Removal Plan
Ash Pond Complex

Tennessee Valley Authority
Gallatin Fossil Plant

Revision 1

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Figure 1. Site Map
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Executive Summary

On July 24, 2019, the Davidson County Chancery Court entered a Consent Order (Order) in Case No. 15-23-IV reflecting an agreement between the Tennessee Valley Authority (TVA), the State of Tennessee, the Tennessee Department of Environment and Conservation (TDEC), and certain Plaintiff-Intervenors to close the Ash Pond Complex (APC) located at the Gallatin Fossil Plant (GAF) located near Gallatin, Sumner County, Tennessee. For purposes of the Order, the APC consists of the Bottom Ash Pond, Middle Pond A, Ash Pond A, Ash Pond E, and Stilling Ponds B, C, and D as shown in **Figure 1.**

Consistent with Section 2.a. of the Order, TVA is required to prepare a plan for the removal and ultimate disposition of the coal combustion residuals (CCR) within the APC for approval by TDEC. TVA has retained AECOM to prepare this Removal Plan (Plan) for the APC in accordance with the Order.

This Removal Plan has been developed to describe the removal or excavation of the CCR from the APC at GAF. This plan details closure by excavation of the APC and final disposition of excavated CCR in a proposed on-site lined CCR landfill expansion. The excavation of CCR and the closure of the APC will be in accordance with applicable provisions of the Order and relevant state law, as well as the federal Disposal of Coal Combustion Residuals from Electric Utilities rule (CCR Rule) (codified at 40 CFR § 257.50 et seq.).

GAF is located on approximately 1,950 acres of land situated on the north bank of the Cumberland River in north-central Tennessee at 1499 Steam Plant Road, Gallatin, Sumner County. GAF is a coal-fired steam plant that operates four turbo-generating units with a combined summer net generating capacity of 976 megawatts. In addition, GAF operates eight combustion-turbine units (oil burning) to provide peak power as needed.

The APC covers an area of approximately 435 acres and contains approximately 11.9 million cubic yards (cy) of CCR. An additional approximately 800,000 cy of impacted soils may be removed from beneath the CCR as part of closure. Operation of the APC began in 1970, with the APC receiving sluiced fly ash and bottom ash, as well as process waters generated at GAF. In 2016, TVA began conversion to dry CCR management by constructing a lime-based dry flue gas desulfurization system, or “dry scrubber,” at GAF. In 2019, TVA completed construction of temporary facilities to convert bottom ash handling facilities from wet to dry. As of June 21, 2019, TVA ceased placing waste streams into the APC. Permanent bottom ash dewatering facilities were completed in January 2020, completing the conversion to dry CCR management at GAF. CCR produced at GAF are currently disposed of in a lined on-site landfill known as the Rail Loop Site North Rail Loop (NRL) landfill which is operated in accordance with a Class II Solid Waste Landfill Permit IDL #83-000-029 issued by the TDEC Division of Solid Waste.

TVA is proposing to excavate the CCR from the APC and place the material within a dedicated lateral expansion to the existing NRL landfill. Removal of the CCR from within the APC will begin once construction of the proposed NRL landfill expansion is complete. The proposed landfill expansion is located directly south of the existing NRL landfill as shown in **Figure 1**, and is referred to as the South Rail Loop (SRL) landfill. A Class II solid waste permit application has been developed and submitted to TDEC Division of Solid Waste under separate cover.

The details presented in this Plan are subject to change. TVA is committed to evaluating emerging technologies and best practices and it should be noted that at the time of preparing this Plan, a contractor has not been selected. Therefore, changes to this Plan may be made to reflect the selected contractor’s means and methods, changing conditions encountered in the field, implementation of new emerging technologies or best practices, or other factors. Once selected, the contractor shall be required to prepare an Execution Plan that describes the contractor’s proposed methodology, construction sequencing, staging area locations, best management practices (BMPs), and moisture conditioning methods. This plan shall be submitted to TDEC for review. In addition, as outlined in Section 2.c. of the Order, TVA may elect to beneficially reuse some portion or all of the CCR within the APC. TVA is committed to evaluating options for further beneficial reuse of CCR and for handling/transportation of CCR. In the future, TVA may choose to beneficially reuse CCR or make use of alternate technologies for CCR handling or transportation (e.g., paste or conveyance technologies). If TVA does elect to beneficially reuse CCR or make use of alternate technologies, material processing and moisture conditioning requirements will be dictated by the selected technology and may differ

from those presented in this Removal Plan. TVA will also conduct annual reviews of this Removal Plan to evaluate compliance with relevant regulations. Should substantial changes or amendments be made to this Plan, it will be resubmitted to TDEC and applicable parties as noted in Section 2.e. of the Order.

Upon approval of this Removal Plan by TDEC, additional actions will commence, including finalization of detailed engineering designs, dewatering and removal of free water and interstitial (pore) water, and contracting and detailed planning for the removal activities.

This Removal Plan provides the necessary guidelines for the safe removal of CCR from the APC, including engineering drawings of the removal (**Attachment A**), karst mitigation measures to be implemented to repair karst features that may be encountered during construction (**Attachment C**), dust control measures and best practices that will be implemented to mitigate fugitive dust (**Attachment E**), guidelines for temporary CCR excavation slopes (**Attachment F.1**), and engineering analysis for the management of storm water for existing and final conditions of the site (**Attachment F.2**). A Dewatering Plan (**Attachment B**) describes the proposed management and treatment of free water, pore water, and contaminated storm water during removal activities in accordance with the facility National Pollutant Discharge Elimination System (NPDES) Permit TN0005428. Following removal of CCR, soils will be tested to document site conditions. The proposed sampling and testing is described in a Source Removal Construction Quality Assurance Plan (SR CQAP) (**Attachment D**).

In accordance with the Order, several associated documents will be prepared in addition to this Removal Plan to address environmental site conditions, monitoring of groundwater and surface waters, and groundwater corrective action. These documents include: (i) an Environmental Assessment Report (EAR), will be submitted to TDEC under separate cover and discussed in Section 2.5; (ii) a Monitoring Plan for continued monitoring of groundwater and other discharge locations during closure, to be submitted to TDEC prior to initiating removal; and (iii) a Corrective Action/Risk Assessment (CARA) Plan for groundwater at the APC, to be submitted within 60 days of TDEC's approval of this Removal Plan.

In accordance with Section 2.f of the Order, CCR from the APC will be removed within 20 years of TDEC's approval of this Removal Plan. TVA will provide annual progress reports to TDEC over the course of the removal to document the work completed and provide updates to the project schedule presented in this Plan.

Site restoration activities may be completed following the 20-year removal timeline required by the Order. At the time of preparing this Removal Plan, TVA has not determined a preferred approach for restoring or otherwise repurposing the site. At a minimum, the site will be graded to promote positive drainage and adequately manage storm water, then planted with native grasses for erosion control. Post-excavation, the site will resemble the land's valley shape before the APC was created. Areas of the site located below the Cumberland River's normal water surface elevation are expected to result in a ponded area over a portion of the site. Appropriate environmental reviews will be performed and any necessary federal, state, or local permits will be obtained prior to any future activities occurring.

Acronyms

APC	Ash Pond Complex
bgs	Below ground surface
BMP	Best Management Practice
CARA	Corrective Action/Risk Assessment
CCR	Coal Combustion Residual
CCR Rule	Coal Combustion Residuals from Electric Utilities rule
CRD	Construction Record Documentation
cy	Cubic yards
EI	Environmental Investigation
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
FM	Flow Management
ft	foot/feet
GAF	Gallatin Fossil Plant
HASP	Health and Safety Plan
HDPE	High-density polyethylene
ISRP	Interim Source Removal Process
ISR QAPP	Interim Source Removal Quality Assurance Project Plan
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NPDES	National Pollutant Discharge Elimination System
NRL	North Rail Loop
Order	Consent Order
OSHA	Occupational Safety and Health Act
PAMP	Perimeter Air Monitoring Plan
PE	Professional Engineer
PG	Professional Geologist
Plan	Removal Plan
PPE	Personal Protective Equipment
ROD	Record of Decision
SDS	Safety data sheets
SIMP	Surveillance and Instrumentation Monitoring Plan
SR CQAP	Source Removal Construction Quality Assurance Plan
SRL	South Rail Loop
SWPPP	Storm Water Pollution Prevention Plan
TCEAP	Temporary Construction Emergency Action Plan
TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority
USACE	United States Army Corps of Engineers
WTS	Water Treatment System

1 Introduction

On July 24, 2019, the Davidson County Chancery Court entered a Consent Order (Order) in Case No. 15-23-IV reflecting an agreement between the Tennessee Valley Authority (TVA), the State of Tennessee, the Tennessee Department of Environment and Conservation (TDEC), and certain Plaintiff-Intervenors to close the Ash Pond Complex (APC) located at the Gallatin Fossil Plant (GAF) located near Gallatin, Sumner County, Tennessee. For purposes of the Order, the APC consists of the Bottom Ash Pond, Middle Pond A, Ash Pond A, Ash Pond E, and Stilling Ponds B, C, and D as shown in **Figure 1**.

Consistent with Section 2.a. of the Order, TVA is required to prepare a plan for the removal and ultimate disposition of the coal combustion residuals (CCR) within the APC for approval by TDEC. TVA is proposing to excavate the existing CCR from the APC and place the material within a dedicated lateral expansion to the existing North Rail Loop (NRL) landfill, referred to as the South Rail Loop (SRL) landfill. TVA has retained AECOM to prepare this Removal Plan (Plan) for the APC in accordance with the Order.

The details presented in this Plan are subject to change. TVA is committed to evaluating emerging technologies and best practices and it should be noted that at the time of preparing this Plan, a contractor has not been selected. Therefore, changes to this Plan may be made to reflect the selected contractor's means and methods, changing conditions encountered in the field, implementation of new emerging technologies or best practices, identification of new beneficial reuse opportunities, or other factors. Once selected, the contractor shall be required to prepare an Execution Plan that describes the contractor's proposed methodology, construction sequencing, staging area locations, best management practices (BMPs), and moisture conditioning methods. This plan shall be submitted to TDEC for review. TVA will also conduct annual reviews of this Removal Plan to evaluate compliance with relevant regulations. Should substantial changes or amendments be made to this Plan, it will be resubmitted to TDEC and applicable parties as noted in Section 2.e. of the Order.

1.1 Removal Plan Objectives

The primary objective of this Removal Plan is to address the safe and effective closure by removal of the CCR from the APC as directed by the Order and to obtain approval from TDEC to develop the additional working documents necessary to complete the closure actions. This Removal Plan describes and communicates the key actions and activities necessary to close the APC in accordance with applicable state law and with requirements for written Closure Plans for CCR surface impoundments presented in the United States Environmental Protection Agency's (EPA's) CCR Rule (40 CFR § 257.102(b)(i-vi)). Planned removal activities include:

- Removal of the free water in the APC;
- Construction and operation of a Water Treatment System (WTS) to manage contaminated storm water and pore water dewatering discharge from the APC during removal;
- Dewatering to support safe excavation of CCR from the APC;
- Excavation of the CCR;
- Source Removal Verification testing of native soils located beneath the CCR;
- Establishing final grades following CCR Removal using soil fill where required;
- Construction of storm water management systems; and
- Site restoration of disturbed areas.

In accordance with Section 2.e. of the Order, TDEC's approval of this Removal Plan serves as any approval that may be required pursuant to Tennessee Code Annotated Section 68-211-106(j) associated with the excavation and removal of CCR from the APC.

1.2 Report Organization

The Removal Plan has been organized into the following Sections:

- **Section 2** provides relevant background information about GAF including site history and a description of the APC;
- **Section 3** provides a summary of CCR excavation and supporting activities including dewatering and water management, instrumentation monitoring, karst mitigation, and source removal verification;
- **Section 4** summarizes the plans for final site restoration following removal of CCR;
- **Section 5** presents a summary of BMPs to be implemented during removal;
- **Section 6** presents anticipated permits that may be required to support APC closure;
- **Section 7** provides details on required reporting during execution of the project;
- **Section 8** presents a proposed schedule for the project; and
- **Section 9** presents a summary of the references cited in this Removal Plan.

Engineering Drawings are provided as **Attachment A**. Additional supporting packages and documents are provided in **Attachment B** through **Attachment F**.

2 Facility Description

2.1 Site History and Operations

GAF is located on approximately 1,950 acres of land situated on the north bank of the Cumberland River in north-central Tennessee at 1499 Steam Plant Road, Gallatin, Sumner County. GAF is a coal-fired steam plant that operates four turbo-generating units with a combined summer net generating capacity of 976 megawatts. In addition, GAF operates eight combustion-turbine units (oil burning) to provide peak power as needed. Groundbreaking at GAF occurred on May 11, 1953. The first, second, third, and fourth turbo-generators began operating on November 8, 1956, June 27, 1957, May 22, 1959, and August 9, 1959, respectively. Cooling water for the plant is diverted from the Cumberland River via an intake channel southeast of the main plant. Water is released back to the Cumberland River via a discharge channel located southwest of the plant.

Dikes associated with the APC were constructed over the course of plant operation. Typical cross-sections of the dikes are provided for reference in the Engineering Drawings in **Attachment A**. A detailed discussion of the construction of operations history of the APC will be presented in the Environmental Assessment Report (EAR), which will be submitted to TDEC under separate cover. The following provides a summary of the APC construction and operation:

- Dikes constructed for the barge unloading area on the southern end of Ash Pond E were constructed in 1953 during plant construction;
- In 1969, additional dikes were constructed to provide containment for the APC area;
- Operation of the APC began in 1970, with the APC receiving sluiced fly ash and bottom ash, as well as process waters generated at GAF;
- In 1978, divider dikes were constructed to create the Stilling Ponds. Completion of these dikes created a pond complex which included Ash Pond A, Ash Pond E, and Stilling Ponds B, C, and D. These dikes were raised over time to increase pond storage capacity;
- In 1988, spillways were constructed for Ash Pond A and the divider dikes around Ash Pond E were raised;
- In the early 1990s, additional dikes were constructed to separate Middle Pond A and the Bottom Ash Pond;
- In 2006, Ash Pond E was expanded by constructing a new raised perimeter dike using soil materials;

- From 2012 to 2014, stability improvements were made to the perimeter dike system including the construction of a rock access bench at the Ash Pond A toe of the slope adjacent to the Stilling Ponds;
- In 2014, the Ash Pond A dikes were lowered to reduce free water capacity and siphons were added to act as primary spillways and increase storm flow capacity. Existing Ash Pond A spillways were stabilized to act as secondary spillways during storm events;
- In 2015, the Outfall 001 spillways in Stilling Pond D were updated to provide increased hydraulic capacity, with primary spillways constructed. The existing spillways were upgraded to serve as secondary spillways during storm events;
- In 2016 and 2017, TVA modified pond operations and diverted flows to Pond A, lowering the water levels within the APC and removing free water from Pond E. This allowed for construction of roads within Ash Ponds A and E to allow safe access for environmental investigations; and
- In 2019, TVA completed construction of temporary facilities to convert bottom ash handling facilities from wet to dry and ceased sending waste streams to the APC.

2.2 Dry Conversion of CCR Management

In 2016, TVA began conversion to dry CCR management by constructing a lime-based dry flue gas desulfurization system, or "dry scrubber," at GAF. In 2019, TVA completed construction of temporary facilities to convert bottom ash handling facilities from wet to dry and ceased sending waste streams to the APC. Permanent bottom ash dewatering facilities were completed in January 2020, completing the conversion to dry CCR management at GAF. CCR produced at GAF are currently disposed of in the lined on-site NRL landfill, which operates as a Class II solid waste disposal facility under TDEC Division of Solid Waste Permit IDL #83-000-0219. The NRL landfill is located within the Rail Loop Site immediately south of Ash Pond A and west of Steam Plant Road.

Precipitation that falls in the APC is ultimately pumped or discharged to the Stilling Ponds through spillways in Ash Pond A or E. Stilling Ponds B, C, and D are connected via open channels. In general, water flows from Stilling Pond B, to C, to D. Water from the Stilling Ponds is discharged to the Cumberland River via Outfall 001 (located at the western end of Stilling Pond D) under National Pollutant Discharge Elimination System (NPDES) permit TN0005428.

2.3 CCR Removal Areas and Volumes

CCR is to be removed from each of the Ponds that comprise the APC. The total area of the APC is approximately 435 acres. The total volume of CCR in the APC is estimated to be approximately 11.8 million cubic yards (cy). **Table 1** provides a summary of approximate area and CCR volume by pond.

Table 1. Summary of Ash Pond Complex Areas and Volumes

Pond	Area (acres)	Volume of CCR (cy)
Ash Pond A	189	5,525,000
Ash Pond E	146	4,829,700[1]
Middle Pond A	32	1,040,000
Bottom Ash Pond	16	400,000
Stilling Ponds	52	30,000
TOTALS:	**435**	**11,824,700**

Note:

[1] Approximately 120,300 cy of CCR that was temporarily stockpiled in Ash Pond E has already been removed and placed in Cell 1 of the NRL landfill. The volume presented herein reflects this.

An additional approximately 800,000 cy of impacted soils underlying the APC may be removed as part of closure. The volume of impacted soil is based on an estimated one foot of over-excavation beneath the CCR contained within the

APC. The actual volume may vary depending upon the results of the source removal verification as described in **Section 3.7**.

2.4 Inspection and Monitoring Summary

This section outlines current, ongoing inspection and monitoring activities associated with the APC. Inspections of the Bottom Ash Pond, Middle Pond A, Ash Pond A, and Ash Pond E governed under the CCR Rule are conducted on a weekly basis. The Stilling Pond dikes are not governed under the CCR Rule and are inspected quarterly. Existing instrumentation consisting of standpipe and vibrating wire piezometers have been installed at the APC to monitor site conditions and verify the stability of the APC perimeter dike system. Existing instrumentation is provided in the Removal Plan drawings provided in **Attachment A**. Instrumentation located in the perimeter dike system is automated, allowing instrumentation readings to be monitored remotely via TVA's iSite Central database. Instruments will continue to be monitored for stability of the perimeter dike system during removal activities. Additional instrumentation will be provided within the APC to monitor removal activities as described in **Section 3.3**.

2.5 Environmental Investigation and Assessment

In accordance with an earlier agreement and as reflected in the Order, an Environmental Investigation (EI) is being conducted for GAF. In 2017, TVA presented available results in a Draft EAR. The EI will result in a Final EAR, which is being developed as of the date of this Removal Plan and will be submitted to TDEC under separate cover. Following the conclusion of ongoing Phase 2 dye trace activities and TDEC's concurrence with a proposed permanent groundwater monitoring network (including background wells), a Final EAR will be provided to TDEC for review and approval. The EAR presents detailed information regarding the site geology and hydrogeology, existing borings and monitoring wells, and the physical (geotechnical) and chemical properties of the CCR and the soils and bedrock beneath the APC. Information gathered as part of the EI (including borings and a desktop study of historical drawings and surveys) was utilized in the development of this Removal Plan to present the extent of CCR within the APC and develop the boundaries of each unit.

2.6 Water Quality Monitoring

In accordance with Section 2.i. of the Order, prior to the commencement of removal activities, TVA will develop and submit to TDEC for approval a plan for continued monitoring of various locations during the closure process. This Monitoring Plan will include identified outfalls, groundwater monitoring wells, and groundwater inflow locations in the Cumberland River. The monitoring well network is based upon the results of the EI presented in the EAR, which will be submitted to TDEC under separate cover. Monitoring will begin no later than 30 days following TDEC's approval of the Monitoring Plan.

2.7 Environmental Review

Because TVA is a federal agency, it is required to evaluate all significant construction activities under the National Environmental Policy Act (NEPA) for potential impacts to the environment. To meet this requirement, TVA prepared an Environmental Impact Statement (EIS) for the GAF Surface Impoundment Closure and Restoration Project, which includes CCR removal activities and the proposed SRL landfill (TVA, 2020). Should an activity be needed that was not evaluated as part of the EIS, a review will be performed by TVA to determine the appropriate NEPA analysis required prior to conducting that activity. The EIS is available on TVA's publicly available website at the following location:

https://www.tva.com/environment/environmental-stewardship/environmental-reviews/nepa-detail/Gallatin-Surface-Impoundment-Closure-and-Restoration-Project

As stated in the EIS (TVA, 2020), TVA determined that impacts from closure by removal of the APC are minor. The EIS Record of Decision (ROD) was completed on 17 September, 2020.

3 Removal Plan Activities

The primary activities associated with closure by removal at the APC are summarized as follows:

- Install BMPs as indicated in the Storm Water Pollution Prevention Plan (SWPPP);
- Removal of the free water in the APC and Stilling Ponds by using existing siphons and removing stoplogs in the existing spillway structures, then using floating pumps, screened intakes, and pumping through the discharge to a NPDES-permitted outfall;
- Install and operate a WTS to manage interstitial/pore water and contaminated storm water during construction;
- Dewater the CCR to allow for safe access;
- Complete CCR excavation from the APC, with sequencing determined by the construction contractor for optimal progression;
- Staging and moisture conditioning of the CCR within the APC prior to transportation for final disposal;
- Instrumentation and monitoring requirements will be developed in a Surveillance and Instrumentation Monitoring Plan (SIMP) prior to construction. The SIMP will be followed to verify construction phase stability. Construction dewatering will be used as needed to provide stable work areas and slopes;
- Perform regular inspection for karst feature development and implement repairs of karst features as required during CCR removal;
- Maintain required storm water storage capacity for collected contaminated storm water through the excavation process. Contaminated storm water and pore water from dewatering activities will be treated in a WTS prior to discharge to a NPDES-permitted outfall;
- Following removal of CCR from area(s), complete source removal verification testing and potentially 1 ft of soil over excavation based on source removal verification results;
- Grade the area to promote positive drainage and seed for vegetative growth; and
- Construction of storm water management systems.

Additional information and details pertaining to these removal activities are provided in the following sections. Accompanying Removal Plan Drawings are provided in **Attachment A**. At the time of preparing this Plan, a contractor has not been selected. Once selected, the contractor shall be required to prepare an Execution Plan that describes the contractor's proposed methodology, construction sequencing, staging area locations, BMPs, and moisture conditioning methods. This plan shall be submitted to TDEC for review.

3.1 Removal Plan Drawings

The Removal Plan Drawings found in **Attachment A** include the following:

- Cover Sheet;
- Existing Conditions Plan;
- Instrumentation Plan;
- Bottom of CCR Plan;
- Final Conditions Plan;
- Cross-Sections;
- Existing Dike Details;
- Existing Spillway Details;
- Paved Haul Road Details;

- Storm Water Management Details; and
- Temporary CCR Excavation Slope Details.

These Removal Plan drawings will be further developed and refined during preparation of construction level drawings following TDEC approval of the Removal Plan. In addition, supplemental drawing sets will be prepared on an as-needed basis to support erosion and sediment control permits, NPDES permit modifications, and other related permits as described in **Section 6**.

3.2 Dewatering and Water Management

Prior to excavation activities in each impoundment, free water within the pool areas of the ponds will be removed. During excavation, the CCR within the impoundments will be dewatered to improve surface conditions within the APC to facilitate equipment access and subsequent excavation. Pore water removed from the CCR as well as contaminated storm water collected during removal activities will be treated during removal activities in a WTS. A Dewatering Plan is provided in **Attachment B** that provides the details for management of free water, pore water, contaminated storm water, and non-contaminated storm water during removal. The Dewatering Plan also provides definitions of key terms associated with the dewatering process, including free water, pore water, and contaminated storm water. The following sections provide a summary of the proposed activities.

3.2.1 Free Water Removal

To enable excavation of the APC, free water will be removed from the APC, as necessary. Free water is proposed to be removed in two stages. A maximum drawdown rate of 1 ft per day will be maintained during free water removal.

Stage 1 consists of removal of the ponded free water using the current routing of wastewater and storm water from the Ash Ponds through the Stilling Ponds to Outfall 001. Stage 2 consists of removing the free water through a WTS, using pumping systems, to Outfall 001. Stage 2 for Ash Ponds A and E will commence when CCR removal is ready to begin and after Stage 1 free water levels are within 5 ft of the bottom of each pond. Stage 2 for the Stilling Ponds will start when CCR removal activities within the Stilling Ponds are ready to commence. A limited quantity of free water may be present at Middle Pond A and the Bottom Ash Pond based on seasonal rainfall; it is anticipated that this water will be managed during Stage 3, if needed.

During free water removal, the effluent limits and monitoring requirements for this discharge will be the same as those currently required under the existing NPDES permit Tier 1 effluent limitations and monitoring requirements for Outfall 001.

3.2.2 Pore Water Removal

Stage 3 of dewatering will begin when dewatering of pore water within the CCR begins. Dependent on Contractor means and methods (i.e. equipment type and size), removal of pore water may need to begin prior to CCR removal to facilitate a stable working platform for construction equipment. Pore water may be removed using active (e.g., well systems) and/or passive (e.g., drainage ditches) dewatering methods. The free water pumping system and WTS utilized during Stage 2 would also likely be utilized during Stage 3. The pore water collected from the dewatering ditches and/or wells will be conveyed and collected within the APC and conveyed through the WTS. Treated water may be discharged to either Outfall 001 or Outfall 010 depending on contractor sequencing and means and methods.

Water quality effluent operational thresholds have been developed and are presented in the Dewatering Plan in **Attachment B** to evaluate the water quality of the WTS discharges and NPDES Outfalls receiving WTS discharges.

3.2.3 Contaminated Storm Water

As part of Stage 3, collected contaminated storm water within the Bottom Ash Pond, Middle Pond A, Ash Pond A, and Ash Pond E will be stored within the ash pond impoundments and pumped to the WTS along with pore water for treatment prior to discharge to either Outfall 001 or 010. Discharge of contaminated storm water to the Stilling Ponds will be prevented by maintaining areas within the Ash Ponds to collect and manage collected contaminated storm water

before pumping it for treatment. The areas where contaminated storm water is to be collected will be designed and maintained to manage runoff resulting from the 25-year/24-hour storm event.

Hydrologic and hydraulic (H&H) analysis was performed to evaluate the existing APC storage capacity to verify that contaminated storm water can be adequately managed during initial removal activities. The H&H analysis determined that the APC has adequate storage volume to contain the 25-year/24-hour storm without discharging to the Stilling Ponds through the Ash Pond A and Ash Pond E spillways. Supporting calculations are provided in **Attachment F.2**. As CCR is removed from the impoundments, available storage capacity will increase and will be maintained to continue to manage the 25-year/24-hour storm event throughout the removal process.

A Temporary Construction Emergency Action Plan (TCEAP) will be developed prior to starting construction and provided to TDEC for review when available. The TCEAP will outline planned responses to various scenarios, including a contingency plan for management of storm events greater than the 25-year/24-hour storm.

During the period of the project when the Stilling Ponds are cleaned to remove CCR, water within the Stilling Ponds will be managed as contaminated storm water and will be sent to the WTS for treatment.

Once CCR has been excavated from an area within the APC, diversion berms and channels, temporary pumping systems, or other means will be used to prevent contaminated storm water from flowing into these areas. Should contaminated storm water inadvertently enter an area where source removal verification has already been completed, those areas will be re-tested in accordance with the procedures described in **Section 3.7**.

Outfall 001 and 010 will continue to be monitored in accordance with the NPDES Permit and the Dewatering Plan provided in **Attachment B**. Details of the existing spillway structures are provided in the Engineering Plans in **Attachment A**.

3.2.4 Non-Contaminated Storm Water

The Stilling Ponds will continue to manage non-contaminated storm water run-on from large offsite areas north of GAF during removal activities. Non-contaminated storm water collected in the Stilling Ponds during the project will be managed within the Stilling Ponds and discharged through NPDES Outfall 001.

In order to minimize generation of contaminated storm water and associated wastewater treatment, non-contaminated storm water will be diverted to the Stilling Ponds or areas within the APC from which CCR has been removed. Diversion berms and channels, temporary pumping systems, or other means of diverting non-contaminated storm water may be developed as part of detailed engineering design to divert non-contaminated storm water. The means and methods of diverting the non-contaminated storm water will be developed as part of the detailed engineering design.

As noted in **Section 3.2.3**, during the period of the project when the Stilling Ponds are cleaned to remove CCR, water within the Stilling Ponds will be managed as contaminated storm water and will be sent to the WTS for treatment. In accordance with the Order, following removal of CCR from Stilling Ponds B, C, and D, TVA will submit a plan for continued use of Stilling Ponds B, C, and D for storm water management to TDEC for consideration and approval.

3.3 Surveillance and Instrumentation Monitoring

During dewatering and excavation within the APC, the interior portions of the perimeter dikes and cut slopes in ash may be vulnerable to localized instability and associated slope movements. A SIMP will be developed to support APC closure and to outline the proposed procedures for monitoring the performance of the dikes and construction working areas including temporary excavations and slopes. Existing instrumentation, as described in **Section 2.4**, may be used as part of the instrumentation network for monitoring the performance of the slopes. However, the SIMP will include a plan to install additional piezometers at appropriate locations and depths to monitor pore water pressures during dewatering and excavation. Other additional instrumentation (e.g., inclinometers, surface monuments, etc.) may be installed on a case-by-case basis as determined by the means and methods of the contractor and Engineer. Threshold and action levels will be developed for the piezometers (and other instrumentation, if installed) based on slope stability analyses and current/assumed piezometric water levels. Where practical, instrumentation will be automated and monitored remotely via TVA's iSite Central database. In addition to instrumentation measurements, the SIMP will also

layout a framework for visual observations, by appropriately trained staff, of ash slopes and surfaces, and documentation during the construction work. Following preparation of the SIMP, the plan will be provided to TDEC for review.

A TCEAP will be developed prior to starting construction and provided to TDEC for review when available. The TCEAP will outline planned responses to various scenarios, including contingency plans related to instability during construction. Should an instability or release occur, the TCEAP will be activated and the appropriate steps followed to make required contacts and take mitigative actions.

3.4 Debris Management

TVA expects to encounter non-CCR debris/waste during excavation of the APC that may not be permitted for disposal within the SRL landfill. The APC contains areas of tree and brush vegetation, rip rap, as well as culvert pipes and other structures maintained during the operation of the facility. Vegetation and other construction debris encountered or removed during the progression of the work will be assessed for potential to contain CCR constituents. Any debris that may not be disposed of within the SRL landfill will be characterized and staged in a designated collection area within the boundaries of the APC until TDEC authorization is granted for disposal of the debris under a minor modification or special waste permit, if needed. The debris may also be disposed of in an approved offsite landfill. Vegetation will go through reduction steps (e.g. chipping, incineration, etc.) to render it for disposal, either in the onsite landfill or, if necessary, to an approved offsite landfill.

3.5 CCR Excavation

3.5.1 Excavation Rates

In accordance with Section 2.f of the Order, CCR will be removed from the APC within 20 years of TDEC's approval of this Removal Plan. TVA is anticipating removal of CCR located in the APC and disposal in the SRL landfill over an approximately 15-year time period that would commence after permitting and construction of the SRL landfill. **Table 2** provides a summary of the estimated annual and daily waste disposal volumes.

Table 2. Summary of Estimated Waste Disposal Volumes

Cubic Yards/Year	Cubic Yards/Day
800,000 – 1,000,000	3,800 – 4,800

Note:

[1] CCR excavation and disposal rates shown are based on CCR disposal rates and proposed 30 acre operational working area as presented in the pending SRL landfill class II solid waste permit application developed and submitted to TDEC Division of Solid Waste under separate cover. TVA understands that this assumed working face is subject to TDEC's review of the solid waste permit application and may change in the approved permit. Should the permitted SRL landfill working area be less than the assumed 30 acres, recalculation of disposal rates and corresponding changes to removal timelines may be necessary.

As shown in **Table 2**, TVA estimates excavation rates from the APC ranging from 800,000 cy per year (average) to 1,000,000 cy per year (maximum). Therefore, on a daily basis over the 15-year timeframe, the SRL landfill is expected to receive approximately 3,800 cy per day on average. It should be noted that excavation rates presented in **Table 2** are estimates and are subject to change based on conditions encountered in the field, efficiencies that may be found in the excavation/dewatering processes, or the size of permitted SRL landfill working area.

3.5.2 Staging and Moisture Conditioning

As noted in **Section 1**, CCR excavated from the APC is planned to be disposed of within the proposed SRL landfill. Prior to transportation to the SRL landfill, the excavated CCR must be moisture conditioned to facilitate handling, transportation, compaction, and to control fugitive dust emissions. Excavated CCR may be staged within the APC footprint to promote decanting. Proposed moisture conditioning methods will be submitted by the contractor and reviewed by TVA and TVA's Engineer prior to construction. Moisture conditioning requirements for placing material in

the SRL landfill are set forth in the SRL landfill Operations Manual submitted as part of the Part II Permit Application. Staging locations within the APC will need to be reviewed and evaluated for stability by the Engineer. The excavation and staging areas will also be managed consistent with any applicable air permits to control fugitive dust emissions.

Material will be required to pass the paint filter test, per EPA Method 9095A, prior to transportation to the proposed SRL landfill to ensure CCR transported from the APC meets acceptable moisture content requirements.

3.5.3 Temporary Excavation Slopes

As excavation within the APC progresses, temporary slopes will be cut in the CCR as various areas reach different excavation depths. As described in **Section 3.3**, these slopes will be monitored both visually and by using instrumentation. It is important to evaluate the stability of these slopes to verify the safety of the workers and efficient progress in excavation of the CCR prior to starting construction.

Many different slope and dewatering scenarios may be found acceptable. Proposed dewatering and slope configurations will depend on the contractor's proposed means and methods for CCR removal and phasing. The means and methods of achieving excavation grades and a particular dewatered state are not dictated in this Removal Plan.

Therefore, proposed temporary CCR slopes will be evaluated for slope stability and signed and sealed by a licensed Professional Engineer (PE) in the State of Tennessee. The slope stability evaluations will be submitted by the contractor and reviewed by TVA and TVA's Engineer prior to construction. Proposed slope configurations must meet a minimum Factor of Safety (FS) of 1.3 for both drained and undrained, static conditions for these interim slopes per United States Army Corps of Engineers (USACE) guidance (USACE, 2003).

The stability analysis performed must provide maximum vertical slope height, consider equipment setbacks from the edge of the slope crest, and provide minimum dewatering depths to be achieved while maintaining the temporary excavation slope. The analysis should also consider contingencies to account for downtime during dewatering system maintenance, dewatering system failures, or other incidents such as large storm events that could result in seepage faces developing.

In development of this Removal Plan, two example temporary excavation slope geometries were considered and analyzed in accordance with these requirements. These two scenarios are based on potential dewatering approaches to be taken by the contractor – passive dewatering (e.g., rim ditches, gravity draining) or active dewatering (e.g., well points and pumping). The two slope scenarios are summarized in **Table 3**, below.

Table 3. Example Temporary CCR Excavation Slope Scenarios

	Passive Dewatering	Active Dewatering
Slope (horizontal : vertical)	10H:1V	5H:1V
Maximum Vertical Slope Height (ft)	20	10
Minimum Equipment Setback from Edge of Crest (ft)	100	100
Minimum Dewatering Depth Below Toe (ft)	5	5
Minimum Dewatering Depth Below Slope (ft)	5	Varies
Minimum Dewatering Depth Below Crest (ft)	5	15

Details showing the two temporary slope scenarios are provided in the Removal Plan Drawings, presented in **Attachment A**. Supporting calculations are provided in **Attachment F.1**. The temporary CCR excavation slope scenarios presented in **Table 3** meet acceptable factors of safety for workers and are therefore acceptable for use in construction, unless unanticipated equipment loading or other field conditions warrant a re-evaluation during construction.

3.5.4 Fugitive Dust Control

A Perimeter Air Monitoring Plan (PAMP) that supports APC closure will be prepared once a contractor has been selected. The PAMP will be submitted to TDEC for review. At a minimum, the PAMP will describe:

- Baseline condition survey to determine Background Threshold Values;
- Real-time monitoring procedures;
- Laboratory analytical sampling procedures;
- Perimeter air monitoring locations;
- Perimeter air monitoring equipment;
- Establishment of action levels;
- Actions to be taken based on detected levels during real-time monitoring and laboratory evaluation; and
- Reporting requirements.

The proposed APC Closure activities will be completed in accordance with the PAMP and Fugitive Dust Control Plan for GAF. The Fugitive Dust Control Plan, provided as **Attachment E**, is a general plan for the day to day operations at GAF. It presents minimum requirements to comply with the existing Construction Permit #978223, which sets forth requirements for managing fugitive dust. TVA will perform the appropriate visual inspections and reporting requirements listed in the Construction Permit #978223 throughout the closure project. Note that should the Fugitive Dust Control Plan be updated, it would supersede the version provided herein. The amended Fugitive Dust Control Plan will be uploaded to the facility's operating record and TVA's public website per the CCR Rule with appropriate notifications to TDEC. Dust control measure best practices (i.e., water trucks) will be implemented during the removal work. Furthermore, the GAF Title V Air Permit is being revised to include the removal and hauling activities associated with the APC Closure Project. This air permit revision prescribes monitoring and operational solutions to prevent fugitive dust emissions from impacting adjacent landowners or to persons engaged in supervising and operating activities.

Contractors will be required to develop and implement their own site-specific air monitoring plans in accordance with the PAMP and Construction Permit #978223 in order to monitor site conditions and protect workers from potential exposures to metals and respirable silica during CCR removal activities. This plan will be provided as part of the contractor developed Health and Safety Plan (HASP) which will be required prior to initiating construction, as discussed in **Section 5.5**.

3.5.5 Transportation

An existing paved haul road runs through part of the Bottom Ash Pond and Middle Pond A. This haul road is used to transport material from the GAF Plant to the existing NRL landfill and will also be used to provide transportation of excavated CCR from the APC to the proposed SRL landfill from the north. The haul road will be routinely inspected and maintained throughout the life of the APC Closure project. Temporary CCR excavation slopes (with interim cover) or other measures shall be implemented to protect and maintain use of the paved haul roads while allowing excavation of adjacent CCR material. Refer to **Attachment A** for the location and associated details related to the protection on the haul road. CCR remaining beneath the haul road will be removed at the conclusion of removal activities. The existing road may then be relocated or rebuilt as needed following removal of CCR.

The contractor may propose alternative material handling/transportation methods (e.g., conveyors or paste technology). Appropriate environmental reviews will be performed prior to using these methods/technologies.

3.5.6 Removal, Relocation, and Decommissioning of Existing Structures

In order to perform CCR removal, several existing structures and features will need to be removed and relocated or decommissioned. Refer to the Removal Plan Drawings provided in **Attachment A**. The following provides a summary of features that will be removed and relocated or decommissioned during removal:

- The existing 54-inch diameter high-density polyethylene (HDPE) treated wastewater discharge pipeline from the flow management (FM) tanks will be relocated around the perimeter of the APC to allow for CCR removal. The containment tank and final 63-inch Outfall 010 discharge piping located in the southwest corner of Pond E will remain in place. During construction of the containment tank and piping, the subgrade for the tank and surrounding area was excavated and confirmed to contain no CCR;
- Existing monitoring wells and instrumentation located within the CCR removal area will be removed and/or decommissioned in-place as closure progresses;
- Existing spillway structures will be removed and/or decommissioned in-place along with dikes containing CCR;
- Approximately 300,000 cy of soil stockpiles and soil materials contained within the perimeter dike system will be removed. Material will be visually inspected during excavation. Removed soil materials may be staged for reuse within the APC to construct temporary diversions or berms or for use as structural fill. Materials containing CCR will be disposed of in accordance with this Plan; and
- Appropriate environmental reviews will be performed and any necessary federal, state, or local permits will be obtained prior to performing the aforementioned actions.

3.6 Karst Mitigation

GAF is located in an area known to exhibit karst terrain (Weary and Doctor, 2014). During the environmental investigation, karst features were identified at GAF and published in a karst inventory completed as part of the ongoing EI and submitted to TDEC under separate cover. A Karst Mitigation Plan, provided in **Attachment C**, has been developed to provide information on the locations of existing karst features and the details and locations of existing known sinkhole repair areas. In addition, the Karst Mitigation Plan provides guidance for the repair of karst features that may develop during closure activities. It should be noted that as part of site-specific safety training, all personnel working on-site shall be trained to be familiar with the contents of the Karst Mitigation Plan and to be able to identify karst features or an incipient karst feature. In addition, and as noted in the Karst Mitigation Plan, all repair plans shall be reviewed by a karst specialist who is a PE or Professional Geologist (PG), licensed in Tennessee, with direct experience with karst hydrology/geomorphic processes and karst repair. If a karst drop-out develops during closure activities, TVA will immediately notify TDEC and repairs will be made in accordance with the Karst Mitigation Plan. Provisions for implementing groundwater monitoring in the event of karst drop-out development will be presented in the Monitoring Plan provided under separate cover and described in **Section 2.6**.

3.7 Source Removal Verification

Removal of the CCR (i.e., the source) will be conducted in accordance with TVA's governing documents which include the Interim Source Removal Process (ISRP) (TVA, 2019) and Interim Source Removal Quality Assurance Project Plan (ISR QAPP) (Environmental Standards, 2019). TDEC previously reviewed and approved these governing documents in 2019. A Source Removal Construction Quality Assurance Plan (SR CQAP) has been prepared to outline procedures for visual inspection and documentation of CCR removal, proposed post-removal soil sampling, and reporting that will be provided at the completion of construction to document source removal activities. A maximum of 1 ft of soil beneath the CCR may be over excavated depending on the results of source removal verification testing. The SR CQAP is provided as **Attachment D**.

3.8 Final Disposition of CCR

As noted in **Section 1**, TVA is proposing to excavate the CCR from the APC and place the material within a proposed lateral expansion to the existing NRL Landfill. A Class II solid waste permit application has been developed and submitted to TDEC Division of Solid Waste under separate cover. Placement and compaction requirements for CCR at the landfill are presented in the proposed solid waste permit.

As outlined in Section 2.c. of the Order, TVA may elect to beneficially reuse some portion or all of the CCR removed from the APC. Although this Removal Plan reflects disposal of the CCR in an on-site landfill, TVA is committed to evaluating emerging technologies and best practices for further beneficial reuse of CCR and for handling/transportation of CCR. In the future, TVA may choose to beneficially reuse CCR or make use of alternate technologies for CCR

handling or transportation (e.g., paste or conveyance technologies). If TVA does elect to beneficially reuse CCR or make use of alternate technologies, material processing and moisture conditioning requirements will be dictated by the selected technology and may differ from those presented in this Removal Plan. In this case, a revised Removal Plan would be submitted to TDEC and applicable parties as noted in Section 2.e. of the Order.

4 Site Restoration

Site restoration activities will be completed following the CCR removal required by the Order. Areas of the site may be restored as removal progresses based on contractor phasing of the work. However, final site restoration may be completed following the 20-year removal timeline required by Section 2.f of the Order.

At a minimum, the site will be graded to promote positive drainage and adequately manage storm water. Borrow soils from existing on-site soil stockpiles or off-site TVA borrow site may be used during site restoration. Disturbed areas will be re-vegetated in accordance with the SWPPP.

Post-excavation, the site will resemble the land's valley shape before the APC was created. Areas of the site located below the Cumberland River's normal water surface elevation are expected to result in a ponded area over a portion of the site. **Figure 4-1** illustrates the existing and proposed post-excavation conditions of the APC as presented in this Removal Plan. Also shown is the final conditions of the proposed SRL landfill.

Existing Conditions

Proposed Final Conditions

Figure 4-1. Existing and Proposed Final Conditions

At the time of preparing this Removal Plan, TVA has not determined a preferred approach for restoring or otherwise repurposing the site shown in **Figure 4-1**. Detailed engineering design for storm water management features and the discharge of storm water to the Cumberland River will be completed as part of site restoration activities based on the final conditions encountered and any proposed future use for the site. Appropriate environmental reviews will be performed and any necessary federal, state, or local permits will be obtained prior to any future activities occurring.

5 Best Management Practices

5.1 Fuel/Oil Spills

The following precautions and BMPs will be adhered to during construction. These are the minimum requirements, and more may be necessary depending on varying site conditions:

- Maintain a dedicated fueling area that is level, protected to prevent stormwater run-on/run-off, and located at least 50 ft from downstream drainage features or surface water;
- Large spill kits (55-gallon drums) and individual spill kits (located on closed cab equipment) will be the primary means to contain oil and fuel spills;
- Petroleum products will be stored in approved containers and secondary containment (110 percent capacity, minimum) will be used if required;
- Material safety data sheets (SDS) will be maintained onsite at all times; and
- Equipment will be inspected daily for worn hoses and seals. Hydraulic hoses will be wrapped in absorbent pads when working near waters of the United States, which includes the Cumberland River.

5.2 Coal Combustion Residuals Spills

Excavation, staging, and loading of CCRs will all be done within the footprint of the APC. Grading of CCR will occur within the SRL landfill in accordance with the landfill permit. Any spills in these areas will be fully contained within the APC or the landfill.

Transportation of the material will be conducted within the existing boundaries of the CCR facilities and the GAF property. Haul routes will be selected to keep material away from the Cumberland River or other waterways. Any CCR that may spill during transportation will be removed using standard earthwork equipment and transported to the SRL landfill for disposal.

5.3 Access Roads

CCR may be moved within the APC boundary to facilitate construction of temporary access roads and other ancillary features, e.g. temporary staging areas, within the APC. Construction may include the use of geosynthetics and/or stone aggregate as needed. Plans for construction and the proposed locations of any access roads or other features within the APC will be reviewed by TVA's Engineer.

5.4 Erosion and Sediment Control

Prior to earth disturbing activities, TVA will apply for coverage under the Tennessee General NPDES Permit for Stormwater Discharges from Construction Activities (TNR100000). BMPs associated with erosion and sediment control will be included in a Stormwater Pollution Prevention Plan as described in the Tennessee Erosion & Sediment Control Handbook. The SWPPP will include engineering plans detailing the limits of work; work sequence; initial and final grading and land cover; and the BMPs to be implemented, maintained, and inspected during and after construction. Soil disturbance will be minimized at any given time through sequencing and stabilizing disturbed areas as work progresses. The selected contractor will be responsible for establishing and maintaining all BMPs during the project.

5.5 Health and Safety

Each of TVA's selected contractor(s) and subcontractors will be required to prepare and implement a site-specific HASP to establish the health, safety and environmental requirements for workers and the public during the project. The HASP will be provided to TDEC for review and will also be available onsite throughout the duration of the work.

The HASP will be prepared in accordance with the most recent provisions found in the Federal safety and health regulations under 29 CFR Part 1910, Occupational Safety and Health Act (OSHA) of 1970 Standard, 29 CFR Part 1926, Safety and Health Regulations for Construction; 29 CFR Part 1904, Recording and Reporting Occupational Injuries and Illnesses; applicable state Department of Labor regulations, the TVA Safety Manual, and applicable TVA Health, Safety, and Environmental Procedures and Guidelines. At a minimum, the HASP will provide information including, but not limited to, the following:

- Anticipated hazards and hazard mitigation will be discussed, documented and controls established to mitigate these hazards;
- Personal protective equipment (PPE), qualification and training requirements, and personnel medical surveillance program requirements;
- Safety and emergency procedures;
- Monitoring Plan(s);
- Health and safety responsibilities;
- Site control and decontamination;
- Engineering controls;
- Standard operating procedures; and
- Material SDS.

6 Anticipated Permitting Activities

Several permitting activities are required to support the removal activities presented in this Removal Plan. Anticipated permits may include, but are not limited to, the following:

- Air quality permit modifications necessary to incorporate removal activities into the existing Title V permit (TDEC);
- Clean Water Act Section 404 Permit (USACE) and State 401 Water Quality Certification/Aquatic Resource Alteration Permit (TDEC) for creation of the ponded area following closure;
- General or Individual Construction Storm Water Permit (TDEC) for construction activities that result in the disturbance of 1 or more acres of soil;
- An updated TDEC Multisector General Permit Notice of Coverage will be needed for post-construction storm water discharges to the ponded area;
- TDEC Wastewater Plans Approval will be required for WTS;
- Class II Solid Waste Permit for the Rail Loop Site, SRL landfill (TDEC); and
- Special waste permits as needed for disposal of any unanticipated wastes encountered during removal.

TVA will make every effort to develop application materials and obtain the necessary permits such that Removal Activities may proceed as outlined in this Removal Plan.

7 Reporting

Progress reports will be prepared on a semi-annual basis to document the status of the APC closure project. The Semi-Annual Progress Reports covering January through June and July through December will be submitted to TDEC by September 1 of that year and March 1 of the following year, respectively.

The Semi-Annual Progress Report will include, when applicable, the following:

- An annual survey and summary of the volume of CCR removed;
- Source removal verification activities and results;
- Details of karst repairs;
- Details of other substantial activities and milestones completed; and
- An updated project schedule.

At the conclusion of removal activities, a Final Construction Record Documentation (CRD) Report will be prepared and submitted for TDEC's review. The CRD Report will be certified, signed, and sealed by a licensed PE in the State of Tennessee and will document that the APC removal has been completed in accordance with this Removal Plan.

8 Schedule

A schedule for the completion of closure by removal is provided below in **Table 4** and **Table 5**. TVA anticipates completion of removal activities within 20 years of TDEC's final approval of this Removal Plan. TVA may request extensions of time for closure of the APC as approved by TDEC for good cause shown as outlined in Section 2.g of the Order.

Table 4. Schedule for Required Document Submittals

Document	Submittal Date	Approval/Completion Date
EIS Record of Decision	N/A	September 2020 (Actual)
APC Removal Plan (This Document)	September 2020 (Actual)	2021 (Assumed)
APC Monitoring Plan	April 2021 (Estimated)	2021 (Assumed)
APC Groundwater CARA Plan	60 days following APC Removal Plan Approval	2021 (Assumed)
Class II Solid Waste Permit	August 2020 (Actual)	January 2022 (Assumed)

Table 5. Estimated Schedule for Construction Activities

Activity	Years	Notes
SRL Landfill Initial Construction	2022 - 2023	Begin CCR removal following landfill construction
CCR Removal	2024 – 2038	Complete removal 20 years following APC Removal Plan approval
Dewatering	2021 – 2038	Dewatering may begin following APC Removal Plan approval
Water Quality Monitoring	Begin 2021	Monitoring to begin 30 days following APC Monitoring Plan approval

Note:

[1] The schedule presented herein is based on CCR disposal rates and proposed 30 acre operational working area as presented in the pending SRL landfill class II solid waste permit application developed and submitted to TDEC Division of Solid Waste under separate cover. TVA understands that this assumed working face is subject to TDEC's review of the solid waste permit application and may change in the approved permit. Refer to **Table 2**. Should the permitted SRL landfill working area be less than the assumed 30 acres, recalculation of disposal rates and corresponding changes to removal timelines may be necessary.

9 References

Environmental Standards (2019), Quality Assuarance Project Plan, Tenneesee Valley Authority Source Removal Projects, Revision 0, January 2019

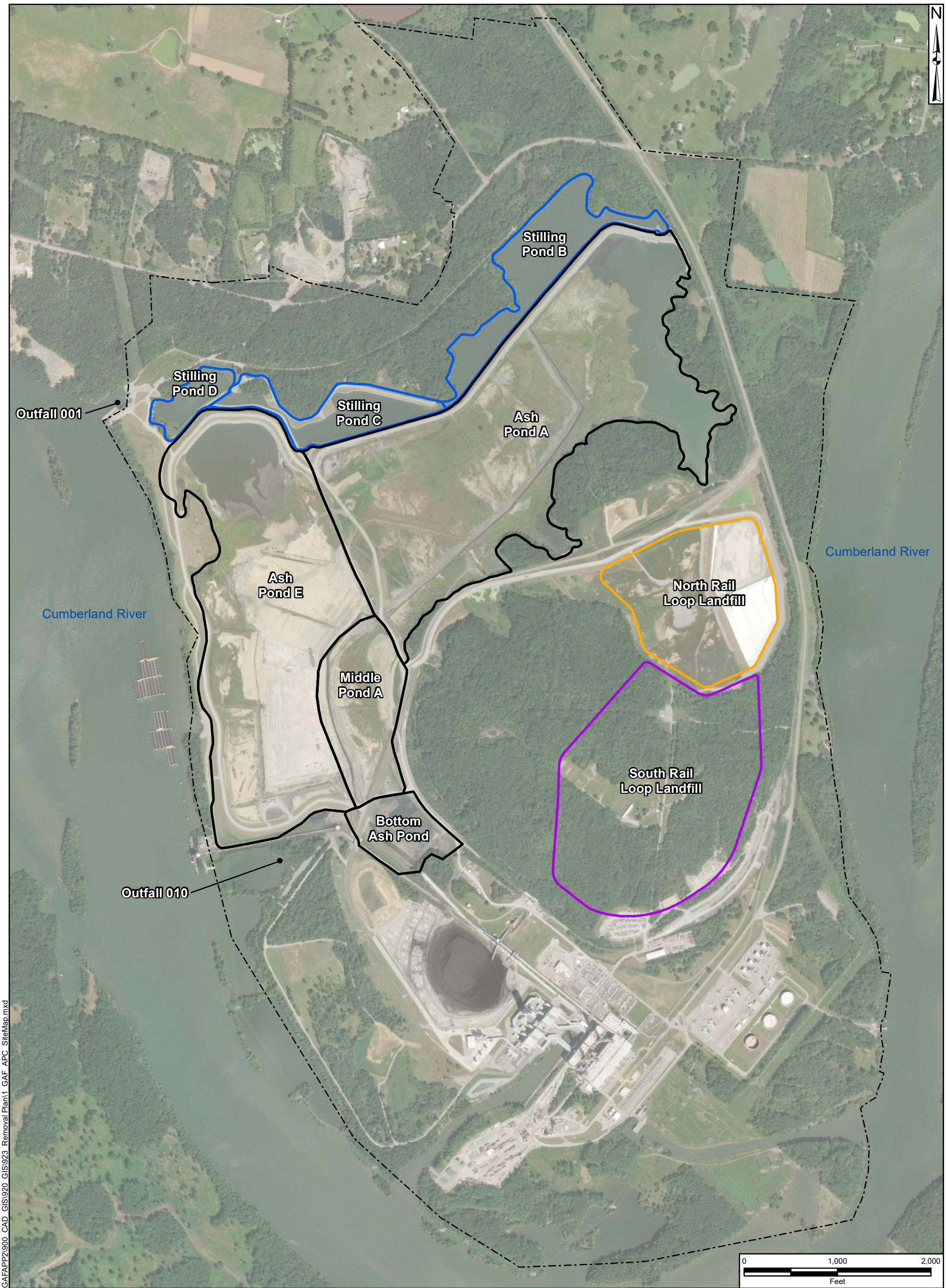
Tennessee Valley Authority (2019), Interim Source Removal Process, January 11, 2019.

Tennessee Valley Authority (2020), Gallatin Fossil Plant Surface Impoundment Closure and Restoration Project Environmental Impact Statement, Sumner County, Tennessee, August 2020.

USACE (2003), Engineering and Design: Slope Stability Engineering Manual, EM 1110-2-1902, 31 October, 2003.

Weary, D.J., and Doctor, D.H. (2014), Karst in the United States: A digital map compilation and database: U.S. Geological Survey Open-File Report 2014–1156, 23 p., http://dx.doi.org/10.3133/ofr20141156.

FIGURES



LEGEND

- Ash Ponds
- Stilling Ponds
- North Rail Loop Landfill
- South Rail Loop Landfill
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

AECOM

Figure 1

SITE MAP

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
J.COLLEY	D.SKEGGS	-	REV. 0

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

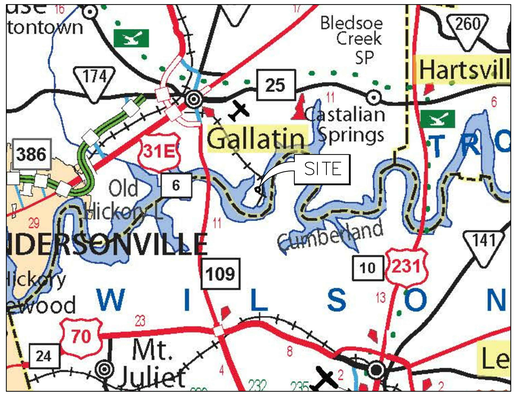
DATE:	DEPT:
JUNE 2020	FOSSIL AND HYDRO ENGINEERING

Document Path: L:\DCS\Projects\ENV\60624653_TVAGAFAPP2\900_CAD_GIS\920_GIS\923_Removal Plan\1_GAF_APC_SiteMap.mxd

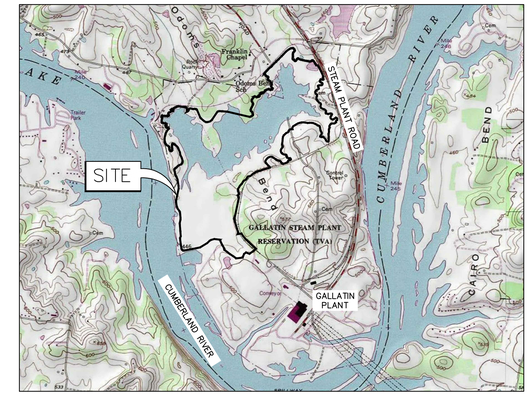
ATTACHMENTS

Attachment A – Removal Plan Drawings

ASH POND COMPLEX REMOVAL PLAN
TENNESSEE VALLEY AUTHORITY
GALLATIN FOSSIL PLANT
FINAL DRAFT SUBMITTAL



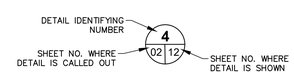
SITE VICINITY MAP
N.T.S



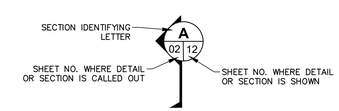
SITE LOCATION MAP

2000 0 2000 4000
SCALE FEET

DWG. NO.	DWG. DESCRIPTION
10W272-01	TITLE SHEET
10W272-02	EXISTING CONDITIONS SITE PLAN
10W272-03	EXISTING INSTRUMENTATION PLAN
10W272-04	ESTIMATED BOTTOM OF CCR GRADES
10W272-05	FINAL CONDITIONS SITE PLAN
10W272-06	CROSS-SECTION PLAN
10W272-07	CROSS-SECTION I
10W272-08	CROSS-SECTION II
10W272-09	CROSS-SECTION III
10W272-10	CROSS-SECTION IV
10W272-11	EXISTING DIKE SECTIONS I
10W272-12	EXISTING DIKE SECTIONS II
10W272-13	PAVED HAUL ROAD DETAILS
10W272-14	SPILLWAY STRUCTURE DETAILS I
10W272-15	SPILLWAY STRUCTURE DETAILS II
10W272-16	STORM WATER MANAGEMENT DETAILS
10W272-17	TEMPORARY CCR EXCAVATION SLOPE DETAILS



DETAIL REFERENCE ON SHEET WHERE DETAIL IS CALLED OUT



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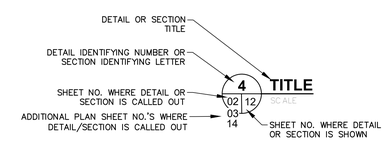

DETAIL OR SECTION, NUMBER OR LETTER & TITLE ON SHEET WHERE DETAIL OR SECTION IS SHOWN

PREPARED FOR:

TENNESSEE VALLEY AUTHORITY
1101 MARKET STREET
CHATTANOOGA, TN 37402

PREPARED BY:

AECOM CORPORATION
1600 PERIMETER PARK DRIVE
SUITE 400
MORRISVILLE, NC 27560
PHONE: (919) 461-1100

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PROVIDE 3 WORKING DAYS NOTICE

FOR SUPPORTING DESIGN CALCULATIONS SEE

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R											
R 0	09/18/20	RLP	RLP	DES	GWL	N/A	N/A	TVA	XXXXXXX		

DISCIPLINE INTERFACE

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM LANG
REGISTERED ENGINEER
AGRICULTURE
9/18/20
STATE OF TENNESSEE

SCALE: AS SHOWN EXCEPT AS NOTED

TITLE SHEET

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

AECOM

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 09/18/20 | 39 | C | 10W272-01 | R 0

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING DO NOT ALTER MANUALLY

AECOM | 0
TASK COMPLETED BY: | REV NO.

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N

0 300 600
SCALE IN FEET

LEGEND

- EXISTING MAJOR CONTOUR (25 FT)
- EXISTING MINOR CONTOUR (5 FT)
- SITE VEGETATION BOUNDARY
- PIPES/CULVERTS
- EDGE OF WATER
- ROADWAY EXTENTS (UNPAVED)
- ROADWAY EXTENTS (PAVED)
- OVERHEAD ELECTRIC LINE
- TRANSMISSION TOWER
- 100-YR FLOODPLAIN
- TVA PROPERTY LINE
- BUILDINGS, STRUCTURES
- FENCE
- NATIONAL REGISTER OF HISTORIC PLACES (NRHP) ELIGIBLE SITE
- CEMETERY
- NRHP AND CEMETERY BUFFER/SETBACK
- WETLAND
- WET WEATHER CONVEYANCE
- INTERMITTENT STREAM
- LANDFILL LIMIT OF WASTE
- LIMIT OF CCR REMOVAL
- SOIL EMBANKMENTS AND STOCKPILES TO BE REMOVED

NOTES:

1. TOPOGRAPHIC SURVEY OF THE SITE IS BASED ON DATA COMPILED BY TVA SURVEYING ON MAY 30, 2019. HORIZONTAL DATUM IS TVA NAD27 LOCAL GRID. VERTICAL DATUM IS NGVD29.
2. SUPPLEMENTAL TOPOGRAPHIC SURVEY (AREA EAST OF STEAM PLANT ROAD) IS BASED ON DATA COMPILED BY DDS ENGINEERING ON MARCH 9, 2017. DATA WAS OBTAINED BY QUANTUM SPATIAL, INC. ON FEBRUARY 4, 2017. HORIZONTAL DATUM IS TVA NAD27 LOCAL GRID. VERTICAL DATA IS NGVD29.
3. SOIL STOCKPILES AND SOIL UTILIZED IN THE CONSTRUCTION OF THE PERIMETER DIKE SYSTEM SHALL BE INSPECTED DURING EXCAVATION AND CLEAN SOIL MATERIAL SHALL BE SEGREGATED BASED ON VISUAL OBSERVATION. SOIL MATERIALS MAY BE STOCKPILED WITHIN THE APC FOR REUSE AS NEEDED. REFER TO TYPICAL DIKE SECTION DETAILS.
4. THE LOCATION OF EXISTING CULTURAL RESOURCES AND ENVIRONMENTAL FEATURES INCLUDING WETLANDS, INTERMITTENT STREAMS, WET WEATHER CONVEYANCES, CEMETERIES, AND NRHP ELIGIBLE SITES ARE BASED ON DATA PROVIDED BY TVA USING HANDHELD GPS UNITS.
5. WATER SURFACE ELEVATIONS FOR ASH POND A AND THE STILLING PONDS ARE BASED ON WATER LEVEL GAUGING PERFORMED JANUARY 13, 2020.
6. CONTOURS SHOWN UNDERWATER IN STILLING PONDS AND POND A POOL AREA ARE FROM BATHYMETRIC SURVEY DATA COMPLETED BY TVA SURVEYING IN 2017.

FOR SUPPORTING DESIGN CALCULATIONS SEE

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM LONG
REGISTERED ENGINEER
AGRICULTURE
STATE OF TENNESSEE
9/18/20

AECOM

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R 0	09/18/20	RLP	RLP	DES	GWL	N/A	N/A	TVA	XXXXXX		

DISCIPLINE INTERFACE

SCALE: AS SHOWN EXCEPT AS NOTED

EXISTING CONDITIONS SITE PLAN

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 09/18/20 | 39 | C | 10W272-02 | R 0

AECOM	0
TASK COMPLETED BY:	REV NO.

PLOT FACTOR:XX
W_TVA

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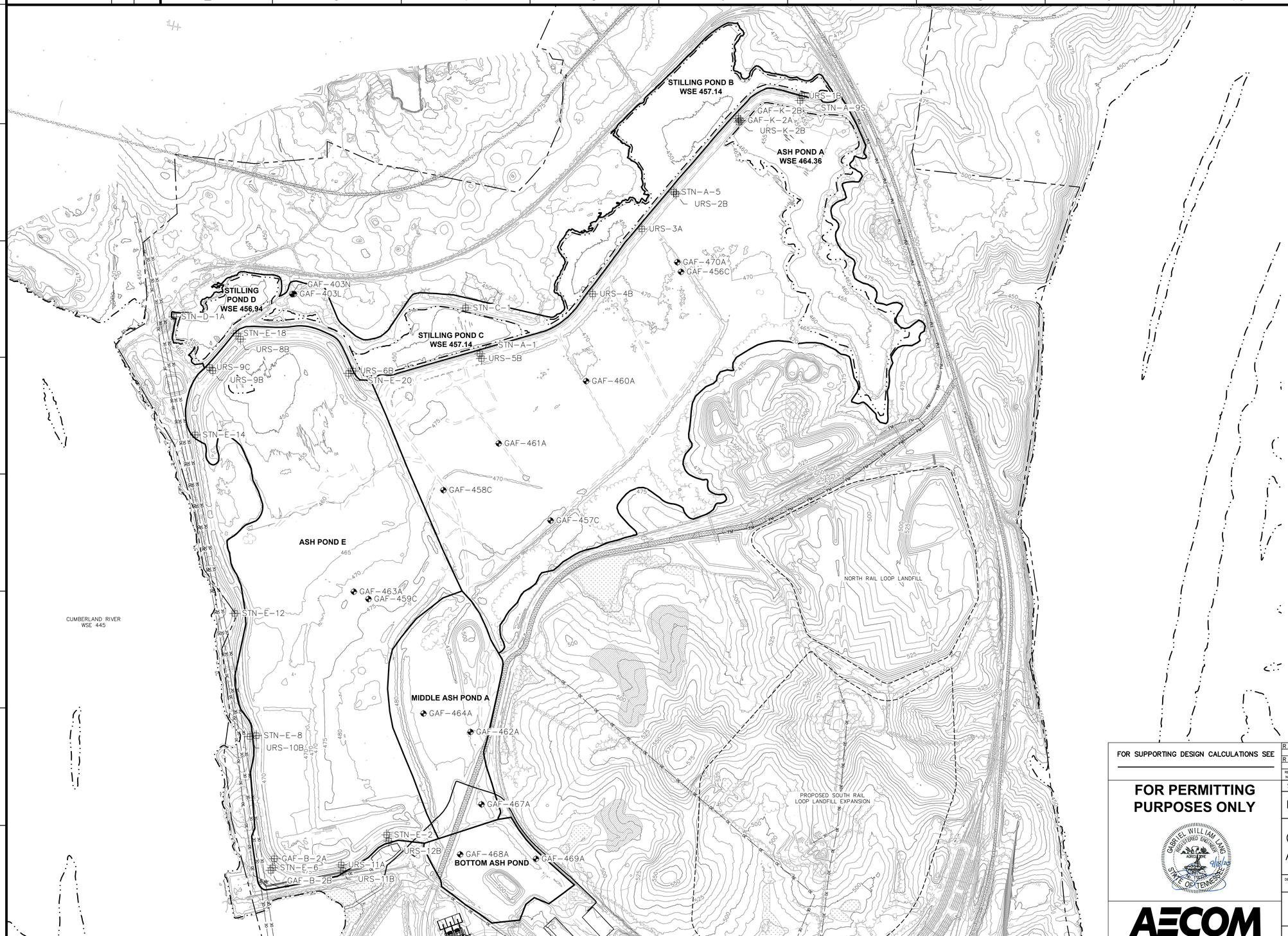

LEGEND

- EXISTING MAJOR CONTOUR (25 FT)
- EXISTING MINOR CONTOUR (5 FT)
- SITE VEGETATION BOUNDARY
- WELL
- PIEZOMETER
- EDGE OF WATER
- ROADWAY EXTENTS (UNPAVED)
- ROADWAY EXTENTS (PAVED)
- OVERHEAD ELECTRIC LINE
- TRANSMISSION TOWER
- 100-YR FLOODPLAIN
- TVA PROPERTY LINE
- BUILDINGS, STRUCTURES
- FENCE
- NATIONAL REGISTER OF HISTORIC PLACES (NRHP) ELIGIBLE SITE
- CEMETERY
- NRHP AND CEMETERY BUFFER/SETBACK
- WETLAND
- WET WEATHER CONVEYANCE
- INTERMITTENT STREAM
- LANDFILL LIMIT OF WASTE
- ASH & STILLING POND BOUNDARY

NOTES:

1. ONLY INSTRUMENTATION AND WELLS LOCATED WITHIN THE LIMIT OF CCR REMOVAL ARE SHOWN FOR CLARITY. WELLS LOCATED OUTSIDE OF THE LIMIT OF CCR REMOVAL ARE NOT SHOWN AND WILL BE ADDRESSED IN A SEPARATE MONITORING PLAN.
2. A SURVEILLANCE AND INSTRUMENTATION MONITORING PLAN (SIMP) WILL BE DEVELOPED PRIOR TO CONSTRUCTION AND WILL BE FOLLOWED TO VERIFY CONSTRUCTION PHASE STABILITY DURING CCR REMOVAL AND DEWATERING.
3. ALL WELLS, PIEZOMETERS, AND ANY OTHER INSTRUMENTS WITHIN THE CLOSURE AREA WILL BE REMOVED OR ABANDONED IN PLACE BY GROUTING IN PLACE AND REMOVING THE ABOVE GROUND COMPONENTS. REMOVAL OF MONITORING WELLS, PIEZOMETERS, AND ANY OTHER INSTRUMENTS WILL BE BASED ON CCR REMOVAL SEQUENCE. A DETAILED DEMOLITION PLAN WILL BE DEVELOPED PRIOR TO CONSTRUCTION.

FOR SUPPORTING DESIGN CALCULATIONS SEE

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM LIVING
REGISTERED ENGINEER
AGRICULTURE
STATE OF TENNESSEE
9/18/20

AECOM

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R 0	09/18/20	RLP	RLP	DES	GWL	N/A	N/A	TVA	XXXXXXX		

DISCIPLINE INTERFACE

SCALE: AS SHOWN EXCEPT AS NOTED

EXISTING INSTRUMENTATION PLAN

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 09/18/20 | 39 | C | 10W272-03 | R 0

AECOM	0
TASK COMPLETED BY:	REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

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N

0 300 600
SCALE IN FEET

LEGEND

- 500 — EXISTING MAJOR CONTOUR (25 FT)
- EXISTING MINOR CONTOUR (5 FT)
- 500 — ESTIMATED EXCAVATION MAJOR CONTOUR (25 FT)
- ESTIMATED EXCAVATION MINOR CONTOUR (5 FT)
- SITE VEGETATION BOUNDARY
- EDGE OF WATER
- ROADWAY EXTENTS (UNPAVED)
- ROADWAY EXTENTS (PAVED)
- OE — OVERHEAD ELECTRIC LINE
- TRANSMISSION TOWER
- 100-YR — 100-YR FLOODPLAIN
- TVA PROPERTY LINE
- BUILDINGS, STRUCTURES
- FENCE
- NATIONAL REGISTER OF HISTORIC PLACES (NRHP) ELIGIBLE SITE
- CEMETERY
- NRHP AND CEMETERY BUFFER/SETBACK
- WETLAND
- WET WEATHER CONVEYANCE
- INTERMITTENT STREAM
- LANDFILL LIMIT OF WASTE
- LIMIT OF CCR REMOVAL
- CCR TO REMAIN UNTIL COMPLETION OF REMOVAL ACTIVITIES

NOTES:

1. THE FINAL GRADES PRESENTED IN THIS PLAN ARE INTENDED TO PRESENT THE REMOVAL OF ALL CCR FROM THE APC AREA AND ARE PROVIDED FOR PERMITTING APPROVAL PURPOSES ONLY. DETAILED ENGINEERING PLANS AND SEQUENCING PLANS WILL BE DEVELOPED PRIOR TO CONSTRUCTION.
2. THE FINAL GRADES SHOWN ARE BASED ON ESTIMATED BOTTOM OF CCR ELEVATIONS AND WILL VARY BASED ON SITE CONDITIONS ENCOUNTERED DURING REMOVAL. ESTIMATED BOTTOM OF CCR CONTOURS WERE DEVELOPED BASED ON PRE-CONSTRUCTION SITE TOPOGRAPHICAL MAPS PRESENTED IN "PROJECT AREA MAP"DATED FEBRUARY 14, 1952 AND TVA DRAWING 10N240 DATED NOVEMBER 4, 1969. THE BOTTOM OF CCR HAS BEEN UPDATED BASED ON EXISTING BORING DATA. REFER TO DRAWING -06.
3. THE LIMIT OF CCR REMOVAL SHOWN IS BASED ON THE WASTE BOUNDARY INVESTIGATION CONDUCTED AND PRESENTED IN THE GALLATIN ENVIRONMENTAL ASSESSMENT REPORT.
4. THE EXISTING PAVED HAUL ROAD LOCATED WITHIN THE CCR REMOVAL AREA SHALL BE MAINTAINED DURING CCR REMOVAL TO ALLOW FOR TRANSPORTATION OF CCR. CCR LOCATED BENEATH THE ROAD WILL BE REMOVED AT THE CONCLUSION OF THE PROJECT. THE EXISTING ROAD MAY BE RELOCATED OR REBUILT AS NEEDED FOLLOWING REMOVAL OF CCR FROM BENEATH THE ROAD.
5. A SURVEILLANCE AND INSTRUMENTATION MONITORING PLAN (SIMP) WILL BE DEVELOPED PRIOR TO CONSTRUCTION AND WILL BE FOLLOWED TO VERIFY CONSTRUCTION PHASE STABILITY DURING CCR REMOVAL AND DEWATERING.
6. FREE WATER, PORE WATER, AND CONTAMINATED STORM WATER WITHIN THE APC CCR REMOVAL AREA WILL BE MANAGED IN ACCORDANCE WITH THE PROJECT DEWATERING PLAN. DEWATERING IS TO BE COMPLETED AS NEEDED PRIOR TO CCR REMOVAL TO SUPPORT PLANNED EXCAVATION SEQUENCING AND CONSTRUCTION ACCESS. REFER TO TEMPORARY CCR EXCAVATION DETAILS PRESENTED ON DRAWING -17.
7. UPON REMOVAL OF CCR FROM AN AREA, SOURCE REMOVAL VERIFICATION TESTING IS REQUIRED. REFER TO THE SOURCE REMOVAL VERIFICATION CQA PLAN FOR ADDITIONAL DETAILS.
8. TVA HAS NOT DETERMINED THE PREFERRED APPROACH FOR DISCHARGE OF STORM WATER FROM THE PONDED AREA SHOWN FOLLOWING CCR REMOVAL ACTIVITIES. ADDITIONAL ENVIRONMENTAL REVIEWS MAY BE REQUIRED FOR THIS ACTIVITY. DETAILED ENGINEERING DESIGN FOR STORM WATER DISCHARGE WILL COMPLETED AS PART OF SITE RESTORATION ACTIVITIES.

FOR SUPPORTING DESIGN CALCULATIONS SEE

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM LANG
REGISTERED ENGINEER
AGRICULTURE
STATE OF TENNESSEE

AECOM

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R											
R 0	09/18/20	RLP	RLP	DES	GWL	N/A	N/A	TVA	XXXXXXX		

DISCIPLINE INTERFACE

SCALE: AS SHOWN — EXCEPT AS NOTED

ESTIMATED BOTTOM OF CCR GRADES

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 09/18/20 | 39 | C | 10W272-04 | R 0

AECOM	0
TASK COMPLETED BY:	REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

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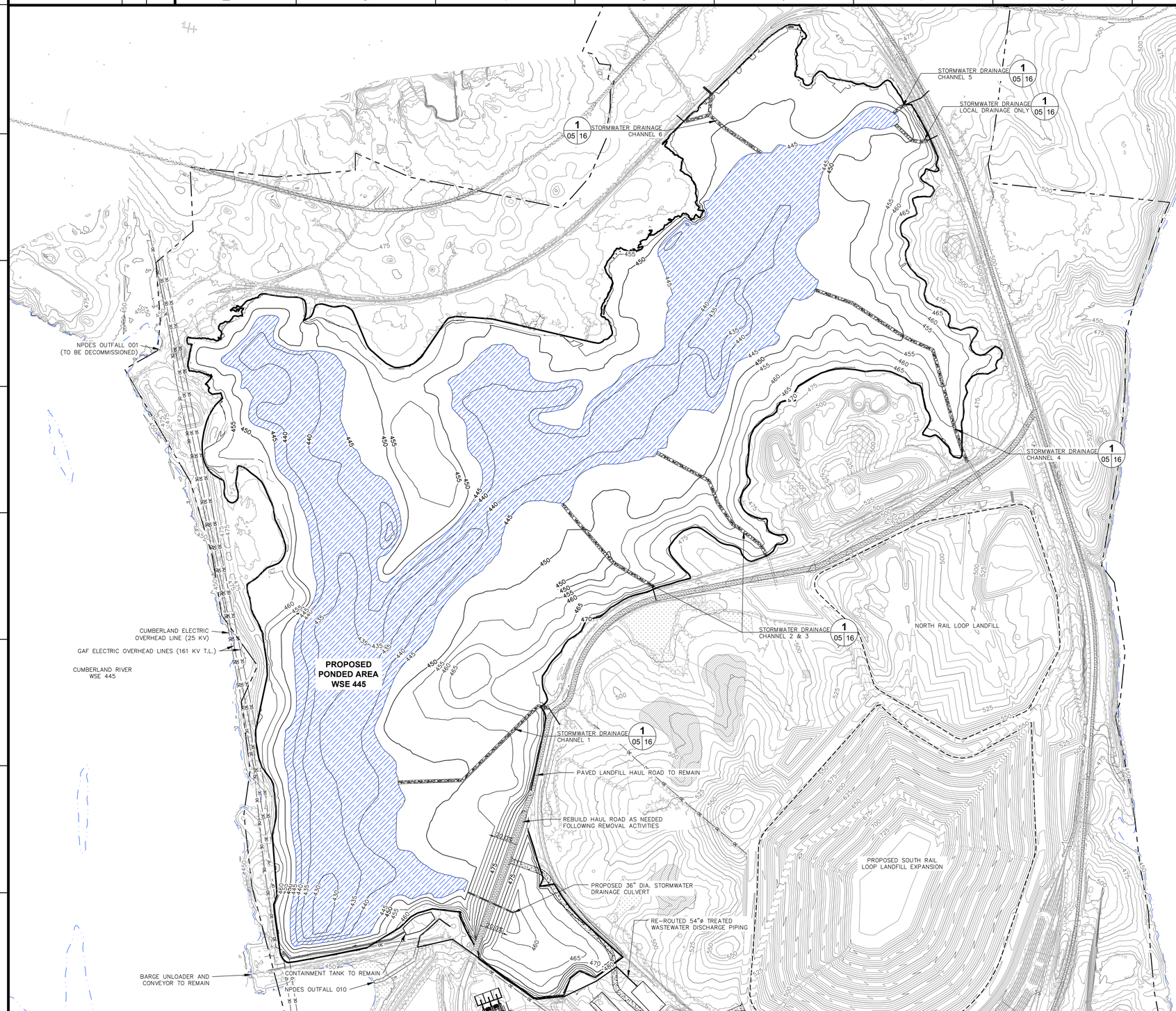

N

0 300 600
SCALE IN FEET

LEGEND

- EXISTING MAJOR CONTOUR (25 FT)
- EXISTING MINOR CONTOUR (5 FT)
- ESTIMATED EXCAVATION MAJOR CONTOUR (25 FT)
- ESTIMATED EXCAVATION MINOR CONTOUR (5 FT)
- SITE VEGETATION BOUNDARY
- EDGE OF WATER
- ROADWAY EXTENTS (UNPAVED)
- ROADWAY EXTENTS (PAVED)
- OVERHEAD ELECTRIC LINE
- TRANSMISSION TOWER
- 100-YR FLOODPLAIN
- TVA PROPERTY LINE
- BUILDINGS, STRUCTURES
- FENCE
- NATIONAL REGISTER OF HISTORIC PLACES (NRHP) ELIGIBLE SITE
- CEMETERY
- NRHP AND CEMETERY BUFFER/SETBACK
- WETLAND
- WET WEATHER CONVEYANCE
- INTERMITTENT STREAM
- LANDFILL LIMIT OF WASTE
- LIMIT OF CCR REMOVAL
- PROPOSED STORMWATER DRAINAGE CHANNELS
- PROPOSED PONDED AREA FOLLOWING CCR REMOVAL

NOTES:

1. THE FINAL GRADES PRESENTED IN THIS PLAN ARE INTENDED TO PRESENT THE REMOVAL OF ALL CCR FROM THE APC AREA AND THE OVER EXCAVATION OF 1 FOOT OF SOILS BENEATH THE CCR AND ARE PROVIDED FOR PERMITTING APPROVAL PURPOSES ONLY. DETAILED ENGINEERING PLANS AND SEQUENCING PLANS WILL BE DEVELOPED PRIOR TO CONSTRUCTION.
2. THE FINAL GRADES SHOWN ON THIS DRAWING ARE BASED ON ESTIMATED BOTTOM OF CCR ELEVATIONS MINUS 1 FT FOR OVER-EXCAVATION AND WILL VARY BASED ON SITE CONDITIONS ENCOUNTERED DURING REMOVAL. ESTIMATED BOTTOM OF CCR CONTOURS WERE DEVELOPED BASED ON PRE-CONSTRUCTION SITE TOPOGRAPHICAL MAPS PRESENTED IN "PROJECT AREA MAP" DATED FEBRUARY 14, 1952 AND TVA DRAWING 10N240 DATED NOVEMBER 4, 1969. THE BOTTOM OF CCR HAS BEEN UPDATED BASED ON EXISTING BORING DATA. REFER TO DRAWING -06.
3. THE LIMIT OF CCR REMOVAL SHOWN IS BASED ON THE WASTE BOUNDARY INVESTIGATION CONDUCTED AND PRESENTED IN THE GALLATIN ENVIRONMENTAL ASSESSMENT REPORT.
4. THE EXISTING PAVED HAUL ROAD LOCATED WITHIN THE CCR REMOVAL AREA SHALL BE MAINTAINED DURING CCR REMOVAL TO ALLOW FOR TRANSPORTATION OF CCR. CCR LOCATED BENEATH THE ROAD WILL BE REMOVED AT THE CONCLUSION OF THE PROJECT. THE EXISTING ROAD MAY BE RELOCATED OR REBUILT AS NEEDED FOLLOWING REMOVAL OF CCR FROM BENEATH THE ROAD.
5. A SURVEILLANCE AND INSTRUMENTATION MONITORING PLAN (SIMP) WILL BE DEVELOPED PRIOR TO CONSTRUCTION AND WILL BE FOLLOWED TO VERIFY CONSTRUCTION PHASE STABILITY DURING CCR REMOVAL AND DEWATERING.
6. FREE WATER, PORE WATER, AND CONTAMINATED STORM WATER WITHIN THE APC CCR REMOVAL AREA WILL BE MANAGED IN ACCORDANCE WITH THE PROJECT DEWATERING PLAN. DEWATERING IS TO BE COMPLETED AS NEEDED PRIOR TO CCR REMOVAL TO SUPPORT PLANNED EXCAVATION SEQUENCING AND CONSTRUCTION ACCESS. REFER TO TEMPORARY CCR EXCAVATION DETAILS PRESENTED ON DRAWING -17.
7. UPON REMOVAL OF CCR FROM AN AREA, SOURCE REMOVAL VERIFICATION TESTING IS REQUIRED. REFER TO THE SOURCE REMOVAL VERIFICATION CQA PLAN FOR ADDITIONAL DETAILS.
8. TVA HAS NOT DETERMINED THE PREFERRED APPROACH FOR DISCHARGE OF STORM WATER FROM THE PONDED AREA SHOWN FOLLOWING CCR REMOVAL ACTIVITIES. ADDITIONAL ENVIRONMENTAL REVIEWS MAY BE REQUIRED FOR THIS ACTIVITY. DETAILED ENGINEERING DESIGN FOR STORM WATER DISCHARGE WILL COMPLETED AS PART OF SITE RESTORATION ACTIVITIES.

FOR SUPPORTING DESIGN CALCULATIONS SEE

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM LANG REGISTERED ENGINEER AGRICULTURE 19154 STATE OF TENNESSEE

AECOM

REV NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R											
R 0	09/18/20	RLP	RLP	DES	GWL	N/A	N/A	TVA	XXXXXXX		

DISCIPLINE INTERFACE

SCALE: AS SHOWN EXCEPT AS NOTED

FINAL CONDITIONS SITE PLAN

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD	2019	DATE 09/18/20	39	C	10W272-05	R 0

AECOM	0
TASK COMPLETED BY:	REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING DO NOT ALTER MANUALLY

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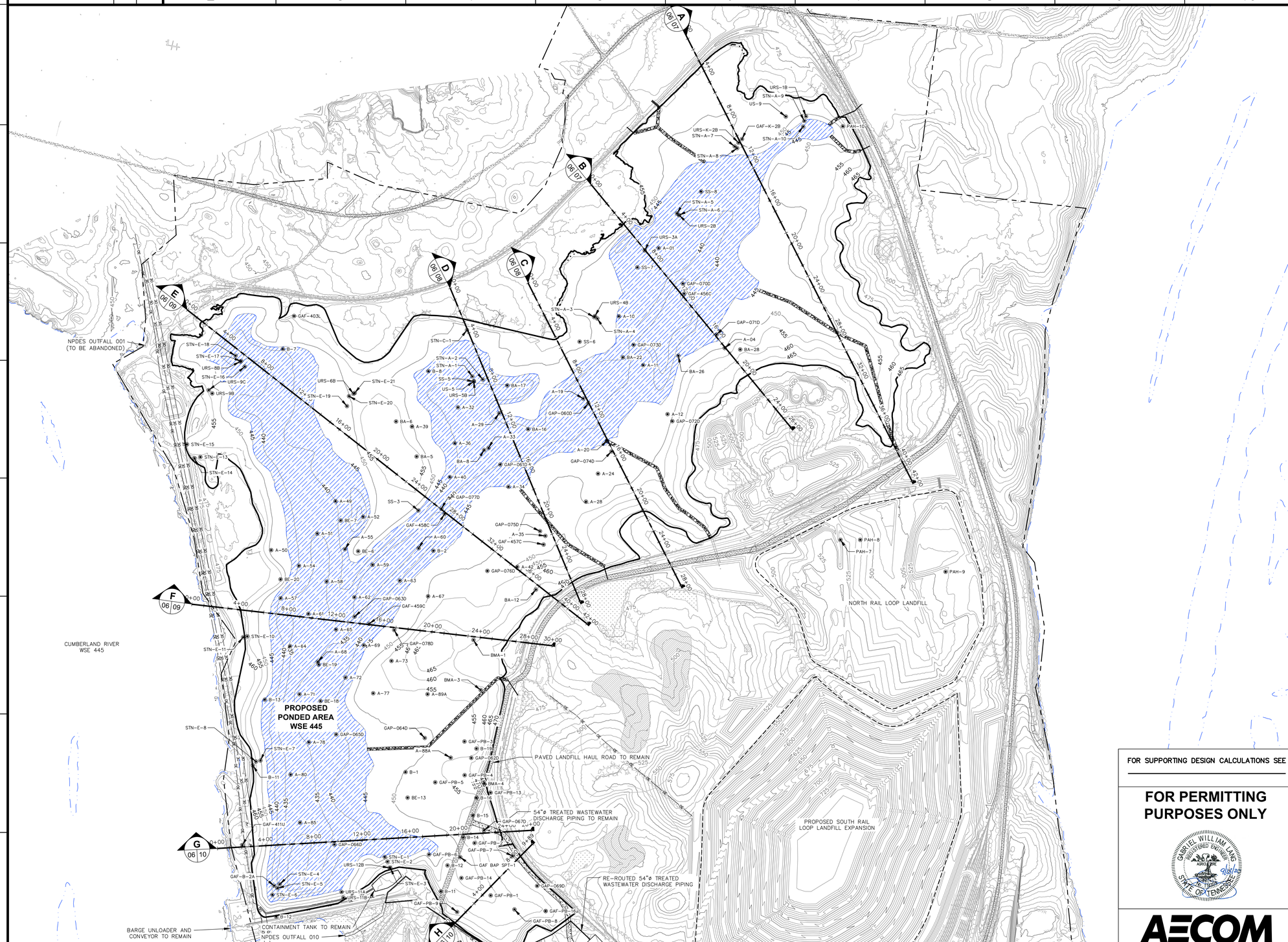

N

0 300 600
SCALE IN FEET

LEGEND

- EXISTING MAJOR CONTOUR (25 FT)
- EXISTING MINOR CONTOUR (5 FT)
- ESTIMATED EXCAVATION MAJOR CONTOUR (25 FT)
- ESTIMATED EXCAVATION MINOR CONTOUR (5 FT)
- SITE VEGETATION BOUNDARY
- EDGE OF WATER
- ROADWAY EXTENTS (UNPAVED)
- ROADWAY EXTENTS (PAVED)
- OVERHEAD ELECTRIC LINE
- TRANSMISSION TOWER
- 100-YR FLOODPLAIN
- TVA PROPERTY LINE
- BUILDINGS, STRUCTURES
- FENCE
- NATIONAL REGISTER OF HISTORIC PLACES (NRHP) ELIGIBLE SITE
- CEMETERY
- NRHP AND CEMETERY BUFFER/SETBACK
- WETLAND
- WET WEATHER CONVEYANCE
- INTERMITTENT STREAM
- LANDFILL LIMIT OF WASTE
- LIMIT OF CCR REMOVAL
- PROPOSED STORMWATER DRAINAGE CHANNELS
- PROPOSED PONDED AREA FOLLOWING CCR REMOVAL
- ASH POND CROSS-SECTIONS
- URS-K-2B EXISTING BORING LOCATIONS

NOTES:

1. REFER TO DRAWING -05 FOR FINAL GRADES.
2. BORINGS SHOWN ON THIS PLAN REPRESENT BORINGS COMPLETED WITHIN THE APC THAT ENCOUNTERED THE BOTTOM OF CCR AND WERE UTILIZED IN DEVELOPING THE FINAL GRADES SHOWN IN THIS PLAN.
3. THE LIMIT OF CCR REMOVAL SHOWN IS BASED ON THE WASTE BOUNDARY INVESTIGATION CONDUCTED AND PRESENTED IN THE GALLATIN ENVIRONMENTAL ASSESSMENT REPORT.
4. THE EXISTING PAVED HAUL ROAD LOCATED WITHIN THE CCR REMOVAL AREA SHALL BE MAINTAINED DURING CCR REMOVAL TO ALLOW FOR TRANSPORTATION OF CCR. CCR LOCATED BENEATH THE ROAD WILL BE REMOVED AT THE CONCLUSION OF THE PROJECT. THE EXISTING ROAD MAY BE RELOCATED OR REBUILT AS NEEDED FOLLOWING REMOVAL OF CCR FROM BENEATH THE ROAD.
5. A SURVEILLANCE AND INSTRUMENTATION MONITORING PLAN (SIMP) WILL BE DEVELOPED PRIOR TO CONSTRUCTION AND WILL BE FOLLOWED TO VERIFY CONSTRUCTION PHASE STABILITY DURING CCR REMOVAL AND DEWATERING.
6. FREE WATER, PORE WATER, AND CONTAMINATED STORM WATER WITHIN THE APC CCR REMOVAL AREA WILL BE MANAGED IN ACCORDANCE WITH THE PROJECT DEWATERING PLAN. DEWATERING IS TO BE COMPLETED AS NEEDED PRIOR TO CCR REMOVAL TO SUPPORT PLANNED EXCAVATION SEQUENCING AND CONSTRUCTION ACCESS. REFER TO TEMPORARY CCR EXCAVATION DETAILS PRESENTED ON DRAWING -17.
7. UPON REMOVAL OF CCR FROM AN AREA, SOURCE REMOVAL VERIFICATION TESTING IS REQUIRED. REFER TO THE SOURCE REMOVAL VERIFICATION QA PLAN FOR ADDITIONAL DETAILS. FOLLOWING VERIFICATION OF SOURCE REMOVAL, NON-CONTAMINATED STORM WATER MAY BE ROUTED TO THE STILLING PONDS OR OTHERWISE DIVERTED USING TEMPORARY DIVERSIONS. REFER TO TYPICAL STORM WATER DIVERSION DETAILS ON DRAWING -16.

FOR SUPPORTING DESIGN CALCULATIONS SEE

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM LANG
REGISTERED ENGINEER
AGREEDONE
STATE OF TENNESSEE

AECOM

REV NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST
R										
R 0	09/18/20	RLP	RLP	DES	GWL	N/A	N/A	TVA	XXXXXXX	

DISCIPLINE INTERFACE: 1 2 3 4

SCALE: AS SHOWN EXCEPT AS NOTED

CROSS-SECTIONS PLAN

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 09/18/20 | 39 | C | 10W272-06 | R 0

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

AECOM	0
TASK COMPLETED BY:	REV NO.

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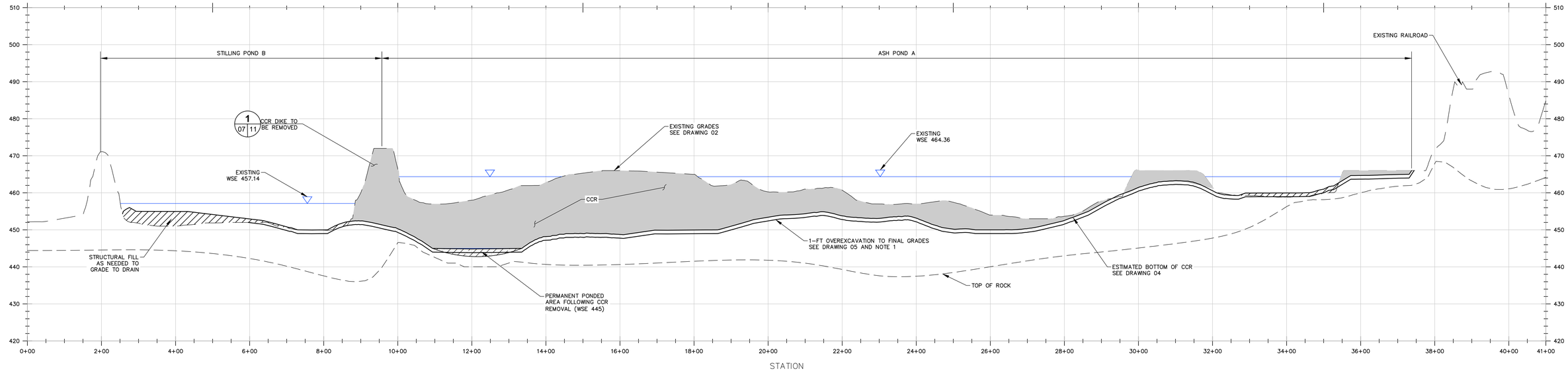

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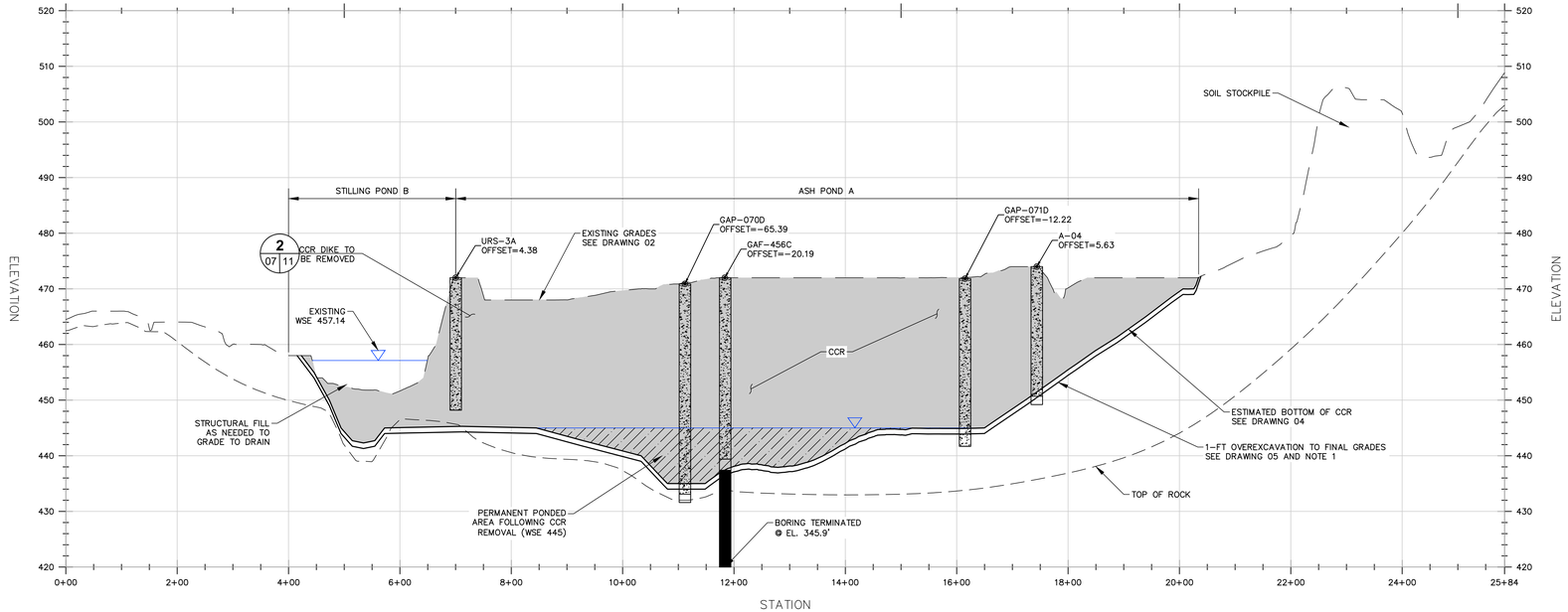

B 06 07 CROSS-SECTION B-B'

NOTES:

1. OVEREXCAVATION IS TO BE PERFORMED BASED ON THE RESULTS OF SOURCE REMOVAL VERIFICATION TESTING. REFER TO THE FACILITY SOURCE REMOVAL VERIFICATION CQA PLAN.

