment monitoring was conducted in 2018. This section provides a summary of the results of the groundwater monitoring with a focus on those Appendix IV monitoring parameters that had SSLs above GWPS for assessment monitoring.

The results of the assessment monitoring are summarized below:

- Arsenic exceeded GWPS at GAF-410U, which is screened in alluvium/unconsolidated materials. The SSL concentration of arsenic detected at GAF-410U was 0.0214 milligrams per liter (mg/L). The calculated lower confidence limit on the mean SSL concentration of arsenic was 0.0219 mg/L. The published GWPS for arsenic is 0.010 mg/L.

- Cobalt exceeded GWPS at GAF-450C, which is screened in the Carters limestone. The SSL concentration of cobalt detected at GAF-450C was 0.00751 mg/L. The calculated lower confidence limit on the mean SSL concentration of cobalt was 0.0056 mg/L. The published GWPS for cobalt is 0.006 mg/L.

- Cobalt exceeded GWPS at GAF-450L, which is screened in the Lebanon limestone. The SSL concentration of cobalt detected at GAF-450L was 0.0116 mg/L. The calculated lower confidence limit on the mean SSL concentration of cobalt was 0.0083 mg/L. The published GWPS for cobalt is 0.006 mg/L.

- Lithium exceeded GWPS at GAF-452C, which is screened in the Carters limestone. The SSL concentration of lithium detected at GAF-452C was 0.0970 mg/L. The calculated lower confidence limit on the mean SSL concentration of lithium was 0.0729 mg/L. The GWPS for lithium in the Carters limestone is 0.045 mg/L (site background).

3.3 Summary of Alternative Source Demonstration

An alternate source demonstration (ASD) has been completed at GAF for the APC (AECOM, 2019). The ASD was made for Appendix IV parameters that exceeded the GWPS for cobalt and lithium. Thus, these Appendix IV parameters have been eliminated from this ACM.

The alternate source for the SSLs for cobalt and lithium in wells downgradient from the APC is natural groundwater variability, as demonstrated through the following lines of evidence:

- The APC is unlikely to be the source of cobalt and lithium above GWPSs, because concentrations in the ash pore water are themselves below the GWPSs, and lower than or similar to background groundwater concentrations. As a result, the APC cannot be the source of elevated concentrations in groundwater.
- The alternate source for cobalt is natural groundwater chemistry:
  - Cobalt is known to be associated with manganese and/or iron minerals.
  - Data from GAF shows a clear correlation between cobalt and iron/manganese.
  - Data from GAF do not show a correlation between cobalt and boron, the primary CCR indicator at GAF.
  - Cobalt is related to the presence of iron and/or manganese and redox conditions, and is not related to CCR. Certain redox conditions favor the dissolution of naturally occurring manganese and iron minerals. When the iron and manganese are dissolved into groundwater, the associated cobalt is also dissolved in groundwater and is present in groundwater samples.
- The alternate source for lithium is natural groundwater chemistry. The concentration of lithium in GAF-452C is elevated for the Carters Limestone, but is consistent with background conditions for the Lebanon Limestone. The greater depth of this well compared to other Carters wells, along with chemistry that is consistent with regional studies of the Central Basin Aquifer, indicates the groundwater at this well is less influenced from the surface and more influenced by contact with the limestone bedrock.

3.4 Groundwater Characterization

Additional characterization of the nature and extent of the sole GWPS exceedance for arsenic in groundwater is not necessary as the site conditions that affect this ACM are already understood. Section 5 discusses supplemental investigations that may be conducted during Selection of Remedy to aid in selection and design of a remedy.

- GAF-410U is screened in alluvium, which is localized in this area (**Figure 3**). Alluvium is not present and/or water-bearing zones are not found in overburden in the areas surrounding this well. Thus, its horizontal extent is defined by the limited extent of water in alluvium.
- In the vertical direction, a nearby well is screened in the underlying Carters Limestone (GAF-446C, **Figure 4**). This well is already part of the CCR Rule monitoring network, and arsenic is not above the GWPS in this well. Thus the vertical extent is defined by the existing well network.

4.0 Assessment of Corrective Measures

Groundwater assessment monitoring conducted for the APC Multiunit has determined that arsenic was present at an SSL above the GWPS as defined in 40 CFR § 257.95(h) at monitoring well GAF-410U.

This section of the report provides an ACM to address groundwater exhibiting arsenic above the GWPS.

4.1 Analysis of Corrective Measures

The objective of the ACM is defined in 40 CFR § 257.96(a) and consists of the following required elements:

- *Prevent further releases*;
- *Remediate any releases*; and
- *Restore the affected area to original conditions.*

Analysis of potential corrective measures for the arsenic exceedance of GWPS was conducted in accordance with 40 CFR § 257.96(c).

4.2 Potential Source Control Measures

The objectives of corrective measures under § 257.96(a) are to "prevent further releases [from the CCR Unit], to remediate any releases, and to restore affected areas to original conditions." Ultimately, in accordance with § 257.97(b)(3), the selected corrective measure must at a minimum "[c]ontrol the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in appendix IV to this part into the environment." The Preamble (80 Fed. Reg. 21302, 21406) to the CCR Rule discusses that source control measures may include modifying operational procedures. TVA has already implemented operational changes such as reducing free water in Ash Pond E, constructed a new flow management system, rerouted process water flows from the APC to the flow management system, rerouted NRL Landfill leachate from Ash Pond A to the flow management system, and rerouted NRL landfill contact water and stormwater to Stilling Pond B.

The APC Multiunit, which consists of unlined surface impoundments, has already ceased receiving flows. Stopping flows to the APC and dewatering the ponds will lead to further control of the source and prevention of releases. To achieve TVA's commitment to convert from wet to dry handling of CCR, to comply with regulatory requirements under the CCR Rule, and in accordance with the agreement between TDEC and TVA, the APC Multiunit will be closed by removal (see Section 2.2.1) subject to all necessary environmental reviews.

Closure-by-removal (CBR) of the APC Multiunit will serve as source control measures as required under 40 CFR § 257.97(b)(2). These measures will eliminate the potential for migration of CCR constituents to groundwater after completion of the removal efforts.

Groundwater assessment monitoring as required by 40 CFR 257.96(b) will continue until a groundwater remedy is selected. Once a remedy is selected, a Corrective Action Groundwater Monitoring Program (CAWGMP) will be instituted to document the effectiveness of the corrective action remedy.

4.3 Potential Remedial Technologies

Groundwater assessment monitoring conducted for the APC Multiunit has determined that arsenic is present at an SSL above the GWPS as defined in 40 CFR § 257.95(h) at monitoring well GAF-410U.

Subject to all necessary environmental reviews, the APC Multiunit will be closed-by-removal in accordance with 40 CFR § 257.102 and applicable state law.

In addition to this source control measure, four primary strategies have been evaluated to address groundwater exhibiting concentrations above the arsenic GWPS including the following:

- Monitored Natural Attenuation (MNA);
- In-Situ Physical/Chemical Treatment;
- Permeable Reactive Barriers (PRB); and
- Hydraulic Containment and Treatment.

Appendix A provides a detailed summary of each of these corrective measures.

The hydraulic containment and treatment and the in-situ treatment corrective measures both require treatment of groundwater. **Table 1** presents a summary of technologies used to treat arsenic in groundwater. Further evaluation of the specific groundwater treatment technologies will occur during remedy selection as discussed in Section 5.

4.4 Effectiveness of Proposed Corrective Measures

Each of the corrective measures presented in Section 4.3 meets the requirements and objectives of the remedy as defined in 40 CFR § 257.97.

The effectiveness of each corrective measure presented in Section 4.3 was assessed in accordance with 40 CFR § 257.96(c). A qualitative approach was utilized to compare the effectiveness of the proposed corrective measures to criteria in § 257.96(c)(1).

The following qualitative scoring system was utilized:

- Performance, Reliability and Ease of Implementation: These criteria were scored as High, Medium or Low. The High ranking indicates a corrective measure performs well in that evaluation category; and
- Potential Impacts of Potential Remedies to Safety, Cross Media Impacts, and Exposure to residual Constituents of Interest (COI): These criteria were scored as Low Risk, Medium Risk and High Risk. The Low Risk ranking indicates a corrective measure performs well in that evaluation category.

The criteria in 40 CFR § 257.96(c)(2) and (3) do not lend themselves to qualitative scoring, so these criteria are addressed in **Table B.1** as general comments.

Appendix B provides the qualitative evaluation. **Table B.1** summarizes the results of the qualitative evaluation of corrective measures completed for the APC Multiunit.

5.0 Selection of Remedy

A remedy to address SSLs in groundwater will be selected in accordance with 40 CFR § 257.97 and the CARA Plan. This section of the report summarizes additional information that will be obtained and reviewed prior to selection of a groundwater remedy.

5.1 Data requirements for design of groundwater corrective action

The horizontal extent of arsenic impacts downgradient of the APC Multiunit may be further characterized, if required in the ongoing EI. Characterization in accordance with 40 CFR § 257.95(g) is complete based upon the limited extent of the unconsolidated unit in the vicinity of well GAF-410U.

In order to further refine the targeted areas for corrective measures, develop detailed remedy cost estimates, and finalize the alternative for the APC, the currently available site-specific data will require further refinement. To this end, as part of this ACM, some potential data gaps have been identified. The identified data gaps pertain to one or more of the evaluated corrective measure alternatives. The complexity and breadth of the data gap evaluations will be based on the final selection of a corrective measures alternative for the APC. It is noted that additional data collection requirements may include ongoing EI work that is reported separately.