LEGEND

- EXISTING GRADES
- TOP OF ROCK
- PROPOSED GRADES
- PERMANENT PONDED AREA
- SOIL BORING (ASH, SOIL, ROCK)

0 100 200 HORIZONTAL SCALE IN FEET

0 10 20 VERTICAL SCALE IN FEET

FOR SUPPORTING DESIGN CALCULATIONS SEE

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM LANG REGISTERED ENGINEER AGRICULTURE STATE OF TENNESSEE

AECOM

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R											
R 0	09/18/20	RLP	RLP	DES	GWL	N/A	N/A	TVA	XXXXXXX		

DISCIPLINE INTERFACE

SCALE: AS SHOWN EXCEPT AS NOTED

CROSS-SECTIONS I

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 09/18/20 | 39 | C | 10W272-07 | R 0

AECOM	0
TASK COMPLETED BY:	REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING DO NOT ALTER MANUALLY

39 C 10W272-07

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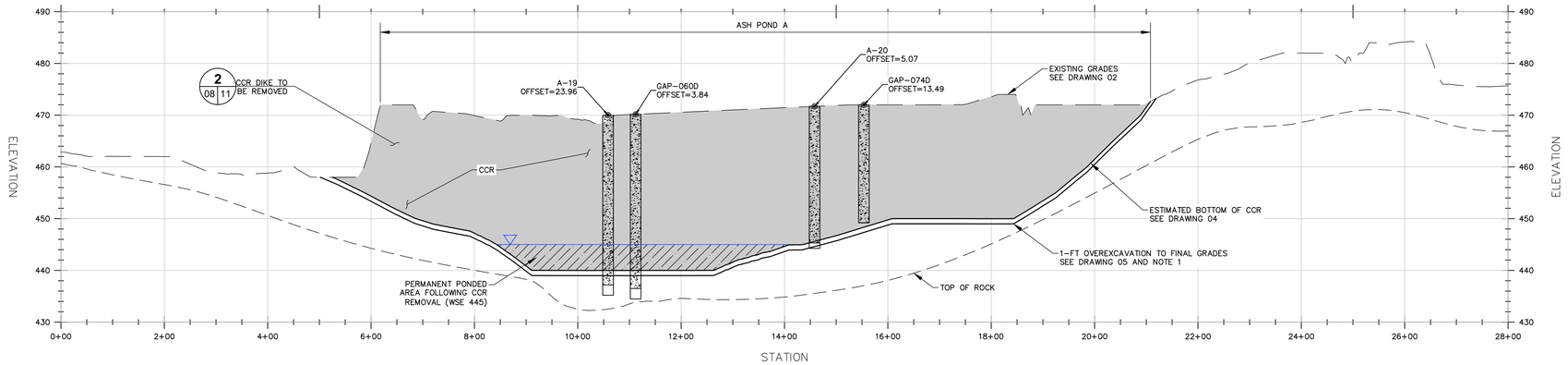
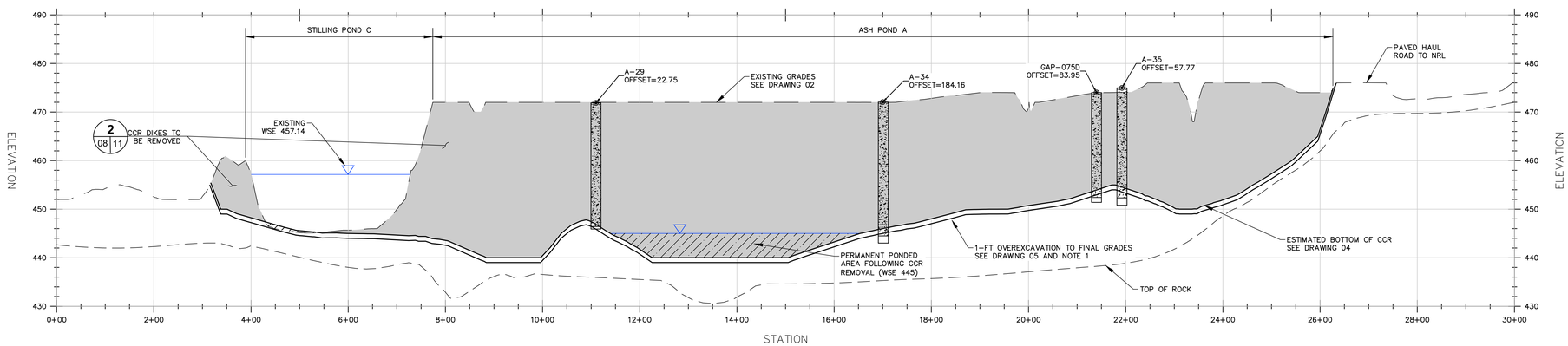


C 06 08 CROSS-SECTION C-C'



D 06 08 CROSS-SECTION D-D'

NOTES:

1. OVEREXCAVATION IS TO BE PERFORMED BASED ON THE RESULTS OF SOURCE REMOVAL VERIFICATION TESTING. REFER TO THE FACILITY SOURCE REMOVAL VERIFICATION CQA PLAN.

LEGEND

- EXISTING GRADES
- TOP OF ROCK
- PROPOSED GRADES
- PERMANENT PONDED AREA
- SOIL BORING (ASH, SOIL, ROCK)

0 100 200
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

FOR SUPPORTING DESIGN CALCULATIONS SEE

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM CRAIG REGISTERED ENGINEER AGRICULTURE 9/18/20 STATE OF TENNESSEE

AECOM

REV NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R											
R 0	09/18/20	RLP	RLP	DES	GWL	N/A	N/A	TVA	XXXXXXX		

DISCIPLINE INTERFACE

SCALE: AS SHOWN EXCEPT AS NOTED

CROSS-SECTIONS II

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 09/18/20 | 39 | C | 10W272-08 | R 0

AECOM	0
TASK COMPLETED BY:	REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING DO NOT ALTER MANUALLY

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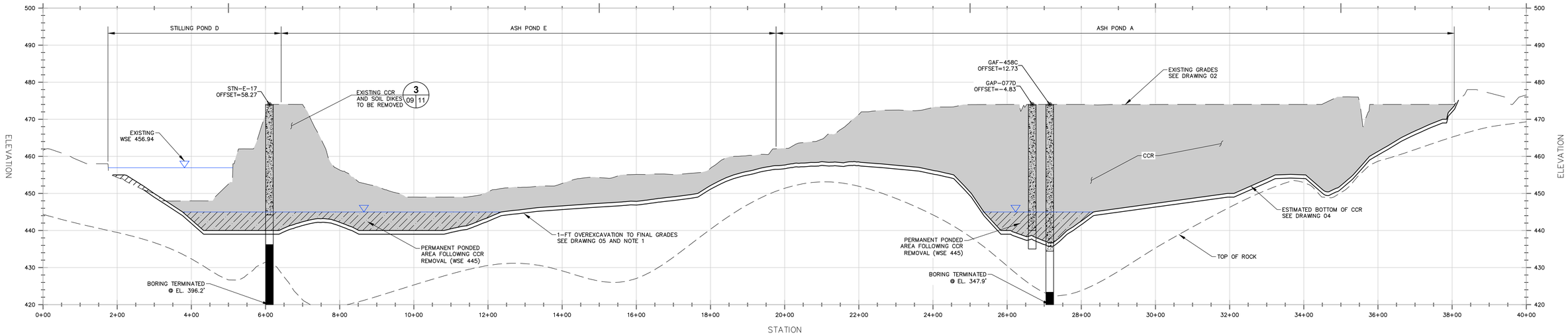
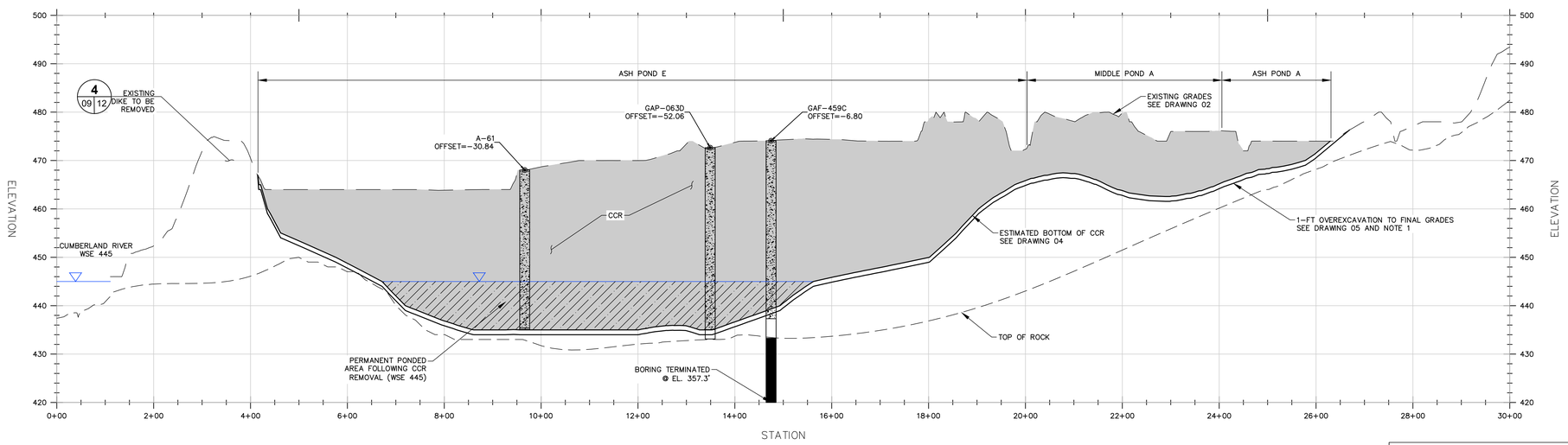


E 06 09 CROSS-SECTION E-E'



F 06 09 CROSS-SECTION F-F'

NOTES:

1. OVEREXCAVATION IS TO BE PERFORMED BASED ON THE RESULTS OF SOURCE REMOVAL VERIFICATION TESTING. REFER TO THE FACILITY SOURCE REMOVAL VERIFICATION CQA PLAN.

LEGEND

- EXISTING GRADES
- TOP OF ROCK
- PROPOSED GRADES
- PERMANENT PONDED AREA
- SOIL BORING (ASH, SOIL, ROCK)

0 100 200
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

FOR SUPPORTING DESIGN CALCULATIONS SEE

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST
R 0	09/18/20	RLP	RLP	DES	GWL	N/A	N/A	TVA	XXXXXXX	

DISCIPLINE INTERFACE: 1 2 3 4

SCALE: AS SHOWN EXCEPT AS NOTED

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM LANG REGISTERED ENGINEER AGRICULTURE 1 TENNESSEE STATE OF TENNESSEE

CROSS-SECTIONS III

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

AECOM

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 09/18/20 | 39 | C | 10W272-09 | R 0

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING DO NOT ALTER MANUALLY

AECOM	0
TASK COMPLETED BY:	REV NO.

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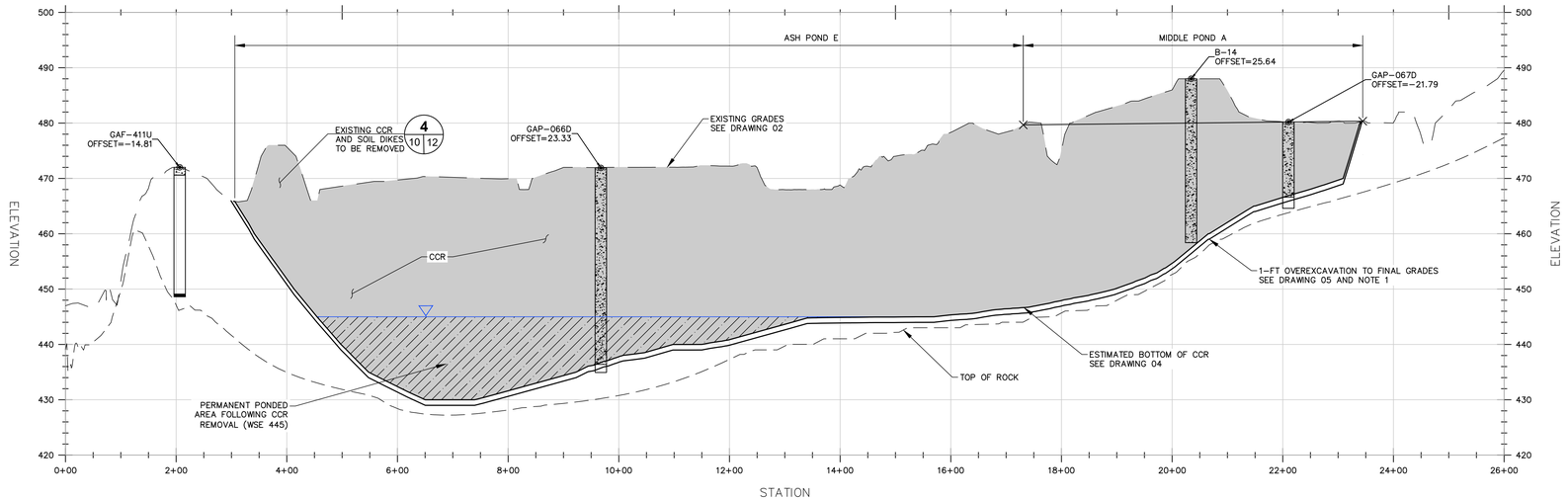
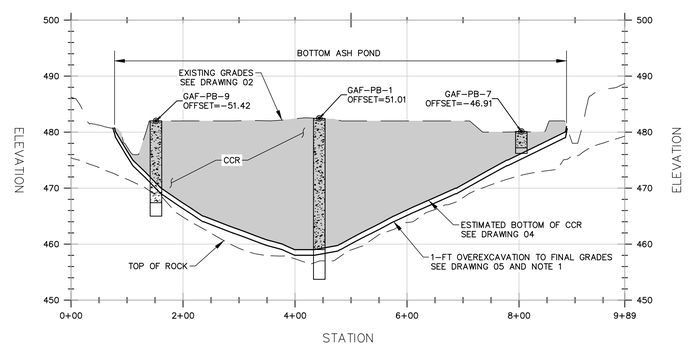


G 06 10 CROSS-SECTION G-G'



H 06 10 CROSS-SECTION H-H'

NOTES:

1. OVEREXCAVATION IS TO BE PERFORMED BASED ON THE RESULTS OF SOURCE REMOVAL VERIFICATION TESTING. REFER TO THE FACILITY SOURCE REMOVAL VERIFICATION CQA PLAN.

LEGEND

- EXISTING GRADES
- TOP OF ROCK
- PROPOSED GRADES
- PERMANENT PONDED AREA
- SOIL BORING (ASH, SOIL, ROCK)

0 100 200
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

FOR SUPPORTING DESIGN CALCULATIONS SEE

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R 0	09/18/20	RLP	RLP	DES	GWL	N/A	N/A	TVA	XXXXXXX		

DISCIPLINE INTERFACE

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM CRAIG
REGISTERED ENGINEER
AGRICULTURE
9/18/20
STATE OF TENNESSEE

SCALE: AS SHOWN EXCEPT AS NOTED

CROSS-SECTIONS IV

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

AECOM

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 09/18/20 | 39 | C | 10W272-10 | R 0

AECOM	0
TASK COMPLETED BY:	REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING DO NOT ALTER MANUALLY

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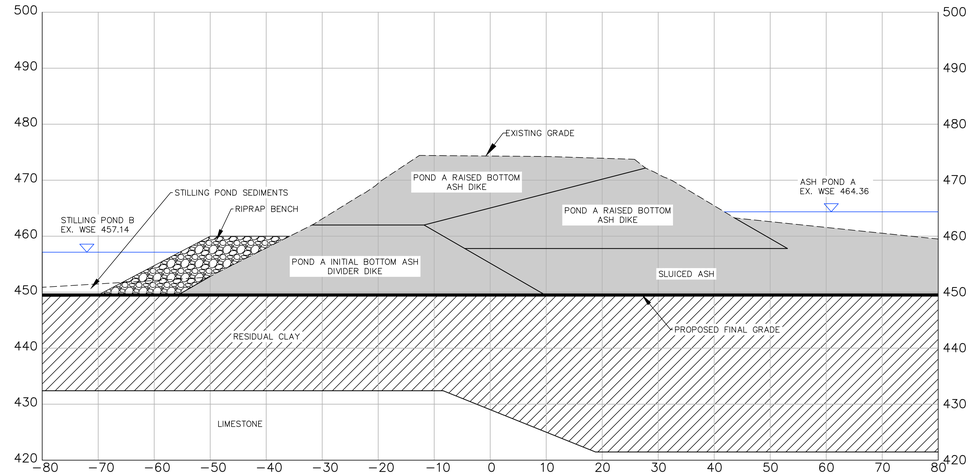
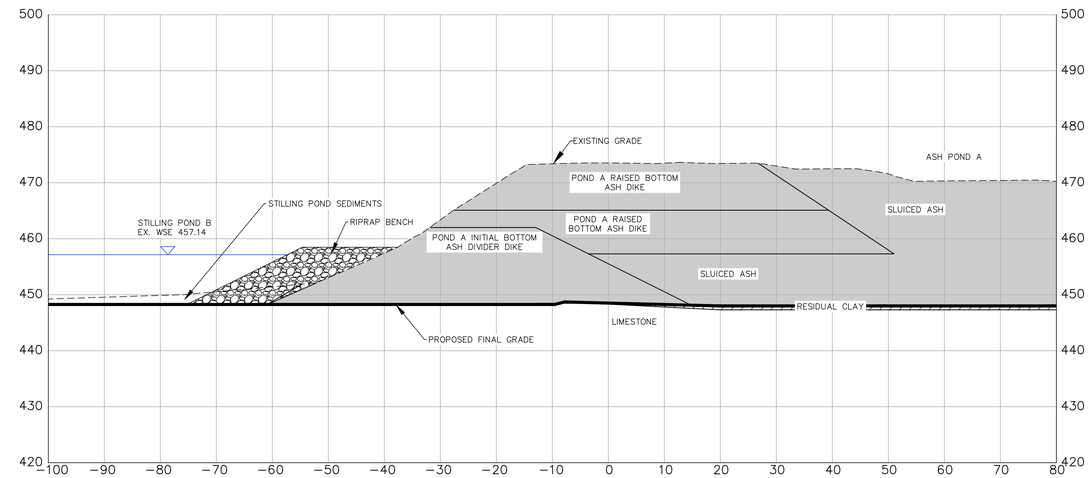
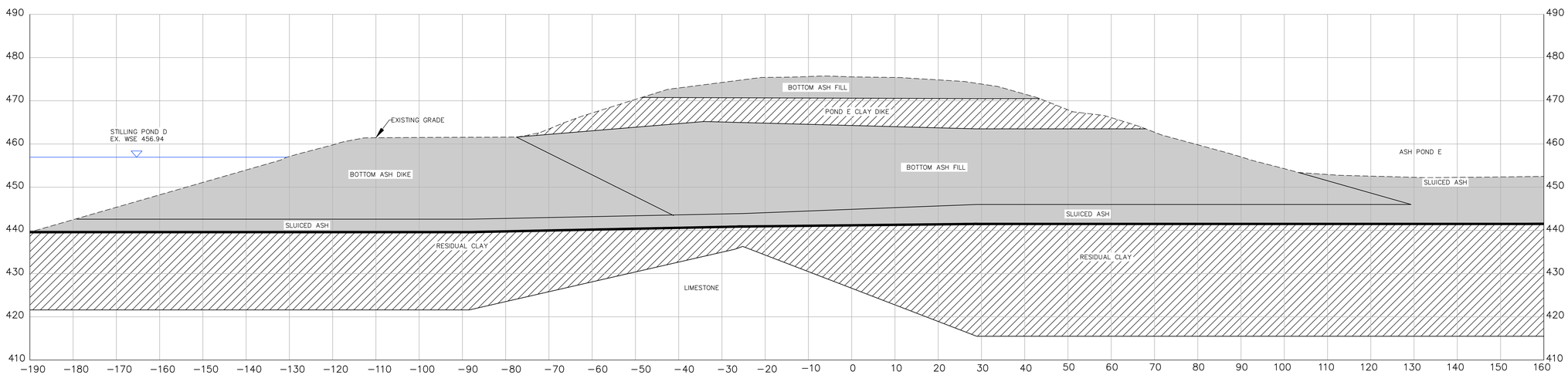


1 DIKE BETWEEN ASH POND A AND STILLING PONDS
02 11 07
SCALE: AS SHOWN



2 DIKE BETWEEN ASH POND A AND STILLING PONDS
02 11 07 08
SCALE: AS SHOWN



3 DIKE BETWEEN ASH POND E AND STILLING PONDS
02 11 09
SCALE: AS SHOWN

LEGEND

EXISTING GRADE

APPROXIMATE STRATA DIVIDERS

0 10 20
VERTICAL SCALE IN FEET

0 10 20
HORIZONTAL SCALE IN FEET

NOTES:

1. DIKE CROSS-SECTIONS SHOWN ARE ADOPTED AND MODIFIED FROM STABILITY CROSS-SECTIONS PROVIDED IN THE FOLLOWING GEOTECHNICAL REPORTS:

   STANTEC CONSULTING SERVICES INC., 2010. REPORT OF GEOTECHNICAL EXPLORATION AND SLOPE STABILITY EVALUATION, ASH POND/ STILLING POND COMPLEX, GALLATIN FOSSIL PLANT – GALLATIN, TENNESSEE. MAY 27, 2010.

   URS, 2014. ASH POND A AND E DIKES GEOTECHNICAL SITE EVALUATION REPORT (REV. 0). FEBRUARY 21, 2014.

FOR SUPPORTING DESIGN CALCULATIONS SEE

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM WANG
REGISTERED ENGINEER
AGRICULTURE
STATE OF TENNESSEE
9/18/20

AECOM

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST
R										
R 0	09/18/20	RLP	RLP	DES	GWL	N/A	N/A	TVA	XXXXXXX	

DISCIPLINE INTERFACE

SCALE: AS SHOWN EXCEPT AS NOTED

EXISTING DIKE SECTIONS I

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 09/18/20 | 39 | C | 10W272-11 | R 0

AECOM | 0
TASK COMPLETED BY: | REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

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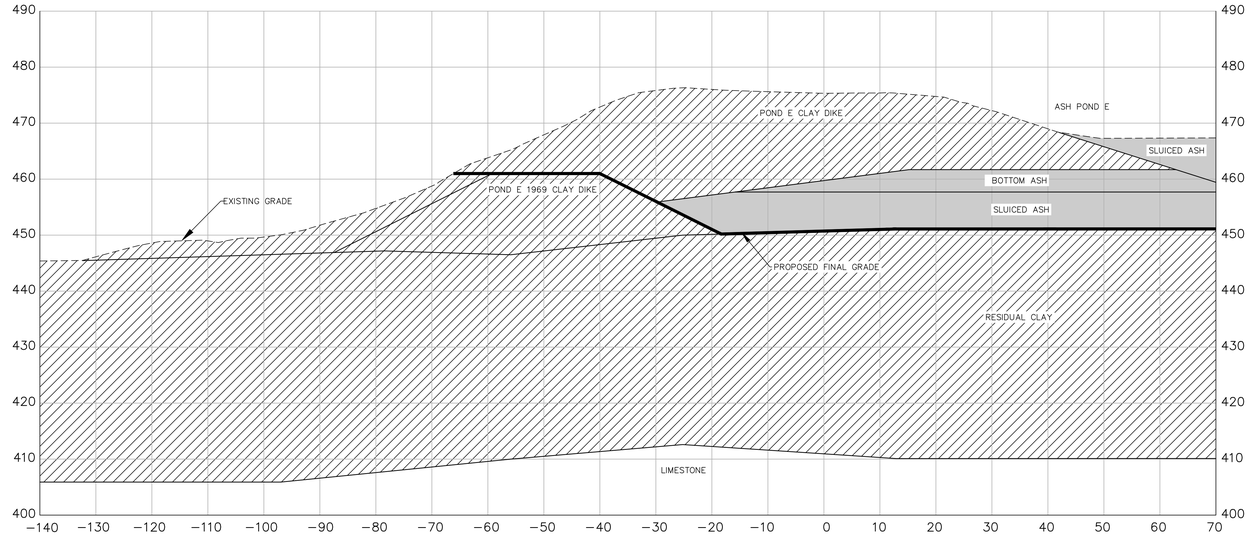
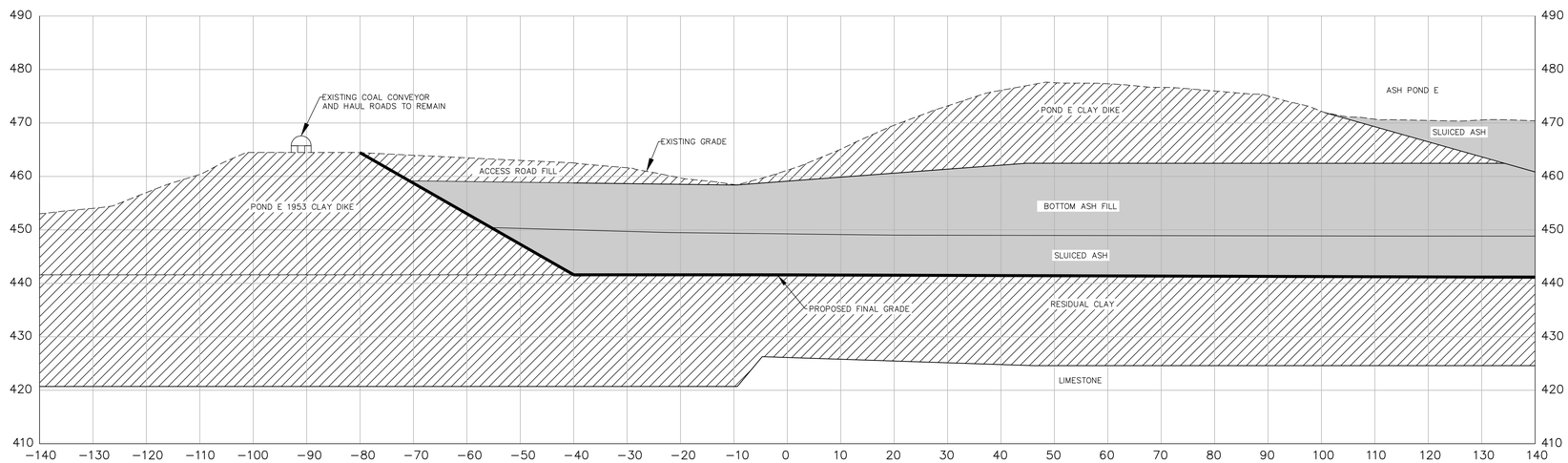


4 WESTERN DIKE BETWEEN POND E AND CUMBERLAND RIVER
02 12 09 10 SCALE: AS SHOWN



5 SOUTHERN DIKE BETWEEN POND E AND CUMBERLAND RIVER
02 12 SCALE: AS SHOWN

LEGEND

- GROUNDWATER TABLE
- EXISTING GRADE
- APPROXIMATE STRATA DIVIDERS

0 10 20 VERTICAL SCALE IN FEET

0 10 20 HORIZONTAL SCALE IN FEET

NOTES:

1. DIKE CROSS-SECTIONS SHOWN ARE ADOPTED AND MODIFIED FROM STABILITY CROSS-SECTIONS PROVIDED IN THE FOLLOWING GEOTECHNICAL REPORTS:

   STANTEC CONSULTING SERVICES INC., 2010. REPORT OF GEOTECHNICAL EXPLORATION AND SLOPE STABILITY EVALUATION, ASH POND/ STILLING POND COMPLEX, GALLATIN FOSSIL PLANT – GALLATIN, TENNESSEE. MAY 27, 2010.

   URS, 2014. ASH POND A AND E DIKES GEOTECHNICAL SITE EVALUATION REPORT (REV. 0). FEBRUARY 21, 2014.

FOR SUPPORTING DESIGN CALCULATIONS SEE

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM LANG REGISTERED ENGINEER AGRICULTURE STATE OF TENNESSEE

AECOM

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R											
R 0	09/18/20	RLP	RLP	DES	GWL	N/A	N/A	TVA	XXXXXXX		

SCALE: AS SHOWN EXCEPT AS NOTED

EXISTING DIKE SECTIONS II

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 DATE 09/18/20 39 C 10W272-12 R 0

AECOM	0
TASK COMPLETED BY:	REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

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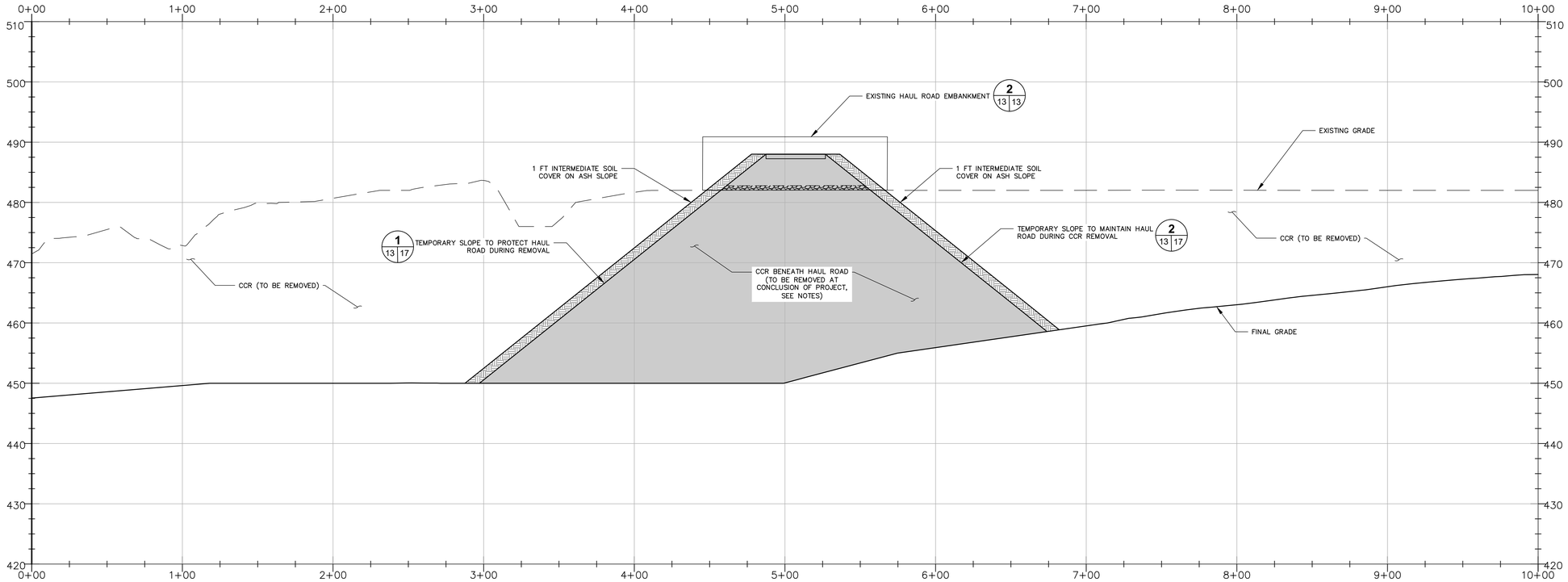
39 C 10W272-12

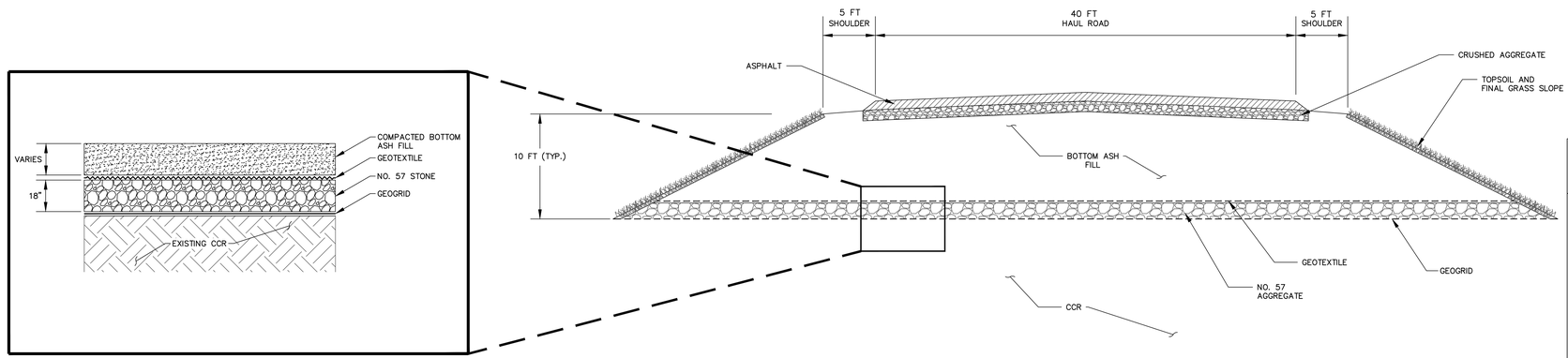


1 04 13 PAVED HAUL ROAD MAINTENANCE DURING REMOVAL

NOT TO SCALE

NOTES:

1. THE EXISTING PAVED HAUL ROAD PROVIDES ACCESS FOR THE TRANSPORTATION AND DISPOSAL OF CCR GENERATED BY THE GAF PLANT AND CCR REMOVED FROM THE ASH POND COMPLEX. THEREFORE, THE HAUL ROAD SHALL BE PROTECTED DURING CCR REMOVAL ACTIVITIES TO MAINTAIN USE OF THE HAUL ROAD.
2. TEMPORARY CCR SLOPES (AS SHOWN) OR OTHER MEASURES SHALL BE IMPLEMENTED TO PROTECT THE HAUL ROAD WHILE ALLOWING EXCAVATION OF ADJACENT CCR.
3. CCR REMAINING BENEATH THE HAUL ROAD WILL BE REMOVED AT THE CONCLUSION OF REMOVAL ACTIVITIES. THE EXISTING ROAD MAY BE RELOCATED OR REBUILT AS NEEDED FOLLOWING REMOVAL OF CCR.



2 13 13 EXISTING HAUL ROAD EMBANKMENT

NOT TO SCALE

FOR SUPPORTING DESIGN CALCULATIONS SEE

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM LANG REGISTERED ENGINEER AGRICULTURE 9/18/20 STATE OF TENNESSEE

AECOM

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV NO
R											
R 0	09/18/20	RLP	RLP	DES	GWL	N/A	N/A	TVA	XXXXXXX		

DISCIPLINE INTERFACE

SCALE: AS SHOWN EXCEPT AS NOTED

PAVED HAUL ROAD DETAILS

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 09/18/20 | 39 | C | 10W272-13 | R 0

AECOM | 0
TASK COMPLETED BY: | REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING DO NOT ALTER MANUALLY

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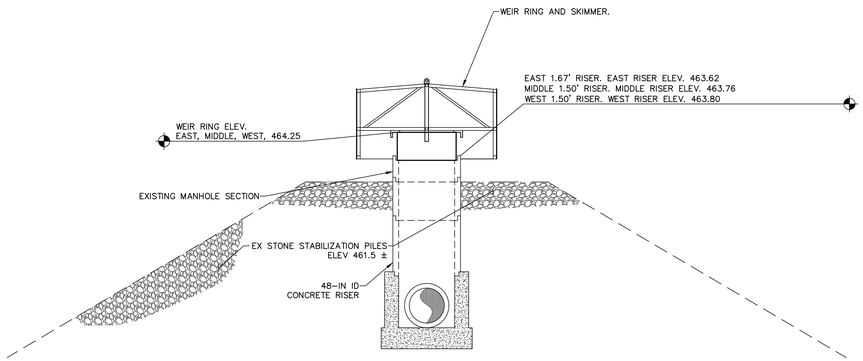
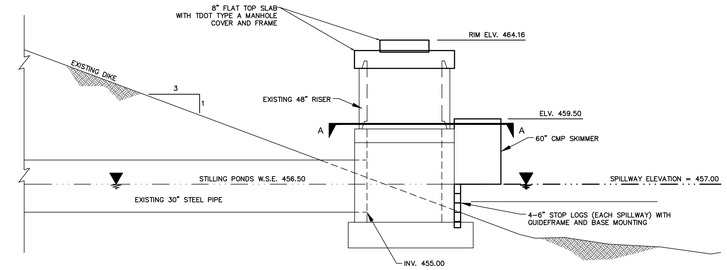
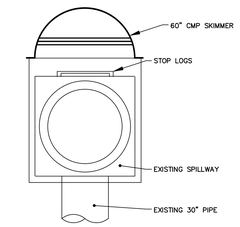


1 POND A SPILLWAY
02 | 14 N.T.S.

NOTES:

1. FOLLOWING INITIAL DRAWDOWN OF FREE WATER, THE SPILLWAYS IN THEIR CURRENT CONFIGURATION CAN DETAIN THE 24-HOUR/25-YEAR STORM EVENT WITHOUT DISCHARGE TO THE STILLING PONDS.
2. THE SPILLWAYS MAY BE MODIFIED FROM THEIR CURRENT CONFIGURATION TO PROMOTE FREE WATER REMOVAL OR DEWATERING. HOWEVER, THE CONTRACTOR SHALL AT ALL TIMES MAINTAIN CAPACITY FOR MANAGEMENT OF THE 25-YEAR/24-HOUR STORM EVENT WITHOUT DISCHARGE TO THE STILLING PONDS.
3. THE CONTRACTOR IS RESPONSIBLE FOR MAINTAINING AND SUPPORTING THE POND A SPILLWAYS AS NEEDED DURING CCR REMOVAL ACTIVITIES UNTIL THE DESIGN STORM EVENT IS OTHERWISE CONTAINED AND THE SPILLWAYS MAY BE DECOMMISSIONED OR REMOVED.
4. THE POND A SPILLWAYS WILL BE REMOVED AS PART OF CCR REMOVAL ACTIVITIES. DETAILED SEQUENCING PLANS TO BE DEVELOPED PRIOR TO CONSTRUCTION.



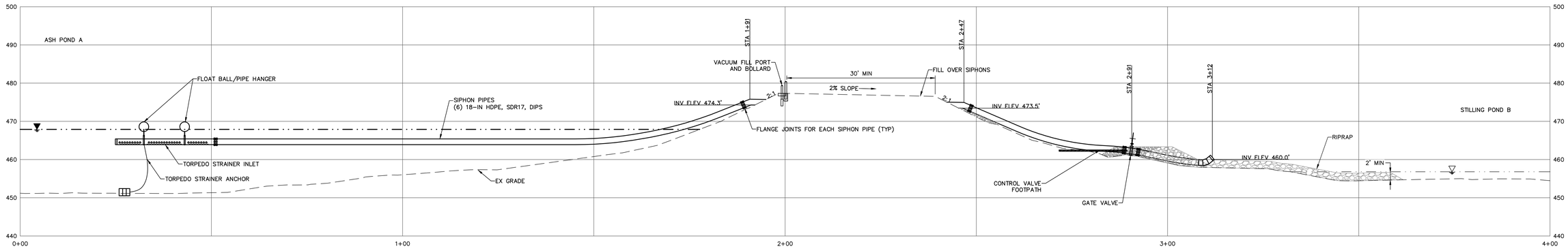


SECTION A-A

2 POND E SPILLWAY
02 | 14 N.T.S.

NOTES:

1. FOLLOWING INITIAL DRAWDOWN OF FREE WATER, THE SPILLWAYS IN THEIR CURRENT CONFIGURATION CAN DETAIN THE 24-HOUR/25-YEAR STORM EVENT WITHOUT DISCHARGE TO THE STILLING PONDS.
2. THE SPILLWAYS MAY BE MODIFIED FROM THEIR CURRENT CONFIGURATION TO PROMOTE FREE WATER REMOVAL OR DEWATERING. HOWEVER, THE CONTRACTOR SHALL AT ALL TIMES MAINTAIN CAPACITY FOR MANAGEMENT OF THE 25-YEAR/24-HOUR STORM EVENT WITHOUT DISCHARGE TO THE STILLING PONDS.
3. THE CONTRACTOR IS RESPONSIBLE FOR MAINTAINING AND SUPPORTING THE POND A SPILLWAYS AS NEEDED DURING CCR REMOVAL ACTIVITIES UNTIL THE DESIGN STORM EVENT IS OTHERWISE CONTAINED AND THE SPILLWAYS MAY BE DECOMMISSIONED OR REMOVED.
4. THE POND E SPILLWAYS WILL BE REMOVED AS PART OF CCR REMOVAL ACTIVITIES. DETAILED SEQUENCING PLANS TO BE DEVELOPED PRIOR TO CONSTRUCTION.



3 POND A SIPHON PROFILE
02 | 14 1"=10"

0 10 20
HORZ AND VERT SCALE

NOTES:

1. SIPHONS MAY BE USED TO LOWER THE WATER SURFACE ELEVATION DURING INITIAL FREE WATER DRAWDOWN. REFER TO THE PROJECT DEWATERING PLAN FOR SIPHON RATING CURVES AND DRAWDOWN LIMITS.
2. THE POND A SIPHONS WILL BE REMOVED AS PART OF CCR REMOVAL ACTIVITIES. DETAILED SEQUENCING PLANS TO BE DEVELOPED PRIOR TO CONSTRUCTION.

FOR SUPPORTING DESIGN CALCULATIONS SEE

FOR PERMITTING PURPOSES ONLY

GARY L. WILLIAM LING
REGISTERED ENGINEER
AGRICULTURE
9/18/20
STATE OF TENNESSEE

AECOM

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST
R 0	09/18/20	RLP	RLP	DES	GWL	N/A	N/A	TVA	XXXXXXX	

R

DISCIPLINE INTERFACE: 1 2 3 4

SCALE: AS SHOWN EXCEPT AS NOTED

SPILLWAY STRUCTURE DETAILS I

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 09/18/20 | 39 | C | 10W272-14 | R 0

AECOM	0
TASK COMPLETED BY:	REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING
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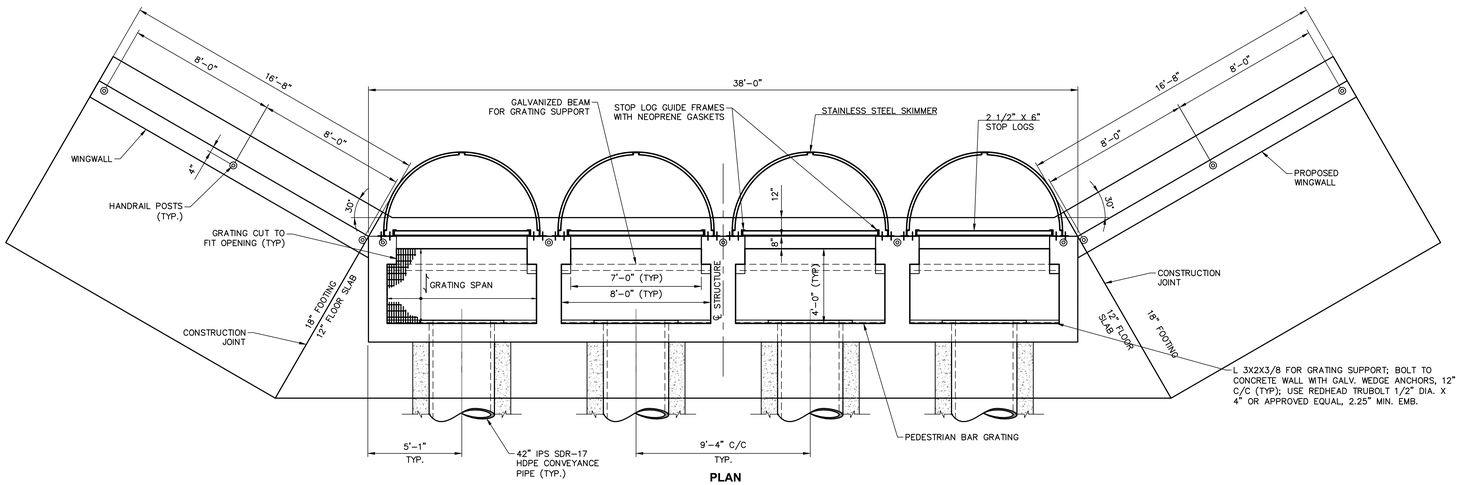
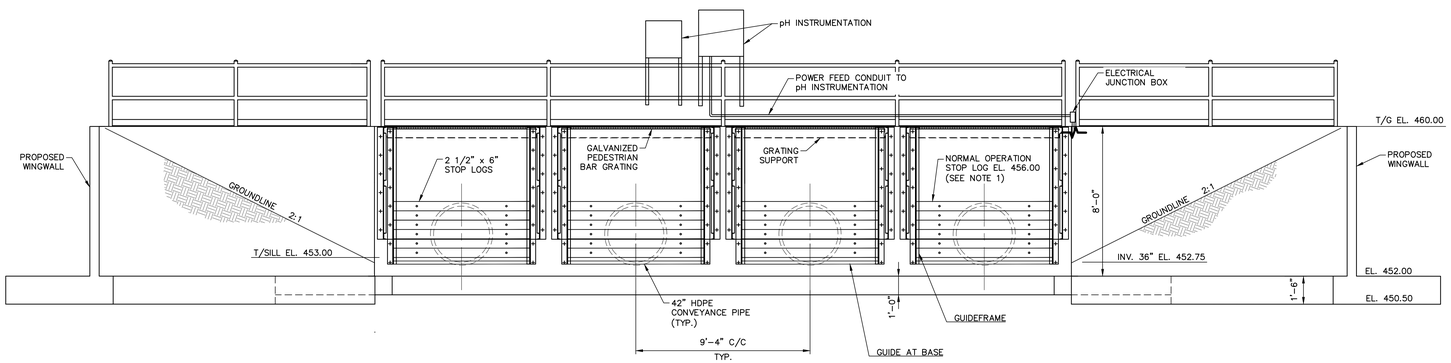


PLAN



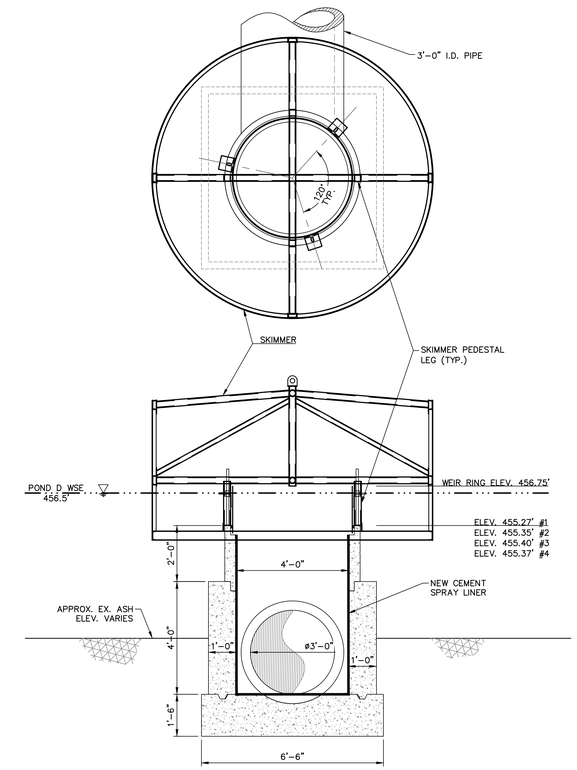
ELEVATION

4 STILLING POND D (OUTFALL 001) PRIMARY SPILLWAY STRUCTURE

02 15 N.T.S.

NOTES:

1. STOP LOGS MAY BE SEQUENTIALLY REMOVED TO LOWER STILLING POND NORMAL WATER LEVELS DURING FREE WATER REMOVAL. REFER TO PROJECT DEWATERING PLAN.
2. OUTFALL 001 TO BE DECOMMISSIONED FOLLOWING CCR REMOVAL ACTIVITIES.



5 STILLING POND D (OUTFALL 001) SECONDARY SPILLWAY

02 15 N.T.S.

NOTES:

1. SECONDARY SPILLWAY TO REMAIN IN PLACE TO PROVIDE HYDRAULIC CAPACITY FOR LARGE STORM EVENTS DURING REMOVAL AND CLOSURE.
2. OUTFALL 001 TO BE DECOMMISSIONED FOLLOWING CCR REMOVAL ACTIVITIES.

FOR SUPPORTING DESIGN CALCULATIONS SEE

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM LANG REGISTERED ENGINEER AGRICULTURE STATE OF TENNESSEE

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REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT IS	AS CONST
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DISCIPLINE INTERFACE: REV 1, REV 2, REV 3, REV 4

SCALE: AS SHOWN EXCEPT AS NOTED

SPILLWAY STRUCTURE DETAILS II

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

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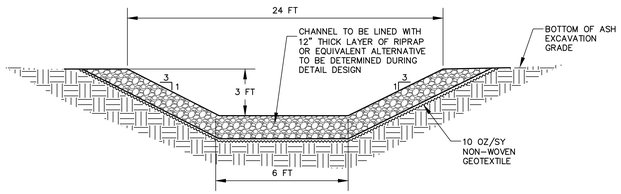
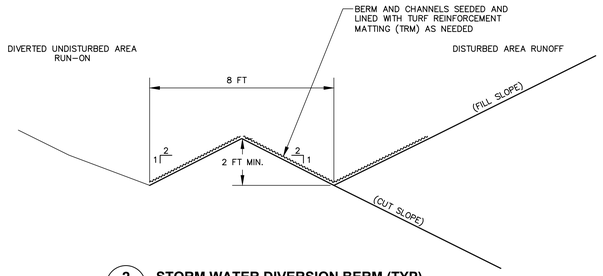
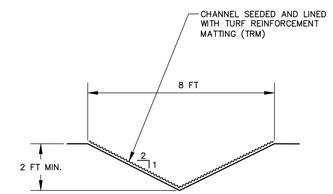


1 / 05 16 PERMANENT STORMWATER DRAINAGE CHANNEL
NOT TO SCALE



2 / 05 16 STORM WATER DIVERSION BERM (TYP)
NOT TO SCALE



3 / 05 16 TEMPORARY STORM WATER DIVERSION CHANNEL (TYP)
NOT TO SCALE

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GABRIEL WILLIAM LANG
REGISTERED ENGINEER
AQ09-0PE
STATE OF TENNESSEE

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DISCIPLINE INTERFACE

SCALE: AS SHOWN EXCEPT AS NOTED

STORM WATER MANAGEMENT DETAILS

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

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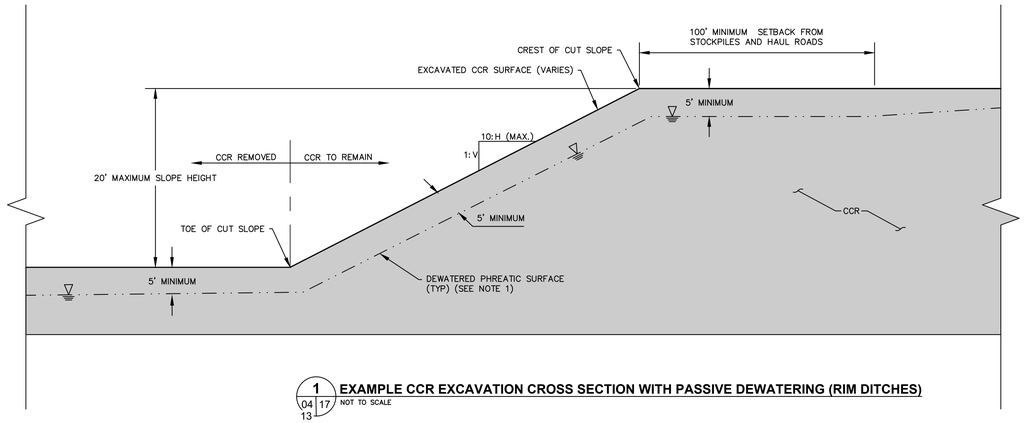
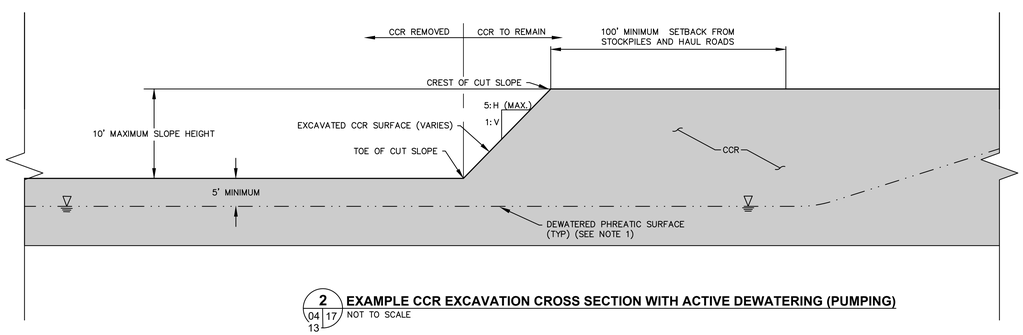


1 04 17 13 **EXAMPLE CCR EXCAVATION CROSS SECTION WITH PASSIVE DEWATERING (RIM DITCHES)**
NOT TO SCALE



2 04 17 13 **EXAMPLE CCR EXCAVATION CROSS SECTION WITH ACTIVE DEWATERING (PUMPING)**
NOT TO SCALE

NOTES:

1. THE TYPICAL CCR EXCAVATIONS SHOWN ARE ACCEPTABLE BASED ON STABILITY ANALYSIS PERFORMED DURING REMOVAL PLAN DEVELOPMENT. ALTERNATIVE TEMPORARY EXCAVATION SLOPES AND ASSOCIATED DEWATERING CONFIGURATIONS MAY BE PROPOSED BY THE CONTRACTOR AND APPROVED BY THE ENGINEER BASED ON ACTUAL SEQUENCING OF CCR REMOVAL.
2. CONTRACTOR TO DEWATER CCR AND ADJACENT AREAS AS REQUIRED TO ACHIEVE DRAWDOWN SHOWN PRIOR TO EXCAVATION OF CCR. DEWATERING MAY BE ACCOMPLISHED USING ANY COMBINATION OF DEEP WELLS, WELL POINTS AND SUMPS AND PUMPS. CONTRACTOR SHALL SUBMIT DEWATERING PLAN TO ENGINEER FOR REVIEW PRIOR TO COMMENCING EXCAVATION.
3. CONTRACTOR SHALL PROVIDE BACKUP PUMPS AND POWER SUPPLY AS REQUIRED TO MAINTAIN DEWATERING AND PHREATIC SURFACE CONTINUOUSLY.
4. CONTRACTOR SHALL INSTALL AND OPERATE ACCEPTABLE MONITORING SYSTEM TO ESTABLISH WATER LEVELS WITHIN CCR PRIOR TO CCR EXCAVATION.
5. CCR EXCAVATION CAN BE COMPLETED IN STAGES ONCE PHREATIC SURFACE IS DRAWN DOWN TO DEPTHS BELOW EXCAVATION GRADES SHOWN.
6. CONTRACTOR MAY PROPOSE TEMPORARY EXCAVATION SUPPORT TO ACHIEVE CCR EXCAVATION. CONTRACTOR TO PROVIDE EXCAVATION PLAN TO THE ENGINEER FOR REVIEW. SAID PLAN SHALL BE PREPARED, SIGNED AND SEALED BY A REGISTERED PROFESSIONAL ENGINEER IN THE STATE OF TENNESSEE.
7. CONTRACTOR SHALL DIVERT SURFACE WATER RUNOFF FROM ACTIVE CCR EXCAVATION SLOPES TO THE DEGREE PRACTICAL.

FOR SUPPORTING DESIGN CALCULATIONS SEE

FOR PERMITTING PURPOSES ONLY

GABRIEL WILLIAM LANG REGISTERED ENGINEER AGRICULTURE STATE OF TENNESSEE

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TEMPORARY CCR EXCAVATION SLOPE DETAILS

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
RLP	RLP	DES	GWL	N/A	N/A	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

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Attachment B – Dewatering Plan

Drawdown and Dewatering Plan
Ash Pond Complex

Tennessee Valley Authority
Gallatin Fossil Plant

Revision 1

February 8, 2021

Prepared for:

Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37402-2801

Prepared by:

AECOM Imagine it. Delivered.

1600 Perimeter Park Drive
Suite 400
Morrisville, NC 27560

Quality information

Prepared by	Checked by	Verified by	Approved by
Jeff Heyman, PE	Josh Colley, PE	Griff Wyatt, PE	Gabe Lang, PE

Revision History

Revision	Revision date	Description
0	09/18/2020	Initial issue
1	02/08/2021	Revised to address comments

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Attachments

Attachment A – Stage-Storage Relationship
Attachment B – Trigger/Action Matrix

Acronyms

APC	Ash Pond Complex
BMP	Best Management Practice
CCR	Coal Combustion Residual
CSW	Contaminated storm water
Dewatering Plan	Drawdown and Dewatering Plan
ft	feet
ft NGVD29	Feet National Geodetic Vertical Datum of 1929
GAF	Gallatin Fossil Plant
mg/L	Milligrams per liter
MGD	Million gallons per day
ng/L	Nanograms per liter
NGVD29	National Geodetic Vertical Datum of 1929
NPDES	National Pollutant Discharge Elimination System
SRL	South Rail Loop
SU	Standard Unit
TSS	Total suspended solids
TVA	Tennessee Valley Authority
WTS	Water Treatment System

Definition of Terms

Free water: Defined as the ponded water remaining within the APC at the time of commencement of free water removal activities (start of Stage 1 Dewatering). It is assumed, for the purpose of this Dewatering Plan, that the free water volume would be the water volume stored at a normal operating water level.

Pore water: Defined as the water in the interstitial spaces within the CCR that is able to yield to drains, wells, or wellpoints. The pore water dewatering will be achieved using gravity drains or well systems.

Contaminated storm water (CSW): Stormwater that flows across or contacts the CCR yet is not otherwise defined as leachate.

Non-contaminated storm water: Defined as storm water flows that do not flow across or come in contact with CCR.

1 Introduction

On July 24, 2019, the Davidson County Chancery Court entered a Consent Order (Order) in Case No. 15-23-IV reflecting an agreement between the Tennessee Valley Authority (TVA), the State of Tennessee, the Tennessee Department of Environment and Conservation (TDEC), and certain Plaintiff-Interveners to close the Ash Pond Complex (APC) located at the Gallatin Fossil Plant (GAF) located near Gallatin, Sumner County, Tennessee. For purposes of the Order, the APC consists of the Bottom Ash Pond, Middle Pond A, Ash Pond A, Ash Pond E, and Stilling Ponds, B, C, and D as shown in the site plan provided in **Figure 1**.

To enable excavation of the APC, free water will be removed from the APC. Following free water removal and during excavation, the coal combustion residuals (CCR) within the APC will be dewatered to improve surface conditions within the APC to facilitate equipment access and subsequent excavation.

This Drawdown and Dewatering Plan (Dewatering Plan) has been developed as part of the overall GAF APC Removal Plan. Following approval of the Removal Plan, TVA will complete detailed engineering design of the project. The objective of this Dewatering Plan is to provide guidance for meeting the GAF National Pollutant Discharge Elimination System (NPDES) permit obligations during the free water removal and CCR dewatering activities. This Dewatering Plan may be amended as needed based on detailed engineering design, sequencing of removal activities, and contractor means and methods.

2 Background

The locations of the ponds are shown in **Figure 1**. A summary of the surface areas and volume of free water contained at normal pool elevations for the APC is provided in **Table 1** below. The APC has a total surface area of approximately 435 acres and contains approximately 155.1 million gallons of free water under current conditions.

Currently at GAF, the water collected within the APC from precipitation is routed from Ash Ponds E and A to the Stilling Ponds (Stilling Ponds B, C, and D). Precipitation that collects in the northern portion of Ash Pond E is removed by pumping to the Pond E spillway structure which discharges to Stilling Pond C. Precipitation from Middle Pond A and the Bottom Ash Pond flows through a channel to Ash Pond A. An open pool of free water exists in Ash Pond A and is controlled by a spillway structure and siphon system that discharge to Stilling Pond B. A limited volume of standing water may be present seasonally within Middle Pond A and the Bottom Ash Pond. Relevant spillway detail drawings are provided for reference in Attachment A of the APC Removal Plan (Drawings 14 and 15).

Stilling Ponds B, C, and D contain open pools of water and are connected by open channels such that water collected in the Stilling Ponds flows from Pond B to C to D. Following the removal of process wastewater inflows to Ash Ponds A and E, Middle Pond A, and the Bottom Ash Pond in 2019, the water elevations of the APC vary seasonally with rainfall, with Stilling Ponds C and D becoming dry during portions of the year. Outfall 001 is located at the western end of Stilling Pond D and discharges water from the APC to the Cumberland River through spillway structures. Outfall 010 is located south of Ash Pond E and discharges treated water from the Flow Management (FM) system to the Cumberland River. A pond by pond summary of estimated free water volumes is presented below in **Table 1**.

Table 1. Summary of Ash Pond Complex Areas and Free Water Volumes

Pond	Area (acres)	Normal Pool Elevation (ft NGVD29)[1,2]	Volume of Free Water (millions of gallons)[3]
Ash Pond A	189	463.62	55.3
Ash Pond E	146	459.42[4]	N/A (dry)[4]
Middle Pond A	32	N/A (dry)	N/A (dry)[5]
Bottom Ash Pond	16	N/A (dry)	N/A (dry)[5]
Stilling Ponds B and C	27 (Pond B) 16 (Pond C)	457.1	84.6
Stilling Pond D	9	456.9	15.2
TOTALS:	**435**	**--**	**155.1**

Notes:

[1] NGVD29 = National Geodetic Vertical Datum of 1929.
[2] Water elevation at time of drawdown is assumed to be the normal operating level or spillway (siphon) elevation. It is noted that the actual water elevation varies, and the water level may be lower, or the pond may even be nearly dry at time of free water drawdown.
[3] Approximate volume based on normal pool elevation and stage-storage relationships presented in **Attachment A**.
[4] Pond E Normal Pool Elevation shown reflects the existing gravity spillway elevation. However, Pond E free water is removed via pumping such that the pond is normally dry. Pond E has the potential for 56.3 million gallons of free water storage below the spillway elevation.
[5] A limited volume of standing water may be present seasonally within Middle Pond A and the Bottom Ash Pond.

2.1 Effluent Criteria

Operational parameters presented in subsequent sections of this document have been developed in order to mitigate the potential for exceedance of the effluent criteria established in NPDES permit TN0005428 (NPDES permit), with effective date of June 1, 2018, and/or causing an exceedance of applicable in-stream Water Quality Standards. The NPDES permit consists of two tiers of effluent limitations and monitoring requirements for Outfall 001:

- Tier 1 – Effluent limitations and monitoring requirements during current operations and ash pond complex dewatering; and
- Tier 2 – Effluent limitations and monitoring requirements subsequent to ash pond dewatering and conversion to wastewater treatment (switch to Outfall 010).

The NPDES permit discharge effluent limitations and monitoring requirements for Tier 1 and Tier 2 at Outfall 001 are provided in **Table 2** and **Table 3**, respectively. The NPDES permit discharge effluent limitations and monitoring requirements for Outfall 010 are provided in **Table 4**. It is expected that Tier 1 limits for Outfall 001 (**Table 2**) and limits for Outfall 010 (**Table 4**) will apply during APC closure. As indicated on **Table 2** through **Table 4**, compliance monitoring frequencies will remain the same as required by the NPDES Permit during closure. Monthly NPDES compliance monitoring results will be included in the Monitoring Plan required per Section 2.i. of the Order.

3 Free Water Removal and Ash Dewatering Sequence

The free water removal and ash dewatering sequence will be completed in the following stages:

- Stage 0: Setup
- Stage 1: Initial Free Water Removal
- Stage 2: Final Free Water Drawdown

- Stage 3: Pore Water Dewatering

The first stage in the sequence, Stage 0, consists of setting up for free water removal and includes installation of Best Management Practice (BMP) systems. Stage 0 may also potentially include setup of monitoring systems (i.e. Turbidity, pH).

Table 5 provides the summary of work for each stage in the sequence. The sequence of dewatering is also illustrated in **Figure 2** through **Figure 5**. The following subsections provide narrative of the three stages that follow setup, which consist of free water removal (Stages 1 and 2) and pore water dewatering (Stage 3). During all of these stages the collection of storm water will still require handling. Subsections 3.3 and 3.4 provide narrative of the plan for handling of contaminated and non-contaminated storm water during closure of the APC.

3.1 Free Water Removal Plan

The ponded areas of free water within the APC are planned for removal and conveyance to the Cumberland River through Outfall 001. The free water removal activities are planned to occur before CCR pore water dewatering activities commence to support the removal of CCR within the APC. The proposed removal (drawdown) of free water remaining in the APC will occur in two stages:

- Stage 1: Initial Free Water Removal, and
- Stage 2: Final Free Water Removal.

Stage 1 consists of removal of the ponded free water using the current routing of wastewater and storm water from the Ash Ponds through the stilling ponds to Outfall 001. Stage 2 consists of removal of the free water through a Water Treatment System (WTS), using pumping systems, to Outfall 001. Stage 2 for Ash Ponds A and E will commence when CCR removal is ready to begin and after Stage 1 free water levels are within 5 feet (ft) of the bottom of each pond. Stage 2 for the Stilling Ponds will start when CCR removal activities within the Stilling Ponds are ready to commence. The setup and routing for Stage 1 and Stage 2 of the free water removal are shown in **Figure 2** and **Figure 3**, respectively. **Table 5** describes planned activities for both stages of the free water removal. A limited quantity of free water may be present at Middle Pond A and the Bottom Ash Pond based on seasonal rainfall; it is anticipated that this water will be managed during Stage 3, if needed.

The current configuration of the APC including the location of the areas of free water ponds is shown on **Figure 1**. Currently, free water that collects, including storm water, in the northern portion of Ash Pond E is being conveyed to the Stilling Ponds by pumping into the Pond E outlet structure spillway. Similarly, free water collects in the northern portion of Pond A adjacent to the spillway and siphon and this ponded water conveys to the stilling ponds through the existing gravity spillway and siphon. The water from Ponds A and E flow through the stilling ponds and ultimately into the Cumberland River through the Pond D (Stilling Pond D) spillway structure. The proposed routing of ponded water from the Ash Ponds during Stage 1 will remain the same as the current operation of the APC. The free water within Ash Pond E will continue to be pumped to the Stilling Ponds during Stage 1 of the free water drawdown. The free water from the Ash Pond A will be discharged into Stilling Pond B and flow through Stilling Ponds C and D to be discharged to the Cumberland River through Outfall 001.

During Stage 1, the free water will be removed from the Ash Ponds and Stilling Ponds using existing spillway and siphons at Pond A and a controlled (planned) removal of stop logs at Stilling Pond D to lower limit of Pond D spillway (elevation 454.1 ft NGVD29). It is anticipated that a pump system will be installed at Pond A after the free water level reaches the effective lower limit of the siphon system (approximately elevation 462.0 ft NGVD29). The pump at Pond A will continue to discharge free water to Stilling Pond B until the water level is within 5 ft of the bottom of the pond (elevation 455 ft NGVD29). Free water removal may also include the modification of spillway structures and siphons to lower the elevations of the water intake for these structures/systems within Pond A and Stilling Pond D. Any modifications to spillway structures should not impact the ability of the structures to handle the design storm event as discussed in Section 3.3. The relevant design drawings are provided for reference in Attachment A of the APC Removal Plan (Drawings 14 and 15).

The transition to Stage 2 of the drawdown and dewatering sequence will occur when water levels are within 5 ft of the bottom of Pond A and Pond E. Stage 2 for the Stilling Ponds will start when CCR removal activities within the Stilling Ponds are ready to commence.The transition from Stage 1 to Stage 2 may also occur sooner if water quality monitoring at Outfall 001 indicates a trend toward exceedance of permitted effluent limits in Table 2 or metals threshold trigger levels are exceeded, as introduced in Section 3.5 of this plan. A transition to Stage 2, before water levels reach within 5 feet of the bottom of the ponds, may also be made based on contractor means and methods. Free water will be lowered within the ponds at a maximum water level drawdown rate of 1-foot per day.

Stage 2 consists of the installation of a pumping system to remove the remaining free water as shown in **Figure 3**. The switch to a pumping system in Stage 2 will provide the ability for treatment of water using a WTS. The WTS will be used to treat the free water pumped from the APC to Outfall 001 to meet the Tier 1 effluent limits for the outfall under the existing NPDES permit. **Figure 3** shows the preliminary plan for pump locations, discharge pipe routing, and the location of the WTS. Following Stage 2, the WTS may either remain in-place, or the system may be moved adjacent to Outfall 010 to support subsequent pore water and contaminated storm water removal and treatment during CCR excavation.

During free water removal, the effluent limits and monitoring requirements for this discharge will be the same as those currently required under the existing NPDES permit Tier 1 effluent limitations and monitoring requirements for Outfall 001 provided in **Table 2**. The details of this free water drawdown plan and sequence of activities may be subject to change based on information gathered in the field and contractor means and methods.

3.2 Pore Water Removal Plan

Stage 3 involves the removal of pore water from CCR. Dependent on Contractor means and methods (i.e. equipment type and size), removal of pore water may need to begin prior to CCR removal to facilitate a stable working platform for construction equipment. Pore water removal may be accomplished through use of open dewatering (i.e., drainage ditches), well systems, and/or horizontal drains. Discharge of pore water during CCR removal will be conveyed through the WTS to either Outfall 001 (Stage 3A) or Outfall 010 (Stage 3B) depending on contractor sequencing and their means and methods. **Figure 4** and **Figure 5** show the routing of the dewatering discharge to either Outfall 001 or Outfall 010, respectively. **Table 5** describes planned activities for Stage 3A and 3B ash dewatering to either Outfall 001 or Outfall 010, respectively. The free water pumping system installed during Stage 2 will remain during Stage 3. The water collected from the dewatering ditches and/or wells will be conveyed and collected within the areas of the two suction pump locations in Pond A and Pond E. In Stage 3A, the discharge would be routed through the WTS and discharged to Outfall 001. In Stage 3B, the discharge would be routed through the WTS discharged to Outfall 010. The outfall for discharge of treated flows (and thus the use of Stage 3A or 3B) will be selected through the means and methods of the closure construction contractor.

The dewatering flows collected within the Bottom Ash Pond will either be conveyed to Middle Pond A or Pond E using a constructed gravity piping through the haul road or a pumping system. No dewatering of pore water is anticipated within the Stilling Ponds due to expected *de minimus* quantities of CCR within these ponds.

It is anticipated that this plan will change as excavation and dewatering of the APC progresses over the life of the removal project. The effluent limits and monitoring requirements for discharge during Stage 3A will be consistent with those currently identified as Tier 1 within the current NPDES permit for Outfall 001 listed in **Table 2**. The effluent limits and monitoring requirements for discharge during Stage 3B will be consistent with those currently required under the NPDES permit for Outfall 010 listed in **Table 4.**

3.3 Contaminated Storm Water

As part of Stage 3, collected contaminated storm water within the Bottom Ash Pond, Middle Pond A, Ash Pond A, and Ash Pond E will be collected within the ash pond impoundments and pumped to the WTS along with pore water for treatment prior to discharge to either Outfall 001 or 010, as described in Section 3.2. Discharge of contaminated storm water to the Stilling Ponds will be prevented by maintaining areas within the Ash Ponds to collect and manage collected contaminated storm water before pumping it for treatment. The areas where contaminated storm water is to be collected will be designed and maintained to manage runoff resulting from the 25-year, 24-hour storm event. The APC

has adequate storage volume to contain the 25-year, 24-hour storm without discharging to the Stilling Ponds. As CCR is removed from the impoundments, available storage capacity will increase and will be maintained to continue to manage the 25-year, 24-hour storm event throughout the removal process. A Temporary Construction Emergency Action Plan (TCEAP) will be developed prior to starting construction and provided to TDEC for review when available. The TCEAP will outline planned responses to various scenarios, including a contingency plan for management of storm events greater than the 25-year/24-hour storm.

Planning for potential reduction in the generation of contaminated storm water will be part of the final design for closure. The reduction of the generation of contaminated storm water may consist of using temporary liners, diversion berms and sump-pumps for capture and diversion of non-contaminated storm water as closure excavation progresses.

During the period of the project when the Stilling Ponds are cleaned to remove CCR, water within the Stilling Ponds will be managed as contaminated storm water and will be sent to the WTS for treatment. Otherwise, during removal activities, the Stilling Ponds will be maintained for management of non-contaminated storm water as described in the following section.

3.4 Non-Contaminated Storm Water

The Stilling Ponds will continue to manage non-contaminated storm water run-on from large offsite areas north of GAF during removal activities. Non-contaminated storm water collected in the Stilling Ponds during the project will be managed within the Stilling Ponds and discharged through NPDES Outfall 001.

In order to minimize generation of contaminated storm water and associated wastewater treatment, non-contaminated storm water will be diverted to the Stilling Ponds or areas within the APC from which CCR has been removed. Diversion berms and channels, pumping systems, or other means of diverting non-contaminated storm water may be developed as part of detailed engineering design to divert non-contaminated storm water. The means and methods of diverting the non-contaminated storm water will be developed as part of the detailed engineering design.

As noted in Section 3.3, during the period of the project when the Stilling Ponds are cleaned to remove CCR, water within the Stilling Ponds will be managed as contaminated storm water and will be sent to the WTS for treatment. In accordance with the Order, following removal of CCR from Stilling Ponds B, C, and D, TVA will submit a plan for continued use of Stilling Ponds B, C, and D for storm water management to TDEC for consideration and approval.

3.5 Water Quality Effluent Operational Thresholds

During closure, a WTS will be utilized to treat removed free water, pore water, and contaminated storm water. As previously noted, the discharge from the WTS may be routed to either Outfall 001 or Outfall 010 depending on the stage of dewatering and/or the means and methods of the closure construction contractor.

To evaluate the operation of the WTS system and to maintain water quality of the discharge from the WTS, TVA is proposing a Dewatering Operational Assessment Point to be located at the discharge of the WTS. The Dewatering Operational Assessment Point will be established during Stage 1 and monitoring will start when the WTS is operational in Stage 2. Monitoring of total suspended solids (TSS), pH, and temperature within the free water ponds at Pond A and E during Stage 1 will occur on weekly basis to evaluate water quality of flows conveying to the stilling ponds. Beginning at Stage 2, the Dewatering Operational Assessment Point will be located upstream of either Outfall 001 or Outfall 010, prior to mixing of the WTS discharges with other outfall flows. Monitoring of TSS, pH, and temperature at the Dewatering Operational Assessment Point will occur on a weekly basis. **Table 6** provides the parameters and proposed water quality effluent operational thresholds that will be monitored at the Dewatering Operational Assessment Point. These operational thresholds will be measured on a weekly basis.

Tables 7 and **8** provide the parameters and proposed water quality effluent operational thresholds that will be monitored at Outfalls 001 and 010, respectively. To evaluate the water quality of the Outfall receiving WTS discharges, water quality effluent operational thresholds have also been developed for Outfall 001 and 010. Should the operational thresholds in **Table 6** be exceeded for the Dewatering Operation Assessment Point, TVA will also monitor the receiving outfall and compare to either **Table 7** or **Table 8**.

Table 6 through **Table 8** include maximum operational threshold concentrations for parameters which have water quality standards. These thresholds were calculated by reasonable potential analysis method. The analysis was used to validate that the permitted effluent, following discharge to Cumberland River, is non-toxic to fish and aquatic life would not cause an exceedance of Water Quality Criteria for Fish and Aquatic Life (considering a 1Q10 [1 day, 10 year] river flow rate of 552 million gallons per day [MGD]), and would not exceed human health-related drinking water standards. These water-quality monitoring thresholds have been established for wastewater effluent flow rates of 3.7 MGD at the WTS assessment point, 4.8 MGD at Outfall 001 and 29.66 MGD at Outfall 010 when combined with effluent from the FM. If the actual discharge flow rates differ from these values, then limits would be either increased (for a lower flow rate) or decreased (for a higher flow rate), so the net loading (in pounds per day [lbs/day]) would remain stable. Parameters without water quality standards were not assigned operational thresholds.

3.6 Water Treatment System

The use of a WTS is included in the planned routing of free water flows during Stage 2 (pumping). During Stage 3, all of the dewatering and contaminated storm water flows will be routed through the WTS. **Figure 6** shows the basic flow diagram for routing through a WTS, to be used during free water removal and the CCR pore water dewatering. The WTS is a mobile, physical-chemical treatment plant consisting of either one to multiple treatment trains, depending on the flow (pumping) rates expected during removal. Each train may consist of: (a) equalization, (b) chemical treatment for pH neutralization, and (c) filtration. It is anticipated that the WTS would consist of basic media filtration methods (i.e., sand filter) and pH control. The WTS may also include an optional advanced filtration module, which may not be required but is included in the schematic for the contingency of providing more aggressive treatment for metals. The type and use of a WTS may be subject to change based on information gathered in the field and contractor means and methods. TVA and the Contractor may select to use the existing FM treatment system if capacity allows for use. Filter media from the WTS or FM system may be placed within the South Rail Loop (SRL) Landfill in accordance with the SRL Landfill Part II Permit Application. The design of the WTS will be provided to TDEC following the selection of a contractor and their development of the detailed design.

As described in Section 3.5., a Dewatering Operational Assessment Point will be established for monitoring the treated discharge of the WTS. The Dewatering Operational Assessment Point (operational sampling point) will be established between Stage 1 and Stage 2. The operational sampling point will be located downstream of the WTS to sample the effluent from the WTS.

3.7 Drawdown and Dewatering Sequence

The sequential stages to remove the free water in the APC and dewater the CCR are summarized in **Table 5**. The stages are illustrated on **Figure 2** through **Figure 5**. However, the proposed sequential steps may be subject to change based on conditions encountered in the field.

4 Water Quality and Flow Rate Monitoring

TVA currently monitors water quality of the APC effluent at Outfall 001 and of the FM system effluent at Outfall 010. The monitoring will continue to occur at the Outfalls during all Stages of the free water drawdown and ash dewatering at the currently-permitted frequencies as indicated on **Table 2** and **Table 4**.

The sampling and monitoring for metals will occur on a monthly basis at Outfall 001 and Outfall 010 as required by the NPDES permit. As noted above, sampling and monitoring at the Dewatering Operational Assessment Point established downstream of the WTS will occur weekly. The Dewatering Operational Assessment Point will allow for operational monitoring of water quality at a higher frequency to assure of the adequate operation of the WTS. If operational thresholds are exceeded at the Dewatering Operational Assessment Point, that will trigger a comparison of the receiving outfall against calculated operational thresholds for Outfall 001 (**Table 7**) or Outfall 010 (**Table 8**).

It is expected that there will be operational water quality monitoring during the free water removal and dewatering for the purpose of operation of the WTS. The WTS will include in-line monitoring to monitor influent water quality and

effluent water quality. The output from each monitoring device (flow meters, turbidity meter, pH meter) will be routed to a data logger. Field monitoring devices (turbidity and pH monitoring devices) may be installed, as required for operation of WTS, in the APC. These field monitoring devices would monitor changes in TSS (using turbidity meters) and pH during each phase of the free water removal and dewatering for the purposes of the operation of the WTS. Field sampling data, which may include pH, turbidity, and other site-specific parameters (i.e. precipitation) will be maintained in the office trailer in the daily log and in a spreadsheet.

5 Contingency Plan

Water quality monitoring results may indicate that contingency actions should be implemented to reduce the potential for an NPDES threshold exceedance occurring. A Trigger/Action matrix table of the monitoring thresholds and trigger limits with the corresponding actions to be taken is included in **Attachment B**.

TABLES

Table 2. Tier 1 Effluent Limits and Monitoring Requirements from NPDES permit TN0005428 – Outfall 001

Parameter	Qualifier	Value	Unit	Sample Type	Monitoring Frequency	Statistical Base
pH	>=	6	SU	Grab	Weekly	Minimum
pH	<=	9	SU	Grab	Weekly	Maximum
Total Suspended Solids (TSS)	<=	28	mg/L	Grab	Monthly	Monthly Average
Total Suspended Solids (TSS)	<=	93	mg/L	Grab	Monthly	Daily Maximum
Oil & Grease	<=	18	mg/L	Grab	Monthly	Daily Maximum
Oil & Grease	<=	14	mg/L	Grab	Monthly	Monthly Average
Sulfate, total (as SO4)	Report	-	mg/L	Grab	Quarterly	Value
Fluoride, total (as F)	Report	-	mg/L	Grab	Quarterly	Value
Arsenic, total (as As)	Report	-	mg/L	Grab	Monthly	Value
Barium, total (as Ba)	Report	-	mg/L	Grab	Monthly	Value
Beryllium, total (as Be)	Report	-	mg/L	Grab	Monthly	Value
Boron, total (as B)	Report	-	mg/L	Grab	Quarterly	Value
Cadmium, total (as Cd)	Report	-	mg/L	Grab	Monthly	Value
Chromium, total (as Cr)	Report	-	mg/L	Grab	Monthly	Value
Copper, total (as Cu)	Report	-	mg/L	Grab	Monthly	Value
Iron, total (as Fe)	Report	-	mg/L	Grab	Monthly	Value
Lead, total (as Pb)	Report	-	mg/L	Grab	Monthly	Value
Thallium, total (as Tl)	Report	-	mg/L	Grab	Monthly	Value
Molybdenum, total (as Mo)	Report	-	mg/L	Grab	Quarterly	Value
Nickel, total (as Ni)	Report	-	mg/L	Grab	Monthly	Value
Silver, total (as Ag)	Report	-	mg/L	Grab	Monthly	Value
Zinc, total (as Zn)	Report	-	mg/L	Grab	Monthly	Value
Antimony, total (as Sb)	Report	-	mg/L	Grab	Monthly	Value
Aluminum, total (as Al)	Report	-	mg/L	Grab	Monthly	Value
Lithium, total (as Li)	Report	-	mg/L	Grab	Quarterly	Value
Selenium, total (as Se)	Report	-	mg/L	Grab	Monthly	Value
Radium 226 + Radium 228, total	Report	-	mg/L	Grab	Quarterly	Value
Flow	Report	-	Mgal/d	Instantaneous	Weekly	Daily Maximum
Flow	Report	-	Mgal/d	Instantaneous	Weekly	Monthly Average
IC25 Static Renewal 7 Day Chronic Ceriodaphnia	>=	3.6	%	Composite	Once per permit cycle	Minimum
IC25 Static Renewal 7 Day Chronic Pimephales	>=	3.6	%	Composite	Once per permit cycle	Minimum
Calcium, total (as CA)	Report	-	mg/L	Grab	Quarterly	Value
Total Dissolved Solids (TDS)	Report	-	mg/L	Grab	Quarterly	Value
Mercury, total (as Hg)	Report	-	ng/L	Grab	Monthly	Value

mg/L – milligrams per liter

SU – Standard Unit

Table 3. Tier 2 Effluent Limits and Monitoring Requirements from NPDES permit TN0005428 – Outfall 001

Parameter	Qualifier	Value	Unit	Sample Type	Monitoring Frequency	Statistical Base
pH	>=	6.0	SU	Grab	Weekly	Minimum
pH	<=	9.0	SU	Grab	Weekly	Maximum
Total Suspended Solids (TSS)	<=	28	mg/L	Grab	Monthly	Monthly Average
Total Suspended Solids (TSS)	<=	93	mg/L	Grab	Monthly	Daily Maximum
Oil & Grease	<=	18	mg/L	Grab	Monthly	Daily Maximum
Oil & Grease	<=	14	mg/L	Grab	Monthly	Monthly Average
Arsenic, total (as As)	Report	-	mg/L	Grab	Monthly	Value
Barium, total (as Ba)	Report	-	mg/L	Grab	Monthly	Value
Beryllium, total (as Be)	Report	-	mg/L	Grab	Monthly	Value
Cadmium, total (as Cd)	Report	-	mg/L	Grab	Monthly	Value
Chromium, total (as Cr)	Report	-	mg/L	Grab	Monthly	Value
Copper, total (as Cu)	Report	-	mg/L	Grab	Monthly	Value
Iron, total (as Fe)	Report	-	mg/L	Grab	Monthly	Value
Lead, total (as Pb)	Report	-	mg/L	Grab	Monthly	Value
Thallium, total (as Tl)	Report	-	mg/L	Grab	Monthly	Value
Nickel, total (as Ni)	Report	-	mg/L	Grab	Monthly	Value
Silver, total (as Ag)	Report	-	mg/L	Grab	Monthly	Value
Zinc, total (as Zn)	Report	-	mg/L	Grab	Monthly	Value
Antimony, total (as Sb)	Report	-	mg/L	Grab	Monthly	Value
Aluminum, total (as Al)	Report	-	mg/L	Grab	Monthly	Value
Selenium, total (as Se)	Report	-	mg/L	Grab	Monthly	Value
Flow	Report	-	Mgal/d	Instantaneous	Weekly	Monthly Average
Flow	Report	-	Mgal/d	Instantaneous	Weekly	Daily Maximum
Mercury, total (as Hg)	Report	-	ng/L	Grab	Monthly	Value
IC25 Static Renewal 7 Day Chronic Ceriodaphnia	>=	3.6	%	Composite	Once per permit cycle	Minimum
IC25 Static Renewal 7 Day Chronic Pimephales	>=	3.6	%	Composite	Once per permit cycle	Minimum

ng/L – nanograms per liter

Table 4. Effluent Limits and Monitoring Requirements from NPDES permit TN0005428 – Outfall 010

Parameter	Qualifier	Value	Unit	Sample Type	Monitoring Frequency	Statistical Base
pH	>=	6.0	SU	Grab	Weekly	Minimum
pH	<=	9.0	SU	Grab	Weekly	Maximum
Total Suspended Solids (TSS)	<=	28	mg/L	Grab	Monthly	Monthly Average
Total Suspended Solids (TSS)	<=	93	mg/L	Grab	Monthly	Daily Maximum
Oil & Grease	<=	18	mg/L	Grab	Monthly	Daily Maximum
Oil & Grease	<=	14	mg/L	Grab	Monthly	Monthly Average
Arsenic, total (as As)	Report	-	mg/L	Grab	Monthly	Value
Barium, total (as Ba)	Report	-	mg/L	Grab	Monthly	Value
Beryllium, total (as Be)	Report	-	mg/L	Grab	Monthly	Value
Cadmium, total (as Cd)	Report	-	mg/L	Grab	Monthly	Value
Chromium, total (as Cr)	Report	-	mg/L	Grab	Monthly	Value
Copper, total (as Cu)	Report	-	mg/L	Grab	Monthly	Value
Iron, total (as Fe)	Report	-	mg/L	Grab	Monthly	Value
Lead, total (as Pb)	Report	-	mg/L	Grab	Monthly	Value
Thallium, total (as Tl)	Report	-	mg/L	Grab	Monthly	Value
Nickel, total (as Ni)	Report	-	mg/L	Grab	Monthly	Value
Silver, total (as Ag)	Report	-	mg/L	Grab	Monthly	Value
Zinc, total (as Zn)	Report	-	mg/L	Grab	Monthly	Value
Antimony, total (as Sb)	Report	-	mg/L	Grab	Monthly	Value
Aluminum, total (as Al)	Report	-	mg/L	Grab	Monthly	Value
Selenium, total (as Se)	Report	-	mg/L	Grab	Monthly	Value
Flow	Report	-	Mgal/d	Instantaneous	Weekly	Monthly Average
Flow	Report	-	Mgal/d	Instantaneous	Weekly	Daily Maximum
Mercury, total (as Hg)	Report	-	ng/L	Grab	Monthly	Value
IC25 Static Renewal 7 Day Chronic Ceriodaphnia	>=	3.6	%	Composite	Once per permit cycle	Minimum
IC25 Static Renewal 7 Day Chronic Pimephales	>=	3.6	%	Composite	Once per permit cycle	Minimum

Table 5. Dewatering Stages

Stage No.[1]	Stage Work Task Description	Estimated Independent Stage Duration[2]	Estimated Pool Level or Nominal Ash Elevation (ft NGVD29[3])
0	**Set Up** 1. Implement Best Management Practices (BMPs) 2. Set up contingency water quality monitoring instrumentation equipment to measure turbidity (TSS), pH, and temperature within the free water pools of each pond, as required for utilization by water treatment operations.	2 weeks (1 months)	Current Pond Levels at start of closure construction
1	**Initial Free Water Removal** (Maximum drawdown rate of 1 foot per day) 1. Remove stop logs at Stilling Pond D to start the initial drawdown of the Stilling Ponds until the free water is drawn down to water surface elevation (WSE) 454.1 ft. 2. Begin monitoring turbidity, pH, and temperature at the free water ponds to monitor water quality conveying to Stilling Ponds.[4] 3. Concurrent with step 1, use existing siphons and spillways to draw down the water in Pond A to WSE 462 ft (effective lower limit of siphon). 4. Install pumping system at Pond A, setup to discharge to Stilling Pond B. After step 3 is complete to WSE 462 ft, start pumping system and drawdown to within 5 ft of bottom (WSE 455 ft). 5. Concurrent with steps 1 through 4, use the existing pump in Pond E to pump water into Stilling Ponds, through existing Pond E spillway, such that the water in Pond E is drawn down to within 5 ft of bottom (WSE 450 ft). 6. Install the remaining pumping systems for Stage 2 free water removal within Stilling Ponds (Pond B, Pond C, and Pond D). 7. Install the WTS for the treatment of the pumped water during Stage 2. 8. Establish the Dewatering Operational Assessment Point downstream of the WTS. 9. When the water in the stilling ponds has drained to the respective target elevations, replace the stop logs and proceed to Stage 2.	12 to 16 weeks (3 to 4 months)	Ash Pond A: 463.6 ft (spillway intake elevation) Stilling Pond B & C: 457.1 ft Stilling Pond D: 456.9 ft (operating level) Ash Pond E: 459.4 ft (spillway intake elevation)
2	**Final Free Water Removal** (Maximum drawdown rate of 1 foot per day) 1. Setup turbidity, pH, and temperature monitoring stations within the free water areas, and start monitoring. 2. Setup in-line monitoring of turbidity, pH, and temperature upstream (influent) and downstream (effluent) of the WTS. 3. Complete site-specific system training for pumping system and WTS. 4. Start-up test run(s) and commissioning of free water removal system. 5. Switch over to the free water removal pumping and the WTS bypass system, and begin monitoring TSS, pH, temperature, and total flow at the influent and effluent side of the WTS. 6. Route discharge from pumping system at Pond E to the WTS. 7. Pump water from Pond A through the WTS to Outfall 001. 8. Commence pumping water from Ponds B, C, and D through the WTS to Outfall 001 when the CCR removal activities commence within the Stilling Ponds. 9. The WTS will discharge to Outfall 001.	12 to 18 weeks[5] (3 to 4.5 months)	Ash Pond A: 455 ft (5 ft from the bottom of the pond) Stilling Pond B & C: 454.1 ft (~5 ft from the bottom of the pond) Stilling Pond D: 454.1 ft (lower limit of spillway outlet, within about 7 ft from bottom of pond) Ash Pond E: 450 ft (5 ft from bottom of pond)

Stage No.[1]	Stage Work Task Description	Estimated Independent Stage Duration[2]	Estimated Pool Level or Nominal Ash Elevation (ft NGVD29[3])
3A	**Pore Water and Contaminated Storm Water Removal** 1. Construct dewatering collection sumps within the footprints of Pond A and Pond E to collect dewatering flows. 2. Retain the free water removal pump system and WTS at the edge of Stilling Pond D near Outfall 001. 3. Excavate dewatering ditches in Pond A and Pond E to channel water toward the sumps; install shallow wellpoints to evacuate additional water from the ash if required. 4. Continue monitoring turbidity and pH at monitoring stations within the free water areas; continue in-line monitoring of turbidity, pH, and temperature upstream of the WTS; begin monitoring TSS, pH, temperature, and total flow at both the influent and effluent side of the WTS.	216 months (18 years)	Existing Pore Water and all Contaminated Storm Water Removed (initial free water removal completed)
3B	**Pore Water and Contaminated Storm Water Removal** 1. Construct dewatering collection sumps within the footprints of Pond A and Pond E to collect dewatering flows and continue use of pumps installed during Stage 1 and 2. 2. Move the free water removal pump and WTS from the edge of Stilling Pond D near Outfall 001 to the southern end of Pond E near Outfall 010. 3. Excavate dewatering ditches in Pond A and Pond E to channel water toward the sumps; install shallow wellpoints to evacuate additional water from the ash if required. 4. Pump water through WTS for discharge to Outfall 010, following treatment. Continue monitoring turbidity and pH at monitoring stations within the free water areas; continue in-line monitoring of turbidity, pH, and temperature upstream of the WTS; begin monitoring TSS, pH, temperature, and total flow at both the influent and effluent side of the WTS.	216 months (18 years)	Existing Pore Water and all Contaminated Storm Water Removed (initial free water removal completed)

Notes:

[1] The proposed sequence may be subject to change based on conditions encountered in the field.
[2] The stages are independent of one another and can commence simultaneously if necessary.
[3] NGVD29 = National Geodetic Vertical Datum of 1929.
[4] Monitoring will continue to occur at the Outfalls 001 and 010 during all Stages of the free water drawdown and ash dewatering at the currently-permitted frequencies as indicated on Table 2 and Table 4.
[5] Pumping on a 24-hour, 7-day a week schedule assumed for the duration of Stage 2

Table 6. Proposed Monitoring Parameters – Dewatering Operational Assessment Point at Estimated Discharge of 3.76 MGD

Parameter	Unit	Average Monthly Threshold	Maximum Daily Threshold	Sampling Frequency
pH	SU	6 - 9	6 - 9	Weekly
Total Suspended Solids (TSS)	mg/L	28	93	Weekly
Oil & Grease	mg/L	14	18	Weekly
Sulfate, total (as SO4)	mg/L	-	-	Weekly
Fluoride, total (as F)	mg/L	-	-	Weekly
Arsenic	mg/L	0.72	25.212	Weekly
Barium	mg/L	148.436	NA	Weekly
Beryllium	mg/L	0.297	NA	Weekly
Boron	mg/L	-	-	Weekly
Cadmium	mg/L	0.228	0.568	Weekly
Chromium[2]	mg/L	0.816	1.187	Weekly
Copper	mg/L	2.512	3.740	Weekly
Iron	mg/L	-	-	Weekly
Lead	mg/L	0.353	26.118	Weekly
Thallium	mg/L	0.148	NA	Weekly
Molybdenum	mg/L	-	-	Weekly
Nickel	mg/L	7.311	141.265	Weekly
Silver	mg/L	7.422	0.204	Weekly
Zinc	mg/L	58.124	57.653	Weekly
Antimony	mg/L	0.416	NA	Weekly
Aluminum	mg/L	-	-	Weekly
Lithium	mg/L	-	-	Weekly
Selenium	mg/L	0.334	1.448	Weekly
Radium 226 + Radium 228, total	mg/L	-	-	Quarterly
Flow	Mgal/d	-	-	Weekly
Calcium, total (as CA)	mg/L	-	-	Weekly
Total Dissolved Solids (TDS)	mg/L	-	-	Weekly
Mercury	mg/L	0.004	0.104	Weekly

Notes:

[1] Weekly monitoring of TSS and pH will also be performed at the Dewatering Operational Assessment Point. TSS estimations will be generated using Turbidity measurement instruments as indicated in Table 5. Should the operational thresholds in Table 6 be exceeded for the Dewatering Operation Assessment Point, TVA will perform a single sampling and testing of the receiving outfall and compare to either Table 7 or Table 8.

[2] The threshold value for total chromium is equivalent to Chromium IV, the most stringent threshold when comparing Chromium IV and III. In the event of an exceedance of the total chromium threshold at the WTS assessment point, TVA will evaluate the threshold at the outfall to the Cumberland River (outfall 001 or 010). Should this value be exceeded, TVA may choose to sample separately for Chromium IV and III at the WTS and evaluate against speciated thresholds.

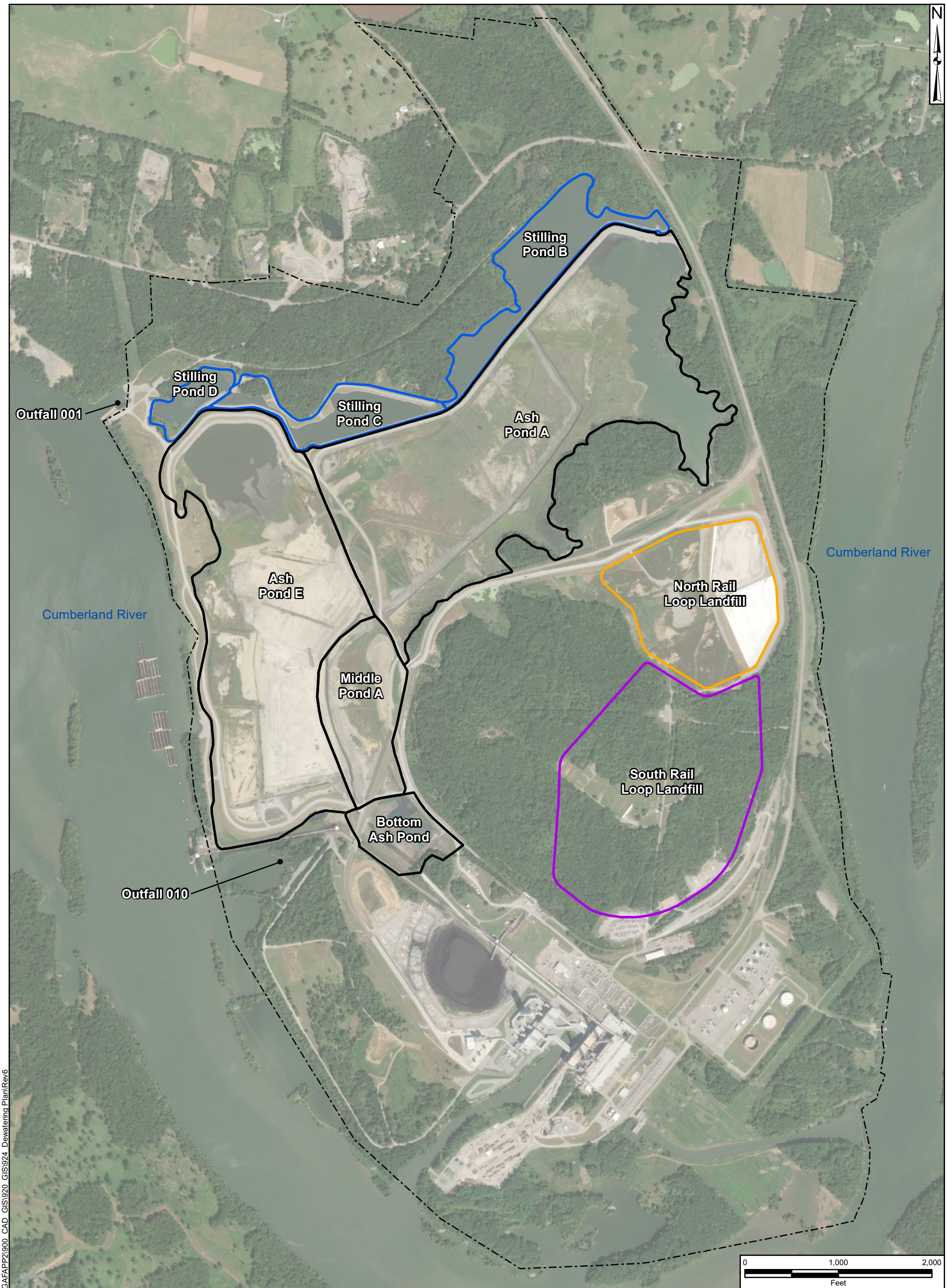
Table 7. Proposed Monitoring Parameters – Outfall 001 at Estimated Discharge of 4.8 MGD

Parameter	Unit	Average Monthly Threshold	Maximum Daily Threshold	Sampling Frequency
pH	SU	6 - 9	6 - 9	Weekly
Total Suspended Solids (TSS)	mg/L	28	93	Monthly
Oil & Grease	mg/L	14	18	Monthly
Sulfate, total (as SO4)	mg/L	-	-	Quarterly
Fluoride, total (as F)	mg/L	-	-	Quarterly
Arsenic	mg/L	0.560	19.606	Monthly
Barium	mg/L	115.428	NA	Monthly
Beryllium	mg/L	0.231	NA	Monthly
Boron	mg/L	-	-	Quarterly
Cadmium	mg/L	0.177	0.442	Monthly
Chromium	mg/L	0.635	0.923	Monthly
Copper	mg/L	1.953	2.908	Monthly
Iron	mg/L	-	-	Monthly
Lead	mg/L	0.274	20.310	Monthly
Thallium	mg/L	0.115	NA	Monthly
Molybdenum	mg/L	-	-	Quarterly
Nickel	mg/L	5.686	109.852	Monthly
Silver	mg/L	5.771	0.159	Monthly
Zinc	mg/L	45.199	44.832	Monthly
Antimony	mg/L	0.323	NA	Monthly
Aluminum	mg/L	-	-	Monthly
Lithium	mg/L	-	-	Quarterly
Selenium	mg/L	0.260	1.126	Monthly
Radium 226 + Radium 228, total	mg/L	-	-	Quarterly
Flow	Mgal/d	-	-	Weekly
Calcium, total (as CA)	mg/L	-	-	Quarterly
Total Dissolved Solids (TDS)	mg/L	-	-	Quarterly
Mercury	mg/L	0.003	0.081	Monthly

Table 8. Proposed Monitoring Parameters – Outfall 010 at Estimated Discharge of 29.66 MGD

Parameter	Unit	Average Monthly Threshold	Maximum Daily Threshold	Sampling Frequency
pH	SU	6 - 9	6 - 9	Weekly
Total Suspended Solids (TSS)	mg/L	28	93	Monthly
Oil & Grease	mg/L	14	18	Monthly
Sulfate, total (as SO4)	mg/L	-	-	Quarterly
Fluoride, total (as F)	mg/L	-	-	Quarterly
Arsenic	mg/L	0.095	3.331	Monthly
Barium	mg/L	19.608	NA	Monthly
Beryllium	mg/L	0.039	NA	Monthly
Boron	mg/L	-	-	Quarterly
Cadmium	mg/L	0.03	0.075	Monthly
Chromium	mg/L	0.108	0.157	Monthly
Copper	mg/L	0.332	0.494	Monthly
Iron	mg/L	-	-	Monthly
Lead	mg/L	0.047	3.450	Monthly
Thallium	mg/L	0.02	NA	Monthly
Molybdenum	mg/L	-	-	Quarterly
Nickel	mg/L	0.966	18.662	Monthly
Silver	mg/L	0.980	0.027	Monthly
Zinc	mg/L	7.678	7.616	Monthly
Antimony	mg/L	0.055	NA	Monthly
Aluminum	mg/L	-	-	Monthly
Lithium	mg/L	-	-	Quarterly
Selenium	mg/L	0.044	0.191	Monthly
Radium 226 + Radium 228, total	mg/L	-	-	Quarterly
Flow	Mgal/d	-	-	Weekly
Calcium, total (as CA)	mg/L	-	-	Quarterly
Total Dissolved Solids (TDS)	mg/L	-	-	Quarterly
Mercury	mg/L	0	0.014	Monthly

FIGURES



LEGEND

- Ash Ponds
- Stilling Ponds
- North Rail Loop Landfill
- South Rail Loop Landfill
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

AECOM

Figure 1

SITE MAP

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
J.COLLEY	D.SKEGGS	-	REV. 0

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
AUG 2020	FOSSIL AND HYDRO ENGINEERING

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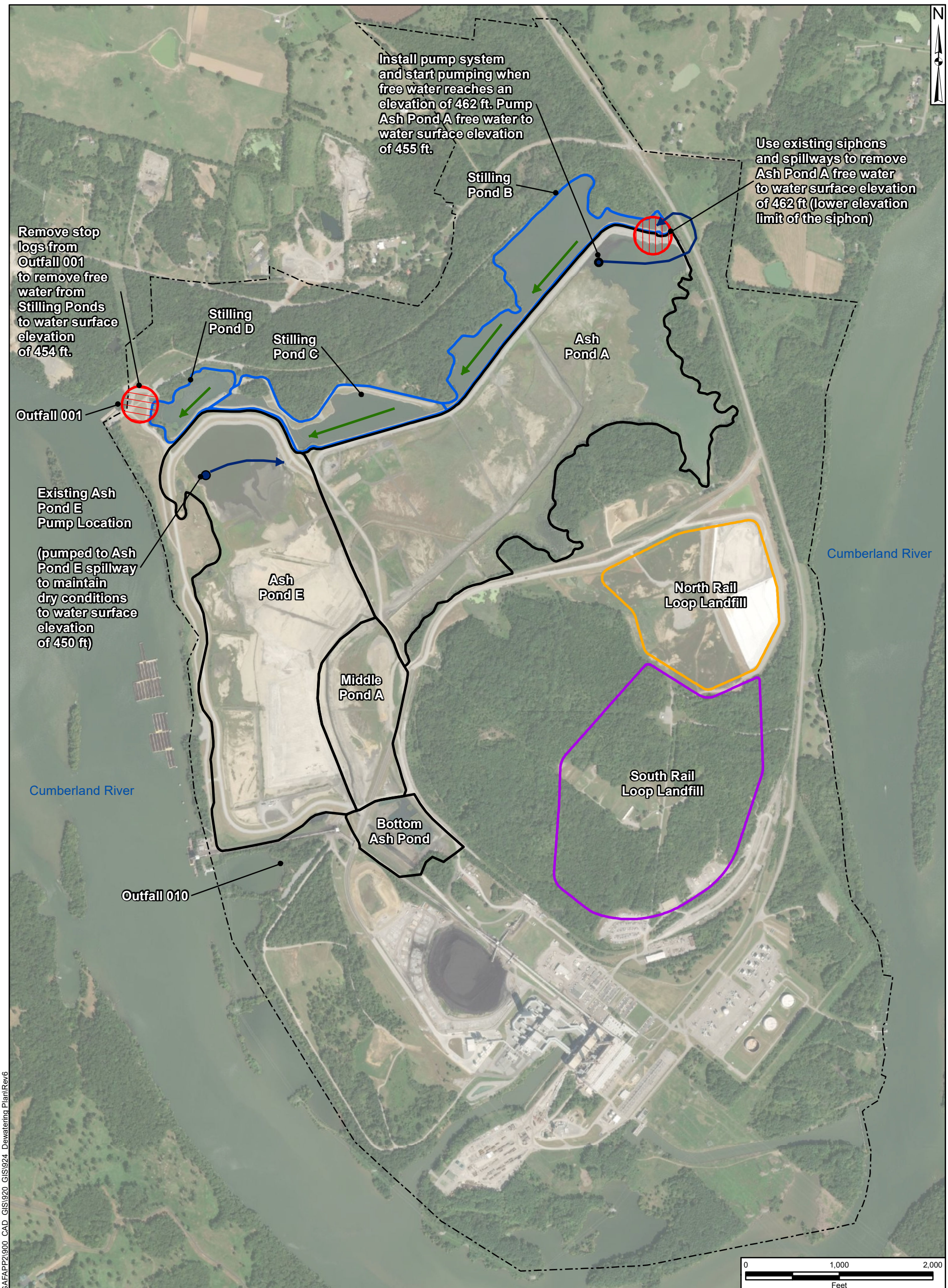

LEGEND

- Ash Ponds
- Stilling Ponds
- North Rail Loop Landfill
- South Rail Loop Landfill
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

AECOM

Figure 2

STAGE 1:
INITIAL FREE WATER REMOVAL

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J.COLLEY	D.SKEGGS	-	REV. 0

GALLATIN FOSSIL PLANT
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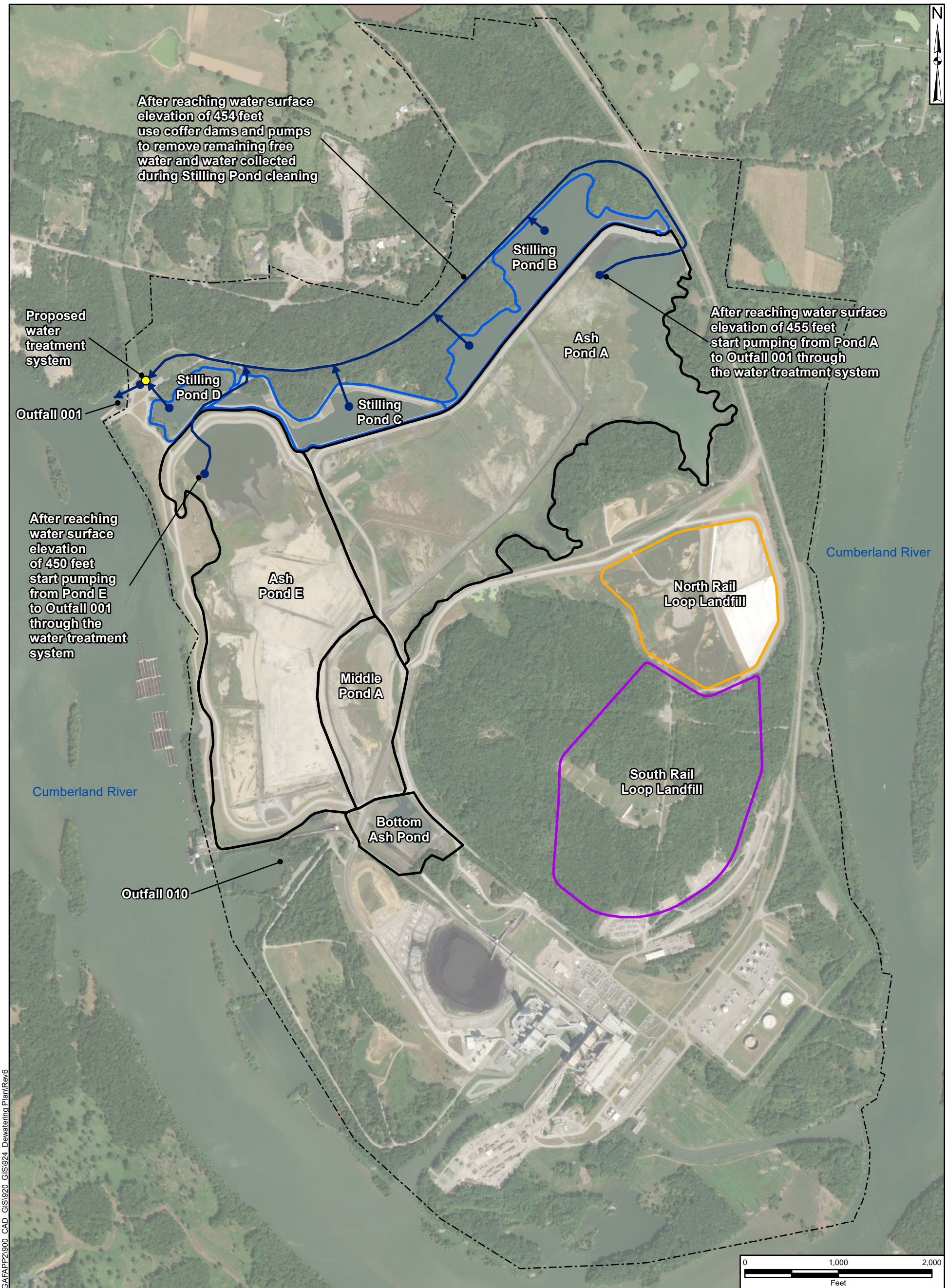

LEGEND

- Ash Ponds
- Stilling Ponds
- North Rail Loop Landfill
- South Rail Loop Landfill
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

AECOM

Figure 3

STAGE 2:
FINAL FREE WATER REMOVAL

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TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
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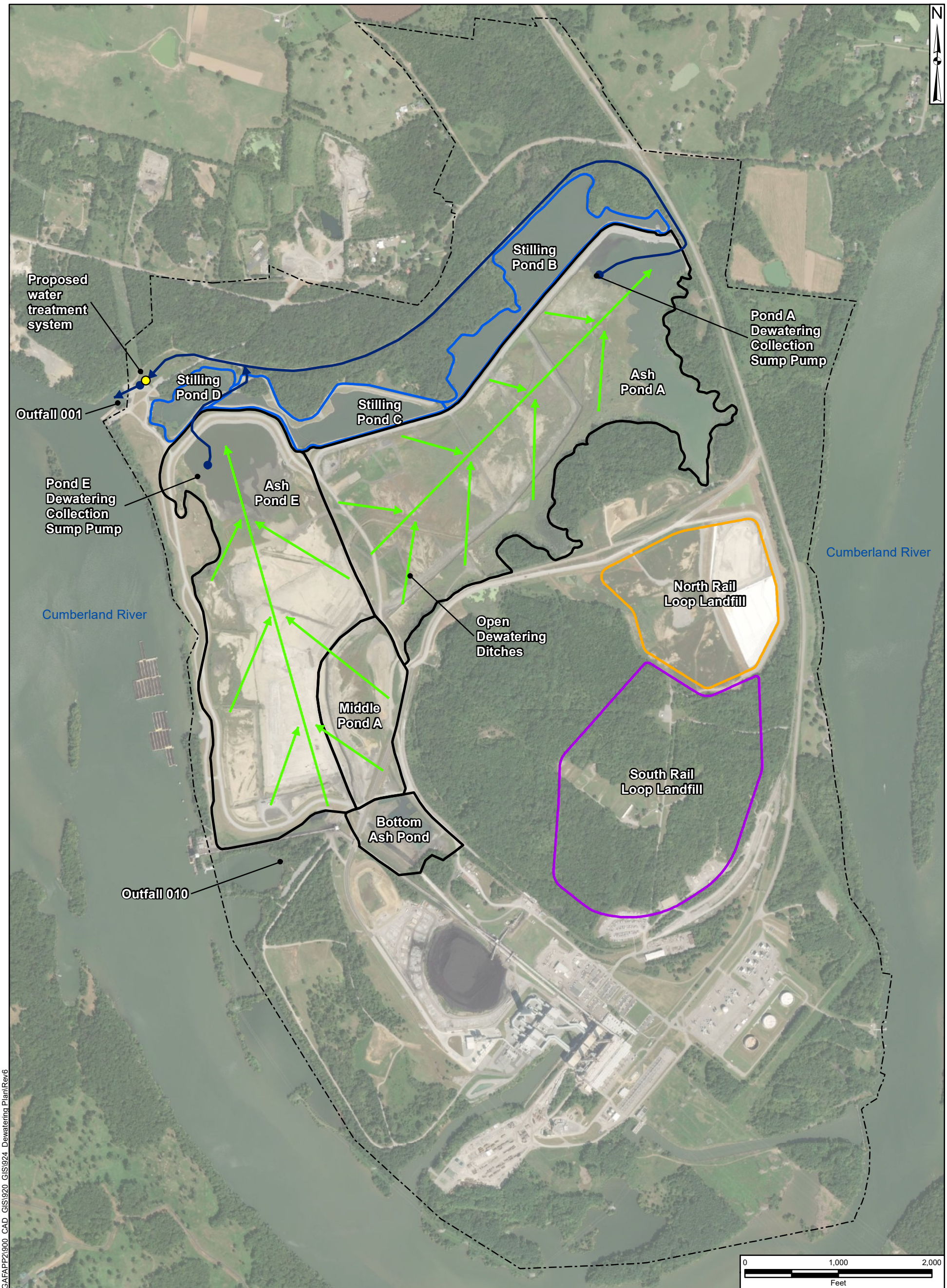

LEGEND

- Ash Ponds
- Stilling Ponds
- North Rail Loop Landfill
- South Rail Loop Landfill
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

AECOM

Figure 4

STAGE 3A:
ASH DEWATERING TO OUTFALL 001

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GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
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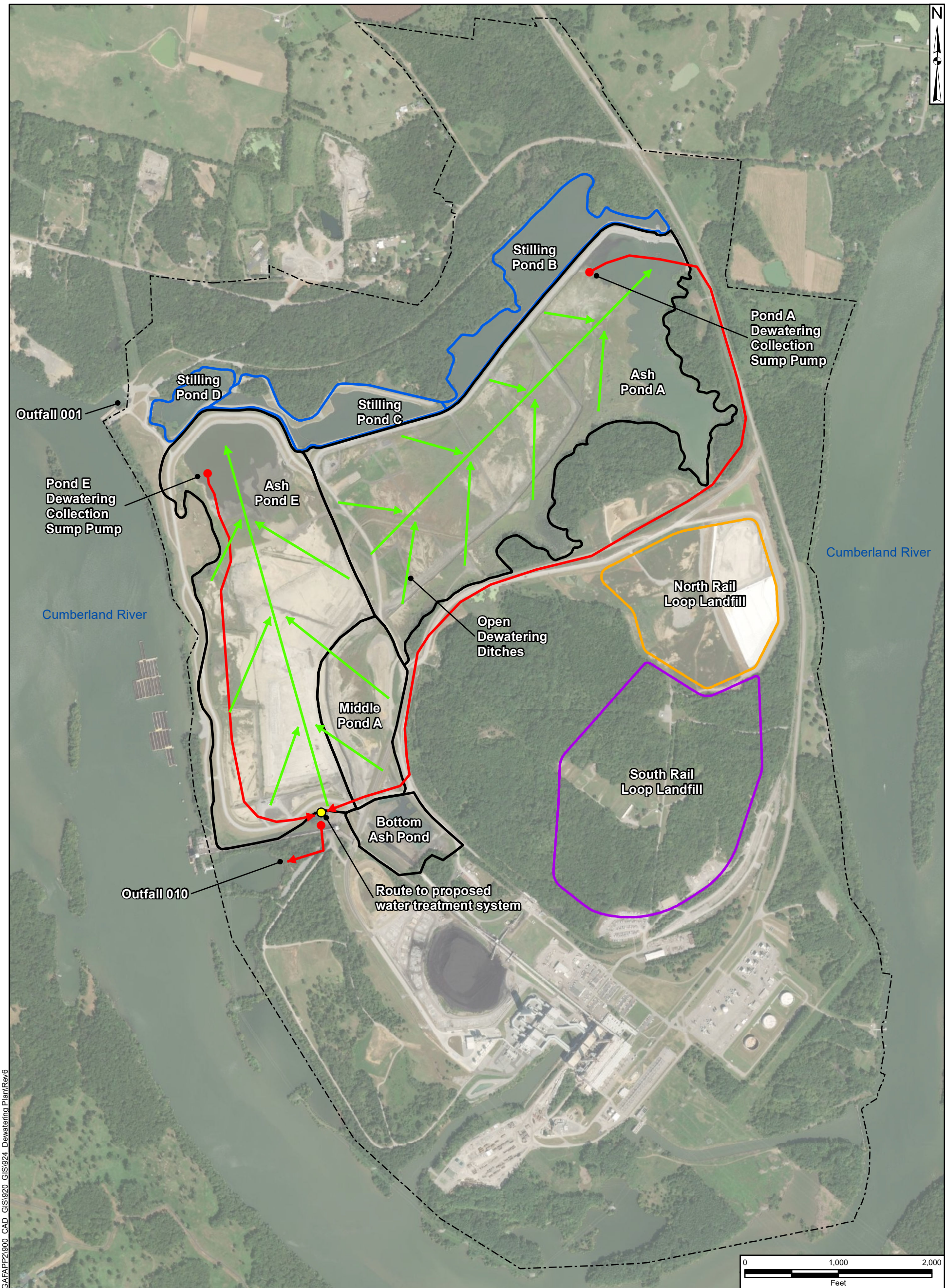

LEGEND

- Ash Ponds
- Stilling Ponds
- North Rail Loop Landfill
- South Rail Loop Landfill
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

AECOM

Figure 5

STAGE 3B:
ASH DEWATERING TO OUTFALL 010

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
J.COLLEY	D.SKEGGS	-	REV. 0

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
AUG 2020	FOSSIL AND HYDRO ENGINEERING

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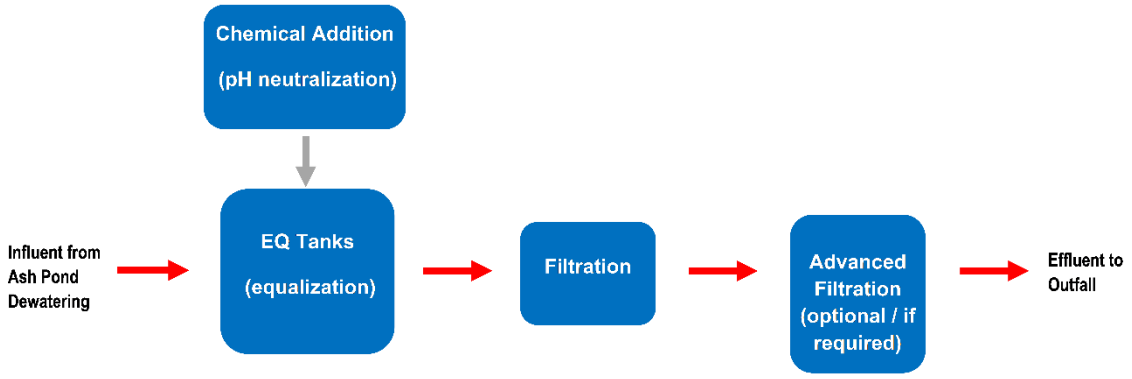
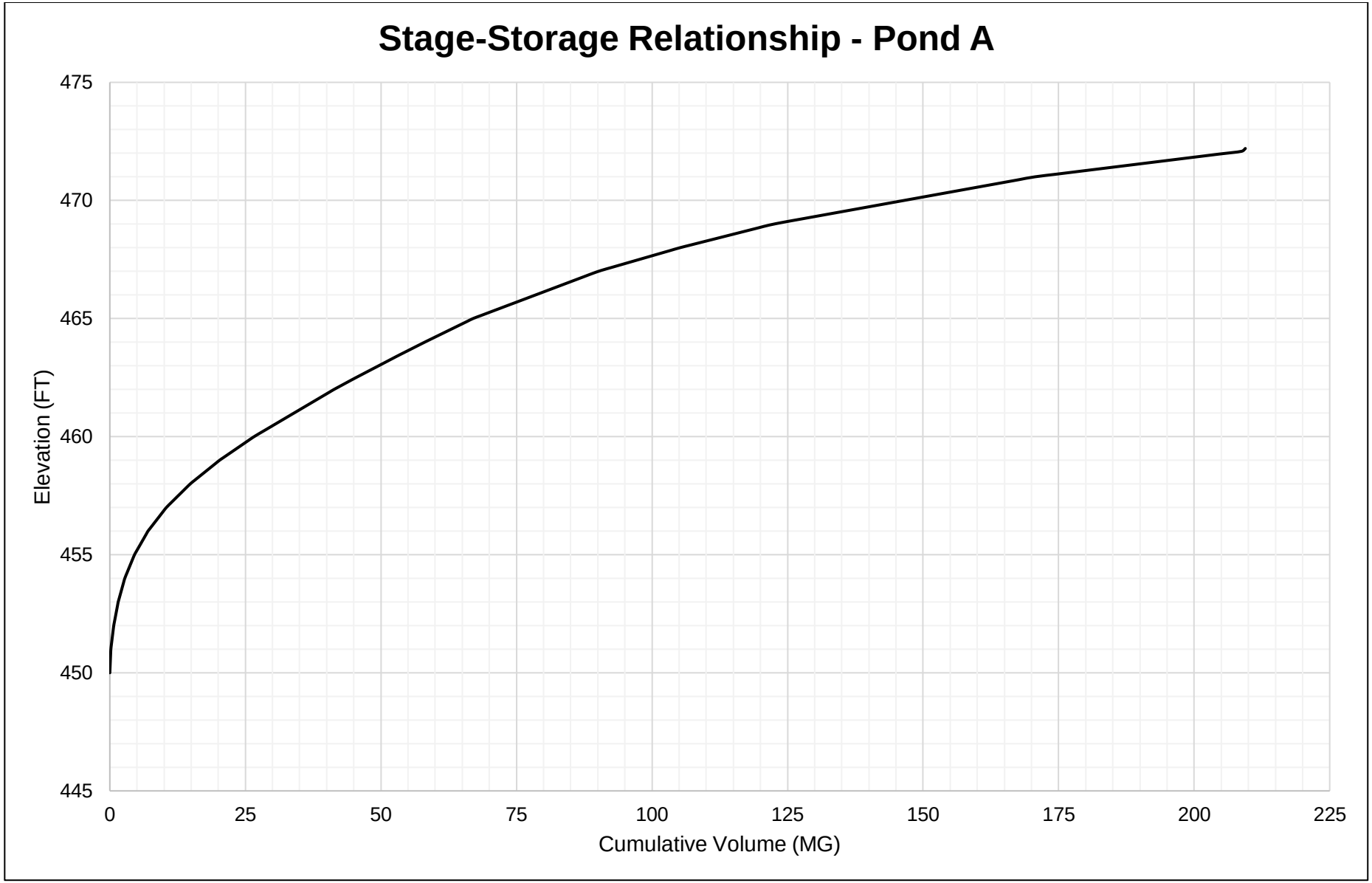


Figure 6. Free Water Removal and Ash Pond Dewatering Water Treatment System Schematic

ATTACHMENTS

Attachment A – Stage-Storage Relationship


Stage-Storage Relationship - Pond A
475
470
465
460
455
450
445
Elevation (FT)
0
25
50
75
100
125
150
175
200
225
Cumulative Volume (MG)

Stage-Storage Relationship Data – Pond A

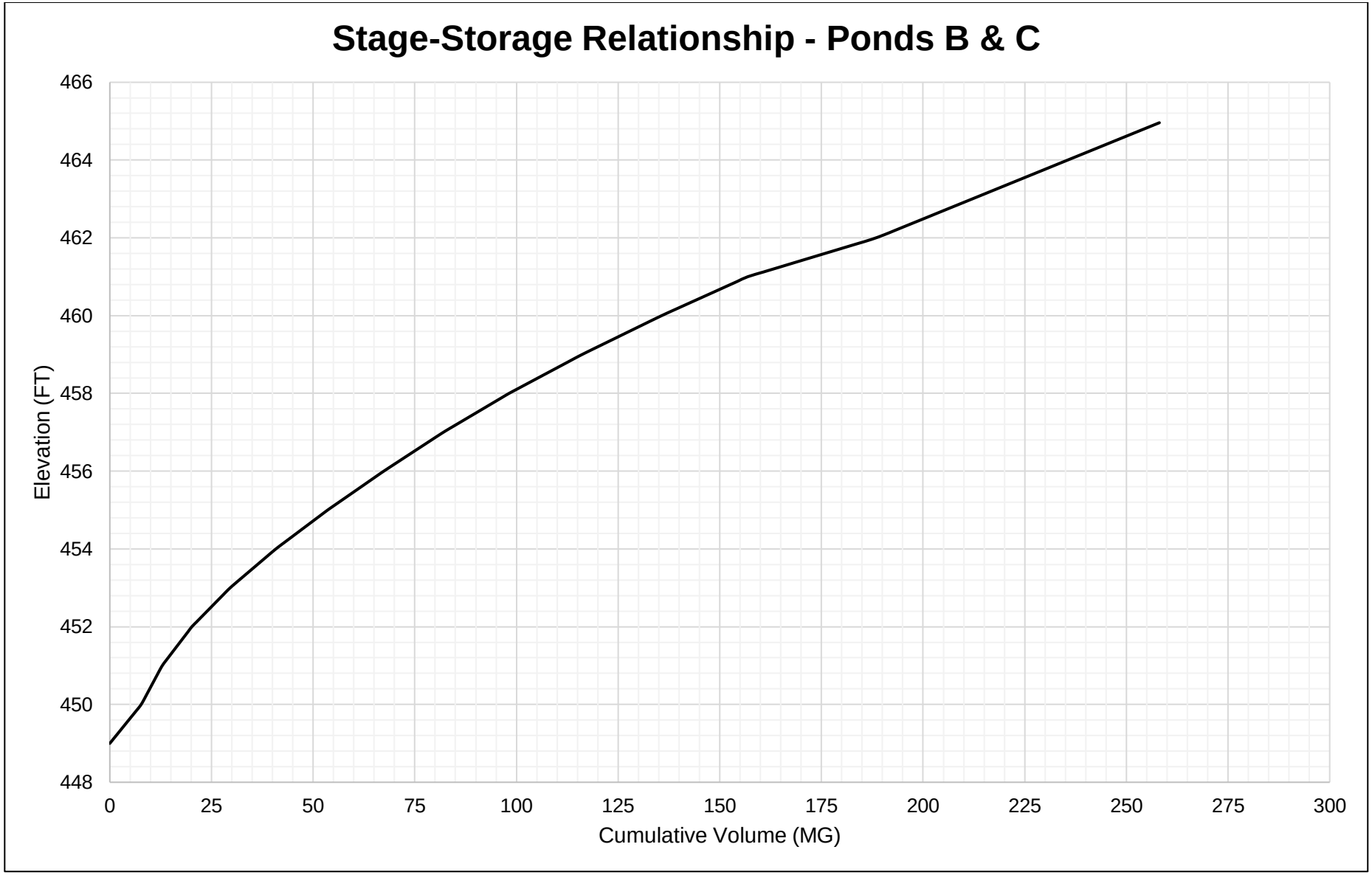
Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
450.00	0.00	0	0	0.00
450.12	0.12	5,903	2,952	0.02
450.24	0.24	11,807	5,903	0.04
450.36	0.36	17,710	8,855	0.07
450.48	0.48	23,614	11,807	0.09
450.60	0.60	29,517	14,759	0.11
450.72	0.72	35,420	17,710	0.13
450.84	0.84	41,324	20,662	0.15
450.96	0.96	47,227	23,614	0.18
451.08	1.08	52,743	30,307	0.23
451.20	1.20	58,064	38,871	0.29
451.32	1.32	63,386	47,435	0.35
451.44	1.44	68,707	55,999	0.42
451.56	1.56	74,029	64,564	0.48
451.68	1.68	79,350	73,128	0.55
451.80	1.80	84,672	81,692	0.61
451.92	1.92	89,993	90,256	0.68
452.04	2.04	94,875	100,374	0.75
452.16	2.16	98,879	113,601	0.85
452.28	2.28	102,882	126,828	0.95
452.40	2.40	106,885	140,054	1.05
452.52	2.52	110,889	153,281	1.15
452.64	2.64	114,892	166,507	1.25
452.76	2.76	118,895	179,734	1.34
452.88	2.88	122,899	192,960	1.44
453.00	3.00	126,902	206,187	1.54
453.12	3.12	135,200	225,564	1.69
453.24	3.24	143,499	244,942	1.83
453.36	3.36	151,797	264,319	1.98
453.48	3.48	160,095	283,697	2.12
453.60	3.60	168,394	303,074	2.27
453.72	3.72	176,692	322,452	2.41
453.84	3.84	184,991	341,829	2.56
453.96	3.96	193,289	361,206	2.70
454.08	4.08	202,979	386,812	2.89
454.20	4.20	213,364	415,531	3.11
454.32	4.32	223,749	444,250	3.32
454.44	4.44	234,135	472,970	3.54
454.56	4.56	244,520	501,689	3.75
454.68	4.68	254,906	530,408	3.97
454.80	4.80	265,291	559,128	4.18

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
454.92	4.92	275,676	587,847	4.40
455.04	5.04	286,692	620,343	4.64
455.16	5.16	298,968	660,393	4.94
455.28	5.28	311,244	700,443	5.24
455.40	5.40	323,520	740,493	5.54
455.52	5.52	335,796	780,543	5.84
455.64	5.64	348,072	820,593	6.14
455.76	5.76	360,348	860,643	6.44
455.88	5.88	372,624	900,693	6.74
456.00	6.00	384,900	940,743	7.04
456.12	6.12	400,927	994,945	7.44
456.24	6.24	416,955	1,049,146	7.85
456.36	6.36	432,982	1,103,348	8.25
456.48	6.48	449,009	1,157,550	8.66
456.60	6.60	465,037	1,211,751	9.06
456.72	6.72	481,064	1,265,953	9.47
456.84	6.84	497,091	1,320,155	9.88
456.96	6.96	513,119	1,374,356	10.28
457.08	7.08	529,785	1,439,562	10.77
457.20	7.20	546,771	1,510,271	11.30
457.32	7.32	563,757	1,580,979	11.83
457.44	7.44	580,743	1,651,687	12.36
457.56	7.56	597,729	1,722,396	12.88
457.68	7.68	614,715	1,793,104	13.41
457.80	7.80	631,701	1,863,812	13.94
457.92	7.92	648,687	1,934,521	14.47
458.04	8.04	665,164	2,010,636	15.04
458.16	8.16	680,621	2,097,566	15.69
458.28	8.28	696,079	2,184,497	16.34
458.40	8.40	711,537	2,271,427	16.99
458.52	8.52	726,994	2,358,357	17.64
458.64	8.64	742,452	2,445,287	18.29
458.76	8.76	757,910	2,532,217	18.94
458.88	8.88	773,367	2,619,147	19.59
459.00	9.00	788,825	2,706,078	20.24
459.12	9.12	803,515	2,808,081	21.01
459.24	9.24	818,205	2,910,085	21.77
459.36	9.36	832,895	3,012,089	22.53
459.48	9.48	847,585	3,114,093	23.30
459.60	9.60	862,275	3,216,097	24.06
459.72	9.72	876,965	3,318,101	24.82
459.84	9.84	891,654	3,420,105	25.58

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
459.96	9.96	906,344	3,522,109	26.35
460.08	10.08	917,311	3,635,080	27.19
460.20	10.20	926,416	3,753,533	28.08
460.32	10.32	935,520	3,871,987	28.96
460.44	10.44	944,625	3,990,441	29.85
460.56	10.56	953,730	4,108,894	30.74
460.68	10.68	962,835	4,227,348	31.62
460.80	10.80	971,939	4,345,802	32.51
460.92	10.92	981,044	4,464,255	33.39
461.04	11.04	990,149	4,582,709	34.28
461.16	11.16	999,254	4,701,163	35.17
461.28	11.28	1,008,358	4,819,616	36.05
461.40	11.40	1,017,463	4,938,070	36.94
461.52	11.52	1,026,568	5,056,524	37.83
461.64	11.64	1,035,673	5,174,977	38.71
461.76	11.76	1,044,777	5,293,431	39.60
461.88	11.88	1,053,882	5,411,885	40.48
462.00	12.00	1,062,987	5,530,339	41.37
462.12	12.12	1,070,229	5,659,454	42.34
462.24	12.24	1,077,471	5,788,569	43.30
462.36	12.36	1,084,713	5,917,685	44.27
462.48	12.48	1,091,478	6,048,719	45.25
462.60	12.60	1,097,575	6,182,441	46.25
462.72	12.72	1,103,673	6,316,162	47.25
462.84	12.84	1,109,770	6,449,883	48.25
462.96	12.96	1,115,868	6,583,604	49.25
463.08	13.08	1,121,965	6,717,325	50.25
463.20	13.20	1,128,063	6,851,047	51.25
463.32	13.32	1,134,161	6,984,768	52.25
463.44	13.44	1,140,197	7,118,871	53.25
463.56	13.56	1,145,561	7,257,169	54.29
463.68	13.68	1,150,925	7,395,468	55.32
463.80	13.80	1,156,289	7,533,767	56.36
463.92	13.92	1,161,653	7,672,066	57.39
464.04	14.04	1,167,364	7,811,941	58.44
464.16	14.16	1,173,767	7,954,970	59.51
464.28	14.28	1,180,171	8,098,000	60.58
464.40	14.40	1,186,575	8,241,029	61.65
464.52	14.52	1,192,978	8,384,058	62.72
464.64	14.64	1,199,382	8,527,088	63.79
464.76	14.76	1,205,786	8,670,117	64.86
464.88	14.88	1,212,189	8,813,146	65.93

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
465.00	15.00	1,218,593	8,956,176	67.00
465.12	15.12	1,257,523	9,141,336	68.38
465.24	15.24	1,296,452	9,326,497	69.77
465.36	15.36	1,335,382	9,511,658	71.15
465.48	15.48	1,374,311	9,696,819	72.54
465.60	15.60	1,413,241	9,881,979	73.92
465.72	15.72	1,452,170	10,067,140	75.31
465.84	15.84	1,491,100	10,252,301	76.69
465.96	15.96	1,530,029	10,437,461	78.08
466.08	16.08	1,568,959	10,622,622	79.46
466.20	16.20	1,607,889	10,807,783	80.85
466.32	16.32	1,646,818	10,992,944	82.23
466.44	16.44	1,685,748	11,178,104	83.62
466.56	16.56	1,724,677	11,363,265	85.00
466.68	16.68	1,763,607	11,548,426	86.39
466.80	16.80	1,802,536	11,733,586	87.77
466.92	16.92	1,841,466	11,918,747	89.16
467.04	17.04	1,879,645	12,122,998	90.69
467.16	17.16	1,916,324	12,365,427	92.50
467.28	17.28	1,953,002	12,607,857	94.31
467.40	17.40	1,989,681	12,850,286	96.13
467.52	17.52	2,026,360	13,092,716	97.94
467.64	17.64	2,063,038	13,335,145	99.75
467.76	17.76	2,099,717	13,577,575	101.57
467.88	17.88	2,136,395	13,820,005	103.38
468.00	18.00	2,173,074	14,062,434	105.19
468.12	18.12	2,202,713	14,338,023	107.26
468.24	18.24	2,232,353	14,613,611	109.32
468.36	18.36	2,261,992	14,889,200	111.38
468.48	18.48	2,291,631	15,164,788	113.44
468.60	18.60	2,321,270	15,440,377	115.50
468.72	18.72	2,350,910	15,715,965	117.56
468.84	18.84	2,380,549	15,991,554	119.63
468.96	18.96	2,410,188	16,267,142	121.69
469.08	19.08	2,484,444	16,616,987	124.30
469.20	19.20	2,581,009	17,003,960	127.20
469.32	19.32	2,677,573	17,390,932	130.09
469.44	19.44	2,774,138	17,777,905	132.99
469.56	19.56	2,870,703	18,164,878	135.88
469.68	19.68	2,967,267	18,551,850	138.78
469.80	19.80	3,063,832	18,938,823	141.67
469.92	19.92	3,160,396	19,325,796	144.57

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
470.04	20.04	3,256,961	19,712,769	147.46
470.16	20.16	3,353,525	20,099,741	150.36
470.28	20.28	3,450,090	20,486,714	153.25
470.40	20.40	3,546,654	20,873,687	156.15
470.52	20.52	3,643,219	21,260,659	159.04
470.64	20.64	3,739,783	21,647,632	161.94
470.76	20.76	3,836,348	22,034,605	164.83
470.88	20.88	3,932,912	22,421,577	167.73
471.00	21.00	4,029,477	22,808,550	170.62
471.12	21.12	4,179,768	23,374,748	174.86
471.24	21.24	4,330,059	23,940,945	179.09
471.36	21.36	4,480,350	24,507,142	183.33
471.48	21.48	4,630,642	25,073,340	187.56
471.60	21.60	4,780,933	25,639,537	191.80
471.72	21.72	4,931,224	26,205,734	196.03
471.84	21.84	5,081,515	26,771,932	200.27
471.96	21.96	5,231,806	27,338,129	204.50
472.08	22.08	5,382,097	27,904,327	208.74
472.20	22.20	5,407,146	27,998,693	209.44


Stage-Storage Relationship - Ponds B & C
466
464
462
460
458
456
454
452
450
448
Elevation (FT)
0
25
50
75
100
125
150
175
200
225
250
275
300
Cumulative Volume (MG)

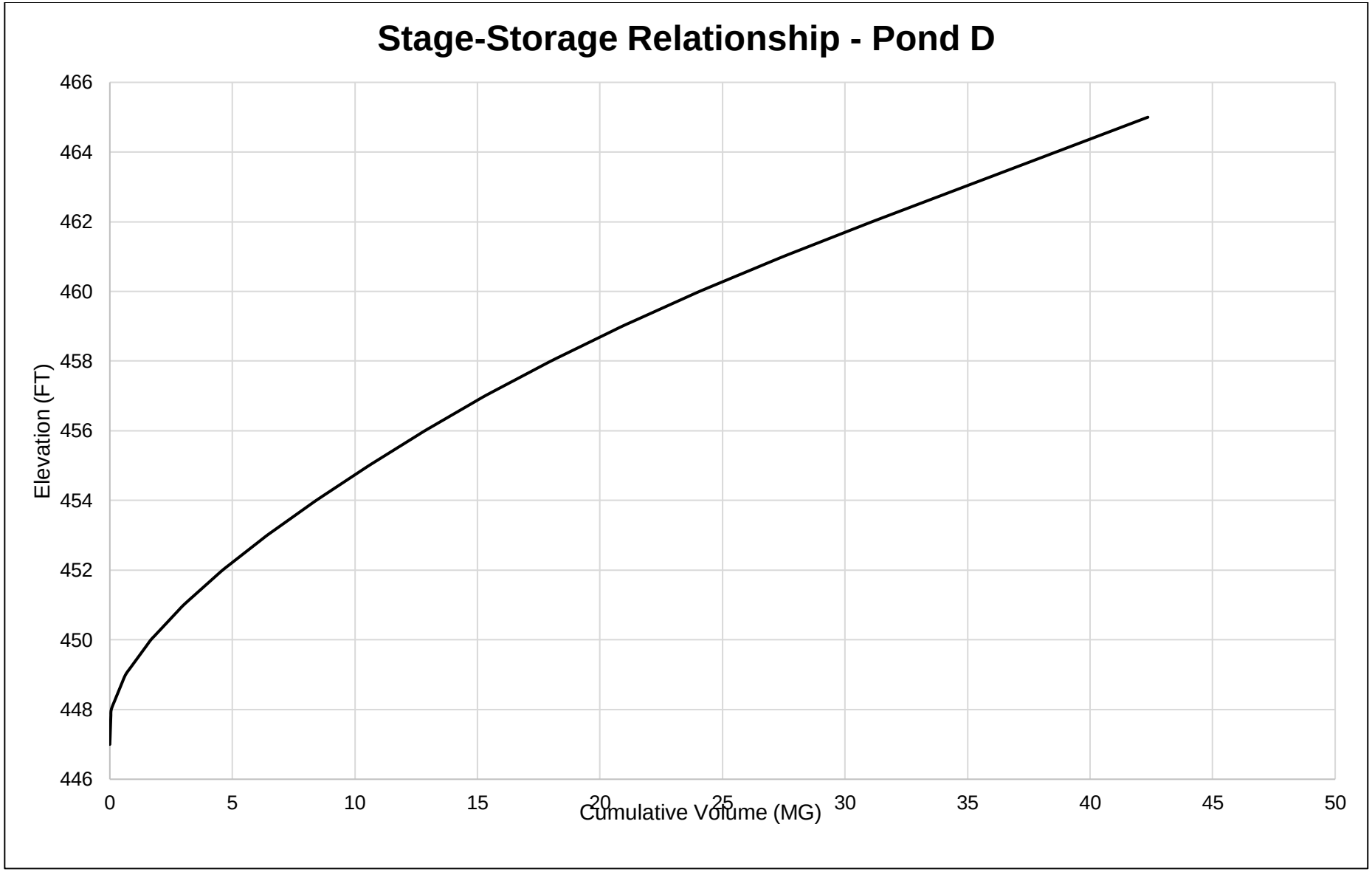
Stage-Storage Relationship Data – Ponds B & C

Elevation (ft, NGVD29)	Cumulative Volume (acre-ft)	(cubic-ft)	(MG)
449	0	0	0.00
449.12	2.855	124,364	0.93
449.24	5.709	248,683	1.86
449.36	8.564	373,047	2.79
449.48	11.419	497,410	3.72
449.6	14.273	621,730	4.65
449.72	17.128	746,094	5.58
449.84	19.983	870,457	6.51
449.96	22.837	994,777	7.44
450.08	25.044	1,090,914	8.16
450.2	26.927	1,172,937	8.77
450.32	28.81	1,254,961	9.39
450.44	30.693	1,336,984	10.00
450.56	32.575	1,418,964	10.61
450.68	34.458	1,500,987	11.23
450.8	36.341	1,583,010	11.84
450.92	38.224	1,665,034	12.46
451.04	40.376	1,758,775	13.16
451.16	43.069	1,876,081	14.03
451.28	45.761	1,993,345	14.91
451.4	48.453	2,110,608	15.79
451.52	51.145	2,227,871	16.67
451.64	53.837	2,345,134	17.54
451.76	56.53	2,462,441	18.42
451.88	59.222	2,579,704	19.30
452	61.914	2,696,968	20.17
452.12	65.372	2,847,598	21.30
452.24	68.83	2,998,228	22.43
452.36	72.287	3,148,814	23.55
452.48	75.745	3,299,445	24.68
452.6	79.203	3,450,075	25.81
452.72	82.661	3,600,705	26.94
452.84	86.119	3,751,335	28.06
452.96	89.576	3,901,922	29.19
453.08	93.489	4,072,371	30.46
453.2	97.63	4,252,753	31.81
453.32	101.77	4,433,091	33.16
453.44	105.911	4,613,473	34.51
453.56	110.051	4,793,811	35.86
453.68	114.192	4,974,192	37.21
453.8	118.332	5,154,530	38.56

Elevation	Cumulative Volume		
(ft, NGVD29)	(acre-ft)	(cubic-ft)	(MG)
453.92	122.473	5,334,912	39.91
454.04	126.799	5,523,352	41.32
454.16	131.497	5,727,996	42.85
454.28	136.195	5,932,641	44.38
454.4	140.893	6,137,285	45.91
454.52	145.592	6,341,973	47.44
454.64	150.29	6,546,617	48.97
454.76	154.988	6,751,262	50.50
454.88	159.686	6,955,906	52.03
455	164.384	7,160,551	53.56
455.12	169.462	7,381,748	55.22
455.24	174.54	7,602,945	56.87
455.36	179.618	7,824,142	58.53
455.48	184.697	8,045,383	60.18
455.6	189.775	8,266,580	61.84
455.72	194.853	8,487,777	63.49
455.84	199.931	8,708,974	65.15
455.96	205.009	8,930,172	66.80
456.08	210.299	9,160,603	68.53
456.2	215.694	9,395,609	70.28
456.32	221.089	9,630,615	72.04
456.44	226.484	9,865,620	73.80
456.56	231.879	10,100,626	75.56
456.68	237.274	10,335,632	77.32
456.8	242.669	10,570,637	79.07
456.92	248.064	10,805,643	80.83
457.04	253.646	11,048,794	82.65
457.16	259.6	11,308,150	84.59
457.28	265.555	11,567,549	86.53
457.4	271.509	11,826,905	88.47
457.52	277.463	12,086,261	90.41
457.64	283.418	12,345,660	92.35
457.76	289.372	12,605,015	94.29
457.88	295.327	12,864,415	96.23
458	301.281	13,123,770	98.17
458.12	307.889	13,411,614	100.33
458.24	314.498	13,699,501	102.48
458.36	321.106	13,987,345	104.63
458.48	327.714	14,275,189	106.79
458.6	334.322	14,563,033	108.94
458.72	340.931	14,850,920	111.09
458.84	347.539	15,138,764	113.25

Elevation	Cumulative Volume		
(ft, NGVD29)	(acre-ft)	(cubic-ft)	(MG)
458.96	354.147	15,426,608	115.40
459.08	361.155	15,731,876	117.68
459.2	368.364	16,045,899	120.03
459.32	375.572	16,359,879	122.38
459.44	382.78	16,673,859	124.73
459.56	389.988	16,987,838	127.08
459.68	397.196	17,301,818	129.43
459.8	404.404	17,615,798	131.78
459.92	411.613	17,929,821	134.12
460.04	419.019	18,252,426	136.54
460.16	426.822	18,592,324	139.08
460.28	434.626	18,932,265	141.62
460.4	442.429	19,272,163	144.17
460.52	450.232	19,612,061	146.71
460.64	458.035	19,951,959	149.25
460.76	465.839	20,291,900	151.79
460.88	473.642	20,631,798	154.34
461	481.445	20,971,696	156.88
461.12	493.124	21,480,432	160.68
461.24	504.803	21,989,168	164.49
461.36	516.482	22,497,904	168.30
461.48	528.161	23,006,640	172.10
461.6	539.84	23,515,376	175.91
461.72	551.519	24,024,112	179.71
461.84	563.198	24,532,849	183.52
461.96	574.877	25,041,585	187.32
462.08	584.536	25,462,330	190.47
462.2	593.185	25,839,079	193.29
462.32	601.835	26,215,872	196.11
462.44	610.484	26,592,622	198.93
462.56	619.133	26,969,372	201.74
462.68	627.782	27,346,121	204.56
462.8	636.431	27,722,871	207.38
462.92	645.081	28,099,664	210.20
463.04	653.73	28,476,413	213.02
463.16	662.379	28,853,163	215.84
463.28	671.028	29,229,913	218.65
463.4	679.677	29,606,662	221.47
463.52	688.327	29,983,455	224.29
463.64	696.976	30,360,205	227.11
463.76	705.625	30,736,954	229.93
463.88	714.274	31,113,704	232.75

Elevation	Cumulative Volume		
(ft, NGVD29)	(acre-ft)	(cubic-ft)	(MG)
464	722.923	31,490,454	235.56
464.12	731.573	31,867,247	238.38
464.24	740.222	32,243,996	241.20
464.36	748.871	32,620,746	244.02
464.48	757.52	32,997,495	246.84
464.6	766.169	33,374,245	249.66
464.72	774.819	33,751,038	252.48
464.84	783.468	34,127,788	255.29
464.96	792.117	34,504,537	258.11


Stage-Storage Relationship - Pond D
Elevation (FT)
466
464
462
460
458
456
454
452
450
448
446
0
5
10
15
20
25
30
35
40
45
50
Cumulative Volume (MG)

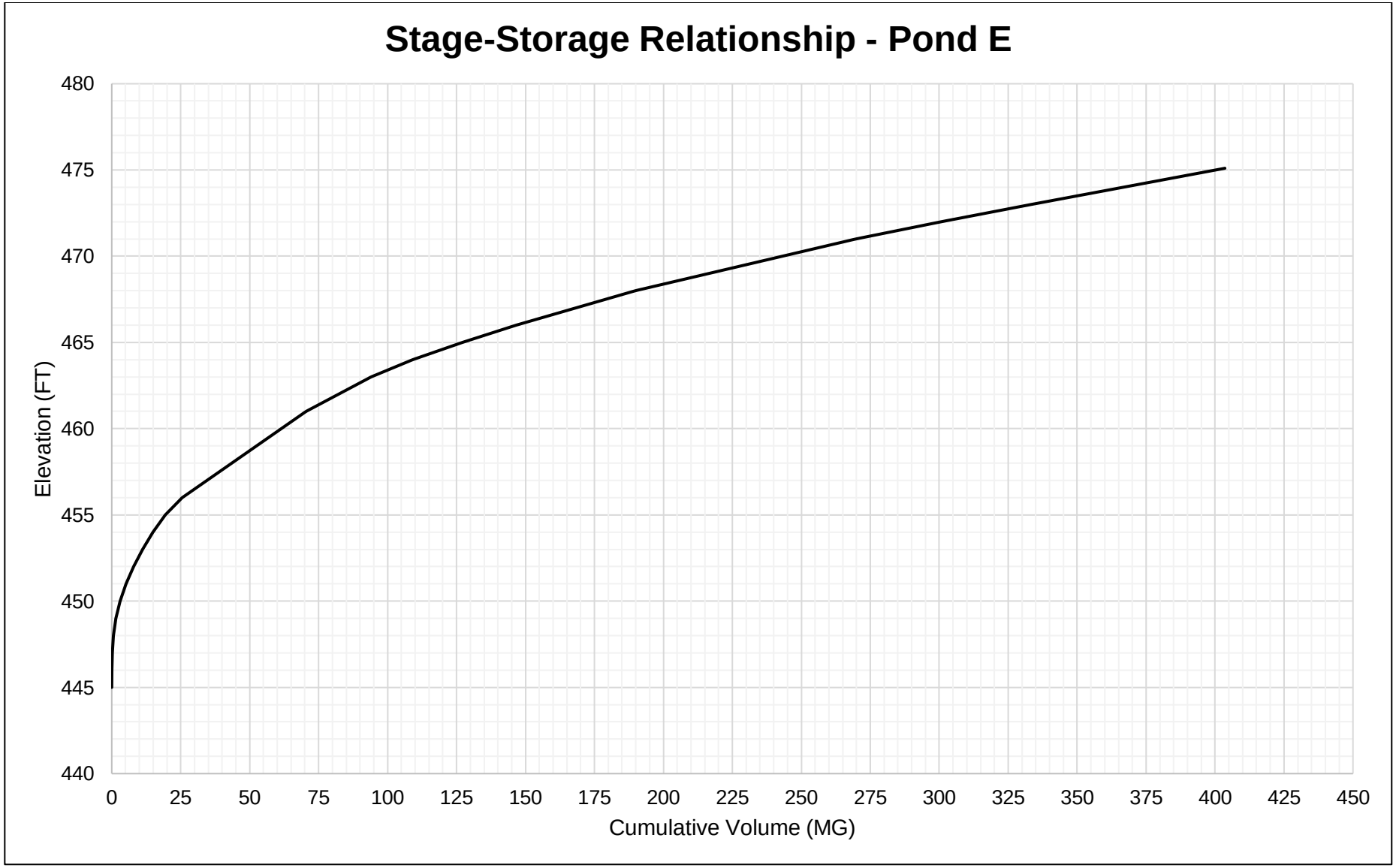
Stage-Storage Relationship Data – Pond D

Elevation (ft, NGVD29)	Cumulative Volume (acre-ft)	(cubic-ft)	(MG)
447	0	0	0.00
447.12	0.018	784	0.01
447.24	0.037	1,612	0.01
447.36	0.055	2,396	0.02
447.48	0.073	3,180	0.02
447.6	0.092	4,008	0.03
447.72	0.11	4,792	0.04
447.84	0.129	5,619	0.04
447.96	0.147	6,403	0.05
448.08	0.296	12,894	0.10
448.2	0.511	22,259	0.17
448.32	0.726	31,624	0.24
448.44	0.941	40,990	0.31
448.56	1.156	50,355	0.38
448.68	1.371	59,721	0.45
448.8	1.586	69,086	0.52
448.92	1.801	78,451	0.59
449.04	2.072	90,256	0.68
449.16	2.454	106,896	0.80
449.28	2.837	123,579	0.92
449.4	3.22	140,263	1.05
449.52	3.603	156,946	1.17
449.64	3.986	173,630	1.30
449.76	4.368	190,270	1.42
449.88	4.751	206,953	1.55
450	5.134	223,637	1.67
450.12	5.625	245,024	1.83
450.24	6.115	266,369	1.99
450.36	6.606	287,757	2.15
450.48	7.096	309,101	2.31
450.6	7.587	330,489	2.47
450.72	8.077	351,833	2.63
450.84	8.568	373,221	2.79
450.96	9.058	394,566	2.95
451.08	9.612	418,698	3.13
451.2	10.198	444,224	3.32
451.32	10.784	469,750	3.51
451.44	11.369	495,233	3.70
451.56	11.955	520,759	3.90
451.68	12.54	546,241	4.09
451.8	13.126	571,767	4.28

Elevation (ft, NGVD29)	Cumulative Volume (acre-ft)	(cubic-ft)	(MG)
451.92	13.712	597,293	4.47
452.04	14.325	623,996	4.67
452.16	14.996	653,224	4.89
452.28	15.666	682,409	5.10
452.4	16.336	711,595	5.32
452.52	17.006	740,780	5.54
452.64	17.676	769,965	5.76
452.76	18.347	799,193	5.98
452.88	19.017	828,379	6.20
453	19.687	857,564	6.42
453.12	20.423	889,624	6.65
453.24	21.159	921,684	6.89
453.36	21.895	953,744	7.13
453.48	22.631	985,804	7.37
453.6	23.367	1,017,864	7.61
453.72	24.103	1,049,924	7.85
453.84	24.839	1,081,984	8.09
453.96	25.575	1,114,044	8.33
454.08	26.349	1,147,760	8.59
454.2	27.142	1,182,303	8.84
454.32	27.935	1,216,846	9.10
454.44	28.728	1,251,389	9.36
454.56	29.521	1,285,932	9.62
454.68	30.314	1,320,475	9.88
454.8	31.107	1,355,018	10.14
454.92	31.9	1,389,561	10.39
455.04	32.709	1,424,801	10.66
455.16	33.55	1,461,435	10.93
455.28	34.391	1,498,069	11.21
455.4	35.232	1,534,702	11.48
455.52	36.073	1,571,336	11.75
455.64	36.914	1,607,970	12.03
455.76	37.755	1,644,604	12.30
455.88	38.596	1,681,238	12.58
456	39.437	1,717,872	12.85
456.12	40.339	1,757,163	13.14
456.24	41.241	1,796,454	13.44
456.36	42.142	1,835,701	13.73
456.48	43.044	1,874,992	14.03
456.6	43.946	1,914,283	14.32
456.72	44.848	1,953,574	14.61
456.84	45.75	1,992,865	14.91

Elevation	Cumulative Volume		
(ft, NGVD29)	(acre-ft)	(cubic-ft)	(MG)
456.96	46.651	2,032,113	15.20
457.08	47.613	2,074,018	15.51
457.2	48.605	2,117,229	15.84
457.32	49.596	2,160,397	16.16
457.44	50.588	2,203,608	16.48
457.56	51.58	2,246,820	16.81
457.68	52.572	2,290,031	17.13
457.8	53.563	2,333,199	17.45
457.92	54.555	2,376,410	17.78
458.04	55.574	2,420,798	18.11
458.16	56.646	2,467,494	18.46
458.28	57.719	2,514,234	18.81
458.4	58.792	2,560,974	19.16
458.52	59.865	2,607,713	19.51
458.64	60.938	2,654,453	19.86
458.76	62.01	2,701,149	20.21
458.88	63.083	2,747,889	20.56
459	64.156	2,794,629	20.91
459.12	65.317	2,845,202	21.28
459.24	66.478	2,895,775	21.66
459.36	67.639	2,946,348	22.04
459.48	68.8	2,996,921	22.42
459.6	69.961	3,047,494	22.80
459.72	71.122	3,098,067	23.18
459.84	72.283	3,148,640	23.55
459.96	73.444	3,199,213	23.93
460.08	74.669	3,252,574	24.33
460.2	75.927	3,307,373	24.74
460.32	77.184	3,362,127	25.15
460.44	78.441	3,416,882	25.56
460.56	79.699	3,471,680	25.97
460.68	80.956	3,526,435	26.38
460.8	82.213	3,581,190	26.79
460.92	83.471	3,635,988	27.20
461.04	84.755	3,691,919	27.62
461.16	86.092	3,750,159	28.05
461.28	87.429	3,808,398	28.49
461.4	88.766	3,866,638	28.92
461.52	90.103	3,924,878	29.36
461.64	91.44	3,983,117	29.80
461.76	92.777	4,041,357	30.23
461.88	94.114	4,099,596	30.67

Elevation (ft, NGVD29)	Cumulative Volume (acre-ft)	(cubic-ft)	(MG)
462	95.451	4,157,836	31.10
462.12	96.833	4,218,036	31.55
462.24	98.214	4,278,192	32.00
462.36	99.596	4,338,392	32.45
462.48	100.978	4,398,592	32.90
462.6	102.36	4,458,791	33.35
462.72	103.741	4,518,948	33.80
462.84	105.123	4,579,147	34.25
462.96	106.505	4,639,347	34.70
463.08	107.886	4,699,503	35.15
463.2	109.268	4,759,703	35.61
463.32	110.65	4,819,903	36.06
463.44	112.032	4,880,103	36.51
463.56	113.413	4,940,259	36.96
463.68	114.795	5,000,459	37.41
463.8	116.177	5,060,659	37.86
463.92	117.559	5,120,858	38.31
464.04	118.94	5,181,015	38.76
464.16	120.322	5,241,214	39.21
464.28	121.704	5,301,414	39.66
464.4	123.085	5,361,570	40.11
464.52	124.467	5,421,770	40.56
464.64	125.849	5,481,970	41.01
464.76	127.231	5,542,170	41.46
464.88	128.612	5,602,326	41.91
465	129.994	5,662,526	42.36


Stage-Storage Relationship - Pond E
Elevation (FT)
480
475
470
465
460
455
450
445
440
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425
450
Cumulative Volume (MG)

Stage-Storage Relationship Data – Pond E

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
445	0	411	0	0.00
445.07	0.07	1,320	483	0.00
445.14	0.14	2,228	966	0.01
445.21	0.21	3,137	1,449	0.01
445.28	0.28	4,045	1,932	0.01
445.35	0.35	4,954	2,415	0.02
445.42	0.42	5,863	2,898	0.02
445.49	0.49	6,771	3,381	0.03
445.56	0.56	7,680	3,865	0.03
445.63	0.63	8,588	4,348	0.03
445.7	0.7	9,497	4,831	0.04
445.77	0.77	10,406	5,314	0.04
445.84	0.84	11,314	5,797	0.04
445.91	0.91	12,223	6,280	0.05
445.98	0.98	13,131	6,763	0.05
446.05	1.05	14,249	7,999	0.06
446.12	1.12	15,450	9,537	0.07
446.19	1.19	16,651	11,075	0.08
446.26	1.26	17,852	12,613	0.09
446.33	1.33	19,053	14,151	0.11
446.4	1.4	20,254	15,689	0.12
446.47	1.47	21,455	17,227	0.13
446.54	1.54	22,656	18,765	0.14
446.61	1.61	23,857	20,302	0.15
446.68	1.68	25,058	21,840	0.16
446.75	1.75	26,259	23,378	0.17
446.82	1.82	27,460	24,916	0.19
446.89	1.89	28,661	26,454	0.20
446.96	1.96	29,862	27,992	0.21
447.03	2.03	31,844	30,435	0.23
447.1	2.1	34,870	34,086	0.25
447.17	2.17	37,895	37,737	0.28
447.24	2.24	40,920	41,388	0.31
447.31	2.31	43,945	45,039	0.34
447.38	2.38	46,970	48,690	0.36
447.45	2.45	49,995	52,341	0.39
447.52	2.52	53,020	55,992	0.42
447.59	2.59	56,045	59,643	0.45
447.66	2.66	59,071	63,293	0.47
447.73	2.73	62,096	66,944	0.50
447.8	2.8	65,121	70,595	0.53

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
447.87	2.87	68,146	74,246	0.56
447.94	2.94	71,171	77,897	0.58
448.01	3.01	74,654	82,209	0.61
448.08	3.08	80,884	90,488	0.68
448.15	3.15	87,115	98,767	0.74
448.22	3.22	93,345	107,045	0.80
448.29	3.29	99,576	115,324	0.86
448.36	3.36	105,806	123,603	0.92
448.43	3.43	112,037	131,881	0.99
448.5	3.5	118,267	140,160	1.05
448.57	3.57	124,497	148,439	1.11
448.64	3.64	130,728	156,717	1.17
448.71	3.71	136,958	164,996	1.23
448.78	3.78	143,189	173,275	1.30
448.85	3.85	149,419	181,553	1.36
448.92	3.92	155,650	189,832	1.42
448.99	3.99	161,880	198,111	1.48
449.06	4.06	167,838	211,594	1.58
449.13	4.13	173,751	225,944	1.69
449.2	4.2	179,664	240,294	1.80
449.27	4.27	185,577	254,645	1.90
449.34	4.34	191,490	268,995	2.01
449.41	4.41	197,403	283,346	2.12
449.48	4.48	203,316	297,696	2.23
449.55	4.55	209,229	312,046	2.33
449.62	4.62	215,141	326,397	2.44
449.69	4.69	221,054	340,747	2.55
449.76	4.76	226,967	355,097	2.66
449.83	4.83	232,880	369,448	2.76
449.9	4.9	238,793	383,798	2.87
449.97	4.97	244,706	398,148	2.98
450.04	5.04	250,413	415,775	3.11
450.11	5.11	255,966	435,858	3.26
450.18	5.18	261,519	455,941	3.41
450.25	5.25	267,071	476,024	3.56
450.32	5.32	272,624	496,107	3.71
450.39	5.39	278,177	516,190	3.86
450.46	5.46	283,729	536,274	4.01
450.53	5.53	289,282	556,357	4.16
450.6	5.6	294,835	576,440	4.31
450.67	5.67	300,388	596,523	4.46
450.74	5.74	305,941	616,606	4.61

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
450.81	5.81	311,493	636,690	4.76
450.88	5.88	317,046	656,773	4.91
450.95	5.95	322,599	676,856	5.06
451.02	6.02	328,180	698,540	5.23
451.09	6.09	333,832	724,226	5.42
451.16	6.16	339,485	749,911	5.61
451.23	6.23	345,138	775,597	5.80
451.3	6.3	350,790	801,283	5.99
451.37	6.37	356,443	826,969	6.19
451.44	6.44	362,095	852,655	6.38
451.51	6.51	367,747	878,340	6.57
451.58	6.58	373,400	904,026	6.76
451.65	6.65	379,052	929,712	6.95
451.72	6.72	384,705	955,398	7.15
451.79	6.79	390,358	981,084	7.34
451.86	6.86	396,010	1,006,769	7.53
451.93	6.93	401,663	1,032,455	7.72
452	7	407,315	1,058,141	7.92
452.07	7.07	411,459	1,088,725	8.14
452.14	7.14	415,602	1,119,309	8.37
452.21	7.21	419,746	1,149,893	8.60
452.28	7.28	423,890	1,180,476	8.83
452.35	7.35	428,033	1,211,060	9.06
452.42	7.42	432,177	1,241,644	9.29
452.49	7.49	436,321	1,272,228	9.52
452.56	7.56	440,464	1,302,812	9.75
452.63	7.63	444,608	1,333,396	9.97
452.7	7.7	448,751	1,363,980	10.20
452.77	7.77	452,895	1,394,564	10.43
452.84	7.84	457,039	1,425,147	10.66
452.91	7.91	461,182	1,455,731	10.89
452.98	7.98	465,326	1,486,315	11.12
453.05	8.05	469,975	1,520,112	11.37
453.12	8.12	474,826	1,555,193	11.63
453.19	8.19	479,677	1,590,274	11.90
453.26	8.26	484,528	1,625,355	12.16
453.33	8.33	489,379	1,660,436	12.42
453.4	8.4	494,230	1,695,518	12.68
453.47	8.47	499,081	1,730,599	12.95
453.54	8.54	503,933	1,765,680	13.21
453.61	8.61	508,784	1,800,761	13.47
453.68	8.68	513,635	1,835,843	13.73

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
453.75	8.75	518,486	1,870,924	14.00
453.82	8.82	523,337	1,906,005	14.26
453.89	8.89	528,188	1,941,086	14.52
453.96	8.96	533,039	1,976,168	14.78
454.03	9.03	539,573	2,014,169	15.07
454.1	9.1	548,350	2,056,065	15.38
454.17	9.17	557,127	2,097,960	15.69
454.24	9.24	565,905	2,139,855	16.01
454.31	9.31	574,682	2,181,751	16.32
454.38	9.38	583,459	2,223,646	16.63
454.45	9.45	592,236	2,265,542	16.95
454.52	9.52	601,014	2,307,437	17.26
454.59	9.59	609,791	2,349,333	17.57
454.66	9.66	618,568	2,391,228	17.89
454.73	9.73	627,346	2,433,123	18.20
454.8	9.8	636,123	2,475,019	18.51
454.87	9.87	644,900	2,516,914	18.83
454.94	9.94	653,678	2,558,810	19.14
455.01	10.01	664,358	2,602,911	19.47
455.08	10.08	686,460	2,660,246	19.90
455.15	10.15	708,562	2,717,580	20.33
455.22	10.22	730,663	2,774,915	20.76
455.29	10.29	752,765	2,832,250	21.19
455.36	10.36	774,867	2,889,585	21.62
455.43	10.43	796,968	2,946,920	22.04
455.5	10.5	819,070	3,004,255	22.47
455.57	10.57	841,172	3,061,590	22.90
455.64	10.64	863,273	3,118,925	23.33
455.71	10.71	885,375	3,176,260	23.76
455.78	10.78	907,477	3,233,595	24.19
455.85	10.85	929,578	3,290,930	24.62
455.92	10.92	951,680	3,348,264	25.05
455.99	10.99	973,782	3,405,599	25.48
456.06	11.06	982,304	3,485,818	26.08
456.13	11.13	988,562	3,569,850	26.70
456.2	11.2	994,821	3,653,883	27.33
456.27	11.27	1,001,080	3,737,915	27.96
456.34	11.34	1,007,338	3,821,948	28.59
456.41	11.41	1,013,597	3,905,980	29.22
456.48	11.48	1,019,856	3,990,013	29.85
456.55	11.55	1,026,115	4,074,045	30.48
456.62	11.62	1,032,373	4,158,078	31.10

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
456.69	11.69	1,038,632	4,242,111	31.73
456.76	11.76	1,044,891	4,326,143	32.36
456.83	11.83	1,051,149	4,410,176	32.99
456.9	11.9	1,057,408	4,494,208	33.62
456.97	11.97	1,063,667	4,578,241	34.25
457.04	12.04	1,069,926	4,662,273	34.88
457.11	12.11	1,076,184	4,746,306	35.50
457.18	12.18	1,082,443	4,830,338	36.13
457.25	12.25	1,088,702	4,914,371	36.76
457.32	12.32	1,094,960	4,998,403	37.39
457.39	12.39	1,101,219	5,082,436	38.02
457.46	12.46	1,107,478	5,166,468	38.65
457.53	12.53	1,113,737	5,250,501	39.28
457.6	12.6	1,119,995	5,334,533	39.91
457.67	12.67	1,126,254	5,418,566	40.53
457.74	12.74	1,132,513	5,502,598	41.16
457.81	12.81	1,138,771	5,586,631	41.79
457.88	12.88	1,145,030	5,670,663	42.42
457.95	12.95	1,151,289	5,754,696	43.05
458.02	13.02	1,157,548	5,838,728	43.68
458.09	13.09	1,163,806	5,922,761	44.31
458.16	13.16	1,170,065	6,006,793	44.93
458.23	13.23	1,176,324	6,090,826	45.56
458.3	13.3	1,182,582	6,174,858	46.19
458.37	13.37	1,188,841	6,258,891	46.82
458.44	13.44	1,195,100	6,342,923	47.45
458.51	13.51	1,201,359	6,426,956	48.08
458.58	13.58	1,207,617	6,510,988	48.71
458.65	13.65	1,213,876	6,595,021	49.33
458.72	13.72	1,220,135	6,679,053	49.96
458.79	13.79	1,226,393	6,763,086	50.59
458.86	13.86	1,232,652	6,847,118	51.22
458.93	13.93	1,238,911	6,931,151	51.85
459	14	1,245,170	7,015,184	52.48
459.07	14.07	1,251,428	7,099,216	53.11
459.14	14.14	1,257,687	7,183,249	53.73
459.21	14.21	1,263,946	7,267,281	54.36
459.28	14.28	1,270,204	7,351,314	54.99
459.35	14.35	1,276,463	7,435,346	55.62
459.42	14.42	1,282,722	7,519,379	56.25
459.49	14.49	1,288,981	7,603,411	56.88
459.56	14.56	1,295,239	7,687,444	57.51

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
459.63	14.63	1,301,498	7,771,476	58.13
459.7	14.7	1,307,757	7,855,509	58.76
459.77	14.77	1,314,015	7,939,541	59.39
459.84	14.84	1,320,274	8,023,574	60.02
459.91	14.91	1,326,533	8,107,606	60.65
459.98	14.98	1,332,792	8,191,639	61.28
460.05	15.05	1,339,050	8,275,671	61.91
460.12	15.12	1,345,309	8,359,704	62.53
460.19	15.19	1,351,568	8,443,736	63.16
460.26	15.26	1,357,826	8,527,769	63.79
460.33	15.33	1,364,085	8,611,801	64.42
460.4	15.4	1,370,344	8,695,834	65.05
460.47	15.47	1,376,603	8,779,866	65.68
460.54	15.54	1,382,861	8,863,899	66.31
460.61	15.61	1,389,120	8,947,931	66.94
460.68	15.68	1,395,379	9,031,964	67.56
460.75	15.75	1,401,637	9,115,996	68.19
460.82	15.82	1,407,896	9,200,029	68.82
460.89	15.89	1,414,155	9,284,061	69.45
460.96	15.96	1,420,414	9,368,094	70.08
461.03	16.03	1,428,562	9,463,404	70.79
461.1	16.1	1,439,228	9,573,750	71.62
461.17	16.17	1,449,895	9,684,096	72.44
461.24	16.24	1,460,562	9,794,442	73.27
461.31	16.31	1,471,229	9,904,788	74.09
461.38	16.38	1,481,896	10,015,135	74.92
461.45	16.45	1,492,563	10,125,481	75.74
461.52	16.52	1,503,230	10,235,827	76.57
461.59	16.59	1,513,897	10,346,173	77.39
461.66	16.66	1,524,563	10,456,519	78.22
461.73	16.73	1,535,230	10,566,866	79.05
461.8	16.8	1,545,897	10,677,212	79.87
461.87	16.87	1,556,564	10,787,558	80.70
461.94	16.94	1,567,231	10,897,904	81.52
462.01	17.01	1,577,898	11,008,250	82.35
462.08	17.08	1,588,565	11,118,596	83.17
462.15	17.15	1,599,232	11,228,943	84.00
462.22	17.22	1,609,898	11,339,289	84.82
462.29	17.29	1,620,565	11,449,635	85.65
462.36	17.36	1,631,232	11,559,981	86.47
462.43	17.43	1,641,899	11,670,327	87.30
462.5	17.5	1,652,566	11,780,674	88.13

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
462.57	17.57	1,663,233	11,891,020	88.95
462.64	17.64	1,673,900	12,001,366	89.78
462.71	17.71	1,684,567	12,111,712	90.60
462.78	17.78	1,695,234	12,222,058	91.43
462.85	17.85	1,705,900	12,332,404	92.25
462.92	17.92	1,716,567	12,442,751	93.08
462.99	17.99	1,727,234	12,553,097	93.90
463.06	18.06	1,763,079	12,689,746	94.93
463.13	18.13	1,803,120	12,830,780	95.98
463.2	18.2	1,843,160	12,971,813	97.04
463.27	18.27	1,883,201	13,112,847	98.09
463.34	18.34	1,923,242	13,253,880	99.15
463.41	18.41	1,963,283	13,394,914	100.20
463.48	18.48	2,003,324	13,535,947	101.26
463.55	18.55	2,043,365	13,676,981	102.31
463.62	18.62	2,083,405	13,818,014	103.37
463.69	18.69	2,123,446	13,959,048	104.42
463.76	18.76	2,163,487	14,100,081	105.48
463.83	18.83	2,203,528	14,241,115	106.53
463.9	18.9	2,243,569	14,382,148	107.59
463.97	18.97	2,283,610	14,523,182	108.64
464.04	19.04	2,309,194	14,679,867	109.81
464.11	19.11	2,323,937	14,848,293	111.07
464.18	19.18	2,338,679	15,016,718	112.33
464.25	19.25	2,353,422	15,185,143	113.59
464.32	19.32	2,368,164	15,353,568	114.85
464.39	19.39	2,382,906	15,521,993	116.11
464.46	19.46	2,397,649	15,690,418	117.37
464.53	19.53	2,412,391	15,858,843	118.63
464.6	19.6	2,427,134	16,027,268	119.89
464.67	19.67	2,441,876	16,195,693	121.15
464.74	19.74	2,456,618	16,364,119	122.41
464.81	19.81	2,471,361	16,532,544	123.67
464.88	19.88	2,486,103	16,700,969	124.93
464.95	19.95	2,500,846	16,869,394	126.19
465.02	20.02	2,515,108	17,041,791	127.48
465.09	20.09	2,528,171	17,224,119	128.85
465.16	20.16	2,541,234	17,406,447	130.21
465.23	20.23	2,554,297	17,588,774	131.57
465.3	20.3	2,567,360	17,771,102	132.94
465.37	20.37	2,580,423	17,953,430	134.30
465.44	20.44	2,593,486	18,135,758	135.66

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
465.51	20.51	2,606,549	18,318,086	137.03
465.58	20.58	2,619,612	18,500,413	138.39
465.65	20.65	2,632,674	18,682,741	139.76
465.72	20.72	2,645,737	18,865,069	141.12
465.79	20.79	2,658,800	19,047,397	142.48
465.86	20.86	2,671,863	19,229,724	143.85
465.93	20.93	2,684,926	19,412,052	145.21
466	21	2,697,989	19,594,380	146.58
466.07	21.07	2,711,579	19,796,829	148.09
466.14	21.14	2,725,169	19,999,279	149.60
466.21	21.21	2,738,760	20,201,728	151.12
466.28	21.28	2,752,350	20,404,178	152.63
466.35	21.35	2,765,940	20,606,627	154.15
466.42	21.42	2,779,530	20,809,077	155.66
466.49	21.49	2,793,121	21,011,526	157.18
466.56	21.56	2,806,711	21,213,976	158.69
466.63	21.63	2,820,301	21,416,425	160.21
466.7	21.7	2,833,891	21,618,874	161.72
466.77	21.77	2,847,481	21,821,324	163.23
466.84	21.84	2,861,072	22,023,773	164.75
466.91	21.91	2,874,662	22,226,223	166.26
466.98	21.98	2,888,252	22,428,672	167.78
467.05	22.05	2,901,842	22,631,122	169.29
467.12	22.12	2,915,433	22,833,571	170.81
467.19	22.19	2,929,023	23,036,021	172.32
467.26	22.26	2,942,613	23,238,470	173.84
467.33	22.33	2,956,203	23,440,920	175.35
467.4	22.4	2,969,793	23,643,369	176.86
467.47	22.47	2,983,384	23,845,818	178.38
467.54	22.54	2,996,974	24,048,268	179.89
467.61	22.61	3,010,564	24,250,717	181.41
467.68	22.68	3,024,154	24,453,167	182.92
467.75	22.75	3,037,745	24,655,616	184.44
467.82	22.82	3,051,335	24,858,066	185.95
467.89	22.89	3,064,925	25,060,515	187.47
467.96	22.96	3,078,515	25,262,965	188.98
468.03	23.03	3,095,778	25,485,484	190.64
468.1	23.1	3,117,938	25,734,763	192.51
468.17	23.17	3,140,097	25,984,042	194.37
468.24	23.24	3,162,257	26,233,321	196.24
468.31	23.31	3,184,416	26,482,600	198.10
468.38	23.38	3,206,576	26,731,879	199.97

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
468.45	23.45	3,228,736	26,981,158	201.83
468.52	23.52	3,250,895	27,230,438	203.70
468.59	23.59	3,273,055	27,479,717	205.56
468.66	23.66	3,295,215	27,728,996	207.43
468.73	23.73	3,317,374	27,978,275	209.29
468.8	23.8	3,339,534	28,227,554	211.16
468.87	23.87	3,361,693	28,476,833	213.02
468.94	23.94	3,383,853	28,726,112	214.89
469.01	24.01	3,406,013	28,975,391	216.75
469.08	24.08	3,428,172	29,224,670	218.62
469.15	24.15	3,450,332	29,473,949	220.48
469.22	24.22	3,472,492	29,723,229	222.35
469.29	24.29	3,494,651	29,972,508	224.21
469.36	24.36	3,516,811	30,221,787	226.07
469.43	24.43	3,538,970	30,471,066	227.94
469.5	24.5	3,561,130	30,720,345	229.80
469.57	24.57	3,583,290	30,969,624	231.67
469.64	24.64	3,605,449	31,218,903	233.53
469.71	24.71	3,627,609	31,468,182	235.40
469.78	24.78	3,649,768	31,717,461	237.26
469.85	24.85	3,671,928	31,966,741	239.13
469.92	24.92	3,694,088	32,216,020	240.99
469.99	24.99	3,716,247	32,465,299	242.86
470.06	25.06	3,738,407	32,714,578	244.72
470.13	25.13	3,760,567	32,963,857	246.59
470.2	25.2	3,782,726	33,213,136	248.45
470.27	25.27	3,804,886	33,462,415	250.32
470.34	25.34	3,827,045	33,711,694	252.18
470.41	25.41	3,849,205	33,960,973	254.05
470.48	25.48	3,871,365	34,210,252	255.91
470.55	25.55	3,893,524	34,459,532	257.78
470.62	25.62	3,915,684	34,708,811	259.64
470.69	25.69	3,937,844	34,958,090	261.50
470.76	25.76	3,960,003	35,207,369	263.37
470.83	25.83	3,982,163	35,456,648	265.23
470.9	25.9	4,004,322	35,705,927	267.10
470.97	25.97	4,026,482	35,955,206	268.96
471.04	26.04	4,044,713	36,227,846	271.00
471.11	26.11	4,059,997	36,518,007	273.17
471.18	26.18	4,075,281	36,808,167	275.34
471.25	26.25	4,090,565	37,098,328	277.51
471.32	26.32	4,105,849	37,388,488	279.69

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
471.39	26.39	4,121,134	37,678,649	281.86
471.46	26.46	4,136,418	37,968,810	284.03
471.53	26.53	4,151,702	38,258,970	286.20
471.6	26.6	4,166,986	38,549,131	288.37
471.67	26.67	4,182,270	38,839,292	290.54
471.74	26.74	4,197,554	39,129,452	292.71
471.81	26.81	4,212,838	39,419,613	294.88
471.88	26.88	4,228,123	39,709,773	297.05
471.95	26.95	4,243,407	39,999,934	299.22
472.02	27.02	4,258,163	40,294,197	301.42
472.09	27.09	4,271,599	40,598,718	303.70
472.16	27.16	4,285,035	40,903,239	305.98
472.23	27.23	4,298,471	41,207,759	308.26
472.3	27.3	4,311,907	41,512,280	310.53
472.37	27.37	4,325,343	41,816,801	312.81
472.44	27.44	4,338,779	42,121,322	315.09
472.51	27.51	4,352,215	42,425,842	317.37
472.58	27.58	4,365,651	42,730,363	319.65
472.65	27.65	4,379,087	43,034,884	321.92
472.72	27.72	4,392,523	43,339,404	324.20
472.79	27.79	4,405,959	43,643,925	326.48
472.86	27.86	4,419,395	43,948,446	328.76
472.93	27.93	4,432,831	44,252,966	331.04
473	28	4,446,267	44,557,487	333.31
473.07	28.07	4,448,058	44,870,606	335.66
473.14	28.14	4,449,849	45,183,726	338.00
473.21	28.21	4,451,640	45,496,845	340.34
473.28	28.28	4,453,431	45,809,964	342.68
473.35	28.35	4,455,223	46,123,084	345.02
473.42	28.42	4,457,014	46,436,203	347.37
473.49	28.49	4,458,805	46,749,322	349.71
473.56	28.56	4,460,596	47,062,442	352.05
473.63	28.63	4,462,387	47,375,561	354.39
473.7	28.7	4,464,178	47,688,680	356.74
473.77	28.77	4,465,969	48,001,800	359.08
473.84	28.84	4,467,760	48,314,919	361.42
473.91	28.91	4,469,551	48,628,038	363.76
473.98	28.98	4,471,342	48,941,158	366.11
474.05	29.05	4,473,134	49,254,277	368.45
474.12	29.12	4,474,925	49,567,397	370.79
474.19	29.19	4,476,716	49,880,516	373.13
474.26	29.26	4,478,507	50,193,635	375.47

Elevation (ft, NGVD29)	Depth (ft)	Surface Area (sq-ft)	Cumulative Volume (cubic-ft)	(MG)
474.33	29.33	4,480,298	50,506,755	377.82
474.4	29.4	4,482,089	50,819,874	380.16
474.47	29.47	4,483,880	51,132,993	382.50
474.54	29.54	4,485,671	51,446,113	384.84
474.61	29.61	4,487,462	51,759,232	387.19
474.68	29.68	4,489,253	52,072,351	389.53
474.75	29.75	4,491,044	52,385,471	391.87
474.82	29.82	4,492,836	52,698,590	394.21
474.89	29.89	4,494,627	53,011,709	396.56
474.96	29.96	4,496,418	53,324,829	398.90
475.03	30.03	4,498,209	53,637,948	401.24
475.1	30.1	4,500,000	53,951,067	403.58

Attachment B – Trigger/Action Matrix

Trigger/Action Matrix

Drawdown Stage	Operational Monitoring				Trigger Value	Action	Supporting Documentation
	Parameter	Sampling Frequency	Report Statistical Base	Threshold Value			
Stage 1: Initial Free Water Decanting (Drawdown to WSE 455.0 ft in Pond A, 454.0 feet in Stilling Ponds (Ponds B, C, and D), and 450.0 ft in Pond E discharge through Outfall 001	Rainfall over last 24 hours	Daily	Daily Average	Rainfall = 0.14”/d	Rainfall = 0.14”/d	Maintain drawdown flow rate	Gravity Systems Operation (Stop logs and Siphons)
	Rainfall over last 24 hours	Daily	Daily Maximum	Rainfall = 1"/d	Rainfall = 0.80"/d	Verify Turbidity, and possibly lower flow rate	Gravity Systems Operation (Stop logs and Siphons)
	Free water level elevation change (Pond A and Pond E)	Daily	Daily Maximum	Elevation Change = 1 ft/day	Elevation Change = 1 ft/day	Reduce drawdown rate (add stop logs break suction on siphons)	Gravity Systems Operation (Stop logs and Siphons)
	Outfall 001 TSS	Grab, Daily	Monthly Average	TSS = 28 mg/L (Turbidity = 28 NTU)	Instantaneous Tur = 28 NTU	Reduce drawdown rate (add stop logs break suction on siphons)	Gravity Systems Operation (Stop logs and Siphons)
	Outfall 001 TSS	Grab, Daily	Daily Maximum	TSS = 93 mg/L (Turbidity = 93 NTU)	Instantaneous Tur = 83.7 NTU	Cease discharge OR Proceed with Stage 2 if exceedances persist or if ceasing discharge is not practical	Gravity Systems Operation (Stop logs and Siphons)
	Outfall 001 Flow Rate	Daily	Daily Average	4.82 MGD = 3,350 GPM	N/A	Maintain pump rate at 4.82 MGD	Pump operator’s manual
	Flow Rate from Pond A	Daily	Daily Average	2.74 MGD = 1,900 GPM	N/A	Maintain pump rate at 2.74 MGD	Pump operator’s manual
	Flow Rate from Pond E	Daily	Daily Average	1.30 MGD = 900 GPM	N/A	Maintain pump rate at 1.30 MGD	Pump operator’s manual
	Pond A Water Level	Daily	Daily Minimum	462.0 ft	Pool Level = 462.0 ft	Cease use of siphon and switch to pump system	Gravity Systems Operation (Siphons)
	Pond A Water Level	Daily	Daily Minimum	455.0 ft	Pool Level = 455.0 ft	Cease drawdown	Pump operator’s manual
	Pond E Water Level	Daily	Daily Minimum	450.0 ft	Pool Level = 450.0 ft	Cease Pumping from Pond E	Pump operator’s manual

Drawdown Stage	Operational Monitoring				Trigger Value	Action	Supporting Documentation
	Parameter	Sampling Frequency	Report Statistical Base	Threshold Value			
	Stilling Ponds B&C Water Level	Daily	Daily Minimum	454.1 ft	Pool Level = 454.1 ft	Cease drawdown (add stop logs break suction on siphons)	Gravity Systems Operation (Stop logs and Siphons)
	Stilling Pond D Water Level	Daily	Daily Minimum	454.1 ft	Pool Level = 454.1 ft	Cease drawdown (add stop logs break suction on siphons)	Gravity Systems Operation (Stop logs and Siphons)
Stage 2: Final Free Water Decanting. (Drawdown to WSE 450.0 ft in Pond A, 449.0 feet in Stilling Ponds B&C, 447.0 in Stilling Pond D, and 445.0 ft in Pond E) discharge through Outfall 001	Rainfall over last 24 hours	Daily	Daily Average	Rainfall = 0.14”/d	Rainfall = 0.14”/d	Maintain drawdown pump flow rate	Pump operator’s manual
	Rainfall over last 24 hours	Daily	Daily Maximum	Rainfall = 1"/d	Rainfall = 0.80"/d	Verify Turbidity, and possibly lower flow rate	Pump operator’s manual
	Free water level elevation change (Pond A and Pond E)	Daily	Daily Maximum	Elevation Change = 1 ft/day	Elevation Change = 1 ft/day	Reduce drawdown pump rate	Pump operator’s manual
	Dewatering Operational Assessment Point TSS (downstream of temporary WTS)	Grab, Daily	Monthly Average	TSS = 28 mg/L (Turbidity = 28 NTU)	Instantaneous Tur = 28 NTU	Recirculate through temporary WTS (increase cycles)	Pump operator’s manual
	Dewatering Operational Assessment Point TSS (downstream of temporary WTS)	Grab, Daily	Daily Maximum	TSS = 93 mg/L (Turbidity = 93 NTU	Instantaneous Tur = 74.4 NTU	Recirculate through temporary WTS (increase cycles)	Pump operator’s manual
	Outfall 001 TSS	Grab, Daily	Monthly Average	TSS = 28 mg/L (Turbidity = 28 NTU)	Instantaneous Tur = 28 NTU	Reduce pumping rate	Pump operator’s manual
	Outfall 001 TSS	Grab, Daily	Daily Maximum	TSS = 93 mg/L (Turbidity = 93 NTU)	Instantaneous Tur = 83.7 NTU	Cease pumping	Pump operator’s manual
	Outfall 001 Flow Rate	Daily	Daily Average	3.74 MGD = 2,600 GPM	N/A	Maintain pump rate at 3.74 MGD	Pump operator’s manual
	Flow Rate from Pond A	Daily	Daily Average	2.09 MGD = 1,450 GPM	N/A	Maintain pump rate at 2.09 MGD	Pump operator’s manual
	Flow Rate from Pond E	Daily	Daily Average	0.58 MGD = 400 GPM	N/A	Maintain pump rate at 0.58 MGD	Pump operator’s manual
	Pond A Water Level	Daily	Daily Minimum	450.0 ft (bottom of the pond)	Pool Level = 450.0 ft (bottom of the pond)	Cease Pumping from Pond A	Pump operator’s manual
	Pond E Water Level	Daily	Daily Minimum	445.0 ft (bottom of the pond)	Pool Level = 445.0 ft (bottom of the pond)	Cease Pumping from Pond E	Pump operator’s manual
	Stilling Ponds B&C Water Level	Daily	Daily Minimum	449.0 ft (bottom of the pond)	Pool Level = 449.0 ft (bottom of the pond)	Cease Pumping from Ponds B&C	Pump operator’s manual

Drawdown Stage	Operational Monitoring				Trigger Value	Action	Supporting Documentation
	Parameter	Sampling Frequency	Report Statistical Base	Threshold Value			
	Stilling Pond D W water Level	Daily	Daily Minimum	447.0 ft (bottom of the pond)	Pool Level = 447.0 ft (bottom of the pond)	Cease Pumping from Pond D	Pump operator's manual
Stage 3A: Pore water and contact water removal by gravity. (Pond A and Pond E discharge through Outfall 001)	Rainfall over last 24 hours	Daily	Daily Average	Rainfall = 0.14"/d	Rainfall = 0.14"/d	Maintain drawdown pump flow rate	Pump operator's manual
	Rainfall over last 24 hours	Daily	Daily Maximum	Rainfall = 1"/d	Rainfall = 0.80"/d	Verify Turbidity, and possibly lower flow rate	Pump operator's manual
	Dewatering Operational Assessment Point TSS (downstream of temporary WTS)	Grab, Daily	Monthly Average	TSS = 28 mg/L (Turbidity = 28 NTU)	Instantaneous Tur = 28 NTU	Recirculate through temporary WTS (increase cycles)	Pump operator's manual
	Dewatering Operational Assessment Point TSS (downstream of temporary WTS)	Grab, Daily	Daily Maximum	TSS = 93 mg/L (Turbidity = 93 NTU	Instantaneous Tur = 74.4 NTU	Recirculate through temporary WTS (increase cycles)	Pump operator's manual
	Outfall 001 TSS	Grab, Daily	Monthly Average	TSS = 28 mg/L (Turbidity = 28 NTU)	Instantaneous Tur = 28 NTU	Reduce pumping rate	Pump operator's manual
	Outfall 001 TSS	Grab, Daily	Daily Maximum	TSS = 93 mg/L (Turbidity = 93 NTU)	Instantaneous Tur = 83.7 NTU	Cease pumping	Pump operator's manual
	Outfall 001 Flow Rate	Daily	Daily Average	3.74 MGD = 2,600 GPM	N/A	Maintain pump rate at 3.74 MGD	Pump operator's manual
Stage 3B: Pore water and contact water removal by pumping. (Pond A and Pond E discharge through Outfall 010)	Rainfall over last 24 hours	Daily	Daily Average	Rainfall = 0.14"/d	Rainfall = 0.14"/d	Maintain drawdown pump flow rate	Pump operator's manual
	Rainfall over last 24 hours	Daily	Daily Maximum	Rainfall = 1"/d	Rainfall = 0.80"/d	Verify Turbidity, and possibly lower flow rate	Pump operator's manual
	Dewatering Operational Assessment Point TSS (downstream of temporary WTS)	Grab, Daily	Monthly Average	TSS = 28 mg/L (Turbidity = 28 NTU)	Instantaneous Tur = 28 NTU	Recirculate through temporary WTS (increase cycles)	Pump operator's manual
	Dewatering Operational Assessment Point TSS (downstream of temporary WTS)	Grab, Daily	Daily Maximum	TSS = 93 mg/L (Turbidity = 93 NTU	Instantaneous Tur = 74.4 NTU	Recirculate through temporary WTS (increase cycles)	Pump operator's manual

Drawdown Stage	Operational Monitoring				Trigger Value	Action	Supporting Documentation
	Parameter	Sampling Frequency	Report Statistical Base	Threshold Value			
	Outfall 010 Flow Rate	Daily	Daily Average	29.66 MGD = 20,600 GPM	N/A	Maintain pump rate at 29.66 MGD	Pump operator's manual

Additional NPDES Threshold Values – All Stages – Outfalls 001 and 010

Operational Monitoring at Outfalls						
Parameter	Sampling Frequency	Report Statistical Base	Permitted Value	Trigger Value	Action	Supporting Documentation
Drawdown Flow	Daily	Daily Maximum	Not regulated, just reported	N/A	Decrease drawdown pump rate	Pump operator's manual
Effluent pH	Weekly	Daily Minimum	pH 6.0 to 9.0	Daily minimum = 6.6	Decrease drawdown pump rate	Pump operator's manual
Effluent pH	Weekly	Daily Minimum	pH 6.0 to 9.0	Daily minimum = 6.0	Cease pumping; investigate source of low pH	Pump operator's manual
Effluent pH	Weekly	Daily Maximum	pH 6.0 to 9.0	Daily maximum = 8.1	Decrease drawdown pump rate	Pump operator's manual
Effluent pH	Weekly	Daily Maximum	pH 6.0 to 9.0	Daily maximum = 9.0	Cease pumping; investigate source of high pH	Pump operator's manual
Outfall Total Suspended Solids (TSS)	Weekly	Daily Maximum	TSS = 93 mg/L	Instantaneous TSS = 83.7 mg/L	Cease pumping; operate coagulant injection per controls manual	Pump operator's manual
Outfall Total Suspended Solids (TSS)	Weekly	Monthly Average	TSS = 28 mg/L	Instantaneous TSS = 28 mg/L	Decrease pump rate; operate coagulant injection per controls manual	Pump operator's manual; coagulant feed system manual
Outfall Oil and Grease (O&G)	Monthly	Daily Maximum	O&G = 18 mg/L	Daily O&G = 16.2 mg/L	Decrease pump rate; set effluent battle, then raise flow rate	Pump operator's manual; coagulant feed system manual
Outfall Oil and Grease (O&G)	Monthly	Monthly Average	O&G = 14 mg/L	Daily O&G = 12.6 mg/L	Decrease pump rate; set effluent battle, then raise flow rate	Pump operator's manual

Additional Outfall 001 Threshold Values during Gravity Drainage (Stage 1)

Operational Monitoring				Trigger Value	Action	Supporting Documentation
Parameter	Sampling Frequency	Report Statistical Base	Threshold Value			
Antimony	Weekly	Daily Maximum	N/A	N/A	-	-
Antimony	Weekly	Monthly Average	0.323 mg/L	0.1615 mg/L	Decrease flow rate	Gravity Systems Operation (Stop logs and Siphons)
Arsenic	Weekly	Daily Maximum	19.61 mg/L	9.805 mg/L	Cease flow or proceed to Stage 2	Gravity Systems Operation (Stop logs and Siphons)
Arsenic	Weekly	Monthly Average	0.560 mg/L	0.280 mg/L	Decrease flow rate	Gravity Systems Operation (Stop logs and Siphons)
Barium	Weekly	Daily Maximum	N/A	N/A	-	-
Barium	Weekly	Monthly Average	115.43 mg/L	57.715 mg/L	Decrease flow rate	Gravity Systems Operation (Stop logs and Siphons)
Beryllium	Weekly	Daily Maximum	N/A	N/A	-	-
Beryllium	Weekly	Monthly Average	0.231 mg/L	0.1155 mg/L	Decrease flow rate	Gravity Systems Operation (Stop logs and Siphons)
Cadmium	Weekly	Daily Maximum	0.442 mg/L	0.2210 mg/L	Cease flow or proceed to Stage 2	Gravity Systems Operation (Stop logs and Siphons)
Cadmium	Weekly	Monthly Average	0.177 mg/L	0.0885 mg/L	Decrease flow rate	Gravity Systems Operation (Stop logs and Siphons)
Chromium	Weekly	Daily Maximum	0.923 mg/L	0.4615 mg/L	Cease flow or proceed to Stage 2	Gravity Systems Operation (Stop logs and Siphons)
Chromium	Weekly	Monthly Average	0.635 mg/L	0.3175 mg/L	Decrease flow rate	Gravity Systems Operation (Stop logs and Siphons)
Copper	Weekly	Daily Maximum	2.91 mg/L	1.455 mg/L	Cease flow or proceed to Stage 2	Gravity Systems Operation (Stop logs and Siphons)
Copper	Weekly	Monthly Average	1.95 mg/L	0.9750 mg/L	Decrease flow rate	Gravity Systems Operation (Stop logs and Siphons)
Iron	Weekly	Daily Maximum	N/A	N/A	-	-
Iron	Weekly	Monthly Average	N/A	N/A	-	-
Lead	Weekly	Daily Maximum	20.31 mg/L	10.155 mg/L	Cease flow or proceed to Stage 2	Gravity Systems Operation (Stop logs and Siphons)
Lead	Weekly	Monthly Average	0.274 mg/L	0.1370 mg/L	Decrease flow rate	Gravity Systems Operation (Stop logs and Siphons)
Mercury	Weekly	Daily Maximum	0.081 mg/L	0.0405 mg/L	Cease flow or proceed to Stage 2	Gravity Systems Operation (Stop logs and Siphons)
Mercury	Weekly	Monthly Average	0.003 mg/L	0.0015 mg/L	Decrease flow rate	Gravity Systems Operation (Stop logs and Siphons)

Operational Monitoring				Trigger Value	Action	Supporting Documentation
Parameter	Sampling Frequency	Report Statistical Base	Threshold Value			
Nickel	Weekly	Daily Maximum	109.85 mg/L	54.925 mg/L	Cease flow or proceed to Stage 2	Gravity Systems Operation (Stop logs and Siphons)
Nickel	Weekly	Monthly Average	5.69 mg/L	2.845 mg/L	Decrease flow rate	Gravity Systems Operation (Stop logs and Siphons)
Selenium	Weekly	Daily Maximum	1.13 mg/L	0.5650 mg/L	Cease flow or proceed to Stage 2	Gravity Systems Operation (Stop logs and Siphons)
Selenium	Weekly	Monthly Average	0.260 mg/L	0.130 mg/L	Decrease flow rate	Gravity Systems Operation (Stop logs and Siphons)
Silver	Weekly	Daily Maximum	0.159 mg/L	0.0795 mg/L	Cease flow or proceed to Stage 2	Gravity Systems Operation (Stop logs and Siphons)
Silver	Weekly	Monthly Average	5.77 mg/L	2.885 mg/L	Decrease flow rate	Gravity Systems Operation (Stop logs and Siphons)
Thallium	Weekly	Daily Maximum	N/A	N/A	-	-
Thallium	Weekly	Monthly Average	0.115 mg/L	0.0575 mg/L	Decrease flow rate	Gravity Systems Operation (Stop logs and Siphons)
Zinc	Weekly	Daily Maximum	44.83 mg/L	22.415 mg/L	Cease flow or proceed to Stage 2	Gravity Systems Operation (Stop logs and Siphons)
Zinc	Weekly	Monthly Average	45.20 mg/L	22.60 mg/L	Decrease flow rate	Gravity Systems Operation (Stop logs and Siphons)

The above Additional Outfall 001 Parameter Values have been established for an Outfall 001 effluent flow rate of 4.82 MGD, which is the current typical daily flow rate. Would the actual discharge flow rate differ from that value, then limits would be either increased (for a lower flow rate) or decreased (for a higher flow rate), so the net loading (in lbs/day) would remain stable. The only exception is arsenic concentration, that remains the same, whatever the discharge flow rate.