- Supplemental Hydraulic Properties Evaluation – This evaluation would consist of additional monitoring well installations to provide additional data related to the hydraulic characteristics of the subsurface, pumping tests to evaluate hydraulic capture geometry and potential groundwater recovery rates. These data would inform the feasibility, design, and implementation of any groundwater recovery systems.
- Supplemental Geotechnical Investigation – Additional geotechnical investigation would consist of geotechnical drilling to evaluate the subsurface conditions in areas considered for a PRB. Boring data would be used to further evaluate the length and depth of the PRB.
- Supplemental Groundwater Flow Modeling Simulations – The existing groundwater flow model would be refined as needed based on ongoing EI findings and the findings of the above investigations. The model would then be used to simulate a variety of groundwater extraction scenarios that optimize hydraulic containment of the arsenic impacted groundwater while balancing physical site constraints and treatment discharge capacity.
- Supplemental Groundwater Fate and Transport Modeling Simulations – The existing groundwater fate and transport model would be refined as needed based on on-going EI findings and the finding of the above investigations. The model would be used to

further evaluate the estimated time for natural attenuation mechanisms to reduce the arsenic concentrations to below GWPS.

- Groundwater Treatability Study – For in-situ and/or ex-situ treatment of extracted groundwater, treatability studies will be needed to evaluate technologies for the treatment of arsenic identified in **Table 1**.
- Wastewater Treatment Capacity Study – Further evaluation of the existing wastewater treatment capacity in existing or to be constructed on-site water treatment systems will be needed. Options may include on-site process water basin(s), temporary ash dewatering treatment systems, or a standalone system to manage extracted groundwater. A site-wide evaluation of on-site water treatment needs and capabilities is appropriate.

5.2 Semi-Annual Reporting, Public Meeting, Remedy Selection, and Final Report

Following completion of this ACM, the owner/operator must select a remedy as soon as feasible to comply with 40 CFR § 257.97(a). Progress toward the selection of the remedy will be documented in semi-annual reports in accordance with 40 CFR § 257.97(a). These semi-annual reports will include a description on the progress in selecting and designing the remedy.

At least 30 days prior to selecting a remedy, a public meeting to discuss the results of the corrective measures assessment will be conducted as required by 40 CFR § 257.96(e).

A final report will be generated after the remedy is selected. This final report will describe the remedy and how it meets the standards specified in 40 CFR § 257.97(b) and 257.97(c).

Recordkeeping requirements specified in 40 CFR § 257.105(h), notification requirements specified in 40 CFR § 257.106(h), and internet requirements specified in 40 CRF § 257.107(h) will be complied with as required by 40 CFR § 257.96(f).

6.0 References

AECOM, 2019. *Appendix IV Alternate Source Demonstration – Ash Pond Complex.* May 15, 2019.

Arcadis, 2015. *Groundwater Assessment Monitoring Project Summary and Risk Assessment Report. TVA Gallatin Fossil Plant. Non-registered Site #83-1324.* November 24, 2014.

Brahana and Bradley, 1986. *Preliminary Delineation and Description of the Regional Aquifers of Tennessee – The Central Basin Aquifer System*. Prepared by the United States Geological Survey in cooperation with the U.S. Environmental Protection Agency. USGS Water- Resources Investigations Report 82-4002.

Hanchar, 1988. *Geology of an Area Near Brentwood, Williamson County, Tennessee.* Prepared by the United States Geological Survey in cooperation with the Tennessee Department of Health and Environment, Division of Superfund. USGS Water-Resources Investigation Report 88-4176.

Newcome, 1958. Ground water in the Central Basin of Tennessee. Tennessee Division of Geology Report on Investigations 4.

USACE, 1959. Master Regulation Manual for Reservoirs in the Cumberland River Basin, Appendix D – Regulation Manual for Old Hickory, U. S. Army Engineer District, Nashville Corps of Engineers, Nashville, TN. November, 1959.

Wilson, 1991. *The Geology of Nashville, TN.* State of Tennessee Department of Environment and Conservation, Division of Geology, Bulletin 52, Second Edition.

Tables

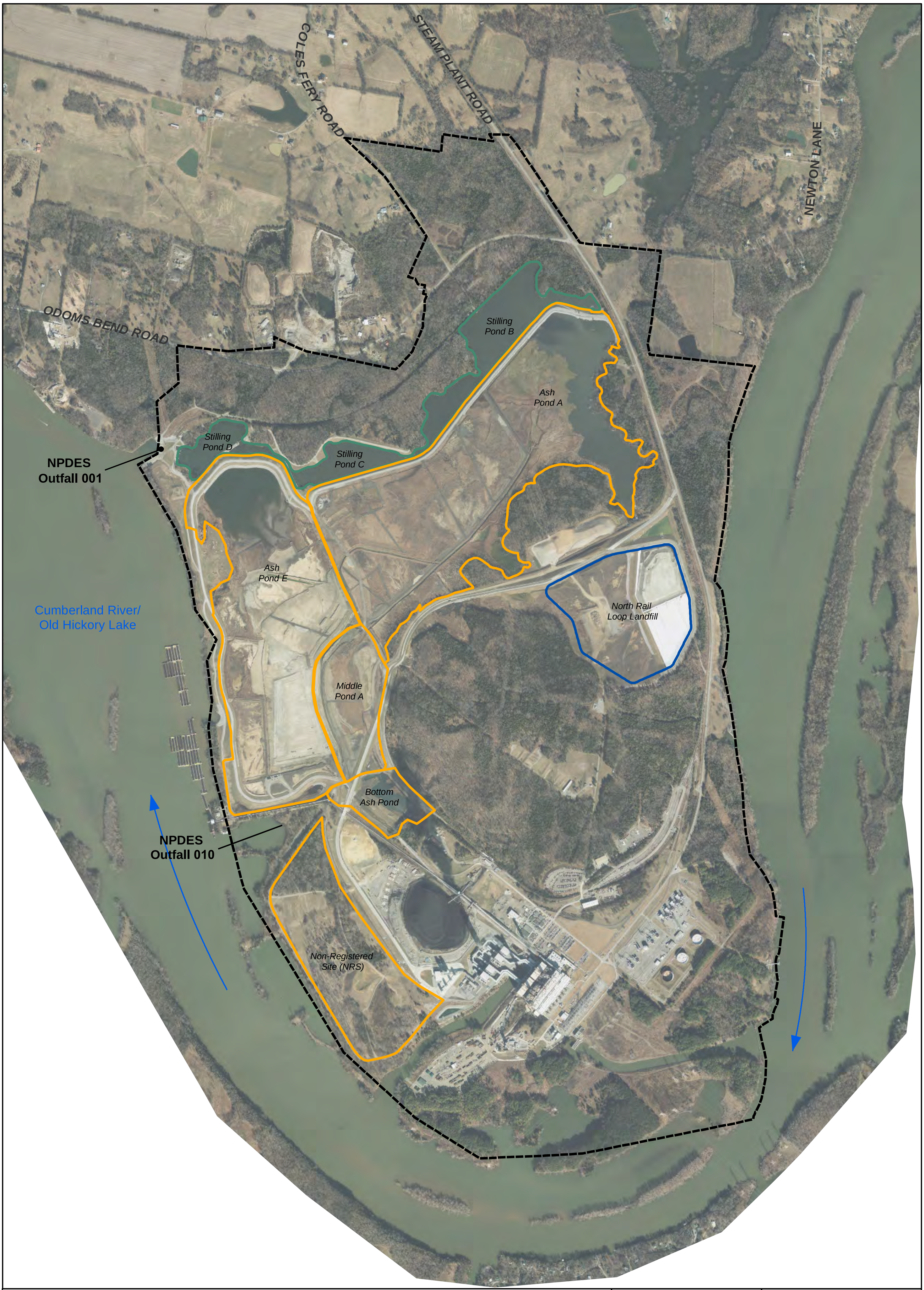
TABLE 1

WATER TREATMENT TECHNOLOGIES FOR ARSENIC
ASH POND COMPLEX MULTIUNIT

TVA GALLATIN FOSSIL PLANT
GALLATIN, TENNESSEE

Water Treatment Technology
Coagulation/Filtration
Reverse Osmosis
Co-precipitation
Lime Precipitation
Sulfide Precipitation
Ion Exchange
Activated Carbon Adsorption
Activated Alumina Adsorption
Membrane Filtration
Iron Oxide Adsorption
Oxyhydroxide Adsorption
Oxidation
Biological Treatment

Figures



LEGEND
- Cumberland River Flow Direction
- TVA Gallatin Fossil Plant Property Boundary (Approximate)
- CCR Management Units
- North Rail Loop (NRL) Landfill
- Stilling Ponds

N

0 1,200 2,400
Feet

NOTE: Aerial image dated February 2017

AECOM

Figure 1

OVERVIEW OF
CCR MANAGEMENT AREAS

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MARK.P.SMITH	SCHEIPC		REV. 9

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
4/24/2017	FOSSIL AND HYDRO ENGINEERING

STRATIGRAPHIC and GAMMA RESPONSE DESCRIPTIONS

Bigby-Cannon Limestone
Medium to dark gray, microcrystalline to medium-grained, fossiliferous limestone, with shaly and fossil-hash beds. Only encountered in extreme topographic high of site (e.g. North Rail Loop).

Hermitage Formation
Medium to dark gray, slightly fossiliferous, very fine-grained argillaceous limestone and calcareous shale, laminated to thinly bedded. Characterized by a locally high and broad gamma signature.