Additional Threshold Values during Pumping – Dewatering Operational Assessment Point

Operational Monitoring				Trigger Value	Action	Supporting Documentation
Parameter	Sampling Frequency	Report Statistical Base	Threshold Value			
Antimony	Weekly	Daily Maximum	N/A	N/A	-	-
Antimony	Weekly	Monthly Average	0.416 mg/L	0.2080 mg/L	Increase cycles through WTS and/or decrease pump rate; Check Tested Values for Outfall 001 or 010	Pump operator's manual
Arsenic	Weekly	Daily Maximum	25.21 mg/L	12.605 mg/L	Cease pumping	Pump operator's manual
Arsenic	Weekly	Monthly Average	0.720 mg/L	0.3600 mg/L	Increase cycles through WTS and/or decrease pump rate; Check Tested Values for Outfall 001 or 010	Pump operator's manual
Barium	Weekly	Daily Maximum	N/A	N/A	-	-
Barium	Weekly	Monthly Average	148.44 mg/L	74.220 mg/L	Increase cycles through WTS and/or decrease pump rate; Check Tested Values for Outfall 001 or 010	Pump operator's manual
Beryllium	Weekly	Daily Maximum	N/A	N/A	-	-
Beryllium	Weekly	Monthly Average	0.297 mg/L	0.1485 mg/L	Increase cycles through WTS and/or decrease pump rate; Check Tested Values for Outfall 001 or 010	Pump operator's manual
Cadmium	Weekly	Daily Maximum	0.568 mg/L	0.2840 mg/L	Cease pumping	Pump operator's manual
Cadmium	Weekly	Monthly Average	0.228 mg/L	0.1140 mg/L	Increase cycles through WTS and/or decrease pump rate; Check Tested Values for Outfall 001 or 010	Pump operator's manual
Chromium	Weekly	Daily Maximum	1.19 mg/L	0.5950 mg/L	Cease pumping	Pump operator's manual
Chromium	Weekly	Monthly Average	0.816 mg/L	0.4080 mg/L	Increase cycles through WTS and/or decrease pump rate; Check Tested Values for Outfall 001 or 010	Pump operator's manual
Copper	Weekly	Daily Maximum	3.74 mg/L	1.870 mg/L	Cease pumping	Pump operator's manual
Copper	Weekly	Monthly Average	2.51 mg/L	1.255 mg/L	Increase cycles through WTS and/or decrease pump rate; Check Tested Values for Outfall 001 or 010	Pump operator's manual
Iron	Weekly	Daily Maximum	N/A	N/A	-	-
Iron	Weekly	Monthly Average	N/A	N/A	-	-
Lead	Weekly	Daily Maximum	26.12 mg/L	13.060 mg/L	Cease pumping	Pump operator's manual

Operational Monitoring						
Parameter	Sampling Frequency	Report Statistical Base	Threshold Value	Trigger Value	Action	Supporting Documentation
Lead	Weekly	Monthly Average	0.353 mg/L	0.1765 mg/L	Increase cycles through WTS and/or decrease pump rate; Check Tested Values for Outfall 001 or 010	Pump operator's manual
Mercury	Weekly	Daily Maximum	0.104 mg/L	0.0520 mg/L	Cease pumping	Pump operator's manual
Mercury	Weekly	Monthly Average	0.004 mg/L	0.0020 mg/L	Increase cycles through WTS and/or decrease pump rate; Check Tested Values for Outfall 001 or 010	Pump operator's manual
Nickel	Weekly	Daily Maximum	141.27 mg/L	70.635 mg/L	Cease pumping	Pump operator's manual
Nickel	Weekly	Monthly Average	7.31 mg/L	3.655 mg/L	Increase cycles through WTS and/or decrease pump rate; Check Tested Values for Outfall 001 or 010	Pump operator's manual
Selenium	Weekly	Daily Maximum	1.45 mg/L	0.7250 mg/L	Cease pumping	Pump operator's manual
Selenium	Weekly	Monthly Average	0.334 mg/L	0.1670 mg/L	Increase cycles through WTS and/or decrease pump rate; Check Tested Values for Outfall 001 or 010	Pump operator's manual
Silver	Weekly	Daily Maximum	0.204 mg/L	0.1020 mg/L	Cease pumping	Pump operator's manual
Silver	Weekly	Monthly Average	7.42 mg/L	3.710 mg/L	Increase cycles through WTS and/or decrease pump rate; Check Tested Values for Outfall 001 or 010	Pump operator's manual
Thallium	Weekly	Daily Maximum	N/A	N/A	-	-
Thallium	Weekly	Monthly Average	0.148 mg/L	0.0740 mg/L	Increase cycles through WTS and/or decrease pump rate; Check Tested Values for Outfall 001 or 010	Pump operator's manual
Zinc	Weekly	Daily Maximum	57.65 mg/L	28.825 mg/L	Cease pumping	Pump operator's manual
Zinc	Weekly	Monthly Average	58.12 mg/L	29.060 mg/L	Increase cycles through WTS and/or decrease pump rate; Check Tested Values for Outfall 001 or 010	Pump operator's manual

The above Additional Parameter Values for the Dewatering Operational Assessment Point have been established for effluent flow rate of 3.74 MGD, which is the current typical daily flow rate. Would the actual discharge flow rate differ from that value, then limits would be either increased (for a lower flow rate) or decreased (for a higher flow rate), so the net loading (in lbs/day) would remain stable. The only exception is arsenic concentration, that remains the same, whatever the discharge flow rate.

Attachment C – Karst Mitigation Plan

Karst Mitigation Plan
Ash Pond Complex

Tennessee Valley Authority
Gallatin Fossil Plant

Revision 1

February 8, 2021

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Revision History

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Attachments

Attachment A – TVA Historical Drawings

Acronyms

AASHTO	American Association of State Highway and Transportation Officials
APC	Ash Pond Complex
bgs	Below ground surface
BMP	Best Management Practice
CCR	Coal Combustion Residual
CLSM	Controlled Low Strength Materials
ft	feet/foot
GAF	Gallatin Fossil Plant
KMP	Karst Mitigation Plan
Order	Consent Order
SIMP	Surveillance and Instrumentation Monitoring Plan
SWPPP	Stormwater Pollution Prevention Plan
TDEC	Tennessee Department of Environment and Conservation
TDOT	Tennessee Department of Transportation
TVA	Tennessee Valley Authority

Definition of Terms

Cut-off: A cut-off is the criteria at which an injection requirement has been met for a stage. Cut-off criteria include volume, pressure, and ground surface heave considerations. Achieving a cut off indicates that a particular stage has been completed. Stage cut off may also be as directed by the Engineer.

Drop-out: A specific type of karst feature consisting of a hole or "drop-out" at the ground surface caused by erosion and subsurface collapse of overburden into cavities created by karst activity. Also referred to as a "Sinkhole."

Effective Grouting Pressure: Pressure of grout, while being pumped, at the midpoint of the stage being grouted, as calculated from the gauge grouting pressure at the header plus the pressure head (due to the weight of grout in the hole), minus the static groundwater pressure, and minus the line loss.

Gauge Pressure for Grouting: Pressure of grout, as measured at the ground surface within a specified distance from the header, while grout is being pumped into the hole.

Ground Stabilization Plan: A plan to be developed by the Contractor to stabilize the ground surface at a sinkhole location to allow safe access to repair equipment. The plan will be reviewed by the Engineer and the Owner.

Karst: Geologic topography formed from the dissolution of soluble rocks upon contact with acidic groundwater. At the APC, karst is developed as a result of the underlying limestone formations. Karst is characterized by underground drainage systems with sinkholes and caves that form as the soluble limestone is dissolved. At GAF, karst manifests as weathered and fractured limestone, open voids in limestone, sinkholes, and an irregular bedrock surface consisting of pinnacles with normally consolidated to under-consolidated clays within the intervening slots formed by the hard rock. The pinnacles can extend to the ground surface from depths of 30-ft.

Low Mobility Grouting: Normally a soil-cement with sufficient silt sizes to provide mobility together with sufficient sand and gravel sizes to develop enough internal friction to cause the grout to act as a growing mass as injection continues under pressure. The grout generally does not enter soil pores but remains a homogeneous mass that gives controlled displacement to compact loose non-plastic soils and gives controlled displacement for soft, plastic soils or lifting structures, or both.

Natural Soil: Beneath the CCR, the APC consists of alluvial deposits and residual clay soils. The alluvial deposits are highly variable, with some layers of predominantly fine-grained material with trace coarse grained, and some layers of predominantly coarse-grained material. Residual soils consist of predominantly clay with chert gravel, and weathered pieces of limestone.

Primary Holes: Primary holes are the first grout locations located by the Engineer.

Secondary Holes: Secondary holes are drilled midway between primary holes and the grouting be completed before drilling the tertiary series of holes.

Sinkhole: A specific type of karst feature consisting of a drop-out or hole at the ground surface caused by erosion and subsurface collapse of overburden into cavities created by karst activity. Also referred to as a "Drop-out."

Stage: A stage is one complete grouting operation performed over a predetermined vertical interval of a grout hole. The stage is complete when refusal or other cutoff criteria have been met.

Tertiary Holes: Tertiary holes are drilled midway between the secondary holes and primary holes and the grouting be completed before any succeeding holes are drilled.

Top of Rock: Top of rock refers to the point at which the advancement of the grouting drill tip would be expected to refuse on the bedrock surface based on known subsurface data.

1 Introduction and Purpose

On July 24, 2019, the Davidson County Chancery Court entered a Consent Order (Order) in Case No. 15-23-IV reflecting an agreement between the Tennessee Valley Authority (TVA), the State of Tennessee, the Tennessee Department of Environment and Conservation (TDEC), and certain Plaintiff-Intervenors to close the Ash Pond Complex (APC) located at the Gallatin Fossil Plant (GAF) located near Gallatin, Sumner County, Tennessee. For purposes of the Order, the APC consists of the Bottom Ash Pond, Middle Pond A, Ash Pond A, Ash Pond E, and Stilling Ponds B, C, and D as shown in **Figure 1**.

This Karst Mitigation Plan (KMP) has been developed to provide guidelines to help reduce the risk associated with the impact of karst features (specifically sinkholes) on the closure process. Specifically, the following potential impacts are associated with karst and sinkhole development:

- Loss of ash and impounded water from the APC into the bedrock system
- Loss of contaminated stormwater into the bedrock system
- Safety risk to project personnel and equipment

2 Roles and Responsibilities

This section outlines the roles and responsibilities of the various parties that may be required to carry out activities associated with the maintenance of existing karst features or repair of new features. It should be noted that, in general, all onsite personnel should be familiar with features that may be representative of a karst feature. Presented below is a summary of anticipated required parties including a definition of the role and a general overview of their responsibilities.

Contractor: The Contractor will be responsible for performing and delivering all Closure activities. This includes developing a plan for karst repair, in general agreement with this KMP. In addition, the Contractor will be responsible for procuring the Grouting Contractor.

Engineer: The Engineer will be responsible for the overall closure design. Additionally, the Engineer will be responsible for reviewing the repair plan prepared by the Contractor and providing comments and direction as needed.

Karst Specialist: The Karst Specialist may be employed by either the Contractor or Engineer and is responsible for assisting in the preparation of the repair plan. The Karst Specialist shall be a TN registered Professional Engineer or TN registered Professional Geologist with direct experience with karst hydrology/geomorphic processes and karst repair.

Grouting Contractor: The Grouting Contractor will be responsible for providing all personnel, equipment, and materials necessary to perform grouting activities related to karst mitigation. The Grouting Contractor must utilize properly qualified personnel for all personnel who will be working on the project. The Grouting Contractor must be licensed in the state of Tennessee and must provide records of at least three prior grouting projects completed within the last 2 years in karst geology and provided personnel that meet the following minimum experience levels or as otherwise approved by the Engineer:

Project Manager, On-Site Superintendent, Drillers, Grouting Professional, and Safety Lead: Listed personnel must have a minimum of 3 years cumulative experience in similar drilling/grouting roles within karst geology. All personnel shall meet the minimum requirements of the TVA safety plan.

The Grouting Contractor shall submit the name and qualifications of the aforementioned personnel, plus the project-specific dam safety training plan (and trainer), not less than 10 days prior to the commencement of low mobility grouting. Dam safety training shall be completed prior to personnel performing any fieldwork on the project. Changes in personnel will require additional submittals for acceptance of these personnel

Owner: (TVA) The Owner will procure the Engineer and Contractor. The Owner will retain ownership of all data generated as part of closure and karst mitigation. Additionally, the Owner will review safe work plans, training requirements, changes to the work plan, proposed specific karst mitigation activities, and will retain the right to direct the Contractor. In addition, the Owner is responsible for communicating and coordinating with TDEC.

As part of site-specific safety training, all personnel working on-site shall be trained to be familiar with the contents of this plan and to be able to identify karst features or an incipient karst feature.

3 Karst Development and Mechanics

In this geologic setting, the principal risk to infrastructure associated with karst features is sinkhole development from the subsurface erosion of soil into voids in the underlying bedrock. Sinkhole development begins after voids or solution conduits form from dissolution of carbonate bedrock over geologic time. Subsurface erosion of soil overburden into these voids then tends to occur during typical construction project life cycles. Soft to very soft cohesive materials that have been historically documented in this geologic setting can indicate soil loss from downward migration of fines into the underlying bedrock conduits. There is a strong correlation between heavy or extended precipitation events and sinkhole development. Rapid increases in hydraulic gradient can occur locally during these types of precipitation events when infiltration exceeds the capacity of the complex bedrock groundwater system.

Groundwater is temporarily forced upward and laterally though bedrock joints and voids that contain soil that bridge the void in the bedrock and support the upper interval of overburden. The elevated groundwater levels provide a temporary but significant buoyant force supporting the soil bridging the void in the bedrock. Ultimately, with groundwater levels eventually falling, the soil is no longer supported by the buoyant force but the soil pore space remains saturated. In addition, the saturation reduces the soil shear strength which increases collapse potential and can lead to eventual soil collapse, resulting in a sinkhole at the ground surface. Other potential karst features of interest include:

- Springs
- Bedrock enclosed conduits or voids
- Solution pockets that extend beyond visual examination range (and therefore may be open)
- Soil voids
- Highly fractured karst bedrock.

As discussed in Section 4 below, karst features and sinkholes have been observed within the APC and across the GAF reservation. The construction of the APC dates to 1953, operations started in 1970, and ash was sluiced and stacked into the APC for many years. As a result, within the limits of the APC, the pore water elevation has remained above the natural ground elevation in most areas for the duration of operations, and many existing features have likely been filled in or plugged. As such, the formation of new dropouts will occur at a different rate than would the development of features within natural ground.

In addition, in consideration of the closure process, it is likely that incipient sinkhole development could accelerate once the majority of coal combustion residuals (CCR) has been removed but dewatering activities are still being performed. Within limited thickness, relatively permeable CCR overburden over the thin intervals of residual soil and exposed bedrock, incipient sinkholes or previously plugged sinkholes may be more susceptible to the “flushing” action from significant rainfall events.

4 Background and Historical Information

As shown on **Figure 1**, historical karst features have been observed within the APC. The historical features shown on **Figure 1** are categorized as historic karst features, field confirmed karst features, repaired karst features, and suspected sinkhole repairs. The majority of the locations identified on **Figure 1** consist of historic, or unconfirmed locations. However, information is known about several specific features shown in **Figure 1** and the subsequent repairs performed. For the purpose of familiarity, background, and understanding of existing karst features, select existing karst features are described below.

"Donut" Sinkhole – This feature was a sinkhole located within the southern Ash Pond A and featured a diameter of approximately 90-feet (ft) and depth of at least 15-ft at the time of construction. The sinkhole was repaired by over-excavating by placing non-woven filter fabric and backfilling with crushed stone, Type A and B rip rap, crushed stone, and compacted earth fill. The repair details are shown on TVA historical drawing 10W271 contained in **Attachment A**.

Class I Fix (Suspected Sinkhole Locations) – These four locations are within the northern half of Ash Pond E near the perimeter dike. Based on drawing 10W271-316, Class I fixes consisted of the placement of a layer of 6-inch to 12-inch rip rap as a bridge lift over existing ash. Number 67 stone was then placed over the rip rap to cap the layer. Filter fabric was then placed over the #67 stone, and 2-ft thick layer of compacted clay fill. The repair details are shown on TVA historical drawing 10W271 contained in **Attachment A**.

Class II Fixes (Suspected Sinkhole Locations) – These four locations are within the northwestern half of Ash Pond E near the perimeter dike. Based on drawing 10W271-316, Class II fixes consisted of over-excavating existing drop-outs placement of a layer of 6-inch to 12-inch rip rap as a bridge lift over existing ash. Number 67 stone was then placed over the rip rap to cap the layer. Filter fabric was then placed over the #67 stone, and 2-ft thick layer of compacted clay fill. The repair details are shown on TVA historical drawing 10W271 contained in **Attachment A**.

Class III Fixes (Suspected Sinkhole Locations) – These two locations are within the eastern half of Ash Pond E. Based on drawing 10W271-316, Class III fixes consisted of the placement of a 2-ft thick layer of compacted clay fill over fissures or thin vertical joints in the bedrock. The repair details are shown on TVA historical drawing 10W271 contained in **Attachment A**.

Guidelines for maintaining these areas during closure activities are provided below in Section 6.

5 Approach to Karst Mitigation

If a suspected karst drop-out is identified during construction, or forms within the working area during removal activities, a Karst Specialist will conduct an inspection of the feature. This inspection shall consist of observation and documentation of the following:

- Soil subsidence
- Rock collapse
- Sediment filling
- The swallet, spring/seep, or cave
- Identification of potential connectivity of the drop-out to the shallow aquifer and risk for impacting groundwater quality.

If the karst drop-out does not appear to have connectivity, the feature can be stabilized, and construction may continue after the feature is stabilized. TDEC will be notified of the non-connected feature and the stabilization method to be employed prior to starting the stabilization work. If the karst drop-out appears to be connected, TVA will notify TDEC of the new karst feature and proposed mitigation activity. TDEC may request to review the feature and that additional

investigation be performed prior to stabilization. Note that removal activities may continue in other areas of the APC whilst the feature in question is being investigated and/or stabilized.

As discussed, karst features and historic sinkholes are present at the APC. To reduce the potential impact of karst on closure activities, and specifically the potential for loss of containment through sinkholes, three specific strategies have been developed in this document:

- Maintenance of existing sinkholes and repaired karst features
- Repair of sinkholes by over-excavation and backfilling
- Repair of sinkholes by grouting

Selection of the appropriate repair methods will be dependent upon site specific conditions and proposed means and methods by the Contractor. A work plan is to be prepared by the Contractor and submitted to the Owner and Engineer for review prior to performing sinkhole repairs. In addition, a Ground Stabilization Plan is to be developed by the Contractor to stabilize the ground surface at a sinkhole location to allow safe access to repair equipment.

Karst mitigation and sinkhole repair activities performed in the field during closure are intended to provide structural repairs and to reduce the potential for a release of CCR or contaminated stormwater through the subsurface. Note that best management practices (BMPs) will be installed as indicated in the Stormwater Pollution Prevention Plan (SWPPP) to prevent sediment laden stormwater flowing into karst features. This plan does not address sampling and/or source removal and testing at the CCR subgrade elevation. Depending on the type of repair performed, source removal verification may not be possible to coordinate with karst repair activities. Such repaired features will have to be re-exposed as part of the Source Removal Verification Plan to be provided as a separate attachment to this Removal Plan. Following removal of CCR, any areas that were repaired by grouting will be inspected by the Engineer, and improvements made on an as needed basis.

5.1 Maintenance of Existing Sinkholes and Repaired Karst Features

As shown on **Figure 2** and **Figure 3** and discussed above, several existing sinkholes or suspected sinkholes have previously been identified and repaired within the APC. Specifically, the identified locations on **Figure 2** and **Figure 3** correspond with the existing features as follows:

- Area 1: Corresponds with the “Donut” sinkhole repair
- Area 2: Corresponds with Class I repair locations
- Area 3: Corresponds with Class II repair locations
- Area 4: Corresponds with Class III repair locations

As described in Section 4 the repairs have been structural in nature and have included excavation and backfilling with aggregate or clay fill. Since the completion of the repairs, the APC remained in service. No additional drop-outs have been observed in the vicinity of these features; however, subsurface observations have not been possible since construction.

During the closure process, care should be taken as these areas are exposed, particularly the “Donut” sinkhole due to its size and the Class I repair locations as they consisted of constructing a bridge lift over ash. Damage to these areas could result in unplugging the sinkhole and leading to loss of containment. The remaining repaired locations (Area 3 and Area 4) consisted of clay fill being placed directly on the bedrock surface and can therefore be approached in a standard manner through the course of closure.

Details provided on **Figure 2** and **Figure 3** describe the approach to exposing and repairing these features during closure.

5.2 Repair of Sinkholes by Over-Excavation and Backfilling

The preferred method for sinkhole repair for karst features exposed within soil will be over-excavation and backfilling. Repair procedures will depend on whether the karst features are exposed within soil (overburden) areas or bedrock areas. General repair procedures are provided below for sinkholes and openings in bedrock. Details and specifics pertaining to the repair of each exposed feature will require field observation by the Engineer. As noted above, the Contractor will be required to provide a work plan prior to initiating the repair measures discussed below, and as a result, means and methods associated with the over-excavation and backfilling may vary. If the Karst Specialist determines upon inspection that there is potential for connectivity of the drop-out to the shallow aquifer and risk for impacting groundwater quality, then additional groundwater monitoring shall be initiated in accordance with the Monitoring Plan to be provided under a separate cover.

5.2.1 Sinkholes by Over-Excavation

To remediate sinkholes at GAF, a graded filter application has proven to be an effective historical measure for repairs and is the recommended approach. This application removes soil from the drop-out area, plugs or “chokes” voids or open throats in the bedrock, and results in a high strength, crushed stone aggregate backfill which will allow groundwater flow to continue unimpeded without potential for additional migration of fines into the subsurface.

Initially, each feature will be flagged and turned into an exclusion zone. The size of the exclusion zone will be established by the geotechnical engineer depending on the type, size, and location of the feature. Only authorized personnel will enter the exclusion zone, and all work will be performed in accordance with the Contractor’s Safe Work Plan and in accordance with project safe work plans. No lone worker activity is permitted within the limits of identified exclusion zones. A spotter must be used when workers enter a flagged perimeter. The limits of collapsed zones will initially be carefully probed to estimate lateral limits, and the exclusion zone will be adjusted as needed based on the results of probing.

In addition, the Contractor shall construct an earthen berm or other suitable surface flow diversion measure between the sinkhole and any upgradient CCR not contained by a containment berm.

The repair will be observed by the Engineer and details pertaining to the total thickness of each layer (aside from recommended minimums) will be determined based on observation in the field. The general repair procedure will be as follows:

1. The Contractor will cease all work at the location and establish an exclusion zone within a 50-ft radius (or more if warranted based on observed conditions) of the observed sinkhole and prepare a work plan for the proposed over-excavation and backfilling. Notification will be made to TVA. TVA will then notify TDEC.
2. The Contractor shall perform ground stabilization at the feature to allow for repair activities to proceed safely in accordance with the submitted Ground Stabilization Plan and the instrumentation data.
3. Progressively remove overburden soil within the drop-out, chasing the “throat” until the opening is visible, and bedrock is exposed along sides and base of excavation. To facilitate the excavation, bedrock pinnacles may need to be removed. The over-excavation will likely result in the existing drop-out being widened, deepened, and lengthened. Side slopes of the excavation should be maintained in accordance with OSHA requirements.
4. After the “throat” has been exposed, the throat should be plugged, and the excavation initially backfilled with a layer of Tennessee Department of Transportation (TDOT) Class A-1 rip rap or shot rock of similar dimension previously generated from other site projects. Thereafter, the rip rap or shot rock should be backfilled to a depth determined in the field by the Engineer and Contractor.
5. Above the layer of rip rap, #2 sized stone (American Association of State Highway and Transportation Officials, AASHTO) should be placed. The #2 Stone should fill gaps within the top of the rip rap or shot rock layer and constitute an additional minimum thickness of 6-inches. The material should be compacted in place using the excavator bucket.

6. Above the #2 stone, #57 stone (AASHTO) should be placed and compacted in a similar manner. Maximum individual lift thickness of #57 stone should not exceed 12 inches.

7. Above the #57 stone, the contractor should place and compact crusher run dense graded aggregate (in accordance with TDOT Standard Specification Section 903.05). The material should be compacted to maximum 6-inch horizontal lifts and compacted to at least 95 percent of the modified Proctor maximum density. A minimum of 12-inches of compacted dense graded aggregate is recommended.

8. Above the compacted dense graded aggregate, compacted soil fill should be placed. Soil fill should be placed and compacted to at least 95 percent of the standard Proctor maximum dry density and within +2/-2 percentage points of the optimum moisture content. A minimum overall thickness of 24-inches of compacted clay is recommended. The finished ground surface should be graded to promote positive drainage away from the repaired feature.

Upon completion, each repair will be documented by the Engineer and observations and quantities compiled in a daily report for distribution to the project team. The limits of each repair, including depths where they can be safely measured, will be recorded using survey methods for documentation and reporting. A conceptual diagram illustrating the recommended sinkhole repair procedure is provided in **Figure 4**. Please note that this is the recommended approach, but the thickness of various layers and type of aggregate may change based on conditions encountered in the field.

5.2.2 Karst Features in Bedrock

AECOM expects that some karst features will be exposed at the bedrock surface as voids or vertical joints. These features have previously been encountered at GAF following excavation during construction of other projects. A photograph showing a typical karst feature exposed within 12-inches of the bedrock surface following excavation is provided in **Figure 5.**

Karst features exposed in bedrock or very near the bedrock surface should also be repaired. Initially, identified areas should be made into exclusion zones as recommended for sinkholes and notifications made to TVA. TVA will then notify TDEC. Generally, repair of these features should consist of widening the feature as needed to clean out any loose material that has accumulated and expose bedrock along all sides. After over-excavation, the joint should be backfilled to the surface of the rock with flowable fill (Controlled Low Strength Materials, CLSM) designed as a high flowability mix in accordance with the guide specification for CLSM issued by the National Ready Mixed Concrete Association. The CLSM should be allowed a minimum of 48-hours to field cure prior to performing any subsequent construction activities within the exclusion zone. Alternative procedures may be pursued depending on the width of the exposed feature.

5.3 Repair of Sinkholes by Grouting

If a sinkhole occurs during dewatering and excavation activities within CCR areas and cannot be addressed through over-excavation and backfilling, the following grouting procedures are anticipated to be performed. As noted above, the Contractor will be required to provide a work plan prior to initiating the grouting measures discussed below, and as a result, means and methods associated with the grouting may vary. In addition, if a remediation method beyond what is discussed in this document is proposed by the Contractor, the Engineer and TVA will review and submit to TDEC.

1. The Contractor will cease all work at the location and establish an exclusion zone within a 50-ft radius (or more if warranted based on observed conditions) of the observed sinkhole and prepare a work plan for the proposed grouting operation. Notification will be made to TVA. TVA will then notify TDEC.

2. Additional groundwater monitoring may be initiated in accordance with the TDEC reviewed work plan.

3. Geotechnical instrumentation installed within the APC by the Contractor in the nearest vicinity of the sinkhole shall be reviewed to assess pore water pressure conditions in the subgrade.

4. The Contractor shall perform ground stabilization at the feature to allow for repair activities to proceed safely in accordance with the submitted Ground Stabilization Plan and the instrumentation data.

5. As part of the ground stabilization plan, initial remediation of the sinkhole will be performed by backfilling with dense graded aggregate stone to re-establish the surface and reduce the potential for slips, trips, and falls. The approximate lateral limits of the sinkhole will also be marked and surveyed. In addition, localized grading should be performed to direct surface water flow away from the feature.

6. A two-part system of low mobility grouting repairs is anticipated.

Initial compaction grouting is anticipated around the perimeter of the sinkhole area. Then, final grouting directly at the suspected sinkhole location utilizing higher injection pressures and a higher slump mix in conjunction with the resistance generated by the initial compaction grouting barrier. Each stage of the grouting procedure is discussed below.

5.3.1 Initial Compaction Grouting

Compaction grouting uses a material blend of fine aggregate, fines and water to achieve a pumpable, thixotropic, viscous grout of a low slump to enable pumping at high pressure and remain intact after injection. The grout does not penetrate soil pores but displaces the subsurface soils by forming a homogeneous grout bulb near the grout pipe tip.

Compaction grouting leads to a reinforced composite subgrade, with the relatively tightly spaced grout bulbs leading to arching of the overburden between the bulbs and reducing the risk of sudden settlement. Therefore, the risk of sinkhole collapse is reduced within areas where compaction grouting has been performed.

As discussed, the Contractor will submit a work plan including proposed grouting locations and operations for review by the Owner and Engineer. The Engineer may then revise initial location plan consisting of primary grout injection holes. The primary injection locations should be located around the sinkhole. As the primary locations are performed, a real time evaluation of the grouting data will be used to determine the need for additional injection points. The grouting process is iterative and typically performed in a primary/secondary/tertiary sequence based on specific conditions exposed in the field.

Grout holes shall be advanced to top of rock. The Grouting Contractor will provide the capability to pre-drill or advance through boulders or obstructions to reach top-of-rock elevations that are reasonable compared to the expected top of rock elevation based on existing site subsurface data or to the satisfaction of the Engineer.

Initial compaction grouting should be performed at the cap grouting locations by injecting low mobility grout bulbs in approximate 2-foot stages extending from refusal to no higher than 5-feet below the ground surface. At each 2-foot stage, grout would be injected until one of the following cut-off criteria is met:

- Sustained pumping at an effective pressure of 75 pounds per square inch (psi)
- An injected grout volume equal to 1 cubic yard and a maximum injection rate of 2 cubic feet per second.
- Any singular, upward movement of the adjacent ground surface in excess of 0.5-inch

Note: Grout injection that occurs under gravity flow only (no pressure generated in the line) are likely filling an open void, which is a desirable effect. Therefore, volume cut-offs will not be considered if no pressure is developed during grout placement. In this case, the Engineer and Contractor shall determine the cut-off criteria.

Compaction grout should be injected at the point of placement with a slump between 0 and 3 inches.

5.3.2 Final Compaction Grouting

After the initial compaction grouting activities have been performed, grouting is anticipated at the suspected throat location and between other initial compaction grouting locations. The purpose of final locations will be to fill additional voids in the subsurface and cap the underlying bedrock to minimize sinkhole formation. This grouting is not intended to extend into the underlying rock, but rather create a cap at the soil-rock interface to minimize the migration of fines into the underlying rock, until the point which all CCR is removed from the area. This type of grout program is intended to allow the continued movement of water in the underlying bedrock while minimizing overburden erosion. It should be

noted that the grout columns themselves will be rippable and will be removed as CCR excavation progresses. Once exposed, the cap at the soil-rock interface will be inspected to confirm the repair was adequate.

The Contractor will submit a work plan including proposed final grouting locations and operations for review by the Owner and Engineer. Grout holes shall be advanced to top of rock. The Grouting Contractor will provide the capability to pre-drill or advance through boulders or obstructions to reach top-of-rock elevations.

Final compaction grouting should be performed at the cap grouting locations by injecting low mobility grout bulbs in approximate 2-foot stages extending from refusal to no higher than 5-feet below the ground surface. At each 2-foot stage, grout would be injected until one of the following cut-off criteria is met:

Final grouting cut-off criteria will differ slightly from the initial grouting criteria, as follows;

- Sustained pumping at an effective pressure of 150 psi or sustained effective pressure increase by judgement of the Engineer and Contractor.
- An injected grout volume equal to 2 cubic yards and a maximum injection rate of 2 cubic feet per second.
- Any singular, upward movement of the adjacent ground surface in excess of 0.5-inch

Note: Grout injection that occurs under gravity flow only (no pressure generated in the line) are likely filling an open void, which is a desirable effect. Therefore, volume cut-offs will not be considered if now pressure is developed during grout placement. In this case, the Engineer and Contractor shall determine the cut-off criteria.

For this stage of grouting, the slump of the mixture should be more mobile, between 3 to 6 inches.

Depending on the results of secondary grouting, tertiary grouting operations (to be performed in accordance with secondary grouting procedures provided above) may be undertaken if deemed appropriate by the Engineer and Contractor.

5.3.3 General Grouting Requirements

The grout mix should generally consist of fly ash, cement, water, and naturally occurring aggregate. Additives may be used as necessary subject to the review of the Engineer. Fly ash, if used in the grout mix, shall be in conformance with ASTM C618, Type F, if available (Type C as an alternative). Portland Cement used for grout shall be in conformance with ASTM C150, Type I or Type II. Other cement types may be used subject to the Engineer's review. Cement can be delivered to the job site in bags or by bulk delivery. Bulk delivered cement shall be stored in appropriate silos or other containers specially designed for cement storage. Any cement storage facilities shall be subject to the Engineer's review. Fine aggregate shall be in conformance with ASTM C33. Sand should have a fines content (percent passing No. 200 sieve) of not less than 5 percent and not more than 20 percent. All aggregates used in the grout mixture should be non-calcium carbonate based due to the potential reaction with CCR.

Upon discharge into the pump hopper or holding tank, the grout must be continuously agitated. Mixed grout may not be held in the agitator for more than 90 minutes unless a set retarder, reviewed and accepted by the Engineer and Owner, is used.

Grout pipes, casings, and connections shall be steel casing of adequate strength to maintain the hole and to withstand the required installation, jacking and pumping stresses. The pipes shall be of a sufficient diameter to adequately handle the specified material without plugging. All casing shall be flush joint threaded or a single piece tubing to provide a smooth inner wall and unobstructed inside diameter. All fittings (elbows, bends, adapters, reducers, etc.) shall be long sweep, gradual transition pieces specifically designed and manufactured for high pressure grout and concrete pumping applications. Standard pipe elbows and reducers will not be allowed. It shall be the Grouting Contractor's responsibility to install casing that does not detrimentally impact the grouting procedure.

Performing grouting under pressure in near proximity to existing infrastructure can result in uplift or other structural damage. For this project, when performing grouting within 100 feet of the perimeter dike, divider dike, or haul road, continuous monitoring of the structure should be performed during the grouting process, and any upward movement of

½ inch should result in immediate termination of grouting activities. The Grouting Contactor should be responsible for all aspects of monitoring of existing site infrastructure during grouting activities. The monitoring system should be equipped with an audible alarm or other approved warning signal.

6 General Recommendations

It is not possible to accurately predict the development or occurrence of sinkholes at the ground surface. However, some key data can provide a general idea as to the relative risk of a sinkhole to occur and for preparations to be made accordingly. Particularly, these general recommendations should be considered at the stage of closure where CCR thickness has been reduced and dewatering has drawn the water elevations to near the existing ground surface. The following recommendations should also be implemented as part of the karst mitigation plan:

Existing instrumentation within the existing perimeter dike and new instrumentation to be installed within the interior limits of the APC will be monitored by the Owner, the Engineer, and the Contractor during closure as part of the Instrumentation Monitoring activities. Data pertaining to pore water pressure and lateral and vertical deflection will be generated at regular intervals (to be determined) and monitored/reviewed. This data will be primarily used to assess structural stability during closure, but aspects of the data can also be used to assist with assessing karst risk. For example, sudden vertical settlement could be an indication of a sinkhole collapse as well as an indication of a static liquefaction failure. As discussed, sudden intense precipitation events, or long, continuous periods of above average precipitation can lead to incipient sinkhole formation. The groundwater response (amount of rise and fall, and rate of rise and fall) to precipitation as observed in vibrating wire piezometers and open standpipe piezometers can be very instructive in identifying localized high-risk sinkhole locations. Therefore, daily instrumentation data should be assessed for karst potential as well, instrumentation and monitoring requirements will be developed in a Surveillance and Instrumentation Monitoring Plan (SIMP) prior to construction.

In addition to instrumentation monitoring, visual observations of the site shall be made on a daily basis by the Contractor. Visual observation and daily documentation shall include visual observation of dropouts or settlement at the ground surface.

A contingency of materials should be maintained on site (see Section 7 below) to allow for rapid, emergency sinkhole repair as described in Section 5.

7 Contingency Plan

For the duration of the closure project, the Contractor should maintain and re-supply as needed the following on-site contingency materials for potential use in karst mitigation:

- 1,000 cubic yards of ASTM C33 filter sand
- 1,000 cubic yards of AASHTO #57 Stone
- 1,000 cubic yards of rip rap
- Silt Fence (1,000 ft)
- Erosion Control Blankets
- Yellow Caution Tape (500-ft) and Stakes (50) to mark off necessary areas

8 References

AECOM (2020), TVA Gallatin Fossil Plant, Part II Permit Application, CCR Disposal Facility – South Rail Loop, Hydrogeological Report, April 2020

ASCE 53-10 (2010), Compaction Grouting Consensus Guide, ASCE/G-I 53-10.

ASCE (1987), Geotechnical Special Publication No. 13. Geotechnical Practice for Waste Disposal. June 15, 1987.

ASCE (1988), Geotechnical Special Publication No. 14. Geotechnical Aspects of Karst Terrains: Exploration, Foundation Design and Performance, and Remedial Measures. May 1988.

FIGURES

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0 300 600

SCALE IN FEET

LEGEND

- EXISTING MAJOR CONTOUR (25 FT)
- EXISTING MINOR CONTOUR (5 FT)
- SITE VEGETATION BOUNDARY
- EDGE OF WATER
- ROADWAY EXTENTS (UNPAVED)
- ROADWAY EXTENTS (PAVED)
- OVERHEAD ELECTRIC LINE
- TRANSMISSION TOWER
- 100-YR FLOODPLAIN
- TVA PROPERTY LINE
- BUILDINGS, STRUCTURES
- FENCE
- NATIONAL REGISTER OF HISTORIC PLACES (NRHP) ELIGIBLE SITE
- CEMETERY
- NRHP AND CEMETERY BUFFER/SETBACK
- WETLAND
- WET WEATHER CONVEYANCE
- INTERMITTENT STREAM
- ASH & STILLING POND BOUNDARY
- EXISTING KARST FEATURE – HISTORIC
- EXISTING KARST FEATURE – FIELD CONFIRMED
- EXISTING KARST FEATURE – REPAIRED
- SUSPECTED SINKHOLE – CLASS I FIX
- SUSPECTED SINKHOLE – CLASS II FIX
- SUSPECTED SINKHOLE – CLASS III FIX
- DONUT SINKHOLE REPAIR

NOTES:

1. TOPOGRAPHIC SURVEY OF THE SITE IS BASED ON DATA COMPILED BY TVA SURVEYING ON MAY 30, 2019. HORIZONTAL DATUM IS TVA NAD27 LOCAL GRID. VERTICAL DATUM IS NGVD29.
2. SUPPLEMENTAL TOPOGRAPHIC SURVEY (AREA EAST OF STEAM PLANT ROAD) IS BASED ON DATA COMPILED BY DDS ENGINEERING ON MARCH 9, 2017. DATA WAS OBTAINED BY QUANTUM SPATIAL, INC. ON FEBRUARY 4, 2017. HORIZONTAL DATUM IS TVA NAD7 LOCAL GRID. VERTICAL DATA IS NGVD29.
3. THE LOCATION OF EXISTING CULTURAL RESOURCES AND ENVIRONMENTAL FEATURES INCLUDING WETLANDS, INTERMITTENT STREAMS, WET WEATHER CONVEYANCES, CEMETERIES, AND NRHP ELIGIBLE SITES ARE BASED ON DATA PROVIDED BY TVA USING HANDHELD GPS UNITS.
4. SETBACKS PROVIDED FROM CULTURAL RESOURCES SHALL BE MAINTAINED IN ACCORDANCE WITH THE "PROGRAMMATIC AGREEMENT (PA) BETWEEN THE TENNESSEE VALLEY AUTHORITY (TVA) AND TENNESSEE STATE HISTORIC PRESERVATION OFFICER (TN SHPO) REGARDING THE GALLATIN FOSSIL PLANT (GAF) EMISSIONS CONTROL EQUIPMENT AND COAL COMBUSTION PRODUCTS (CCP) DISPOSAL FACILITIES, SUMNER COUNTY, TENNESSEE" DATED SEPTEMBER 13, 2012.
5. KARST DATA HAS BEEN PROVIDED FROM HISTORICAL RECORDS FROM TVA. SUSPECTED SINKHOLE DATA IS FROM DRAWING 10W271-311 DATED 10/23/07. SINKHOLE REPAIRS SHOWN ARE FROM DRAWING 10W217-316 DATED 10/23/07.

AECOM

TVA

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL

EXISTING KARST FEATURES
KARST MITIGATION PLAN

DRAWN BY:	CHECKED BY:	PROJECT No:	DATE:	FIGURE No:
RLP/PBL	DES	60624653	MAY 2020	1

C:\Users\bennett.lamb\Desktop\Backup Files\60624653_TVAGAFAPP2\900_CAD\910_CAD\20-SHEETS\Figure 1_Existing Karst Features\xx - FIGURE 1 - EXISTING KARST FEATURES.dwg User:bennett.lamb

N

0 300 600
SCALE IN FEET

LEGEND

- EXISTING MAJOR CONTOUR (25 FT)
- EXISTING MINOR CONTOUR (5 FT)
- SITE VEGETATION BOUNDARY
- EDGE OF WATER
- ROADWAY EXTENTS (UNPAVED)
- ROADWAY EXTENTS (PAVED)
- OVERHEAD ELECTRIC LINE
- TRANSMISSION TOWER
- 100-YR FLOODPLAIN
- TVA PROPERTY LINE
- BUILDINGS, STRUCTURES
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- NATIONAL REGISTER OF HISTORIC PLACES (NRHP) ELIGIBLE SITE
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- WETLAND
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- INTERMITTENT STREAM
- ASH & STILLING POND BOUNDARY
- EXISTING KARST FEATURE – HISTORIC
- EXISTING KARST FEATURE – FIELD CONFIRMED
- EXISTING KARST FEATURE – REPAIRED
- SUSPECTED SINKHOLE – CLASS I FIX
- SUSPECTED SINKHOLE – CLASS II FIX
- SUSPECTED SINKHOLE – CLASS III FIX
- DONUT SINKHOLE REPAIR

NOTES:

1. TOPOGRAPHIC SURVEY OF THE SITE IS BASED ON DATA COMPILED BY TVA SURVEYING ON MAY 30, 2019. HORIZONTAL DATUM IS TVA NAD27 LOCAL GRID. VERTICAL DATUM IS NGVD29.
2. SUPPLEMENTAL TOPOGRAPHIC SURVEY (AREA EAST OF STEAM PLANT ROAD) IS BASED ON DATA COMPILED BY DDS ENGINEERING ON MARCH 9, 2017. DATA WAS OBTAINED BY QUANTUM SPATIAL, INC. ON FEBRUARY 4, 2017. HORIZONTAL DATUM IS TVA NAD7 LOCAL GRID. VERTICAL DATA IS NGVD29.
3. THE LOCATION OF EXISTING CULTURAL RESOURCES AND ENVIRONMENTAL FEATURES INCLUDING WETLANDS, INTERMITTENT STREAMS, WET WEATHER CONVEYANCES, CEMETERIES, AND NRHP ELIGIBLE SITES ARE BASED ON DATA PROVIDED BY TVA USING HANDHELD GPS UNITS.
4. SETBACKS PROVIDED FROM CULTURAL RESOURCES SHALL BE MAINTAINED IN ACCORDANCE WITH THE "PROGRAMMATIC AGREEMENT (PA) BETWEEN THE TENNESSEE VALLEY AUTHORITY (TVA) AND TENNESSEE STATE HISTORIC PRESERVATION OFFICER (TN SHPO) REGARDING THE GALLATIN FOSSIL PLANT (GAF) EMISSIONS CONTROL EQUIPMENT AND COAL COMBUSTION PRODUCTS (CCP) DISPOSAL FACILITIES, SUMNER COUNTY, TENNESSEE" DATED SEPTEMBER 13, 2012.
5. KARST DATA HAS BEEN PROVIDED FROM HISTORICAL RECORDS FROM TVA. SUSPECTED SINKHOLE DATA IS FROM DRAWING 10W271-311 DATED 10/23/07. SINKHOLE REPAIRS SHOWN ARE FROM DRAWING 10W271-316 DATED 10/23/07.

AECOM

TVA

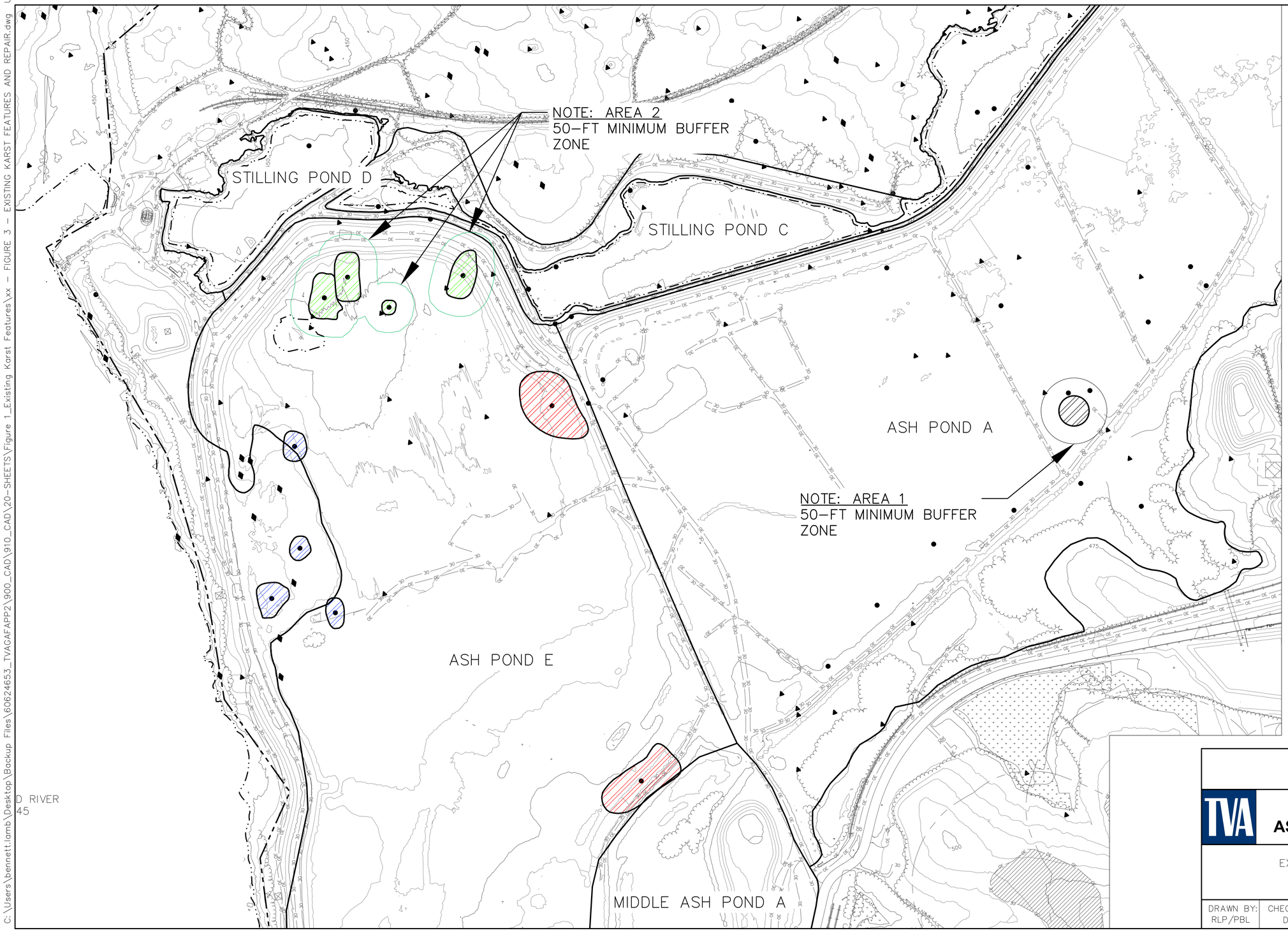
GALLATIN FOSSIL PLANT ASH POND COMPLEX REMOVAL

EXISTING KARST FEATURES AND REPAIR
KARST MITIGATION PLAN

DRAWN BY:	CHECKED BY:	PROJECT No:	DATE:	FIGURE No:
RLP/PBL	DES	60624653	MAY 2020	2

C:\Users\bennett.lamb\Desktop\Backup Files\60624653_TVAGAFAPP2\900_CAD\910_CAD\20-SHEETS\Figure 1_Existing Karst Features\xx - FIGURE 2 - EXISTING KARST FEATURES AND REPAIR.dwg User:

C:\Users\bennett.lamb\Desktop\Backup Files\60624653_TVAGAFAPP2\900_CAD\910_CAD\20-SHEETS\Figure 1_Existing Karst Features\xx - FIGURE 3 - EXISTING KARST FEATURES AND REPAIR.dwg User:



N

0 150 300

SCALE IN FEET

LEGEND

- 800 — EXISTING MAJOR CONTOUR (25 FT)
- EXISTING MINOR CONTOUR (5 FT)
- SITE VEGETATION BOUNDARY
- EDGE OF WATER
- ROADWAY EXTENTS (UNPAVED)
- ROADWAY EXTENTS (PAVED)
- OHE — OVERHEAD ELECTRIC LINE
- TRANSMISSION TOWER
- 100-YR — 100-YR FLOODPLAIN
- TVA PROPERTY LINE
- BUILDINGS, STRUCTURES
- FENCE
- NATIONAL REGISTER OF HISTORIC PLACES (NRHP) ELIGIBLE SITE
- CEMETERY
- NRHP AND CEMETERY BUFFER/SETBACK
- WETLAND
- WET WEATHER CONVEYANCE
- INTERMITTENT STREAM
- ASH & STILLING POND BOUNDARY
- EXISTING KARST FEATURE – HISTORIC
- EXISTING KARST FEATURE – FIELD CONFIRMED
- EXISTING KARST FEATURE – REPAIRED
- SUSPECTED SINKHOLE – CLASS I FIX
- SUSPECTED SINKHOLE – CLASS II FIX
- SUSPECTED SINKHOLE – CLASS III FIX
- DONUT SINKHOLE REPAIR

NOTES:

1. A MINIMUM 50-FT BUFFER ZONE WILL BE ESTABLISHED IN THE FIELD AROUND THE EXISTING "DONUT" REPAIR LOCATION (AREA 1) AND CLASS I REPAIR LOCATIONS (AREA 2) AS SHOWN. THE PURPOSE OF THE BUFFER ZONE WILL BE TO ISOLATE EACH AREA FROM THE GENERAL EXCAVATION ACTIVITIES TO PREVENT DAMAGE TO EXISTING REPAIRS AND LOSS OF CONTAINMENT.
2. WITHIN EACH BUFFER ZONE, THE CONTRACTOR WILL CAREFULLY EXPOSE THE TOP LATERAL LIMITS OF EACH REPAIR FEATURE, WHICH CONSISTS OF FILTER FABRIC. REFER TO TVA HISTORICAL DRAWING 10W271 FOR AREA A AND 10W271-316 FOR DETAILS.
3. UPON EXPOSING THE TOP OF EACH FEATURE, THE OWNER'S ENGINEER AND CONTRACTOR'S ENGINEER SHALL OBSERVE EACH FEATURE TOGETHER IN THE FIELD TO ASSESS CURRENT CONDITION AND DETERMINE ADDITIONAL MEASURES AND REMOVAL PROCEDURES.
4. UPON DIRECTION FROM THE OWNER'S ENGINEER AND CONTRACTOR'S ENGINEER, THE CONTRACTOR WILL PROCEED TO CAREFULLY LATERALLY EXTEND THE EXCAVATION TO THE LIMITS OF THE BUFFER ZONE TO EXPOSE CLEAN SUBGRADE WITHIN THE BUFFER ZONE AND PROCEED WITH REMOVAL. WITHIN AREA 1 AND AREA 2, CAREFUL REMOVAL OF THE EXISTING REPAIR SHOULD PROCEED TO EXPOSE UNDISTURBED CLAY SOIL OR BEDROCK.
5. A TEMPORARY EARTHEN BERM SHALL BE ESTABLISHED AROUND THE BUFFER ZONE TO PREVENT CONTACT BETWEEN EACH AREA AND THE OVERALL ASH POND COMPLEX REMOVAL OPERATIONS. TEMPORARY CCR SLOPES EXTENDING FROM THE BUFFER ZONE INTO THE ASH POND COMPLEX SHALL BE INCLINED IN ACCORDANCE WITH THE RECOMMENDATIONS PROVIDED IN THE ASH REMOVAL PLAN.

AECOM

TVA

GALLATIN FOSSIL PLANT
ASH POND COMPLEX REMOVAL

EXISTING KARST FEATURES AND REPAIR
KARST MITIGATION PLAN

DRAWN BY:	CHECKED BY:	PROJECT No:	DATE:	FIGURE No:
RLP/PBL	DES	60624653	MAY 2020	3

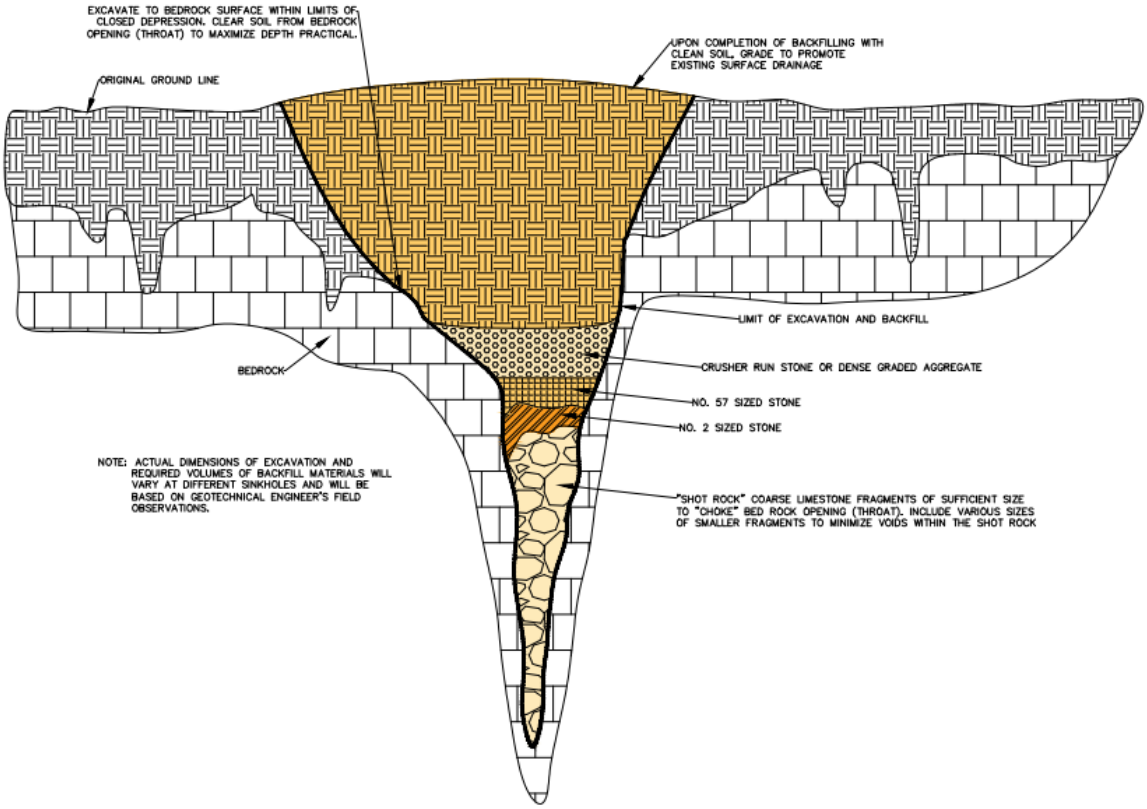
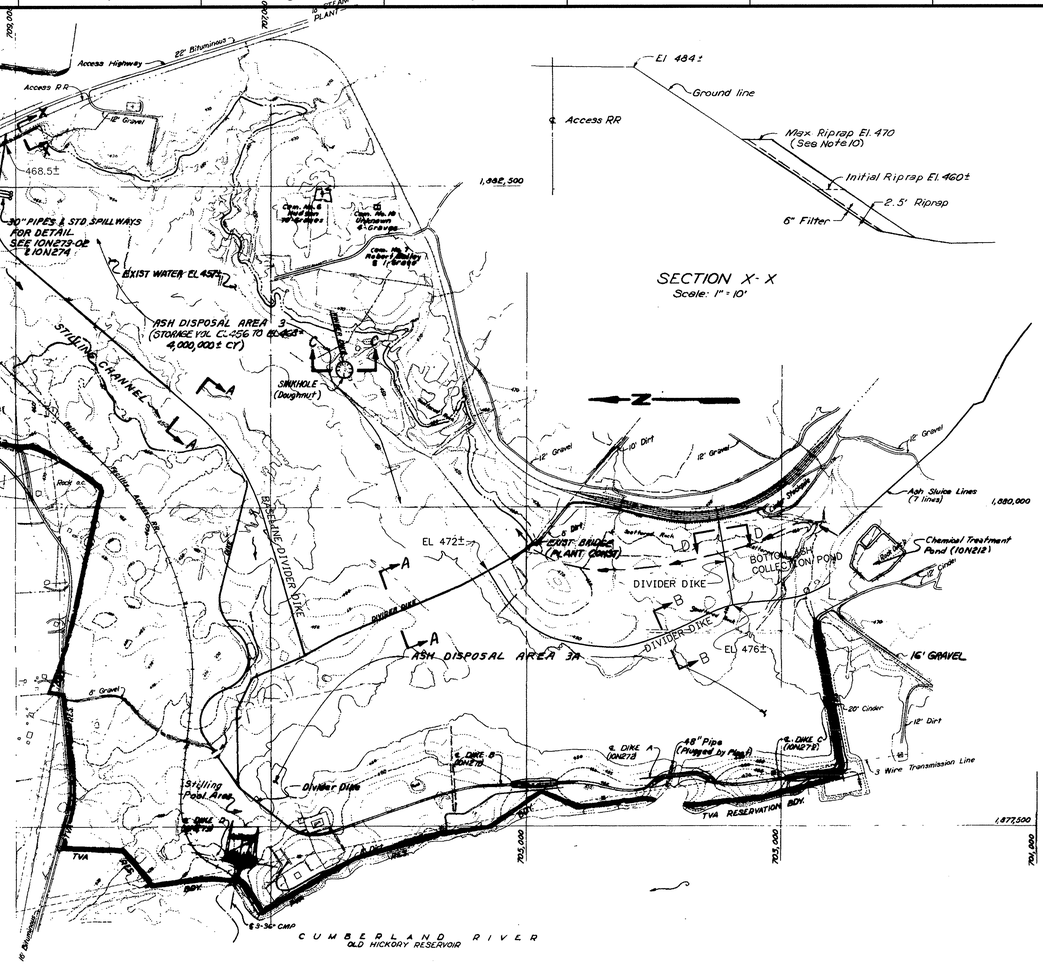


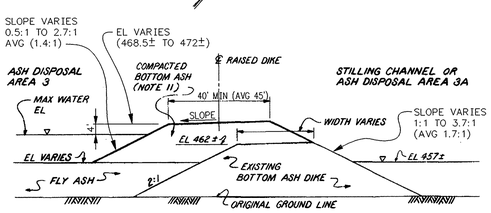
Figure 4. Conceptual Soil Drop-Out Repair

Figure 5. Typical Example of a Karst Feature Exposed in Bedrock

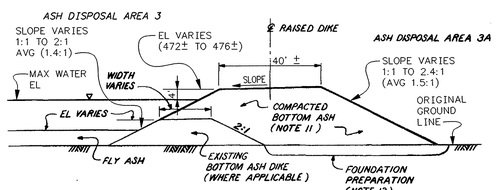
ATTACHMENTS

Attachment A – TVA Historical Drawings



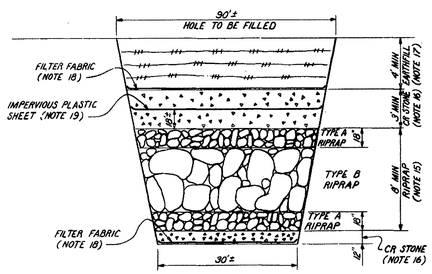


A - A
NTS



B - B
NTS

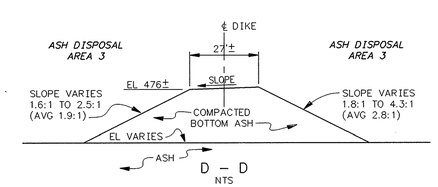
TABLE A		
RIPRAP TYPE A		
PERCENT PASSING BY WEIGHT	MIN	MAX
15"	100	–
12"	90	100
6"	75	95
3"	55	80
1½"	30	55
¼"	10	22
3/8"	0	15



C - C
NTS

* FOR 1986 CONSTRUCTION SEE 10N273-2 & 274

* SUMMARY OF QUANTITIES		
ITEM NO.	DESCRIPTION	QUANTITY
101	Clearing	79 Ac.
120	Unclassified Excavation (Spoil Areas)	1,800 C.Y.
	Channel Excavation - Earth	3,630 C.Y.
	Channel Excavation - Rock (to be used in dike "A" and cofferdams)	900 C.Y.
	Rock Excavation - Borrow	1,000 C.Y.
123	Earth Borrow	9,500 C.Y.
129	Excavation for Structures	550 C.Y.
130 & 132	Seeding & Mulching	8,080 S.Y.
	Surfacing (Ash, Slag, Gravel or Crushed Stone)	720 Tons
610	Steel Beam-Type Guardrail	575 L.F.
830	Riprap	2,570 C.Y.
836	Filter Blanket	750 Tons
602	48" Reinf. Conc. Pipe - Class III - O.R. Gaskets	136 L.F.
	Ash Fill - For Raising Divider Dikes	350,000 CY



D - D
NTS

PA 2624
WO 82-31546

COMPANION DRAWINGS: 10N272 THRU 274 & 10H275

NOTES:
1. ALL WORK SHALL BE IN ACCORDANCE WITH T-1 SPECIFICATIONS EXCEPT AS NOTED.
2. FOR GENERAL SOILS INFORMATION SEE SOILS EXPLORATION REPORT IN MEMORANDUM; J.C.McCRAW TO F.P.LACY DATED SEPTEMBER 24, 1969.
3. CUT SLOPES ADJACENT TO PROPOSED DIKES SHALL NOT BE EXCAVATED STEEPER THAN 3:1 AND TOPE OF CUT SHALL BE A MINIMUM OF 25 FEET FROM THE TOE OF THE DIKE.
4. DIKE FOUNDATIONS SHALL HAVE ALL WEAK SURFACE SOILS REMOVED TO MATERIAL THAT WILL EASILY BEAR THE WEIGHT OF LOADED RUBBER-TIRED EARTH HAULING EQUIPMENT.
5. EARTH FILL COMPACTION SHALL BE DONE WITH SHEEPSFOOT ROLLERS AND SHALL BE AT LEAST 95% OF STANDARD PROCTOR MAXIMUM DENSITY (ASTM D698) AS ESTABLISHED BY THE MATERIALS LABORATORY. COMPACTION SHALL BE CHECKED BY AT LEAST ONE DENSITY-MOISTURE TEST PER DAY. FILL MOISTURE SHALL BE CONTROLLED TO ACHIEVE OPTIMUM COMPACTION.
6. WITH THE EXCEPTION OF THE USEABLE MATERIAL FROM THE DISCHARGE CHANNEL, ALL BORROW SHALL COME FROM INSIDE THE PROPOSED ASH DISPOSAL AREA AND BELOW EL 456 IF POSSIBLE. BORROW AREAS ARE OUTLINED IN THE SOIL REPORT.
7. DIKE "A" IS TO BE CONSTRUCTED LAST. ROCKFILL COFFERDIKES ARE TO BE BUILT AT TOES OF DIKE AS SHOWN IN SECTION A-A (10N272), COMPACTED WITH TRACTORS, COMPACTION BEGINNING AT LOWEST PRACTICAL ELEVATION FOR THE EQUIPMENT. AREA BETWEEN COFFERDIKES IS TO BE PUMPED FREE OF WATER FOR CONSTRUCTION OF EARTH DIKES.
8. RIPRAP SHALL BE PLACED AT LOCATIONS AS SHOWN. AT LEAST 50 PERCENT OF THE RIPRAP SHALL CONSIST OF STONE OF A WEIGHT EQUAL TO OR GREATER THAN 375 LBS. FOR DIKE "C" AND ALONG THE EXISTING RAILROAD AND 270 LBS. FOR DIKE "A" AND DIKE "D". RIPRAP SHALL CONFORM TO SECTION 830.
9. FILTER BLANKET SHALL BE 6" THICK AND IN ACCORDANCE WITH SECTION 836.
10. AS THE ASH POND WATER LEVEL IS RAISED, PLANT PERSONNEL SHALL MAINTAIN THE TOP OF RIPRAP ELEVATION A MINIMUM OF TWO FEET ABOVE THE POND WATER ELEVATION (SEE SECT. X-X)

NOTES FOR RAISING DIVIDER DIKE:
11. EXISTING DIVIDER DIKES SHALL BE RAISED AS SHOWN WITH HEAVY BOTTOM ASH FILL PLACED IN 9-INCH MAXIMUM THICKNESS LOOSE LIFTS AND THOROUGHLY COMPACTED WITH LOADED RUBBER TIRED EARTH HAULING EQUIPMENT MAKING A MINIMUM OF 6 PASSES OVER EACH LAYER.
12. FOR SOILS INFORMATION SEE SINGLETON MATERIALS ENGINEERING LABORATORY REPORT SME-S01-88-017 IN MEMORANDUM B46 880908 004.
13. FOUNDATIONS FOR RAISING DIVIDER DIKES IN AREAS NOT INUNDATED WITH WATER SHALL HAVE ALL WEAK SURFACE SOILS REMOVED TO MATERIAL THAT WILL BEAR THE WEIGHT OF LOADED RUBBER-TIRED EARTH HAULING EQUIPMENT WITHOUT HEAVING.
14. PRIOR TO RAISING THE WATER LEVEL OF ASH DISPOSAL AREA 3 ABOVE ITS PRESENT ELEVATION OF 457±, PROVISIONS MUST BE MADE TO HANDLE STORM DRAINAGE FOR THOSE AREAS INSIDE THE RAILROAD LOOP THAT ARE PRESENTLY DISCHARGING INTO THE ASH DISPOSAL AREA AT AN ELEVATION LOWER THAN 468.0.

NOTES FOR SEALING SINKHOLE:
15. BOTH TYPE A AND TYPE B RIPRAP SHALL BE IN ACCORDANCE WITH SECTION 575. THE GRADATION AND SIZE REQUIREMENTS FOR TYPE A RIPRAP ARE SHOWN IN TABLE A. TYPE B RIPRAP SHALL BE WELL GRADED ROCK WITH SIZES RANGING FROM 36 INCHES TO 6 INCHES.
16. CRUSHED STONE SHALL BE IN ACCORDANCE WITH SECTION 1032. CRUSHED STONE SHALL BE PLACED IN 12 INCH MAXIMUM THICKNESS LOOSE LIFTS AND COMPACTED WITH A MINIMUM OF 5 PASSES WITH A SMALL VIBRATORY ROLLER OR HAND-HELD VIBRATORY COMPACTOR.
17. EARTHFILL SHALL BE A FINE-GRAINED, COHESIVE CLAY SOIL. EARTHFILL SHALL BE PLACED IN 9 INCH MAXIMUM THICKNESS LOOSE LIFTS AND COMPACTED WITH A MINIMUM OF 6 PASSES WITH A TAMPING (SHEEPSFOOT) ROLLER. FILL MOISTURE SHALL BE CONTROLLED TO ACHIEVE OPTIMUM COMPACTION.
18. FILTER FABRIC SHALL BE CLASS B NONWOVEN, NEEDLE PUNCHED POLYESTER OR POLYETHYLENE IN ACCORDANCE WITH SECTION 571.
19. IMPERVIOUS PLASTIC SHEET BE 10 MLS MINIMUM THICKNESS AND SHALL BE PLACED WITH A MINIMUM OF 2 FEET OF OVERLAP.
20. AREA INSIDE ASH FILL TO BE CLEANED OUT TO THE EXTENT PRACTICAL BEFORE PLACEMENT OF RIPRAP.

PROJECT REVISION HISTORY

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT #	AS CONST	REV. CD.
R6		CLM	MGH	JLG	JLG	KWB	RGJ	WDH	4897		
SUPERSEDED BY 10W271: R7											
R5	6-6-90		RDP	MGH	JLG		KWB		JHC		
ADD SECT C-C AND NOTES 15 THRU 20, ADD TABLE A.											
R4	11-7-88		RDP	MGH	RDP		KWB		JHC		
GENERAL REVISIONS FOR RAISING DIVIDER DIKES & ADDED SECTS A-A & B-B.											
R											
R 7	6-12-95	CLM	MGH	JLG	JLG	KWB	RGJ	WDH	4897		J
REDRAWN AND REVISED TO AS CONSTRUCTED.											

DISCIPLINE INTERFACE: NF R7

SCALE: 1" = 400' EXCEPT AS NOTED

MAIN PLANT

PLAN

ASH DISPOSAL AREA NO. 3

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
JLG	JLH	JPHS	MCB	J.M.JOHNSTON	W.N.CALVERT	F.P.LACEY

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

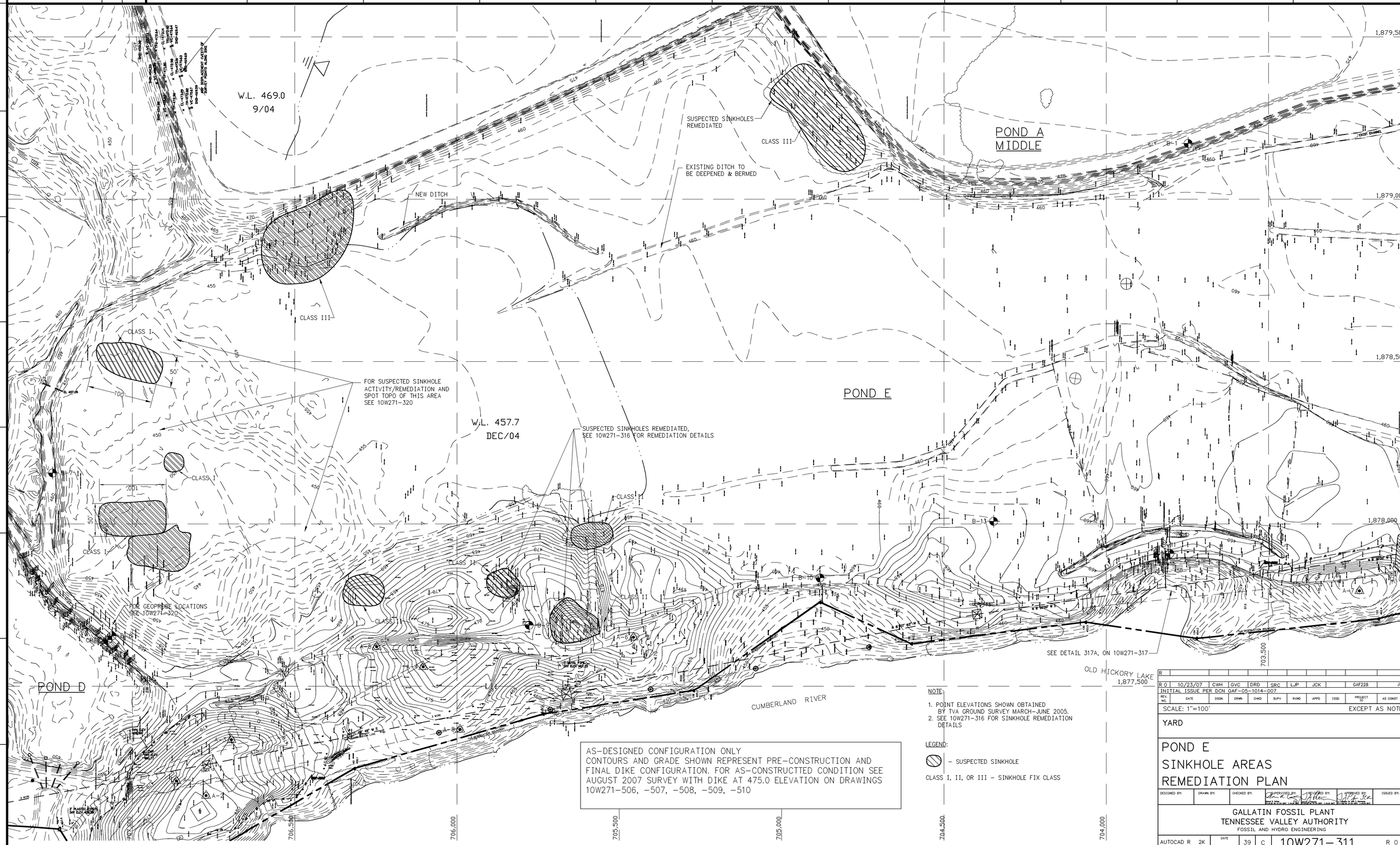
AUTOCAD R12 | DATE | 39 | C | 10W271 | R 7

TASK COMPLETED BY: | REV NO.

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES :(10N271, r6)

PLOT FACTOR: 1:1
W-SIZE
FILENAME: GA271.DWG, .GP4 & .RES

C.A.D. DRAWING
DO NOT ALTER MANUALLY



AS-DESIGNED CONFIGURATION ONLY
CONTOURS AND GRADE SHOWN REPRESENT PRE-CONSTRUCTION AND FINAL DIKE CONFIGURATION. FOR AS-CONSTRUCTTED CONDITION SEE AUGUST 2007 SURVEY WITH DIKE AT 475.0 ELEVATION ON DRAWINGS 10W271-506, -507, -508, -509, -510

NOTE:

1. POINT ELEVATIONS SHOWN OBTAINED BY TVA GROUND SURVEY MARCH-JUNE 2005.
2. SEE 10W271-316 FOR SINKHOLE REMEDIATION DETAILS

LEGEND:

- SUSPECTED SINKHOLE

CLASS I, II, OR III - SINKHOLE FIX CLASS

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R 0	10/23/07	CWH	GVC	DRD	SRC	LJP	JCK		GAF228		J J

INITIAL ISSUE PER DCN GAF-05-1014-007

DISCIPLINE INTERFACE

SCALE: 1"=100' EXCEPT AS NOTED

YARD

POND E
SINKHOLE AREAS
REMEDIATION PLAN

DESIGNED BY: | DRAWN BY: | CHECKED BY: | SUPERVISED BY: | REVIEWED BY: | APPROVED BY: | ISSUED BY:

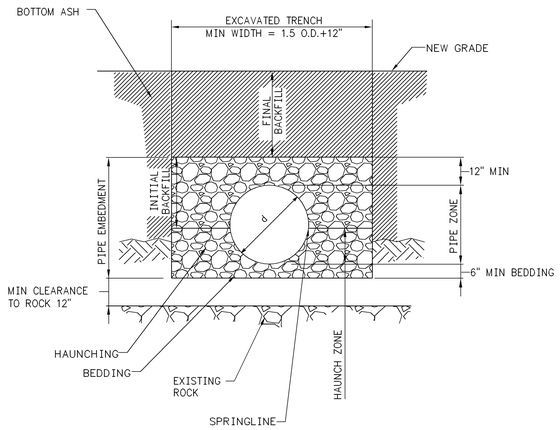
GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R 2K | DATE | 39 | C | 10W271-311 | R 0

TASK COMPLETED BY: | REV NO.

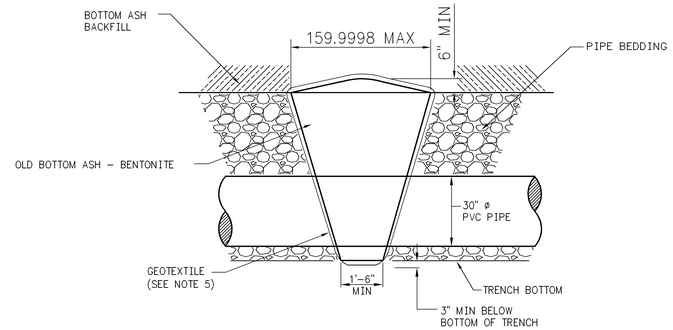
PLOT FACTOR:100
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY



DETAIL 316A

BEDDING FOR CORRUGATED PVC PIPE

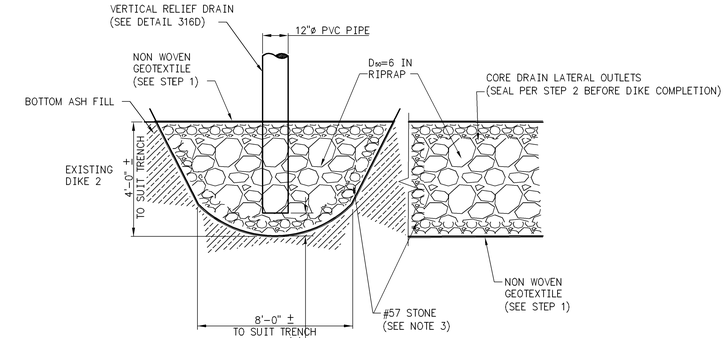


DETAIL 316B

TYPICAL CUTOFF COLLAR

PVC PIPING NOTES:

1. TRENCHING, PIPE INSTALLATION, BEDDING AND BACKFILLING SHALL BE IN ACCORDANCE WITH TVA SPECIFICATION T-1, SECTION 496 EXCEPT FOR MATERIALS AS FOLLOWS.
2. MATERIAL FOR BEDDING, HAUNCH ZONE AND INITIAL BACKFILL SHALL BE BOTTOM ASH
3. MATERIAL FOR CUTOFF COLLARS SHALL BE A MIX CONSISTING OF 1 PART BENTONITE TO 10 PARTS OLD BOTTOM ASH. AFTER THOROUGH MIXING, PLACE DRY IN 6" LIFTS AND COMPACT THOROUGHLY WITH MECHINCAL TAMPERS.
4. BENTONITE SHALL BE GRANULAR GRADE BY AMERICAN COLLOID CO.
5. IMMEDIATALY AFTER TOP LAYER COVER WITH 6" MIN BOTTOM ASH AND HYDRATE OLD BOTTOM ASH – BENTONITE BY WETTING WITH WATER FROM INLET TO POND A.
6. FILTER FABRIC SHALL BE A NON-WOVEN NEEDLE PUNCHED FABRIC THAT MEETS THE REQUIREMENTS OF CLASS C FILTER FABRIC IN ACCORDANCE WITH SECTION 571 OF THE GENERAL CONSTRUCTION SPECIFICATION NO. T1.



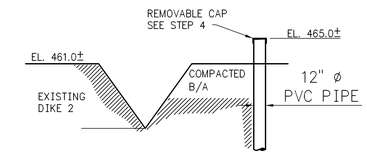
DETAIL 316C

CORE DRAIN

N.T.S.

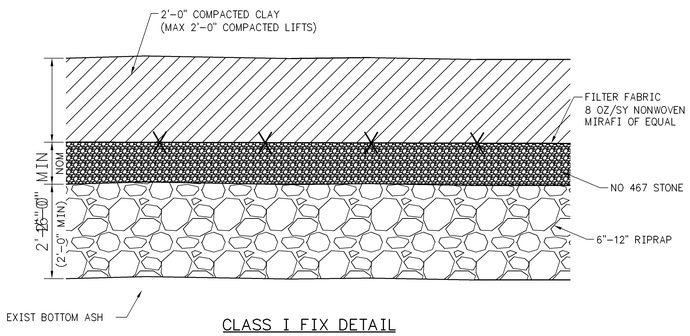
PROCEDURE STEPS:

1. PLACE FILTER FABRIC AROUND STONE FILL.
2. MACHINE DUMP A MINIMUM OF 6 INCHES OF #57 STONE AROUND THE D50=6" IN RIPRAP.
3. DETAILS FOR SEALING OFF LATERAL CORE DRAIN OUTLETS TO BE DETERMINED AT LATER DATE AND APPROVED BY ENGINEERING.
4. EXPOSE AND FLAG RELIEF DRAIN ABOVE GRADING OF DIKE 2 TO APPROXIMATE ELEVATION 465.0±.



DETAIL 316D

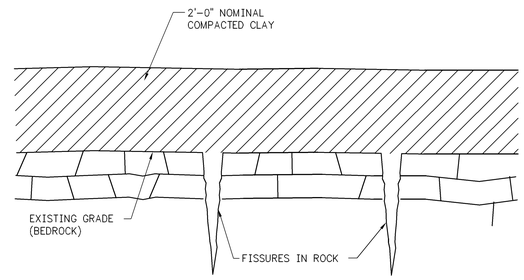
TYP RELIEF DRAIN



CLASS I FIX DETAIL

(SINKHOLE REMEDIATION)

SCALE: 3/4"=1'-0"



CLASS III FIX DETAIL

(SINKHOLE REMEDIATION)

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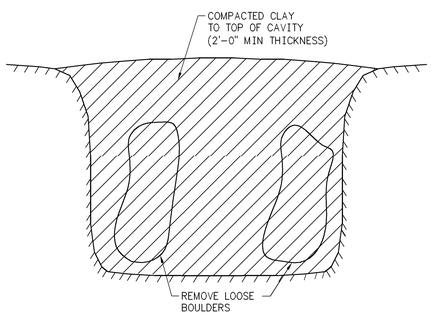

CLASS II FIX DETAIL

(SINKHOLE REMEDIATION)

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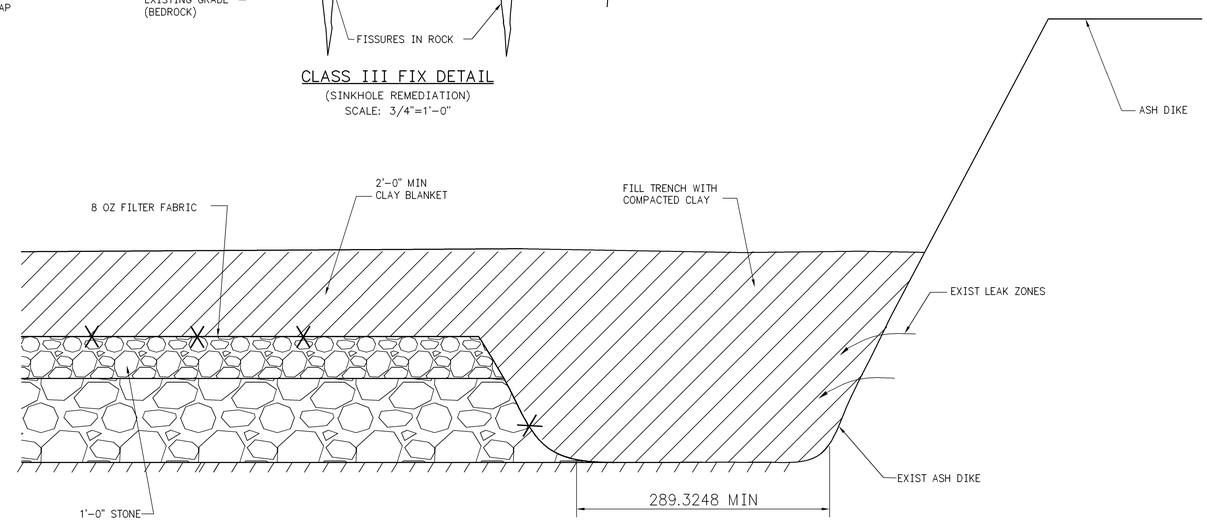

SECTION X-X

SCALE: 3/4"=1'-0"

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R 0	10/23/07	CWH	GVC	DRD	SRC	LJP	JCK		GAF228		J
INITIAL ISSUE PER DCN GAF-05-1014-012											

DISCIPLINE INTERFACE

SCALE: 1"=50 EXCEPT AS NOTED

YARD

POND E SINKHOLE REMEDIATION & MISC. DIKE 2 DETAILS

DESIGNED BY: | DRAWN BY: | CHECKED BY: | SUPERVISED BY: | REVIEWED BY: | APPROVED BY: | ISSUED BY:

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R 2K | DATE | 39 | C | 10W271-316 | R 0

PLOT FACTOR:50
W_TVA

C.A.D. DRAWING DO NOT ALTER MANUALLY

TASK COMPLETED BY: | REV NO.

Attachment D – Source Removal Construction Quality Assurance Plan

Source Removal
Construction Quality Assurance Plan
Ash Pond Complex

Tennessee Valley Authority
Gallatin Fossil Plant

Revision 1

February 8, 2021

Prepared for:

Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37402-2801

Prepared by:

AECOM Imagine it. Delivered.

1600 Perimeter Park Drive
Suite 400
Morrisville, NC 27560

Quality information

Prepared by	Checked by	Verified by	Approved by
Scott Veenstra	Josh Colley, P.E.	David Skeggs, P.E.	Gabe Lang, P.E.

Revision History

Revision	Revision date	Description
0	09/18/2020	Initial issue
1	02/08/2021	Revised to address comments

Table of Contents

Acronyms 1
1 Introduction 2
2 Project Description 2
3 Interim Source Removal and Testing of Subgrade 2
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Acronyms

APC	Ash Pond Complex
CCR	Coal combustion residual
CQA	Construction Quality Assurance
ft	foot
GAF	Gallatin Fossil Plant
GPS	Global positioning system
ISR QAPP	Interim Source Removal Quality Assurance Project Plan
ISRP	Interim Source Removal Process
NGVD29	National Geodetic Vertical Datum of 1929
Order	Consent Order
PLM	Polarized light microscopy
QC	Quality control
SR CQAP	Source Removal Construction Quality Assurance Plan
SSL	Statistically significant level
TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority

1 Introduction

On July 24, 2019, the Davidson County Chancery Court entered a Consent Order (Order) in Case No. 15-23-IV reflecting an agreement between the Tennessee Valley Authority (TVA), the State of Tennessee, the Tennessee Department of Environment and Conservation (TDEC), and certain Plaintiff-Intervenors to close the Ash Pond Complex (APC) located at the Gallatin Fossil Plant (GAF) located near Gallatin, Sumner County, Tennessee. For purposes of the Order, the APC consists of the Bottom Ash Pond, Middle Pond A, Ash Pond A, Ash Pond E, and Stilling Ponds B, C, and D as shown in **Figure 1**. The removal of coal combustion residuals (CCR) from the APC will be conducted in general accordance with the following governing documents:

- Interim Source Removal Process (ISRP) (TVA, 2019), which addresses TVA's process for removal of CCR and describes source removal activities and quality assurance activities in a general manner. The ISRP is included as **Attachment D**.
- Interim Source Removal Quality Assurance Project Plan (ISR QAPP), (Environmental Standards, 2019). The ISR QAPP governs the quality aspects of the sampling and analytical activities associated with source removal. The ISR QAPP is included as **Attachment E**.

The purpose of this Source Removal Construction Quality Assurance Plan (SR CQAP) is to describe the site-specific Construction Quality Assurance (CQA) procedures associated with removal of CCR from the APC. Specifically, this document outlines procedures for visual inspection and documentation of CCR removal, surveying and grid layout, proposed sampling locations, and reporting that will be provided at the completion of construction to document source removal activities.

2 Project Description

The removal of CCR and closure of the APC at GAF is proposed to consist of the following activities:

- Free water removal from Ash Pond A and the Stilling Ponds;
- Pore water removal from Ash Pond A, Ash Pond E, Middle Pond A, and, Bottom Ash Pond to the extent necessary for safe access and CCR removal;
- Removal of CCR from the Ash Pond A, Ash Pond E, Middle Pond A, Bottom Ash Pond, and Stilling Ponds B, C and D.

This SR CQAP outlines the procedures for the sampling of underlying native soils, after the removal of the CCR within the APC. The underlying assumption is that CCR in all portions of the APC will be removed by conventional dewatering and excavation.

3 Interim Source Removal and Testing of Subgrade

Sampling and analytical testing of the native soil materials is required after CCR removal from the floor of the APC. After removal of the CCR is completed, sampling and testing shall begin, and the Contractor shall not conduct any further work on the APC floor until approved to do so by TVA. The following TVA Technical Instructions shall apply:

- ENV-TI-05.80.01 Planning Sampling Events;
- ENV-TI-05.80.02 Sample Labeling and Custody;
- ENV-TI-05.80.03 Field Record Keeping;
- ENV-TI-05.80.04 Field Sampling Quality Control;

- ENV-TI-05.80.05 Field Sampling Equipment and Decontamination;
- ENV-TI-05.80.06 Handling and Shipping of Samples; and
- ENV-TI-05.80.50 Soil and Sediment Sampling.

3.1 Interim Source Removal CQA Team

The ISR CQA team will consist of personnel assigned to the project who will be responsible for implementing and/or enforcing this SR CQAP. The organization chart and lines of communication for interim source removal activities is shown in **Figure 2** below. Roles and responsibilities for each position identified in the organization chart shall be as defined in the ISR QAPP, Section 2.

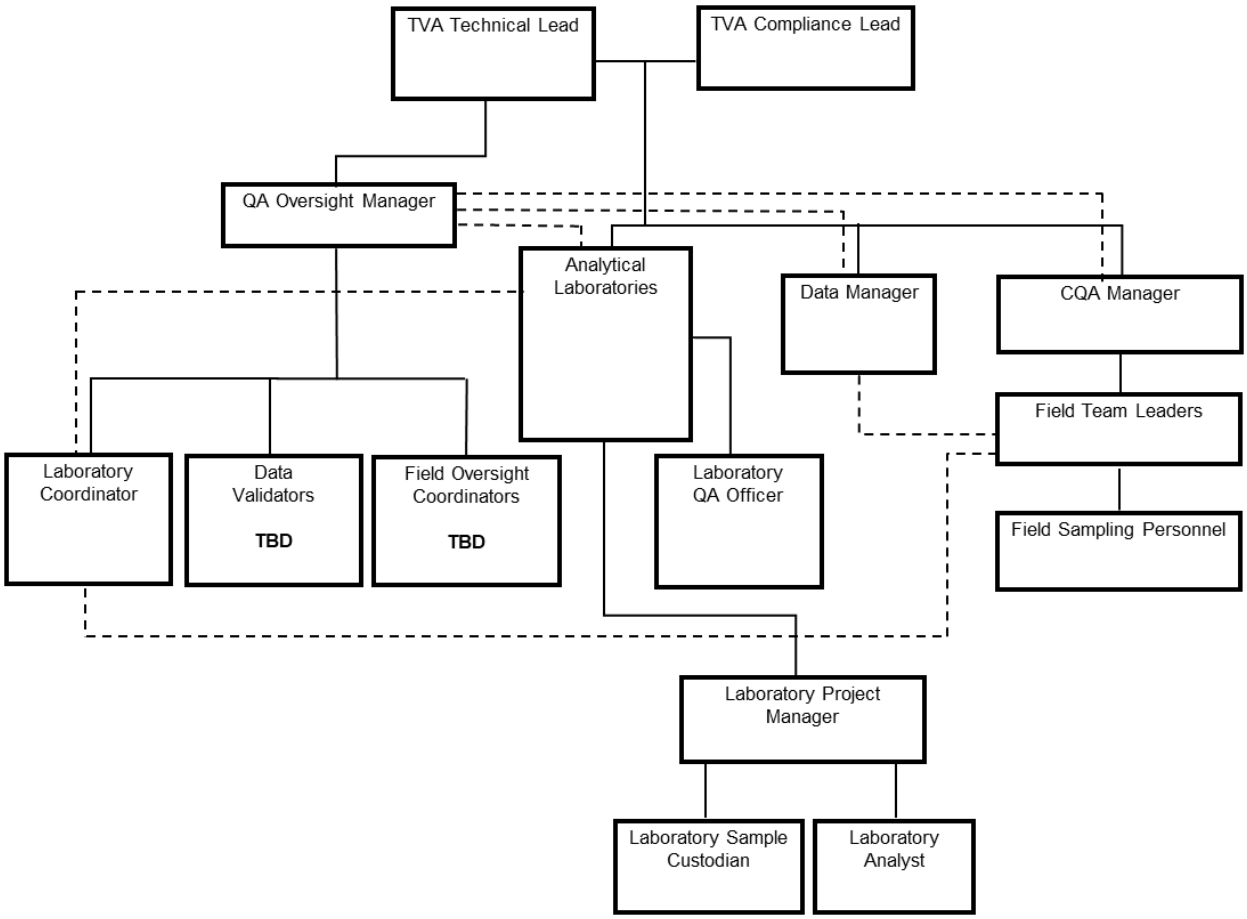


Figure 2. Organization Chart for Interim Source Removal

3.2 Source Removal

The steps outlined in the subsequent subsections below will be taken to confirm CCR source removal sufficient to satisfy project-specific design criteria. Refer to ISRP, Section 2, and ISR QAPP, Sections 7 and 8.

TVA proposes to manage the removal and source removal CQA activities on a unit by unit basis. This is consistent with the management of the units under the CCR Rule on an individual basis (for those units that are subject to the rule). The units comprising the APC have discrete boundaries supporting this unit by unit approach. The various impoundments may be further divided into subunits for post-CCR removal verification testing. The intention is that once a subunit is cleared (met the objectives of post-excavation verification testing), the removal actions associated with that subunit will be considered complete. If other subunits within the impoundment are subject to over-excavation, as

dictated by exceeding established threshold values, only the other subunit will be over excavated. The other units within the impoundment that have already been "cleared" will not be subject to revisiting for over-excavation.

This approach is a site-specific scaled adaptation of the ISRP given the size of the impoundments at GAF. Because of the size of the units at GAF, TVA wants to maintain additional flexibility in managing the units on a sub-unit basis tied to the removal Contractor's planned sequencing of operations.

3.2.1 Establish Geo-Referenced Quality Control Grid

A 100-foot (ft) by 100-ft quality control (QC) grid across the floor of each of the units in the APC has been developed in accordance with ISRP Section 2.1 and is presented in the unit specific Figures A.1 through A.7 in **Attachment A**. The number of QC grids in each unit is summarized in **Table 1** below.

Table 1. Summary of QC Grids

Unit	Number of QC Grids	Number of Grids for CCR Analysis	Number of Grids for PLM Analysis
Ash Pond A	820	82	164
Ash Pond E	633	63	126
Middle Pond A	137	14	28
Bottom Ash Pond	65	7	14
Stilling Pond B	121	12	24
Stilling Pond C	83	8	16
Stilling Pond D	34	4	8

PLM – Polarized Light Microscopy

The contractor will be responsible for surveying and establishing the geo-referenced QC grids and center points in the field as excavation is completed in each grid area. The center points shall be marked with survey stakes which are labelled and tagged with high visibility flagging. Any stakes that are damaged or disturbed during field activities shall be replaced and documented. In addition, the contractor's surveying activities shall include delineation of the 445 ft National Geodetic Vertical Datum of 1929 (NGVD29) elevation. The CQA Manager or designee will use a global positioning system (GPS) unit to capture the coordinates of the staked center points. Each stake will be photographed and documented in a field book or log indicating grid point number/ID, and northing and easting. Along with the GPS coordinates of the grid center point, coordinates will be recorded for each of the four grab sample locations (one from each of the four quadrants within the established grid) used to form a composite sample in accordance with the ISRP Section 2.3. These locations will be included in the CQA Report.

If grids are not accessible due to standing water or extremely muddy conditions, the grid will not be staked nor sampled. Instead, an adjacent grid will be selected for sampling in accordance with the ISRP Section 2.3.

3.2.2 CCR Removal

The Contractor who is performing the work will remove CCR in accordance with the TDEC approved Removal Plan and ISRP Section 2.2. The site-specific geologic conditions underlying the APC include the potential for CCR materials to be in direct contact with the underlying bedrock. CCR removal activities within a specific grid will be terminated when bedrock is encountered. CCR removal will be completed to the extent practical with the excavation equipment being used by the Contractor. If cases where bedrock is encountered and prohibits further removal of CCR materials, notes to this effect will be recorded in the Daily Report including the QC grid identification and photographs of the conditions at termination of CCR removal.

As discussed in the Karst Mitigation Plan, source removal verification may not be possible in areas where karst features were repaired using grouting procedures. However, these repaired areas will be inspected following removal of the CCR, and improvements will be made on an as needed basis. It should also be noted that composite samples shall

not be collected from within the limits of areas that were repaired by over-excavation and backfilling since the material used in backfilling is required to consist of visually clean soil.

3.2.3 Visual Inspection and Documentation of CCR Removal

The removal of CCR from the APC and the determination of non-CCR material shall be field-verified by visual observation, per the ISRP Section 2.2. The required members of the CQA Team who will field-verify the CCR removal include the following personnel:

Engineer CQA Field Representative
Contractor Construction QC Field Representative
TVA Construction Manager

Visual inspection will be completed by walking each 100-ft by 100-ft grid and visually confirming the removal of CCR. Photographic logs will be maintained by the engineering CQA Manager providing photographs of each grid during visual inspection of the grid. An example photographic log is provided in **Attachment B**. Ground elevations after CCR removal will be documented via a field survey by the Contractor's professional surveyor licensed in Tennessee.

3.3 Composite Soil Sampling

Composite soil sampling will be performed after CCR has been removed from the APC, visual inspection completed, the pond floor deemed to be clear of CCR (or extent practical if excavation was terminated due to encountering bedrock or karst feature), and the QC grid has been staked (unless staking is not possible due to encountering bedrock). Sample collection from the underlying native materials shall be done in accordance with the ISRP Section 2.3, the ISR QAPP Sections 7 and 8, and the TVA Technical Instructions ENV-TI-05.80.50 Soil and Sediment Sampling, ENV-TI-05.80.02 Sample Labeling and Custody, ENV-TI-05.80.04 Field Sampling Quality Control, and ENV-TI-05.80.05 Field Sampling Equipment and Decontamination.

If the bottom of the excavation is unable to be maintained in a dry condition, alternative soil sample collection methods specified in ENV-TI-05.80.50, such as Vibracore sampling, may be employed to collect the discrete samples for the QC grid composite sample.

Collected composite samples will be transported to Eurofins Test America and RJ Lee or other testing laboratory selected by TVA for laboratory testing, in accordance with the ISR QAPP Section 9, and TVA Technical Instructions ENV-TI-05.80.06 Handling and Shipping of Samples.

Field record keeping shall be done in accordance with TVA Technical Instructions ENV-TI-05.80.03 Field Record Keeping.

3.3.1 Sample Collection for Analysis of CCR Parameters

Ten percent of the 100-ft by 100-ft QC grid cells will be sampled and submitted for analysis of CCR constituents in accordance with the ISR QAPP.

The collected soil samples will be shipped to the Eurofins Test America for the analysis of CCR constituents in accordance with the ISR QAPP. The contact and address for the laboratory is:

Eurofins Test America Laboratories, Inc.
301 Alpha Drive
Pittsburgh, PA 15237

The laboratory contact for Eurofins Test America is:

Ms. Gail Lage
gail.lage@testamericainc.com

If changes in testing laboratories occur during the implementation of this project, TVA will provide the selected laboratory information to TDEC.

3.3.2 Sample Collection for Analysis of Percent Ash

Twenty percent of the 100-ft by 100-ft QC grid cells will be sampled and submitted for microscopic analysis of percentage of ash, using polarized light microscopy (PLM) in accordance with the ISR QAPP, as shown in **Attachment A**.

The collected soil samples will be shipped to RJ Lee for the PLM analysis in accordance with the ISR QAPP. The address for the laboratory is:

RJ Lee Group
350 Hochberg Road | Monroeville, PA 15146
724.387.1927 Direct

The laboratory contact for RJ Lee Group is:

Ms. Monica Carse
MCarse@rjleegroup.com

If changes in testing laboratories occur during the implementation of this project, TVA will provide the selected laboratory contact information to TDEC.

3.4 Results Evaluation

The analytical results for CCR constituents will be evaluated in accordance with the ISRP Section 2.5 and the ISR QAPP. Site-specific screening criteria are provided in the Risk-Based Closure Approach Memorandum provided as **Attachment C**. Risk-based screening values for areas of the APC to be inundated (elevations less than 445 ft NGVD29) are presented separately from areas of the APC with final excavated elevations greater than 445 ft NGVD29 in **Attachment C**. The reason for two sets of criteria has to do with the potential exposure pathway from residual soil and surface water. For areas below 445 ft NGVD29, the pathway is direct from residual soil to surface water. For areas above 445 ft NGVD29, the pathway is residual soil to groundwater to surface water.

Results of analytical sampling and PLM analysis will be provided in a tabular format for each grid sampled and provided in the Source Removal Record Document described in Section 3.6 of this SR CQAP.

Evaluation of analytical results will follow the appropriate flow chart (soil, soil to groundwater, soil to surface water, and groundwater) included in **Attachment C**.

Section 2.6 of TVA's Interim Source Removal Process (TVA, 2019) programmatic document presents over-excavation of the entire CCR management unit if a single grid cell composite sample from the visually-clean surface does not meet the site statistically significant levels (SSLs) for CCR constituent concentrations. This programmatic document will be followed for the GAF removal action with the site-specific scaled adaptation to the impoundment subunit level. Up to one-foot of remaining native soil in the impoundment sub-unit would be over-excavated. Any QC grids that did not meet site SSLs would be re-sampled for CCR constituents.

TVA is proposing as a minor deviation from the programmatic document to, at its own discretion, proceed with over-excavation of additional soils without awaiting delivery of post-CCR removal QC soil sample results or review of the analytical results. This decision may be driven by the expected 50-day duration from sample collection to receipt of validated analytical results for Radium and/or the removal Contractor's planned excavation sequencing/schedule.

3.5 Data Validation

Data validation shall be performed in accordance with ISRP Section 2.7 and the ISR QAPP.

3.6 Source Removal Record Document

A Source Removal Record Document will be prepared annually (to be submitted with Removal Plan Annual Report) and following completion of removal activities to document the source removal process. The report will include:

- A narrative description of the work performed;
- Daily field reports maintained by the CQA Field Representative;
- Photographic logs of each grid cell following visual inspection;
- As-built surveys upon removal of CCR; and
- The evaluation of analytical laboratory results for each grid cell.

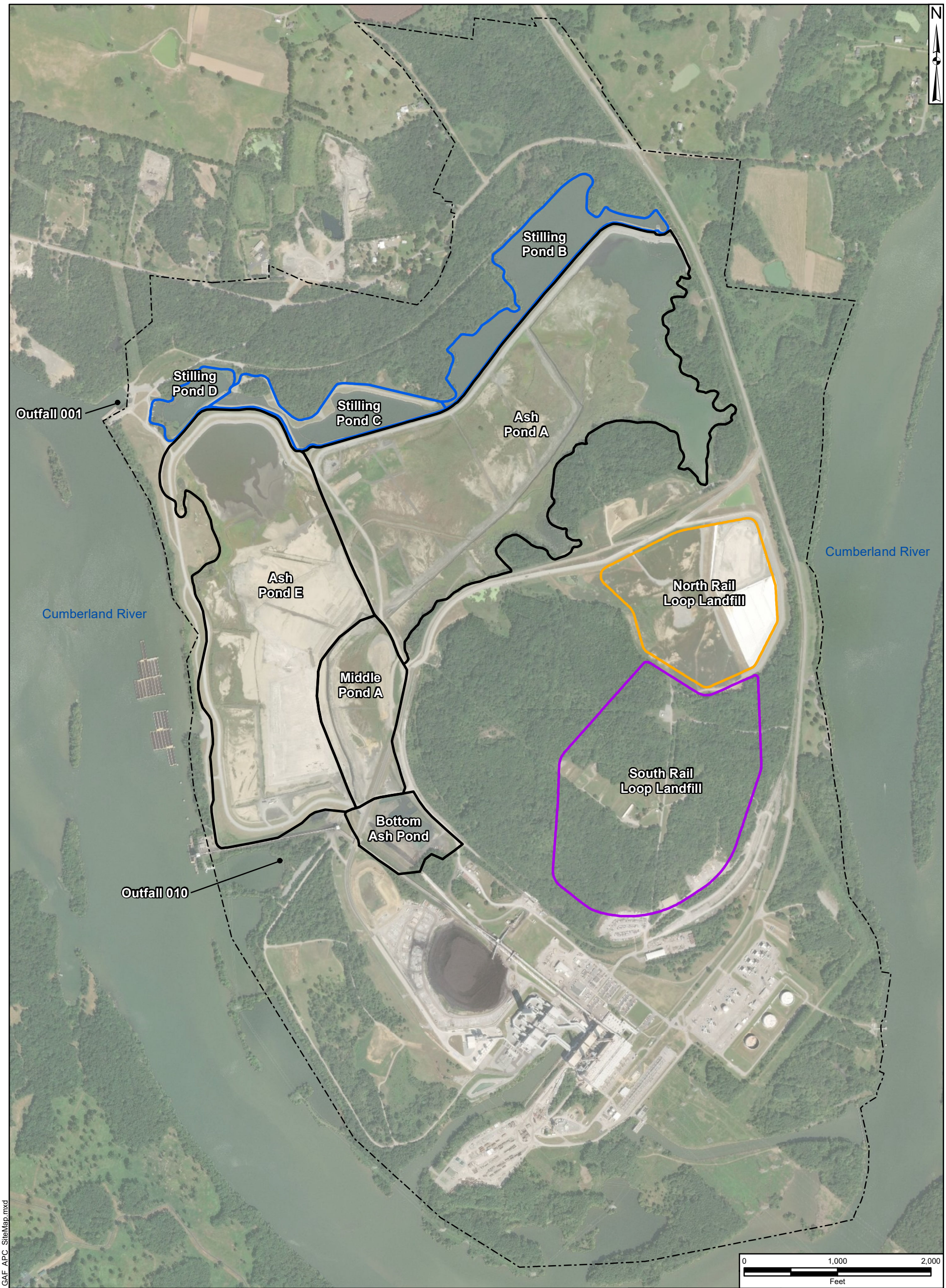
The Source Removal Record Documents will be prepared and certified by a Professional Engineer licensed in Tennessee.

4 References

Environmental Standards (2019), Quality Assuarance Project Plan, Tenneesee Valley Authority Source Removal Projects, Revision 0, January 2019

Tennessee Valley Authority (2019), Interim Source Removal Process, January 11, 2019.

FIGURES



LEGEND

- Ash Ponds
- Stilling Ponds
- North Rail Loop Landfill
- South Rail Loop Landfill
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Figure 1

SITE MAP

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J.COLLEY	D.SKEGGS	-	REV. 0

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

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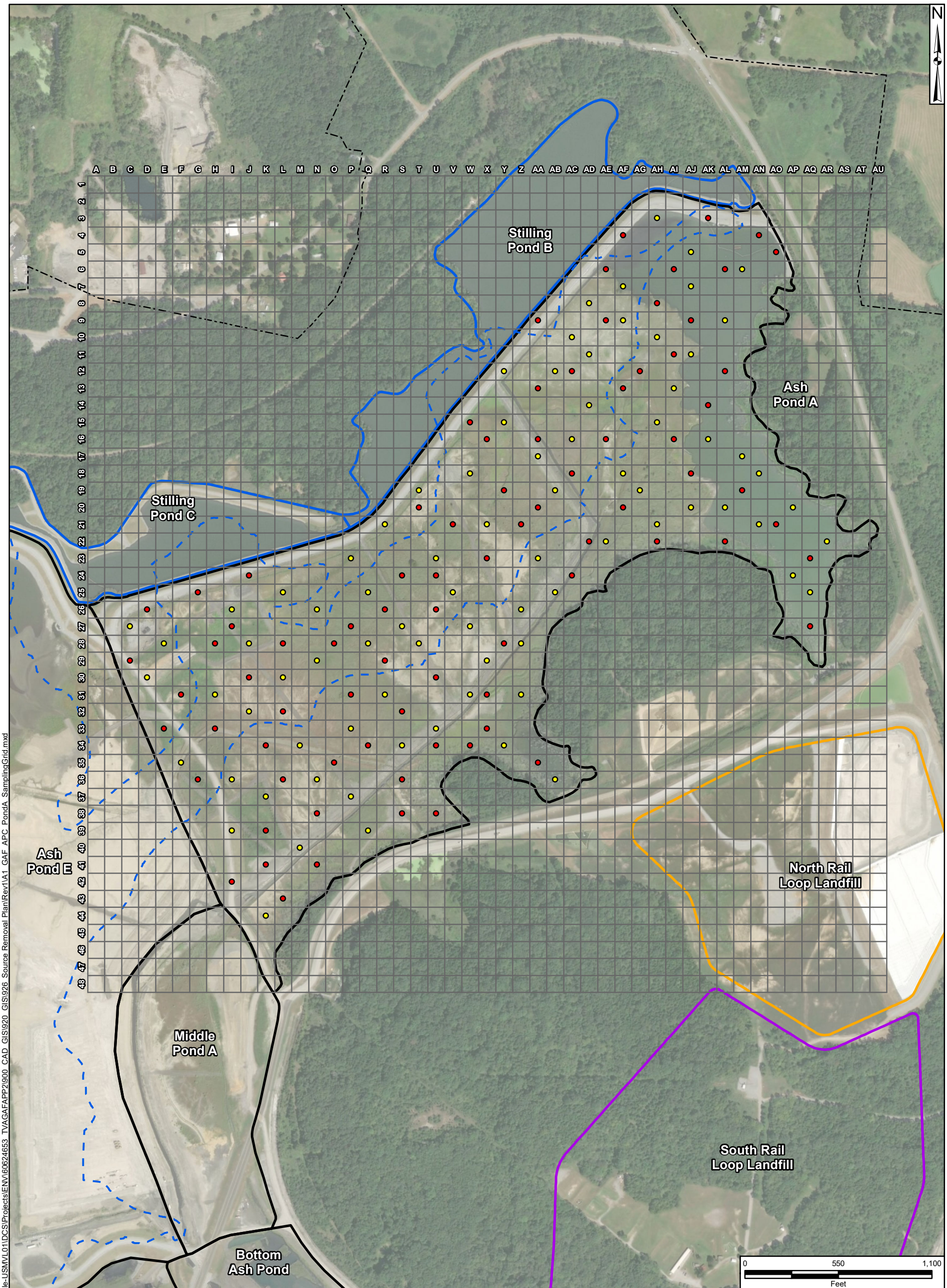
ATTACHMENTS

Attachment A – Source Removal Quality Control Grids



LEGEND

- Sampling Location - Percent Ash & CCR Constituents (82 locations)
- Sampling Location - Percent Ash (82 locations)
- 445 ft Water Level Ele.
- Ash Ponds
- Stilling Ponds
- North Rail Loop Landfill
- South Rail Loop Landfill
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Notes:
[1] The 445 ft elevation line shown represents the approximate limit of ponded area to be created post-closure. Sample elevations shall be field verified by survey and compared to the appropriate risk based screening levels in accordance with the Source Removal CQA Plan.
[2] Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Figure A.1

ASH POND A -
PROPOSED SAMPLING GRID

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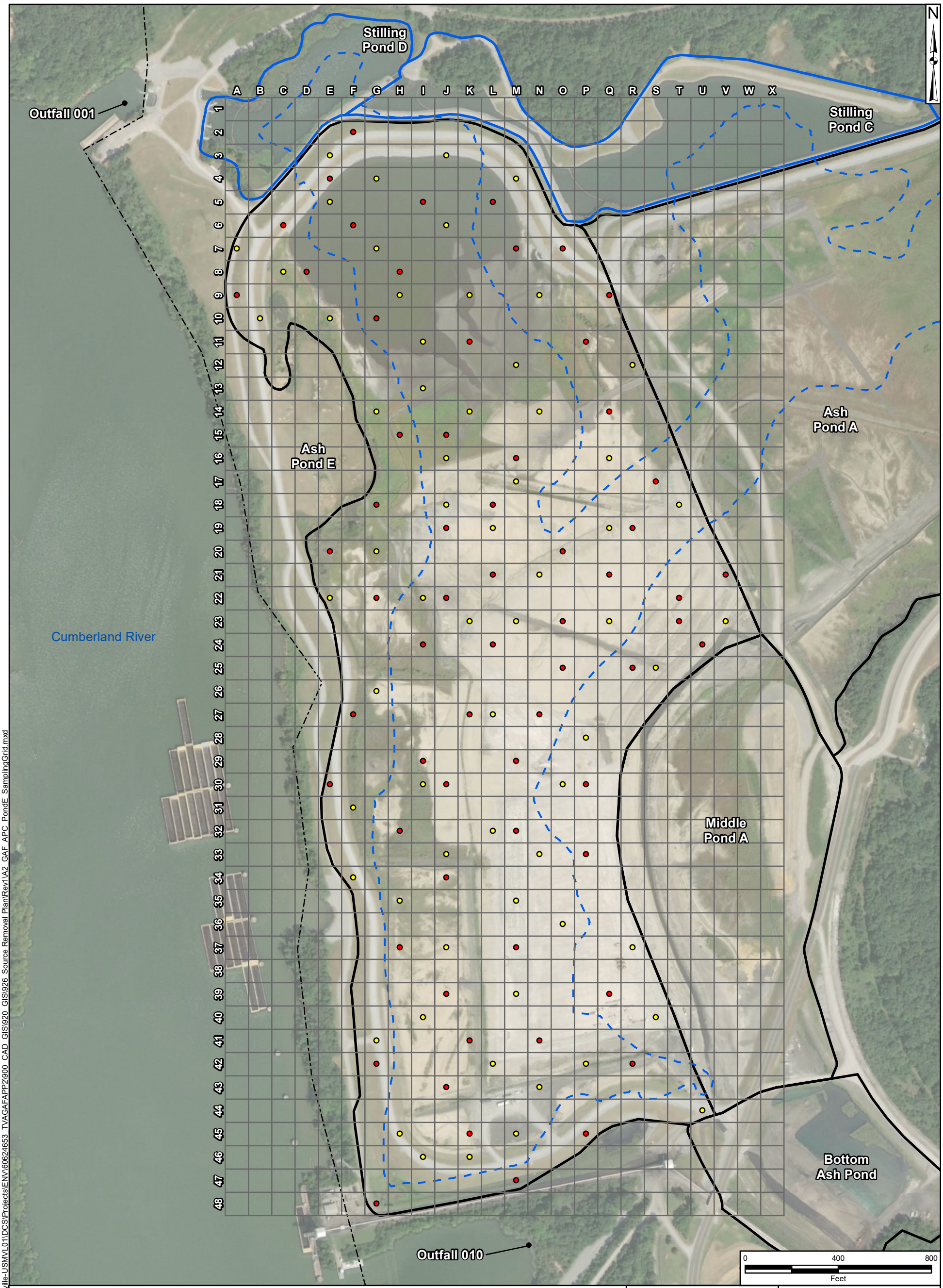

LEGEND

- Sampling Location - Percent Ash & CCR Constituents (64 locations)
- Sampling Location - Percent Ash (64 locations)
- 445 ft Water Level Ele.
- Ash Ponds
- Stilling Ponds
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Notes:
[1] The 445 ft elevation line shown represents the approximate limit of ponded area to be created post-closure. Sample elevations shall be field verified by survey and compared to the appropriate risk based screening levels in accordance with the Source Removal CQA Plan.
[2] Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Figure A.2

ASH POND E -
PROPOSED SAMPLING GRID

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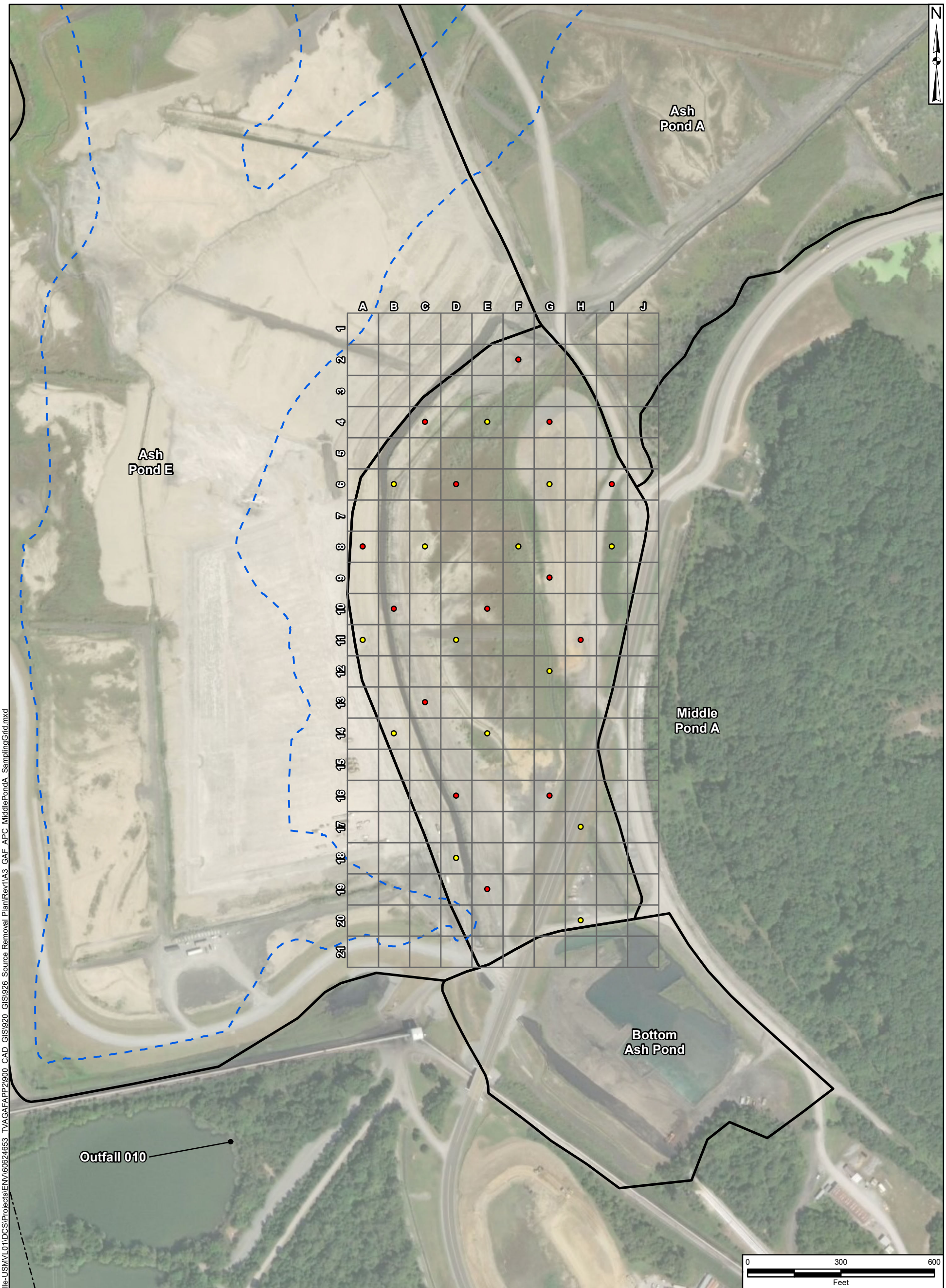

LEGEND

- Sampling Location - Percent Ash & CCR Constituents (14 locations)
- Sampling Location - Percent Ash (14 locations)
- 445 ft Water Level Ele.
- Ash Ponds
- Stilling Ponds
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Notes:
[1] The 445 ft elevation line shown represents the approximate limit of ponded area to be created post-closure. Sample elevations shall be field verified by survey and compared to the appropriate risk based screening levels in accordance with the Source Removal CQA Plan.
[2] Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Figure A.3

MIDDLE POND A -
PROPOSED SAMPLING GRID

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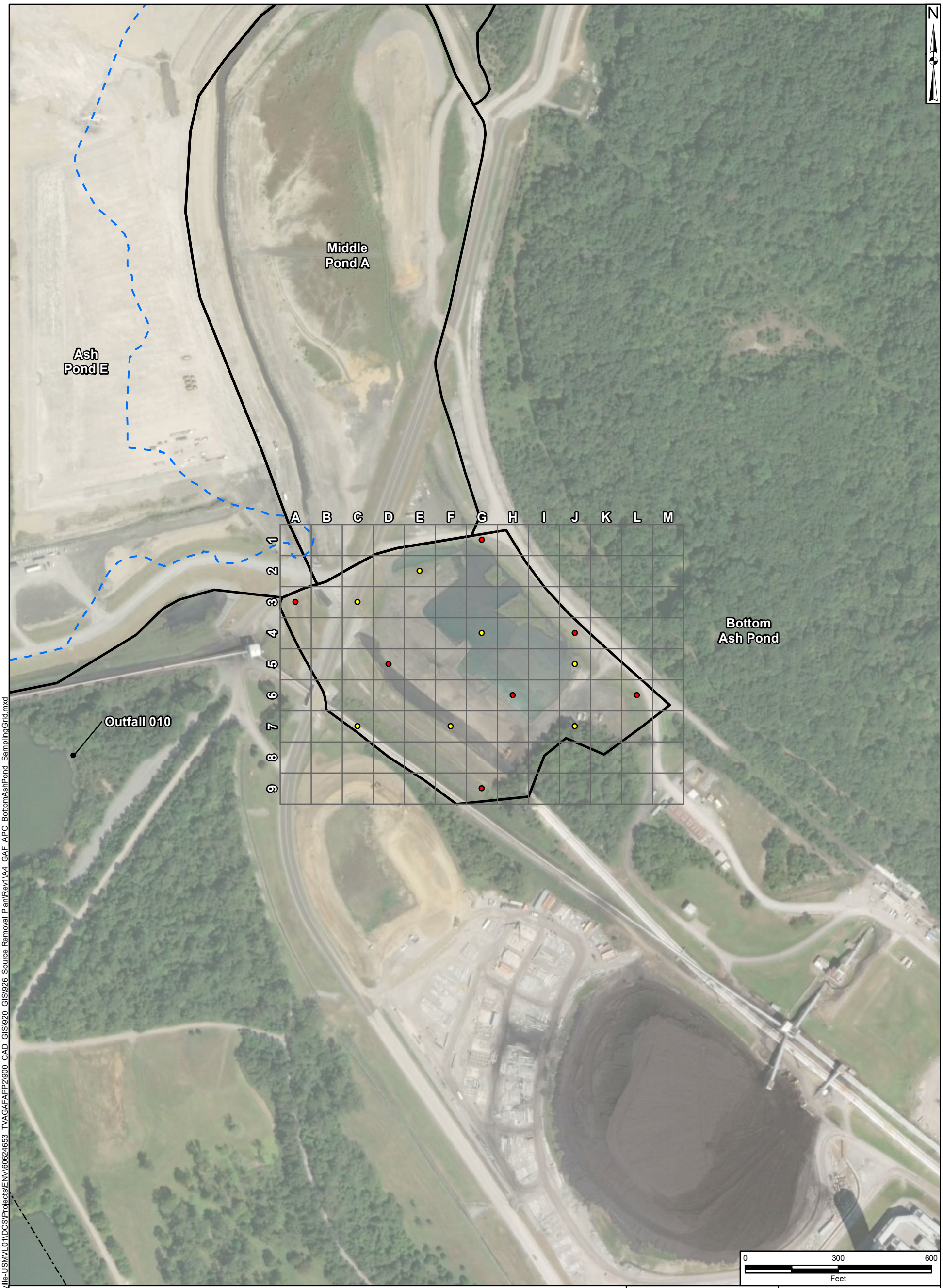

LEGEND

- Sampling Location - Percent Ash & CCR Constituents (7 locations)
- Sampling Location - Percent Ash (7 locations)
- 445 ft Water Level Ele.
- Ash Ponds
- Stilling Ponds
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Notes:
[1] The 445 ft elevation line shown represents the approximate limit of ponded area to be created post-closure. Sample elevations shall be field verified by survey and compared to the appropriate risk based screening levels in accordance with the Source Removal CQA Plan.
[2] Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Figure A.4

BOTTOM ASH POND -
PROPOSED SAMPLING GRID

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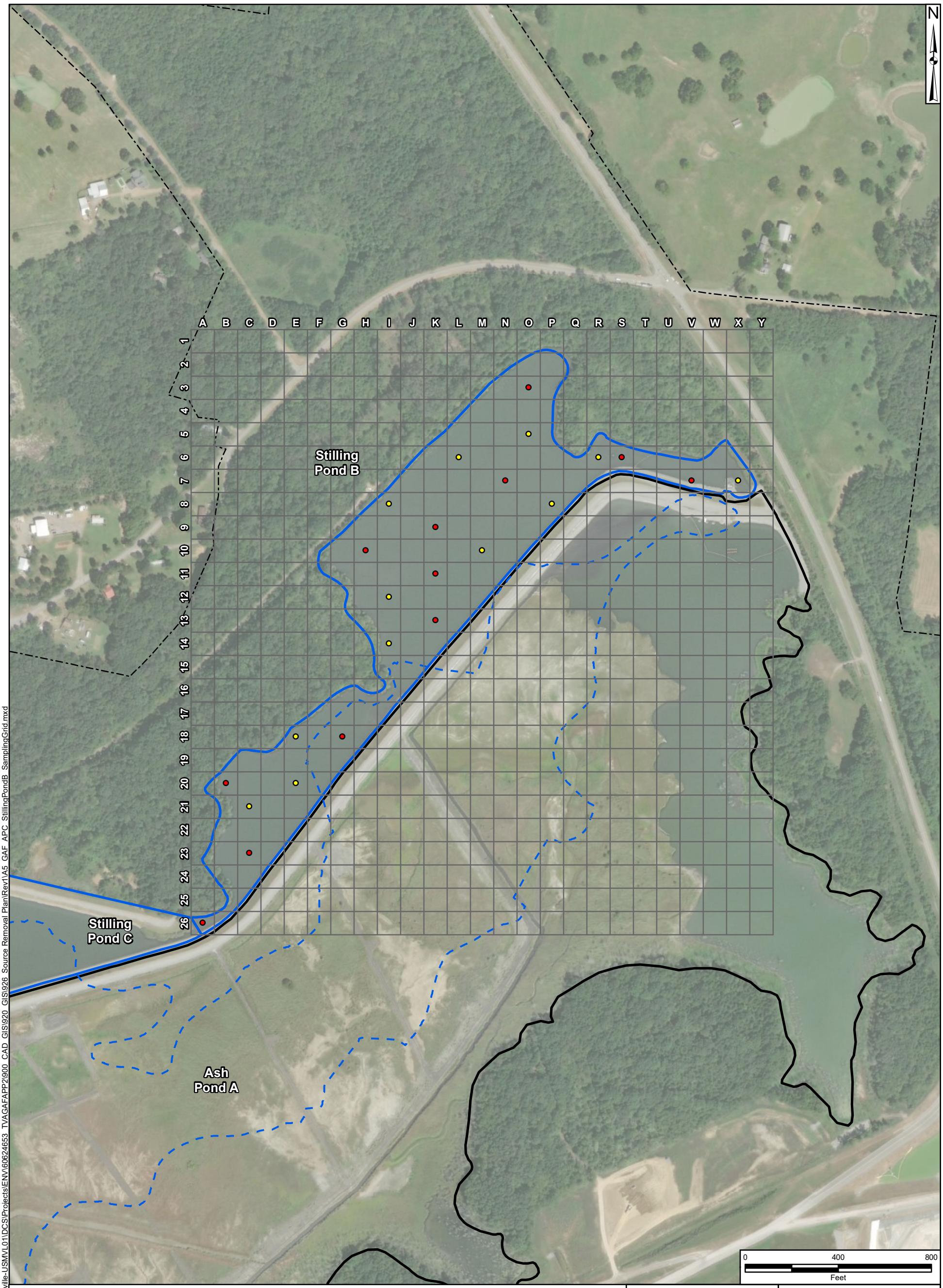

LEGEND

- Sampling Location - Percent Ash & CCR Constituents (12 locations)
- Sampling Location - Percent Ash (12 locations)
- 445 ft Water Level Ele.
- Ash Ponds
- Stilling Ponds
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Notes:
[1] The 445 ft elevation line shown represents the approximate limit of ponded area to be created post-closure. Sample elevations shall be field verified by survey and compared to the appropriate risk based screening levels in accordance with the Source Removal CQA Plan.
[2] Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Figure A.5

STILLING POND B -
PROPOSED SAMPLING GRID

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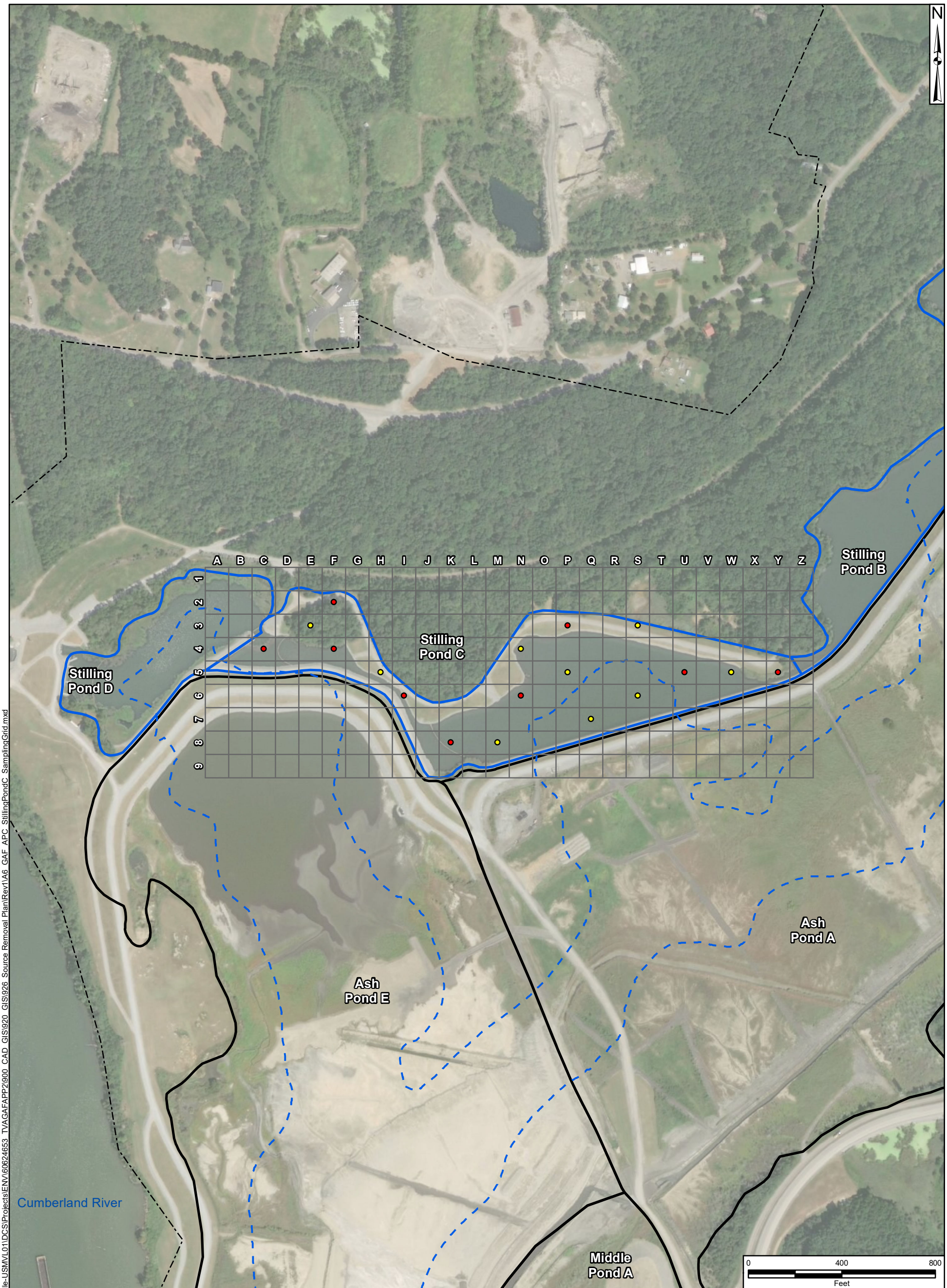

LEGEND

- Sampling Location - Percent Ash & CCR Constituents (9 locations)
- Sampling Location - Percent Ash (9 locations)
- 445 ft Water Level Ele.
- Ash Ponds
- Stilling Ponds
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Notes:
[1] The 445 ft elevation line shown represents the approximate limit of ponded area to be created post-closure. Sample elevations shall be field verified by survey and compared to the appropriate risk based screening levels in accordance with the Source Removal CQA Plan.
[2] Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Figure A.6

STILLING POND C -
PROPOSED SAMPLING GRID

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TENNESSEE VALLEY AUTHORITY

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LEGEND

- Sampling Location - Percent Ash & CCR Constituents (4 locations)
- Sampling Location - Percent Ash (4 locations)
- 445 ft Water Level Ele.
- Ash Ponds
- Stilling Ponds
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Notes:
[1] The 445 ft elevation line shown represents the approximate limit of ponded area to be created post-closure. Sample elevations shall be field verified by survey and compared to the appropriate risk based screening levels in accordance with the Source Removal CQA Plan.
[2] Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Figure A.7

STILLING POND D -
PROPOSED SAMPLING GRID

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Attachment B – Example Daily Report

DAILY ACTIVITY AND OBSERVATION REPORT

Date: xx/xx/xxxx

Facility Name: TVA Gallatin Fossil Plant	**Project:** APC Closure Source Removal Construction Quality Assurance	**Project Phase:**
TVA Project #:	**AECOM Project #:**	**Consecutive Report No.:**

Summary of ISR CQA Activities (Include Additional Sheets as Necessary); Document compliance with ENV-TI-05.80.50 Soil and Sediment Sampling

Personnel on site

Equipment used on site; Document compliance with ENV-TI-05.80.05

Samples collected and/or transported to laboratories (include photographs in photolog section)

Summary of Incidents / Accidents / Health & Safety Issues:

Directives / Approvals Given:

Visitors:

DAILY ACTIVITY AND OBSERVATION REPORT

Date: xx/xx/xxxx

Weather:	**Cloudy / Rain**		**Contractor Started Work:**	**Field Representative Started Work:**
Temperature:	**AM:** xx° F	**PM:** xx° F	**Contractor Stopped Work:**	**Temperature:**
Field Representative:			**Field Representative's Signature:**	**Date:**
Reviewed by:			**Reviewer's Signature:**	**Date:**

AECOM

DAILY ACTIVITY AND OBSERVATION REPORT

Date: xx/xx/xxxx

(Daily progress photos) **(Add as many photolog sheets as necessary)**	**(Description)**
(Photo)	**(Photo)**
(Description)	**(Description)**
(Photo)	**(Photo)**

Attachment C – Risk-Based Closure Approach Memorandum

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REPORT ON

RISK-BASED CLOSURE APPROACH FOR THE ASH POND COMPLEX TVA GALLATIN FOSSIL PLANT

by
Haley & Aldrich, Inc.
Chicago, Illinois

for
Tennessee Valley Authority
Chattanooga, Tennessee

File No. 134812-002
January 2021

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List of Acronyms

APC	Ash Pond Complex
AWQC	Ambient Water Quality Criteria
BTV	Background Threshold Value
CC	Confidence Coefficient
CCC	Continuous Concentration Criterion
CCR	Coal Combustion Residuals
CMC	Continuous Maximum Criterion
CSM	Conceptual Site Model
DAF	Dilution Attenuation Factor
EI	Environmental Investigation
GAF	Gallatin Fossil Plan
Kd	Partition Coefficient
KM	Kaplan-Meier
MCL	Maximum Contaminant Level
MSL	Mean Sea Level
mg/kg	milligram per kilogram
ND	Non-Detect
NOAA	National Oceanic and Atmospheric Administration
NRL	North Rail Loop
pCi/L	picoCuries per liter
RBSL	Risk-Based Screening Level
RSL	USEPA Risk-Based Screening Level
SQuiRTs	Screening Quick Reference Tables
SRL	South Rail Loop
SSL	Soil-to-Groundwater Screening Level
SW-DAF	Surface Water Dilution and Attenuation Factor
TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UTL	Upper Tolerance Limit

1. Introduction

Tennessee Valley Authority (TVA) retained Haley & Aldrich, Inc. (Haley & Aldrich) to provide a preliminary evaluation of a risk-based closure approach for the potential exposure pathways for soil at the Ash Pond Complex (APC) at the TVA Gallatin Fossil Plant (GAF).

1.1 OBJECTIVE

TVA will be closing the Ash Pond Complex at GAF by removal of the coal combustion residuals (CCR), under the programmatic agreement with the Tennessee Department of Environment and Conservation (TDEC). The Interim Source Removal Process and Interim Source Removal Quality Assurance Project Plan guidance documents are provided in Attachments D and E of the Source Removal Construction Quality Assurance Plan, respectively. This document, which is Attachment C of the Interim Source Removal Process document, provides the risk-based closure approach to identify the appropriate extent of excavation of the native soil at the base of the pond. This approach uses site-specific risk-based screening levels for soil to determine when excavation is complete.

The final site restoration has not yet been determined. However, the Removal Plan indicates [see that Plan for more detail]:

> Site restoration activities will be completed following the CCR removal required by the Order. Areas of the site may be restored as removal progresses based on contractor phasing of the work. However, final site restoration may be completed following the 20-year removal timeline required by Section 2.f of the Order.
>
> At a minimum, the site will be graded to promote positive drainage and adequately manage storm water. Borrow soils from existing on-site soil stockpiles or an off-site TVA borrow site may be used during site restoration. Disturbed areas will be seeded with native grasses for erosion control in accordance with the SWPPP [Stormwater Pollution Prevention Plan].
>
> Post-excavation, the site will resemble the land's valley shape before the APC was created. Areas of the site located below the Cumberland River's normal water surface elevation are expected to result in a ponded area over a portion of the site.

For the purposes of this evaluation, two options are considered: the post-excavation area results in a ponded area up to approximately +445 feet Mean Sea Level (MSL) (the typical stage of the Cumberland River), or an alternative where the area could be backfilled with clean fill.

The media of interest are the soils remaining post-excavation, groundwater, and surface water. This report describes the risk-based closure approach for determining comparison values for soil based on background concentrations and protection of human health and the environment via soil, groundwater, and surface water exposure pathways.

1.2 BACKGROUND

On July 24, 2019, the Davidson County Chancery Court entered a Consent Order (Order) in Case No. 15-23-IV reflecting an agreement between the TVA, the State of Tennessee, the TDEC, and certain Plaintiff-Intervenors to close the APC located at the GAF located near Gallatin, Sumner County, Tennessee. TVA is proposing to excavate the CCR from the APC and place the material within a dedicated lateral expansion to the North Rail Loop (NRL) landfill, referred to as the South Rail Loop (SRL) landfill.

This report addresses soils remaining post-excavation and addresses direct contact pathways, the soil-to-groundwater pathways, the groundwater-to-surface water transport and potential exposure pathways, and the potential soil-to-surface water pathway if the final restoration results in a ponded area. Based on the pathway evaluations, risk-based screening levels have been developed to evaluate soils remaining post-excavation at the Ash Pond Complex. Risk-based screening levels for groundwater and surface water have been developed to support this evaluation. Comparison of site data to these screening levels will be conducted in a separate report, once the excavation work is completed.

1.3 CONCEPTUAL SITE MODEL AND RISK-BASED EVALUATION APPROACH TO CLOSURE

A human health and ecological exposure-based conceptual site model (CSM) has been developed to support the tiered evaluation, as described below. **Figure 1** shows the location of GAF, and **Figure 2** shows the site plan and the Cumberland River. The Ash Pond Complex includes Ash Pond A, Ash Pond E, Middle Pond A, Bottom Ash Pond, and Stilling Ponds B, C, and D. **Figure 3** presents the CSM.

The Ash Pond Complex will be closed by removal of the CCR material. After CCR material is excavated, up to an additional one (1) foot of underlying native soils may be removed, however, it is anticipated that bedrock will be exposed at some locations. The remaining soil will be evaluated as described in this document. As noted above, the final method of restoration of the excavated pond has not yet been determined. For the purposes of this evaluation, two options are considered: the post-excavation area results in a ponded area up to approximately +445 feet MSL (the typical stage of the Cumberland River), or an alternative where the area could be backfilled with clean fill.

Native soil remaining after the excavation is completed may contain residual levels of CCR-derived constituents. To evaluate this potential, data collected for soils sampled in background locations are used to calculate a background level to which constituent concentrations in post-excavation composite soil samples will be compared. In addition, three potentially complete direct contact exposure pathways have been identified for the post-excavation soil: direct contact by 1) an industrial worker, 2) a construction worker, and 3) ecological receptors should the final method of restoration result in a ponded area. If the post-excavation area is backfilled with clean fill as the selected method of restoration, post-excavation soil would not be accessible to terrestrial receptors. Construction worker receptors are included in the backfill with clean fill scenario assuming that exposure to remaining post-excavation soils could potentially occur during future construction/excavation activities below the clean fill depth. Per TDEC, industrial receptors are also evaluated as the first step in the screening process, then construction workers. Results for post-excavation soil samples will be compared to background soil levels and to the relevant risk-based screening levels for ecological receptors and/or both worker types. Details and flowcharts of the screening process are presented in Section 2.

Under the ponding scenario, native soil remaining after the excavation is completed may serve as a continuing source of CCR-derived constituents to surface water. Although ecological sediment screening levels are generally considered to be protective of surface water, at the request of TDEC, site-specific soil screening levels have been developed for the soil-to-surface water pathway. Post-excavation soil sample results will be compared first to the background soil levels, direct contact screening levels, and to the soil-to-surface water screening levels.

Native soil remaining after the excavation is completed may serve as a continuing source of CCR-derived constituents to groundwater. To evaluate this potential, site-specific soil screening levels have been developed for the soil-to-groundwater pathway, and post-excavation soil sample results will be compared first to the background levels and then to the soil-to-groundwater screening levels.

CCR-derived constituents potentially present in groundwater when the excavation is complete may move to adjacent surface water. Groundwater beneath the Ash Pond Complex currently flows towards the Cumberland River; if the final method of restoration includes ponding of water, groundwater may also flow into the new ponded area. Groundwater data appropriate for the evaluation of the Ash Pond Complex will be evaluated in the final report for the project.

On-site groundwater is not used as drinking water or for any other purposes. There are water supply wells within a 1-mile radius of the facility. These were identified from a well survey conducted under the GAF Environmental Investigation (EI) and presented in the report entitled: Summary of Water Supply Well Survey and Sampling Activities, Gallatin Fossil Plant, Gallatin, Tennessee, 2 November 2017 (Haley & Aldrich, 2017). The wells are located on 25 properties. Gallatin municipal water is available in the area. Access agreements were obtained for nine (9) properties and sampling for inorganics conducted for 11 wells on those properties. As shown in Table 7 of Haley & Aldrich, 2017, none of the constituents detected in water supply well samples are reported at concentrations above federal primary drinking water standards, and only a few well results were above the state drinking water standard for total dissolved solids. The water supply wells sampled by TVA are not used for drinking water purposes. However, wells for which TVA did not gain access to sample could be used for drinking water. Based on the presence of these wells, the groundwater pathway is designated as potentially complete for current and potential future use of groundwater as drinking water.

The Cumberland River is used for recreation, including boating and fishing. The river is also a source of drinking water; there are two nearby utilities that use the Cumberland River as the source of raw water for treatment for use as potable water. The nearest downstream intake is for the City of Gallatin, approximately one mile downstream. This and the closest upstream intake are shown on **Figure 4**.

A surface water dilution and attenuation factor (SW-DAF) has been derived for groundwater that may flow to the Cumberland River. The SW-DAF derivation is provided in **Appendix C** and the calculations are discussed below. Concentrations in groundwater that are below the SW-DAF-applied risk-based screening levels for ecological receptors and human health recreational receptors will provide supporting evidence that the source removal can be considered to be complete; however, consideration must be given to historical groundwater conditions prior to excavation. Note that groundwater will be addressed under Corrective Action, not by the source removal alone. If there are groundwater concentrations above the screening levels, the specific instances will be evaluated in more detail to assess whether additional actions are appropriate. For example, background levels of some constituents in the Cumberland River upstream and downstream of GAF are available from U.S.

Geological Survey (USGS) sources, and from data collected under the EI, that can be used to put the screening levels into context.

2. Risk-Based Evaluation of Soil Remaining Post Excavation

There are three exposure pathways evaluated for the post excavation soils. These are listed below.

Tier 1: Direct Contact with Soils Pathway. To address the direct contact with soils pathway, analytical results for potentially CCR-derived constituents for composite soil samples collected on a grid after completion of the Ash Pond Complex excavation will be compared to:

1. Direct Contact Step 1 – Site-specific Background Threshold Values (BTVs) developed for background soils (see below).
2. Direct Contact Step 2 – Soil screening levels from U.S. Environmental Protection Agency (USEPA, 2020a) Industrial Soils Risk-Based Screening Levels (RSLs).
3. Direct Contact Step 3 – Risk-based screening levels (RBSLs) developed for a site-specific construction/utility worker exposure scenario.
4. Direct Contact Step 4 – If the selected method of restoration includes a ponded area, USEPA Region 4 Freshwater Sediment and Soil Screening Values (USEPA, 2018a).

Tier 2: Soil-to-Groundwater Pathway. To address the soil-to-groundwater pathway, the post-excavation soil samples will be compared to:

1. Soil-to-Groundwater Step 1 – BTVs developed for background soils (see below).
2. Soil-to-Groundwater Step 2 – Soil Screening Levels (SSLs) developed by USEPA (USEPA, 2020c) for the potential soil-to-groundwater leaching pathway based on the use of groundwater as drinking water.
3. Soil-to-Groundwater Step 3 – Site-specific RBSLs derived for the potential soil-to-groundwater leaching pathway based on the protection of the use of surface water for drinking water, human recreation, and aquatic organisms.

Tier 3: Soil-to-Surface Water Pathway. If the selected method of restoration includes a ponded area, to address the soil-to-surface water pathway, the post-excavation soil samples will be compared to:

1. Soil-to-Surface Water Step 1 – BTVs developed for background soils (see below).
2. Soil-to-Surface Water Tier 2 – RBSLs derived for the potential soil-to-surface water leaching pathway protective of the use of surface water as drinking water, human recreation, and aquatic organisms.

2.1 STEP 1 FOR ALL PATHWAYS – DERIVATION OF BACKGROUND THRESHOLD VALUES FOR SOIL

The purpose of the background soil evaluation is to develop a site-specific descriptor of background for constituents of interest, i.e., a site-specific BTV. If a sample result is below the BTV, there is reasonable confidence that the constituent concentration is consistent with background. By contrast, a sample

result above a BTV means only that statistically it cannot be determined to be consistent with background based on the available background dataset.

Overburden soil samples were collected at 25 boring locations (one per 2,000-foot grid cell) across the Site. The purpose of collecting and analyzing overburden samples was to calculate background concentrations of CCR Rule Appendix III and IV constituents in soil and leachate. Drilling logs and soil analytical results were examined to identify potentially disturbed grid locations that might not represent background conditions due to historical plant construction work such as rail, dike, or building activity; eight of the 25 locations were considered non-background based on this evaluation. These locations were approved by TDEC in response to the GAF EIP Sampling and Analysis Plan (SAP) for Overburden Soil Borings, Native Soil Characterization, and Seep Sampling Revision 1 (AECOM, 10/14/2016); approved by TDEC on 11/08/2016. The 17 background sample locations used in this evaluation are shown on **Figure 5**.

Table 1a provides a list of the background soil samples used in this evaluation, and **Table 1b** provides data for the background soil samples. These data are for samples collected in January and February 2017. Duplicate samples were treated similarly to other quality control samples and were reviewed but not included in this evaluation.

Table 2 presents summary statistics and the calculated site-specific BTVs for the background soil dataset. In accordance with USEPA guidance, BTVs were calculated using USEPA ProUCL Statistical Software for Environmental Applications version 5.1.002 (USEPA, 2016). The selected BTV is the 95% Upper Tolerance Limit (UTL) with 95% coverage. **Appendix B** presents the ProUCL output sheets.

Descriptive statistics for constituents in the background soil dataset were computed and tabulated in **Table 2**. These include the Frequency of Detection, Percent Detects, Range of Non-Detects (ND), Mean, Variance, Standard Deviation, Coefficient of Variation, 50th percentile, 95th Percentile, and Maximum Detects. Information such as the requirement for a certain minimum number of samples and percent NDs were evaluated during this step.

An analysis using the Dixon's Outlier Test from USEPA ProUCL software (USEPA, 2016) indicated the presence of some outliers in the data set. It is assumed that the background dataset used to estimate BTVs represents an unimpacted, single statistical population that is free from outliers. However, since outliers are inevitable in most environmental data, the decision to include or exclude outliers in statistical computations was decided by the project team based on constituent and facility-specific knowledge.

The following were considered for the outlier evaluation:

- Proximity to potential source of contamination, and potential pathway to the soil boring;
- Depth of soil sample and the nature of potential contamination source (e.g., surface source of contamination vs. subsurface soils);
- Consistency between the individual 5-ft composite samples and the composite samples that span the entire sample range of the boring;
- Knowledge of geology at the boring locations; and

- Concentrations of parameters in ash porewater samples.

Based on this evaluation, there was no reason to exclude data from any of the background samples, with the exception of samples from GAP002, based on molybdenum identified as a potential outlier. Due to the boring's proximity to the APC and data indicating molybdenum is elevated in the ash porewater, it was decided to exclude all GAP002 samples from the background dataset.

The site-specific BTVs were generated using USEPA ProUCL software (USEPA, 2016), which also tests for normal, lognormal and gamma distributions to establish the appropriate distribution. If the ProUCL test statistics suggested the data follow normal, lognormal or gamma distributions, parametric methods were utilized to estimate BTV values. If the normality assumption was not met the data were considered to be distribution free, and non-parametric statistical methods were used to estimate BTV values. The BTVs for the constituents were estimated using the appropriate parametric (normal, lognormal or gamma) or non-parametric Upper Tolerance Limits (UTL95-95) with 95% confidence and 95% coverage.

A tolerance limit is a confidence limit on a specified proportion of the population, rather than a confidence limit on the mean. A UTL95-95 is a value for which there is a 95% probability (i.e., with a Confidence Coefficient (CC) of 0.95) that 95% of current and future observations from the target population will be less than or equal to that value. Stated differently, the UTL95-95 represents a 95% UCL of the 95th percentile of the data distribution. A UTL95-95 can be used as a BTV when there are numerous on-site observations. For moderately-to-highly-skewed data sets such as those with a high percentage of NDs, if the detected observations in the left-censored data set follow a gamma distribution, then upper limits using Kaplan-Meier (KM) estimates in gamma UTL equations provide better results.

The nonparametric upper limits (e.g., UTLs) are computed by the higher order statistics such as the largest, the second largest, the third largest, and so on of the background data. The order of the statistic used to compute a nonparametric upper limit depends on the sample size, coverage probability, and the desired CC. In practice, unless the sample size is large, non-parametric upper limits do not provide the desired coverage to the population parameter (upper threshold).

Table 2 presents the estimated site-specific BTV values and applicable methods used in estimating these values.

Note that a BTV was calculated for the sum of the radiums (radium-226 and radium-228). However, this constituent is not carried forward for the development of risk-based screening levels. Available groundwater data to date collected under the EIP indicate that groundwater is below the primary drinking water standard of 5 picoCuries per liter (pCi/L). Should the sum of the radiums be present in post-excavation soils at levels above the BTV, additional risk-based evaluation will be conducted at that time.

2.2 TIER 1 – DIRECT CONTACT PATHWAYS

Figure 6 graphically depicts the soil screening steps. Step 1 for all pathways is comparison of constituent concentrations in post-excavation soil to BTVs. The remaining steps for the Tier 1 screening of soils are discussed in more detail below.

2.2.1 Direct Contact Step 2 – RSLs for Industrial Soils

Table 3 identifies the RSLs for Industrial Soils (USEPA, 2020a). The RSLs are published by USEPA for a default industrial worker exposure scenario, which assumes an exposure frequency of 250 days per year, 8 hours per day, for a 25-year working duration. Exposure routes include incidental ingestion, dermal contact, and inhalation of soil-derived dust. Post-excavation soils within all areas of the former Ash Pond Complex will not be available for direct contact by industrial workers on a daily basis. Therefore, using the USEPA RSLs for Industrial Soils as a screening level in this evaluation is a very conservative approach.

Note that for all of the trace element constituents in **Table 3**, only arsenic is considered by USEPA to be carcinogenic by the ingestion route of exposure. In the Federal Superfund program, the USEPA evaluates potential risk using the target risk range of 1 in 1 million (10^{-6}) to 1 in ten thousand (10^{-4}). USEPA generally requires a remedy if a site risk is above the 10^{-4} risk level (USEPA, 1991). Therefore, for arsenic, the RSL selected for comparison (300 milligrams per kilogram (mg/kg)) is the lower of the noncancer (480 mg/kg) and 10^{-4} cancer risk-based (300 mg/kg) concentrations. Consistent with the work conducted to date under the TDEC-issued Commissioner's Order No. OGC15-0177 (TDEC Order) to TVA, the RSLs for the remaining constituents are based on a target hazard quotient of 1.

2.2.2 Direct Contact Step 3 – RBSLs for Soil for a Construction/Utility Worker Scenario

After closure of the Ash Pond Complex and cessation of excavation activities associated with pond closure, exposure to remaining post-excavation soils could potentially occur during future construction/excavation activities. This would be expected to be of a very brief duration. Should such a scenario occur, the relevant receptor would be a future construction/utility worker.

The theoretical risk posed to a future construction/utility worker would be due to potential contact with CCR-derived constituents in post-excavation soil directly via incidental ingestion and dermal contact. Additionally, construction workers might inhale particulates entrained in dusts. The construction worker scenario is intended to characterize risks associated with high-intensity, short-duration exposures to soil. Such exposures are characterized using USEPA national standardized parameters for construction worker scenarios, which allow for use of site-specific exposure frequencies. For this scenario, an exposure frequency of 60 days per year was used, assuming that a large-scale development project would involve soil excavation activities over a total of 12 weeks in a project that would take up to a year to complete. However, any future excavation in the closed pond area is unlikely and probably would be of much shorter duration, thus, the exposure assumptions used here are conservative.

Table 3 provides the site-specific RBSLs for the construction/utility worker scenario. The RBSLs were calculated using the USEPA RSL calculator and USEPA-derived inputs for the "construction worker – other construction activities" scenario as well as site-specific inputs where appropriate (USEPA, 2020b).

As was the case for the RSL for arsenic for the Direct Contact Step 2, the RBSL selected for arsenic for the Direct Contact Step 3 (98.6 mg/kg) is the lower of the noncancer (98.6 mg/kg) and the 10^{-4} cancer-based risk (9,250 mg/kg) concentrations. Consistent with the work conducted to date under the TDEC-issued Commissioner's Order No. OGC15-0177 (TDEC Order) to TVA, the RSLs for the remaining constituents are based on a target hazard quotient of 1. **Table 4** provides the exposure assumptions used for the

RBSL calculations. The RBSL inputs and RSL calculator output values are provided in **Appendix A**. Additional construction worker inputs specific to the construction worker scenario are shown in the "site-specific construction worker equation inputs for soil – other construction activities" page of **Appendix A**.

2.2.3 Direct Contact Step 4 – Ecological Screening Levels for Soil and Sediment

Direct contact Step 4 screening will be conducted if the selected method of restoration includes a ponded area. **Table 5** presents the USEPA Region 4 ecological screening levels for soil and sediment (USEPA, 2018a) and the site-specific BTVs derived in **Table 2**.

The National Oceanic and Atmospheric Administration Screening Quick Reference Tables (NOAA SQuiRTs) were also reviewed and do not provide screening levels for constituents that do not already have a screening level (NOAA, 2008). The NOAA SQuiRTs have not been updated since 2008 and are not maintained; newer screening level sources are available from USEPA as shown in **Table 5**.

2.3 TIER 2 – SOIL-TO-GROUNDWATER PATHWAY

Step 1 for all pathways is comparison of constituent concentrations in post-excavation soil to BTVs. As noted above, the soil-to-groundwater pathway addresses target concentrations for the potential use of groundwater as drinking water and the protection of surface water for human health and aquatic organisms. Each of these pathways is discussed below.

2.3.1 Soil-to-Groundwater Step 2 — Potential Use of Groundwater as Drinking Water

Table 6 presents the derivation of the site-specific soil screening levels for the potential soil-to-groundwater leaching pathway for groundwater assumed to be used as drinking water. As shown in **Table 6**, USEPA provides default soil-to-groundwater soil screening levels (SSLs) based on the use of groundwater as drinking water using the maximum contaminant level (MCL) (USEPA, 2020c). Where MCL-based soil-to-groundwater SSLs are unavailable, USEPA default soil-to-groundwater SSLs are derived based on risk-based tapwater RSLs. The USEPA MCL-based SSLs are calculated using the USEPA MCLs, a default DAF of 1, and USEPA default geotechnical soil characteristics for partition coefficients (K_d) and other values. The USEPA risk-based SSLs are calculated using the USEPA tapwater RSLs and the same default DAF and USEPA default geotechnical soil characteristics. The USEPA MCLs are primary drinking water standards that are enforceable for municipal drinking water supplies, and the tapwater RSLs are protective for residential receptor exposure to groundwater and are based on a target cancer risk of 10^{-6} and a target hazard quotient of 1. Arsenic is the only constituent of potential concern in groundwater that is considered by USEPA to be carcinogenic by the ingestion route of exposure. However, the selected screening level for potential use of groundwater in drinking water for arsenic, as shown on Table 6, is the MCL, rather than the tapwater RSL.

The USEPA-provided default SSL values use a DAF of 1 (USEPA, 2020c). However, the USEPA Supplemental Soil Guidance (USEPA, 2002) developed two default DAFs (DAF=1 and DAF=20) that are appropriate for deriving generic SSLs. USEPA recommends that a DAF of 20 be used "to account for reductions in contaminant concentration due to natural processes occurring in the subsurface," and that a DAF of one be used "assuming no dilution or attenuation between the source and the receptor well" (USEPA, 2002, Appendix A).

In previous consultation with TDEC, the SSLs shown in **Table 6** were adjusted to use a default DAF of 20. These provide the screening levels for the second step of the soil-to-groundwater pathway evaluation.

2.3.2 Soil-to-Groundwater Step 3 — Groundwater Protection of Surface Water

The purpose of this step of the evaluation is to develop a screening level for soil that is protective of two scenarios: groundwater used as a source of drinking water, and groundwater that discharges to surface water. For the latter, the soil concentration needs to be protective of both human health and ecological exposures to surface water. These values are developed and presented on **Table 7**.

As noted above, **Table 6** provides the soil SSLs for a DAF of 20. These SSLs are protective of groundwater used as drinking water and are also presented on **Table 7**.

Groundwater concentrations that are protective of human health and ecological exposures to surface water are developed in Section 3, as presented on **Table 10**. The target groundwater screening levels developed on **Table 10** are provided on **Table 7**.

The same ratio used by USEPA to develop the SSL for soil based on a drinking water use scenario for groundwater can be used to develop an SSL for soil based on a groundwater concentration protective of uses of surface water as shown in the equation below and in the last column of **Table 7**.

Site-Specific Surface Water Protection-Based Soil-to-Groundwater SSL (mg/kg) =

$$\frac{\text{USEPA Drinking Water-Based SSL (DAF of 20)} \times \text{(Target Groundwater Screening Level Protective of Surface Water)}}{\text{USEPA Drinking Water Value}}$$

These calculations are shown in **Table 7** for the Cumberland River using the site-specific target groundwater concentrations.

2.4 TIER 3 – SOIL-TO-SURFACE WATER PATHWAY

Step 1 for all pathways is comparison of constituent concentrations in post-excavation soil to BTVs.

Derivation and evaluation of site-specific screening levels for the soil-to-surface water pathway is appropriate only if the selected method of restoration includes a ponded area. It is generally accepted that ecological sediment screening levels are also protective of dissolution of those constituents to surface water that may occur due to the presence of the constituents at the screening levels in the sediment. However, to address this pathway in a more quantitative manner, the following steps have been taken.

As noted above, the SSLs predict dissolution of constituents from soil to groundwater. The DAF of 20 used above is conservative for the evaluation of dilution and attenuation that occurs from soil to groundwater. For the soil-to-surface water scenario, attenuation is not a mechanism, but dissolution from the soil and dilution directly into the surface water is a factor. Dilution into surface water is expected to be much greater than the factor of 20 used above. However, it is difficult to define a

specific dilution factor for the ponding scenario. Therefore, these calculations will use the same SSL approach with a DAF of 20.

Target surface water concentrations that are protective of human health and ecological exposures to surface water are developed in Section 3.5, as shown on **Table 11**. **Table 11** presents the selected human health and ecological screening levels (from **Tables 9 and 10**) and identifies the lowest screening level for surface water for the four potential exposure scenarios. The target surface water screening level developed on **Table 11** is provided on **Table 8,** where the target water concentrations are surface water screening levels protective for both human health (drinking and recreational) and for aquatic ecological receptors.

The same ratio used by USEPA to develop the SSL for soil based on a groundwater drinking water use scenario and a DAF of 20 has been used here to conservatively develop an SSL for soil based on a surface water concentration protective of human health (drinking and recreational) and aquatic ecological receptor uses of surface water as shown in the equation below and on **Table 8**.

Thus, instead of using the equation above to calculate a soil concentration based on a target groundwater concentration assuming a DAF of 20 (and all of the other physico-chemical interactions embedded in the SSL derivation), the equation is used to predict a soil concentration that is protective of a target surface water concentration via the dissolution of constituents from soil to surface water assuming a DAF of 20 (and all of the other physico-chemical interactions between soil and water embedded in the SSL derivation).

Site-Specific Surface Water Protection-Based Soil-to-Surface Water SSL (mg/kg) =

$$\frac{\text{USEPA Drinking Water-Based SSL (DAF of 20)} \times \text{(Target Surface Water Screening Level)}}{\text{USEPA Drinking Water Value}}$$

These calculations are presented in **Table 8**. Note that the target surface water screening levels shown in **Table 8** are the lowest of the human health drinking water, recreational, and aquatic ecological receptor screening levels (as derived on **Table 10**). Where that lowest value is the USEPA drinking water value, also shown in **Table 8** and used in the above equation, the Site-Specific Surface Water Protection-Based Soil-to-Surface Water SSL will be equal to the USEPA Drinking Water-Based SSL (DAF of 20). For constituents with a human health recreational or ecological based target surface water screening level that is selected because it is lower than the human health drinking water screening level, the above equation is used to scale the non-USEPA drinking water value-based target surface water screening level to an equivalent SSL for the soil to surface water pathway.

The DAF of 20 is used for the evaluation of dilution and attenuation that occurs between soil and groundwater and for the dissolution from soil directly into surface water in the ponding scenario, as shown on **Table 8**.

[Note that the separate DAF of 230, derived in **Appendix C** and discussed in Section 3.4, is used for the evaluation of dilution and attenuation of groundwater to the Cumberland River surface water (as shown on **Table 11**).]

2.5 APPLICATION OF THE TIERED APPROACH TO THE EVALUATION OF POST-EXCAVATION SOILS

Composite samples of post-excavation soils will be analyzed for potentially CCR-derived constituents. The comparison to screening levels will be conducted in two parts, as shown in **Figure 6**. Tier 1 compares the soil data to BTVs, to the direct contact RSLs for an industrial worker, and then to the RBSLs for a construction/utility worker.

Tier 2 compares the soil data to BTVs, to the SSLs for the soil-to-groundwater pathway for a potential drinking water scenario, and then to the SSLs for the protection of the groundwater to surface water pathway.

Tier 3 addresses the soil-to-surface water pathway, should the selected method of restoration include a ponded area. Soil data are compared to BTVs, and then to the site-specific risk-based soil to surface water SSL.

2.5.1 Tier 1 – Direct Contact Pathways Screening

Step 1. Constituent concentrations in post-excavation soils will be compared to the BTVs; results less than or equal to the BTVs will be considered to be acceptable, and no further evaluation will be conducted in Tier 1 for those constituents.

Step 2. Constituent concentrations above their respective BTVs will be compared to the RSLs for Industrial Soils; results less than or equal to the RSLs will be considered to be acceptable, and no further evaluation will be conducted for those constituents for human health.

Step 3. Constituent concentrations above both their respective BTVs and Industrial Soils RSLs will be compared to the RBSLs for the construction/utility worker scenario; results less than or equal to the RBSLs will be considered to be acceptable, and no further evaluation will be conducted in Tier 1 for those constituents for human health.

Step 4. If the selected method of restoration includes a ponded area, constituent concentrations in post-excavation soils above their respective BTVs will also be compared to the ecological screening levels for soil and sediment; results less than or equal to the screening level will be considered to be acceptable, and no further evaluation will be conducted in Tier 1 for those constituents for ecological receptors.

For constituents with concentrations above both their respective BTVs and above ecological screening levels for soil and sediment, the area-wide average constituent concentrations will be calculated for the excavation area. Those constituents with area-wide concentrations less than or equal to the ecological screening levels will be considered to be acceptable, and no further evaluation will be conducted for those constituents.

Constituents that have post-excavation soil concentrations above both their respective BTV and RBSL in Tier 1 or, where appropriate, BTV and ecological screening level, will be considered for further evaluation to assess whether additional actions may be appropriate.

2.5.2 Tier 2 – Soil-to-Groundwater Pathways Screening

In addition to the Tier 1 evaluations for direct contact, soil screening in Tier 2 addresses the soil-to-groundwater pathway.

Step 1. Constituent concentrations in post-excavation soils will be compared to the BTVs; results less than or equal to the BTVs will be considered to be acceptable, and no further evaluation in Tier 2 will be conducted for those constituents.

Step 2. This step addresses drinking water use of groundwater. Constituents with concentrations above their respective BTVs will be compared to the drinking water-based soil-to-groundwater screening levels based on a DAF=20 (**Table 6**); results less than or equal to the respective drinking water-based soil-to-groundwater screening level will be considered to be acceptable. Constituents with concentrations above both their respective BTV and the drinking water-based soil-to-groundwater screening levels will be considered for further evaluation if the drinking water pathway for that area of groundwater is considered to be complete.

Step 3. This step addresses groundwater that may flow to surface water. Constituents with concentrations above both their respective BTV and the drinking water-based soil-to-groundwater screening level will be compared to the site-specific soil-to-groundwater screening level for the protection of surface water (for both human and ecological receptors) (**Table 7**); results less than or equal to these screening levels can be considered to be acceptable, and no further evaluation will be conducted in Tier 2 for those constituents.

Constituents that have post-excavation soil concentrations above their respective BTVs, drinking water-based soil-to-groundwater screening levels, and site-specific soil-to-groundwater screening levels for the protection of surface water will be considered for further evaluation to assess whether further actions may be appropriate. One step in that evaluation may include the evaluation of groundwater data, using the screening levels described in Section 3.

2.5.3 Tier 3 – Soil-to-Surface Water Pathway Screening

If the selected method of restoration includes a ponded area, in addition to the Tier 1 and Tier 2 evaluations, the Tier 3 evaluation for the soil-to-surface water pathway will be conducted.

Step 1. Constituent concentrations in post-excavation soils will be compared to the BTVs; results less than or equal to the BTVs will be considered to be acceptable, and no further evaluation in Tier 3 will be conducted for those constituents.

Step 2. Constituents with concentrations above their respective BTVs will be compared to the soil-to-surface water screening levels developed and presented on **Table 8**. These screening levels are based on the lowest human health and ecological screening levels presented in **Table 10**, using a conservative DAF=20 for the dilution of surface soil/sediment to surface water. Constituents with concentrations less than or equal to their respective soil-to-surface water screening level will be considered to be acceptable, and no further evaluation in Tier 3 will be conducted for those constituents.

Constituents that have post-excavation soil concentrations above their respective Step 1 BTVs and Step 2 soil-to-surface water screening levels will be considered for further evaluation to assess whether further actions may be appropriate.

3. Groundwater and Surface Water Screening Levels in Support of the Soil Evaluation

This section describes the development of the risk-based screening levels for groundwater in the context of evaluating the excavation remedy. The development of the screening levels in this section supports the soil-to-groundwater and soil-to-surface water pathways described above. As noted in the CSM, there are monitoring wells adjacent to the Ash Pond Complex. At the end of this section, it is described how these screening levels can be used with the groundwater data to provide context for the soil screening levels post-excavation.

3.1 TIER 1 – DRINKING-WATER BASED SCREENING LEVELS FOR GROUNDWATER

As the first step in the groundwater pathway evaluation process, drinking water values available from Tennessee and the USEPA are used as screening levels. This is a conservative screening step as the on-site groundwater is not used as a source of drinking water.

The selected human health drinking water screening levels are, in the order of the sources used (sources will be updated if needed):

- TDEC, Tennessee Board of Water Quality, Oil and Gas. General Water Quality Criteria Chapter 0400-40-03, values for Human Health Domestic Water Supply (TDEC, 2019);
- USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Maximum contaminant Levels (USEPA, 2018b);
- USEPA Regional Screening Levels (RSLs), May 2020, Values for Tap Water (USEPA, 2020a); and
- USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Secondary Maximum Contaminant Levels (USEPA, 2018b).

The first half of **Table 9** provides these values, and the second-to-last column provides the selected drinking water screening level.

3.2 TIER 2 – HUMAN HEALTH RECREATIONAL SURFACE WATER SCREENING LEVELS

Groundwater may flow to surface water, thus, risk-based surface water screening levels for both ecological receptors and recreational human health receptors are identified.

Human health screening levels for surface water are generally derived to be protective of the use of surface water as a drinking water source, and the consumption of fish from a surface water body. The drinking water screening levels are also protective of recreational uses of a surface water body (such as swimming or boating) because drinking water exposure is of a higher magnitude and frequency. The human health recreational surface water screening levels are, in the order used:

- TDEC, Tennessee Board of Water Quality, Oil and Gas. General Water Quality Criteria Chapter 0400-40-03, values for Recreation Water and Organism, and Recreation Organism Only (TDEC, 2019); and
- USEPA Ambient Water Quality Criteria (AWQC) Human Health Consumption of Water and Organism and Consumption of Organism Only (USEPA, 2020d).

The second half of **Table 9** provides the human health recreational use of surface water screening levels, and the last column provides the selected screening level.

3.3 TIER 3 – ECOLOGICAL SURFACE WATER SCREENING LEVELS

There is no direct exposure to groundwater by ecological receptors, however, groundwater can serve as a source to surface water where ecological contact can occur. **Table 10** presents the ecological screening levels for surface water. Some screening levels apply only to total surface water concentrations, and some apply only to dissolved surface water concentrations. Values for both scenarios are provided.

Ecological screening levels also are available for two exposure durations:

- Chronic AWQC: The continuous concentration criterion (CCC) is the USEPA national water quality criteria recommendation for the highest in stream concentration of a toxicant or an effluent to which organisms can be exposed indefinitely without causing unacceptable effect; and
- Acute AWQC: The continuous maximum concentration (CMC) is the USEPA national water quality criteria recommendation for the highest in stream concentration of a toxicant or an effluent to which organisms can be exposed for a brief period of time (CMC derived using 48 to 96-hour toxicity tests) without causing an acute effect.

Ecological screening levels were obtained from both TDEC and USEPA sources, and were used in the following order:

- TDEC Fish and Aquatic Life Criteria, acute and chronic (TDEC, 2019);
- USEPA acute and chronic AWQC (USEPA, 2020e); and
- USEPA Region 4 Surface Water Screening Values, acute and chronic (USEPA, 2018a).

The National Oceanic and Atmospheric Administration Screening Quick Reference Tables (NOAA SQuiRTs) were also reviewed and do not provide screening levels for constituents that do not already have a screening level (NOAA, 2008). The NOAA SQuiRTs have not been updated since 2008 and are not maintained; newer screening level sources are available from the TDEC and USEPA as shown in **Table 10**.

The last two columns of **Table 10** also identify the selected ecological risk-based screening levels for further evaluation.

In the Tier 2 and Tier 3 evaluation of groundwater, constituent concentrations in groundwater will be compared to the selected lowest screening levels in **Tables 9 and 10**, respectively. Constituents with concentrations in groundwater above the selected ecological and/or human health screening levels for surface water would then be evaluated in Tier 4.

3.4 TIER 4 – DEVELOPMENT AND APPLICATION OF A GROUNDWATER-TO-SURFACE WATER DILUTION ATTENUATION FACTOR

A groundwater concentration above a surface water-based screening level does not necessarily mean that surface water will be adversely impacted by the groundwater. Dilution and attenuation mechanisms can occur as groundwater moves to surface water. This section describes the approach to evaluating the magnitude of dilution effects resulting from the mixing of groundwater that may flow from beneath the Ash Pond Complex to surface water in the Cumberland River.

Groundwater data from previous studies indicates that CCR-derived constituents have migrated from the APC to nearby groundwater. Previous monitoring indicates that groundwater near the Ash Pond Complex flows towards the Cumberland River.

To make a conservative estimate of the potential impacts of groundwater to the Cumberland River, a Surface Water Dilution Attenuation Factor (SW-DAF) has been calculated. The SW-DAF describes the effect of mixing on constituent concentrations expected for the surface water body potentially receiving the impacted groundwater.

The details of the SW-DAF development and results are provided in **Appendix C**. This evaluation takes into account the rate of potential groundwater recharge into the Ash Pond Complex area and flow of the Cumberland River. The assumptions used to calculate the SW-DAF are very conservative and are based on standard hydrogeological practices. Water levels and flows of the Cumberland River in this area are influenced by operations of the Old Hickory, Cordell Hull, and Center Hill dams. Because the management of these dams has a buffering effect on extreme conditions, recurrence interval-based low flow estimates for the watershed are not likely to reflect the actual low flow conditions of the Cumberland River near GAF. Therefore, representative flow rates were obtained from a hydrothermal model developed by TVA to calculate the thermal impact of GAF cooling water effluent to the Cumberland River. The SW-DAF calculated from this method is **830**. An even more conservative DAF was estimated using the 1Q10 low flow rate specified in GAF's National Pollution Discharge Elimination System permit. The SW-DAF calculated from this method is **230**. The derivation of the SW-DAF can be revisited when the excavation is completed and may be further updated as described below.

3.4.1 Application of the SW-DAF

Table 11 presents the selected human health and ecological screening levels (from **Tables 9 and 10**) and identifies the lowest screening level for surface water for the four potential exposure scenarios.

The SW-DAF is applied to the selected risk-based screening levels to develop the Tier 4 screening levels in **Table 11**. Target groundwater concentrations are developed based on the more conservative SW-DAF for the Cumberland River of **230**, as described in **Attachment C.** The modeling used herein to develop the SW-DAFs is conservative in that the effects of groundwater on surface water quality likely are over-estimated.

3.5 APPLICATION OF THE GROUNDWATER SCREENING LEVELS TO THE SOIL EVALUATION

While the evaluation of groundwater is not necessary for determining if excavation is complete, the screening levels developed here to evaluate the soil-to-groundwater and the soil to groundwater-to-surface water pathways can be used to evaluate groundwater.

Constituent concentrations in groundwater can be compared to background groundwater values (if available) and to screening levels protective of surface water, as shown in **Figure 7**. These values calculated using the site-specific DAF and protective of drinking water use of surface water, human recreational use, and ecological receptors are presented in **Table 11**. Screening levels for the soil to groundwater pathway are known to be very conservative, i.e., they are more likely to overestimate the impact of soil on groundwater than to underestimate the impact. Where a confirmatory soil sample concentration is above the screening level for the soil-to-groundwater pathway, groundwater in the immediate vicinity of that soil sample can be compared to the groundwater screening levels to determine if such impact occurs.

4. Summary of Application of the Site-Specific Screening Levels

Table 12 presents the screening levels derived for soil. These are based on direct contact with soils scenarios, and the soil-to-groundwater pathways and the soil-to-groundwater-to-surface water scenarios that are based on the screening levels derived for groundwater presented in **Table 13**, and the screening levels derived for surface water presented in **Table 14**. **Figure 6** graphically depicts the soil screening steps. **Figure 7** graphically depicts the groundwater screening steps that can be used to further evaluate the soils screening results.

Additional information may be available by the time the excavation sampling is conducted that can be used to inform or modify the screening levels as appropriate, with TDEC review and approval of any modifications. Some of these data may provide context for the derived screening levels (for example, surface water and/or groundwater data may be available to show whether the Ash Pond Complex in its post-excavation configuration is posing an adverse impact to human health and/or the environment). Such data will be reviewed with TDEC prior to finalizing the evaluation.

5. References

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TABLES

Table 1a
List of Background Samples
Gallatin Fossil Plant
Tennessee Valley Authority

Sample Location	Sample ID	Date	Start Depth (feet)	End Depth (feet)
GAF-NRL015D	NRL015D-SB-0-10-20170209	02/09/2017	0	10
GAF-NRL015D	NRL015D-SB-0-5-20170209	02/09/2017	0	5
GAF-NRL015D	NRL015D-SB-5-10-20170209	02/09/2017	5	10
GAF-NRL220	GAF-NRL220-SB-0-10-20170124	01/24/2017	0	10
GAF-NRL220	GAF-NRL220-SB-0-5-20170124	01/24/2017	0	5
GAF-NRL220	GAF-NRL220-SB-5-10-20170124	01/24/2017	5	10
GAP001	GAP001-SB-1-5-20170120	01/20/2017	1	5
GAP001	GAP001-SB-1-7-20170120	01/20/2017	1	7
GAP001	GAP001-SB-5-7-20170120	01/20/2017	5	7
GAP002 (a)	GAP002-SB-0-5-20170117	01/17/2017	0	5
GAP002 (a)	GAP002-SB-10-15-20170117	01/17/2017	10	15
GAP002 (a)	GAP002-SB-15-20-20170117	01/17/2017	15	20
GAP002 (a)	GAP002-SB-15-20-20170117-DUP1	01/17/2017	15	20
GAP002 (a)	GAP002-SB-20-25-20170117	01/17/2017	20	25
GAP002 (a)	GAP002-SB-25-26-20170117	01/17/2017	25	26
GAP002 (a)	GAP002-SB-5-10-20170117	01/17/2017	5	10
GAP002 (a)	GAP002-SB-5-26-20170117	01/17/2017	5	26
GAP006	GAP006-SB-10-15-01122017	01/12/2017	10	15
GAP006	GAP006-SB-5-10-20170112	01/12/2017	5	10
GAP007	GAP007-SB-1-5-20170120	01/20/2017	1	5
GAP012	GAP012-SB-0-2.5-20170123	01/23/2017	0	2.5
GAP015	GAP015-SB-0-10-20170125	01/25/2017	0	10
GAP015	GAP015-SB-0-5-20170125	01/25/2017	0	5
GAP015	GAP015-SB-5-10-20170125	01/25/2017	5	10
GAP019	GAP019-SB-0-2-01122017	01/12/2017	0	2
GAP019	GAP019-SB-0-2-01122017-DUP	01/12/2017	0	2
GAP031	GAP031-SB-10-15-20170117	01/17/2017	10	15
GAP031	GAP031-SB-15-18-20170117	01/17/2017	15	18
GAP031	GAP031-SB-5-10-20170117	01/17/2017	5	10
GAP032	GAP032-SB-0-17.9-20170124	01/24/2017	0	17.9
GAP032	GAP032-SB-0-5-20170124	01/24/2017	0	5
GAP032	GAP032-SB-10-15-20170124	01/24/2017	10	15
GAP032	GAP032-SB-15-17.9-20170124	01/24/2017	15	17.9
GAP032	GAP032-SB-5-10-20170124	01/24/2017	5	10
GAP033	GAP033-SB-0-10-20170124	01/24/2017	0	10
GAP033	GAP033-SB-0-5-20170124	01/24/2017	0	5
GAP033	GAP033-SB-5-10-20170124	01/24/2017	5	10
GAP034	GAP034-SB-0-3.5-20170111	01/11/2017	0	3.5
GAP036	GAP036-SB-0-21.5-20170124	01/24/2017	0	21.5
GAP036	GAP036-SB-0-5-20170124	01/24/2017	0	5
GAP036	GAP036-SB-0-5-20170124-DUP	01/24/2017	0	5
GAP036	GAP036-SB-10-15-20170124	01/24/2017	10	15
GAP036	GAP036-SB-15-20-20170124	01/24/2017	15	20
GAP036	GAP036-SB-20-21.5-20170124	01/24/2017	20	21.5
GAP036	GAP036-SB-5-10-20170124	01/24/2017	5	10
GAP037	GAP037-SB-0-10-20170110	01/10/2017	0	10
GAP037	GAP037-SB-0-5-20170110	01/10/2017	0	5
GAP037	GAP037-SB-5-10-20170110	01/10/2017	5	10
GAP045	GAP045-SB-0-5-20170117	01/17/2017	0	5
GAP045	GAP045-SB-1-10-20170117	01/17/2017	1	10
GAP045	GAP045-SB-5-10-20170117	01/17/2017	5	10
GAP055	GAP055-SB-0-5-20170125	01/25/2017	0	5
GAP055	GAP055-SB-0-8-20170125	01/25/2017	0	8
GAP055	GAP055-SB-5-8-20170125	01/25/2017	5	8

Notes:
(a) - Based on the outlier evaluation, samples from location GAP002 were not included in the background dataset.
See text for additional information.

Table 1b
Summary of Background Soil Quality Data
Gallatin Fossil Plant
Tennessee Valley Authority

Location Name	GAF-NRL015D	GAF-NRL015D	GAF-NRL015D	GAF-NRL220	GAF-NRL220	GAF-NRL220	GAP001
Sample Name	NRL015D-SB-0-10-20170209	NRL015D-SB-0-5-20170209	NRL015D-SB-5-10-20170209	GAF-NRL220-SB-0-10-20170124	GAF-NRL220-SB-0-5-20170124	GAF-NRL220-SB-5-10-20170124	GAP001-SB-1-5-20170120
Sample Date	02/09/2017	02/09/2017	02/09/2017	01/24/2017	01/24/2017	01/24/2017	01/20/2017
Lab Sample ID	180-63358-8	180-63358-1	180-63358-2	180-62839-18	180-62839-13	180-62839-14	180-62738-5
Sample Depth (bgs)	0 - 10 (ft)	0 - 5 (ft)	5 - 10 (ft)	0 - 10 (ft)	0 - 5 (ft)	5 - 10 (ft)	1 - 5 (ft)
Inorganic Compounds (mg/kg)							
Antimony	0.091 J	0.117 J	0.13 J	0.177 J	0.183 J	0.05 J	0.0402 UJ
Arsenic	4.91 J	5.38 J	3.37 J	5.48	6.97 J	4.71 J	2.77 J
Barium	104 J	91 J	48.3 J	147	145	140	87
Beryllium	0.979 J	0.871 J	0.807 J	1.49	1.42 J	1.38 J	1
Boron	3.73 J	1.84 J	10.7	3.43 J	3.12 J	4.67 J	4.12 J
Cadmium	0.0317 J	0.0163 J	0.0264 J	0.0813 J	0.0816 J	0.0741 J	0.0594 U*
Calcium	9940 J	2250 J	15300 J	12900	12500 J	19800 J	8650 J
Chromium	14.6 J	14.1	12.2 J	14.1	17.3	15.4	11.7
Cobalt	5.76	7.59	9.03	10.7	10.1	13.5	13.6 J
Copper	7.83	6.93	11.3	8.31	7.4 J	9.15 J	10.4
Lead	14	12.3	10.6	13.1	15.7 J	12.8 J	10.5
Lithium	13.1 J	11.4 J	14.6 J	11.3 J	8.73 J	15.4 J	15.1 J
Mercury	0.104 U*	0.0428 U*	0.0485 U*	0.0584	0.0555	0.0331 J	0.0566
Molybdenum	0.261 J	0.385 J	0.263 J	0.521 J	0.569 J	0.228 J	0.188 J
Nickel	14.7	13.1	26	14.2	12.4	20.9	24.4
Selenium	3.3 J	2.35 J	3.12 J	0.335 J	0.55 J	0.471 J	0.416 J
Silver	0.0167 U	0.016 J	0.0233 J	0.0201 J	0.0196 J	0.0161 U	0.0165 U
Thallium	0.194	0.175	0.194	0.208	0.232	0.169	0.177
Vanadium	16.3 J	21.7 J	11.5 J	19.9	26.7	17.1	10.9
Zinc	34.8 J	39.3 J	66.1 J	35.1 J	31.9 J	59.3 J	73.8
Radiological (pCi/g)							
Radium-226 & 228	1.57 U ± 0.69	2.65 ± 0.76	2.65 J ± 0.95	2.60 U ± 0.87	2.44 ± 0.7	1.87 J ± 0.92	1.78 ± 1.2

Notes:
-: Not Analyzed
*: LCS or LCSD is outside limits.
bgs: below ground surface
ft: feet
J: Value is estimated
mg/kg: milligram per kilogram
NA: Not Applicable
pCi/g: picoCurie per gram
U: Not detected, number is the laboratory detection limit

(a) - Based on the outlier evaluation, samples from location GAP002 were not included in the background dataset. See text for additional information.

Table 1b
Summary of Background Soil Quality Data
Gallatin Fossil Plant
Tennessee Valley Authority

Location Name	GAP001	GAP001	GAP002 (a)	GAP002 (a)	GAP002 (a)	GAP002 (a)	GAP002 (a)
Sample Name	GAP001-SB-1-7-20170120	GAP001-SB-5-7-20170120	GAP002-SB-0-5-20170117	GAP002-SB-5-10-20170117	GAP002-SB-5-26-20170117	GAP002-SB-10-15-20170117	GAP002-SB-15-20-20170117
Sample Date	01/20/2017	01/20/2017	01/17/2017	01/17/2017	01/17/2017	01/17/2017	01/17/2017
Lab Sample ID	180-62738-8	180-62738-6	180-62630-1	180-62630-2	180-62630-16	180-62630-3	180-62630-4
Sample Depth (bgs)	1 - 7 (ft)	5 - 7 (ft)	0 - 5 (ft)	5 - 10 (ft)	5 - 26 (ft)	10 - 15 (ft)	15 - 20 (ft)
Inorganic Compounds (mg/kg)							
Antimony	0.0536 J	0.0356 UJ	0.166 J	0.242 J	0.217 J	0.233 J	0.212 J
Arsenic	1.92	2.35 J	3.86 J	6.72 J	5.19	6.28 J	5.6 J
Barium	53.6	48.7	41.9	91.4	119	115	127
Beryllium	0.839	0.883	0.435	1.05	1.54	1.59	1.75
Boron	6.92 J	5.46 J	1.5 U	1.51 U	1.83 J	1.62 U	2.29 J
Cadmium	0.0216 J	0.0294 U*	0.0542 J	0.165	0.236	0.203	0.273
Calcium	34300 J	54300 J	2280 J	1980 J	2640 J	2280 J	2690 J
Chromium	10.3 J	11	11 J	14.1 J	17.4 J	15.4 J	20.7 J
Cobalt	8.73	9.55 J	7.2	14.9	8.22	10	9.12
Copper	9.23	9.67	5.71	11.4	11.1	12.7	10.7
Lead	8.36	10.1	14.9	22.9	16.5	22.1	20.6
Lithium	16.3 J	17 J	4.14	6.73	8.04 J	6.72	7.6
Mercury	0.0531	0.0329 J	0.0386 J	0.0414	0.0723	0.0571	0.062
Molybdenum	0.514 J	0.354 J	0.91 J	1.31 J	1.43	1.32 J	1.24 J
Nickel	19.7	20.6	6.22	12.6	14.1	13.7	14.5
Selenium	0.506 J	0.376 J	0.477 J	0.27 J	0.512 J	0.292 J	0.276 J
Silver	0.0154 U	0.0205 J	0.0154 U	0.0155 U	0.0192 J	0.0244 J	0.0237 J
Thallium	0.134	0.17	0.207 J	0.238 J	0.183	0.209 J	0.211 J
Vanadium	7.84 J	9.05	19.6 J	29.2 J	24 J	29 J	27.7 J
Zinc	56	57.8	28.5 J	58.5 J	68.8	73.5 J	64.6 J
Radiological (pCi/g)							
Radium-226 & 228	2.08 J ± 0.95	2.36 ± 0.97	2.31 U ± 0.6	1.93 U ± 1	2.55 UJ ± 0.81	2.77 U ± 0.47	2.41 U ± 0.62

Notes:
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J: Value is estimated
mg/kg: milligram per kilogram
NA: Not Applicable
pCi/g: picoCurie per gram
U: Not detected, number is the laboratory detection limit

(a) - Based on the outlier evaluation, samples from location GAP002 were not included in the background dataset. See text for additional information.

Table 1b
Summary of Background Soil Quality Data
Gallatin Fossil Plant
Tennessee Valley Authority

Location Name	GAP002 (a)	GAP002 (a)	GAP002 (a)	GAP006	GAP006	GAP007	GAP012
Sample Name	GAP002-SB-15-20-20170117-DUP1	GAP002-SB-20-25-20170117	GAP002-SB-25-26-20170117	GAP006-SB-5-10-20170112	GAP006-SB-10-15-01122017	GAP007-SB-1-5-20170120	GAP012-SB-0-2.5-20170123
Sample Date	01/17/2017	01/17/2017	01/17/2017	01/12/2017	01/12/2017	01/20/2017	01/23/2017
Lab Sample ID	180-62630-7	180-62630-5	180-62630-6	180-62503-4	180-62503-5	180-62738-4	180-62776-1
Sample Depth (bgs)	15 - 20 (ft)	20 - 25 (ft)	25 - 26 (ft)	5 - 10 (ft)	10 - 15 (ft)	1 - 5 (ft)	0 - 2.5 (ft)
Inorganic Compounds (mg/kg)							
Antimony	0.213 J	0.265 J	0.296 J	0.135 J	0.33	0.0351 UJ	0.0971 J
Arsenic	6.54 J	7.05 J	8.83 J	6.59	13.7	1.61 J	4.09 J
Barium	123	141	132	99.4 J	111 J	21.7	153
Beryllium	1.84	1.93	2.03	2.86	2.15	0.597	1.44 J
Boron	1.91 J	3.62 J	4.09 J	1.84 J	2.25 J	5.56 J	4.88 J
Cadmium	0.299	0.47	0.424	0.421	0.319	0.0289 U*	0.0938 J
Calcium	2780 J	3270 J	3490 J	2620 J	4010 J	85900 J	137000 J
Chromium	21.6 J	22.4 J	24.1 J	8.64 J	15.1 J	8.14	16.8
Cobalt	9.7	11.2	10.8	14.2	6.46	7.79 J	7.21
Copper	10.6	14.2	15.5	15.8	20.5	7.88	11.9 J
Lead	23.5	21.1	25.3	24.7	28.1	7.06	13.7
Lithium	7.24	10.4	9.68	6.14 J	11.1 J	12.8 J	10.4 J
Mercury	0.0649	0.076	0.0759	0.103	0.165	0.0299 J	0.0521 J
Molybdenum	1.08 J	7.95 J	4.17 J	0.644	1.1	0.229 J	0.361 J
Nickel	15.6	20.1	20.5	20.5 J	21.3 J	15.6	15.3
Selenium	0.487 J	0.393 J	0.411 J	0.382 J	0.683	0.397 J	0.403 J
Silver	0.0175 J	0.0345 J	0.0338 J	0.0161 U	0.0442 J	0.0144 U	0.0277 J
Thallium	0.216 J	0.393 J	0.29 J	0.296	0.277	0.137	0.202
Vanadium	28.1 J	30.3 J	31.2 J	17.6 J	34.6 J	6.99	18.6
Zinc	63.7 J	73.7 J	77.5 J	101	110	46.2	34.9
Radiological (pCi/g)							
Radium-226 & 228	1.96 ± 0.61	2.73 ± 0.45	1.74 U ± 0.44	2.37 U ± 0.61	2.43 J ± 0.71	2.19 U ± 0.8	1.46 U ± 0.75

Notes:
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ft: feet
J: Value is estimated
mg/kg: milligram per kilogram
NA: Not Applicable
pCi/g: picoCurie per gram
U: Not detected, number is the laboratory detection limit

(a) - Based on the outlier evaluation, samples from location GAP002 were not included in the background dataset. See text for additional information.

Table 1b
Summary of Background Soil Quality Data
Gallatin Fossil Plant
Tennessee Valley Authority

Location Name	GAP015	GAP015	GAP015	GAP019	GAP019	GAP031	GAP031
Sample Name	GAP015-SB-0-10-20170125	GAP015-SB-0-5-20170125	GAP015-SB-5-10-20170125	GAP019-SB-0-2-01122017	GAP019-SB-0-2-01122017-DUP	GAP031-SB-5-10-20170117	GAP031-SB-10-15-20170117
Sample Date	01/25/2017	01/25/2017	01/25/2017	01/12/2017	01/12/2017	01/17/2017	01/17/2017
Lab Sample ID	180-62855-11	180-62855-1	180-62855-2	180-62503-6	180-62503-7	180-62630-12	180-62630-13
Sample Depth (bgs)	0 - 10 (ft)	0 - 5 (ft)	5 - 10 (ft)	0 - 2 (ft)	0 - 2 (ft)	5 - 10 (ft)	10 - 15 (ft)
Inorganic Compounds (mg/kg)							
Antimony	0.21 J	0.29 J	0.242 J	0.175 J	0.164 J	0.254 J	0.229 J
Arsenic	6.03 J	9.28 J	7.96 J	4.48 J	5.03	9.6 J	8.7 J
Barium	81.1 J	87.5	85.4	53.3 J	52.8 J	107	117
Beryllium	0.775 J	1.08	0.993	0.559	0.654 J	2.13	1.54
Boron	1.56 J	1.61 U	1.39 U	1.65 U	1.66 U	1.45 U	1.58 U
Cadmium	0.0809 J	0.0809 J	0.0766 J	0.0851 J	0.0594 J	0.0521 J	0.0799 J
Calcium	19500 J	3610	17400 J	33400 J	2910 J	504 J	861 J
Chromium	19	31.2 J	22 J	13.5 J	13.8 J	19.1 J	11.1 J
Cobalt	12.6	15.7	12	10.7 J	10.8	14.2	16.1
Copper	7.13	8.53 J	6.86 J	4.86 J	4.7	7.15	8.87
Lead	23.8	30.8 J	28.4 J	17.8	17.7	12	14.3
Lithium	5.41 J	6.15 J	3.86 J	1.94 J	2.28 J	4.44	3.64
Mercury	0.0533 U*	0.0718	0.00855 U	0.0338 U*	0.0402 U*	0.0551	0.038 J
Molybdenum	0.68	0.898	0.762	0.72 J	0.421 J	1.36 J	1.2 J
Nickel	7.43	10.2	6.77	5.17 J	6.19 J	6.1	9.03
Selenium	1.51 J	0.668	0.496 J	0.484 J	0.466 J	0.625 J	0.388 J
Silver	0.0235 J	0.0297 J	0.0256 J	0.0249 J	0.0238 J	0.0168 J	0.0162 U
Thallium	0.186	0.256	0.181	0.126 J	0.133	0.23 J	0.261 J
Vanadium	24.6 J	34.1	24.8	17.7 J	19.7 J	41.8 J	30.9 J
Zinc	29.2 J	42.6	33.3	19.3 J	21	21.5 J	23.4 J
Radiological (pCi/g)							
Radium-226 & 228	3.14 U ± 0.69	2.14 U ± 0.77	3.10 U ± 0.61	2.07 U ± 0.58	1.90 U ± 0.55	2.40 ± 0.68	2.60 J ± 0.66

Notes:
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ft: feet
J: Value is estimated
mg/kg: milligram per kilogram
NA: Not Applicable
pCi/g: picoCurie per gram
U: Not detected, number is the laboratory detection limit

(a) - Based on the outlier evaluation, samples from location GAP002 were not included in the background dataset. See text for additional information.

Table 1b
Summary of Background Soil Quality Data
Gallatin Fossil Plant
Tennessee Valley Authority

Location Name	GAP031	GAP032	GAP032	GAP032	GAP032	GAP032	GAP033
Sample Name	GAP031-SB-15-18-20170117	GAP032-SB-0-17.9-20170124	GAP032-SB-0-5-20170124	GAP032-SB-5-10-20170124	GAP032-SB-10-15-20170124	GAP032-SB-15-17.9-20170124	GAP033-SB-0-10-20170124
Sample Date	01/17/2017	01/24/2017	01/24/2017	01/24/2017	01/24/2017	01/24/2017	01/24/2017
Lab Sample ID	180-62630-14	180-62839-16	180-62839-1	180-62839-2	180-62839-3	180-62839-4	180-62839-17
Sample Depth (bgs)	15 - 18 (ft)	0 - 17.9 (ft)	0 - 5 (ft)	5 - 10 (ft)	10 - 15 (ft)	15 - 17.9 (ft)	0 - 10 (ft)
Inorganic Compounds (mg/kg)							
Antimony	0.214 J	0.121 J	0.0789 J	0.0934 J	0.166 J	0.0958 J	0.0928 J
Arsenic	9.13 J	3.28	3.23 J	3.22 J	4.91 J	3.64 J	4.32
Barium	59.3	72.6	30	46.1	135	230 J	122
Beryllium	1.46	0.576	0.389 J	0.417 J	0.961 J	1.59 J	1.51
Boron	1.56 U	1.44 U	1.51 U	1.45 U	1.64 U	8.28 J	3.96 J
Cadmium	0.0758 J	0.0771 J	0.0446 U*	0.0933 J	0.0782 J	0.587 J	0.12 J
Calcium	636 J	788	409 J	411 J	817 J	4400 J	33100
Chromium	11.1 J	8.11	6.4	7.47	10.3	18.1 J	14.5
Cobalt	8.24	6.05	6.18	6.67	10.1	6.05 J	14.1
Copper	11	7.13	4.61 J	4.73 J	8.74 J	23 J	17.6
Lead	11.2	8.15	5.22 J	8.3 J	12.3 J	16.6 J	12.8
Lithium	3.03	3.97 J	2.88 J	3.11 J	5.63 J	10.2 J	14.5 J
Mercury	0.0396	0.0349 J	0.0235 J	0.0261 J	0.0367 J	0.0492 J	0.0593
Molybdenum	1.25 J	0.934	0.898	0.715	0.837	0.84 J	0.781
Nickel	11.7	7.26	5.92	6.48	11.1	18.1 J	23.3
Selenium	0.241 J	0.194 J	0.142 U	0.136 U	0.455 J	0.922 J	0.314 J
Silver	0.016 U	0.018 J	0.0155 U	0.0148 U	0.0364 J	0.0773 J	0.0368 J
Thallium	0.146 J	0.135	0.0999 J	0.119	0.212	0.257 J	0.424
Vanadium	25.5 J	13.8	10.4	12.8	25.2	25.9 J	15.5
Zinc	28.1 J	22 J	14.8 J	16.5 J	31.7 J	89.6 J	48.5 J
Radiological (pCi/g)							
Radium-226 & 228	1.57 U ± 0.74	1.54 J ± 0.6	1.64 U ± 0.37	1.39 J ± 0.63	2.75 ± 0.89	2.29 J ± 1.4	1.83 U ± 0.47

Notes:
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J: Value is estimated
mg/kg: milligram per kilogram
NA: Not Applicable
pCi/g: picoCurie per gram
U: Not detected, number is the laboratory detection limit

(a) - Based on the outlier evaluation, samples from location GAP002 were not included in the background dataset. See text for additional information.