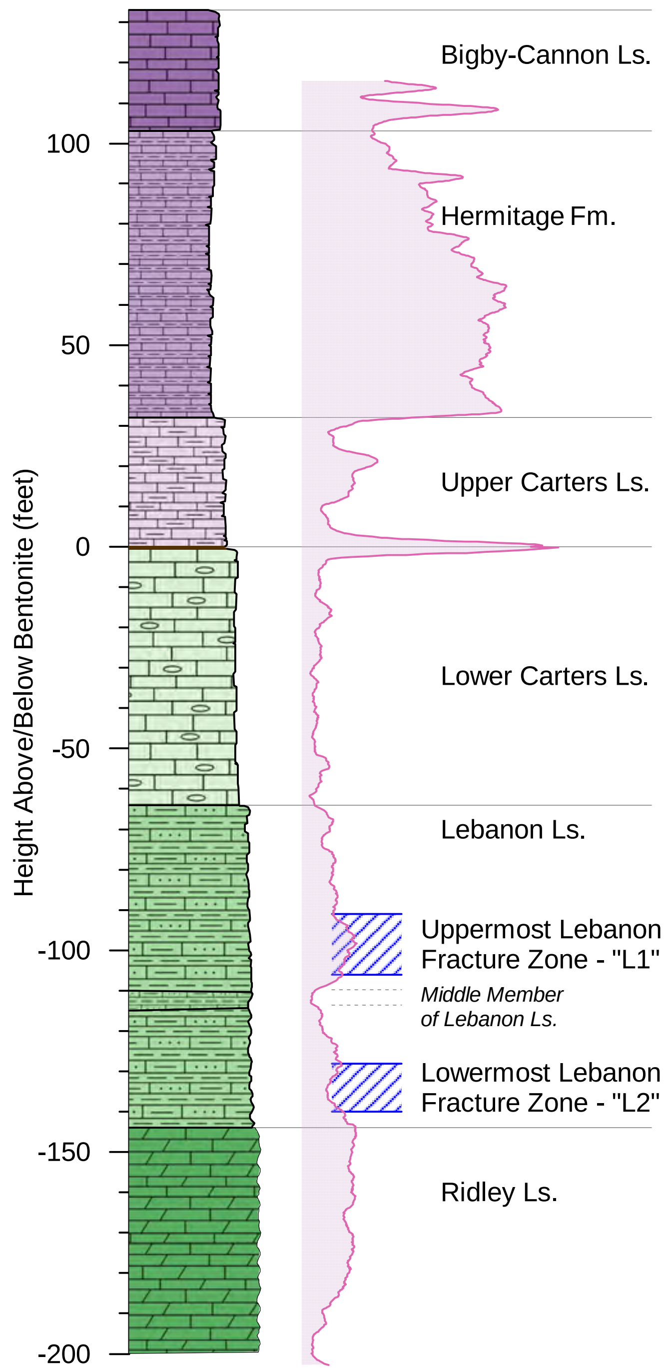
Upper Carters Limestone
Gray to dark gray microcrystalline to medium-grained, fossiliferous limestone, with shale laminations and trace fossils. Abrupt drop in gamma response from the overlying Hermitage formation. A locally moderate gamma reponse.

T-3 Bentonite
Light gray to bluish-gray, fat clay; volcanic ash. Regionally identified as the T3 bentonite. Gamma response is the local extreme high.

Lower Carters Limestone
Light gray and yellowish brown, fossiliferous, medium-grained limestone, with shale laminations, chert nodules and chert lenses, trace fossils, and stylolites. A locally low and broad gamma signature.

Lebanon Limestone
Medium gray to olive gray, very fine to medium-grained, fossiliferous limestone, with thin shaly beds. Characterized by a locally moderate-high and broad gamma signature. Massive-bedded member ("Middle Member") exhibiting a low gamma response is typically present approximately 110-115 feet below the T3 Bentonite.

Ridley Limestone
Medium to thick-bedded, fine to medium-grained, gray dolomitic limestone, with calcareous shale and shaly limestone. Very little drilling completed to Ridley Ls. during site investigation activities.



NOTES:
Example gamma profile is an averaged composite profile from boreholes NRL045, GAP055-L, and GAP045-L

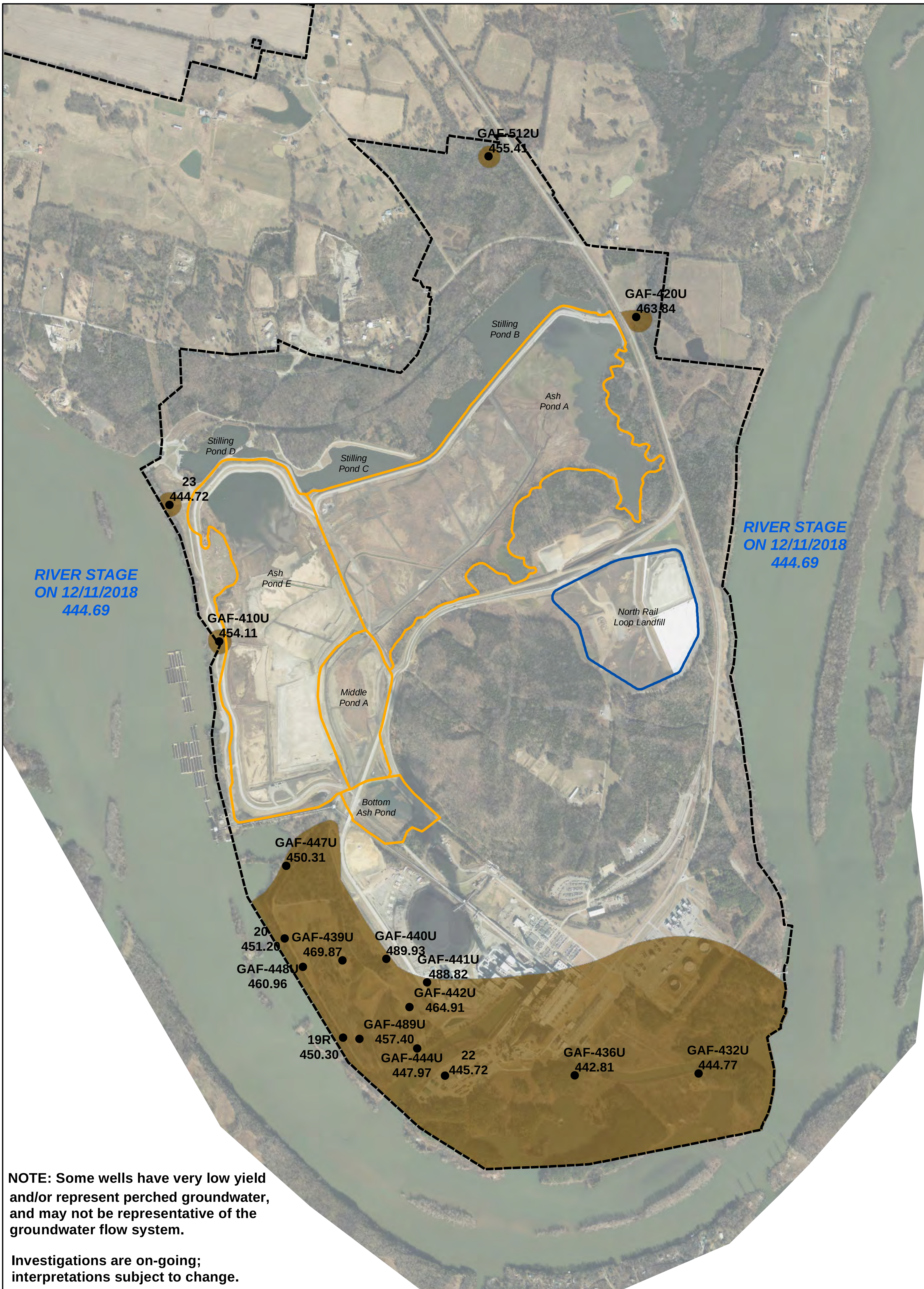
AECOM | **Figure 2**

TYPE LOG OF STRATIGRAPHY AND NATURAL GAMMA RESPONSE

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
WILSON/SCHEIP	SCHEIPC	KEYSV	REV. 0

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
03/22/2017	FOSSIL AND HYDRO ENGINEERING



NOTE: Some wells have very low yield and/or represent perched groundwater, and may not be representative of the groundwater flow system.

Investigations are on-going; interpretations subject to change.

LEGEND:

22 Well ID
445.72 Groundwater Elevation (feet MSL) on 12/11/2018

● Well Location

TVA Gallatin Fossil Plant Property Boundary (Approximate)

CCR Management Units

Estimated Extent of Groundwater in Unconsolidated Unit

N

0 1,200 2,400
Feet

NOTE: Aerial image dated February 2017

AECOM

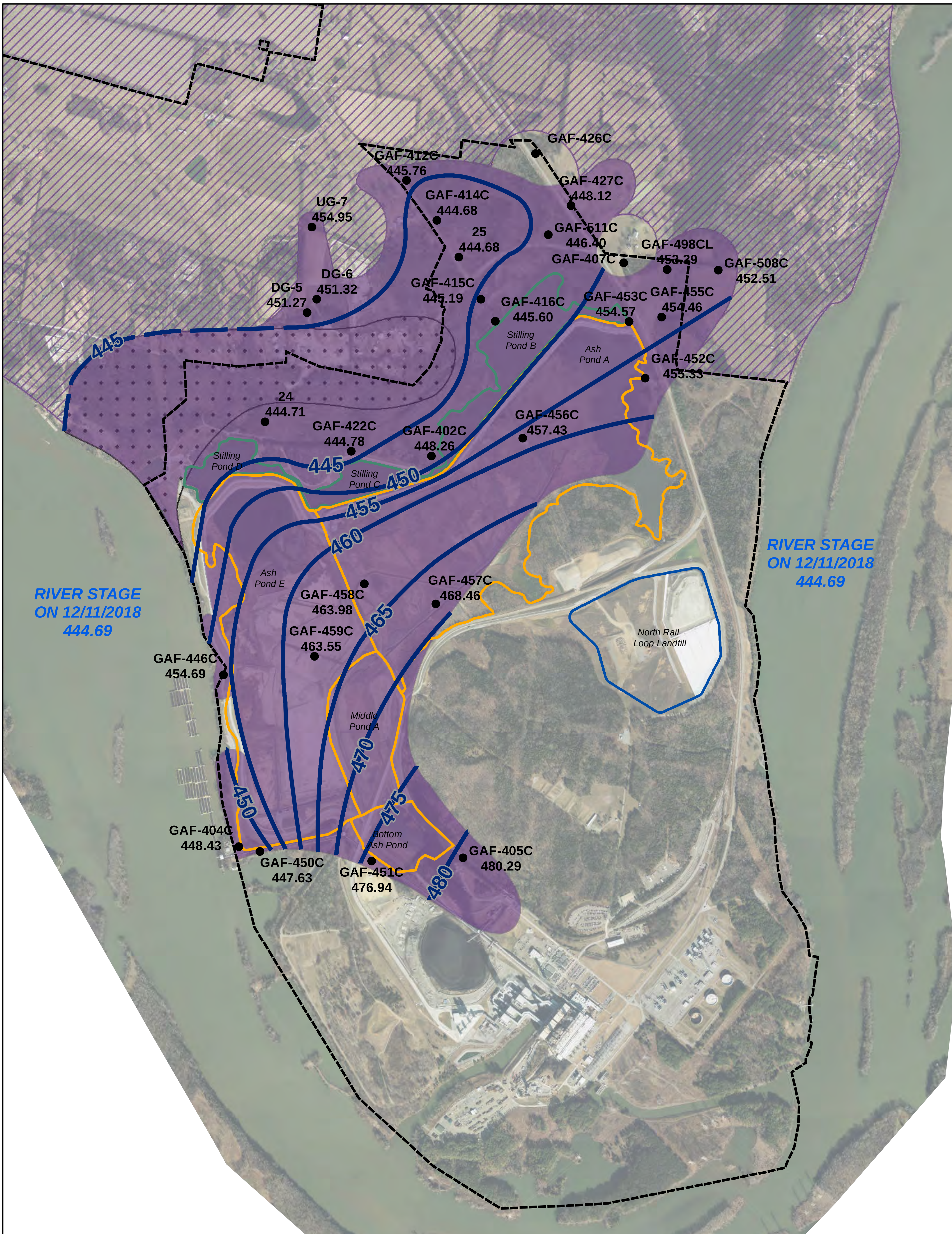
Figure 3

HYDRAULIC HEADS
UNCONSOLIDATED UNIT,
DECEMBER 11, 2018

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MARK.P.SMITH	C.GARLINGTON		REV. 0

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
1/21/2019	FOSSIL AND HYDRO ENGINEERING



NOTE: Some wells have very low yield and/or represent perched groundwater, and may not be representative of the groundwater flow system.
Investigations are on-going; interpretations subject to change.

LEGEND:

GAF-405C Well Screened in Carters Limestone
480.29 Hydraulic Head feet MSL on 12/11/2018

● Well Screened in Carters Limestone

Hydraulic Head Contour in Aquifer, Dashed where Inferred

TVA Gallatin Fossil Plant Property Boundary (Approximate)

Ash Pond Complex

North Rail Loop (NRL) Landfill

Stilling Ponds

Estimated Extent of Lower Carters Limestone

Presence of Carters Aquifer Unknown

1st Water Encountered in Lebanon; Contiguous with Carters Aquifer

NOTE: Aerial image dated February 2017

N

0 1,200 2,400
Feet

AECOM

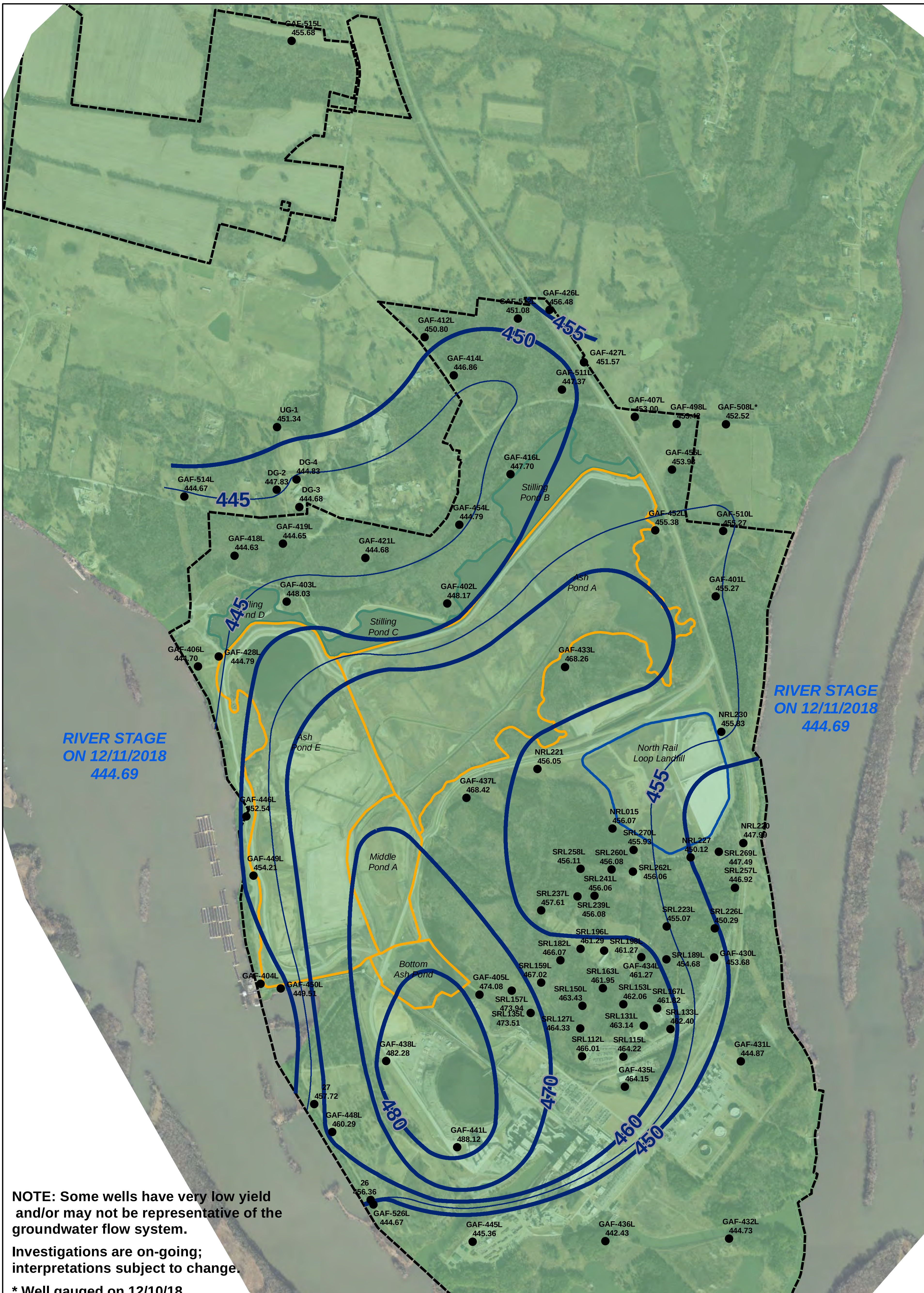
Figure 4

HYDRAULIC HEADS
CARTERS AQUIFER,
DECEMBER 11, 2018

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MARK.P.SMITH	C.GARLINGTON	E.PERRY	REV. 1

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
3/28/2019	FOSSIL AND HYDRO ENGINEERING



NOTE: Some wells have very low yield and/or may not be representative of the groundwater flow system.

Investigations are on-going; interpretations subject to change.

*** Well gauged on 12/10/18**

LEGEND:

GAF-445L Well Screened in Lebanon Limestone
445.36 Hydraulic Head feet MSL on 12/11/2018

- Well Screened in Lebanon Limestone
- Hydraulic Head Contour in Aquifer
- TVA Gallatin Fossil Plant Property Boundary (Approximate)
- Ash Pond Complex
- North Rail Loop (NRL) Landfill
- Stilling Ponds
- Estimated Extent of Lebanon Limestone Aquifer