Table 1b
Summary of Background Soil Quality Data
Gallatin Fossil Plant
Tennessee Valley Authority

Location Name	GAP033	GAP033	GAP034	GAP036	GAP036	GAP036	GAP036
Sample Name	GAP033-SB-0-5-20170124	GAP033-SB-5-10-20170124	GAP034-SB-0-3.5-20170111	GAP036-SB-0-21.5-20170124	GAP036-SB-0-5-20170124	GAP036-SB-0-5-20170124-DUP	GAP036-SB-5-10-20170124
Sample Date	01/24/2017	01/24/2017	01/11/2017	01/24/2017	01/24/2017	01/24/2017	01/24/2017
Lab Sample ID	180-62839-11	180-62839-12	180-62477-4	180-62839-15	180-62839-5	180-62839-6	180-62839-7
Sample Depth (bgs)	0 - 5 (ft)	5 - 10 (ft)	0 - 3.5 (ft)	0 - 21.5 (ft)	0 - 5 (ft)	0 - 5 (ft)	5 - 10 (ft)
Inorganic Compounds (mg/kg)							
Antimony	0.0417 J	0.0882 J	0.0369 UJ	0.208 J	0.243 J	0.248 J	0.161 J
Arsenic	3.38 J	4.99 J	1.73	5.48	7.02 J	6.51 J	4.19 J
Barium	127	76.7	25.7	25.8	25	24.2	20
Beryllium	1.59 J	1.25 J	0.655	0.333	0.318 J	0.336 J	0.235 J
Boron	4.05 J	2.52 J	7.54 J	1.47 U	1.55 J	1.38 U	1.28 U
Cadmium	0.077 J	0.0771 J	0.0232 J	0.0594 J	0.0289 U*	0.0291 U*	0.0389 U*
Calcium	14400 J	8510 J	91900 J	324 J	1300 J	827 J	164 J
Chromium	19.3	19.9	7.41 J	7.14 J	13.5	10.3	6.59
Cobalt	12	11.9	6.8	2.79	2.3	2.2	2.14
Copper	23.3 J	17 J	7.02	7.61	8.36 J	8.08 J	5.24 J
Lead	12.6 J	11.9 J	8.01	4.01	6.15 J	5.41 J	4.18 J
Lithium	15.8 J	11 J	11.8 J	4.72 J	4.33 J	4.44 J	2.77 J
Mercury	0.0455	0.0623	0.039 J	0.0417	0.0342 J	0.0406	0.0253 J
Molybdenum	0.266 J	0.541 J	0.185 J	1.71	1.82	1.8	1.28
Nickel	30.5	22.3	14.1 J	7.41	7.59	7.08	5.42
Selenium	0.205 J	0.378 J	0.467 J	0.286 J	0.22 J	0.154 J	0.126 J
Silver	0.0169 J	0.0323 J	0.0151 U	0.0151 U	0.0146 U	0.0142 U	0.0131 U
Thallium	0.272	0.158	0.139	0.124	0.159	0.142	0.0968 J
Vanadium	15.5	19.8	6.28 J	16.9 J	31.5	25.3	17
Zinc	59.5 J	67.3 J	34.5	23.3	26.5 J	24.1 J	15.9 J
Radiological (pCi/g)							
Radium-226 & 228	2.17 J ± 0.84	1.78 U ± 0.84	1.86 U ± 0.57	1.08 U ± 0.36	1.20 J ± 0.9	1.92 J ± 0.69	1.40 U ± 0.35

Notes:
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J: Value is estimated
mg/kg: milligram per kilogram
NA: Not Applicable
pCi/g: picoCurie per gram
U: Not detected, number is the laboratory detection limit

(a) - Based on the outlier evaluation, samples from location GAP002 were not included in the background dataset. See text for additional information.

Table 1b
Summary of Background Soil Quality Data
Gallatin Fossil Plant
Tennessee Valley Authority

Location Name	GAP036	GAP036	GAP036	GAP037	GAP037	GAP037	GAP045
Sample Name	GAP036-SB-10-15-20170124	GAP036-SB-15-20-20170124	GAP036-SB-20-21.5-20170124	GAP037-SB-0-10-20170110	GAP037-SB-0-5-20170110	GAP037-SB-5-10-20170110	GAP045-SB-0-5-20170117
Sample Date	01/24/2017	01/24/2017	01/24/2017	01/10/2017	01/10/2017	01/10/2017	01/17/2017
Lab Sample ID	180-62839-8	180-62839-9	180-62839-10	180-62437-3	180-62437-1	180-62437-2	180-62630-8
Sample Depth (bgs)	10 - 15 (ft)	15 - 20 (ft)	20 - 21.5 (ft)	0 - 10 (ft)	0 - 5 (ft)	5 - 10 (ft)	0 - 5 (ft)
Inorganic Compounds (mg/kg)							
Antimony	0.225 J	0.227 J	0.173 J	0.119 J	0.0574 J	0.0422 J	0.195 J
Arsenic	8.52 J	10.7 J	12.8 J	4.74 J	3.69	2.93	5.57 J
Barium	51.6	55	41.5	198 J	185	142	21.6
Beryllium	0.363 J	0.609 J	1.12 J	1.92 J	2.13	1.51	0.284
Boron	1.37 U	1.71 J	2.02 J	2.26 J	4.1 J	2.67 J	1.39 U
Cadmium	0.121	0.208	0.262	0.141	0.0584 J	0.0344 J	0.013 J
Calcium	264 J	438 J	626 J	8190 J	5810 J	5610 J	452 J
Chromium	10.5	11.8	6.62	12.9 J	12 J	10.5 J	10.8 J
Cobalt	9	8.68	10.7	16 J	8.61	10.6	1.44
Copper	10.4 J	14.5 J	19.3 J	17.1 J	11.9	9.24	7.66
Lead	5.42 J	7.52 J	10.8 J	18.1 J	10.6	11.1	4.8
Lithium	2.78 J	2.28 J	2.38 J	13.6 J	9.29 J	9.5 J	4.98
Mercury	0.0617	0.0265 J	0.038 J	0.0434 J	0.0705	0.0395	0.0438
Molybdenum	2.29	2.04	1.03	0.377 J	0.273 J	0.161 J	1.53 J
Nickel	13.8	18.9	20.1	37.1 J	19.1 J	18.6 J	4.99
Selenium	0.212 J	0.312 J	0.339 J	0.568 J	0.539 J	0.463 J	0.242 J
Silver	0.0141 U	0.0162 U	0.0148 U	0.0275 J	0.0197 J	0.0161 U	0.0143 U
Thallium	0.208	0.145	0.172	0.299 J	0.135	0.153	0.181 J
Vanadium	21.7	20.6	16.8	15.5 J	13.7 J	11.2 J	18.9 J
Zinc	32 J	45.3 J	79.5 J	46.3	34.5	39.9	18.5 J
Radiological (pCi/g)							
Radium-226 & 228	0.755 U ± 0.72	1.08 U ± 0.35	1.52 U ± 0.43	2.84 U ± 0.69	2.59 U ± 0.79	2.82 ± 0.98	1.65 U ± 0.46

Notes:
-: Not Analyzed
*: LCS or LCSD is outside limits.
bgs: below ground surface
ft: feet
J: Value is estimated
mg/kg: milligram per kilogram
NA: Not Applicable
pCi/g: picoCurie per gram
U: Not detected, number is the laboratory detection limit

(a) - Based on the outlier evaluation, samples from location GAP002 were not included in the background dataset. See text for additional information.

Table 1b
Summary of Background Soil Quality Data
Gallatin Fossil Plant
Tennessee Valley Authority

Location Name	GAP045	GAP045	GAP055	GAP055	GAP055
Sample Name	GAP045-SB-1-10-20170117	GAP045-SB-5-10-20170117	GAP055-SB-0-5-20170125	GAP055-SB-0-8-20170125	GAP055-SB-5-8-20170125
Sample Date	01/17/2017	01/17/2017	01/25/2017	01/25/2017	01/25/2017
Lab Sample ID	180-62630-17	180-62630-9	180-62855-7	180-62855-13	180-62855-8
Sample Depth (bgs)	1 - 10 (ft)	5 - 10 (ft)	0 - 5 (ft)	0 - 8 (ft)	5 - 8 (ft)
Inorganic Compounds (mg/kg)					
Antimony	0.227 J	0.242 J	0.171 J	0.174 J	0.04 J
Arsenic	6.22	7.68 J	6.7 J	5.18 J	2.96
Barium	108	50.7	231	106 J	47
Beryllium	0.904	0.659	1.4	0.808 J	0.939
Boron	1.47 U	7.01 J	2 J	2.46 J	6.89 J
Cadmium	0.0269 J	0.385	0.041 J	0.0401 J	0.0117 U
Calcium	881 J	105000 J	3960 J	4340 J	22000 J
Chromium	16 J	11 J	16.3 J	15.6	10.6
Cobalt	10.7	5.93	7.77	8.81	9.91
Copper	5.21	12.5	9.04 J	6.61	9.76 J
Lead	10.6	25.3	18.9 J	13.1	10.2
Lithium	5.23 J	10	11.6 J	8.24 J	14.3 J
Mercury	0.0395	0.048	0.115	0.0309 U*	0.0277 J
Molybdenum	1.13	1.06 J	0.79	0.583 J	0.201 U*
Nickel	5.21	13.2	12.3	10.1	20.2
Selenium	0.515 J	1.45 J	0.819	1.84 J	0.421 J
Silver	0.0151 U	0.0266 J	0.0165 U	0.0165 J	0.0158 J
Thallium	0.205	0.532 J	0.247	0.229	0.144
Vanadium	24.4 J	15.4 J	25.6	24 J	9.8
Zinc	17.3	107 J	33.6	28.5 J	37.6
Radiological (pCi/g)					
Radium-226 & 228	1.64 J ± 0.75	2.40 U ± 0.47	2.74 U ± 0.82	2.36 U ± 0.7	1.98 U ± 0.55

Notes:
-: Not Analyzed
*: LCS or LCSD is outside limits.
bgs: below ground surface
ft: feet
J: Value is estimated
mg/kg: milligram per kilogram
NA: Not Applicable
pCi/g: picoCurie per gram
U: Not detected, number is the laboratory detection limit

(a) - Based on the outlier evaluation, samples from location GAP002 were not included in the background dataset. See text for additional information.

Table 2
Background Data Statistical Evaluation
Gallatin Fossil Plant
Tennessee Valley Authority

Variable (a)	Units	Frequency of Detection	Percent Detects	Range of Non-Detects	KM Mean	KM Variance	KM Standard Deviation	KM Coefficient of Variation	50th Percentile	95th Percentile	Maximum Detect	Outlier Presence*	Outlier Removed	Distribution	BTV	Method
Antimony	mg/Kg	40 / 44	91%	0.0351 : 0.0402	0.145	0.0062	0.0787	0.541	0.148	0.252	0.33	No	No	Normal	0.3	95% Normal KM UTL with 95% Coverage
Arsenic	mg/Kg	44 / 44	100%	NA	5.593	7.944	2.818	0.504	4.95	10.54	13.7	No	No	Gamma	13	95% WH Approx. Gamma UTL with 95% Coverage
Barium	mg/Kg	44 / 44	100%	NA	91.22	3038	55.12	0.604	86.2	196.1	231	No	No	Normal	207	95% Normal UTL with 95% Coverage
Beryllium	mg/Kg	44 / 44	100%	NA	1.085	0.345	0.587	0.541	0.97	2.13	2.86	No	No	Normal	2	95% Normal UTL with 95% Coverage
Boron	mg/Kg	29 / 44	66%	1.28 : 1.65	3.148	5.307	2.304	0.732	2.135	7.461	10.7	No	No	Normal	8	95% Normal KM UTL with 95% Coverage
Cadmium	mg/Kg	37 / 44	84%	0.0117 : 0.0594	0.0993	0.0141	0.119	1.195	0.0762	0.375	0.587	Yes	No	Lognormal	0.5	95% KM UTL (Lognormal) with 95% Coverage
Calcium	mg/Kg	44 / 44	100%	NA	17943	9.44E+08	30725	1.712	5005	91000	137000	Yes	No	Gamma	91995	95% WH Approx. Gamma UTL with 95% Coverage
Chromium	mg/Kg	44 / 44	100%	NA	13.18	23.74	4.872	0.37	12.1	19.81	31.2	Yes	No	Normal	23	95% Normal UTL with 95% Coverage
Cobalt	mg/Kg	44 / 44	100%	NA	9.295	13.44	3.666	0.394	9.015	15.48	16.1	No	No	Normal	17	95% Normal UTL with 95% Coverage
Copper	mg/Kg	44 / 44	100%	NA	10.42	23.17	4.814	0.462	8.955	20.32	23.3	No	No	Lognormal	23	95% Lognormal UTL with 95% Coverage
Lead	mg/Kg	44 / 44	100%	NA	13.09	44.11	6.642	0.507	11.95	27.68	30.8	No	No	Gamma	30	95% WH Approx. Gamma KM UTL with 95% Coverage
Lithium	mg/Kg	44 / 44	100%	NA	8.562	22.12	4.703	0.549	9.01	15.74	17	No	No	Gamma	22	95% WH Approx. Gamma KM UTL with 95% Coverage
Mercury	mg/Kg	37 / 44	84%	0.0086 : 0.104	0.0472	7.12E-04	0.0267	0.565	0.0431	0.104	0.165	Yes	No	Gamma	0.1	95% WH Approx. Gamma KM UTL with 95% Coverage
Molybdenum	mg/Kg	43 / 44	98%	0.201 : 0.201	0.789	0.27	0.52	0.658	0.718	1.804	2.29	No	No	Normal	2	95% Normal KM UTL with 95% Coverage
Nickel	mg/Kg	44 / 44	100%	NA	14.73	55.17	7.427	0.504	13.95	25.76	37.1	No	No	Normal	30	95% Normal UTL with 95% Coverage
Selenium	mg/Kg	42 / 44	95%	0.136 : 0.142	0.665	0.504	0.71	1.068	0.438	2.274	3.3	Yes	No	Distribution Free	3	95% UTL with 95% Coverage
Silver	mg/Kg	23 / 44	52%	0.0131 : 0.0167	0.0203	1.35E-04	0.0116	0.571	0.0165	0.0367	0.0773	Yes	No	Gamma	0.04	95% WH Approx. Gamma KM UTL with 95% Coverage
Thallium	mg/Kg	44 / 44	100%	NA	0.2	0.00661	0.0813	0.407	0.181	0.299	0.532	Yes	No	Gamma	0.4	95% WH Approx. Gamma UTL with 95% Coverage
Vanadium	mg/Kg	44 / 44	100%	NA	19.24	62.74	7.921	0.412	17.65	33.71	41.8	No	No	Normal	36	95% Normal UTL with 95% Coverage
Zinc	mg/Kg	44 / 44	100%	NA	43.49	606.3	24.62	0.566	34.85	99.29	110	No	No	Gamma	103	95% WH Approx. Gamma UTL with 95% Coverage
Radium-226 & 228	pCi/g	44 / 44	100%	NA	2.063	0.332	0.576	0.279	2.11	2.837	3.14	No	No	Normal	3	95% Normal UTL with 95% Coverage

Notes:

* - Tested at 5% significance level.
BTV - Background Threshold Value.
KM - Kaplan-Meier Method.
mg/kg - milligram per kilogram.
NA - Not Available.
pCi/g - picoCurie per gram.
UTLs - Upper Tolerance Limits.
Var - Variance.
WH - Wilson Hilferty Transformation.

BTV values and statistics were calculated using ProUCL v. 5.1.002.

(a) - Based on the outlier evaluation, samples from location GAP002 were not included in the background dataset.
See text for additional information.

Table 3
Human Health Soil Screening Levels
Gallatin Fossil Plant
Tennessee Valley Authority

Constituent	CAS	May 2020 USEPA Industrial Soil RSLs (a) (mg/kg)		On-Site Construction/Utility Worker - Other Construction Activities Calculated RBSL (b) (mg/kg)	
Antimony	7440-36-0	470	(g)	135	(g)
Arsenic	7440-38-2	300	(c) (e)	98.6	(c) (f)
Barium	7440-39-3	220,000		40,600	
Beryllium	7440-41-7	2,300		326	
Boron	7440-42-8	230,000		58,100	
Cadmium	7440-43-9	980		86.2	
Calcium	7440-70-2	NA		NA	
Chromium	16065-83-1	>1,000,000	(h)	84,300	(h)
Cobalt	7440-48-4	350		289	
Copper	7440-50-8	47,000		3,390	
Lead	7439-92-1	800		800	(k)
Lithium	7439-93-2	2,300		679	
Mercury	7487-94-7	350	(i)	610	(i)
Molybdenum	7439-98-7	5,800		1,700	
Nickel	7440-02-0	22,000	(j)	2,530	(j)
Selenium	7782-49-2	5,800		1,690	
Silver	7440-22-4	5,800		1,700	
Thallium	7440-28-0	12	(d)	14	(d)
Vanadium	7440-62-2	5,800		1,270	
Zinc	7440-66-6	350,000		102,000	

Notes:

CAS - Chemical Abstracts Service.
mg/kg - milligram per kilogram.
NA - not available.
RBSL - Risk Based Screening Levels.
RSL - Risk-based Screening Levels (USEPA).
USEPA - United States Environmental Protection Agency.

(a) - USEPA Risk-Based Screening Levels (May 2020). Values for industrial soil. Hazard Index = 1.0.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
(b) - Site-specific risk based screening levels (RBSLs) calculated for construction worker exposure to soil - Other Construction Activities using USEPA exposure factors and equations from the USEPA screening levels calculator. See Appendix A.
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search
(c) - Arsenic RSL and RBSL are based on the lower of the values based on a hazard index of 1 and an excess lifetime cancer risk of 1E-04. Note that of the constituents evaluated, arsenic is the only constituent with an RSL based on potential carcinogenic effects.
(d) - RSL for Thallium (Soluble Salts) used for Thallium.
(e) - RSL based on cancer endpoint (noncancer based RSL is 480 mg/kg).
(f) - RBSL based on noncancer endpoint (cancer-based RBSL at 1E-4 is 9,250 mg/kg).
(g) - RSL for Antimony (metallic) used for Antimony.
(h) - RSL for Chromium (III), Insoluble Salts used for Chromium. RSL greater than a million parts per million.
(i) - RSL for Mercuric Chloride used for Mercury.
(j) - RSL for Nickel Soluble Salts used for Nickel.
(k) - USEPA industrial soil RSL value used.

Table 4
Human Health Exposure Parameters for Calculation of Construction/Utility Worker RBSL for Soil
Gallatin Fossil Plant
Tennessee Valley Authority

Parameter		Units	Current/Future On-Site Construction Worker (a)	
Standard Parameters				
Body Weight	BW	kg	80	USEPA, 2014
Exposure Duration	ED	years	1	USEPA, 2002
Non–carcinogenic Averaging Time	Atnc	days	365	ED expressed in days
Carcinogenic Averaging Time	Atc	days	25550	70 year lifetime
Incidental Ingestion of Soil				
Exposure Frequency	EF	days/year	60	Site-specific - 12 weeks excavation
Soil Ingestion Rate	IR	mg/day	330	USEPA, 2002
Fraction Ingested	FI	unitless	1.0	USEPA, 2002
Dermal Exposure with Soil				
Exposed Skin Surface Area	SA	cm^2	3527	USEPA, 2014
Soil Adherence Factor	AF	mg/cm^2	0.3	USEPA, 2002
Fraction Dermal	EV	event/day	1.0	USEPA, 2002
Particulate Inhalation				
Exposure Time	ET_{Part}	hours/day	8	USEPA, 2014

Notes:
RBSL - Risk-based screening level.
USEPA - United States Environmental Protection Agency.

USEPA, 2002 - Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OWSWER 9355.4-24
USEPA, 2014 - Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER 9200.1-120. February 6, 2014.

(a) - RBSL calculations are provided in Appendix A.

Table 5
Ecological Soil and Sediment Screening Levels
Gallatin Fossil Plant
Tennessee Valley Authority

Constituent	CAS	Background Threshold Value (a) (mg/kg)	USEPA Region 4 Ecological Soil Screening Value (b) (mg/kg)	USEPA Region 4 Ecological Freshwater Sediment Threshold Effects Concentration (c) (mg/kg)	USEPA Region 4 Ecological Freshwater Sediment Probable Effects Concentration (c) (mg/kg)
Antimony	7440-36-0	0.3	0.27	2	25
Arsenic	7440-38-2	13	18	9.8	33
Barium	7440-39-3	207	330	20	60
Beryllium	7440-41-7	2.3	2.5	NA	NA
Boron	7440-42-8	8.0	7.5	NA	NA
Cadmium	7440-43-9	0.5	0.36	1	5
Calcium	7440-70-2	91995	NA	NA	NA
Chromium	16065-83-1	23	23	43.4	111
Cobalt	7440-48-4	17	13	50	NA
Copper	7440-50-8	23	28	31.6	149
Lead	7439-92-1	30	11	35.8	128
Lithium	7439-93-2	22	2	NA	NA
Mercury	7487-94-7	0.1	0.013	0.17	0.17
Molybdenum	7439-98-7	2	2	NA	NA
Nickel	7440-02-0	30	38	22.7	48.6
Selenium	7782-49-2	3	0.52	0.72	2.9
Silver	7440-22-4	0.04	4.2	1	2.2
Thallium	7440-28-0	0.4	0.05	NA	NA
Vanadium	7440-62-2	36	7.8	NA	NA
Zinc	7440-66-6	103	46	121	459

Notes:
BTV - Background Threshold Value.
CAS - Chemical Abstracts Service.
mg/kg - milligram per kilogram.
NA - not available.
USEPA - United States Environmental Protection Agency.

(a) - BTVs calculated in Table 2.
(b) - USEPA Region 4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. March 2018.
Table 3 Soil Screening Levels.
https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf
(c) - USEPA Region 4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. March 2018.
Table 2a Region 4 Sediment Ecological Screening Values (ESV) and Refinement Screening Values (RSV).
https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf

Table 6
Derivation of Site-Specific Soil-to-Groundwater Soil Screening Levels for the Drinking Water Pathway
Gallatin Fossil Plant
Tennessee Valley Authority

Constituent	CAS	USEPA Drinking Water Value (a) (mg/L)			May 2020 USEPA DW-Based Soil-to-Groundwater SSL DAF = 1 (b) (mg/kg)		Adjusted USEPA DW-Based Soil-to-Groundwater SSL DAF = 20 (b) (mg/kg)	
Antimony	7440-36-0	0.006	(e)	MCL	0.27	(e)	5.4	(e)
Arsenic	7440-38-2	0.01		MCL	0.29		5.8	
Barium	7440-39-3	2		MCL	82		1,640	
Beryllium	7440-41-7	0.004		MCL	3.2		64	
Boron	7440-42-8	4		RSL	13		260	
Cadmium	7440-43-9	0.005		MCL	0.38		7.6	
Calcium	7440-70-2	NA		MCL	NA		NA	
Chromium	16065-83-1	0.1	(g)	MCL	> 1,000,000	(g,h)	> 1,000,000	(g,h)
Cobalt	7440-48-4	0.006		RSL	0.27		5.4	
Copper	7440-50-8	1.3		MCL	46		920	
Lead	7439-92-1	0.015		MCL	14		280	
Lithium	7439-93-2	0.04		RSL	12		240	
Mercury	7487-94-7	0.002	(c)	MCL	0.1	(c)	2	(c)
Molybdenum	7439-98-7	0.1		RSL	2		40	
Nickel	7440-02-0	0.39	(d)	RSL	26	(d)	520	(d)
Selenium	7782-49-2	0.05		MCL	0.26		5.2	
Silver	7440-22-4	0.094		RSL	0.8		16	
Thallium	7440-28-0	0.002	(f)	MCL	0.14	(f)	2.8	(f)
Vanadium	7440-62-2	0.086		RSL	86		1,720	
Zinc	7440-66-6	6		RSL	370		7,400	

Notes:

DAF - Dilution Attenuation Factor.
DW - Drinking Water.
CAS - Chemical Abstracts Service.
MCL - Maximum Contaminant Level (USEPA).
mg/kg - milligram per kilogram.
mg/L - milligram per liter.
NA - not available.
RSL - Risk-based Screening Levels (USEPA).
SSL - Soil Screening Level.
USEPA - United States Environmental Protection Agency.

(a) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf
Where USEPA MCLs are unavailable, the USEPA Risk Based Screening Level values for tapwater are used (May 2020). Hazard Index = 1.0.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

(b) - USEPA Risk-Based Screening Levels (May 2020). Values for MCL-based SSL, or where unavailable, USEPA risk-based SSL (Hazard Index = 1.0.) .
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
The default Dilution Attenuation Factor (DAF) used in the USEPA SSLs = 1. Values are adjusted using a DAF of 20, as recommended in USEPA, 2002.
Supplemental Soil Guidance. https://semspub.epa.gov/work/HQ/175878.pdf

(c) - Value for Inorganic Mercury used for Mercury.
(d) - Value for Nickel Soluble Salts used for Nickel.
(e) - Value for Antimony (metallic) used for Antimony.
(f) - Value for Thallium (Soluble Salts) used for Thallium.
(g) - Value for Chromium (III), Insoluble Salts used for Chromium.
(h) - Value greater than a million parts per million.

Table 7
Derivation of Site-Specific Soil-to-Groundwater Soil Screening Levels for the Protection of Surface Water Pathway
Gallatin Fossil Plant
Tennessee Valley Authority

Constituent	CAS	USEPA Screening Levels: USEPA Drinking Water Value (a) (mg/L)		USEPA Screening Levels: May 2020 USEPA DW-Based Soil-to-Groundwater SSL DAF = 20 (b) (mg/kg)		GAF Calculated Target Groundwater Screening Levels Protective of Surface Water - Cumberland River (c) (mg/L)	Site-Specific Risk-Based Soil-to-Groundwater SSL - Cumberland River (d) (mg/kg)
Antimony	7440-36-0	0.006	(e)	5.4	(e)	1.4	1,242
Arsenic	7440-38-2	0.01		5.8		2.3	1,334
Barium	7440-39-3	2		1,640		51	41,492
Beryllium	7440-41-7	0.004		64		0.92	14,720
Boron	7440-42-8	4		260		920	59,800
Cadmium	7440-43-9	0.005		7.6		0.17	251
Calcium	7440-70-2	NA		NA		26,680	NA
Chromium	16065-83-1	0.1	(g)	> 1,000,000	(g,h)	17	> 1,000,000 (g,h)
Cobalt	7440-48-4	0.006		5.4		1.4	1,242
Copper	7440-50-8	1.3		920		2.1	1,458
Lead	7439-92-1	0.015		280		0.58	10,805
Lithium	7439-93-2	0.04		240		9.2	55,200
Mercury	7487-94-7	0.002	(i)	2	(i)	0.012	12
Molybdenum	7439-98-7	0.1		40		23	9,200
Nickel	7440-02-0	0.39	(j)	520	(j)	12	15,949
Selenium	7782-49-2	0.05		5.2		0.71	74
Silver	7440-22-4	0.094		16		0.74	126
Thallium	7440-28-0	0.002	(f)	2.8	(f)	0.11	151
Vanadium	7440-62-2	0.086		1,720		6.2	124,200
Zinc	7440-66-6	6		7,400		27	33,240

Notes:

CAS - Chemical Abstracts Service.
DAF - Dilution Attenuation Factor.
GAF - Gallatin Fossil Plant.
MCL - Maximum Contaminant Level (USEPA).
mg/kg - milligram per kilogram.
mg/L - milligram per liter.
NA - not available.
RSL - Risk-based Screening Levels (USEPA).
SSL - Soil Screening Level.
USEPA - United States Environmental Protection Agency.

(a) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf
Where USEPA MCLs are unavailable, the USEPA Risk Based Screening Level values for tapwater are used (May 2020). Hazard Index = 1.0.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

(b) - USEPA Risk-Based Screening Levels (May 2020). Values for MCL-based SSL, or where unavailable, USEPA risk-based SSL (Hazard Index = 1.0.) .
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
The default Dilution Attenuation Factor (DAF) used in the USEPA SSLs = 1. Values are adjusted using a DAF of 20, as recommended in USEPA, 2002. Supplemental Soil Guidance. https://semspub.epa.gov/work/HQ/175878.pdf

(c) - Target groundwater concentrations for the Cumberland River are calculated in Table 10.

(d) - Risk-Based SSLs calculated as follows:

$$\text{Site-Specific Risk-Based Soil-to-Groundwater SSL (mg/kg)} = \frac{\text{(USEPA DW-Based Soil-to-Groundwater SSL * Target Groundwater Screening Level)}}{\text{USEPA Drinking Water Value.}}$$

$$\text{USEPA DW-Based Soil-to-Groundwater SSL (mg/kg)} = \frac{Cw * [Kd + (\theta w + \theta a * H')]}{\rho b}$$

Where:

Parameter/Definition	Units	Default USEPA Value
C_w/target soil leachate concentration	mg/L	USEPA Drinking Water Value (mg/L) * DAF
DAF	Unitless	20
K_d/soil-water partition coefficient	L/kg	chemical-specific
K_{oc} /soil organic carbon/water partition coefficient	L/kg	chemical-specific
f_{oc} /fraction organic carbon in soil	g/g	0.002 (0.2%)
θ_w /water-filled soil porosity	Lwater/Lsoil	0.3
θ_a/air-filled soil porosity	Lair/Lsoil	n - θ_w
ρ_b/dry soil bulk density	kg/L	1.5
n/soil porosity	Lpore/Lsoil	1-(ρ_b /ρ_s)
ρ_s/soil particle density	kg/L	2.65
H'/dimensionless Henry's law constant	Unitless	chemical-specific

Values from USEPA. 2002. Supplemental Soil Guidance. Equation 4-10 Soil Screening Level Partitioning Equation for Migration to Ground Water
Available at: https://semspub.epa.gov/work/HQ/175878.pdf

(e) - RSL for Antimony (metallic) used for Antimony.
(f) - RSL for Thallium (Soluble Salts) used for Thallium.
(g) - RSL/SSL for Chromium (III), Insoluble Salts used for Chromium.
(h) - RSL/SSL greater than a million parts per million.
(i) - MCL for Inorganic Mercury used for Mercury.
(j) - RSL for Nickel Soluble Salts used for Nickel.

Table 8
Derivation of Site-Specific Soil-to-Surface Water Soil Screening Levels
Gallatin Fossil Plant
Tennessee Valley Authority

Constituent	CAS	USEPA Screening Levels: USEPA Drinking Water Value (a) (mg/L)		USEPA Screening Levels: May 2020 USEPA DW-Based Soil-to-Groundwater SSL DAF = 20 (b) (mg/kg)		Target Surface Water Screening Level (mg/L) (c) (mg/L)	Site-Specific Risk-Based Soil-to-Surface Water SSL (d) (mg/kg)
Antimony	7440-36-0	0.006	(e)	5.4	(e)	0.006	5
Arsenic	7440-38-2	0.01		5.8		0.01	6
Barium	7440-39-3	2		1,640		0.22	180
Beryllium	7440-41-7	0.004		64		0.004	64
Boron	7440-42-8	4		260		4	260
Cadmium	7440-43-9	0.005		7.6		0.00072	1
Calcium	7440-70-2	NA		NA		116	NA
Chromium	16065-83-1	0.1	(g)	> 1,000,000	(g,h)	0.074	> 1,000,000 (g,h)
Cobalt	7440-48-4	0.006		5.4		0.006	5
Copper	7440-50-8	1.3		920		0.009	6
Lead	7439-92-1	0.015		280		0.0025	47
Lithium	7439-93-2	0.04		240		0.04	240
Mercury	7487-94-7	0.002	(i)	2	(i)	0.000051	0.051
Molybdenum	7439-98-7	0.1		40		0.1	40
Nickel	7440-02-0	0.39	(j)	520	(j)	0.052	69
Selenium	7782-49-2	0.05		5.2		0.0031	0.3
Silver	7440-22-4	0.094		16		0.0032	0.5
Thallium	7440-28-0	0.002	(f)	2.8	(f)	0.00047	0.7
Vanadium	7440-62-2	0.086		1,720		0.027	540
Zinc	7440-66-6	6		7,400		0.12	145

Notes:

CAS - Chemical Abstracts Service.
DAF - Dilution Attenuation Factor.
GAF - Gallatin Fossil Plant.
MCL - Maximum Contaminant Level (USEPA).
mg/kg - milligram per kilogram.
mg/L - milligram per liter.
NA - not available.
RSL - Risk-based Screening Levels (USEPA).
SSL - Soil Screening Level.
USEPA - United States Environmental Protection Agency.

(a) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf
Where USEPA MCLs are unavailable, the USEPA Risk Based Screening Level values for tapwater are used (May 2020). Hazard Index = 1.0.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

(b) - USEPA Risk-Based Screening Levels (May 2020). Values for MCL-based SSL, or where unavailable, USEPA risk-based SSL (Hazard Index = 1.0.) .
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
The default Dilution Attenuation Factor (DAF) used in the USEPA SSLs = 1. Values are adjusted using a DAF of 20, as recommended in USEPA, 2002.
Supplemental Soil Guidance. https://semspub.epa.gov/work/HQ/175878.pdf

(c) - The target surface water screening level is the lower of the HH DW, HH Rec, and Eco surface water screening levels as shown in Table 10.

(d) - Risk-Based SSLs calculated as follows:

$$\text{Site-Specific Risk-Based Soil-to-Surface Water SSL (mg/kg)} = \frac{\text{(USEPA DW-Based Soil-to-Groundwater SSL * Target Surface Water Screening Level)}}{\text{USEPA Drinking Water Value.}}$$

$$\text{USEPA DW-Based Soil-to-Groundwater SSL (mg/kg)} = \frac{Cw * [Kd + (\theta w + \theta a * H')]}{\rho b}$$

Where:

Parameter/Definition	Units	Default USEPA Value
C_w/target soil leachate concentration	mg/L	USEPA Drinking Water Value (mg/L) * DAF
DAF	Unitless	20
K_d/soil-water partition coefficient	L/kg	chemical-specific
K_{oc} /soil organic carbon/water partition coefficient	L/kg	chemical-specific
f_{oc} /fraction organic carbon in soil	g/g	0.002 (0.2%)
θ_w /water-filled soil porosity	Lwater/Lsoil	0.3
θ_a/air-filled soil porosity	Lair/Lsoil	n - θ_w
ρ_b/dry soil bulk density	kg/L	1.5
n/soil porosity	Lpore/Lsoil	1-(ρ_b /ρ_s)
ρ_s/soil particle density	kg/L	2.65
H'/dimensionless Henry's law constant	Unitless	chemical-specific

Values from USEPA. 2002. Supplemental Soil Guidance. Equation 4-10 Soil Screening Level Partitioning Equation for Migration to Ground Water
Available at: https://semspub.epa.gov/work/HQ/175878.pdf

(e) - RSL for Antimony (metallic) used for Antimony.
(f) - RSL for Thallium (Soluble Salts) used for Thallium.
(g) - RSL/SSL for Chromium (III), Insoluble Salts used for Chromium.
(h) - RSL/SSL greater than a million parts per million.
(i) - MCL for Inorganic Mercury used for Mercury.
(j) - RSL for Nickel Soluble Salts used for Nickel.

Table 9
Derivation of Human Health Drinking Water and Recreational Surface Water Screening Levels
Gallatin Fossil Plant
Tennessee Valley Authority

		Human Health Published Screening Level - Drinking Water				Human Health Published Screening Level - Surface Water				Selected Published Human Health Screening Levels	
Constituent	**CAS**	**TDEC Domestic Water Supply (a) (mg/L)**	**MCLs (b) (mg/L)**	**SMCLs (b) (mg/L)**	**May 2020 USEPA Tapwater RSLs (c) (mg/L)**	**TDEC Recreation Water and Organism (a) (mg/L)**	**TDEC Recreation Organism Only (a) (mg/L)**	**USEPA AWQC Consumption of Water and Organism (d) (mg/L)**	**USEPA AWQC Consumption of Organism Only (d) (mg/L)**	**Human Health Drinking Water Screening Level (e) (mg/L)**	**Human Health Recreational Screening Level (f) (mg/L)**
Antimony	7440-36-0	0.006	0.006	NA	0.0078 (n)	0.0056	0.64	0.0056	0.64	0.006	0.64
Arsenic	7440-38-2	0.01	0.01	NA	0.000052	0.01 (m)	0.01 (m)	0.000018 (p)	0.00014 (p)	0.01	0.01
Barium	7440-39-3	2	2	NA	3.8	NA	NA	1	NA	2	NA
Beryllium	7440-41-7	0.004	0.004	NA	0.025	NA	NA	NA	NA	0.004	NA
Boron	7440-42-8	NA	NA	NA	4	NA	NA	NA	NA	4	NA
Cadmium	7440-43-9	0.005	0.005	NA	0.0092	NA	NA	NA	NA	0.005	NA
Calcium	7440-70-2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	16065-83-1	0.1	0.1 (o)	NA	22 (i)	NA	NA	NA	NA	0.1	NA
Cobalt	7440-48-4	NA	NA	NA	0.006	NA	NA	NA	NA	0.006	NA
Copper	7440-50-8	NA	1.3 (h)	1	0.8	NA	NA	1.3	NA	1.3	NA
Lead	7439-92-1	0.005	0.015 (g)	NA	0.015	NA	NA	NA	NA	0.005	NA
Lithium	7439-93-2	NA	NA	NA	0.04	NA	NA	NA	NA	0.04	NA
Mercury	7487-94-7	0.002	0.002	NA	0.0057 (j)	0.00005	0.000051	NA	NA	0.002	0.000051
Molybdenum	7439-98-7	NA	NA	NA	0.1	NA	NA	NA	NA	0.1	NA
Nickel	7440-02-0	0.1	NA	NA	0.39 (k)	0.61	4.6	0.61	4.6	0.1	4.6
Selenium	7782-49-2	0.05	0.05	NA	0.1	0.17	4.2	0.17	4.2	0.05	4.2
Silver	7440-22-4	NA	NA	0.1	0.094	NA	NA	NA	NA	0.094	NA
Thallium	7440-28-0	0.002	0.002	NA	0.0002 (l)	0.00024	0.00047	0.00024	0.00047	0.002	0.00047
Vanadium	7440-62-2	NA	NA	NA	0.086	NA	NA	NA	NA	0.086	NA
Zinc	7440-66-6	NA	NA	5	6	7.4	26	7.4	26	6	26

Table 9
Derivation of Human Health Drinking Water and Recreational Surface Water Screening Levels
Gallatin Fossil Plant
Tennessee Valley Authority

Notes:

AWQC - Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
MCL - Maximum Contaminant Level.
mg/L - milligrams per liter.
NA - Not Available.
RSL - Risk-based Screening Levels (USEPA).
TDEC - Tennessee Department of Environment and Conservation.
USEPA - United States Environmental Protection Agency.

(a) - Tennessee Department of Environment and Conservation. Tennessee Board of Water Quality, Oil and Gas.
General Water Quality Criteria. Chapter 0400-40-03. December 2013. Revised September 2019.
https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20190911.pdf
(b) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf
(c) - USEPA Risk-Based Screening Levels (May 2020). Values for tapwater. Hazard Index = 1.0.
https://semspub.epa.gov/work/HQ/197442.pdf
(d) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table
USEPA AWQC Human Health for the Consumption of Organism Only apply to total concentrations.
(e) - Drinking Water Screening Levels selected using the following hierarchy:
TDEC Domestic Water Supply
USEPA MCL for Drinking Water.
USEPA Tapwater RSL.
USEPA SMCL for Drinking Water.
(f) - Recreational Use Screening Levels selected using the following hierarchy:
TDEC Ambient Water Quality Criteria for Human Health Consumption of Organism Only.
USEPA Ambient Water Quality Criteria for Human Health Consumption of Organism Only.
(g) - Lead Treatment Technology Action Level is 0.015 mg/L.
(h) - Copper Treatment Technology Action Level is 1.3 mg/L.
(i) - Value for Chromium (III), Insoluble Salts used for Chromium.
(j) - RSL for Mercuric Chloride used for Mercury.
(k) - RSL for Nickel Soluble Salts used for Nickel.
(l) - RSL for Thallium (Soluble Salts) used for Thallium.
(m) - 10^{-5} risk level is used for all carcinogenic pollutants.
(n) - RSL for Antimony (metallic) used for Antimony.
(o) - Value for Total Chromium.
(p) - Value applies to inorganic form of arsenic only.

Table 10
Derivation of Ecological Surface Water Screening Levels
Gallatin Fossil Plant
Tennessee Valley Authority

		Ecological Published Screening Level - Surface Water																	
		TDEC Fish and Aquatic Life (a) CMC (acute) (mg/L)		TDEC Fish and Aquatic Life (a) CCC (chronic) (mg/L)		USEPA AWQC (b) CMC (acute) (mg/L)		USEPA AWQC (b) CCC (chronic) (mg/L)		USEPA Region 4 Freshwater Acute Screening Value (c) (mg/L)		USEPA Region 4 Freshwater Chronic Screening Value (c) (mg/L)		Selected Ecological Screening Level (acute) (m) (mg/L)		Selected Ecological Screening Level (chronic) (m) (mg/L)	
Constituent	**CAS**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**
Antimony	7440-36-0	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.9	NA	0.19	NA	0.9	NA	0.19
Arsenic	7440-38-2	0.34 (d)	0.34 (d)	0.15 (d)	0.15 (d)	0.34 (d, e)	0.34 (d, j)	0.15 (d, e)	0.15 (d, j)	0.34 (d)	0.34 (d)	0.15 (d)	0.15 (d)	0.34	0.34	0.15	0.15
Barium	7440-39-3	NA	NA	NA	NA	NA	NA	NA	NA	NA	2	NA	0.22	NA	2	NA	0.22
Beryllium	7440-41-7	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.093 (k)	NA	0.011 (k)	NA	0.093	NA	0.011
Boron	7440-42-8	NA	NA	NA	NA	NA	NA	NA	NA	NA	34	NA	7.2	NA	34	NA	7.2
Cadmium	7440-43-9	0.0018 (e, f)	0.0019 (f, j)	0.00072 (e, f)	0.00079 (f, j)	0.0018 (e, f)	0.0019 (f, j)	0.00072 (e, f)	0.00079 (f, j)	0.00094 (k)	0.00096 (k)	0.00043 (k)	0.00045 (k)	0.0018	0.0019	0.00072	0.00079
Calcium	7440-70-2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	116	NA	NA	NA	116
Chromium	16065-83-1	0.57 (e, f, g)	1.8 (f, g, j)	0.074 (e, f, g)	0.086 (f, g, j)	0.57 (e, f, g)	1.8 (f, g, j)	0.074 (e, f, g)	0.086 (f, g, j)	0.32 (g, k)	1.0 (g, k)	0.042 (g, k)	0.049 (g, k)	0.57	1.8	0.074	0.086
Cobalt	7440-48-4	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.12	NA	0.019	NA	0.12	NA	0.019
Copper	7440-50-8	0.013 (e, f)	0.014 (f, j)	0.009 (e, f)	0.0093 (f, j)	0.013 (e, f)	0.013999 (f, j)	0.0090 (e, f)	0.009329 (f, j)	0.0070 (k)	0.0073 (k)	0.0050 (k)	0.0052 (k)	0.013	0.014	0.0090	0.0093
Lead	7439-92-1	0.065 (e, f)	0.082 (f, j)	0.0025 (e, f)	0.0032 (f, j)	0.065 (e, f)	0.082 (f, j)	0.0025 (e, f)	0.0032 (f, j)	0.030 (k)	0.034 (k)	0.0012 (k)	0.0013 (k)	0.065	0.082	0.0025	0.0032
Lithium	7439-93-2	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.91	NA	0.44	NA	0.91	NA	0.44
Mercury	7487-94-7	0.0014 (e)	NA	0.00077 (e)	NA	0.0014 (e, h)	0.0016 (h, j)	0.00077 (e, h)	0.00091 (h, j)	0.0014	0.0016	0.00077	0.00091	0.0014	0.0016	0.00077	0.00091
Molybdenum	7439-98-7	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.2	NA	0.8	NA	7.2	NA	0.8
Nickel	7440-02-0	0.47 (e, f)	0.47 (f, j)	0.052 (e, f)	0.052 (f, j)	0.47 (e, f)	0.47 (f, j)	0.052 (e, f)	0.052 (f, j)	0.26 (k)	0.26 (k)	0.0289 (k)	0.0290 (k)	0.47	0.47	0.052	0.052
Selenium	7782-49-2	0.02	0.02	0.0031	0.0031	NA	NA	NA	0.0031 (i)	NA	0.02	NA	0.005	0.02	0.02	0.0031	0.0031
Silver	7440-22-4	0.0032 (e, f)	0.0038 (f, j)	NA	NA	0.0032 (e, f)	0.0038 (f, j)	NA	NA	0.00098 (k)	0.0011 (k)	NA	NA	0.0032	0.0038	NA	NA
Thallium	7440-28-0	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.054	NA	0.006	NA	0.054	NA	0.006
Vanadium	7440-62-2	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.079	NA	0.027	NA	0.079	NA	0.027
Zinc	7440-66-6	0.12 (e, f)	0.12 (f, j)	0.12 (e, f)	0.12 (f, j)	0.12 (e, f)	0.12 (f, j)	0.12 (e, f)	0.12 (f, j)	0.065 (k)	0.067 (k)	0.066 (k)	0.067 (k)	0.12	0.12	0.12	0.12

Notes:

AWQC - Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
CCC - Criterion Continuous Concentration.
CMC - Criterion Maximum Concentration.
mg/L - milligrams per liter.
NA - Not Available.
TDEC - Tennessee Department of Environment and Conservation.
USEPA - United States Environmental Protection Agency.

(a) - Tennessee Department of Environment and Conservation. Tennessee Board of Water Quality, Oil and Gas. General Water Quality Criteria. Chapter 0400-40-03.
December 2013. Revised September 2019.
https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20190911.pdf
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table
(c) - USEPA Region 4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. March 2018.
https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf
(d) - Value applies to inorganic form of arsenic only.
(e) - Criterion expressed as dissolved.
(f) - Criterion expressed as a function of total hardness (mg/L). Value displayed corresponds to total hardness of 100 mg/L.
(g) - Value for Chromium (III), Insoluble Salts used for Chromium.
(h) - Value for Inorganic Mercury.
(i) - USEPA Office of Water. Final Criterion: Aquatic Life Ambient Water Quality Criterion for Selenim - Freshwater. 30 June 2016.
Freshwater value for chronic (30 day) water column concentration (ug/L) of dissolved selenium in lotic (flowing) surface water.
https://www.epa.gov/sites/production/files/2016-07/documents/aquatic_life_awqc_for_selenium_-_freshwater_2016.pdf
(j) - Criterion expressed as total.
(k) - Criterion expressed as a function of total hardness (mg/L). Value displayed corresponds to total hardness of 50 mg/L.
(l) - For hardness-dependent metals (beryllium, cadmium, chromium+3, copper, lead, nickel, and zinc), freshwater chronic criteria are based on soft water with a total hardness of 50 mg/L as CaCO3. Soft water is common within Region 5 and this water ESL may be recalculated when site specific water hardness is less than 50 mg/L.
(m) - Ecological Screening Levels selected using the following hierarchy:
TDEC Fish and Aquatic Life (Chronic).
USEPA Aquatic Life Ambient Water Quality Criteria (Chronic).
USEPA Region 4 Freshwater Chronic Screening Value (Chronic).
TDEC Fish and Aquatic Life (Acute).
USEPA Aquatic Life Ambient Water Quality Criteria (Acute).
USEPA Region 4 Freshwater Acute Screening Value (Acute).

Table 11
Derivation of Target Groundwater Screening Levels Protective of Surface Water
Gallatin Fossil Plant
Tennessee Valley Authority

								Dilution Attenuation Factor - Cumberland River (d)	230	
Constituent	**CAS**	**HH DW SL (a) (mg/L)**	**HH REC SL (b) (mg/L)**	**ECO SL - Dissolved (acute) (c) (mg/L)**	**ECO SL - Total (acute) (c) (mg/L)**	**ECO SL - Dissolved (chronic) (c) (mg/L)**	**ECO SL - Total (chronic) (c) (mg/L)**	**Lowest of the Human Health and Ecological Screening Levels (mg/L)**	**Target Surface Water Screening Level (e) (mg/L)**	**Target Groundwater Screening Level - Cumberland River (f) (mg/L)**
Antimony	7440-36-0	0.006	0.64	NA	0.9	NA	0.19	0.006	0.006	1.4
Arsenic	7440-38-2	0.01	0.01	0.34	0.34	0.15	0.15	0.01	0.01	2.3
Barium	7440-39-3	2	NA	NA	2	NA	0.22	0.22	0.22	51
Beryllium	7440-41-7	0.004	NA	NA	0.093	NA	0.011	0.004	0.004	0.92
Boron	7440-42-8	4	NA	NA	34	NA	7.2	4	4	920
Cadmium	7440-43-9	0.005	NA	0.0018	0.0019	0.00072	0.00079	0.00072	0.00072	0.17
Calcium	7440-70-2	NA	NA	NA	NA	NA	116	116	116	26,680
Chromium	16065-83-1	0.1	NA	0.57	1.8	0.074	0.086	0.074	0.074	17
Cobalt	7440-48-4	0.006	NA	NA	0.12	NA	0.019	0.006	0.006	1.4
Copper	7440-50-8	1.3	NA	0.013	0.014	0.009	0.0093	0.009	0.009	2.1
Lead	7439-92-1	0.005	NA	0.065	0.082	0.0025	0.0032	0.0025	0.0025	0.58
Lithium	7439-93-2	0.04	NA	NA	0.91	NA	0.44	0.04	0.04	9.2
Mercury	7487-94-7	0.002	0.000051	0.0014	0.0016	0.00077	0.00091	0.000051	0.000051	0.012
Molybdenum	7439-98-7	0.1	NA	NA	7.2	NA	0.8	0.1	0.1	23
Nickel	7440-02-0	0.1	4.6	0.47	0.47	0.052	0.052	0.052	0.052	12
Selenium	7782-49-2	0.05	4.2	0.02	0.02	0.0031	0.0031	0.0031	0.0031	0.71
Silver	7440-22-4	0.094	NA	0.0032	0.0038	NA	NA	0.0032	0.0032	0.74
Thallium	7440-28-0	0.002	0.00047	NA	0.054	NA	0.006	0.00047	0.00047	0.11
Vanadium	7440-62-2	0.086	NA	NA	0.079	NA	0.027	0.027	0.027	6.2
Zinc	7440-66-6	6	26	0.12	0.12	0.12	0.12	0.12	0.12	27

Notes:
CAS - Chemical Abstracts Service.
ECO SL - Ecological Screening Level.
HH DW SL - Human Health Drinking Water Screening Level.
HH REC SL - Human Health Recreational Use Screening Level.
MCL - Maximum Contaminant Level (USEPA).
mg/L - milligram per liter.
NA - Not Available.
RSL - Risk-based Screening Levels (USEPA).
SMCL - Secondary Maximum Contaminant Level.
TDEC - Tennessee Department of Environment and Conservation.
USEPA - United States Environmental Protection Agency.

(a) - Drinking Water Screening Levels selected in Table 8 using the following hierarchy:
TDEC Domestic Water Supply.
USEPA MCL for Drinking Water.
USEPA Tapwater RSL.
USEPA SMCL for Drinking Water.
(b) - Recreational Use Screening Levels selected in Table 8 using the following hierarchy:
TDEC Ambient Water Quality Criteria for Human Health Consumption of Organism Only.
USEPA Ambient Water Quality Criteria for Human Health Consumption of Organism Only.
(c) - Ecological Screening Levels selected in Table 9 using the following hierarchy:
TDEC Fish and Aquatic Life (Chronic).
USEPA Aquatic Life Ambient Water Quality Criteria (Chronic).
USEPA Region 4 Freshwater Chronic Screening Value (Chronic).
TDEC Fish and Aquatic Life (Acute).
USEPA Aquatic Life Ambient Water Quality Criteria (Acute).
USEPA Region 4 Freshwater Acute Screening Value (Acute).
(d) - Estimated value, see text for derivation.
(e) - The target surface water screening level is the lower of the HH DW, HH Rec, and Eco SLs.
(f) - The Target Groundwater Screening Level = Minimum SL x Dilution Factor.

Table 12
Soil Screening Levels Summary Table
Gallatin Fossil Plant
Tennessee Valley Authority

Constituent	CAS	Background Threshold Value (a) (mg/kg)	May 2020 USEPA Industrial Soil RSLs (b) (mg/kg)	On-Site Construction/Utility Worker - Other Construction Activities Calculated RBSL (c) (mg/kg)	USEPA DW-Based Soil-to-Groundwater SSL DAF = 20 (d) (mg/kg)	Site-Specific Risk-Based Soil-to-Groundwater SSL - Cumberland River (e) (mg/kg)	Site-Specific Risk-Based Soil-to-Surface Water SSL (f) (mg/kg)	USEPA Region 4 Ecological Soil Screening Value (g) (mg/kg)	USEPA Region 4 Ecological Freshwater Sediment Threshold Effects Concentration (h) (mg/kg)	USEPA Region 4 Ecological Freshwater Sediment Probable Effects Concentration (h) (mg/kg)
Antimony	7440-36-0	0.3	470 (p)	135	5.4	1,242	5	0.27	2	25
Arsenic	7440-38-2	13	300 (m,o)	98.6 (n,o)	5.8	1,334	6	18	9.8	33
Barium	7440-39-3	207	220,000	40,600	1,640	41,492	180	330	20	60
Beryllium	7440-41-7	2	2,300	326	64	14,720	64	2.5	NA	NA
Boron	7440-42-8	8	230,000	58,100	260	59,800	260	7.5	NA	NA
Cadmium	7440-43-9	0.5	980	86.2	7.6	251	1	0.36	1	5
Calcium	7440-70-2	91995	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	16065-83-1	23	>1,000,000 (q,r)	84,300 (q)	> 1,000,000 (q,r)	> 1,000,000 (q,r)	> 1,000,000 (q,r)	23	43.4	111
Cobalt	7440-48-4	17	350	289	5.4	1,242	5	13	50	NA
Copper	7440-50-8	23	47,000	3,390	920	1,458	6	28	31.6	149
Lead	7439-92-1	30	800	800 (l)	280	10,805	47	11	35.8	128
Lithium	7439-93-2	22	2,300	679	240	55,200	240	2	NA	NA
Mercury	7487-94-7	0.1	350 (j)	610 (j)	2	11.73	0.1	0.013	0.17	0.17
Molybdenum	7439-98-7	2	5,800	1,700	40	9,200	40	2	NA	NA
Nickel	7440-02-0	30	22,000 (k)	2,530 (k)	520	15,949	69	38	22.7	48.6
Selenium	7782-49-2	3	5,800	1,690	5.2	74	0.3	0.52	0.72	2.9
Silver	7440-22-4	0.04	5,800	1,700	16	126	0.5	4.2	1	2.2
Thallium	7440-28-0	0.4	12 (i)	14 (i)	2.8	151	0.7	0.05	NA	NA
Vanadium	7440-62-2	36	5,800	1,270	1,720	124,200	540	7.8	NA	NA
Zinc	7440-66-6	103	350,000	102,000	7,400	33,240	145	46	121	459

Notes:

BTV - Background Threshold Value.
DW - Drinking Water.
CAS - Chemical Abstracts Service.
HI - Hazard Index (noncancer child).
mg/kg - milligram per kilogram.
NA - not available.
RBSL - Risk- based screening level.
RSL - Risk-based Screening Levels (USEPA).
SSL - Soil Screening Level.
TR - Target Risk (carcinogenic).
USEPA - United States Environmental Protection Agency.

(a) - BTVs calculated in Table 2.
(b) - USEPA Regional Screening Levels (May 2020). Values for industrial soil. Hazard Index = 1.0.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
(c) - Site-specific risk based screening levels (RBSLs) calculated for construction worker exposure to soil - Other Construction Activities
(see Appendix A) using USEPA exposure factors and equations from the USEPA screening levels calculator.
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search
(d) - USEPA Risk-Based Screening Levels (May 2020). Values for MCL-based SSL, or where unavailable, USEPA risk-based SSL (Hazard Index = 1.0.) .
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
The default Dilution Attenuation Factor (DAF) used in the USEPA SSLs = 1. Values are adjusted using a DAF of 20, as recommended in USEPA, 2002.
Supplemental Soil Guidance. https://semspub.epa.gov/work/HQ/175878.pdf
(e) - Soil to groundwater SSLs calculated in Table 7.
(f) - Soil to surface water SSLs calculated in Table 8.
(g) - USEPA Region 4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. March 2018.
Table 3 Soil Screening Levels.
https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf
(h) - USEPA Region 4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. March 2018.
Table 2a Region 4 Sediment Ecological Screening Values (ESV) and Refinement Screening Values (RSV).
https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf
(i) - RSL for Thallium (Soluble Salts) used for Thallium.
(j) - RSL for Mercuric Chloride used for Mercury.
(k) - RSL for Nickel Soluble Salts used for Nickel.
(l) - USEPA industrial soil RSL value used.
(m) - RSL based on cancer endpoint at 1E-4 (noncancer based RSL is 480 mg/kg).
(n) - RBSL based on noncancer endpoint (cancer-based RBSL at 1E-4 is 9,250 mg/kg).
(o) - Arsenic RSL and RBSL are based on the lower of the values based on a hazard index of 1 and an excess lifetime cancer risk of 1E-04.
Note that of the constituents evaluated, arsenic is the only constituent with an RSL based on potential carcinogenic effects.
(p) - RSL for Antimony (metallic) used for Antimony.
(q) - Value for Chromium (III), Insoluble Salts used for Chromium.
(r) - Value greater than a million parts per million.

Table 13
Groundwater Screening Levels Summary Table
Gallatin Fossil Plant
Tennessee Valley Authority

Constituent	CAS	USEPA Drinking Water Value (a) (mg/L)		Target Groundwater Screening Level - Cumberland River (b) (mg/L)
Antimony	7440-36-0	0.006	(c)	1.4
Arsenic	7440-38-2	0.01		2.3
Barium	7440-39-3	2		51
Beryllium	7440-41-7	0.004		0.92
Boron	7440-42-8	4		920
Cadmium	7440-43-9	0.005		0.17
Calcium	7440-70-2	NA		26,680
Chromium	16065-83-1	0.1	(d)	17
Cobalt	7440-48-4	0.006		1.4
Copper	7440-50-8	1.3		2.1
Lead	7439-92-1	0.015		0.58
Lithium	7439-93-2	0.04		9.2
Mercury	7487-94-7	0.002	(e)	0.012
Molybdenum	7439-98-7	0.1		23
Nickel	7440-02-0	0.39	(f)	12
Selenium	7782-49-2	0.05		0.71
Silver	7440-22-4	0.094		0.74
Thallium	7440-28-0	0.002	(g)	0.11
Vanadium	7440-62-2	0.086		6.2
Zinc	7440-66-6	6		27

Notes:
CAS - Chemical Abstracts Service.
MCL - Maximum Contaminant Level (USEPA).
mg/L - milligram per liter.
NA - not available.
RSL - Risk-based Screening Levels (USEPA).
USEPA - United States Environmental Protection Agency.

(a) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf
Where USEPA MCLs are unavailable, the USEPA Risk Based Screening Level values for tapwater
are used (May 2020). Hazard Index = 1.0. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
(b) - Target groundwater concentrations for the Cumberland River are calculated in Table 10.
(c) - RSL for Antimony (metallic) used for Antimony.
(d) - RSL for Chromium (III), Insoluble Salts used for Chromium.
(e) - MCL for Inorganic Mercury used for Mercury.
(f) - RSL for Nickel Soluble Salts used for Nickel.
(g) - RSL for Thallium (Soluble Salts) used for Thallium.

Table 14
Surface Water Screening Levels Summary Table
Gallatin Fossil Plant
Tennessee Valley Authority

Constituent	CAS	HH DW SL (a) (mg/L)	HH REC SL (b) (mg/L)	ECO SL - Dissolved (acute) (c) (mg/L)	ECO SL - Total (acute) (c) (mg/L)	ECO SL - Dissolved (chronic) (c) (mg/L)	ECO SL - Total (chronic) (c) (mg/L)	Lowest of the Human Health and Ecological Screening Levels (mg/L)
Antimony	7440-36-0	0.006	0.64	NA	0.9	NA	0.19	0.006
Arsenic	7440-38-2	0.01	0.01	0.34	0.34	0.15	0.15	0.01
Barium	7440-39-3	2	NA	NA	2	NA	0.22	0.22
Beryllium	7440-41-7	0.004	NA	NA	0.093	NA	0.011	0.004
Boron	7440-42-8	4	NA	NA	34	NA	7.2	4
Cadmium	7440-43-9	0.005	NA	0.0018	0.0019	0.00072	0.00079	0.00072
Calcium	7440-70-2	NA	NA	NA	NA	NA	116	116
Chromium	16065-83-1	0.1	NA	0.57	1.8	0.074	0.086	0.07
Cobalt	7440-48-4	0.006	NA	NA	0.12	NA	0.019	0.006
Copper	7440-50-8	1.3	NA	0.013	0.014	0.009	0.0093	0.01
Lead	7439-92-1	0.005	NA	0.065	0.082	0.0025	0.0032	0.003
Lithium	7439-93-2	0.04	NA	NA	0.91	NA	0.44	0.04
Mercury	7487-94-7	0.002	0.000051	0.0014	0.0016	0.00077	0.00091	0.000051
Molybdenum	7439-98-7	0.1	NA	NA	7.2	NA	0.8	0.1
Nickel	7440-02-0	0.1	4.6	0.47	0.47	0.052	0.052	0.052
Selenium	7782-49-2	0.05	4.2	0.02	0.02	0.0031	0.0031	0.0031
Silver	7440-22-4	0.094	NA	0.0032	0.0038	NA	NA	0.0032
Thallium	7440-28-0	0.002	0.00047	NA	0.054	NA	0.006	0.00047
Vanadium	7440-62-2	0.086	NA	NA	0.079	NA	0.027	0.027
Zinc	7440-66-6	6	26	0.12	0.12	0.12	0.12	0.12

Notes:

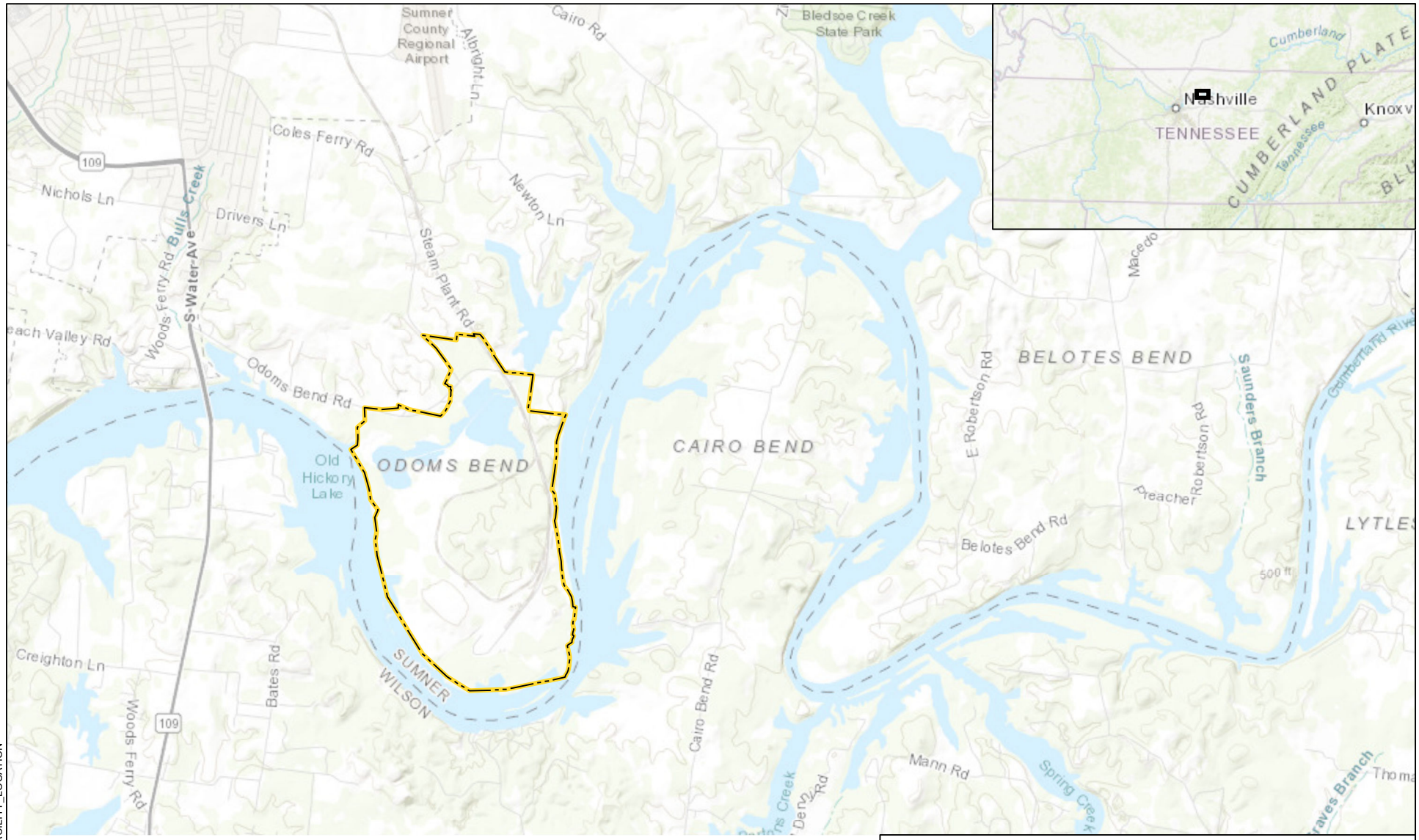
CAS - Chemical Abstracts Service.
ECO SL - Ecological Screening Level.
HH DW SL - Human Health Drinking Water Screening Level.
HH REC SL - Human Health Recreational Use Screening Level.
MCL - Maximum Contaminant Level (USEPA).
mg/L - milligram per liter.
NA - Not Available.
RSL - Risk-based Screening Levels (USEPA).
SMCL - Secondary Maximum Contaminant Level.
TDEC - Tennessee Department of Environment and Conservation.
USEPA - United States Environmental Protection Agency.

(a) - Drinking Water Screening Levels selected in Table 8 using the following hierarchy:
TDEC Domestic Water Supply.
USEPA MCL for Drinking Water.
USEPA Tapwater RSL.
USEPA SMCL for Drinking Water.

(b) - Recreational Use Screening Levels selected in Table 8 following the using hierarchy:
TDEC Ambient Water Quality Criteria for Human Health Consumption of Organism Only.
USEPA Ambient Water Quality Criteria for Human Health Consumption of Organism Only.

(c) - Ecological Screening Levels selected in Table 9 using the following hierarchy:
TDEC Fish and Aquatic Life (Chronic).
USEPA Aquatic Life Ambient Water Quality Criteria (Chronic).
USEPA Region 4 Freshwater Chronic Screening Value (Chronic).
TDEC Fish and Aquatic Life (Acute).
USEPA Aquatic Life Ambient Water Quality Criteria (Acute).
USEPA Region 4 Freshwater Acute Screening Value (Acute).

FIGURES



LEGEND

GALLATIN FOSSIL PLANT PROPERTY BOUNDARY

NOTE

BASE MAP SOURCE: ESRI

N

0 0.5 1

SCALE IN MILES

HALEY ALDRICH

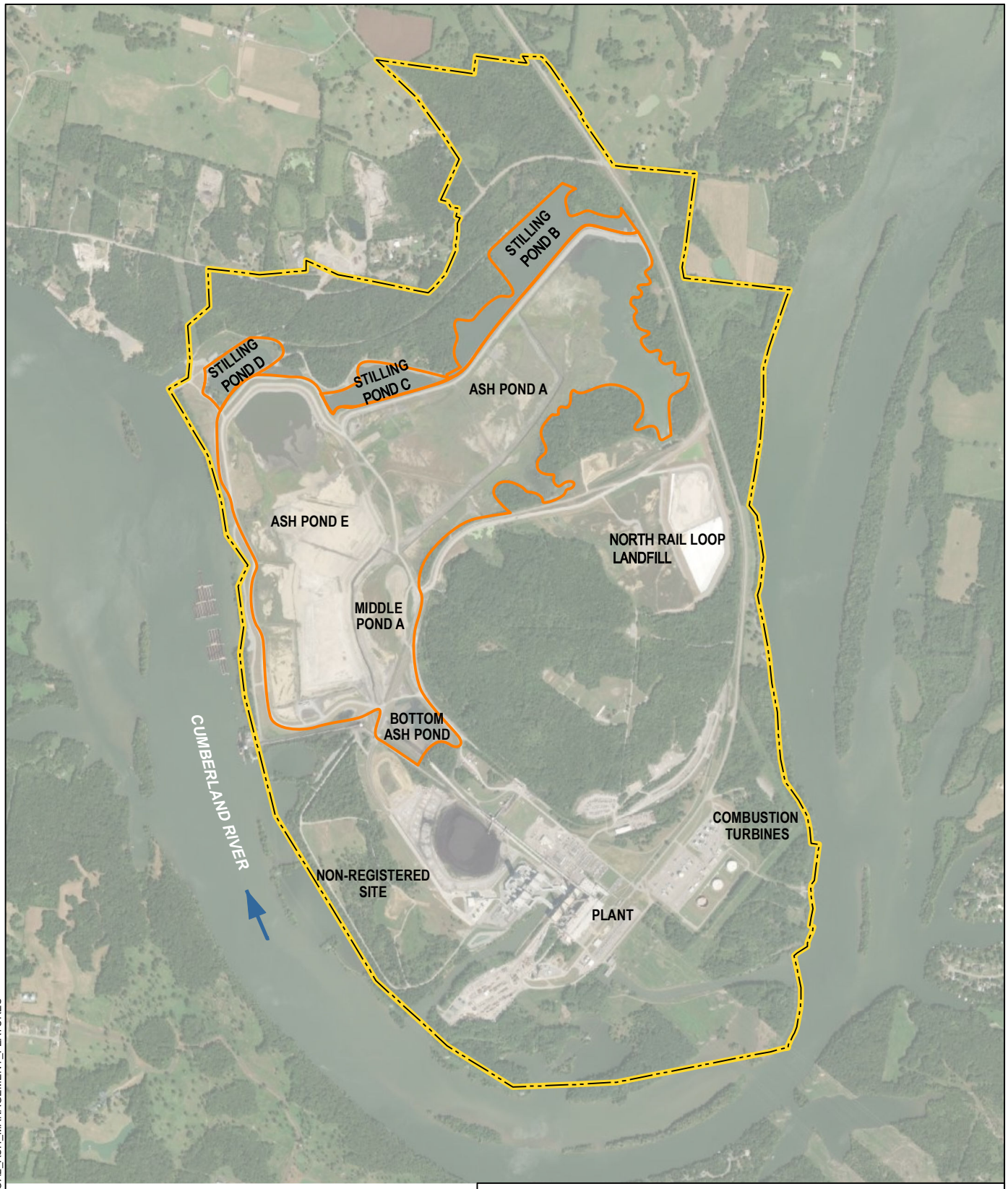
TENNESSEE VALLEY AUTHORITY
GALLATIN FOSSIL PLANT

FACILITY LOCATION

AUGUST 2020

FIGURE 1

DOCUMENT NAME: 134812_002_0001_FACILITY_LOCATION



LEGEND

- RIVER FLOW DIRECTION
- ASH POND COMPLEX
- GALLATIN FOSSIL PLANT PROPERTY BOUNDARY

N

0 900 1,800
SCALE IN FEET

AERIAL IMAGERY SOURCE: ESRI

HALEY ALDRICH

TENNESSEE VALLEY AUTHORITY
GALLATIN FOSSIL PLANT

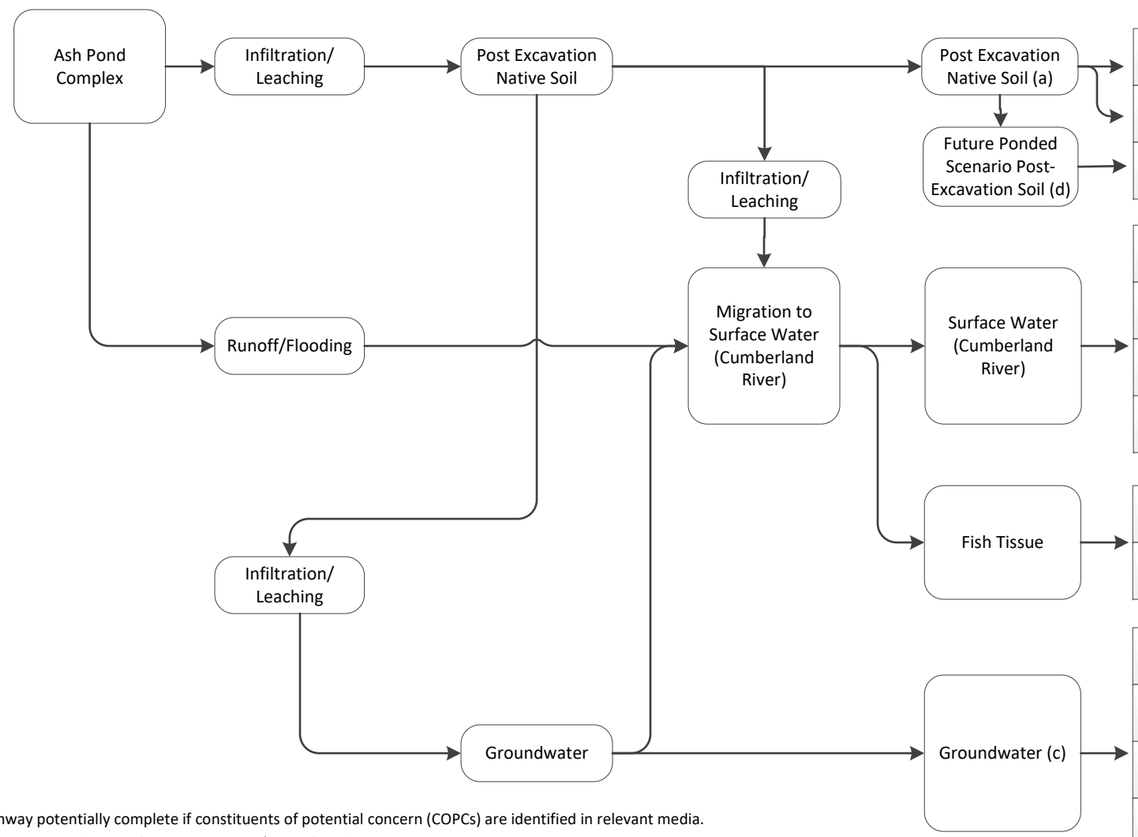
COAL ASH MANAGEMENT FEATURES

AUGUST 2020

FIGURE 2

DOCUMENT NAME: 134812_002_0002_COAL_ASH_MANAGEMENT_FEATURES

FIGURE 3
CONCEPTUAL SITE MODEL
TENNESSEE VALLEY AUTHORITY
GALLATIN FOSSIL PLANT



Potential Exposure Media	Potential Exposure Route	Potential Human Health Receptors: Current/Future Off-Site Resident Adult/Child (d)	Current/Future Off-Site Recreational User	Future On-Site Commercial/ Industrial Worker	Future On-Site Construction Worker	Potential Ecological Receptors: Aquatic and Terrestrial
Post Excavation Native Soil (a)	Incidental Ingestion	○	○	●	●	NA
	Dermal Contact	○	○	●	●	NA
Future Ponded Scenario Post-Excavation Soil (d)	Ecological Receptors	○	○	○	○	●
Surface Water (Cumberland River)	Drinking Water Use (b)	●	○	○	○	NA
	Incidental Ingestion	○	●	○	○	NA
	Dermal Contact	○	●	○	○	NA
	Aquatic Exposure	NA	NA	NA	NA	●
Fish Tissue	Ingestion	○	●	○	○	NA
	Aquatic Exposure	NA	NA	NA	NA	●
Groundwater (c)	Drinking Water Use	●	○	○	○	NA
	Incidental Ingestion	○	○	○	○	NA
	Dermal Contact	○	○	○	○	NA
	Aquatic Exposure	NA	NA	NA	NA	NA

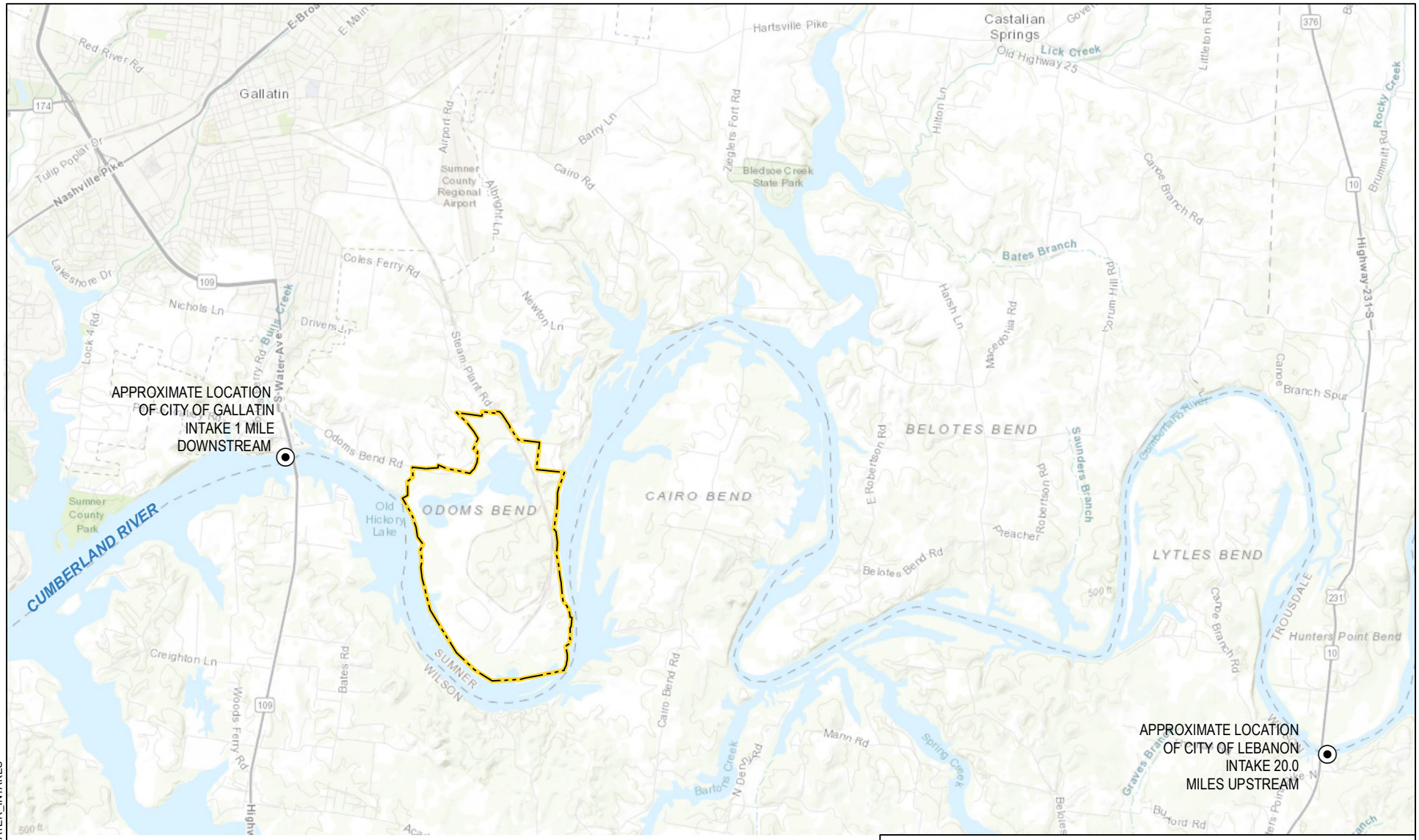
● Pathway potentially complete if constituents of potential concern (COPCs) are identified in relevant media.
○ Pathway evaluated and found incomplete/insignificant.

(a) The Ash Pond Complex will be closed by removal of the CCR material. After CCR material is excavated, up to an additional one (1) foot of underlying native soils may be removed, however, it is anticipated that bedrock will be exposed at some locations. Native soil remaining after the excavation is completed may contain residual levels of CCR-derived constituents.

(b) The Cumberland River is a source of drinking water; the nearest downstream utility that uses the Cumberland River as the source of raw water for treatment for use as potable water is approximately one mile downstream .

(c) On-site groundwater is not used as drinking water or for any other purposes. There are water supply wells within a 1-mile radius of the facility, see text for discussion of these wells. Based on the presence of these wells, the groundwater pathway is designated as potentially complete for current and future use of groundwater as drinking water.

(d) A terrestrial ecological soil evaluation will be included if the selected method of restoration includes a ponded area, as in that scenario there is an exposure pathway for terrestrial receptors. If the post-excavation area is backfilled with clean fill as the selected method of restoration, post-excavation soil would not be accessible to terrestrial receptors. Evaluation of the potential ecological soil pathway is generally considered to be protective of surface water.



LEGEND

- APPROXIMATE LOCATION OF WATER INTAKE
- GALLATIN FOSSIL PLANT PROPERTY BOUNDARY

NOTES

1. WATER INTAKE LOCATIONS ESTIMATED FROM ARMY CORPS OF ENGINEERS RIVER CHARTS.
2. BASE MAP SOURCE: ESRI

N

0 0.5 1
SCALE IN MILES

HALEY ALDRICH

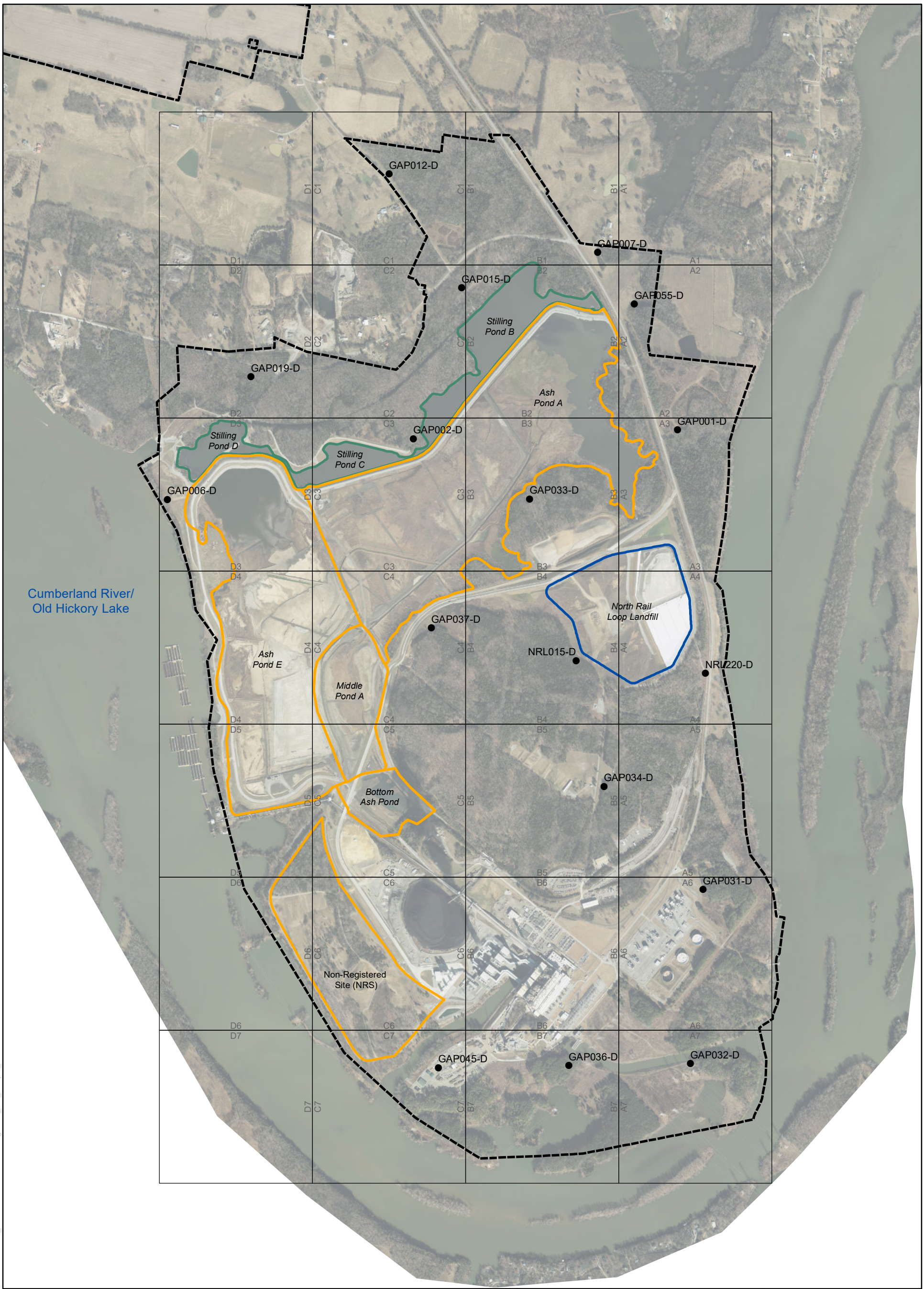
TENNESSEE VALLEY AUTHORITY
GALLATIN FOSSIL PLANT

ESTIMATED LOCATIONS OF PUBLIC DRINKING WATER INTAKES

AUGUST 2020

FIGURE 4

DOCUMENT NAME: 134812_002_0003_WATER_INTAKES



LEGEND

- Overburden Sampling Point (DPT)
- 2000' Grid
- TVA Gallatin Fossil Plant Property Boundary (Approximate)
- CCR Management Units
- North Rail Loop (NRL) Landfill
- Stilling Ponds

NOTE: Aerial image dated February 2017

N

0 1,200 2,400
Feet

AECOM

Figure 5

BACKGROUND SOIL SAMPLE LOCATIONS

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MARK.P.SMITH	L.BRADLEY		REV. 0

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
5/14/2020	FOSSIL AND HYDRO ENGINEERING

Document Path: L:\DCS\Projects\L_URS\Jobs4_Projects\TVA\Gallatin_General\EIP\11.0 GIS\background_soil_sample_locations.mxd

Figure 6
Evaluation of Post-Excavation Soil Results Flowchart
Gallatin Fossil Plant
Tennessee Valley Authority

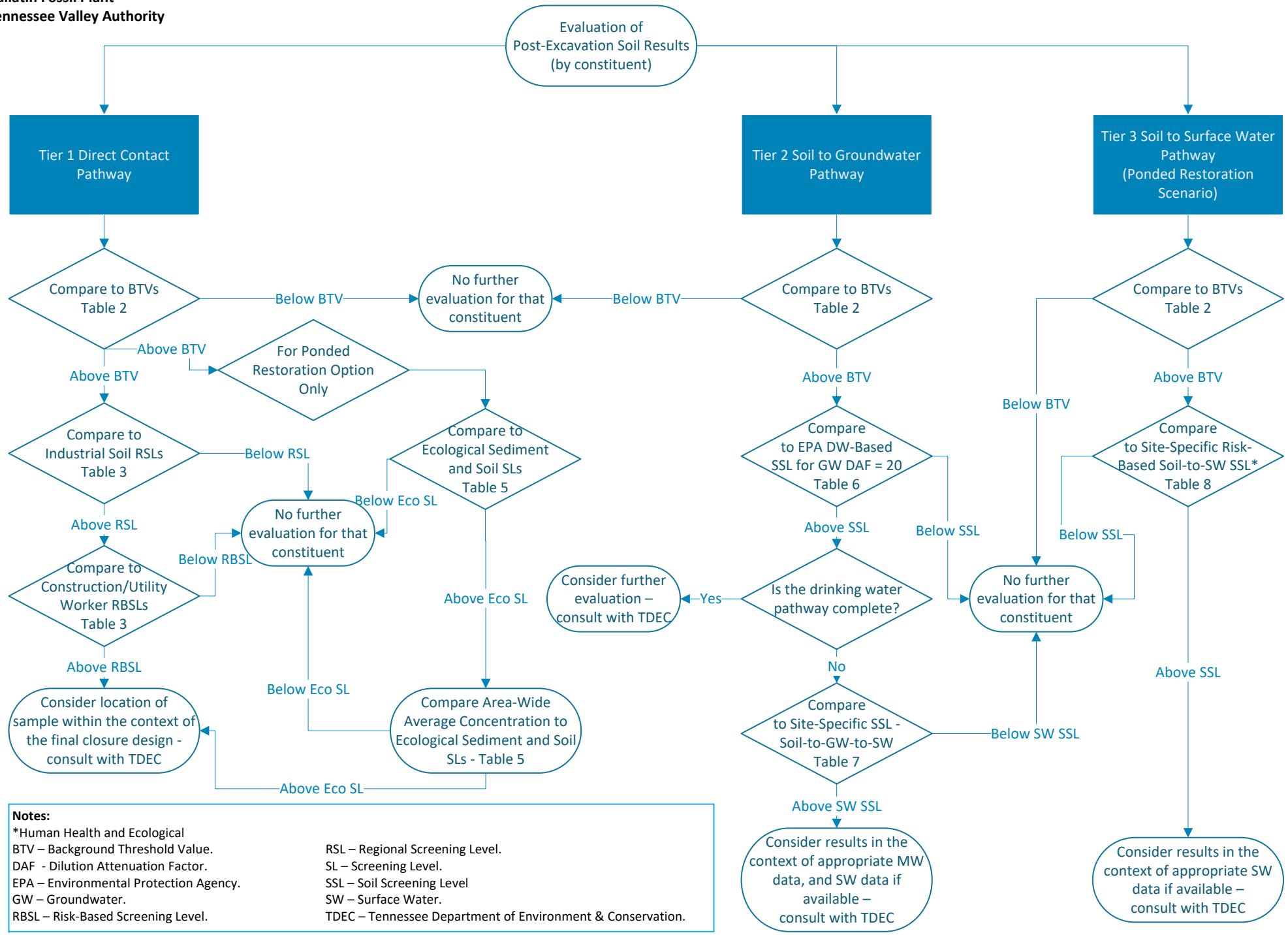
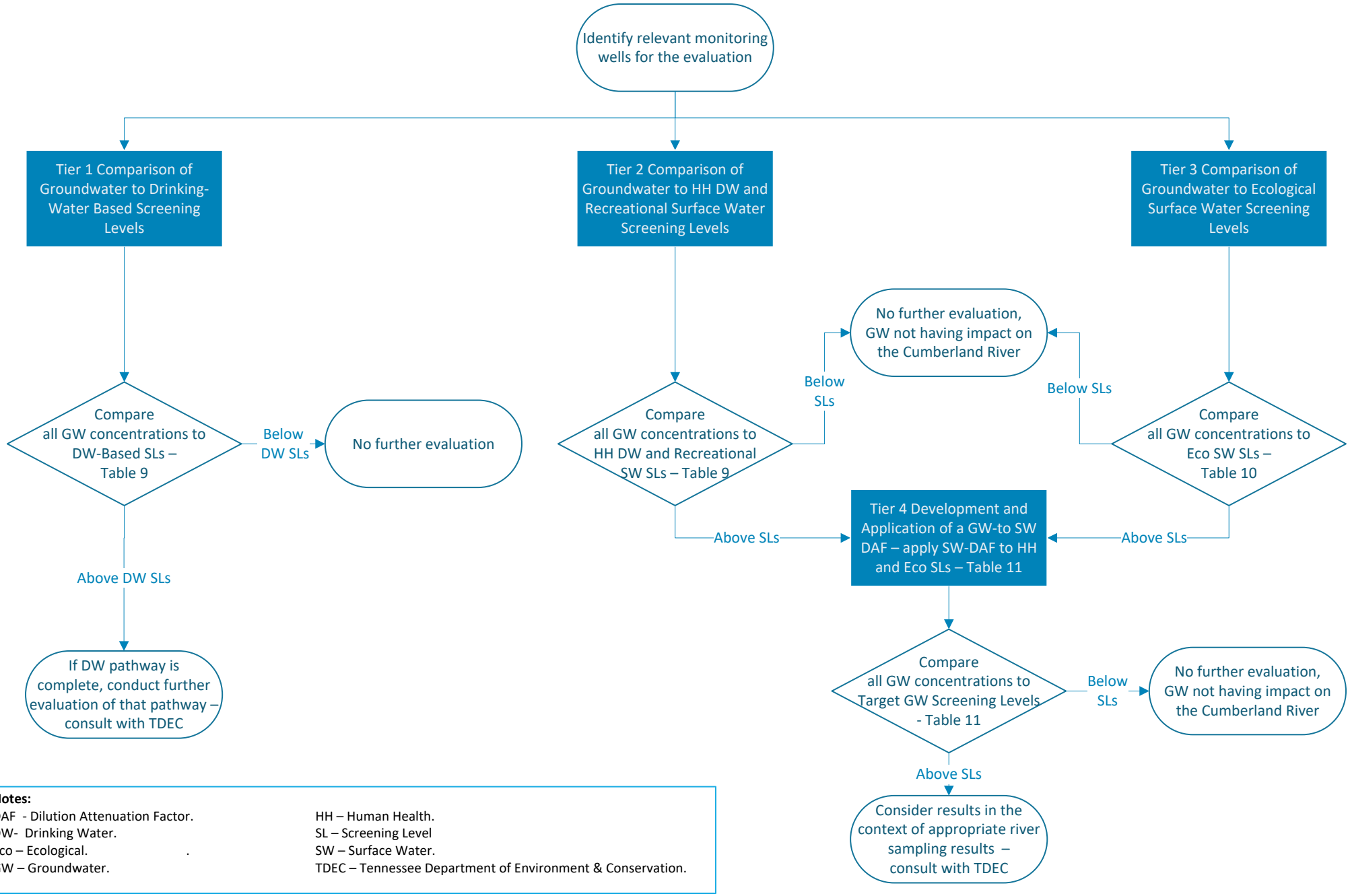


Figure 7
Evaluation of Post-Excavation Groundwater Results Flowchart for Potential Impact on the Cumberland River
Gallatin Fossil Plant
Tennessee Valley Authority



Notes:

DAF - Dilution Attenuation Factor.
DW- Drinking Water.
Eco – Ecological.
GW – Groundwater.
HH – Human Health.
SL – Screening Level
SW – Surface Water.
TDEC – Tennessee Department of Environment & Conservation.