NOTE: Aerial image dated February 2017

AECOM

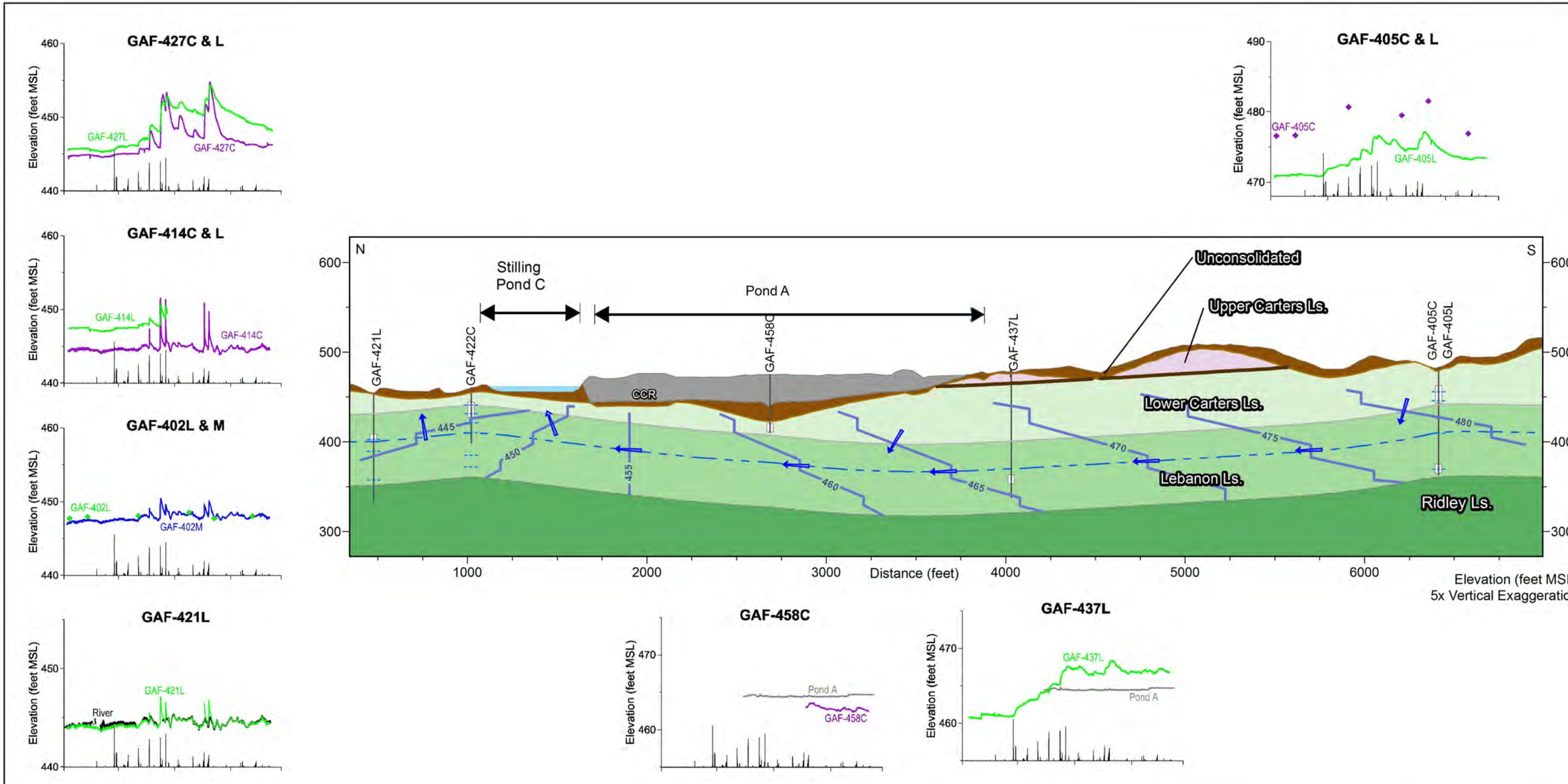
Figure 5

HYDRAULIC HEADS
LEBANON AQUIFER,
DECEMBER 11, 2018

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MARK.P.SMITH	C.GARLINGTON	E.PERRY	REV. 0

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
3/28/2019	FOSSIL AND HYDRO ENGINEERING

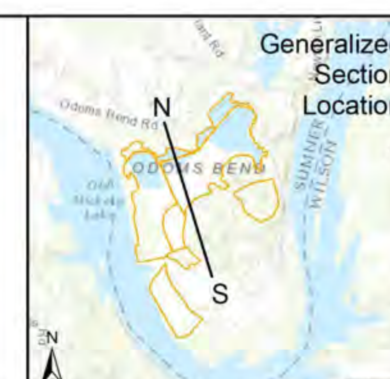


LEGEND

- Bentonite
- Equipotential Lines
- Approximate Location of the Upper Water Bearing Lebanon Ls. Fractures (Confined)
- Boring or Well
- Well Screen
- Arrows represent direction of groundwater flow
- Water-bearing Zone

Notes:

1. Section based on Geologic Cross Section C-C' (see Appendix of EAR)
2. Equipotential lines shown here represent an interpretation of the groundwater flow system in the vicinity of the APC, based on water level data from 1/23/2017.
3. The geologic units are not all water-bearing at all locations, including locations on this section. For example, there are no water-bearing zones in the Carters Limestone in the vicinity of GAF-437L, but there are such zones elsewhere south of the APC. The L1 and L2 Lebanon fracture zones are variably water-bearing.
4. Investigations are on-going; interpretations subject to change.



AECOM

Figure 6

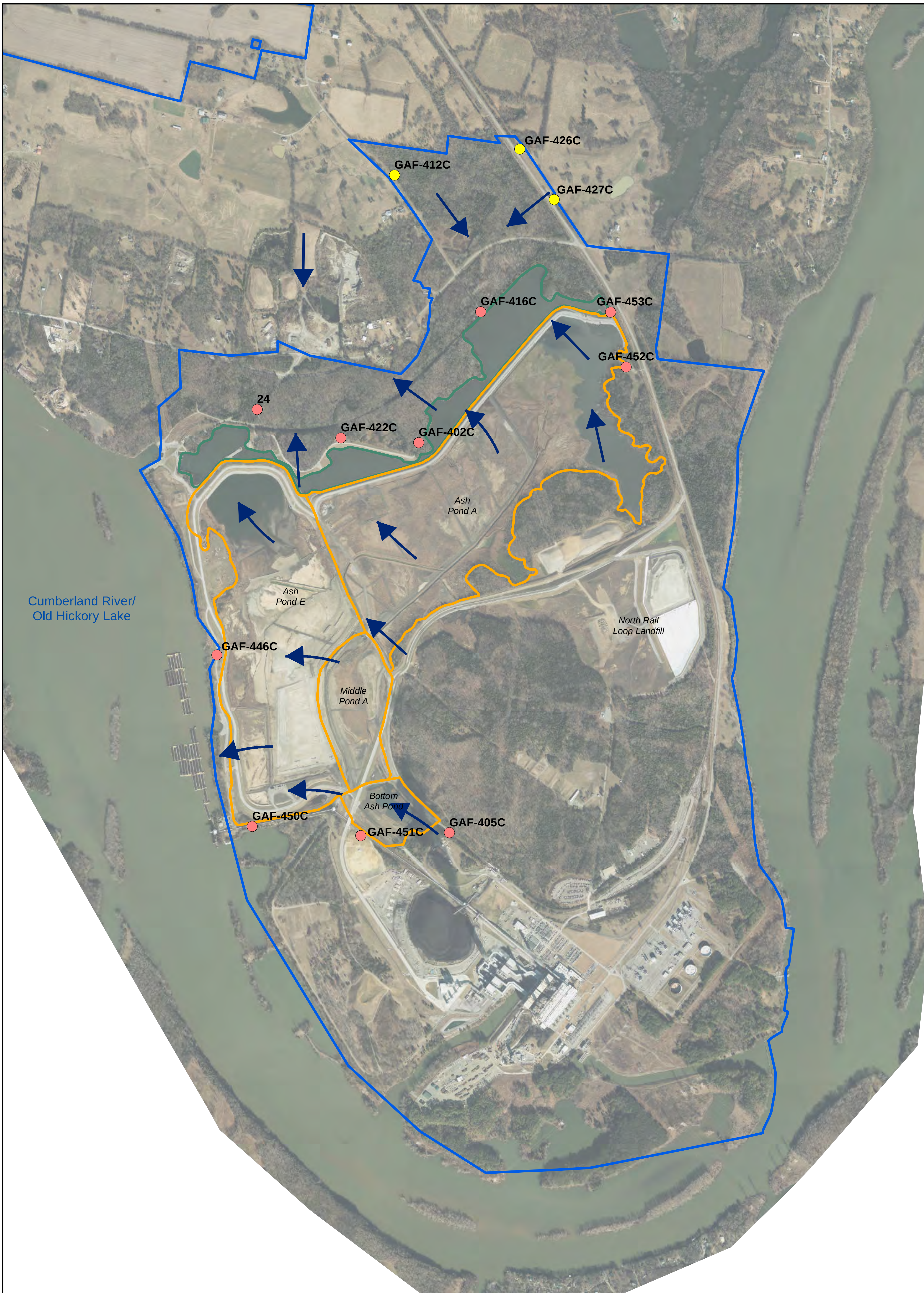
EXAMPLE NORTH-SOUTH CROSS SECTION WITH HYDRAULIC HEADS

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MCKINNEYR	SCHEIPC	KEYSV	REV. 1

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE: 4/27/2017 DEPT: FOSSIL AND HYDRO ENGINEERING

Document Path: M:\USCHA3_Data\200\TVA\GAF\RobbiGIS\CrossSectionCCSpecialReq.mxd



LEGEND

- CCR Rule Monitoring System - Background Well (Carters)
- CCR Rule Monitoring System - Downgradient Well (Carters)
- Hydraulic Gradient
- Ash Pond Complex
- Stilling Ponds
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

N

0 1,200 2,400
Feet

NOTE: Aerial image dated February 2017

AECOM

Figure 7

GENERALIZED HYDRAULIC GRADIENTS - CARTERS AQUIFER, JUNE 18, 2018

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MARK.P.SMITH	C.GARLINGTON		REV. 0

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
1/25/2019	FOSSIL AND HYDRO ENGINEERING

LEGEND

- CCR Rule Monitoring System - Background Well (Lebanon)
- CCR Rule Monitoring System - Downgradient Well (Lebanon)
- Hydraulic Gradient
- Ash Pond Complex
- Stilling Ponds
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

N

0 1,200 2,400
Feet

NOTE: Aerial image dated February 2017

AECOM

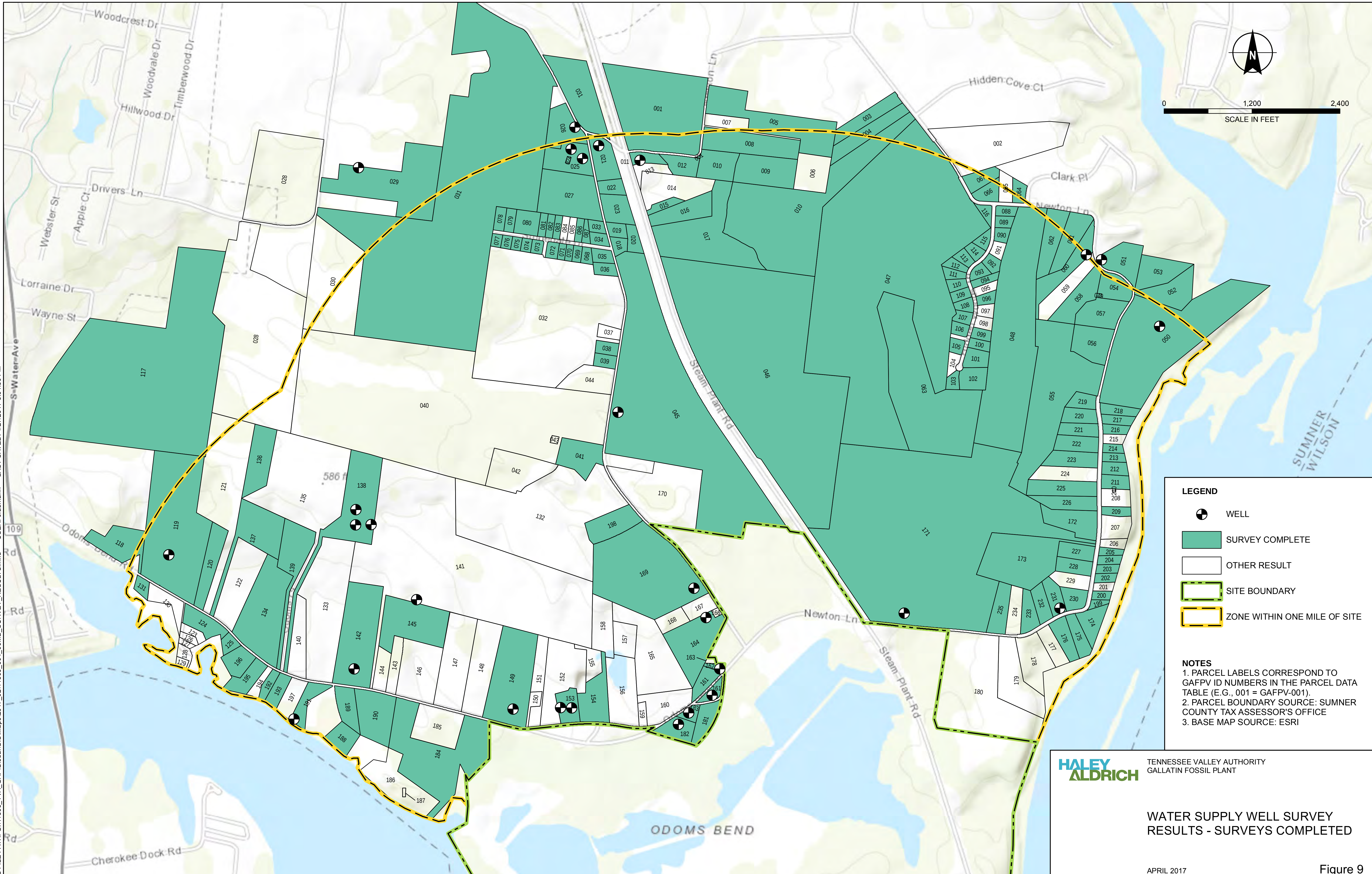
Figure 8

GENERALIZED HYDRAULIC GRADIENTS - LEBANON AQUIFER, JUNE 18, 2018

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MARK.P.SMITH	C.GARLINGTON		REV. 0

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
1/25/2019	FOSSIL AND HYDRO ENGINEERING



HALEY ALDRICH

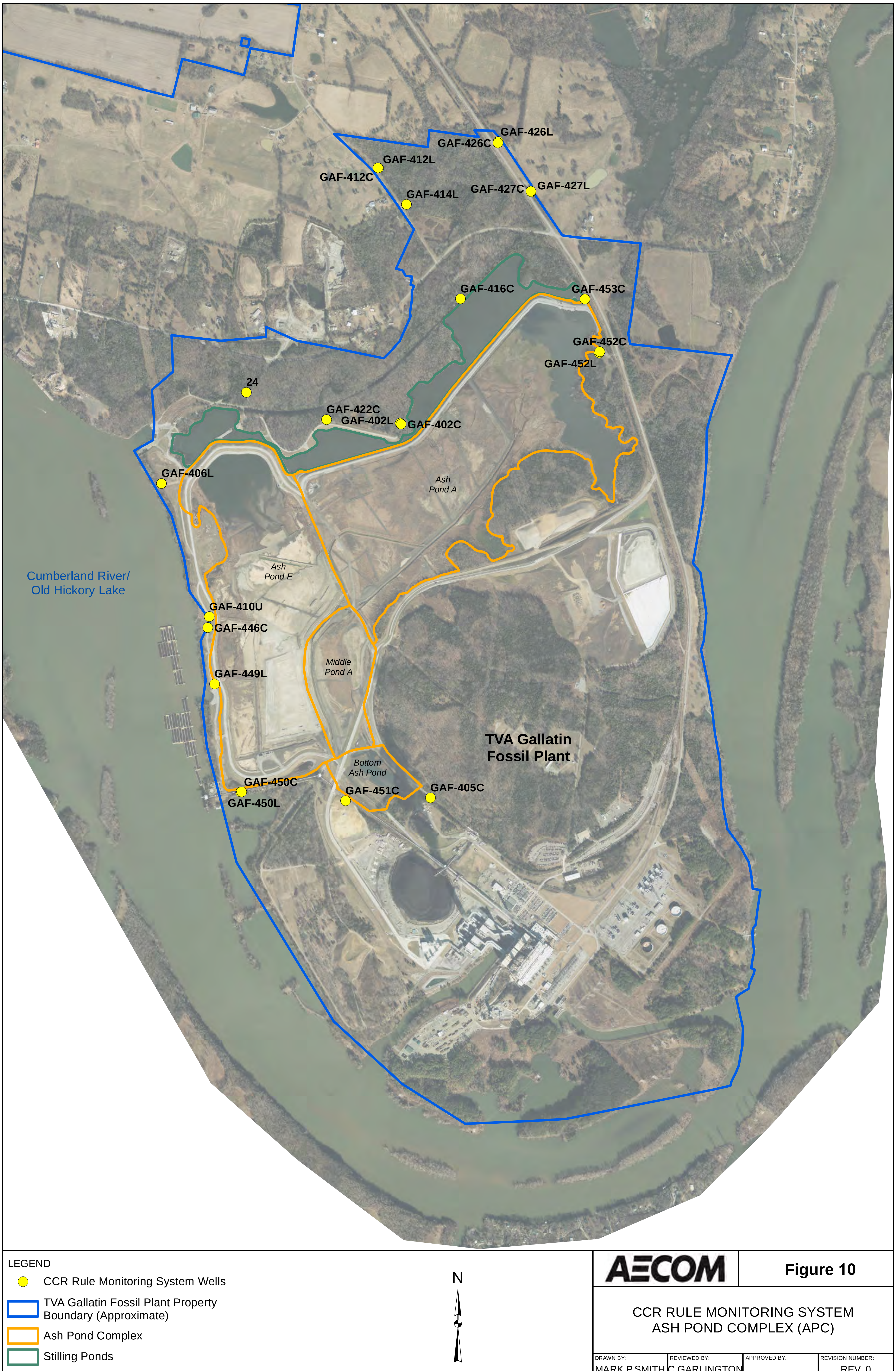
TENNESSEE VALLEY AUTHORITY
GALLATIN FOSSIL PLANT

WATER SUPPLY WELL SURVEY RESULTS - SURVEYS COMPLETED

APRIL 2017

Figure 9

GIS FILE PATH: G:\41803_TVA_GAF\Global\GIS\Maps\2017_02\41803_001_00MB_SURVEY_RESULTS.mxd — USER: craumann — LAST SAVED: 4/27/2017 3:04:30 PM



LEGEND

- CCR Rule Monitoring System Wells
- TVA Gallatin Fossil Plant Property Boundary (Approximate)
- Ash Pond Complex
- Stilling Ponds

NOTE: Aerial image dated February 2017

AECOM

Figure 10

CCR RULE MONITORING SYSTEM
ASH POND COMPLEX (APC)

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MARK.P.SMITH	C.GARLINGTON		REV. 0

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
10/13/2017	FOSSIL AND HYDRO ENGINEERING

Appendix A
Corrective Measures Technologies

1.0 Corrective Measures Technologies

The following remedial technologies are regarded as potentially applicable to corrective measures for CCR groundwater impacts:

- Monitored Natural Attenuation (MNA)
- In-situ Physical/Chemical Treatment
- Permeable Reactive Barriers (PRB)
- Hydraulic Containment and Treatment

A brief overview of these technologies is provided in the subsequent subsections.

1.1 Monitored Natural Attenuation (MNA)

MNA is a remedial strategy that involves establishing an assessment program to monitor the physical, chemical, or biological processes that currently exist at a site. These processes can often work to reduce the toxicity, concentration, or mobility of site constituents of concern (COCs) in a timeframe that is comparable to other remedial technologies. MNA is effective at sites where COC concentrations are near threshold levels, do not have an immediate pathway to sensitive receptors, and/or are not resultant from an on-going source. When compared to other active remedial alternatives, MNA often requires an extended timeframe to achieve remedial objectives.