APPENDIX A

USEPA RSL Calculator Output

Site-specific

Construction Worker Equation Inputs for Soil - Other Construction Activities

*** Inputted values different from Construction Worker defaults are highlighted.**

Variable	Construction Worker Soil - Other Default Value	Form-input Value
$A_{c\text{-}doz}$ (areal extent of dozing) acres	0	0.5
A_{excav} (area of excavation site) m^2	0	2023.42821
$A_{c\text{-}grade}$ (areal extent of grading) acres	0	0.5
A (PEF Dispersion Constant)	2.4538	2.4538
A_{surf} (areal extent of site) m^2	2023.43	2023.43
A_{till} (areal extent of tilling) acres	0	0.5
$B_{l\text{-}doz}$ (dozing blade length) m	0	2.44
$B_{l\text{-}grade}$ (grading blade length) m	0	2.44
B (PEF Dispersion Constant)	17.566	17.566
C (PEF Dispersion Constant)	189.0426	189.0426
d_{excav} (average depth of excavation site) m	0	1
F_D Unitless Dispersion Correction Factor	0.185837208	0.187853235
F(x) (function dependant on U_m/U_t derived using Cowherd et al. (1985))	0.194	0.194
$M_{m\text{-}doz}$ (Gravimetric soil moisture content) %	7.9	7.9
$M_{m\text{-}excav}$ (Gravimetric soil moisture content) %	12	12
M_{wind} (dust emitted by wind erosion) g	51288.84717	51288.84717
$N_{A\text{-}doz}$ (number of times site was dozed)	0	2
$N_{A\text{-}dump}$ (number of times soil is dumped)	2	2
$N_{A\text{-}grade}$ (number of times site was graded)	0	2
$N_{A\text{-}till}$ (number of times soil is tilled)	2	2
Q/C_{sa} (inverse of the ratio of the geometric mean air concentration to the emission flux at the center of a square source) g/m^2-s per kg/m^3	14.31407	14.31407
ρ_{soil} (density) g/cm^3 - chemical-specific	1.68	1.68
s_{doz} (soil silt content) %	6.9	6.9
AF_{cw} (skin adherence factor - construction worker) mg/cm^2	0.3	0.3
AT_{cw} (averaging time - construction worker) days	365	84
BW_{cw} (body weight - construction worker) kg	80	80
ED_{cw} (exposure duration - construction worker) yr	1	1
EF_{cw} (exposure frequency - construction worker) day/yr	250	60
ET_{cw} (exposure time - construction worker) hr/day	8	8
THQ (target hazard quotient) unitless	0.1	1
IRS_{cw} (soil ingestion rate - construction worker) mg/day	330	330
LT (lifetime) yr	70	70
SA_{cw} (surface area - construction worker) cm^2/day	3527	3527
TR (target cancer risk) unitless	0.000001	0.000001
S_{doz} (dozing speed) kph	11.4	11.4
S_{grade} (grading speed) kph	11.4	11.4
s_{till} (soil silt content) %	18	18
t_c (overall duration of construction) hours	8400	2016
T_c (overall duration of construction) s	30240000	7257600
T (time over which traffic occurs) s	7200000	1728000
T_t (overall duration of traffic) s	7200000	1728000
U_m (mean annual wind speed) m/s	4.69	4.69
U_t (equivalent threshold value) m/s	11.32	11.32
V (fraction of vegetative cover)	0	0

Output generated 12MAY2020:10:00:42

Site-specific

Construction Worker Regional Screening Levels (RSL) for Soil - Other Construction Activities

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = DWSHA; W = TEF applied; E = RPF applied; G = see user's guide; U = user provid
ca = cancer; nc = noncancer; * = where: nc SL < 100X ca SL; ** = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	CAS Number	Mutagen?	Volatile?	Sfo (mg/kg-day)$^{-1}$	SF_o Ref	IUR (ug/m^3)$^{-1}$	IUR Ref	RfD (mg/kg-day)	RfD Ref	RfC (mg/m^3)	RfC Ref	GIABS	ABS	RBA	Soil Saturation Concentration (mg/kg)	S (mg/L)	K_{oc} (cm^3/g)	K_d (cm^3/g)	HLC (atm-m^3/mole)	Henry's Law Constant Used in Calcs (unitless)	H` and HLC Ref
Antimony (metallic)	7440-36-0	No	No	-		-		4.00E-04	/Subchronic	1.00E-03	/Subchronic	1.50E-01	-	1.00E+00	-	-	-	4.50E+01	-	-	
Arsenic, Inorganic	7440-38-2	No	No	1.50E+00	I	4.30E-03	I	3.00E-04	I /Chronic	1.50E-05	C /Chronic	1.00E+00	3.00E-02	6.00E-01	-	-	-	2.90E+01	-	-	
Barium	7440-39-3	No	No	-		-		2.00E-01	/Subchronic	5.00E-03	/Subchronic	7.00E-02	-	1.00E+00	-	-	-	4.10E+01	-	-	
Beryllium and compounds	7440-41-7	No	No	-		2.40E-03	I	5.00E-03	/Subchronic	2.00E-05	I /Chronic	7.00E-03	-	1.00E+00	-	-	-	7.90E+02	-	-	
Boron And Borates Only	7440-42-8	No	No	-		-		2.00E-01	/Subchronic	2.00E-02	/Subchronic	1.00E+00	-	1.00E+00	-	-	-	3.00E+00	-	-	
Cadmium (Diet)	7440-43-9	No	No	-		1.80E-03	I	5.00E-04	/Subchronic	1.00E-05	A /Chronic	2.50E-02	1.00E-03	1.00E+00	-	-	-	7.50E+01	-	-	
Chromium(III), Insoluble Salts	16065-83-1	No	No	-		-		1.50E+00	/Subchronic	5.00E-03	/Subchronic	1.30E-02	-	1.00E+00	-	-	-	1.80E+06	-	-	
Cobalt	7440-48-4	No	No	-		9.00E-03	P	3.00E-03	/Subchronic	2.00E-05	/Subchronic	1.00E+00	-	1.00E+00	-	-	-	4.50E+01	-	-	
Copper	7440-50-8	No	No	-		-		1.00E-02	/Subchronic	-		1.00E+00	-	1.00E+00	-	-	-	3.50E+01	-	-	
Lithium	7439-93-2	No	No	-		-		2.00E-03	/Subchronic	-		1.00E+00	-	1.00E+00	-	-	-	3.00E+02	-	-	
Mercuric Chloride	7487-94-7	No	No	-		-		2.00E-03	/Subchronic	3.00E-04	G /Chronic	7.00E-02	-	1.00E+00	-	6.90E+04	-	-	-	-	
Molybdenum	7439-98-7	No	No	-		-		5.00E-03	/Subchronic	-		1.00E+00	-	1.00E+00	-	-	-	2.00E+01	-	-	
Nickel Soluble Salts	7440-02-0	No	No	9.10E-01	C	2.60E-04	C	2.00E-02	/Subchronic	2.00E-04	/Subchronic	4.00E-02	-	1.00E+00	-	-	-	6.50E+01	-	-	
Selenium	7782-49-2	No	No	-		-		5.00E-03	/Subchronic	2.00E-02	C /Chronic	1.00E+00	-	1.00E+00	-	-	-	5.00E+00	-	-	
Silver	7440-22-4	No	No	-		-		5.00E-03	/Subchronic	-		4.00E-02	-	1.00E+00	-	-	-	8.30E+00	-	-	
Thallium (Soluble Salts)	7440-28-0	No	No	-		-		4.00E-05	/Subchronic	-		1.00E+00	-	1.00E+00	-	-	-	7.10E+01	-	-	
Vanadium and Compounds	7440-62-2	No	No	-		-		1.00E-02	/Subchronic	1.00E-04	A /Chronic	2.60E-02	-	1.00E+00	-	-	-	1.00E+03	-	-	
Zinc and Compounds	7440-66-6	No	No	-		-		3.00E-01	/Subchronic	-		1.00E+00	-	1.00E+00	-	-	-	6.20E+01	-	-	

Output generated 12MAY2020:10:00:42

Site-specific

Construction Worker Regional Screening Levels (RSL) for Soil - Other Construction Activities

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = DWSHA; W = TEF applied; E = RPF applied; G = see user's guide; U = user provided; ca = cancer; nc = noncancer; * = where: nc SL < 100X ca SL; ** = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	Normal Boiling Point BP (K)	BP Ref	Critical Temperature TC (K)	TC Ref	Chemical Type	D_{ia} (cm^2/s)	D_{iw} (cm^2/s)	D_A (cm^2/s)	Particulate Emission Factor (m^3/kg)	Volatilization Factor (m^3/kg)	Ingestion SL TR=1E-06 (mg/kg)	Dermal SL TR=1E-06 (mg/kg)	Inhalation SL TR=1E-06 (mg/kg)	Carcinogenic SL TR=1E-06 (mg/kg)	Ingestion SL THQ=1 (mg/kg)	Dermal SL THQ=1 (mg/kg)	Inhalation SL THQ=1 (mg/kg)	Noncarcinogenic SL THI=1 (mg/kg)	Screening Level (mg/kg)
Antimony (metallic)	1.91E+03	PHYSPROP	5.07E+03	YAWS	INORGANIC	-	-	-	4.81E+06	-	-	-	-	-	1.36E+02	-	2.02E+04	1.35E+02	1.35E+02 nc
Arsenic, Inorganic	8.88E+02	PHYSPROP	1.67E+03	CRC89	INORGANIC	-	-	-	4.81E+06	-	1.15E+02	7.15E+02	1.43E+03	9.25E+01	1.70E+02	1.06E+03	3.03E+02	9.86E+01	9.25E+01 ca**
Barium	1.87E+03	PHYSPROP	3.57E+03	YAWS	INORGANIC	-	-	-	4.81E+06	-	-	-	-	-	6.79E+04	-	1.01E+05	4.06E+04	4.06E+04 nc
Beryllium and compounds	3.04E+03	PERRY	5.21E+03	CRC89	INORGANIC	-	-	-	4.81E+06	-	-	-	2.56E+03	2.56E+03	1.70E+03	-	4.04E+02	3.26E+02	3.26E+02 nc
Boron And Borates Only	4.27E+03	CRC89	7.93E+03	YAWS	INORGANIC	-	-	-	4.81E+06	-	-	-	-	-	6.79E+04	-	4.04E+05	5.81E+04	5.81E+04 nc
Cadmium (Diet)	1.04E+03	PHYSPROP	2.29E+03	YAWS	INORGANIC	-	-	-	4.81E+06	-	-	-	3.41E+03	3.41E+03	1.70E+02	1.32E+03	2.02E+02	8.62E+01	8.62E+01 nc
Chromium(III), Insoluble Salts	-		-		INORGANIC	-	-	-	4.81E+06	-	-	-	-	-	5.09E+05	-	1.01E+05	8.43E+04	8.43E+04 nc
Cobalt	3.20E+03	CRC89	7.40E+03	YAWS	INORGANIC	-	-	-	4.81E+06	-	-	-	6.82E+02	6.82E+02	1.02E+03	-	4.04E+02	2.89E+02	2.89E+02 nc
Copper	2.87E+03	PHYSPROP	5.12E+03	YAWS	INORGANIC	-	-	-	4.81E+06	-	-	-	-	-	3.39E+03	-	-	3.39E+03	3.39E+03 nc
Lithium	1.61E+03	PERRY	3.22E+03	CRC89	INORGANIC	-	-	-	4.81E+06	-	-	-	-	-	6.79E+02	-	-	6.79E+02	6.79E+02 nc
Mercuric Chloride	5.77E+02	CRC89	9.73E+02	CRC89	INORGANIC	-	-	-	4.81E+06	-	-	-	-	-	6.79E+02	-	6.06E+03	6.10E+02	6.10E+02 nc
Molybdenum	4.91E+03	PHYSPROP	9.62E+03	YAWS	INORGANIC	-	-	-	4.81E+06	-	-	-	-	-	1.70E+03	-	-	1.70E+03	1.70E+03 nc
Nickel Soluble Salts	3.19E+03	CRC89	6.99E+03	YAWS	INORGANIC	-	-	-	4.81E+06	-	1.13E+02	-	2.36E+04	1.13E+02	6.79E+03	-	4.04E+03	2.53E+03	1.13E+02 ca*
Selenium	9.58E+02	PHYSPROP	1.77E+03	CRC89	INORGANIC	-	-	-	4.81E+06	-	-	-	-	-	1.70E+03	-	4.04E+05	1.69E+03	1.69E+03 nc
Silver	2.27E+03	PHYSPROP	6.41E+03	CRC89	INORGANIC	-	-	-	4.81E+06	-	-	-	-	-	1.70E+03	-	-	1.70E+03	1.70E+03 nc
Thallium (Soluble Salts)	1.73E+03	PHYSPROP	4.65E+03	YAWS	INORGANIC	-	-	-	4.81E+06	-	-	-	-	-	1.36E+01	-	-	1.36E+01	1.36E+01 nc
Vanadium and Compounds	3.68E+03	CRC89	1.13E+04	YAWS	INORGANIC	-	-	-	4.81E+06	-	-	-	-	-	3.39E+03	-	2.02E+03	1.27E+03	1.27E+03 nc
Zinc and Compounds	1.18E+03	PHYSPROP	3.17E+03	YAWS	INORGANIC	-	-	-	4.81E+06	-	-	-	-	-	1.02E+05	-	-	1.02E+05	1.02E+05 max

Output generated 12MAY2020:10:00:42

APPENDIX B

ProUCL Output

	A	B	C	D	E	F	G	H	I	J	K	L
1				Background Statistics for Data Sets with Non-Detects								
2			User Selected Options									
3			Date/Time of Computation	ProUCL 5.15/12/2020 3:06:40 PM								
4			From File	2020-0512_HAI-Bkg Soil ProUCL Input_c.xls								
5			Full Precision	OFF								
6			Confidence Coefficient	95%								
7			Coverage	95%								
8			Different or Future K Observations	1								
9			Number of Bootstrap Operations	2000								
10												
88	Antimony											
89												
90						General Statistics						
91						Total Number of Observations	44			Number of Missing Observations		0
92						Number of Distinct Observations	42					
93						Number of Detects	40			Number of Non-Detects		4
94						Number of Distinct Detects	38			Number of Distinct Non-Detects		4
95						Minimum Detect	0.04			Minimum Non-Detect		0.0351
96						Maximum Detect	0.33			Maximum Non-Detect		0.0402
97						Variance Detected	0.00562			Percent Non-Detects		9.091%
98						Mean Detected	0.157			SD Detected		0.075
99						Mean of Detected Logged Data	-1.996			SD of Detected Logged Data		0.579
100												
101						Critical Values for Background Threshold Values (BTVs)						
102						Tolerance Factor K (For UTL)	2.091			d2max (for USL)		2.906
103												
104						Normal GOF Test on Detects Only						
105						Shapiro Wilk Test Statistic	0.955			Shapiro Wilk GOF Test		
106						5% Shapiro Wilk Critical Value	0.94			Detected Data appear Normal at 5% Significance Level		
107						Lilliefors Test Statistic	0.111			Lilliefors GOF Test		
108						5% Lilliefors Critical Value	0.139			Detected Data appear Normal at 5% Significance Level		
109						Detected Data appear Normal at 5% Significance Level						
110												
111						Kaplan Meier (KM) Background Statistics Assuming Normal Distribution						
112						KM Mean	0.145			KM SD		0.0787
113						95% UTL95% Coverage	0.31			95% KM UPL (t)		0.279
114						90% KM Percentile (z)	0.246			95% KM Percentile (z)		0.275
115						99% KM Percentile (z)	0.329			95% KM USL		0.374
116												
117						DL/2 Substitution Background Statistics Assuming Normal Distribution						
118						Mean	0.144			SD		0.0819
119						95% UTL95% Coverage	0.315			95% UPL (t)		0.283
120						90% Percentile (z)	0.249			95% Percentile (z)		0.279
121						99% Percentile (z)	0.335			95% USL		0.382
122						DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons						
123												
124						Gamma GOF Tests on Detected Observations Only						
125						A-D Test Statistic	0.777			Anderson-Darling GOF Test		
126						5% A-D Critical Value	0.753			Data Not Gamma Distributed at 5% Significance Level		

	A	B	C	D	E	F	G	H	I	J	K	L
127					K-S Test Statistic	0.14	Kolmogorov-Smirnov GOF					
128					5% K-S Critical Value	0.14	Data Not Gamma Distributed at 5% Significance Level					
129	Data Not Gamma Distributed at 5% Significance Level											
130												
131	Gamma Statistics on Detected Data Only											
132					k hat (MLE)	3.701				k star (bias corrected MLE)		3.44
133					Theta hat (MLE)	0.0423				Theta star (bias corrected MLE)		0.0455
134					nu hat (MLE)	296.1				nu star (bias corrected)		275.2
135					MLE Mean (bias corrected)	0.157						
136					MLE Sd (bias corrected)	0.0844				95% Percentile of Chisquare (2kstar)		13.89
137												
138	Gamma ROS Statistics using Imputed Non-Detects											
139	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
140	GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)											
141	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
142	This is especially true when the sample size is small.											
143	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
144					Minimum	0.0354				Mean		0.146
145					Maximum	0.33				Median		0.148
146					SD	0.0795				CV		0.546
147					k hat (MLE)	2.813				k star (bias corrected MLE)		2.637
148					Theta hat (MLE)	0.0518				Theta star (bias corrected MLE)		0.0552
149					nu hat (MLE)	247.6				nu star (bias corrected)		232
150					MLE Mean (bias corrected)	0.146				MLE Sd (bias corrected)		0.0897
151					95% Percentile of Chisquare (2kstar)	11.49				90% Percentile		0.266
152					95% Percentile	0.317				99% Percentile		0.43
153	The following statistics are computed using Gamma ROS Statistics on Imputed Data											
154	Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods											
155					WH	HW					WH	HW
156				95% Approx. Gamma UTL with 95% Coverage	0.384	0.402				95% Approx. Gamma UPL	0.322	0.332
157					95% Gamma USL	0.538	0.584					
158												
159	Estimates of Gamma Parameters using KM Estimates											
160					Mean (KM)	0.145				SD (KM)		0.0787
161					Variance (KM)	0.0062				SE of Mean (KM)		0.012
162					k hat (KM)	3.417				k star (KM)		3.199
163					nu hat (KM)	300.7				nu star (KM)		281.5
164					theta hat (KM)	0.0426				theta star (KM)		0.0455
165					80% gamma percentile (KM)	0.206				90% gamma percentile (KM)		0.255
166					95% gamma percentile (KM)	0.3				99% gamma percentile (KM)		0.398
167												
168	The following statistics are computed using gamma distribution and KM estimates											
169	Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods											
170					WH	HW					WH	HW
171				95% Approx. Gamma UTL with 95% Coverage	0.382	0.4				95% Approx. Gamma UPL	0.32	0.33
172				95% KM Gamma Percentile	0.312	0.321				95% Gamma USL	0.533	0.579
173												
174	Lognormal GOF Test on Detected Observations Only											
175					Shapiro Wilk Test Statistic	0.913	Shapiro Wilk GOF Test					

	A	B	C	D	E	F	G	H	I	J	K	L
176					5% Shapiro Wilk Critical Value	0.94		Data Not Lognormal at 5% Significance Level				
177					Lilliefors Test Statistic	0.165		**Lilliefors GOF Test**				
178					5% Lilliefors Critical Value	0.139		Data Not Lognormal at 5% Significance Level				
179					**Data Not Lognormal at 5% Significance Level**							
180												
181					**Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects**							
182					Mean in Original Scale	0.146					Mean in Log Scale	-2.109
183					SD in Original Scale	0.0792					SD in Log Scale	0.66
184					95% UTL95% Coverage	0.483					95% BCA UTL95% Coverage	0.319
185					95% Bootstrap (%) UTL95% Coverage	0.324					95% UPL (t)	0.373
186					90% Percentile (z)	0.283					95% Percentile (z)	0.359
187					99% Percentile (z)	0.564					95% USL	0.827
188												
189					**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
190					KM Mean of Logged Data	-2.118					95% KM UTL (Lognormal)95% Coverage	0.486
191					KM SD of Logged Data	0.668					95% KM UPL (Lognormal)	0.375
192					95% KM Percentile Lognormal (z)	0.361					95% KM USL (Lognormal)	0.839
193												
194					**Background DL/2 Statistics Assuming Lognormal Distribution**							
195					Mean in Original Scale	0.144					Mean in Log Scale	-2.177
196					SD in Original Scale	0.0819					SD in Log Scale	0.801
197					95% UTL95% Coverage	0.605					95% UPL (t)	0.442
198					90% Percentile (z)	0.316					95% Percentile (z)	0.423
199					99% Percentile (z)	0.73					95% USL	1.162
200					**DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.**							
201												
202					**Nonparametric Distribution Free Background Statistics**							
203					**Data appear to follow a Discernible Distribution at 5% Significance Level**							
204												
205					**Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)**							
206					Order of Statistic, r	44					95% UTL with95% Coverage	0.33
207					Approx, f used to compute achieved CC	2.316					Approximate Actual Confidence Coefficient achieved by UTL	0.895
208					Approximate Sample Size needed to achieve specified CC	59					95% UPL	0.281
209					95% USL	0.33					95% KM Chebyshev UPL	0.492
210												
211					Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.							
212					Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers							
213					and consists of observations collected from clean unimpacted locations.							
214					The use of USL tends to provide a balance between false positives and false negatives provided the data							
215					represents a background data set and when many onsite observations need to be compared with the BTV.							
216												
217	**Arsenic**											
218												
219	**General Statistics**											
220					Total Number of Observations	44					Number of Distinct Observations	42
221					Minimum	1.61					First Quartile	3.378
222					Second Largest	12.8					Median	4.95
223					Maximum	13.7					Third Quartile	6.983
224					Mean	5.593					SD	2.818

	A	B	C	D	E	F	G	H	I	J	K	L
225					Coefficient of Variation	0.504					Skewness	1.015
226					Mean of logged Data	1.599					SD of logged Data	0.509
227												
228					**Critical Values for Background Threshold Values (BTVs)**							
229					Tolerance Factor K (For UTL)	2.091					d2max (for USL)	2.906
230												
231					**Normal GOF Test**							
232					Shapiro Wilk Test Statistic	0.924	**Shapiro Wilk GOF Test**					
233					5% Shapiro Wilk Critical Value	0.944	Data Not Normal at 5% Significance Level					
234					Lilliefors Test Statistic	0.14	**Lilliefors GOF Test**					
235					5% Lilliefors Critical Value	0.132	Data Not Normal at 5% Significance Level					
236					**Data Not Normal at 5% Significance Level**							
237												
238					**Background Statistics Assuming Normal Distribution**							
239				95% UTL with	95% Coverage	11.49					90% Percentile (z)	9.205
240					95% UPL (t)	10.38					95% Percentile (z)	10.23
241					95% USL	13.78					99% Percentile (z)	12.15
242												
243					**Gamma GOF Test**							
244					A-D Test Statistic	0.177	**Anderson-Darling Gamma GOF Test**					
245					5% A-D Critical Value	0.753	Detected data appear Gamma Distributed at 5% Significance Level					
246					K-S Test Statistic	0.0752	**Kolmogorov-Smirnov Gamma GOF Test**					
247					5% K-S Critical Value	0.134	Detected data appear Gamma Distributed at 5% Significance Level					
248					**Detected data appear Gamma Distributed at 5% Significance Level**							
249												
250					**Gamma Statistics**							
251					k hat (MLE)	4.254					k star (bias corrected MLE)	3.979
252					Theta hat (MLE)	1.315					Theta star (bias corrected MLE)	1.406
253					nu hat (MLE)	374.4					nu star (bias corrected)	350.2
254					MLE Mean (bias corrected)	5.593					MLE Sd (bias corrected)	2.804
255												
256					**Background Statistics Assuming Gamma Distribution**							
257					95% Wilson Hilferty (WH) Approx. Gamma UPL	10.96					90% Percentile	9.352
258					95% Hawkins Wixley (HW) Approx. Gamma UPL	11.11					95% Percentile	10.86
259					95% WH Approx. Gamma UTL with 95% Coverage	12.73					99% Percentile	14.07
260					95% HW Approx. Gamma UTL with 95% Coverage	13.03						
261					95% WH USL	17					95% HW USL	17.82
262												
263					**Lognormal GOF Test**							
264					Shapiro Wilk Test Statistic	0.981	**Shapiro Wilk Lognormal GOF Test**					
265					5% Shapiro Wilk Critical Value	0.944	Data appear Lognormal at 5% Significance Level					
266					Lilliefors Test Statistic	0.0519	**Lilliefors Lognormal GOF Test**					
267					5% Lilliefors Critical Value	0.132	Data appear Lognormal at 5% Significance Level					
268					**Data appear Lognormal at 5% Significance Level**							
269												
270					**Background Statistics assuming Lognormal Distribution**							
271				95% UTL with	95% Coverage	14.34					90% Percentile (z)	9.5
272					95% UPL (t)	11.75					95% Percentile (z)	11.43
273					95% USL	21.71					99% Percentile (z)	16.16

	A	B	C	D	E	F	G	H	I	J	K	L
274												
275						Nonparametric Distribution Free Background Statistics						
276						Data appear Gamma Distributed at 5% Significance Level						
277												
278						Nonparametric Upper Limits for Background Threshold Values						
279					Order of Statistic, r	44				95% UTL with 95% Coverage		13.7
280					Approx, f used to compute achieved CC	2.316				Approximate Actual Confidence Coefficient achieved by UTL		0.895
281										Approximate Sample Size needed to achieve specified CC		59
282				95% Percentile Bootstrap UTL with 95% Coverage		13.57				95% BCA Bootstrap UTL with 95% Coverage		13.25
283					95% UPL	12.28				90% Percentile		9.235
284					90% Chebyshev UPL	14.14				95% Percentile		10.54
285					95% Chebyshev UPL	18.02				99% Percentile		13.31
286					95% USL	13.7						
287												
288					Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.							
289					Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers							
290					and consists of observations collected from clean unimpacted locations.							
291					The use of USL tends to provide a balance between false positives and false negatives provided the data							
292					represents a background data set and when many onsite observations need to be compared with the BTV.							
293												
294	Barium											
295												
296	General Statistics											
297					Total Number of Observations	44				Number of Distinct Observations		44
298					Minimum	20				First Quartile		48.6
299					Second Largest	230				Median		86.2
300					Maximum	231				Third Quartile		123.3
301					Mean	91.22				SD		55.12
302					Coefficient of Variation	0.604				Skewness		0.808
303					Mean of logged Data	4.314				SD of logged Data		0.671
304												
305						Critical Values for Background Threshold Values (BTVs)						
306					Tolerance Factor K (For UTL)	2.091				d2max (for USL)		2.906
307												
308						Normal GOF Test						
309					Shapiro Wilk Test Statistic	0.921				Shapiro Wilk GOF Test		
310					5% Shapiro Wilk Critical Value	0.944				Data Not Normal at 5% Significance Level		
311					Lilliefors Test Statistic	0.131				Lilliefors GOF Test		
312					5% Lilliefors Critical Value	0.132				Data appear Normal at 5% Significance Level		
313						Data appear Approximate Normal at 5% Significance Level						
314												
315						Background Statistics Assuming Normal Distribution						
316					95% UTL with 95% Coverage	206.5				90% Percentile (z)		161.9
317					95% UPL (t)	184.9				95% Percentile (z)		181.9
318					95% USL	251.4				99% Percentile (z)		219.4
319												
320						Gamma GOF Test						
321					A-D Test Statistic	0.384				Anderson-Darling Gamma GOF Test		
322					5% A-D Critical Value	0.757				Detected data appear Gamma Distributed at 5% Significance Level		

	A	B	C	D	E	F	G	H	I	J	K	L
323					K-S Test Statistic	0.0951	**Kolmogorov-Smirnov Gamma GOF Test**					
324					5% K-S Critical Value	0.135	Detected data appear Gamma Distributed at 5% Significance Level					
325	**Detected data appear Gamma Distributed at 5% Significance Level**											
326												
327	**Gamma Statistics**											
328					k hat (MLE)	2.67					k star (bias corrected MLE)	2.503
329					Theta hat (MLE)	34.16					Theta star (bias corrected MLE)	36.44
330					nu hat (MLE)	235					nu star (bias corrected)	220.3
331					MLE Mean (bias corrected)	91.22					MLE Sd (bias corrected)	57.65
332												
333	**Background Statistics Assuming Gamma Distribution**											
334				95% Wilson Hilferty (WH) Approx. Gamma UPL		204.6					90% Percentile	168.5
335				95% Hawkins Wixley (HW) Approx. Gamma UPL		209.9					95% Percentile	201.9
336				95% WH Approx. Gamma UTL with	95% Coverage	244.8					99% Percentile	275.1
337				95% HW Approx. Gamma UTL with	95% Coverage	255						
338					95% WH USL	344.9					95% HW USL	372.2
339												
340	**Lognormal GOF Test**											
341					Shapiro Wilk Test Statistic	0.946	**Shapiro Wilk Lognormal GOF Test**					
342					5% Shapiro Wilk Critical Value	0.944	Data appear Lognormal at 5% Significance Level					
343					Lilliefors Test Statistic	0.101	**Lilliefors Lognormal GOF Test**					
344					5% Lilliefors Critical Value	0.132	Data appear Lognormal at 5% Significance Level					
345	**Data appear Lognormal at 5% Significance Level**											
346												
347	**Background Statistics assuming Lognormal Distribution**											
348				95% UTL with	95% Coverage	304.4					90% Percentile (z)	176.8
349					95% UPL (t)	234.1					95% Percentile (z)	225.6
350					95% USL	526.2					99% Percentile (z)	356.5
351												
352	**Nonparametric Distribution Free Background Statistics**											
353	**Data appear Approximate Normal at 5% Significance Level**											
354												
355	**Nonparametric Upper Limits for Background Threshold Values**											
356					Order of Statistic, r	44					95% UTL with 95% Coverage	231
357					Approx, f used to compute achieved CC	2.316	Approximate Actual Confidence Coefficient achieved by UTL					0.895
358											Approximate Sample Size needed to achieve specified CC	59
359				95% Percentile Bootstrap UTL with	95% Coverage	230.9					95% BCA Bootstrap UTL with 95% Coverage	230
360					95% UPL	222					90% Percentile	151.2
361					90% Chebyshev UPL	258.4					95% Percentile	196.1
362					95% Chebyshev UPL	334.2					99% Percentile	230.6
363					95% USL	231						
364												
365	Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.											
366	Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers											
367	and consists of observations collected from clean unimpacted locations.											
368	The use of USL tends to provide a balance between false positives and false negatives provided the data											
369	represents a background data set and when many onsite observations need to be compared with the BTV.											
370												
371	**Beryllium**											

	A	B	C	D	E	F	G	H	I	J	K	L
372												
373	General Statistics											
374					Total Number of Observations	44				Number of Distinct Observations		41
375					Minimum	0.235				First Quartile		0.644
376					Second Largest	2.15				Median		0.97
377					Maximum	2.86				Third Quartile		1.468
378					Mean	1.085				SD		0.587
379					Coefficient of Variation	0.541				Skewness		0.801
380					Mean of logged Data	-0.0771				SD of logged Data		0.599
381												
382					Critical Values for Background Threshold Values (BTVs)							
383					Tolerance Factor K (For UTL)	2.091				d2max (for USL)		2.906
384												
385					Normal GOF Test							
386					Shapiro Wilk Test Statistic	0.941				Shapiro Wilk GOF Test		
387					5% Shapiro Wilk Critical Value	0.944				Data Not Normal at 5% Significance Level		
388					Lilliefors Test Statistic	0.125				Lilliefors GOF Test		
389					5% Lilliefors Critical Value	0.132				Data appear Normal at 5% Significance Level		
390					Data appear Approximate Normal at 5% Significance Level							
391												
392					Background Statistics Assuming Normal Distribution							
393				95% UTL with	95% Coverage	2.313				90% Percentile (z)		1.837
394					95% UPL (t)	2.083				95% Percentile (z)		2.051
395					95% USL	2.792				99% Percentile (z)		2.451
396												
397					Gamma GOF Test							
398					A-D Test Statistic	0.321				Anderson-Darling Gamma GOF Test		
399					5% A-D Critical Value	0.755				Detected data appear Gamma Distributed at 5% Significance Level		
400					K-S Test Statistic	0.102				Kolmogorov-Smirnov Gamma GOF Test		
401					5% K-S Critical Value	0.134				Detected data appear Gamma Distributed at 5% Significance Level		
402					Detected data appear Gamma Distributed at 5% Significance Level							
403												
404					Gamma Statistics							
405					k hat (MLE)	3.315				k star (bias corrected MLE)		3.104
406					Theta hat (MLE)	0.327				Theta star (bias corrected MLE)		0.349
407					nu hat (MLE)	291.7				nu star (bias corrected)		273.2
408					MLE Mean (bias corrected)	1.085				MLE Sd (bias corrected)		0.616
409												
410					Background Statistics Assuming Gamma Distribution							
411					95% Wilson Hilferty (WH) Approx. Gamma UPL	2.281				90% Percentile		1.91
412					95% Hawkins Wixley (HW) Approx. Gamma UPL	2.333				95% Percentile		2.254
413					95% WH Approx. Gamma UTL with 95% Coverage	2.69				99% Percentile		2.998
414					95% HW Approx. Gamma UTL with 95% Coverage	2.787						
415					95% WH USL	3.694				95% HW USL		3.945
416												
417					Lognormal GOF Test							
418					Shapiro Wilk Test Statistic	0.959				Shapiro Wilk Lognormal GOF Test		
419					5% Shapiro Wilk Critical Value	0.944				Data appear Lognormal at 5% Significance Level		
420					Lilliefors Test Statistic	0.111				Lilliefors Lognormal GOF Test		

	A	B	C	D	E	F	G	H	I	J	K	L
421					5% Lilliefors Critical Value	0.132	Data appear Lognormal at 5% Significance Level					
422	**Data appear Lognormal at 5% Significance Level**											
423												
424	**Background Statistics assuming Lognormal Distribution**											
425				95% UTL with	95% Coverage	3.24				90% Percentile (z)		1.995
426					95% UPL (t)	2.563				95% Percentile (z)		2.48
427					95% USL	5.279				99% Percentile (z)		3.73
428												
429	**Nonparametric Distribution Free Background Statistics**											
430	**Data appear Approximate Normal at 5% Significance Level**											
431												
432	**Nonparametric Upper Limits for Background Threshold Values**											
433					Order of Statistic, r	44				95% UTL with	95% Coverage	2.86
434					Approx, f used to compute achieved CC	2.316	Approximate Actual Confidence Coefficient achieved by UTL					0.895
435							Approximate Sample Size needed to achieve specified CC					59
436				95% Percentile Bootstrap UTL with	95% Coverage	2.754				95% BCA Bootstrap UTL with	95% Coverage	2.15
437					95% UPL	2.145				90% Percentile		1.821
438					90% Chebyshev UPL	2.866				95% Percentile		2.13
439					95% Chebyshev UPL	3.674				99% Percentile		2.555
440					95% USL	2.86						
441												
442	Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.											
443	Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers											
444	and consists of observations collected from clean unimpacted locations.											
445	The use of USL tends to provide a balance between false positives and false negatives provided the data											
446	represents a background data set and when many onsite observations need to be compared with the BTV.											
447												
448	**Boron**											
449												
450	**General Statistics**											
451					Total Number of Observations	44				Number of Missing Observations		0
452					Number of Distinct Observations	39						
453					Number of Detects	29				Number of Non-Detects		15
454					Number of Distinct Detects	28				Number of Distinct Non-Detects		12
455					Minimum Detect	1.55				Minimum Non-Detect		1.28
456					Maximum Detect	10.7				Maximum Non-Detect		1.65
457					Variance Detected	5.543				Percent Non-Detects		34.09%
458					Mean Detected	4.107				SD Detected		2.354
459					Mean of Detected Logged Data	1.262				SD of Detected Logged Data		0.556
460												
461	**Critical Values for Background Threshold Values (BTVs)**											
462					Tolerance Factor K (For UTL)	2.091				d2max (for USL)		2.906
463												
464	**Normal GOF Test on Detects Only**											
465					Shapiro Wilk Test Statistic	0.891	**Shapiro Wilk GOF Test**					
466					5% Shapiro Wilk Critical Value	0.926	Data Not Normal at 5% Significance Level					
467					Lilliefors Test Statistic	0.153	**Lilliefors GOF Test**					
468					5% Lilliefors Critical Value	0.161	Detected Data appear Normal at 5% Significance Level					
469	**Detected Data appear Approximate Normal at 5% Significance Level**											

	A	B	C	D	E	F	G	H	I	J	K	L
470												
471	**Kaplan Meier (KM) Background Statistics Assuming Normal Distribution**											
472					KM Mean	3.148					KM SD	2.304
473					95% UTL95% Coverage	7.965					95% KM UPL (t)	7.064
474					90% KM Percentile (z)	6.1					95% KM Percentile (z)	6.937
475					99% KM Percentile (z)	8.507					95% KM USL	9.843
476												
477	**DL/2 Substitution Background Statistics Assuming Normal Distribution**											
478					Mean	2.96					SD	2.493
479					95% UTL95% Coverage	8.172					95% UPL (t)	7.198
480					90% Percentile (z)	6.154					95% Percentile (z)	7.06
481					99% Percentile (z)	8.759					95% USL	10.2
482	**DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons**											
483												
484	**Gamma GOF Tests on Detected Observations Only**											
485					A-D Test Statistic	0.518	**Anderson-Darling GOF Test**					
486					5% A-D Critical Value	0.752	Detected data appear Gamma Distributed at 5% Significance Level					
487					K-S Test Statistic	0.128	**Kolmogorov-Smirnov GOF**					
488					5% K-S Critical Value	0.164	Detected data appear Gamma Distributed at 5% Significance Level					
489	**Detected data appear Gamma Distributed at 5% Significance Level**											
490												
491	**Gamma Statistics on Detected Data Only**											
492					k hat (MLE)	3.487					k star (bias corrected MLE)	3.149
493					Theta hat (MLE)	1.178					Theta star (bias corrected MLE)	1.304
494					nu hat (MLE)	202.3					nu star (bias corrected)	182.7
495					MLE Mean (bias corrected)	4.107						
496					MLE Sd (bias corrected)	2.314					95% Percentile of Chisquare (2kstar)	13.04
497												
498	**Gamma ROS Statistics using Imputed Non-Detects**											
499	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
500	GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)											
501	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
502	This is especially true when the sample size is small.											
503	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
504					Minimum	0.01					Mean	2.737
505					Maximum	10.7					Median	2.135
506					SD	2.707					CV	0.989
507					k hat (MLE)	0.488					k star (bias corrected MLE)	0.47
508					Theta hat (MLE)	5.607					Theta star (bias corrected MLE)	5.823
509					nu hat (MLE)	42.95					nu star (bias corrected)	41.36
510					MLE Mean (bias corrected)	2.737					MLE Sd (bias corrected)	3.992
511					95% Percentile of Chisquare (2kstar)	3.691					90% Percentile	7.498
512					95% Percentile	10.75					99% Percentile	18.78
513	**The following statistics are computed using Gamma ROS Statistics on Imputed Data**											
514	**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**											
515					WH	HW					WH	HW
516				95% Approx. Gamma UTL with 95% Coverage	14.62	18.38				95% Approx. Gamma UPL	10.69	12.59
517				95% Gamma USL	25.71	36.65						
518												

	A	B	C	D	E	F	G	H	I	J	K	L
519	**Estimates of Gamma Parameters using KM Estimates**											
520					Mean (KM)	3.148					SD (KM)	2.304
521					Variance (KM)	5.307					SE of Mean (KM)	0.353
522					k hat (KM)	1.867					k star (KM)	1.755
523					nu hat (KM)	164.3					nu star (KM)	154.4
524					theta hat (KM)	1.686					theta star (KM)	1.794
525					80% gamma percentile (KM)	4.785					90% gamma percentile (KM)	6.315
526					95% gamma percentile (KM)	7.786					99% gamma percentile (KM)	11.07
527												
528	**The following statistics are computed using gamma distribution and KM estimates**											
529	**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**											
530					WH	HW					WH	HW
531				95% Approx. Gamma UTL with 95% Coverage	8.723	8.921				95% Approx. Gamma UPL	7.233	7.298
532				95% KM Gamma Percentile	7.038	7.088				95% Gamma USL	12.46	13.16
533												
534	**Lognormal GOF Test on Detected Observations Only**											
535					Shapiro Wilk Test Statistic	0.951	**Shapiro Wilk GOF Test**					
536					5% Shapiro Wilk Critical Value	0.926	Detected Data appear Lognormal at 5% Significance Level					
537					Lilliefors Test Statistic	0.108	**Lilliefors GOF Test**					
538					5% Lilliefors Critical Value	0.161	Detected Data appear Lognormal at 5% Significance Level					
539	**Detected Data appear Lognormal at 5% Significance Level**											
540												
541	**Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects**											
542					Mean in Original Scale	3.04					Mean in Log Scale	0.821
543					SD in Original Scale	2.422					SD in Log Scale	0.77
544					95% UTL95% Coverage	11.37					95% BCA UTL95% Coverage	10.23
545					95% Bootstrap (%) UTL95% Coverage	10.34					95% UPL (t)	8.417
546					90% Percentile (z)	6.098					95% Percentile (z)	8.067
547					99% Percentile (z)	13.63					95% USL	21.31
548												
549	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
550					KM Mean of Logged Data	0.919					95% KM UTL (Lognormal)95% Coverage	9.8
551					KM SD of Logged Data	0.652					95% KM UPL (Lognormal)	7.595
552					95% KM Percentile Lognormal (z)	7.327					95% KM USL (Lognormal)	16.67
553												
554	**Background DL/2 Statistics Assuming Lognormal Distribution**											
555					Mean in Original Scale	2.96					Mean in Log Scale	0.73
556					SD in Original Scale	2.493					SD in Log Scale	0.875
557					95% UTL95% Coverage	12.91					95% UPL (t)	9.175
558					90% Percentile (z)	6.362					95% Percentile (z)	8.742
559					99% Percentile (z)	15.87					95% USL	26.35
560	**DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.**											
561												
562	**Nonparametric Distribution Free Background Statistics**											
563	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
564												
565	**Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)**											
566					Order of Statistic, r	44					95% UTL with95% Coverage	10.7
567					Approx, f used to compute achieved CC	2.316	Approximate Actual Confidence Coefficient achieved by UTL					0.895

	A	B	C	D	E	F	G	H	I	J	K	L
568	Approximate Sample Size needed to achieve specified CC					59					95% UPL	8.095
569					95% USL	10.7					95% KM Chebyshev UPL	13.3
570												
571	Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.											
572	Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers											
573	and consists of observations collected from clean unimpacted locations.											
574	The use of USL tends to provide a balance between false positives and false negatives provided the data											
575	represents a background data set and when many onsite observations need to be compared with the BTV.											
576												
577	**Cadmium**											
578												
579	**General Statistics**											
580					Total Number of Observations	44					Number of Missing Observations	0
581					Number of Distinct Observations	40						
582					Number of Detects	37					Number of Non-Detects	7
583					Number of Distinct Detects	35					Number of Distinct Non-Detects	6
584					Minimum Detect	0.013					Minimum Non-Detect	0.0117
585					Maximum Detect	0.587					Maximum Non-Detect	0.0594
586					Variance Detected	0.0158					Percent Non-Detects	15.91%
587					Mean Detected	0.114					SD Detected	0.126
588					Mean of Detected Logged Data	-2.582					SD of Detected Logged Data	0.888
589												
590	**Critical Values for Background Threshold Values (BTVs)**											
591					Tolerance Factor K (For UTL)	2.091					d2max (for USL)	2.906
592												
593	**Normal GOF Test on Detects Only**											
594					Shapiro Wilk Test Statistic	0.68					**Shapiro Wilk GOF Test**	
595					5% Shapiro Wilk Critical Value	0.936					Data Not Normal at 5% Significance Level	
596					Lilliefors Test Statistic	0.321					**Lilliefors GOF Test**	
597					5% Lilliefors Critical Value	0.144					Data Not Normal at 5% Significance Level	
598	**Data Not Normal at 5% Significance Level**											
599												
600	**Kaplan Meier (KM) Background Statistics Assuming Normal Distribution**											
601					KM Mean	0.0993					KM SD	0.119
602					95% UTL95% Coverage	0.347					95% KM UPL (t)	0.301
603					90% KM Percentile (z)	0.251					95% KM Percentile (z)	0.294
604					99% KM Percentile (z)	0.375					95% KM USL	0.444
605												
606	**DL/2 Substitution Background Statistics Assuming Normal Distribution**											
607					Mean	0.0987					SD	0.12
608					95% UTL95% Coverage	0.35					95% UPL (t)	0.303
609					90% Percentile (z)	0.253					95% Percentile (z)	0.297
610					99% Percentile (z)	0.379					95% USL	0.449
611	**DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons**											
612												
613	**Gamma GOF Tests on Detected Observations Only**											
614					A-D Test Statistic	1.627					**Anderson-Darling GOF Test**	
615					5% A-D Critical Value	0.769					Data Not Gamma Distributed at 5% Significance Level	
616					K-S Test Statistic	0.228					**Kolmogorov-Smirnov GOF**	

	A	B	C	D	E	F	G	H	I	J	K	L
617				5% K-S Critical Value		0.148	Data Not Gamma Distributed at 5% Significance Level					
618	**Data Not Gamma Distributed at 5% Significance Level**											
619												
620	**Gamma Statistics on Detected Data Only**											
621				k hat (MLE)		1.36				k star (bias corrected MLE)		1.268
622				Theta hat (MLE)		0.0839				Theta star (bias corrected MLE)		0.09
623				nu hat (MLE)		100.6				nu star (bias corrected)		93.8
624				MLE Mean (bias corrected)		0.114						
625				MLE Sd (bias corrected)		0.101				95% Percentile of Chisquare (2kstar)		6.992
626												
627	**Gamma ROS Statistics using Imputed Non-Detects**											
628	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
629	GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)											
630	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
631	This is especially true when the sample size is small.											
632	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
633				Minimum		0.01				Mean		0.0975
634				Maximum		0.587				Median		0.0762
635				SD		0.121				CV		1.242
636				k hat (MLE)		1.002				k star (bias corrected MLE)		0.949
637				Theta hat (MLE)		0.0973				Theta star (bias corrected MLE)		0.103
638				nu hat (MLE)		88.19				nu star (bias corrected)		83.51
639				MLE Mean (bias corrected)		0.0975				MLE Sd (bias corrected)		0.1
640				95% Percentile of Chisquare (2kstar)		5.792				90% Percentile		0.227
641				95% Percentile		0.298				99% Percentile		0.461
642	**The following statistics are computed using Gamma ROS Statistics on Imputed Data**											
643	**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**											
644					WH	HW					WH	HW
645				95% Approx. Gamma UTL with 95% Coverage	0.38	0.401				95% Approx. Gamma UPL	0.294	0.301
646				95% Gamma USL	0.611	0.686						
647												
648	**Estimates of Gamma Parameters using KM Estimates**											
649				Mean (KM)		0.0993				SD (KM)		0.119
650				Variance (KM)		0.0141				SE of Mean (KM)		0.0181
651				k hat (KM)		0.7				k star (KM)		0.667
652				nu hat (KM)		61.59				nu star (KM)		58.72
653				theta hat (KM)		0.142				theta star (KM)		0.149
654				80% gamma percentile (KM)		0.163				90% gamma percentile (KM)		0.252
655				95% gamma percentile (KM)		0.344				99% gamma percentile (KM)		0.564
656												
657	**The following statistics are computed using gamma distribution and KM estimates**											
658	**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**											
659					WH	HW					WH	HW
660				95% Approx. Gamma UTL with 95% Coverage	0.358	0.371				95% Approx. Gamma UPL	0.281	0.284
661				95% KM Gamma Percentile	0.271	0.273				95% Gamma USL	0.563	0.613
662												
663	**Lognormal GOF Test on Detected Observations Only**											
664				Shapiro Wilk Test Statistic		0.952	**Shapiro Wilk GOF Test**					
665				5% Shapiro Wilk Critical Value		0.936	Detected Data appear Lognormal at 5% Significance Level					

	A	B	C	D	E	F	G	H	I	J	K	L
666					Lilliefors Test Statistic	0.161	**Lilliefors GOF Test**					
667					5% Lilliefors Critical Value	0.144	Data Not Lognormal at 5% Significance Level					
668	**Detected Data appear Approximate Lognormal at 5% Significance Level**											
669												
670	**Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects**											
671					Mean in Original Scale	0.0991					Mean in Log Scale	-2.808
672					SD in Original Scale	0.12					SD in Log Scale	0.983
673					95% UTL95% Coverage	0.472					95% BCA UTL95% Coverage	0.557
674					95% Bootstrap (%) UTL95% Coverage	0.562					95% UPL (t)	0.321
675					90% Percentile (z)	0.213					95% Percentile (z)	0.304
676					99% Percentile (z)	0.595					95% USL	1.052
677												
678	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
679					KM Mean of Logged Data	-2.8					95% KM UTL (Lognormal)95% Coverage	0.454
680					KM SD of Logged Data	0.961					95% KM UPL (Lognormal)	0.312
681					95% KM Percentile Lognormal (z)	0.296					95% KM USL (Lognormal)	0.994
682												
683	**Background DL/2 Statistics Assuming Lognormal Distribution**											
684					Mean in Original Scale	0.0987					Mean in Log Scale	-2.832
685					SD in Original Scale	0.12					SD in Log Scale	1.018
686					95% UTL95% Coverage	0.495					95% UPL (t)	0.332
687					90% Percentile (z)	0.217					95% Percentile (z)	0.314
688					99% Percentile (z)	0.629					95% USL	1.135
689	**DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.**											
690												
691	**Nonparametric Distribution Free Background Statistics**											
692	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
693												
694	**Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)**											
695					Order of Statistic, r	44					95% UTL with95% Coverage	0.587
696					Approx, f used to compute achieved CC	2.316					Approximate Actual Confidence Coefficient achieved by UTL	0.895
697					Approximate Sample Size needed to achieve specified CC	59					95% UPL	0.412
698					95% USL	0.587					95% KM Chebyshev UPL	0.622
699												
700	Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.											
701	Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers											
702	and consists of observations collected from clean unimpacted locations.											
703	The use of USL tends to provide a balance between false positives and false negatives provided the data											
704	represents a background data set and when many onsite observations need to be compared with the BTV.											
705												
706	**Calcium**											
707												
708	**General Statistics**											
709					Total Number of Observations	44					Number of Distinct Observations	44
710					Minimum	164					First Quartile	809.8
711					Second Largest	105000					Median	5005
712					Maximum	137000					Third Quartile	17925
713					Mean	17943					SD	30725
714					Coefficient of Variation	1.712					Skewness	2.536

	A	B	C	D	E	F	G	H	I	J	K	L
715					Mean of logged Data	8.423					SD of logged Data	1.853
716												
717					Critical Values for Background Threshold Values (BTVs)							
718					Tolerance Factor K (For UTL)	2.091					d2max (for USL)	2.906
719												
720					Normal GOF Test							
721					Shapiro Wilk Test Statistic	0.616	Shapiro Wilk GOF Test					
722					5% Shapiro Wilk Critical Value	0.944	Data Not Normal at 5% Significance Level					
723					Lilliefors Test Statistic	0.281	Lilliefors GOF Test					
724					5% Lilliefors Critical Value	0.132	Data Not Normal at 5% Significance Level					
725					Data Not Normal at 5% Significance Level							
726												
727					Background Statistics Assuming Normal Distribution							
728				95% UTL with	95% Coverage	82188					90% Percentile (z)	57318
729					95% UPL (t)	70177					95% Percentile (z)	68480
730					95% USL	107238					99% Percentile (z)	89419
731												
732					Gamma GOF Test							
733					A-D Test Statistic	1.065	Anderson-Darling Gamma GOF Test					
734					5% A-D Critical Value	0.821	Data Not Gamma Distributed at 5% Significance Level					
735					K-S Test Statistic	0.126	Kolmogorov-Smirnov Gamma GOF Test					
736					5% K-S Critical Value	0.142	Detected data appear Gamma Distributed at 5% Significance Level					
737					Detected data follow Appr. Gamma Distribution at 5% Significance Level							
738												
739					Gamma Statistics							
740					k hat (MLE)	0.468					k star (bias corrected MLE)	0.451
741					Theta hat (MLE)	38342					Theta star (bias corrected MLE)	39766
742					nu hat (MLE)	41.18					nu star (bias corrected)	39.71
743					MLE Mean (bias corrected)	17943					MLE Sd (bias corrected)	26711
744												
745					Background Statistics Assuming Gamma Distribution							
746					95% Wilson Hilferty (WH) Approx. Gamma UPL	66019					90% Percentile	49558
747					95% Hawkins Wixley (HW) Approx. Gamma UPL	69145					95% Percentile	71480
748					95% WH Approx. Gamma UTL with 95% Coverage	91995					99% Percentile	125932
749					95% HW Approx. Gamma UTL with 95% Coverage	101534						
750					95% WH USL	166373					95% HW USL	204292
751												
752					Lognormal GOF Test							
753					Shapiro Wilk Test Statistic	0.949	Shapiro Wilk Lognormal GOF Test					
754					5% Shapiro Wilk Critical Value	0.944	Data appear Lognormal at 5% Significance Level					
755					Lilliefors Test Statistic	0.13	Lilliefors Lognormal GOF Test					
756					5% Lilliefors Critical Value	0.132	Data appear Lognormal at 5% Significance Level					
757					Data appear Lognormal at 5% Significance Level							
758												
759					Background Statistics assuming Lognormal Distribution							
760					95% UTL with 95% Coverage	219456					90% Percentile (z)	48957
761					95% UPL (t)	106337					95% Percentile (z)	95994
762					95% USL	994485					99% Percentile (z)	339461
763												

	A	B	C	D	E	F	G	H	I	J	K	L
764	Nonparametric Distribution Free Background Statistics											
765	Data appear Approximate Gamma Distribution at 5% Significance Level											
766												
767	Nonparametric Upper Limits for Background Threshold Values											
768					Order of Statistic, r	44			95% UTL with	95% Coverage		137000
769					Approx, f used to compute achieved CC	2.316	Approximate Actual Confidence Coefficient achieved by UTL					0.895
770							Approximate Sample Size needed to achieve specified CC					59
771				95% Percentile Bootstrap UTL with	95% Coverage	130235			95% BCA Bootstrap UTL with	95% Coverage		130235
772					95% UPL	101725				90% Percentile		48300
773					90% Chebyshev UPL	111158				95% Percentile		91000
774					95% Chebyshev UPL	153382				99% Percentile		123240
775					95% USL	137000						
776												
777	Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.											
778	Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers											
779	and consists of observations collected from clean unimpacted locations.											
780	The use of USL tends to provide a balance between false positives and false negatives provided the data											
781	represents a background data set and when many onsite observations need to be compared with the BTV.											
782												
783	Chromium											
784												
785	General Statistics											
786					Total Number of Observations	44			Number of Distinct Observations			38
787					Minimum	6.4			First Quartile			10.45
788					Second Largest	22			Median			12.1
789					Maximum	31.2			Third Quartile			15.7
790					Mean	13.18			SD			4.872
791					Coefficient of Variation	0.37			Skewness			1.227
792					Mean of logged Data	2.516			SD of logged Data			0.357
793												
794	Critical Values for Background Threshold Values (BTVs)											
795					Tolerance Factor K (For UTL)	2.091			d2max (for USL)			2.906
796												
797	Normal GOF Test											
798					Shapiro Wilk Test Statistic	0.922	Shapiro Wilk GOF Test					
799					5% Shapiro Wilk Critical Value	0.944	Data Not Normal at 5% Significance Level					
800					Lilliefors Test Statistic	0.102	Lilliefors GOF Test					
801					5% Lilliefors Critical Value	0.132	Data appear Normal at 5% Significance Level					
802	Data appear Approximate Normal at 5% Significance Level											
803												
804	Background Statistics Assuming Normal Distribution											
805					95% UTL with 95% Coverage	23.36			90% Percentile (z)			19.42
806					95% UPL (t)	21.46			95% Percentile (z)			21.19
807					95% USL	27.33			99% Percentile (z)			24.51
808												
809	Gamma GOF Test											
810					A-D Test Statistic	0.278	Anderson-Darling Gamma GOF Test					
811					5% A-D Critical Value	0.75	Detected data appear Gamma Distributed at 5% Significance Level					
812					K-S Test Statistic	0.0841	Kolmogorov-Smirnov Gamma GOF Test					

	A	B	C	D	E	F	G	H	I	J	K	L
813					5% K-S Critical Value	0.133	Detected data appear Gamma Distributed at 5% Significance Level					
814	**Detected data appear Gamma Distributed at 5% Significance Level**											
815												
816	**Gamma Statistics**											
817					k hat (MLE)	8.18				k star (bias corrected MLE)		7.637
818					Theta hat (MLE)	1.611				Theta star (bias corrected MLE)		1.725
819					nu hat (MLE)	719.8				nu star (bias corrected)		672.1
820					MLE Mean (bias corrected)	13.18				MLE Sd (bias corrected)		4.768
821												
822	**Background Statistics Assuming Gamma Distribution**											
823				95% Wilson Hilferty (WH) Approx. Gamma UPL		22.01				90% Percentile		19.53
824				95% Hawkins Wixley (HW) Approx. Gamma UPL		22.15				95% Percentile		21.87
825				95% WH Approx. Gamma UTL with	95% Coverage	24.68				99% Percentile		26.71
826				95% HW Approx. Gamma UTL with	95% Coverage	24.97						
827					95% WH USL	30.91				95% HW USL		31.69
828												
829	**Lognormal GOF Test**											
830					Shapiro Wilk Test Statistic	0.974	**Shapiro Wilk Lognormal GOF Test**					
831					5% Shapiro Wilk Critical Value	0.944	Data appear Lognormal at 5% Significance Level					
832					Lilliefors Test Statistic	0.0985	**Lilliefors Lognormal GOF Test**					
833					5% Lilliefors Critical Value	0.132	Data appear Lognormal at 5% Significance Level					
834	**Data appear Lognormal at 5% Significance Level**											
835												
836	**Background Statistics assuming Lognormal Distribution**											
837				95% UTL with	95% Coverage	26.09				90% Percentile (z)		19.55
838					95% UPL (t)	22.7				95% Percentile (z)		22.25
839					95% USL	34.89				99% Percentile (z)		28.37
840												
841	**Nonparametric Distribution Free Background Statistics**											
842	**Data appear Approximate Normal at 5% Significance Level**											
843												
844	**Nonparametric Upper Limits for Background Threshold Values**											
845					Order of Statistic, r	44				95% UTL with	95% Coverage	31.2
846					Approx, f used to compute achieved CC	2.316	Approximate Actual Confidence Coefficient achieved by UTL					0.895
847							Approximate Sample Size needed to achieve specified CC					59
848				95% Percentile Bootstrap UTL with	95% Coverage	29.51				95% BCA Bootstrap UTL with	95% Coverage	29.82
849					95% UPL	21.48				90% Percentile		19.07
850					90% Chebyshev UPL	27.96				95% Percentile		19.81
851					95% Chebyshev UPL	34.65				99% Percentile		27.24
852					95% USL	31.2						
853												
854	Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.											
855	Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers											
856	and consists of observations collected from clean unimpacted locations.											
857	The use of USL tends to provide a balance between false positives and false negatives provided the data											
858	represents a background data set and when many onsite observations need to be compared with the BTV.											
859												
860	**Cobalt**											
861												

	A	B	C	D	E	F	G	H	I	J	K	L
862	General Statistics											
863					Total Number of Observations	44				Number of Distinct Observations		37
864					Minimum	1.44				First Quartile		6.768
865					Second Largest	16				Median		9.015
866					Maximum	16.1				Third Quartile		11.93
867					Mean	9.295				SD		3.666
868					Coefficient of Variation	0.394				Skewness		-0.119
869					Mean of logged Data	2.122				SD of logged Data		0.531
870												
871					Critical Values for Background Threshold Values (BTVs)							
872					Tolerance Factor K (For UTL)	2.091				d2max (for USL)		2.906
873												
874					Normal GOF Test							
875					Shapiro Wilk Test Statistic	0.968			Shapiro Wilk GOF Test			
876					5% Shapiro Wilk Critical Value	0.944			Data appear Normal at 5% Significance Level			
877					Lilliefors Test Statistic	0.078			Lilliefors GOF Test			
878					5% Lilliefors Critical Value	0.132			Data appear Normal at 5% Significance Level			
879					Data appear Normal at 5% Significance Level							
880												
881					Background Statistics Assuming Normal Distribution							
882				95% UTL with	95% Coverage	16.96				90% Percentile (z)		13.99
883					95% UPL (t)	15.53				95% Percentile (z)		15.32
884					95% USL	19.95				99% Percentile (z)		17.82
885												
886					Gamma GOF Test							
887					A-D Test Statistic	1.023			Anderson-Darling Gamma GOF Test			
888					5% A-D Critical Value	0.753			Data Not Gamma Distributed at 5% Significance Level			
889					K-S Test Statistic	0.117			Kolmogorov-Smirnov Gamma GOF Test			
890					5% K-S Critical Value	0.134			Detected data appear Gamma Distributed at 5% Significance Level			
891					Detected data follow Appr. Gamma Distribution at 5% Significance Level							
892												
893					Gamma Statistics							
894					k hat (MLE)	4.797				k star (bias corrected MLE)		4.485
895					Theta hat (MLE)	1.938				Theta star (bias corrected MLE)		2.072
896					nu hat (MLE)	422.1				nu star (bias corrected)		394.7
897					MLE Mean (bias corrected)	9.295				MLE Sd (bias corrected)		4.389
898												
899					Background Statistics Assuming Gamma Distribution							
900					95% Wilson Hilferty (WH) Approx. Gamma UPL	17.66				90% Percentile		15.18
901					95% Hawkins Wixley (HW) Approx. Gamma UPL	18.18				95% Percentile		17.49
902					95% WH Approx. Gamma UTL with 95% Coverage	20.34				99% Percentile		22.4
903					95% HW Approx. Gamma UTL with 95% Coverage	21.2						
904					95% WH USL	26.79				95% HW USL		28.7
905												
906					Lognormal GOF Test							
907					Shapiro Wilk Test Statistic	0.849			Shapiro Wilk Lognormal GOF Test			
908					5% Shapiro Wilk Critical Value	0.944			Data Not Lognormal at 5% Significance Level			
909					Lilliefors Test Statistic	0.152			Lilliefors Lognormal GOF Test			
910					5% Lilliefors Critical Value	0.132			Data Not Lognormal at 5% Significance Level			

	A	B	C	D	E	F	G	H	I	J	K	L
911	Data Not Lognormal at 5% Significance Level											
912												
913	Background Statistics assuming Lognormal Distribution											
914					95% UTL with 95% Coverage	25.32				90% Percentile (z)		16.48
915					95% UPL (t)	20.58				95% Percentile (z)		19.98
916					95% USL	39.04				99% Percentile (z)		28.69
917												
918	Nonparametric Distribution Free Background Statistics											
919	Data appear Normal at 5% Significance Level											
920												
921	Nonparametric Upper Limits for Background Threshold Values											
922					Order of Statistic, r	44				95% UTL with 95% Coverage		16.1
923					Approx, f used to compute achieved CC	2.316				Approximate Actual Confidence Coefficient achieved by UTL		0.895
924										Approximate Sample Size needed to achieve specified CC		59
925					95% Percentile Bootstrap UTL with 95% Coverage	16.09				95% BCA Bootstrap UTL with 95% Coverage		16
926					95% UPL	15.93				90% Percentile		14.17
927					90% Chebyshev UPL	20.42				95% Percentile		15.48
928					95% Chebyshev UPL	25.45				99% Percentile		16.06
929					95% USL	16.1						
930												
931	Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.											
932	Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers											
933	and consists of observations collected from clean unimpacted locations.											
934	The use of USL tends to provide a balance between false positives and false negatives provided the data											
935	represents a background data set and when many onsite observations need to be compared with the BTV.											
936												
937	Copper											
938												
939	General Statistics											
940					Total Number of Observations	44				Number of Distinct Observations		41
941					Minimum	4.61				First Quartile		7.145
942					Second Largest	23				Median		8.955
943					Maximum	23.3				Third Quartile		11.9
944					Mean	10.42				SD		4.814
945					Coefficient of Variation	0.462				Skewness		1.265
946					Mean of logged Data	2.253				SD of logged Data		0.42
947												
948	Critical Values for Background Threshold Values (BTVs)											
949					Tolerance Factor K (For UTL)	2.091				d2max (for USL)		2.906
950												
951	Normal GOF Test											
952					Shapiro Wilk Test Statistic	0.854				Shapiro Wilk GOF Test		
953					5% Shapiro Wilk Critical Value	0.944				Data Not Normal at 5% Significance Level		
954					Lilliefors Test Statistic	0.19				Lilliefors GOF Test		
955					5% Lilliefors Critical Value	0.132				Data Not Normal at 5% Significance Level		
956	Data Not Normal at 5% Significance Level											
957												
958	Background Statistics Assuming Normal Distribution											
959					95% UTL with 95% Coverage	20.48				90% Percentile (z)		16.58

	A	B	C	D	E	F	G	H	I	J	K	L
960					95% UPL (t)	18.6					95% Percentile (z)	18.33
961					95% USL	24.41					99% Percentile (z)	21.61
962												
963						**Gamma GOF Test**						
964					A-D Test Statistic	1.1	**Anderson-Darling Gamma GOF Test**					
965					5% A-D Critical Value	0.752	Data Not Gamma Distributed at 5% Significance Level					
966					K-S Test Statistic	0.146	**Kolmogorov-Smirnov Gamma GOF Test**					
967					5% K-S Critical Value	0.134	Data Not Gamma Distributed at 5% Significance Level					
968						**Data Not Gamma Distributed at 5% Significance Level**						
969												
970						**Gamma Statistics**						
971					k hat (MLE)	5.688					k star (bias corrected MLE)	5.315
972					Theta hat (MLE)	1.831					Theta star (bias corrected MLE)	1.96
973					nu hat (MLE)	500.5					nu star (bias corrected)	467.7
974					MLE Mean (bias corrected)	10.42					MLE Sd (bias corrected)	4.518
975												
976						**Background Statistics Assuming Gamma Distribution**						
977					95% Wilson Hilferty (WH) Approx. Gamma UPL	18.92					90% Percentile	16.46
978					95% Hawkins Wixley (HW) Approx. Gamma UPL	19.02					95% Percentile	18.78
979					95% WH Approx. Gamma UTL with 95% Coverage	21.61					99% Percentile	23.68
980					95% HW Approx. Gamma UTL with 95% Coverage	21.86						
981					95% WH USL	28.02					95% HW USL	28.82
982												
983						**Lognormal GOF Test**						
984					Shapiro Wilk Test Statistic	0.947	**Shapiro Wilk Lognormal GOF Test**					
985					5% Shapiro Wilk Critical Value	0.944	Data appear Lognormal at 5% Significance Level					
986					Lilliefors Test Statistic	0.119	**Lilliefors Lognormal GOF Test**					
987					5% Lilliefors Critical Value	0.132	Data appear Lognormal at 5% Significance Level					
988						**Data appear Lognormal at 5% Significance Level**						
989												
990						**Background Statistics assuming Lognormal Distribution**						
991					95% UTL with 95% Coverage	22.87					90% Percentile (z)	16.29
992					95% UPL (t)	19.41					95% Percentile (z)	18.97
993					95% USL	32.2					99% Percentile (z)	25.25
994												
995						**Nonparametric Distribution Free Background Statistics**						
996						**Data appear Lognormal at 5% Significance Level**						
997												
998						**Nonparametric Upper Limits for Background Threshold Values**						
999					Order of Statistic, r	44					95% UTL with 95% Coverage	23.3
1000					Approx, f used to compute achieved CC	2.316	Approximate Actual Confidence Coefficient achieved by UTL					0.895
1001							Approximate Sample Size needed to achieve specified CC					59
1002					95% Percentile Bootstrap UTL with 95% Coverage	23.26					95% BCA Bootstrap UTL with 95% Coverage	23
1003					95% UPL	22.38					90% Percentile	17.45
1004					90% Chebyshev UPL	25.02					95% Percentile	20.32
1005					95% Chebyshev UPL	31.63					99% Percentile	23.17
1006					95% USL	23.3						
1007												
1008						Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.						

	A	B	C	D	E	F	G	H	I	J	K	L
1009	Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers											
1010	and consists of observations collected from clean unimpacted locations.											
1011	The use of USL tends to provide a balance between false positives and false negatives provided the data											
1012	represents a background data set and when many onsite observations need to be compared with the BTV.											
1013												
1091	**Lead**											
1092												
1093	**General Statistics**											
1094					Total Number of Observations	44				Number of Distinct Observations		39
1095					Minimum	4.01				First Quartile		8.345
1096					Second Largest	28.4				Median		11.95
1097					Maximum	30.8				Third Quartile		14.65
1098					Mean	13.09				SD		6.642
1099					Coefficient of Variation	0.507				Skewness		1.108
1100					Mean of logged Data	2.452				SD of logged Data		0.501
1101												
1102					**Critical Values for Background Threshold Values (BTVs)**							
1103					Tolerance Factor K (For UTL)	2.091				d2max (for USL)		2.906
1104												
1105					**Normal GOF Test**							
1106					Shapiro Wilk Test Statistic	0.889				**Shapiro Wilk GOF Test**		
1107					5% Shapiro Wilk Critical Value	0.944				Data Not Normal at 5% Significance Level		
1108					Lilliefors Test Statistic	0.181				**Lilliefors GOF Test**		
1109					5% Lilliefors Critical Value	0.132				Data Not Normal at 5% Significance Level		
1110					**Data Not Normal at 5% Significance Level**							
1111												
1112					**Background Statistics Assuming Normal Distribution**							
1113					95% UTL with 95% Coverage	26.98				90% Percentile (z)		21.6
1114					95% UPL (t)	24.38				95% Percentile (z)		24.01
1115					95% USL	32.39				99% Percentile (z)		28.54
1116												
1117					**Gamma GOF Test**							
1118					A-D Test Statistic	0.576				**Anderson-Darling Gamma GOF Test**		
1119					5% A-D Critical Value	0.753				Detected data appear Gamma Distributed at 5% Significance Level		
1120					K-S Test Statistic	0.117				**Kolmogorov-Smirnov Gamma GOF Test**		
1121					5% K-S Critical Value	0.134				Detected data appear Gamma Distributed at 5% Significance Level		
1122					**Detected data appear Gamma Distributed at 5% Significance Level**							
1123												
1124					**Gamma Statistics**							
1125					k hat (MLE)	4.322				k star (bias corrected MLE)		4.043
1126					Theta hat (MLE)	3.028				Theta star (bias corrected MLE)		3.238
1127					nu hat (MLE)	380.4				nu star (bias corrected)		355.8
1128					MLE Mean (bias corrected)	13.09				MLE Sd (bias corrected)		6.51
1129												
1130					**Background Statistics Assuming Gamma Distribution**							
1131					95% Wilson Hilferty (WH) Approx. Gamma UPL	25.54				90% Percentile		21.82
1132					95% Hawkins Wixley (HW) Approx. Gamma UPL	25.85				95% Percentile		25.3
1133					95% WH Approx. Gamma UTL with 95% Coverage	29.62				99% Percentile		32.75
1134					95% HW Approx. Gamma UTL with 95% Coverage	30.27						

	A	B	C	D	E	F	G	H	I	J	K	L
1135					95% WH USL	39.5					95% HW USL	41.29
1136												
1137						Lognormal GOF Test						
1138					Shapiro Wilk Test Statistic	0.964			Shapiro Wilk Lognormal GOF Test			
1139					5% Shapiro Wilk Critical Value	0.944			Data appear Lognormal at 5% Significance Level			
1140					Lilliefors Test Statistic	0.118			Lilliefors Lognormal GOF Test			
1141					5% Lilliefors Critical Value	0.132			Data appear Lognormal at 5% Significance Level			
1142					Data appear Lognormal at 5% Significance Level							
1143												
1144					Background Statistics assuming Lognormal Distribution							
1145				95% UTL with	95% Coverage	33.12					90% Percentile (z)	22.07
1146					95% UPL (t)	27.22					95% Percentile (z)	26.48
1147					95% USL	49.84					99% Percentile (z)	37.26
1148												
1149					Nonparametric Distribution Free Background Statistics							
1150					Data appear Gamma Distributed at 5% Significance Level							
1151												
1152					Nonparametric Upper Limits for Background Threshold Values							
1153					Order of Statistic, r	44					95% UTL with 95% Coverage	30.8
1154					Approx, f used to compute achieved CC	2.316			Approximate Actual Confidence Coefficient achieved by UTL			0.895
1155									Approximate Sample Size needed to achieve specified CC			59
1156				95% Percentile Bootstrap UTL with	95% Coverage	30.44			95% BCA Bootstrap UTL with		95% Coverage	29.98
1157					95% UPL	28.33					90% Percentile	24.43
1158					90% Chebyshev UPL	33.24					95% Percentile	27.68
1159					95% Chebyshev UPL	42.37					99% Percentile	29.77
1160					95% USL	30.8						
1161												
1162					Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.							
1163					Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers							
1164					and consists of observations collected from clean unimpacted locations.							
1165					The use of USL tends to provide a balance between false positives and false negatives provided the data							
1166					represents a background data set and when many onsite observations need to be compared with the BTV.							
1167												
1168	Lithium											
1169												
1170	General Statistics											
1171					Total Number of Observations	44					Number of Distinct Observations	44
1172					Minimum	1.94					First Quartile	4.24
1173					Second Largest	16.3					Median	9.01
1174					Maximum	17					Third Quartile	12.05
1175					Mean	8.562					SD	4.703
1176					Coefficient of Variation	0.549					Skewness	0.174
1177					Mean of logged Data	1.964					SD of logged Data	0.651
1178												
1179					Critical Values for Background Threshold Values (BTVs)							
1180					Tolerance Factor K (For UTL)	2.091					d2max (for USL)	2.906
1181												
1182					Normal GOF Test							
1183					Shapiro Wilk Test Statistic	0.91			Shapiro Wilk GOF Test			

	A	B	C	D	E	F	G	H	I	J	K	L
1184					5% Shapiro Wilk Critical Value	0.944	Data Not Normal at 5% Significance Level					
1185					Lilliefors Test Statistic	0.151	**Lilliefors GOF Test**					
1186					5% Lilliefors Critical Value	0.132	Data Not Normal at 5% Significance Level					
1187	**Data Not Normal at 5% Significance Level**											
1188												
1189	**Background Statistics Assuming Normal Distribution**											
1190				95% UTL with	95% Coverage	18.4				90% Percentile (z)		14.59
1191					95% UPL (t)	16.56				95% Percentile (z)		16.3
1192					95% USL	22.23				99% Percentile (z)		19.5
1193												
1194	**Gamma GOF Test**											
1195					A-D Test Statistic	1.156	**Anderson-Darling Gamma GOF Test**					
1196					5% A-D Critical Value	0.756	Data Not Gamma Distributed at 5% Significance Level					
1197					K-S Test Statistic	0.134	**Kolmogorov-Smirnov Gamma GOF Test**					
1198					5% K-S Critical Value	0.134	Detected data appear Gamma Distributed at 5% Significance Level					
1199	**Detected data follow Appr. Gamma Distribution at 5% Significance Level**											
1200												
1201	**Gamma Statistics**											
1202					k hat (MLE)	2.884				k star (bias corrected MLE)		2.703
1203					Theta hat (MLE)	2.969				Theta star (bias corrected MLE)		3.168
1204					nu hat (MLE)	253.8				nu star (bias corrected)		237.8
1205					MLE Mean (bias corrected)	8.562				MLE Sd (bias corrected)		5.208
1206												
1207	**Background Statistics Assuming Gamma Distribution**											
1208					95% Wilson Hilferty (WH) Approx. Gamma UPL	18.81				90% Percentile		15.54
1209					95% Hawkins Wixley (HW) Approx. Gamma UPL	19.32				95% Percentile		18.52
1210					95% WH Approx. Gamma UTL with 95% Coverage	22.39				99% Percentile		25.02
1211					95% HW Approx. Gamma UTL with 95% Coverage	23.35						
1212					95% WH USL	31.25				95% HW USL		33.74
1213												
1214	**Lognormal GOF Test**											
1215					Shapiro Wilk Test Statistic	0.906	**Shapiro Wilk Lognormal GOF Test**					
1216					5% Shapiro Wilk Critical Value	0.944	Data Not Lognormal at 5% Significance Level					
1217					Lilliefors Test Statistic	0.158	**Lilliefors Lognormal GOF Test**					
1218					5% Lilliefors Critical Value	0.132	Data Not Lognormal at 5% Significance Level					
1219	**Data Not Lognormal at 5% Significance Level**											
1220												
1221	**Background Statistics assuming Lognormal Distribution**											
1222					95% UTL with 95% Coverage	27.79				90% Percentile (z)		16.41
1223					95% UPL (t)	21.55				95% Percentile (z)		20.79
1224					95% USL	47.23				99% Percentile (z)		32.38
1225												
1226	**Nonparametric Distribution Free Background Statistics**											
1227	**Data appear Approximate Gamma Distribution at 5% Significance Level**											
1228												
1229	**Nonparametric Upper Limits for Background Threshold Values**											
1230					Order of Statistic, r	44				95% UTL with 95% Coverage		17
1231					Approx, f used to compute achieved CC	2.316	Approximate Actual Confidence Coefficient achieved by UTL					0.895
1232							Approximate Sample Size needed to achieve specified CC					59

	A	B	C	D	E	F	G	H	I	J	K	L
1233					95% Percentile Bootstrap UTL with 95% Coverage	16.82					95% BCA Bootstrap UTL with 95% Coverage	16.82
1234					95% UPL	16.18					90% Percentile	14.95
1235					90% Chebyshev UPL	22.83					95% Percentile	15.74
1236					95% Chebyshev UPL	29.3					99% Percentile	16.7
1237					95% USL	17						
1238												
1239	Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.											
1240	Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers											
1241	and consists of observations collected from clean unimpacted locations.											
1242	The use of USL tends to provide a balance between false positives and false negatives provided the data											
1243	represents a background data set and when many onsite observations need to be compared with the BTV.											
1244												
1399	**Mercury**											
1400												
1401	**General Statistics**											
1402					Total Number of Observations	44					Number of Missing Observations	0
1403					Number of Distinct Observations	42						
1404					Number of Detects	37					Number of Non-Detects	7
1405					Number of Distinct Detects	35					Number of Distinct Non-Detects	7
1406					Minimum Detect	0.0235					Minimum Non-Detect	0.00855
1407					Maximum Detect	0.165					Maximum Non-Detect	0.104
1408					Variance Detected	7.5498E-4					Percent Non-Detects	15.91%
1409					Mean Detected	0.0507					SD Detected	0.0275
1410					Mean of Detected Logged Data	-3.082					SD of Detected Logged Data	0.423
1411												
1412	**Critical Values for Background Threshold Values (BTVs)**											
1413					Tolerance Factor K (For UTL)	2.091					d2max (for USL)	2.906
1414												
1415	**Normal GOF Test on Detects Only**											
1416					Shapiro Wilk Test Statistic	0.748					**Shapiro Wilk GOF Test**	
1417					5% Shapiro Wilk Critical Value	0.936					Data Not Normal at 5% Significance Level	
1418					Lilliefors Test Statistic	0.201					**Lilliefors GOF Test**	
1419					5% Lilliefors Critical Value	0.144					Data Not Normal at 5% Significance Level	
1420	**Data Not Normal at 5% Significance Level**											
1421												
1422	**Kaplan Meier (KM) Background Statistics Assuming Normal Distribution**											
1423					KM Mean	0.0472					KM SD	0.0267
1424					95% UTL95% Coverage	0.103					95% KM UPL (t)	0.0926
1425					90% KM Percentile (z)	0.0814					95% KM Percentile (z)	0.0911
1426					99% KM Percentile (z)	0.109					95% KM USL	0.125
1427												
1428	**DL/2 Substitution Background Statistics Assuming Normal Distribution**											
1429					Mean	0.0463					SD	0.0277
1430					95% UTL95% Coverage	0.104					95% UPL (t)	0.0934
1431					90% Percentile (z)	0.0818					95% Percentile (z)	0.0918
1432					99% Percentile (z)	0.111					95% USL	0.127
1433	**DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons**											
1434												
1435	**Gamma GOF Tests on Detected Observations Only**											

	A	B	C	D	E	F	G	H	I	J	K	L
1436					A-D Test Statistic	1.035	**Anderson-Darling GOF Test**					
1437					5% A-D Critical Value	0.75	Data Not Gamma Distributed at 5% Significance Level					
1438					K-S Test Statistic	0.129	**Kolmogorov-Smirnov GOF**					
1439					5% K-S Critical Value	0.145	Detected data appear Gamma Distributed at 5% Significance Level					
1440	**Detected data follow Appr. Gamma Distribution at 5% Significance Level**											
1441												
1442	**Gamma Statistics on Detected Data Only**											
1443					k hat (MLE)	5.187				k star (bias corrected MLE)		4.784
1444					Theta hat (MLE)	0.00977				Theta star (bias corrected MLE)		0.0106
1445					nu hat (MLE)	383.8				nu star (bias corrected)		354
1446					MLE Mean (bias corrected)	0.0507						
1447					MLE Sd (bias corrected)	0.0232				95% Percentile of Chisquare (2kstar)		17.71
1448												
1449	**Gamma ROS Statistics using Imputed Non-Detects**											
1450	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
1451	GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)											
1452	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
1453	This is especially true when the sample size is small.											
1454	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
1455					Minimum	0.01				Mean		0.0468
1456					Maximum	0.165				Median		0.0396
1457					SD	0.027				CV		0.577
1458					k hat (MLE)	4.226				k star (bias corrected MLE)		3.953
1459					Theta hat (MLE)	0.0111				Theta star (bias corrected MLE)		0.0118
1460					nu hat (MLE)	371.9				nu star (bias corrected)		347.9
1461					MLE Mean (bias corrected)	0.0468				MLE Sd (bias corrected)		0.0235
1462					95% Percentile of Chisquare (2kstar)	15.37				90% Percentile		0.0784
1463					95% Percentile	0.091				99% Percentile		0.118
1464	**The following statistics are computed using Gamma ROS Statistics on Imputed Data**											
1465	**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**											
1466					WH	HW					WH	HW
1467			95% Approx. Gamma UTL with 95% Coverage		0.106	0.108				95% Approx. Gamma UPL	0.0915	0.092
1468					95% Gamma USL	0.142	0.147					
1469												
1470	**Estimates of Gamma Parameters using KM Estimates**											
1471					Mean (KM)	0.0472				SD (KM)		0.0267
1472					Variance (KM)	7.1197E-4				SE of Mean (KM)		0.00412
1473					k hat (KM)	3.131				k star (KM)		2.932
1474					nu hat (KM)	275.5				nu star (KM)		258
1475					theta hat (KM)	0.0151				theta star (KM)		0.0161
1476					80% gamma percentile (KM)	0.0675				90% gamma percentile (KM)		0.0842
1477					95% gamma percentile (KM)	0.0997				99% gamma percentile (KM)		0.133
1478												
1479	**The following statistics are computed using gamma distribution and KM estimates**											
1480	**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**											
1481					WH	HW					WH	HW
1482			95% Approx. Gamma UTL with 95% Coverage		0.107	0.109				95% Approx. Gamma UPL	0.0921	0.0929
1483				95% KM Gamma Percentile	0.0901	0.0908				95% Gamma USL	0.143	0.149
1484												

	A	B	C	D	E	F	G	H	I	J	K	L
1485	**Lognormal GOF Test on Detected Observations Only**											
1486					Shapiro Wilk Test Statistic	0.942	**Shapiro Wilk GOF Test**					
1487					5% Shapiro Wilk Critical Value	0.936	Detected Data appear Lognormal at 5% Significance Level					
1488					Lilliefors Test Statistic	0.0999	**Lilliefors GOF Test**					
1489					5% Lilliefors Critical Value	0.144	Detected Data appear Lognormal at 5% Significance Level					
1490	**Detected Data appear Lognormal at 5% Significance Level**											
1491												
1492	**Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects**											
1493					Mean in Original Scale	0.0474				Mean in Log Scale		-3.155
1494					SD in Original Scale	0.0265				SD in Log Scale		0.44
1495					95% UTL95% Coverage	0.107				95% BCA UTL95% Coverage		0.156
1496					95% Bootstrap (%) UTL95% Coverage	0.158				95% UPL (t)		0.0901
1497					90% Percentile (z)	0.0749				95% Percentile (z)		0.0879
1498					99% Percentile (z)	0.119				95% USL		0.153
1499												
1500	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
1501					KM Mean of Logged Data	-3.179				95% KM UTL (Lognormal)95% Coverage		0.119
1502					KM SD of Logged Data	0.502				95% KM UPL (Lognormal)		0.0978
1503					95% KM Percentile Lognormal (z)	0.0952				95% KM USL (Lognormal)		0.179
1504												
1505	**Background DL/2 Statistics Assuming Lognormal Distribution**											
1506					Mean in Original Scale	0.0463				Mean in Log Scale		-3.224
1507					SD in Original Scale	0.0277				SD in Log Scale		0.584
1508					95% UTL95% Coverage	0.135				95% UPL (t)		0.107
1509					90% Percentile (z)	0.0841				95% Percentile (z)		0.104
1510					99% Percentile (z)	0.155				95% USL		0.217
1511	**DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.**											
1512												
1513	**Nonparametric Distribution Free Background Statistics**											
1514	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
1515												
1516	**Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)**											
1517					Order of Statistic, r	44				95% UTL with95% Coverage		0.165
1518					Approx, f used to compute achieved CC	2.316				Approximate Actual Confidence Coefficient achieved by UTL		0.895
1519					Approximate Sample Size needed to achieve specified CC	59				95% UPL		0.112
1520					95% USL	0.165				95% KM Chebyshev UPL		0.165
1521												
1522	Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.											
1523	Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers											
1524	and consists of observations collected from clean unimpacted locations.											
1525	The use of USL tends to provide a balance between false positives and false negatives provided the data											
1526	represents a background data set and when many onsite observations need to be compared with the BTV.											
1527												
1528	**Molybdenum**											
1529												
1530	**General Statistics**											
1531					Total Number of Observations	44				Number of Missing Observations		0
1532					Number of Distinct Observations	43						
1533					Number of Detects	43				Number of Non-Detects		1

	A	B	C	D	E	F	G	H	I	J	K	L
1534					Number of Distinct Detects	42					Number of Distinct Non-Detects	1
1535					Minimum Detect	0.161					Minimum Non-Detect	0.201
1536					Maximum Detect	2.29					Maximum Non-Detect	0.201
1537					Variance Detected	0.274					Percent Non-Detects	2.273%
1538					Mean Detected	0.804					SD Detected	0.523
1539					Mean of Detected Logged Data	-0.441					SD of Detected Logged Data	0.706
1540												
1541					**Critical Values for Background Threshold Values (BTVs)**							
1542					Tolerance Factor K (For UTL)	2.091					d2max (for USL)	2.906
1543												
1544					**Normal GOF Test on Detects Only**							
1545					Shapiro Wilk Test Statistic	0.914	**Shapiro Wilk GOF Test**					
1546					5% Shapiro Wilk Critical Value	0.943	Data Not Normal at 5% Significance Level					
1547					Lilliefors Test Statistic	0.11	**Lilliefors GOF Test**					
1548					5% Lilliefors Critical Value	0.134	Detected Data appear Normal at 5% Significance Level					
1549					**Detected Data appear Approximate Normal at 5% Significance Level**							
1550												
1551					**Kaplan Meier (KM) Background Statistics Assuming Normal Distribution**							
1552					KM Mean	0.789					KM SD	0.52
1553					95% UTL95% Coverage	1.876					95% KM UPL (t)	1.673
1554					90% KM Percentile (z)	1.456					95% KM Percentile (z)	1.644
1555					99% KM Percentile (z)	1.999					95% KM USL	2.3
1556												
1557					**DL/2 Substitution Background Statistics Assuming Normal Distribution**							
1558					Mean	0.788					SD	0.528
1559					95% UTL95% Coverage	1.892					95% UPL (t)	1.685
1560					90% Percentile (z)	1.464					95% Percentile (z)	1.656
1561					99% Percentile (z)	2.016					95% USL	2.322
1562					**DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons**							
1563												
1564					**Gamma GOF Tests on Detected Observations Only**							
1565					A-D Test Statistic	0.294	**Anderson-Darling GOF Test**					
1566					5% A-D Critical Value	0.758	Detected data appear Gamma Distributed at 5% Significance Level					
1567					K-S Test Statistic	0.0918	**Kolmogorov-Smirnov GOF**					
1568					5% K-S Critical Value	0.136	Detected data appear Gamma Distributed at 5% Significance Level					
1569					**Detected data appear Gamma Distributed at 5% Significance Level**							
1570												
1571					**Gamma Statistics on Detected Data Only**							
1572					k hat (MLE)	2.399					k star (bias corrected MLE)	2.247
1573					Theta hat (MLE)	0.335					Theta star (bias corrected MLE)	0.358
1574					nu hat (MLE)	206.3					nu star (bias corrected)	193.2
1575					MLE Mean (bias corrected)	0.804						
1576					MLE Sd (bias corrected)	0.536					95% Percentile of Chisquare (2kstar)	10.28
1577												
1578					**Gamma ROS Statistics using Imputed Non-Detects**							
1579					GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs							
1580					GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)							
1581					For such situations, GROS method may yield incorrect values of UCLs and BTVs							
1582					This is especially true when the sample size is small.							