MNA implementation would rely on the existing groundwater monitoring and assessment program to evaluate whether the arsenic concentrations present in the groundwater are being reduced. Existing and potentially new monitoring wells at the APC would be used to characterize and delineate arsenic concentrations downgradient of the APC.

Groundwater monitoring will take place in Assessment and/or Detection modes as appropriate for the current phase of CCR activity. Groundwater monitoring results will be reviewed to evaluate the effectiveness of MNA in attaining the Corrective Action Objectives (CAO).

1.2 In-situ Physical/Chemical Treatment

For inorganic COCs at CCR sites, in-situ treatment is an established technology for a variety of site conditions and contaminants, and it involves enhancement of natural attenuation processes such as dilution, adsorption, and chemical reactions to reduce concentrations to acceptable levels. This technology may be appropriate for sites at which groundwater flow volumes are low, source controls are effective, and impacted groundwater is not expected to be long-lived. In-situ treatment media can be emplaced directly into the source material or in a barrier configuration (e.g., as a PRB) using closely-spaced vertical borings or with trenching equipment.

If this technology is incorporated into a corrective action alternative, further detailed evaluation and/or bench- and pilot-scale studies would be necessary to identify effective in-situ treatment amendments for the COCs. In-situ treatment technologies are retained for circumstances in which groundwater flow volumes are particularly low, source controls are effective, and impacted groundwater is not expected to persist as a treatment demand. The CSM and data gaps investigations, including groundwater flow modeling as needed, will guide the design of any in-situ treatment.

1.3 Permeable Reactive Barriers (PRB)

A PRB is an in-situ technology that consists of a subsurface trench filled with reactive material installed to intercept and react with impacted groundwater. PRBs can be established through direct-push injection (on closely spaced grids) or emplaced as a continuous trench of reactive material. PRBs are typically installed to the depth of impacted groundwater (often the bottom of the shallow aquifer) and are oriented perpendicular to the flow of impacted groundwater. The amendment used to generate the PRB is generally as permeable as or more permeable than the surrounding material, encouraging impacted groundwater to flow through the reactive material. The reactive material then causes chemical reactions to occur within the PRB, resulting in adsorption, precipitation, or degradation.

PRBs are commonly used to control organic contamination in groundwater, and have been successfully used to remediate metals. Bench-scale, column, and pilot testing processes are likely necessary for the design of a PRB to determine the effectiveness of the treatment zone(s).

The use of PRBs is useful for circumstances in which groundwater flow volumes are particularly low or in which they can be paired with physical containment to achieve passive management of impacted groundwater. The CSM, as well as bench and pilot-scale testing will guide the design of any PRB system.

1.4 Hydraulic Containment and Treatment

The use of hydraulic containment as a potential remedial technology is considered. The use of groundwater extraction can be effective at hydraulically controlling long-term downgradient dissolved phase impacts. Hydraulic containment through groundwater extraction and subsequent treatment has historically been a common method for management of groundwater impacted with metals and other inorganics. Groundwater is pumped from wells (vertical or horizontal) or collection trenches to a discharge point (e.g., a permitted outfall) or to an aboveground treatment system. The extraction network would be designed, constructed and operated to provide a hydraulic barrier between the impacted groundwater and the migration pathway to potential receptors. The use of hydraulic containment is retained because it is an effective means of preventing offsite migration of soluble contaminants. Hydraulic containment requires management and potential ex-situ treatment of extracted groundwater, so it is not a stand-alone technology. The CSM will guide the design of any groundwater extraction system to optimize the total capture of groundwater needed to provide hydraulic containment. When compared to other active remedial alternatives, hydraulic containment systems can require an extended timeframe to achieve remedial objectives where continued source loading occurs.

2.0 Additional Supporting Actions

The specific technologies described above would be supported by additional actions implemented for the APC remedy by TVA that contribute to limiting exposure to potential COCs as well as monitoring performance of the remedy.

Institutional controls (ICs), which include Environmental Restrictive Covenant(s), groundwater use restrictions, etc., are a means of mitigating potential exposures to impacted groundwater and are a common element of remedial actions. However, it is noted the ICs are not anticipated to be used as a stand-alone technology. Environmental Covenants, groundwater use restrictions, etc., are expected to be combined with other applicable technologies as part of corrective measures alternatives.

The use of groundwater monitoring (Assessment and/or Detection modes as appropriate) when combined with other applicable technologies as part of any proposed corrective measures alternative will continue to be implemented to track the effectiveness of the overall remedy.

TVA's compliance with existing permits (solid waste, NPDES, etc.) will also continue to mitigate potential environmental impacts and exposure to COCs.

Appendix B
Evaluation of Potential Remedies

1.0 Introduction and Background

A Closure-by-Removal (CBR) plan is being prepared for the APC Multiunit as a result of an agreement between TVA and TDEC, as described in Section 2.2.1 and subject to all necessary environmental reviews. CBR of the APC Multiunit will serve as source control measures as required under 40 CFR § 257.97(b)(2). These measures will address the ACM objective element of preventing further releases in 40 CFR § 257.96(a) by eliminating the potential for migration of CCR constituents to groundwater after completion of the removal efforts.

The assessment monitoring program specified in 40 CFR § 257.95 will continue during remedy selection. CBR of the APC Multiunit is expected to result in decreasing trends of arsenic in the groundwater. The results of continued assessment monitoring will be used to evaluate the effectiveness of operational changes, described in 4.2, and closure activities, and to track changing groundwater conditions to evaluate whether interim actions to control sources are warranted. Reports will be developed to summarize the progress in selecting a groundwater remedy.

For the ACM objective elements of remediating groundwater releases and restoring affected areas to original conditions (from 40 CFR § 257.96(a)), TVA will continue groundwater assessment monitoring as required by 40 CFR 257.96(b) until a groundwater remedy is selected. Once a remedy is selected, TVA will implement a CAGWMP to document the effectiveness of the corrective action remedy. Groundwater monitoring will continue until groundwater protection standards are achieved as defined in 40 CFR § 257.98(c)(2) and under applicable state law.

The remedial technologies assessed in the following sections focus on remediating releases and restoring affected areas to original conditions by addressing the area of groundwater exhibiting arsenic at SSLs above the GWPS. The groundwater remedial technologies that are evaluated herein consist of the following:

- Monitored Natural Attenuation (MNA);
- In-Situ Physical/Chemical Treatment;
- Permeable Reactive Barriers (PRB); and
- Hydraulic Containment and Treatment.

Appendix A provides a description of each of these technologies.

2.0 Requirements for ACM Assessment in 40 CFR § 257.96(c)

The assessment of appropriate remedies to meet the requirements of 40 CFR § 257.96(c) of the CCR Rule is provided in the sections below and summarized in **Table B.1**. A qualitative approach was utilized to compare the effectiveness of the proposed corrective measures, and it consisted of the following qualitative scoring system:

- Performance, Reliability and Ease of Implementation – scored as High, Medium or Low. A High ranking indicates a corrective measure performs well in that evaluation category; and
- Potential Impacts of Safety, Cross Media and Exposure to Constituents of Interest (COIs) – scored as Low Risk, Medium Risk and High Risk. A Low Risk ranking indicates a corrective measure performs well in that evaluation category.

The qualitative assessments in **Table B.1** (low, medium, high) are based on experience and professional judgement.

Additional criteria under 40 CFR § 257.96(c) that were assessed for this ACM are:

- The time required to begin and complete the remedy; and
- The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy(s).

Each of the potential groundwater remedial technologies was assessed relative to these criteria in the following sections.

3.0 Monitored Natural Attenuation

MNA is a remedial strategy that involves establishing an assessment program to monitor the physical, chemical, or biological processes that currently exist at a site. For the APC, MNA is feasible because arsenic concentrations would decrease through natural attenuation mechanisms. An existing groundwater monitoring program is in place to evaluate the effectiveness of MNA.

MNA performance is scored as medium because of the proximity of potential receptors and because of the potential source loading that would continue until CBR is completed. The reliability of MNA is high because the physical processes are naturally-occurring. MNA is easily implemented (scoring high) because the existing monitoring program is in place, and the monitoring scope can be readily updated as needed to evaluate remedy performance.

MNA represents a low risk for potential impacts to safety because all work activities associated with sample collection are conducted in accordance with TVA's Safe Work Practices and with task-specific health and safety planning, review, and approvals. MNA also affords low risk of cross-media impacts and of potential exposure to arsenic because all remediation processes take place in-situ, and the nature and extent of arsenic in groundwater at GAF are well-characterized.

The time to begin an approved MNA groundwater remediation program is estimated to be 1 to 2 years because TDEC input is expected for the groundwater monitoring program update as well as for the other elements of the proposed APC corrective measures (e.g., CBR). State (TDEC), local or other environmental permit requirements are anticipated to affect implementation of MNA and the other elements of the proposed APC corrective measures.

The time period to achieve remedial objectives, i.e., attainment of corrective action objectives (CAOs) established for the selected remedy, is protracted. Groundwater fate and transport modeling would be necessary to provide an estimated range of timeframes to attain CAOs. It should be noted that the naturally-occurring attenuating processes are taking place currently, and they would also take place as part of other remedial approaches.

4.0 In-Situ Physical/Chemical Treatment

For inorganic COIs at CCR sites, in-situ treatment is an established technology for a variety of site conditions and contaminants, and it involves enhancement of natural attenuation processes to reduce concentrations to acceptable levels. System design would adapt selected treatment technologies listed in **Table 1** as part of bench- and pilot-scale testing of potential amendments to enhance naturally-occurring attenuation processes.

Performance and reliability of in-situ treatment both score high because: treatment for arsenic is a mature technology; bench- and pilot-scale testing would allow for an effective plan for injection of amendments; and CBR will provide for effective source control. In-situ treatment media can be emplaced directly into the source material or in a barrier configuration (e.g., as a PRB) using closely-spaced vertical borings or with trenching equipment. Ease of implementation score is medium because the treatment zone includes fractured bedrock that would potentially make trenching difficult, and uniform distribution of amendments is potentially complicated if injection occurs by conventional drilling methods.

In-situ treatment represents medium safety risk because all work activities associated with amendment injection are conducted in accordance with TVA's Safe Work Practices and with task-specific health and safety planning, review, and approvals. Experienced contractors would be used for trenching and drilling activities, and these tasks would require more advanced training for the operators of specialized equipment. In-situ treatment also affords low risk of cross-media impacts and of potential exposure to arsenic because all remediation processes take place in-situ, and the nature and extent of arsenic in groundwater at GAF are well-characterized.

The time to begin an approved in-situ groundwater remediation program is estimated to be 3 to 5 years because: TDEC input is expected for all phases of the design; bench- and pilot-scale testing, reporting, and approval are anticipated to require multiple years; and implementation will need to be coordinated with the sequencing of tasks for the CBR. State (TDEC), local or other environmental permit requirements are anticipated to affect implementation of CBR and in-situ treatment.

In-situ treatment at the release source ends loading to groundwater. A point of compliance downgradient of the treatment zone would be established for the CAOs. The time period for in-situ treatment to achieve remedial objectives, i.e., attainment of CAOs, is protracted.

Groundwater fate and transport modeling would be necessary to provide an estimated range of timeframes to attain CAOs.

5.0 Permeable Reactive Barriers (PRB)

A PRB is an in-situ technology that consists of a subsurface trench filled with reactive material installed to intercept and react with impacted groundwater. System design would adapt selected treatment technologies listed in **Table 1** as part of bench- and pilot-scale testing of potential amendments that result in chemical reactions of adsorption, precipitation, or degradation.

Performance and reliability of PRB score high because treatment for arsenic is a mature technology, bench- and pilot-scale testing would result in effective amendments that form the barrier, and CBR will provide for effective source control. PRBs can be established through direct-push injection (on closely spaced grids) or emplaced as a continuous trench of reactive material. Ease of implementation score is medium because the treatment zone includes fractured bedrock that would potentially make trenching difficult, and uniform distribution of amendments is potentially complicated if injection occurs by conventional drilling methods.

PRB represents medium safety risk because all work activities associated with installation are conducted in accordance with TVA's Safe Work Practices and with task-specific health and safety planning, review, and approvals. Experienced contractors would be used for trenching and drilling activities, and these tasks would require more advanced training for the operators of specialized equipment. PRB also affords low risk of cross-media impacts and of potential exposure to arsenic because all remediation processes take place in-situ, and the nature and extent of arsenic in groundwater at GAF are well-characterized.

The time to begin an approved PRB remedy is estimated to be 3 to 5 years because: TDEC input is expected for all phases of the design; bench- and pilot-scale testing, reporting, and approval are anticipated to require multiple years; and implementation will need to be coordinated with the sequencing of tasks for the CBR. State (TDEC), local or other environmental permit requirements are anticipated to affect implementation of CBR and potentially PRB.

Arsenic treatment at the PRB cuts off the exposure pathway. Currently-impacted groundwater upgradient of the barrier must flow through the barrier to be treated. A point of compliance downgradient of the PRB would be established for the CAOs. The time period for groundwater flow through the natural system to the PRB to achieve remedial objectives, i.e., attainment of CAOs, is protracted. Currently-impacted groundwater downgradient of the PRB would be addressed by MNA. Groundwater fate and transport modeling would be necessary to provide an estimated range of timeframes to attain CAOs.

6.0 Hydraulic Containment and Treatment

Hydraulic containment through groundwater extraction and subsequent treatment has historically been a common method for management of groundwater impacted with metals and other inorganics. Groundwater is pumped from wells (vertical or horizontal) or collection trenches to a discharge point (e.g., a permitted outfall) or to an aboveground treatment system.

Performance, reliability, and ease of implementation of hydraulic containment all score high because it is a well-established and effective technology for cutting off potential exposure and removal of arsenic source mass. The technology is mature and highly adaptable to a wide variety of hydrogeologic settings and contaminants. Extraction systems can be optimized and expanded to accommodate potentially evolving remedial priorities.

Hydraulic containment represents medium safety risk because all work activities associated with construction of the extraction and treatment system are conducted in accordance with TVA's Safe Work Practices and with task-specific health and safety planning, review, and approvals. Experienced contractors would be used for drilling activities, and these tasks would require more advanced training for the operators of specialized equipment.

Hydraulic containment represents medium risk of cross-media impacts and of potential exposure to arsenic because pumping and conveyance of impacted groundwater has the potential for spills or other surface release due to equipment failure. Operations and maintenance, repair, and replacement activities will mitigate this risk.

The time to begin an approved hydraulic containment and treatment remedy is estimated to be 3 to 5 years because TDEC input is expected for all phases of the design, and implementation will need to be coordinated with the sequencing of tasks for the CBR. State (TDEC), local or other environmental permit requirements are anticipated to affect implementation of CBR, and NPDES permit modification may be needed for treated effluent management.

Hydraulic containment cuts off potential exposure at the extraction system location, but currently-impacted groundwater must flow through the natural system to the extraction location(s) from beneath the APC. The time period to achieve remedial objectives, i.e., attainment of CAOs, is protracted, but can potentially be decreased with the addition of extraction capacity. Groundwater fate and transport modeling would be necessary to provide an estimated range of timeframes to attain CAOs.

TABLE B.1
Corrective Measures Qualitative Evaluation - 257.96(c) Analysis Criteria

Criteria	Groundwater Corrective Measures			
	Monitored Natural Attenuation	**In-situ Physical/Chemical Treatment**	**Permeable Reactive Barriers**	**Hydraulic Containment and Treatment**
Part 257.96(c)(1)				
Performance	**Medium** Feasible: COC concentrations would decrease through natural attenuation mechanisms.	**High** System design based on bench- and pilot-scale testing of injected amendments that enhance naturally-occurring attenuation processes.	**High** System design based on bench- and pilot-scale testing of injected amendments that enhance naturally-occurring attenuation processes.	**High** Well-established and effective technology for cutting off potential exposure and removal of COCs source mass.
Reliability	**High** Naturally-occurring attenuation processes.	**High** System design based on bench- and pilot-scale testing of injected amendments that enhance naturally-occurring attenuation processes.	**High** System design based on bench- and pilot-scale testing of injected amendments that enhance naturally-occurring attenuation processes.	**High** Reliability is assured by adherence to well-established O&M practices.
Ease of Implementation	**High** Existing/updated groundwater monitoring program would be implemented as part of this technology.	**Medium** Treatment zone includes fractured bedrock that would make trenching difficult. Uniform distribution of amendments is more difficult if injection is by drilling methods.	**Medium** Treatment zone includes fractured bedrock that would make trenching difficult. Uniform distribution of amendments is more difficult if injection is by drilling methods.	**High** Proven technology that can be effective in a wide variety of hydrogeologic settings.
Potential safety impacts	**Low Risk** All work activities are conducted in accordance with TVA's Safe Work Practices	**Medium Risk** All work activities are conducted in accordance with TVA's Safe Work Practices. More advanced training required to operate specialized equipment.	**Medium Risk** All work activities are conducted in accordance with TVA's Safe Work Practices. More advanced training required to operate specialized equipment.	**Medium Risk** All work activities are conducted in accordance with TVA's Safe Work Practices. More advanced training required to operate specialized equipment.
Potential cross-media impacts	**Low Risk** All remediation processes take place in-situ.	**Low Risk** All remediation processes take place in-situ.	**Low Risk** All remediation processes take place in-situ.	**Medium Risk** Pumping and conveyance of impacted groundwater carries risk of surface release due to potential equipment failure. O&M practices will mitigate this risk.
Potential impacts of exposure to residual COCs	**Low Risk** All remediation processes take place in-situ. Groundwater COCs nature and extent are understood.	**Low Risk** All remediation processes take place in-situ. Groundwater COCs nature and extent are understood.	**Low Risk** All remediation processes take place in-situ. Groundwater COCs nature and extent are understood.	**Medium Risk** Pumping and conveyance of impacted groundwater carries risk of surface release due to potential equipment failure. O&M practices will mitigate this risk.
Part 257.96(c)(2)				
Time required to begin remedy	**1 to 2 years**	**3 to 5 years**	**3 to 5 years**	**3 to 5 years**
Time required to complete remedy	The time period for groundwater natural attenuation mechanisms to provide for attainment is protracted. Groundwater fate and transport modeling can provide estimated range.	In-situ treatment at the source ends loading to groundwater, but currently impacted groundwater must flow through point of compliance. The time period for attainment is protracted. Groundwater fate and transport modeling can provide estimated range.	Barrier treatment cuts off potential exposure at point of compliance, but currently impacted groundwater must flow through it. The time period for attainment is protracted. Groundwater fate and transport modeling can provide estimated range.	Hydraulic containment cuts off potential exposure at point of compliance, but currently impacted groundwater must flow to the extraction system. The time period for attainment is protracted. Groundwater fate and transport modeling can provide estimated range.
Part 257.96(c)(3)				
State, local or other environmental permit requirements that may substantially affect implementation	TDEC input expected for groundwater monitoring program update and corrective measures.	TDEC input expected for groundwater monitoring program update and corrective measures.	TDEC input expected for groundwater monitoring program update and corrective measures.	TDEC input expected for groundwater monitoring program update and corrective measures. NPDES permit modification may be necessary.
Comments	Naturally-occurring processes take place as part of other remedial approaches.	-	-	-