	A	B	C	D	E	F	G	H	I	J	K	L
1583	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
1584					Minimum	0.1					Mean	0.788
1585					Maximum	2.29					Median	0.718
1586					SD	0.528					CV	0.67
1587					k hat (MLE)	2.194					k star (bias corrected MLE)	2.06
1588					Theta hat (MLE)	0.359					Theta star (bias corrected MLE)	0.382
1589					nu hat (MLE)	193.1					nu star (bias corrected)	181.3
1590					MLE Mean (bias corrected)	0.788					MLE Sd (bias corrected)	0.549
1591					95% Percentile of Chisquare (2kstar)	9.682					90% Percentile	1.521
1592					95% Percentile	1.851					99% Percentile	2.581
1593	**The following statistics are computed using Gamma ROS Statistics on Imputed Data**											
1594	**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**											
1595					WH	HW					WH	HW
1596				95% Approx. Gamma UTL with 95% Coverage	2.277	2.389				95% Approx. Gamma UPL	1.877	1.934
1597				95% Gamma USL	3.286	3.591						
1598												
1599	**Estimates of Gamma Parameters using KM Estimates**											
1600					Mean (KM)	0.789					SD (KM)	0.52
1601					Variance (KM)	0.27					SE of Mean (KM)	0.0793
1602					k hat (KM)	2.307					k star (KM)	2.165
1603					nu hat (KM)	203					nu star (KM)	190.5
1604					theta hat (KM)	0.342					theta star (KM)	0.365
1605					80% gamma percentile (KM)	1.171					90% gamma percentile (KM)	1.507
1606					95% gamma percentile (KM)	1.827					99% gamma percentile (KM)	2.532
1607												
1608	**The following statistics are computed using gamma distribution and KM estimates**											
1609	**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**											
1610					WH	HW					WH	HW
1611				95% Approx. Gamma UTL with 95% Coverage	2.22	2.316				95% Approx. Gamma UPL	1.838	1.886
1612				95% KM Gamma Percentile	1.788	1.83				95% Gamma USL	3.18	3.447
1613												
1614	**Lognormal GOF Test on Detected Observations Only**											
1615					Shapiro Wilk Test Statistic	0.959	**Shapiro Wilk GOF Test**					
1616					5% Shapiro Wilk Critical Value	0.943	Detected Data appear Lognormal at 5% Significance Level					
1617					Lilliefors Test Statistic	0.0968	**Lilliefors GOF Test**					
1618					5% Lilliefors Critical Value	0.134	Detected Data appear Lognormal at 5% Significance Level					
1619	**Detected Data appear Lognormal at 5% Significance Level**											
1620												
1621	**Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects**											
1622					Mean in Original Scale	0.789					Mean in Log Scale	-0.471
1623					SD in Original Scale	0.526					SD in Log Scale	0.725
1624					95% UTL95% Coverage	2.845					95% BCA UTL95% Coverage	2.253
1625					95% Bootstrap (%) UTL95% Coverage	2.253					95% UPL (t)	2.143
1626					90% Percentile (z)	1.582					95% Percentile (z)	2.059
1627					99% Percentile (z)	3.375					95% USL	5.14
1628												
1629	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
1630					KM Mean of Logged Data	-0.471					95% KM UTL (Lognormal)95% Coverage	2.794
1631					KM SD of Logged Data	0.716					95% KM UPL (Lognormal)	2.111

	A	B	C	D	E	F	G	H	I	J	K	L
1632					95% KM Percentile Lognormal (z)	2.029					95% KM USL (Lognormal)	5.01
1633												
1634					Background DL/2 Statistics Assuming Lognormal Distribution							
1635					Mean in Original Scale	0.788					Mean in Log Scale	-0.483
1636					SD in Original Scale	0.528					SD in Log Scale	0.752
1637					95% UTL95% Coverage	2.972					95% UPL (t)	2.215
1638					90% Percentile (z)	1.617					95% Percentile (z)	2.125
1639					99% Percentile (z)	3.547					95% USL	5.487
1640					DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.							
1641												
1642					Nonparametric Distribution Free Background Statistics							
1643					Data appear to follow a Discernible Distribution at 5% Significance Level							
1644												
1645					Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)							
1646					Order of Statistic, r	44					95% UTL with95% Coverage	2.29
1647					Approx, f used to compute achieved CC	2.316					Approximate Actual Confidence Coefficient achieved by UTL	0.895
1648					Approximate Sample Size needed to achieve specified CC	59					95% UPL	1.985
1649					95% USL	2.29					95% KM Chebyshev UPL	3.081
1650												
1651					Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.							
1652					Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers							
1653					and consists of observations collected from clean unimpacted locations.							
1654					The use of USL tends to provide a balance between false positives and false negatives provided the data							
1655					represents a background data set and when many onsite observations need to be compared with the BTV.							
1656												
1657	Nickel											
1658												
1659	General Statistics											
1660					Total Number of Observations	44					Number of Distinct Observations	44
1661					Minimum	4.99					First Quartile	7.55
1662					Second Largest	30.5					Median	13.95
1663					Maximum	37.1					Third Quartile	20.13
1664					Mean	14.73					SD	7.427
1665					Coefficient of Variation	0.504					Skewness	0.725
1666					Mean of logged Data	2.557					SD of logged Data	0.537
1667												
1668					Critical Values for Background Threshold Values (BTVs)							
1669					Tolerance Factor K (For UTL)	2.091					d2max (for USL)	2.906
1670												
1671					Normal GOF Test							
1672					Shapiro Wilk Test Statistic	0.934					Shapiro Wilk GOF Test	
1673					5% Shapiro Wilk Critical Value	0.944					Data Not Normal at 5% Significance Level	
1674					Lilliefors Test Statistic	0.105					Lilliefors GOF Test	
1675					5% Lilliefors Critical Value	0.132					Data appear Normal at 5% Significance Level	
1676					Data appear Approximate Normal at 5% Significance Level							
1677												
1678					Background Statistics Assuming Normal Distribution							
1679					95% UTL with 95% Coverage	30.26					90% Percentile (z)	24.25
1680					95% UPL (t)	27.36					95% Percentile (z)	26.95

	A	B	C	D	E	F	G	H	I	J	K	L
1681					95% USL	36.32					99% Percentile (z)	32.01
1682												
1683						Gamma GOF Test						
1684					A-D Test Statistic	0.582	Anderson-Darling Gamma GOF Test					
1685					5% A-D Critical Value	0.753	Detected data appear Gamma Distributed at 5% Significance Level					
1686					K-S Test Statistic	0.116	Kolmogorov-Smirnov Gamma GOF Test					
1687					5% K-S Critical Value	0.134	Detected data appear Gamma Distributed at 5% Significance Level					
1688					Detected data appear Gamma Distributed at 5% Significance Level							
1689												
1690						Gamma Statistics						
1691					k hat (MLE)	3.928					k star (bias corrected MLE)	3.675
1692					Theta hat (MLE)	3.751					Theta star (bias corrected MLE)	4.008
1693					nu hat (MLE)	345.6					nu star (bias corrected)	323.4
1694					MLE Mean (bias corrected)	14.73					MLE Sd (bias corrected)	7.684
1695												
1696						Background Statistics Assuming Gamma Distribution						
1697					95% Wilson Hilferty (WH) Approx. Gamma UPL	29.55					90% Percentile	25.03
1698					95% Hawkins Wixley (HW) Approx. Gamma UPL	30.06					95% Percentile	29.21
1699					95% WH Approx. Gamma UTL with 95% Coverage	34.47					99% Percentile	38.17
1700					95% HW Approx. Gamma UTL with 95% Coverage	35.46						
1701					95% WH USL	46.46					95% HW USL	49.04
1702												
1703						Lognormal GOF Test						
1704					Shapiro Wilk Test Statistic	0.943	Shapiro Wilk Lognormal GOF Test					
1705					5% Shapiro Wilk Critical Value	0.944	Data Not Lognormal at 5% Significance Level					
1706					Lilliefors Test Statistic	0.122	Lilliefors Lognormal GOF Test					
1707					5% Lilliefors Critical Value	0.132	Data appear Lognormal at 5% Significance Level					
1708					Data appear Approximate Lognormal at 5% Significance Level							
1709												
1710						Background Statistics assuming Lognormal Distribution						
1711					95% UTL with 95% Coverage	39.69					90% Percentile (z)	25.69
1712					95% UPL (t)	32.17					95% Percentile (z)	31.23
1713					95% USL	61.52					99% Percentile (z)	45.05
1714												
1715						Nonparametric Distribution Free Background Statistics						
1716						Data appear Approximate Normal at 5% Significance Level						
1717												
1718						Nonparametric Upper Limits for Background Threshold Values						
1719					Order of Statistic, r	44					95% UTL with 95% Coverage	37.1
1720					Approx, f used to compute achieved CC	2.316	Approximate Actual Confidence Coefficient achieved by UTL					0.895
1721							Approximate Sample Size needed to achieve specified CC					59
1722					95% Percentile Bootstrap UTL with 95% Coverage	36.11					95% BCA Bootstrap UTL with 95% Coverage	35.44
1723					95% UPL	29.38					90% Percentile	23
1724					90% Chebyshev UPL	37.27					95% Percentile	25.76
1725					95% Chebyshev UPL	47.47					99% Percentile	34.26
1726					95% USL	37.1						
1727												
1728					Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.							
1729					Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers							

	A	B	C	D	E	F	G	H	I	J	K	L
1730	and consists of observations collected from clean unimpacted locations.											
1731	The use of USL tends to provide a balance between false positives and false negatives provided the data											
1732	represents a background data set and when many onsite observations need to be compared with the BTV.											
1733												
1811	**Selenium**											
1812												
1813	**General Statistics**											
1814	Total Number of Observations					44	Number of Missing Observations					0
1815	Number of Distinct Observations					44						
1816	Number of Detects					42	Number of Non-Detects					2
1817	Number of Distinct Detects					42	Number of Distinct Non-Detects					2
1818	Minimum Detect					0.126	Minimum Non-Detect					0.136
1819	Maximum Detect					3.3	Maximum Non-Detect					0.142
1820	Variance Detected					0.526	Percent Non-Detects					4.545%
1821	Mean Detected					0.69	SD Detected					0.725
1822	Mean of Detected Logged Data					-0.69	SD of Detected Logged Data					0.73
1823												
1824	**Critical Values for Background Threshold Values (BTVs)**											
1825	Tolerance Factor K (For UTL)					2.091	d2max (for USL)					2.906
1826												
1827	**Normal GOF Test on Detects Only**											
1828	Shapiro Wilk Test Statistic					0.62	**Shapiro Wilk GOF Test**					
1829	5% Shapiro Wilk Critical Value					0.942	Data Not Normal at 5% Significance Level					
1830	Lilliefors Test Statistic					0.313	**Lilliefors GOF Test**					
1831	5% Lilliefors Critical Value					0.135	Data Not Normal at 5% Significance Level					
1832	**Data Not Normal at 5% Significance Level**											
1833												
1834	**Kaplan Meier (KM) Background Statistics Assuming Normal Distribution**											
1835	KM Mean					0.665	KM SD					0.71
1836	95% UTL95% Coverage					2.149	95% KM UPL (t)					1.872
1837	90% KM Percentile (z)					1.574	95% KM Percentile (z)					1.832
1838	99% KM Percentile (z)					2.316	95% KM USL					2.728
1839												
1840	**DL/2 Substitution Background Statistics Assuming Normal Distribution**											
1841	Mean					0.662	SD					0.72
1842	95% UTL95% Coverage					2.168	95% UPL (t)					1.886
1843	90% Percentile (z)					1.585	95% Percentile (z)					1.847
1844	99% Percentile (z)					2.338	95% USL					2.755
1845	**DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons**											
1846												
1847	**Gamma GOF Tests on Detected Observations Only**											
1848	A-D Test Statistic					2.781	**Anderson-Darling GOF Test**					
1849	5% A-D Critical Value					0.764	Data Not Gamma Distributed at 5% Significance Level					
1850	K-S Test Statistic					0.233	**Kolmogorov-Smirnov GOF**					
1851	5% K-S Critical Value					0.139	Data Not Gamma Distributed at 5% Significance Level					
1852	**Data Not Gamma Distributed at 5% Significance Level**											
1853												
1854	**Gamma Statistics on Detected Data Only**											
1855	k hat (MLE)					1.715	k star (bias corrected MLE)					1.609

	A	B	C	D	E	F	G	H	I	J	K	L
1856					Theta hat (MLE)	0.402				Theta star (bias corrected MLE)		0.429
1857					nu hat (MLE)	144.1				nu star (bias corrected)		135.1
1858					MLE Mean (bias corrected)	0.69						
1859					MLE Sd (bias corrected)	0.544				95% Percentile of Chisquare (2kstar)		8.188
1860												
1861					**Gamma ROS Statistics using Imputed Non-Detects**							
1862					GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs							
1863					GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)							
1864					For such situations, GROS method may yield incorrect values of UCLs and BTVs							
1865					This is especially true when the sample size is small.							
1866					For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates							
1867					Minimum	0.01				Mean		0.659
1868					Maximum	3.3				Median		0.438
1869					SD	0.723				CV		1.096
1870					k hat (MLE)	1.249				k star (bias corrected MLE)		1.179
1871					Theta hat (MLE)	0.528				Theta star (bias corrected MLE)		0.559
1872					nu hat (MLE)	109.9				nu star (bias corrected)		103.7
1873					MLE Mean (bias corrected)	0.659				MLE Sd (bias corrected)		0.607
1874					95% Percentile of Chisquare (2kstar)	6.667				90% Percentile		1.458
1875					95% Percentile	1.864				99% Percentile		2.798
1876					**The following statistics are computed using Gamma ROS Statistics on Imputed Data**							
1877					**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**							
1878					WH	HW					WH	HW
1879				95% Approx. Gamma UTL with 95% Coverage	2.323	2.476				95% Approx. Gamma UPL	1.838	1.908
1880				95% Gamma USL	3.594	4.057						
1881												
1882					**Estimates of Gamma Parameters using KM Estimates**							
1883					Mean (KM)	0.665				SD (KM)		0.71
1884					Variance (KM)	0.504				SE of Mean (KM)		0.108
1885					k hat (KM)	0.876				k star (KM)		0.832
1886					nu hat (KM)	77.1				nu star (KM)		73.17
1887					theta hat (KM)	0.759				theta star (KM)		0.799
1888					80% gamma percentile (KM)	1.084				90% gamma percentile (KM)		1.601
1889					95% gamma percentile (KM)	2.126				99% gamma percentile (KM)		3.363
1890												
1891					**The following statistics are computed using gamma distribution and KM estimates**							
1892					**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**							
1893					WH	HW					WH	HW
1894				95% Approx. Gamma UTL with 95% Coverage	2.104	2.129				95% Approx. Gamma UPL	1.695	1.689
1895				95% KM Gamma Percentile	1.642	1.633				95% Gamma USL	3.157	3.319
1896												
1897					**Lognormal GOF Test on Detected Observations Only**							
1898					Shapiro Wilk Test Statistic	0.889				**Shapiro Wilk GOF Test**		
1899					5% Shapiro Wilk Critical Value	0.942				Data Not Lognormal at 5% Significance Level		
1900					Lilliefors Test Statistic	0.171				**Lilliefors GOF Test**		
1901					5% Lilliefors Critical Value	0.135				Data Not Lognormal at 5% Significance Level		
1902					**Data Not Lognormal at 5% Significance Level**							
1903												
1904					**Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects**							

	A	B	C	D	E	F	G	H	I	J	K	L
1905					Mean in Original Scale	0.664					Mean in Log Scale	-0.759
1906					SD in Original Scale	0.719					SD in Log Scale	0.782
1907					95% UTL95% Coverage	2.401					95% BCA UTL95% Coverage	3.158
1908					95% Bootstrap (%) UTL95% Coverage	3.273					95% UPL (t)	1.769
1909					90% Percentile (z)	1.275					95% Percentile (z)	1.694
1910					99% Percentile (z)	2.886					95% USL	4.543
1911												
1912					Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution							
1913					KM Mean of Logged Data	-0.753					95% KM UTL (Lognormal)95% Coverage	2.314
1914					KM SD of Logged Data	0.761					95% KM UPL (Lognormal)	1.719
1915					95% KM Percentile Lognormal (z)	1.648					95% KM USL (Lognormal)	4.304
1916												
1917					Background DL/2 Statistics Assuming Lognormal Distribution							
1918					Mean in Original Scale	0.662					Mean in Log Scale	-0.78
1919					SD in Original Scale	0.72					SD in Log Scale	0.826
1920					95% UTL95% Coverage	2.577					95% UPL (t)	1.866
1921					90% Percentile (z)	1.321					95% Percentile (z)	1.783
1922					99% Percentile (z)	3.13					95% USL	5.052
1923					DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.							
1924												
1925					Nonparametric Distribution Free Background Statistics							
1926					Data do not follow a Discernible Distribution (0.05)							
1927												
1928					Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)							
1929					Order of Statistic, r	44					95% UTL with95% Coverage	3.3
1930					Approx, f used to compute achieved CC	2.316					Approximate Actual Confidence Coefficient achieved by UTL	0.895
1931					Approximate Sample Size needed to achieve specified CC	59					95% UPL	2.928
1932					95% USL	3.3					95% KM Chebyshev UPL	3.794
1933												
1934					Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.							
1935					Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers							
1936					and consists of observations collected from clean unimpacted locations.							
1937					The use of USL tends to provide a balance between false positives and false negatives provided the data							
1938					represents a background data set and when many onsite observations need to be compared with the BTV.							
1939												
2017	Silver											
2018												
2019					General Statistics							
2020					Total Number of Observations	44					Number of Missing Observations	0
2021					Number of Distinct Observations	35						
2022					Number of Detects	23					Number of Non-Detects	21
2023					Number of Distinct Detects	23					Number of Distinct Non-Detects	14
2024					Minimum Detect	0.0158					Minimum Non-Detect	0.0131
2025					Maximum Detect	0.0773					Maximum Non-Detect	0.0167
2026					Variance Detected	1.7815E-4					Percent Non-Detects	47.73%
2027					Mean Detected	0.0268					SD Detected	0.0133
2028					Mean of Detected Logged Data	-3.702					SD of Detected Logged Data	0.382
2029												
2030					Critical Values for Background Threshold Values (BTVs)							

	A	B	C	D	E	F	G	H	I	J	K	L
2031					Tolerance Factor K (For UTL)	2.091					d2max (for USL)	2.906
2032												
2033					Normal GOF Test on Detects Only							
2034					Shapiro Wilk Test Statistic	0.718	Shapiro Wilk GOF Test					
2035					5% Shapiro Wilk Critical Value	0.914	Data Not Normal at 5% Significance Level					
2036					Lilliefors Test Statistic	0.211	Lilliefors GOF Test					
2037					5% Lilliefors Critical Value	0.18	Data Not Normal at 5% Significance Level					
2038					Data Not Normal at 5% Significance Level							
2039												
2040					Kaplan Meier (KM) Background Statistics Assuming Normal Distribution							
2041					KM Mean	0.0203					KM SD	0.0116
2042					95% UTL95% Coverage	0.0446					95% KM UPL (t)	0.0401
2043					90% KM Percentile (z)	0.0352					95% KM Percentile (z)	0.0394
2044					99% KM Percentile (z)	0.0473					95% KM USL	0.0541
2045												
2046					DL/2 Substitution Background Statistics Assuming Normal Distribution							
2047					Mean	0.0177					SD	0.0136
2048					95% UTL95% Coverage	0.046					95% UPL (t)	0.0407
2049					90% Percentile (z)	0.0351					95% Percentile (z)	0.04
2050					99% Percentile (z)	0.0492					95% USL	0.0571
2051					DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons							
2052												
2053					Gamma GOF Tests on Detected Observations Only							
2054					A-D Test Statistic	0.85	Anderson-Darling GOF Test					
2055					5% A-D Critical Value	0.746	Data Not Gamma Distributed at 5% Significance Level					
2056					K-S Test Statistic	0.152	Kolmogorov-Smirnov GOF					
2057					5% K-S Critical Value	0.182	Detected data appear Gamma Distributed at 5% Significance Level					
2058					Detected data follow Appr. Gamma Distribution at 5% Significance Level							
2059												
2060					Gamma Statistics on Detected Data Only							
2061					k hat (MLE)	6.303					k star (bias corrected MLE)	5.51
2062					Theta hat (MLE)	0.00425					Theta star (bias corrected MLE)	0.00486
2063					nu hat (MLE)	289.9					nu star (bias corrected)	253.5
2064					MLE Mean (bias corrected)	0.0268						
2065					MLE Sd (bias corrected)	0.0114					95% Percentile of Chisquare (2kstar)	19.7
2066												
2067					Gamma ROS Statistics using Imputed Non-Detects							
2068					GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs							
2069					GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)							
2070					For such situations, GROS method may yield incorrect values of UCLs and BTVs							
2071					This is especially true when the sample size is small.							
2072					For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates							
2073					Minimum	0.01					Mean	0.0188
2074					Maximum	0.0773					Median	0.0159
2075					SD	0.0128					CV	0.68
2076					k hat (MLE)	3.336					k star (bias corrected MLE)	3.124
2077					Theta hat (MLE)	0.00563					Theta star (bias corrected MLE)	0.00601
2078					nu hat (MLE)	293.6					nu star (bias corrected)	274.9
2079					MLE Mean (bias corrected)	0.0188					MLE Sd (bias corrected)	0.0106

	A	B	C	D	E	F	G	H	I	J	K	L
2080				95% Percentile of Chisquare (2kstar)		12.96					90% Percentile	0.033
2081					95% Percentile	0.0389					99% Percentile	0.0518
2082	**The following statistics are computed using Gamma ROS Statistics on Imputed Data**											
2083	**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**											
2084					WH	HW					WH	HW
2085	95% Approx. Gamma UTL with 95% Coverage				0.0461	0.0466				95% Approx. Gamma UPL	0.0391	0.0392
2086				95% Gamma USL	0.0633	0.0654						
2087												
2088	**Estimates of Gamma Parameters using KM Estimates**											
2089					Mean (KM)	0.0203					SD (KM)	0.0116
2090					Variance (KM)	1.3479E-4					SE of Mean (KM)	0.00179
2091					k hat (KM)	3.064					k star (KM)	2.871
2092					nu hat (KM)	269.7					nu star (KM)	252.6
2093					theta hat (KM)	0.00663					theta star (KM)	0.00708
2094					80% gamma percentile (KM)	0.0291					90% gamma percentile (KM)	0.0364
2095					95% gamma percentile (KM)	0.0432					99% gamma percentile (KM)	0.058
2096												
2097	**The following statistics are computed using gamma distribution and KM estimates**											
2098	**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**											
2099					WH	HW					WH	HW
2100	95% Approx. Gamma UTL with 95% Coverage				0.0432	0.0432				95% Approx. Gamma UPL	0.0376	0.0374
2101				95% KM Gamma Percentile	0.0369	0.0367				95% Gamma USL	0.0566	0.0574
2102												
2103	**Lognormal GOF Test on Detected Observations Only**											
2104					Shapiro Wilk Test Statistic	0.902	**Shapiro Wilk GOF Test**					
2105					5% Shapiro Wilk Critical Value	0.914	Data Not Lognormal at 5% Significance Level					
2106					Lilliefors Test Statistic	0.122	**Lilliefors GOF Test**					
2107					5% Lilliefors Critical Value	0.18	Detected Data appear Lognormal at 5% Significance Level					
2108	**Detected Data appear Approximate Lognormal at 5% Significance Level**											
2109												
2110	**Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects**											
2111					Mean in Original Scale	0.0185					Mean in Log Scale	-4.165
2112					SD in Original Scale	0.013					SD in Log Scale	0.572
2113					95% UTL95% Coverage	0.0513					95% BCA UTL95% Coverage	0.0712
2114					95% Bootstrap (%) UTL95% Coverage	0.0723					95% UPL (t)	0.0411
2115					90% Percentile (z)	0.0323					95% Percentile (z)	0.0398
2116					99% Percentile (z)	0.0587					95% USL	0.0818
2117												
2118	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
2119					KM Mean of Logged Data	-3.999					95% KM UTL (Lognormal)95% Coverage	0.0435
2120					KM SD of Logged Data	0.413					95% KM UPL (Lognormal)	0.037
2121					95% KM Percentile Lognormal (z)	0.0362					95% KM USL (Lognormal)	0.0609
2122												
2123	**Background DL/2 Statistics Assuming Lognormal Distribution**											
2124					Mean in Original Scale	0.0177					Mean in Log Scale	-4.26
2125					SD in Original Scale	0.0136					SD in Log Scale	0.652
2126					95% UTL95% Coverage	0.0552					95% UPL (t)	0.0428
2127					90% Percentile (z)	0.0326					95% Percentile (z)	0.0413
2128					99% Percentile (z)	0.0644					95% USL	0.094

	A	B	C	D	E	F	G	H	I	J	K	L
2129	DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.											
2130												
2131	Nonparametric Distribution Free Background Statistics											
2132	Data appear to follow a Discernible Distribution at 5% Significance Level											
2133												
2134	Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)											
2135					Order of Statistic, r	44			95% UTL with95% Coverage			0.0773
2136					Approx, f used to compute achieved CC	2.316			Approximate Actual Confidence Coefficient achieved by UTL			0.895
2137					Approximate Sample Size needed to achieve specified CC	59			95% UPL			0.0424
2138					95% USL	0.0773			95% KM Chebyshev UPL			0.0715
2139												
2140	Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.											
2141	Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers											
2142	and consists of observations collected from clean unimpacted locations.											
2143	The use of USL tends to provide a balance between false positives and false negatives provided the data											
2144	represents a background data set and when many onsite observations need to be compared with the BTV.											
2145												
2352	Thallium											
2353												
2354	General Statistics											
2355					Total Number of Observations	44			Number of Distinct Observations			40
2356					Minimum	0.0968			First Quartile			0.145
2357					Second Largest	0.424			Median			0.181
2358					Maximum	0.532			Third Quartile			0.231
2359					Mean	0.2			SD			0.0813
2360					Coefficient of Variation	0.407			Skewness			2.07
2361					Mean of logged Data	-1.674			SD of logged Data			0.349
2362												
2363	Critical Values for Background Threshold Values (BTVs)											
2364					Tolerance Factor K (For UTL)	2.091			d2max (for USL)			2.906
2365												
2366	Normal GOF Test											
2367					Shapiro Wilk Test Statistic	0.834			Shapiro Wilk GOF Test			
2368					5% Shapiro Wilk Critical Value	0.944			Data Not Normal at 5% Significance Level			
2369					Lilliefors Test Statistic	0.146			Lilliefors GOF Test			
2370					5% Lilliefors Critical Value	0.132			Data Not Normal at 5% Significance Level			
2371	Data Not Normal at 5% Significance Level											
2372												
2373	Background Statistics Assuming Normal Distribution											
2374					95% UTL with 95% Coverage	0.37			90% Percentile (z)			0.304
2375					95% UPL (t)	0.338			95% Percentile (z)			0.334
2376					95% USL	0.436			99% Percentile (z)			0.389
2377												
2378	Gamma GOF Test											
2379					A-D Test Statistic	0.594			Anderson-Darling Gamma GOF Test			
2380					5% A-D Critical Value	0.75			Detected data appear Gamma Distributed at 5% Significance Level			
2381					K-S Test Statistic	0.0924			Kolmogorov-Smirnov Gamma GOF Test			
2382					5% K-S Critical Value	0.133			Detected data appear Gamma Distributed at 5% Significance Level			
2383	Detected data appear Gamma Distributed at 5% Significance Level											

	A	B	C	D	E	F	G	H	I	J	K	L
2384												
2385						Gamma Statistics						
2386					k hat (MLE)	7.929				k star (bias corrected MLE)		7.404
2387					Theta hat (MLE)	0.0252				Theta star (bias corrected MLE)		0.027
2388					nu hat (MLE)	697.8				nu star (bias corrected)		651.5
2389					MLE Mean (bias corrected)	0.2				MLE Sd (bias corrected)		0.0735
2390												
2391						Background Statistics Assuming Gamma Distribution						
2392					95% Wilson Hilferty (WH) Approx. Gamma UPL	0.336				90% Percentile		0.298
2393					95% Hawkins Wixley (HW) Approx. Gamma UPL	0.336				95% Percentile		0.334
2394					95% WH Approx. Gamma UTL with 95% Coverage	0.377				99% Percentile		0.409
2395					95% HW Approx. Gamma UTL with 95% Coverage	0.379						
2396					95% WH USL	0.474				95% HW USL		0.482
2397												
2398						Lognormal GOF Test						
2399					Shapiro Wilk Test Statistic	0.969				Shapiro Wilk Lognormal GOF Test		
2400					5% Shapiro Wilk Critical Value	0.944				Data appear Lognormal at 5% Significance Level		
2401					Lilliefors Test Statistic	0.067				Lilliefors Lognormal GOF Test		
2402					5% Lilliefors Critical Value	0.132				Data appear Lognormal at 5% Significance Level		
2403						Data appear Lognormal at 5% Significance Level						
2404												
2405						Background Statistics assuming Lognormal Distribution						
2406					95% UTL with 95% Coverage	0.389				90% Percentile (z)		0.293
2407					95% UPL (t)	0.34				95% Percentile (z)		0.333
2408					95% USL	0.518				99% Percentile (z)		0.423
2409												
2410						Nonparametric Distribution Free Background Statistics						
2411						Data appear Gamma Distributed at 5% Significance Level						
2412												
2413						Nonparametric Upper Limits for Background Threshold Values						
2414					Order of Statistic, r	44				95% UTL with 95% Coverage		0.532
2415					Approx, f used to compute achieved CC	2.316				Approximate Actual Confidence Coefficient achieved by UTL		0.895
2416										Approximate Sample Size needed to achieve specified CC		59
2417					95% Percentile Bootstrap UTL with 95% Coverage	0.497				95% BCA Bootstrap UTL with 95% Coverage		0.497
2418					95% UPL	0.393				90% Percentile		0.276
2419					90% Chebyshev UPL	0.447				95% Percentile		0.299
2420					95% Chebyshev UPL	0.558				99% Percentile		0.486
2421					95% USL	0.532						
2422												
2423						Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.						
2424						Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers						
2425						and consists of observations collected from clean unimpacted locations.						
2426						The use of USL tends to provide a balance between false positives and false negatives provided the data						
2427						represents a background data set and when many onsite observations need to be compared with the BTV.						
2428												
2429	Vanadium											
2430												
2431	General Statistics											
2432					Total Number of Observations	44				Number of Distinct Observations		41

	A	B	C	D	E	F	G	H	I	J	K	L
2433					Minimum	6.28					First Quartile	13.78
2434					Second Largest	34.6					Median	17.65
2435					Maximum	41.8					Third Quartile	24.65
2436					Mean	19.24					SD	7.921
2437					Coefficient of Variation	0.412					Skewness	0.654
2438					Mean of logged Data	2.869					SD of logged Data	0.436
2439												
2440					**Critical Values for Background Threshold Values (BTVs)**							
2441					Tolerance Factor K (For UTL)	2.091					d2max (for USL)	2.906
2442												
2443					**Normal GOF Test**							
2444					Shapiro Wilk Test Statistic	0.961			**Shapiro Wilk GOF Test**			
2445					5% Shapiro Wilk Critical Value	0.944			Data appear Normal at 5% Significance Level			
2446					Lilliefors Test Statistic	0.0996			**Lilliefors GOF Test**			
2447					5% Lilliefors Critical Value	0.132			Data appear Normal at 5% Significance Level			
2448					**Data appear Normal at 5% Significance Level**							
2449												
2450					**Background Statistics Assuming Normal Distribution**							
2451				95% UTL with	95% Coverage	35.8					90% Percentile (z)	29.39
2452					95% UPL (t)	32.7					95% Percentile (z)	32.26
2453					95% USL	42.26					99% Percentile (z)	37.66
2454												
2455					**Gamma GOF Test**							
2456					A-D Test Statistic	0.194			**Anderson-Darling Gamma GOF Test**			
2457					5% A-D Critical Value	0.752			Detected data appear Gamma Distributed at 5% Significance Level			
2458					K-S Test Statistic	0.0792			**Kolmogorov-Smirnov Gamma GOF Test**			
2459					5% K-S Critical Value	0.134			Detected data appear Gamma Distributed at 5% Significance Level			
2460					**Detected data appear Gamma Distributed at 5% Significance Level**							
2461												
2462					**Gamma Statistics**							
2463					k hat (MLE)	5.889					k star (bias corrected MLE)	5.502
2464					Theta hat (MLE)	3.267					Theta star (bias corrected MLE)	3.496
2465					nu hat (MLE)	518.2					nu star (bias corrected)	484.2
2466					MLE Mean (bias corrected)	19.24					MLE Sd (bias corrected)	8.2
2467												
2468					**Background Statistics Assuming Gamma Distribution**							
2469					95% Wilson Hilferty (WH) Approx. Gamma UPL	34.7					90% Percentile	30.21
2470					95% Hawkins Wixley (HW) Approx. Gamma UPL	35.15					95% Percentile	34.4
2471					95% WH Approx. Gamma UTL with 95% Coverage	39.56					99% Percentile	43.23
2472					95% HW Approx. Gamma UTL with 95% Coverage	40.39						
2473					95% WH USL	51.1					95% HW USL	53.18
2474												
2475					**Lognormal GOF Test**							
2476					Shapiro Wilk Test Statistic	0.974			**Shapiro Wilk Lognormal GOF Test**			
2477					5% Shapiro Wilk Critical Value	0.944			Data appear Lognormal at 5% Significance Level			
2478					Lilliefors Test Statistic	0.105			**Lilliefors Lognormal GOF Test**			
2479					5% Lilliefors Critical Value	0.132			Data appear Lognormal at 5% Significance Level			
2480					**Data appear Lognormal at 5% Significance Level**							
2481												

	A	B	C	D	E	F	G	H	I	J	K	L
2482	Background Statistics assuming Lognormal Distribution											
2483					95% UTL with 95% Coverage	43.82					90% Percentile (z)	30.8
2484					95% UPL (t)	36.96					95% Percentile (z)	36.08
2485					95% USL	62.51					99% Percentile (z)	48.55
2486												
2487	Nonparametric Distribution Free Background Statistics											
2488	Data appear Normal at 5% Significance Level											
2489												
2490	Nonparametric Upper Limits for Background Threshold Values											
2491					Order of Statistic, r	44					95% UTL with 95% Coverage	41.8
2492					Approx, f used to compute achieved CC	2.316					Approximate Actual Confidence Coefficient achieved by UTL	0.895
2493											Approximate Sample Size needed to achieve specified CC	59
2494					95% Percentile Bootstrap UTL with 95% Coverage	40.72					95% BCA Bootstrap UTL with 95% Coverage	40.72
2495					95% UPL	34.48					90% Percentile	29.64
2496					90% Chebyshev UPL	43.27					95% Percentile	33.71
2497					95% Chebyshev UPL	54.15					99% Percentile	38.7
2498					95% USL	41.8						
2499												
2500	Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.											
2501	Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers											
2502	and consists of observations collected from clean unimpacted locations.											
2503	The use of USL tends to provide a balance between false positives and false negatives provided the data											
2504	represents a background data set and when many onsite observations need to be compared with the BTV.											
2505												
2506	Zinc											
2507												
2508	General Statistics											
2509					Total Number of Observations	44					Number of Distinct Observations	43
2510					Minimum	14.8					First Quartile	27.7
2511					Second Largest	107					Median	34.85
2512					Maximum	110					Third Quartile	56.45
2513					Mean	43.49					SD	24.62
2514					Coefficient of Variation	0.566					Skewness	1.268
2515					Mean of logged Data	3.633					SD of logged Data	0.528
2516												
2517	Critical Values for Background Threshold Values (BTVs)											
2518					Tolerance Factor K (For UTL)	2.091					d2max (for USL)	2.906
2519												
2520	Normal GOF Test											
2521					Shapiro Wilk Test Statistic	0.863					Shapiro Wilk GOF Test	
2522					5% Shapiro Wilk Critical Value	0.944					Data Not Normal at 5% Significance Level	
2523					Lilliefors Test Statistic	0.179					Lilliefors GOF Test	
2524					5% Lilliefors Critical Value	0.132					Data Not Normal at 5% Significance Level	
2525	Data Not Normal at 5% Significance Level											
2526												
2527	Background Statistics Assuming Normal Distribution											
2528					95% UTL with 95% Coverage	94.98					90% Percentile (z)	75.05
2529					95% UPL (t)	85.35					95% Percentile (z)	83.99
2530					95% USL	115.1					99% Percentile (z)	100.8

	A	B	C	D	E	F	G	H	I	J	K	L
2531												
2532						Gamma GOF Test						
2533					A-D Test Statistic	0.615	Anderson-Darling Gamma GOF Test					
2534					5% A-D Critical Value	0.753	Detected data appear Gamma Distributed at 5% Significance Level					
2535					K-S Test Statistic	0.134	Kolmogorov-Smirnov Gamma GOF Test					
2536					5% K-S Critical Value	0.134	Data Not Gamma Distributed at 5% Significance Level					
2537					Detected data follow Appr. Gamma Distribution at 5% Significance Level							
2538												
2539						Gamma Statistics						
2540					k hat (MLE)	3.738	k star (bias corrected MLE)					3.498
2541					Theta hat (MLE)	11.63	Theta star (bias corrected MLE)					12.43
2542					nu hat (MLE)	329	nu star (bias corrected)					307.9
2543					MLE Mean (bias corrected)	43.49	MLE Sd (bias corrected)					23.25
2544												
2545					Background Statistics Assuming Gamma Distribution							
2546					95% Wilson Hilferty (WH) Approx. Gamma UPL	88.21	90% Percentile					74.67
2547					95% Hawkins Wixley (HW) Approx. Gamma UPL	89.07	95% Percentile					87.41
2548					95% WH Approx. Gamma UTL with 95% Coverage	103.2	99% Percentile					114.8
2549					95% HW Approx. Gamma UTL with 95% Coverage	105.3						
2550					95% WH USL	139.9	95% HW USL					146.2
2551												
2552						Lognormal GOF Test						
2553					Shapiro Wilk Test Statistic	0.965	Shapiro Wilk Lognormal GOF Test					
2554					5% Shapiro Wilk Critical Value	0.944	Data appear Lognormal at 5% Significance Level					
2555					Lilliefors Test Statistic	0.102	Lilliefors Lognormal GOF Test					
2556					5% Lilliefors Critical Value	0.132	Data appear Lognormal at 5% Significance Level					
2557					Data appear Lognormal at 5% Significance Level							
2558												
2559					Background Statistics assuming Lognormal Distribution							
2560					95% UTL with 95% Coverage	114.1	90% Percentile (z)					74.43
2561					95% UPL (t)	92.84	95% Percentile (z)					90.17
2562					95% USL	175.6	99% Percentile (z)					129.2
2563												
2564					Nonparametric Distribution Free Background Statistics							
2565					Data appear Approximate Gamma Distribution at 5% Significance Level							
2566												
2567					Nonparametric Upper Limits for Background Threshold Values							
2568					Order of Statistic, r	44	95% UTL with 95% Coverage					110
2569					Approx, f used to compute achieved CC	2.316	Approximate Actual Confidence Coefficient achieved by UTL					0.895
2570							Approximate Sample Size needed to achieve specified CC					59
2571					95% Percentile Bootstrap UTL with 95% Coverage	109.6	95% BCA Bootstrap UTL with 95% Coverage					107
2572					95% UPL	105.5	90% Percentile					77.79
2573					90% Chebyshev UPL	118.2	95% Percentile					99.29
2574					95% Chebyshev UPL	152	99% Percentile					108.7
2575					95% USL	110						
2576												
2577					Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.							
2578					Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers							
2579					and consists of observations collected from clean unimpacted locations.							

	A	B	C	D	E	F	G	H	I	J	K	L
2580	The use of USL tends to provide a balance between false positives and false negatives provided the data											
2581	represents a background data set and when many onsite observations need to be compared with the BTV.											
2582												
2815	**Radium-226 & 228**											
2816												
2817	**General Statistics**											
2818					Total Number of Observations	44				Number of Distinct Observations		36
2819					Minimum	0.755				First Quartile		1.623
2820					Second Largest	3.1				Median		2.11
2821					Maximum	3.14				Third Quartile		2.478
2822					Mean	2.063				SD		0.576
2823					Coefficient of Variation	0.279				Skewness		-0.178
2824					Mean of logged Data	0.68				SD of logged Data		0.313
2825												
2826	**Critical Values for Background Threshold Values (BTVs)**											
2827					Tolerance Factor K (For UTL)	2.091				d2max (for USL)		2.906
2828												
2829	**Normal GOF Test**											
2830					Shapiro Wilk Test Statistic	0.973				**Shapiro Wilk GOF Test**		
2831					5% Shapiro Wilk Critical Value	0.944				Data appear Normal at 5% Significance Level		
2832					Lilliefors Test Statistic	0.106				**Lilliefors GOF Test**		
2833					5% Lilliefors Critical Value	0.132				Data appear Normal at 5% Significance Level		
2834	**Data appear Normal at 5% Significance Level**											
2835												
2836	**Background Statistics Assuming Normal Distribution**											
2837					95% UTL with 95% Coverage	3.268				90% Percentile (z)		2.801
2838					95% UPL (t)	3.043				95% Percentile (z)		3.011
2839					95% USL	3.737				99% Percentile (z)		3.403
2840												
2841	**Gamma GOF Test**											
2842					A-D Test Statistic	0.538				**Anderson-Darling Gamma GOF Test**		
2843					5% A-D Critical Value	0.748				Detected data appear Gamma Distributed at 5% Significance Level		
2844					K-S Test Statistic	0.123				**Kolmogorov-Smirnov Gamma GOF Test**		
2845					5% K-S Critical Value	0.133				Detected data appear Gamma Distributed at 5% Significance Level		
2846	**Detected data appear Gamma Distributed at 5% Significance Level**											
2847												
2848	**Gamma Statistics**											
2849					k hat (MLE)	11.57				k star (bias corrected MLE)		10.8
2850					Theta hat (MLE)	0.178				Theta star (bias corrected MLE)		0.191
2851					nu hat (MLE)	1018				nu star (bias corrected)		950.1
2852					MLE Mean (bias corrected)	2.063				MLE Sd (bias corrected)		0.628
2853												
2854	**Background Statistics Assuming Gamma Distribution**											
2855					95% Wilson Hilferty (WH) Approx. Gamma UPL	3.212				90% Percentile		2.897
2856					95% Hawkins Wixley (HW) Approx. Gamma UPL	3.244				95% Percentile		3.193
2857					95% WH Approx. Gamma UTL with 95% Coverage	3.545				99% Percentile		3.797
2858					95% HW Approx. Gamma UTL with 95% Coverage	3.598						
2859					95% WH USL	4.312				95% HW USL		4.429
2860												

	A	B	C	D	E	F	G	H	I	J	K	L
2861	**Lognormal GOF Test**											
2862					Shapiro Wilk Test Statistic	0.939	**Shapiro Wilk Lognormal GOF Test**					
2863					5% Shapiro Wilk Critical Value	0.944	Data Not Lognormal at 5% Significance Level					
2864					Lilliefors Test Statistic	0.125	**Lilliefors Lognormal GOF Test**					
2865					5% Lilliefors Critical Value	0.132	Data appear Lognormal at 5% Significance Level					
2866	**Data appear Approximate Lognormal at 5% Significance Level**											
2867												
2868	**Background Statistics assuming Lognormal Distribution**											
2869				95% UTL with	95% Coverage	3.799				90% Percentile (z)		2.949
2870					95% UPL (t)	3.361				95% Percentile (z)		3.304
2871					95% USL	4.903				99% Percentile (z)		4.089
2872												
2873	**Nonparametric Distribution Free Background Statistics**											
2874	**Data appear Normal at 5% Significance Level**											
2875												
2876	**Nonparametric Upper Limits for Background Threshold Values**											
2877					Order of Statistic, r	44				95% UTL with	95% Coverage	3.14
2878					Approx, f used to compute achieved CC	2.316	Approximate Actual Confidence Coefficient achieved by UTL					0.895
2879							Approximate Sample Size needed to achieve specified CC					59
2880			95% Percentile Bootstrap UTL with		95% Coverage	3.134				95% BCA Bootstrap UTL with	95% Coverage	3.1
2881					95% UPL	3.035				90% Percentile		2.747
2882					90% Chebyshev UPL	3.811				95% Percentile		2.837
2883					95% Chebyshev UPL	4.603				99% Percentile		3.123
2884					95% USL	3.14						
2885												
2886	Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.											
2887	Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers											
2888	and consists of observations collected from clean unimpacted locations.											
2889	The use of USL tends to provide a balance between false positives and false negatives provided the data											
2890	represents a background data set and when many onsite observations need to be compared with the BTV.											
2891												

	A	B	C	D	E	F	G	H	I	J	K	L	M
1				General Statistics on Uncensored Data									
2		Date/Time of Computation		ProUCL 5.15/12/2020 3:05:17 PM									
3		User Selected Options											
4		From File		2020-0512_HAI-Bkg Soil ProUCL Input_c.xls									
5		Full Precision		OFF									
6													
7	From File: 2020-0512_HAI-Bkg Soil ProUCL Input_c.xls												
8													
9	General Statistics for Censored Data Set (with NDs) using Kaplan Meier Method												
10													
11	Variable		NumObs	# Missing	Num Ds	NumNDs	% NDs	Min ND	Max ND	KM Mean	KM Var	KM SD	KM CV
13	Antimony		44	0	40	4	9.09%	0.0351	0.0402	0.145	0.0062	0.0787	0.541
14	Arsenic		44	0	44	0	0.00%	N/A	N/A	5.593	7.944	2.818	0.504
15	Barium		44	0	44	0	0.00%	N/A	N/A	91.22	3038	55.12	0.604
16	Beryllium		44	0	44	0	0.00%	N/A	N/A	1.085	0.345	0.587	0.541
17	Boron		44	0	29	15	34.09%	1.28	1.65	3.148	5.307	2.304	0.732
18	Cadmium		44	0	37	7	15.91%	0.0117	0.0594	0.0993	0.0141	0.119	1.195
19	Calcium		44	0	44	0	0.00%	N/A	N/A	17943	9.440E+8	30725	1.712
20	Chromium		44	0	44	0	0.00%	N/A	N/A	13.18	23.74	4.872	0.37
21	Cobalt		44	0	44	0	0.00%	N/A	N/A	9.295	13.44	3.666	0.394
22	Copper		44	0	44	0	0.00%	N/A	N/A	10.42	23.17	4.814	0.462
24	Lead		44	0	44	0	0.00%	N/A	N/A	13.09	44.11	6.642	0.507
25	Lithium		44	0	44	0	0.00%	N/A	N/A	8.562	22.12	4.703	0.549
28	Mercury		44	0	37	7	15.91%	0.00855	0.104	0.0472	7.1197E-4	0.0267	0.565
29	Molybdenum		44	0	43	1	2.27%	0.201	0.201	0.789	0.27	0.52	0.658
30	Nickel		44	0	44	0	0.00%	N/A	N/A	14.73	55.17	7.427	0.504
32	Selenium		44	0	42	2	4.55%	0.136	0.142	0.665	0.504	0.71	1.068
34	Silver		44	0	23	21	47.73%	0.0131	0.0167	0.0203	1.3479E-4	0.0116	0.571
37	Thallium		44	0	44	0	0.00%	N/A	N/A	0.2	0.00661	0.0813	0.407
38	Vanadium		44	0	44	0	0.00%	N/A	N/A	19.24	62.74	7.921	0.412
39	Zinc		44	0	44	0	0.00%	N/A	N/A	43.49	606.3	24.62	0.566
43	Radium-226 & 228		44	0	44	0	0.00%	N/A	N/A	2.063	0.332	0.576	0.279
44													
45	General Statistics for Raw Data Sets using Detected Data Only												
46													
47	Variable		NumObs	# Missing	Minimum	Maximum	Mean	Median	Var	SD	MAD/0.675	Skewness	CV
49	Antimony		40	0	0.04	0.33	0.157	0.169	0.00562	0.075	0.0882	0.151	0.479
50	Arsenic		44	0	1.61	13.7	5.593	4.95	7.944	2.818	2.513	1.015	0.504
51	Barium		44	0	20	231	91.22	86.2	3038	55.12	55.89	0.808	0.604
52	Beryllium		44	0	0.235	2.86	1.085	0.97	0.345	0.587	0.623	0.801	0.541
53	Boron		29	0	1.55	10.7	4.107	3.73	5.543	2.354	2.535	1.058	0.573
54	Cadmium		37	0	0.013	0.587	0.114	0.0771	0.0158	0.126	0.0535	2.364	1.101
55	Calcium		44	0	164	137000	17943	5005	9.440E+8	30725	6791	2.536	1.712
56	Chromium		44	0	6.4	31.2	13.18	12.1	23.74	4.872	4.67	1.227	0.37
57	Cobalt		44	0	1.44	16.1	9.295	9.015	13.44	3.666	3.632	-0.119	0.394
58	Copper		44	0	4.61	23.3	10.42	8.955	23.17	4.814	2.936	1.265	0.462
60	Lead		44	0	4.01	30.8	13.09	11.95	44.11	6.642	5.367	1.108	0.507
61	Lithium		44	0	1.94	17	8.562	9.01	22.12	4.703	6.568	0.174	0.549
64	Mercury		37	0	0.0235	0.165	0.0507	0.0434	7.5498E-4	0.0275	0.0156	2.554	0.542
65	Molybdenum		43	0	0.161	2.29	0.804	0.72	0.274	0.523	0.532	0.995	0.651
66	Nickel		44	0	4.99	37.1	14.73	13.95	55.17	7.427	9.348	0.725	0.504
68	Selenium		42	0	0.126	3.3	0.69	0.459	0.526	0.725	0.199	2.54	1.051
70	Silver		23	0	0.0158	0.0773	0.0268	0.0235	1.7815E-4	0.0133	0.00815	2.696	0.499
73	Thallium		44	0	0.0968	0.532	0.2	0.181	0.00661	0.0813	0.0638	2.07	0.407

	A	B	C	D	E	F	G	H	I	J	K	L	M
74		Vanadium	44	0	6.28	41.8	19.24	17.65	62.74	7.921	9.266	0.654	0.412
75		Zinc	44	0	14.8	110	43.49	34.85	606.3	24.62	17.05	1.268	0.566
79		Radium-226 & 228	44	0	0.755	3.14	2.063	2.11	0.332	0.576	0.704	-0.178	0.279
80													
81	**Percentiles using all Detects (Ds) and Non-Detects (NDs)**												
82													
83	**Variable**		**NumObs**	**# Missing**	**10%ile**	**20%ile**	**25%ile(Q1)**	**50%ile(Q2)**	**75%ile(Q3)**	**80%ile**	**90%ile**	**95%ile**	**99%ile**
85		Antimony	44	0	0.0407	0.0559	0.0859	0.148	0.211	0.226	0.242	0.252	0.313
86		Arsenic	44	0	2.818	3.26	3.378	4.95	6.983	7.792	9.235	10.54	13.31
87		Barium	44	0	25.73	46.64	48.6	86.2	123.3	137	151.2	196.1	230.6
88		Beryllium	44	0	0.371	0.589	0.644	0.97	1.468	1.51	1.821	2.13	2.555
89		Boron	44	0	1.443	1.494	1.558	2.135	4.105	4.754	6.911	7.461	9.659
90		Cadmium	44	0	0.0242	0.0292	0.0337	0.0762	0.0872	0.104	0.246	0.375	0.516
91		Calcium	44	0	419.1	632	809.8	5005	17925	20680	48300	91000	123240
92		Chromium	44	0	7.428	9.636	10.45	12.1	15.7	16.5	19.07	19.81	27.24
93		Cobalt	44	0	5.811	6.348	6.768	9.015	11.93	12.24	14.17	15.48	16.06
94		Copper	44	0	5.651	7.086	7.145	8.955	11.9	13.3	17.45	20.32	23.17
96		Lead	44	0	5.639	8.094	8.345	11.95	14.65	17.08	24.43	27.68	29.77
97		Lithium	44	0	2.81	3.772	4.24	9.01	12.05	13.3	14.95	15.74	16.7
100		Mercury	44	0	0.0269	0.033	0.0341	0.0431	0.0558	0.0588	0.0714	0.104	0.144
101		Molybdenum	44	0	0.228	0.27	0.359	0.718	1.07	1.158	1.479	1.804	2.183
102		Nickel	44	0	5.974	7.35	7.55	13.95	20.13	20.54	23	25.76	34.26
104		Selenium	44	0	0.207	0.268	0.314	0.438	0.582	0.674	1.492	2.274	3.223
106		Silver	44	0	0.0147	0.0151	0.0155	0.0165	0.0239	0.026	0.0315	0.0367	0.0631
109		Thallium	44	0	0.128	0.138	0.145	0.181	0.231	0.251	0.276	0.299	0.486
110		Vanadium	44	0	9.98	12.28	13.78	17.65	24.65	25.32	29.64	33.71	38.7
111		Zinc	44	0	18.74	23.36	27.7	34.85	56.45	59.38	77.79	99.29	108.7
115		Radium-226 & 228	44	0	1.393	1.558	1.623	2.11	2.478	2.6	2.747	2.837	3.123

	A	B	C	D	E	F	G	H	I	J	K	L
1					**Outlier Tests for Selected Variables excluding nondetects**							
2			**User Selected Options**									
3			Date/Time of Computation	ProUCL 5.15/12/2020 3:06:04 PM								
4				From File	2020-0512_HAI-Bkg Soil ProUCL Input_c.xls							
5				Full Precision	OFF							
6												
7												
29			**Rosner's Outlier Test for 1 Outliers in Antimony**									
30												
31												
32			**Total N**	**44**								
33			**Number NDs**	**4**								
34			**Number Detects**	**40**								
35			**Mean of Detects**	**0.157**								
36			**SD of Detects**	**0.075**								
37			**Number of data**	**40**								
38			**Number of suspected outliers**	**1**								
39			**NDs not included in the following:**									
40												
41				Potential	Obs.	Test	Critical	Critical				
42	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
43	1	0.157	0.074	0.33	8	2.343	3.04	3.38				
44												
45	For 5% Significance Level, there is no Potential Outlier											
46												
47	For 1% Significance Level, there is no Potential Outlier											
48												
49												
50			**Rosner's Outlier Test for 1 Outliers in Arsenic**									
51												
52												
53			**Total N**	**44**								
54			**Number NDs**	**0**								
55			**Number Detects**	**44**								
56			**Mean of Detects**	**5.593**								
57			**SD of Detects**	**2.818**								
58			**Number of data**	**44**								
59			**Number of suspected outliers**	**1**								
60			**NDs not included in the following:**									
61												
62				Potential	Obs.	Test	Critical	Critical				
63	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
64	1	5.593	2.786	13.7	10	2.909	3.08	3.43				
65												
66	For 5% Significance Level, there is no Potential Outlier											
67												
68	For 1% Significance Level, there is no Potential Outlier											
69												
70												

	A	B	C	D	E	F	G	H	I	J	K	L
71	**Rosner's Outlier Test for 1 Outliers in Barium**											
72												
73												
74			**Total N**	**44**								
75			**Number NDs**	**0**								
76			**Number Detects**	**44**								
77			**Mean of Detects**	**91.22**								
78			**SD of Detects**	**55.12**								
79			**Number of data**	**44**								
80			**Number of suspected outliers**	**1**								
81	**NDs not included in the following:**											
82												
83				Potential	Obs.	Test	Critical	Critical				
84	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
85	1	91.22	54.49	231	42	2.565	3.08	3.43				
86												
87	For 5% Significance Level, there is no Potential Outlier											
88												
89	For 1% Significance Level, there is no Potential Outlier											
90												
91												
92	**Rosner's Outlier Test for 1 Outliers in Beryllium**											
93												
94												
95			**Total N**	**44**								
96			**Number NDs**	**0**								
97			**Number Detects**	**44**								
98			**Mean of Detects**	**1.085**								
99			**SD of Detects**	**0.587**								
100			**Number of data**	**44**								
101			**Number of suspected outliers**	**1**								
102	**NDs not included in the following:**											
103												
104				Potential	Obs.	Test	Critical	Critical				
105	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
106	1	1.085	0.581	2.86	11	3.058	3.08	3.43				
107												
108	For 5% Significance Level, there is no Potential Outlier											
109												
110	For 1% Significance Level, there is no Potential Outlier											
111												
112												
113	**Rosner's Outlier Test for 1 Outliers in Boron**											
114												
115												
116			**Total N**	**44**								
117			**Number NDs**	**15**								
118			**Number Detects**	**29**								
119			**Mean of Detects**	**4.107**								

	A	B	C	D	E	F	G	H	I	J	K	L
120			SD of Detects	2.354								
121			Number of data	29								
122			Number of suspected outliers	1								
123	NDs not included in the following:											
124												
125				Potential	Obs.	Test	Critical	Critical				
126	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
127	1	4.107	2.313	10.7	3	2.85	2.89	3.22				
128												
129	For 5% Significance Level, there is no Potential Outlier											
130												
131	For 1% Significance Level, there is no Potential Outlier											
132												
133												
134	Rosner's Outlier Test for 1 Outliers in Cadmium											
135												
136												
137			Total N	44								
138			Number NDs	7								
139			Number Detects	37								
140			Mean of Detects	0.114								
141			SD of Detects	0.126								
142			Number of data	37								
143			Number of suspected outliers	1								
144	NDs not included in the following:											
145												
146				Potential	Obs.	Test	Critical	Critical				
147	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
148	1	0.114	0.124	0.587	20	3.818	3	3.34				
149												
150	For 5% Significance Level, there is 1 Potential Outlier											
151	Therefore, Observation 0.587 is a Potential Statistical Outlier											
152												
153	For 1% Significance Level, there is 1 Potential Outlier											
154												
155												
156	Rosner's Outlier Test for 1 Outliers in Calcium											
157												
158												
159			Total N	44								
160			Number NDs	0								
161			Number Detects	44								
162			Mean of Detects	17943								
163			SD of Detects	30725								
164			Number of data	44								
165			Number of suspected outliers	1								
166	NDs not included in the following:											
167												
168				Potential	Obs.	Test	Critical	Critical				

	A	B	C	D	E	F	G	H	I	J	K	L
169	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
170	1	17943	30374	137000	13	3.92	3.08	3.43				
171												
172	For 5% Significance Level, there is 1 Potential Outlier											
173	Therefore, Observation 137000 is a Potential Statistical Outlier											
174												
175	For 1% Significance Level, there is 1 Potential Outlier											
176												
177												
178	**Rosner's Outlier Test for 1 Outliers in Chromium**											
179												
180												
181	**Total N**			**44**								
182	**Number NDs**			**0**								
183	**Number Detects**			**44**								
184	**Mean of Detects**			**13.18**								
185	**SD of Detects**			**4.872**								
186	**Number of data**			**44**								
187	**Number of suspected outliers**			**1**								
188	**NDs not included in the following:**											
189												
190				Potential	Obs.	Test	Critical	Critical				
191	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
192	1	13.18	4.816	31.2	15	3.742	3.08	3.43				
193												
194	For 5% Significance Level, there is 1 Potential Outlier											
195	Therefore, Observation 31.2 is a Potential Statistical Outlier											
196												
197	For 1% Significance Level, there is 1 Potential Outlier											
198												
199												
200	**Rosner's Outlier Test for 1 Outliers in Cobalt**											
201												
202												
203	**Total N**			**44**								
204	**Number NDs**			**0**								
205	**Number Detects**			**44**								
206	**Mean of Detects**			**9.295**								
207	**SD of Detects**			**3.666**								
208	**Number of data**			**44**								
209	**Number of suspected outliers**			**1**								
210	**NDs not included in the following:**											
211												
212				Potential	Obs.	Test	Critical	Critical				
213	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
214	1	9.295	3.624	1.44	39	2.168	3.08	3.43				
215												
216	For 5% Significance Level, there is no Potential Outlier											
217												

	A	B	C	D	E	F	G	H	I	J	K	L
218	For 1% Significance Level, there is no Potential Outlier											
219												
220												
221	**Rosner's Outlier Test for 1 Outliers in Copper**											
222												
223												
224			**Total N**	**44**								
225			**Number NDs**	**0**								
226			**Number Detects**	**44**								
227			**Mean of Detects**	**10.42**								
228			**SD of Detects**	**4.814**								
229			**Number of data**	**44**								
230			**Number of suspected outliers**	**1**								
231	**NDs not included in the following:**											
232												
233				Potential	Obs.	Test	Critical	Critical				
234	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
235	1	10.42	4.759	23.3	27	2.708	3.08	3.43				
236												
237	For 5% Significance Level, there is no Potential Outlier											
238												
239	For 1% Significance Level, there is no Potential Outlier											
240												
241												
263	**Rosner's Outlier Test for 1 Outliers in Lead**											
264												
265												
266			**Total N**	**44**								
267			**Number NDs**	**0**								
268			**Number Detects**	**44**								
269			**Mean of Detects**	**13.09**								
270			**SD of Detects**	**6.642**								
271			**Number of data**	**44**								
272			**Number of suspected outliers**	**1**								
273	**NDs not included in the following:**											
274												
275				Potential	Obs.	Test	Critical	Critical				
276	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
277	1	13.09	6.566	30.8	15	2.697	3.08	3.43				
278												
279	For 5% Significance Level, there is no Potential Outlier											
280												
281	For 1% Significance Level, there is no Potential Outlier											
282												
283												
284	**Rosner's Outlier Test for 1 Outliers in Lithium**											
285												
286												
287			**Total N**	**44**								

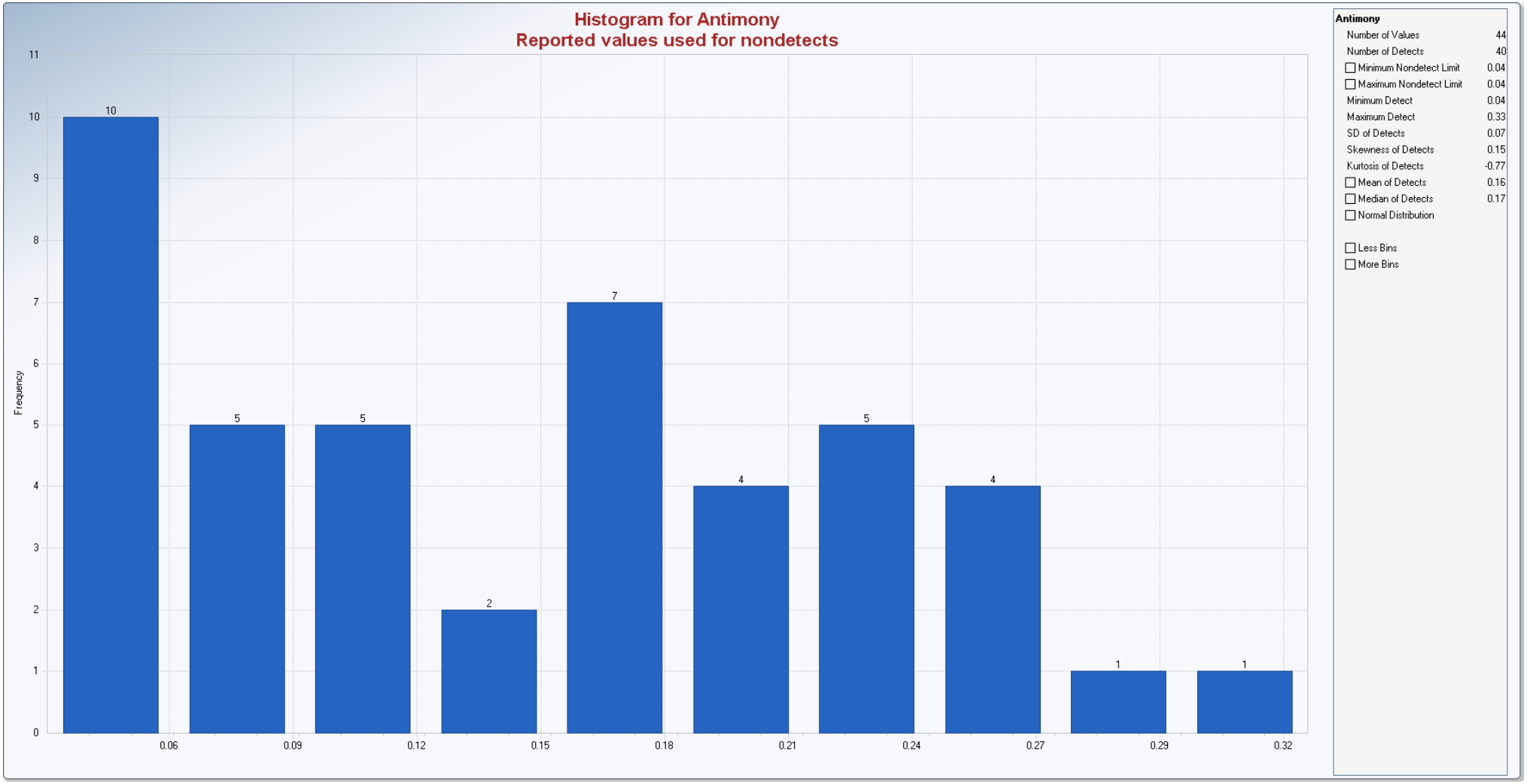
	A	B	C	D	E	F	G	H	I	J	K	L
288			Number NDs	0								
289			Number Detects	44								
290			Mean of Detects	8.562								
291			SD of Detects	4.703								
292			Number of data	44								
293			Number of suspected outliers	1								
294	NDs not included in the following:											
295												
296				Potential	Obs.	Test	Critical	Critical				
297	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
298	1	8.562	4.65	17	9	1.815	3.08	3.43				
299												
300	For 5% Significance Level, there is no Potential Outlier											
301												
302	For 1% Significance Level, there is no Potential Outlier											
303												
304												
349	Rosner's Outlier Test for 1 Outliers in Mercury											
350												
351												
352			Total N	44								
353			Number NDs	7								
354			Number Detects	37								
355			Mean of Detects	0.0507								
356			SD of Detects	0.0275								
357			Number of data	37								
358			Number of suspected outliers	1								
359	NDs not included in the following:											
360												
361				Potential	Obs.	Test	Critical	Critical				
362	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
363	1	0.0507	0.0271	0.165	7	4.218	3	3.34				
364												
365	For 5% Significance Level, there is 1 Potential Outlier											
366	Therefore, Observation 0.165 is a Potential Statistical Outlier											
367												
368	For 1% Significance Level, there is 1 Potential Outlier											
369												
370												
371	Rosner's Outlier Test for 1 Outliers in Molybdenum											
372												
373												
374			Total N	44								
375			Number NDs	1								
376			Number Detects	43								
377			Mean of Detects	0.804								
378			SD of Detects	0.523								
379			Number of data	43								
380			Number of suspected outliers	1								

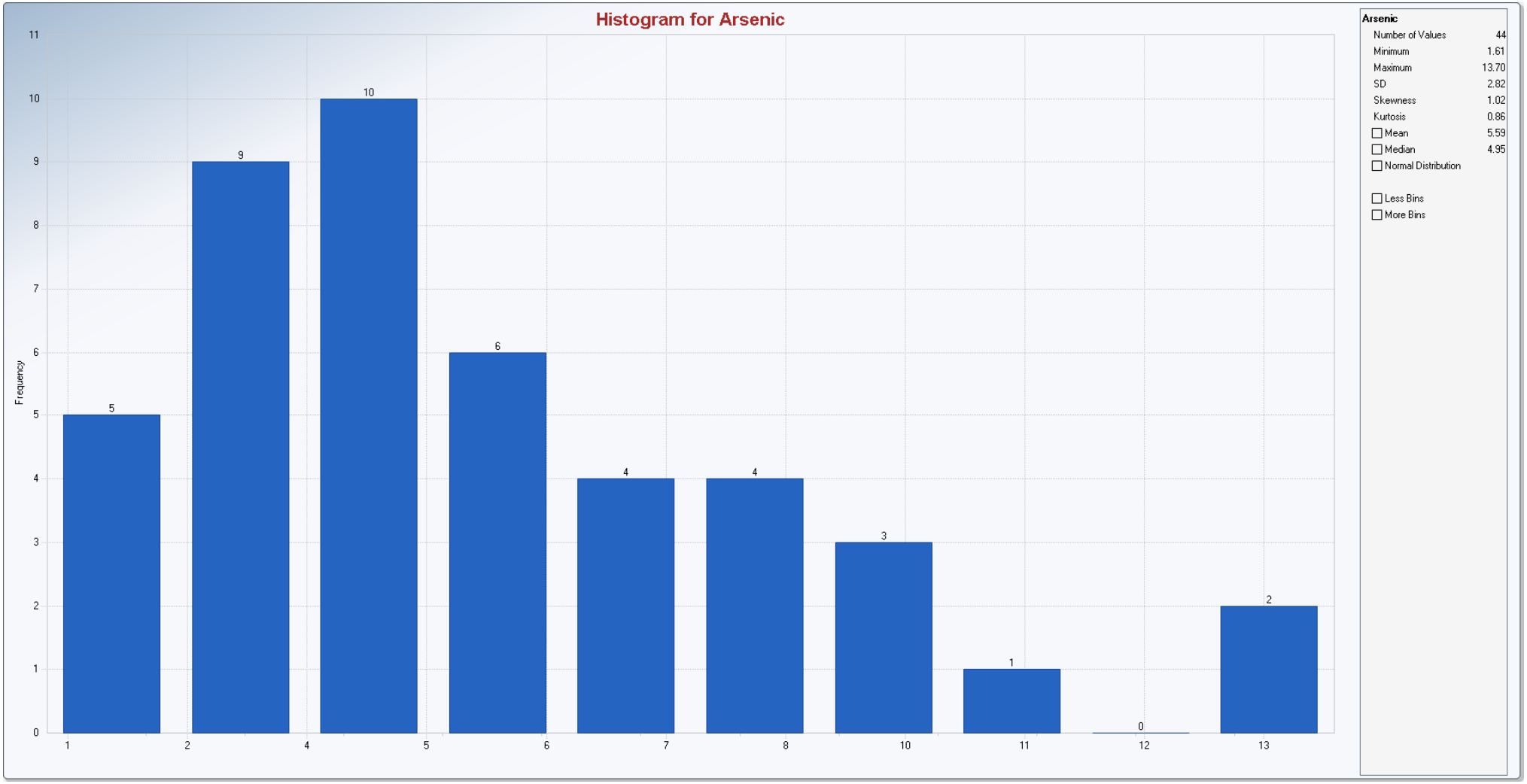
	A	B	C	D	E	F	G	H	I	J	K	L
381	**NDs not included in the following:**											
382												
383				Potential	Obs.	Test	Critical	Critical				
384	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
385	1	0.804	0.517	2.29	32	2.873	3.07	3.41				
386												
387	For 5% Significance Level, there is no Potential Outlier											
388												
389	For 1% Significance Level, there is no Potential Outlier											
390												
391												
392	**Rosner's Outlier Test for 1 Outliers in Nickel**											
393												
394												
395			**Total N**	**44**								
396			**Number NDs**	**0**								
397			**Number Detects**	**44**								
398			**Mean of Detects**	**14.73**								
399			**SD of Detects**	**7.427**								
400			**Number of data**	**44**								
401			**Number of suspected outliers**	**1**								
402	**NDs not included in the following:**											
403												
404				Potential	Obs.	Test	Critical	Critical				
405	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
406	1	14.73	7.343	37.1	36	3.046	3.08	3.43				
407												
408	For 5% Significance Level, there is no Potential Outlier											
409												
410	For 1% Significance Level, there is no Potential Outlier											
411												
412												
434	**Rosner's Outlier Test for 1 Outliers in Selenium**											
435												
436												
437			**Total N**	**44**								
438			**Number NDs**	**2**								
439			**Number Detects**	**42**								
440			**Mean of Detects**	**0.69**								
441			**SD of Detects**	**0.725**								
442			**Number of data**	**42**								
443			**Number of suspected outliers**	**1**								
444	**NDs not included in the following:**											
445												
446				Potential	Obs.	Test	Critical	Critical				
447	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
448	1	0.69	0.717	3.3	1	3.642	3.06	3.4				
449												
450	For 5% Significance Level, there is 1 Potential Outlier											

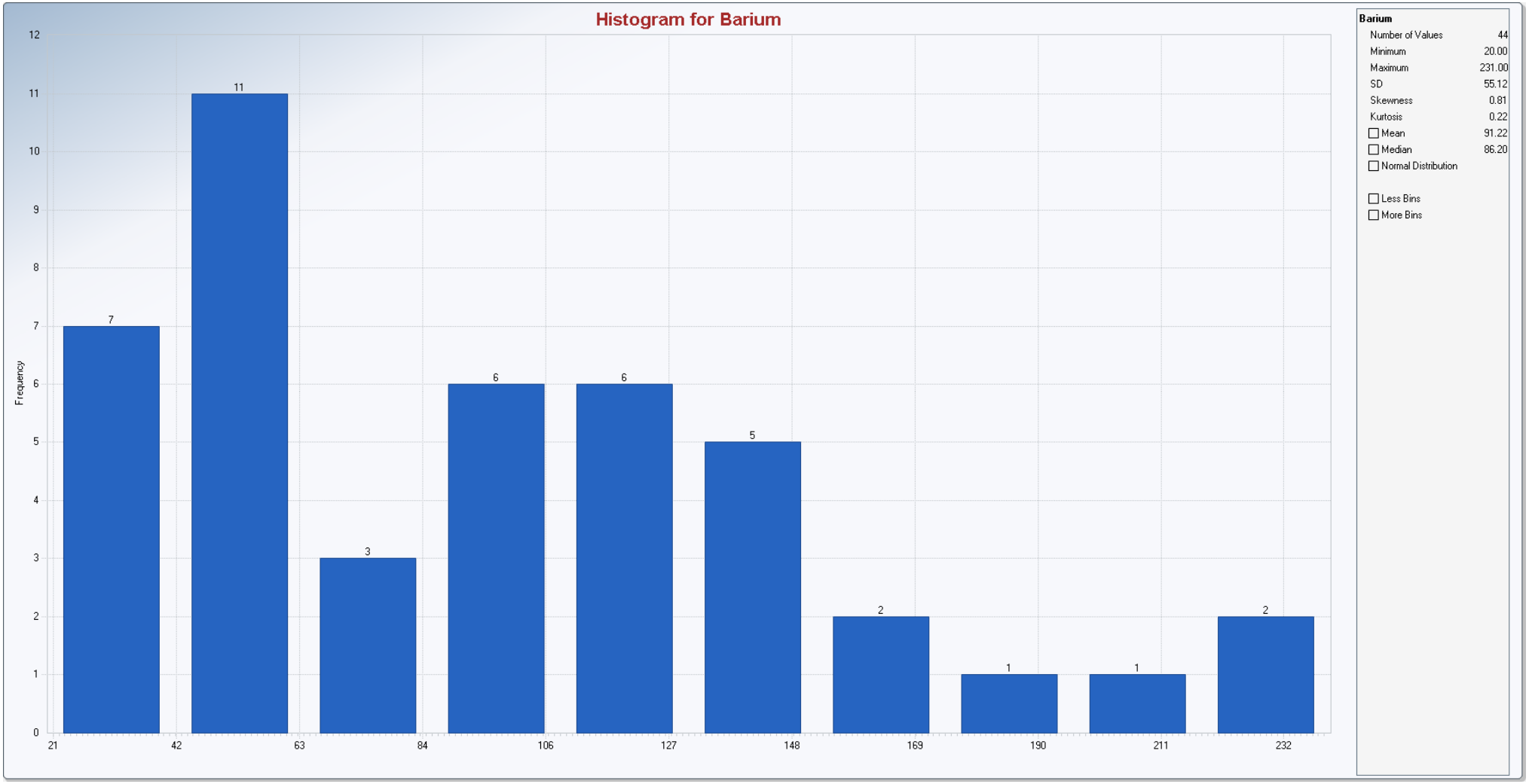
	A	B	C	D	E	F	G	H	I	J	K	L
451	Therefore, Observation 3.3 is a Potential Statistical Outlier											
452												
453	For 1% Significance Level, there is 1 Potential Outlier											
454												
455												
478	**Dixon's Outlier Test for Silver**											
479												
480	Total N = 44											
481	Number NDs = 21											
482	Number Detects = 23											
483	10% critical value: 0.374											
484	5% critical value: 0.421											
485	1% critical value: 0.505											
486	Note: NDs excluded from Outlier Test											
487												
488	**1. Data Value 0.0773 is a Potential Outlier (Upper Tail)?**											
489												
490	Test Statistic: 0.666											
491												
492	For 10% significance level, 0.0773 is an outlier.											
493	For 5% significance level, 0.0773 is an outlier.											
494	For 1% significance level, 0.0773 is an outlier.											
495												
496	**2. Data Value 0.0158 is a Potential Outlier (Lower Tail)?**											
497												
498	Test Statistic: 0.033											
499												
500	For 10% significance level, 0.0158 is not an outlier.											
501	For 5% significance level, 0.0158 is not an outlier.											
502	For 1% significance level, 0.0158 is not an outlier.											
503												
504												
547	**Rosner's Outlier Test for 1 Outliers in Thallium**											
548												
549												
550				**Total N**	**44**							
551				**Number NDs**	**0**							
552				**Number Detects**	**44**							
553				**Mean of Detects**	**0.2**							
554				**SD of Detects**	**0.0813**							
555				**Number of data**	**44**							
556				**Number of suspected outliers**	**1**							
557				**NDs not included in the following:**								
558												
559				Potential	Obs.	Test	Critical	Critical				
560	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
561	1	0.2	0.0804	0.532	41	4.13	3.08	3.43				
562												
563	For 5% Significance Level, there is 1 Potential Outlier											

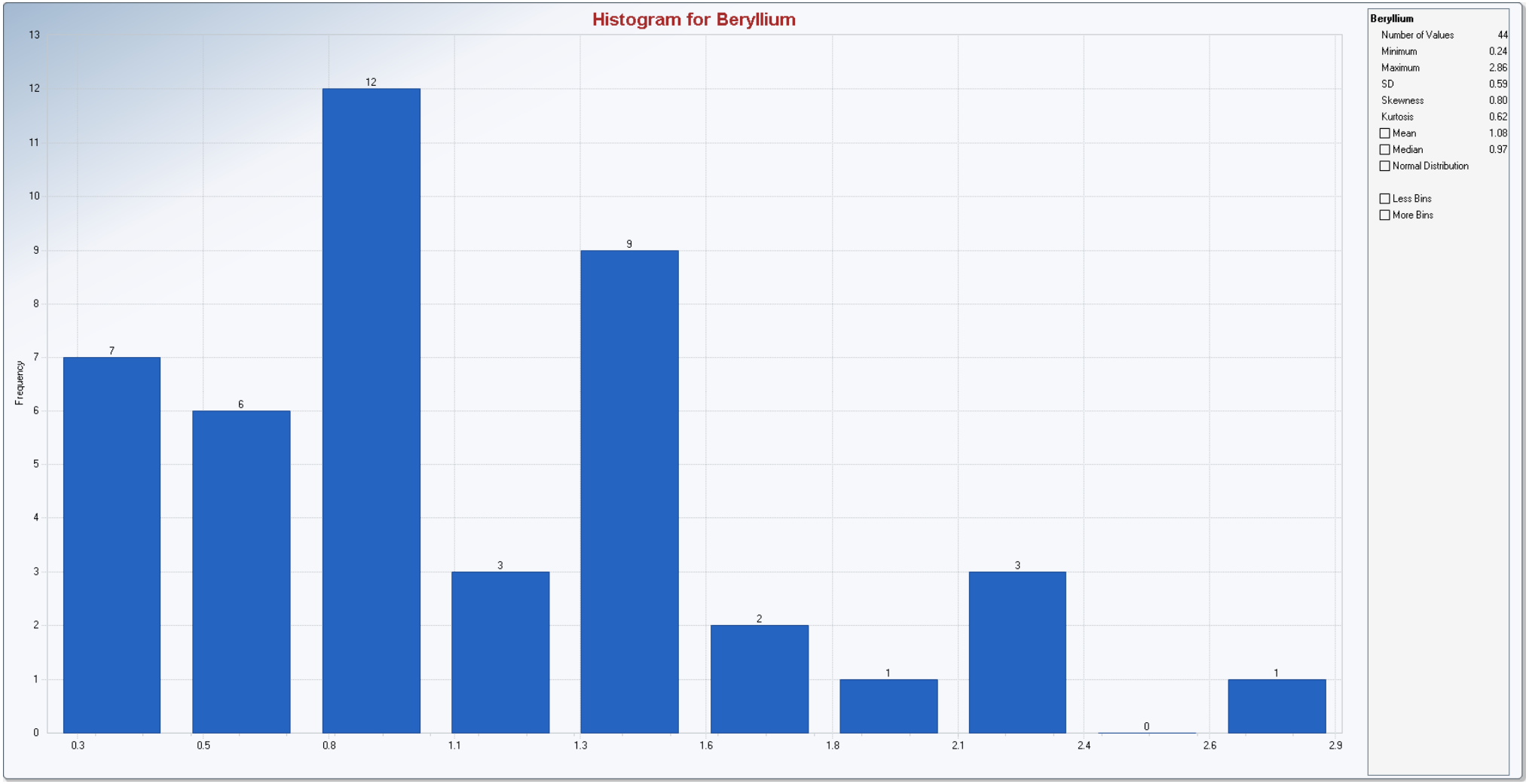
	A	B	C	D	E	F	G	H	I	J	K	L
564	Therefore, Observation 0.532 is a Potential Statistical Outlier											
565												
566	For 1% Significance Level, there is 1 Potential Outlier											
567												
568												
569	**Rosner's Outlier Test for 1 Outliers in Vanadium**											
570												
571												
572			**Total N**	**44**								
573			**Number NDs**	**0**								
574			**Number Detects**	**44**								
575			**Mean of Detects**	**19.24**								
576			**SD of Detects**	**7.921**								
577			**Number of data**	**44**								
578			**Number of suspected outliers**	**1**								
579	**NDs not included in the following:**											
580												
581				Potential	Obs.	Test	Critical	Critical				
582	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
583	1	19.24	7.83	41.8	20	2.882	3.08	3.43				
584												
585	For 5% Significance Level, there is no Potential Outlier											
586												
587	For 1% Significance Level, there is no Potential Outlier											
588												
589												
590	**Rosner's Outlier Test for 1 Outliers in Zinc**											
591												
592												
593			**Total N**	**44**								
594			**Number NDs**	**0**								
595			**Number Detects**	**44**								
596			**Mean of Detects**	**43.49**								
597			**SD of Detects**	**24.62**								
598			**Number of data**	**44**								
599			**Number of suspected outliers**	**1**								
600	**NDs not included in the following:**											
601												
602				Potential	Obs.	Test	Critical	Critical				
603	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
604	1	43.49	24.34	110	10	2.732	3.08	3.43				
605												
606	For 5% Significance Level, there is no Potential Outlier											
607												
608	For 1% Significance Level, there is no Potential Outlier											
609												
610												
676	**Rosner's Outlier Test for 1 Outliers in Radium-226 & 228**											
677												

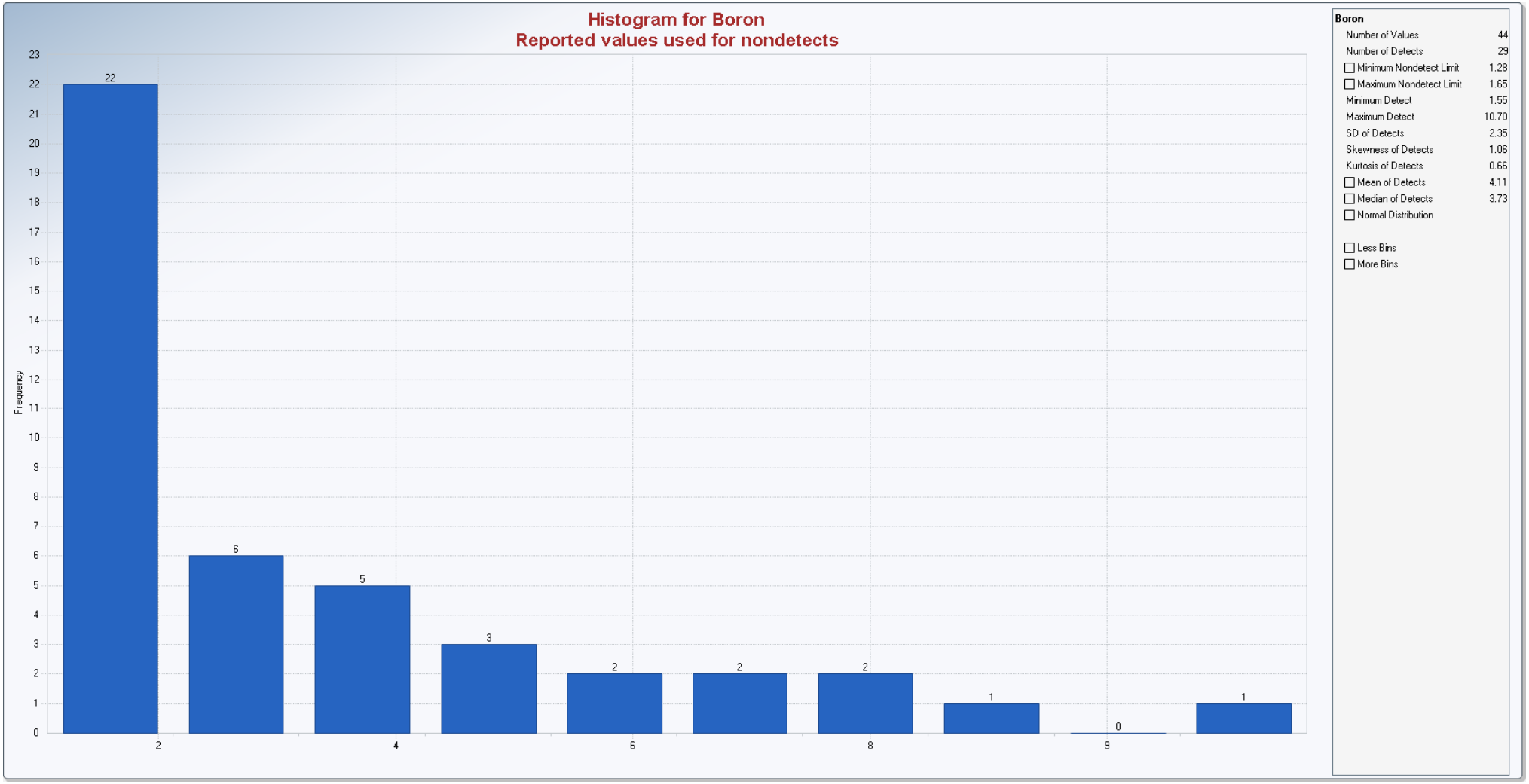
	A	B	C	D	E	F	G	H	I	J	K	L
678												
679				**Total N**	**44**							
680				**Number NDs**	**0**							
681				**Number Detects**	**44**							
682				**Mean of Detects**	**2.063**							
683				**SD of Detects**	**0.576**							
684				**Number of data**	**44**							
685				**Number of suspected outliers**	**1**							
686	**NDs not included in the following:**											
687												
688				Potential	Obs.	Test	Critical	Critical				
689	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
690	1	2.063	0.57	0.755	32	2.297	3.08	3.43				
691												
692	For 5% Significance Level, there is no Potential Outlier											
693												
694	For 1% Significance Level, there is no Potential Outlier											
695												

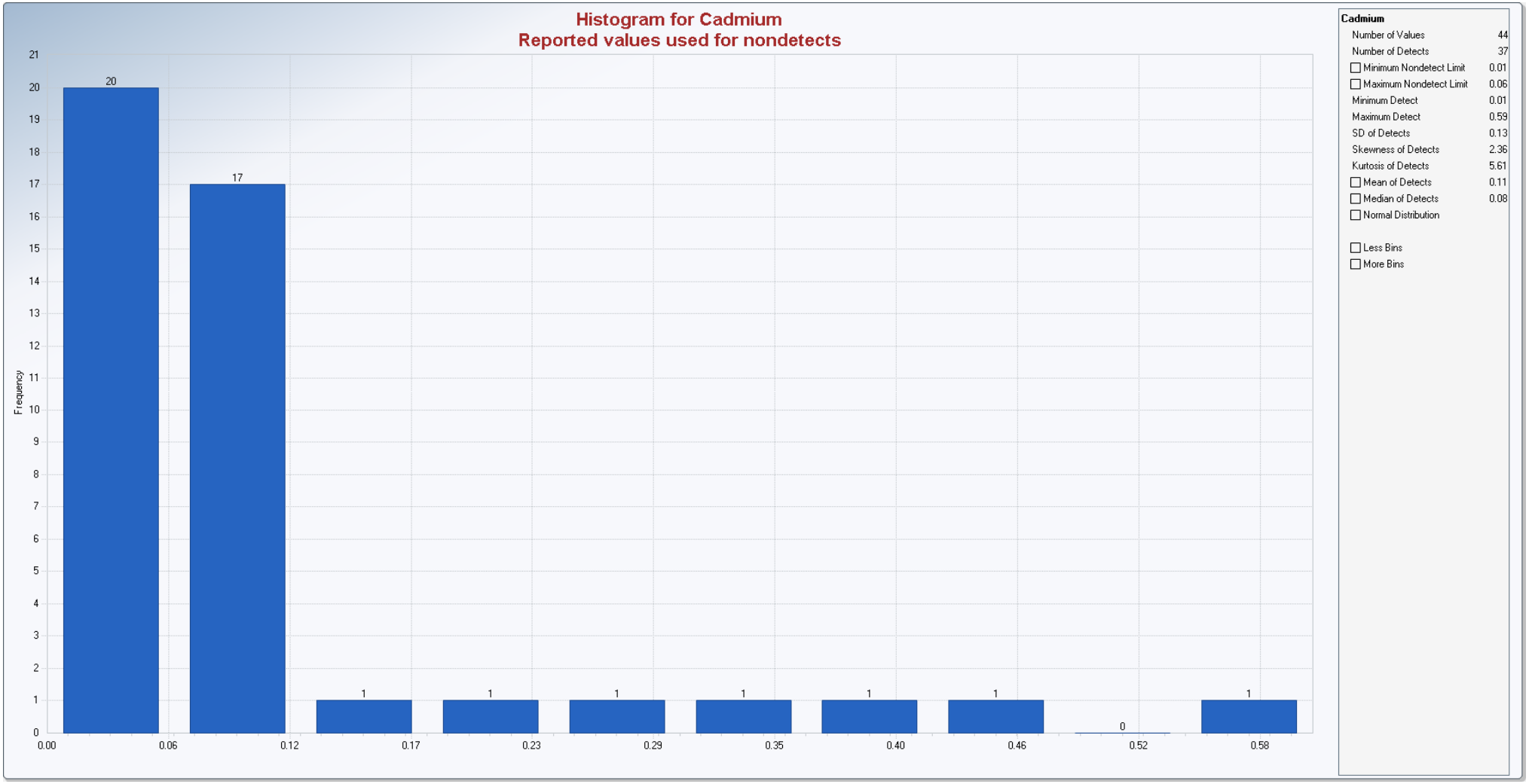

Histogram for Antimony
Reported values used for nondetects
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
10
5
5
2
7
4
5
4
1
1
0.06
0.09
0.12
0.15
0.18
0.21
0.24
0.27
0.29
0.32
Antimony
Number of Values 44
Number of Detects 40
Minimum Nondetect Limit 0.04
Maximum Nondetect Limit 0.04
Minimum Detect 0.04
Maximum Detect 0.33
SD of Detects 0.07
Skewness of Detects 0.15
Kurtosis of Detects -0.77
Mean of Detects 0.16
Median of Detects 0.17
Normal Distribution
Less Bins
More Bins

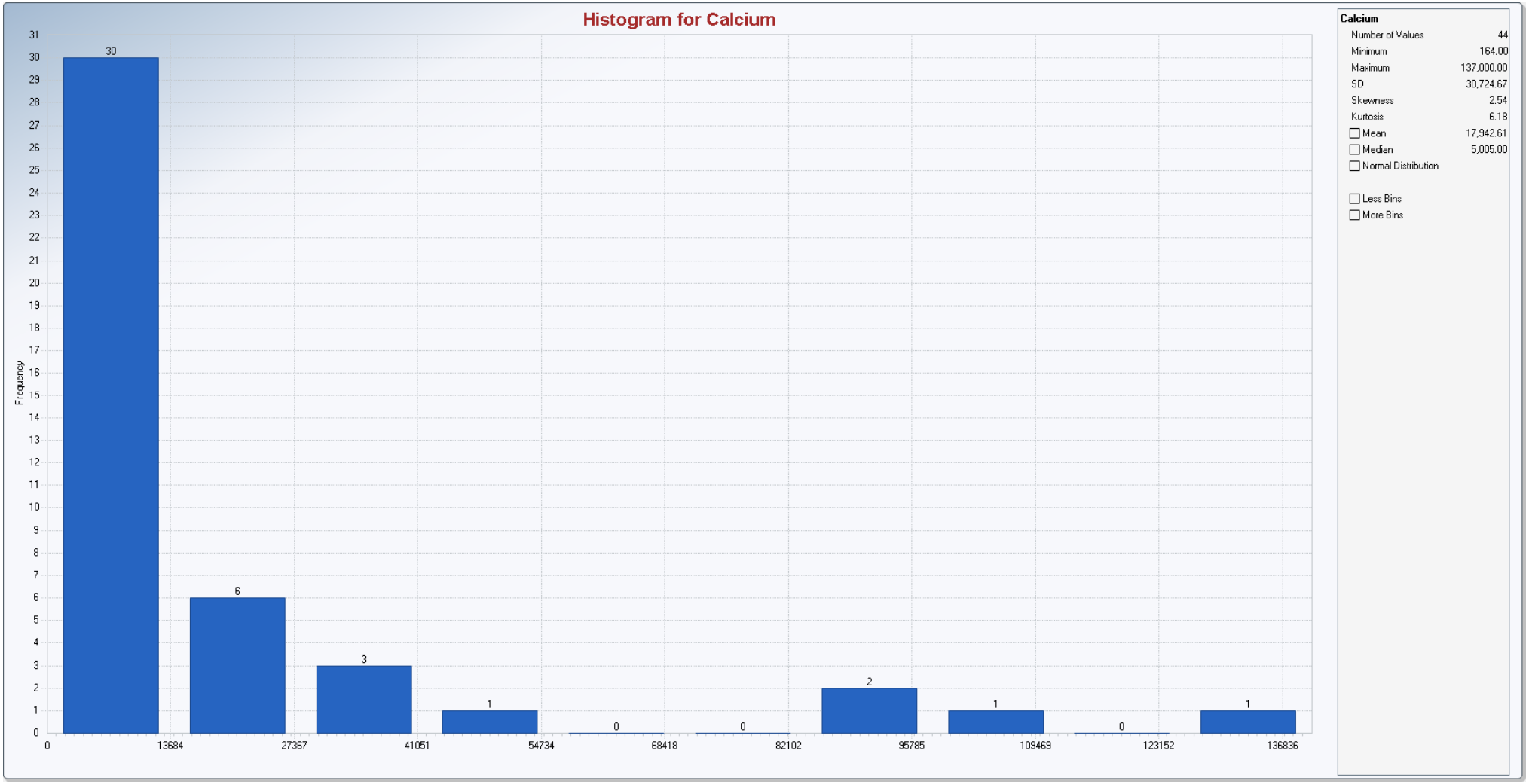

Histogram for Arsenic
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
5
9
10
6
4
4
3
1
0
2
1
2
4
5
6
7
8
10
11
12
13
Arsenic
Number of Values 44
Minimum 1.61
Maximum 13.70
SD 2.82
Skewness 1.02
Kurtosis 0.86
Mean 5.59
Median 4.95
Normal Distribution
Less Bins
More Bins

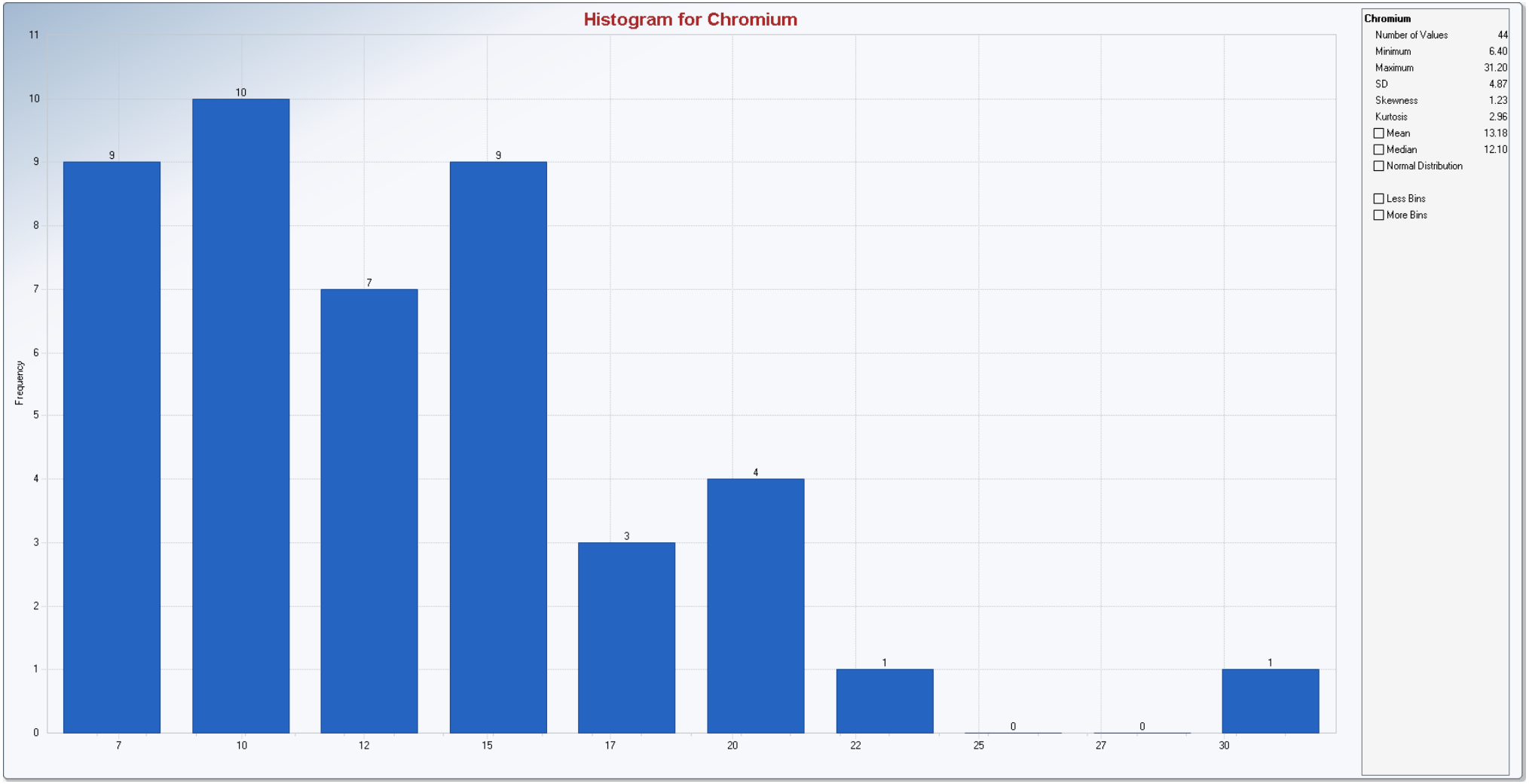

Histogram for Barium
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
12
7
11
3
6
6
5
2
1
1
2
21
42
63
84
106
127
148
169
190
211
232
Barium
Number of Values 44
Minimum 20.00
Maximum 231.00
SD 55.12
Skewness 0.81
Kurtosis 0.22
Mean 91.22
Median 86.20
Normal Distribution
Less Bins
More Bins

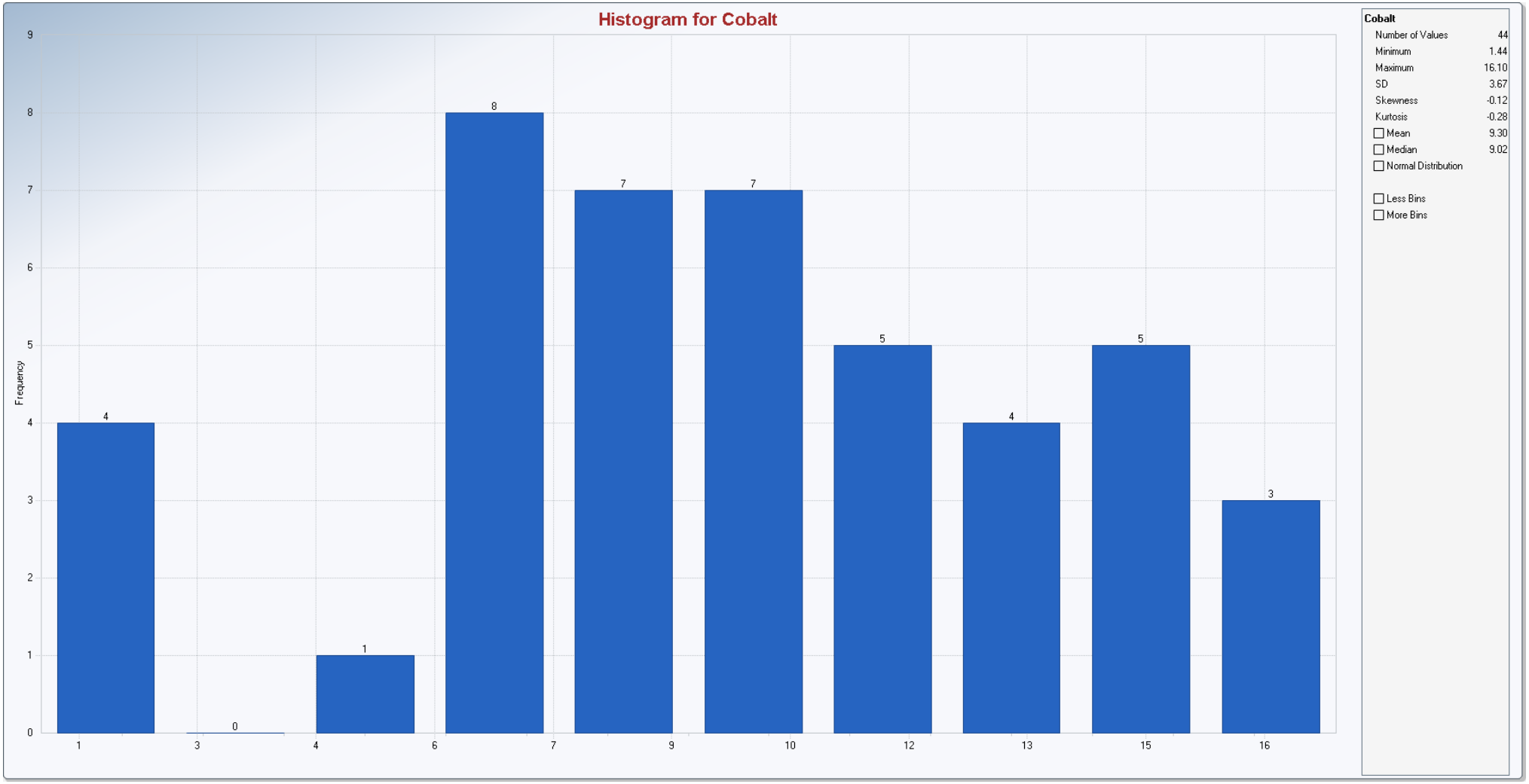

Histogram for Beryllium
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
12
13
7
6
12
3
9
2
1
3
0
1
0.3
0.5
0.8
1.1
1.3
1.6
1.8
2.1
2.4
2.6
2.9
Beryllium
Number of Values 44
Minimum 0.24
Maximum 2.86
SD 0.59
Skewness 0.80
Kurtosis 0.62
Mean 1.08
Median 0.97
Normal Distribution
Less Bins
More Bins

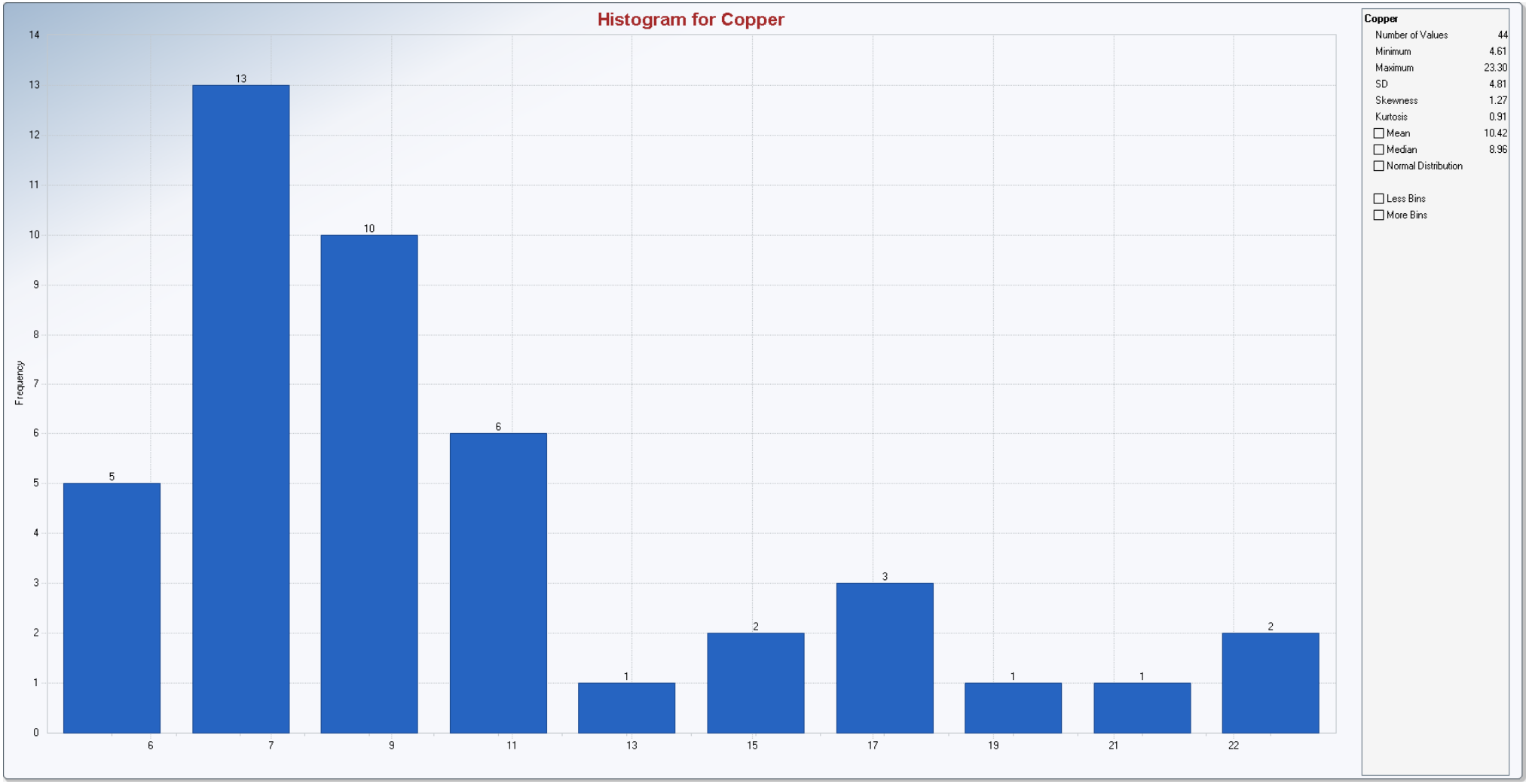

Histogram for Boron
Reported values used for nondetects
Frequency
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
22
6
5
3
2
2
2
1
0
1
2
4
6
8
9
Boron
Number of Values 44
Number of Detects 29
Minimum Nondetect Limit 1.28
Maximum Nondetect Limit 1.65
Minimum Detect 1.55
Maximum Detect 10.70
SD of Detects 2.35
Skewness of Detects 1.06
Kurtosis of Detects 0.66
Mean of Detects 4.11
Median of Detects 3.73
Normal Distribution
Less Bins
More Bins

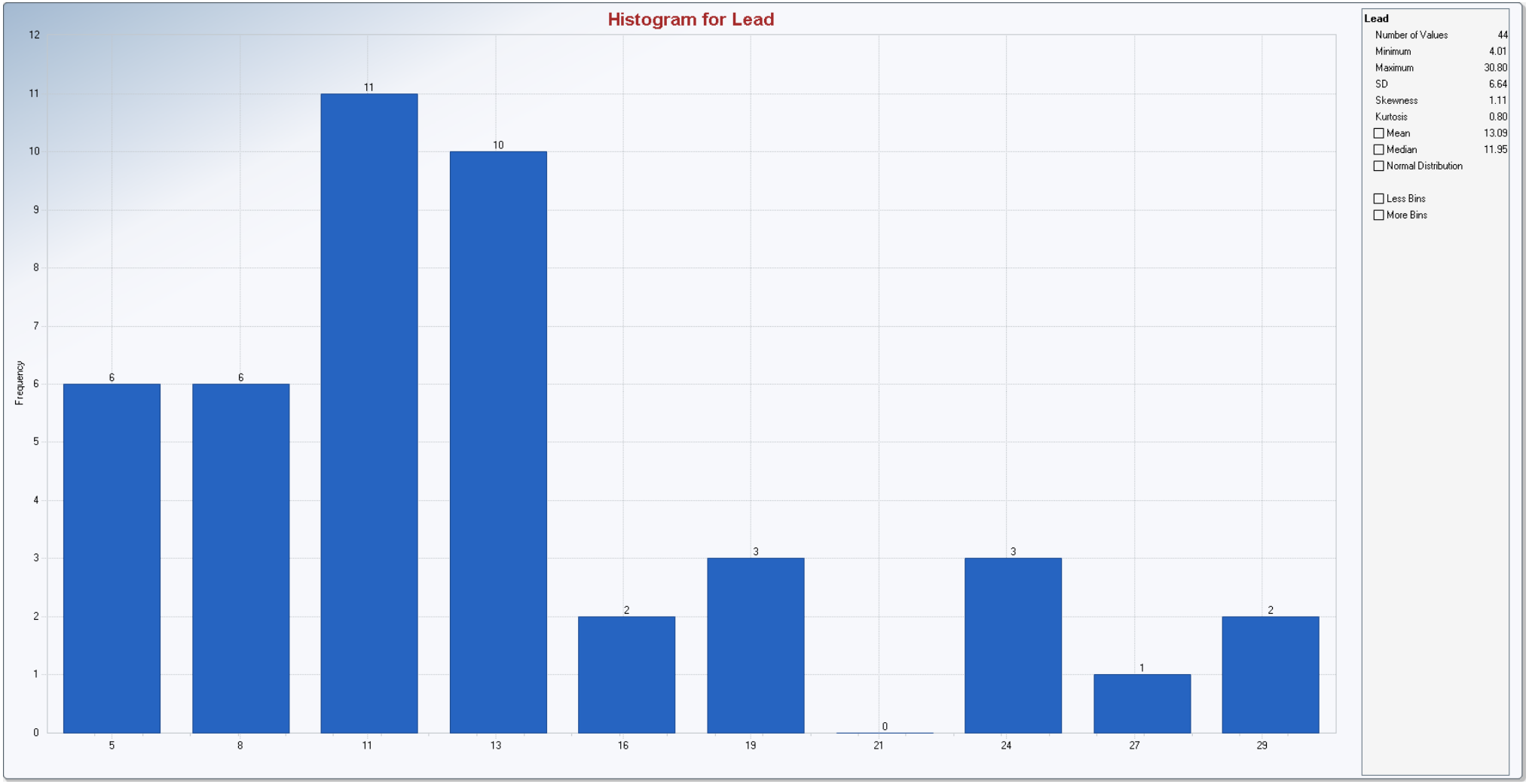

Histogram for Cadmium
Reported values used for nondetects
Frequency
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
20
17
1
1
1
1
1
1
0
1
0.00
0.06
0.12
0.17
0.23
0.29
0.35
0.40
0.46
0.52
0.58
Cadmium
Number of Values 44
Number of Detects 37
Minimum Nondetect Limit 0.01
Maximum Nondetect Limit 0.06
Minimum Detect 0.01
Maximum Detect 0.59
SD of Detects 0.13
Skewness of Detects 2.36
Kurtosis of Detects 5.61
Mean of Detects 0.11
Median of Detects 0.08
Normal Distribution
Less Bins
More Bins

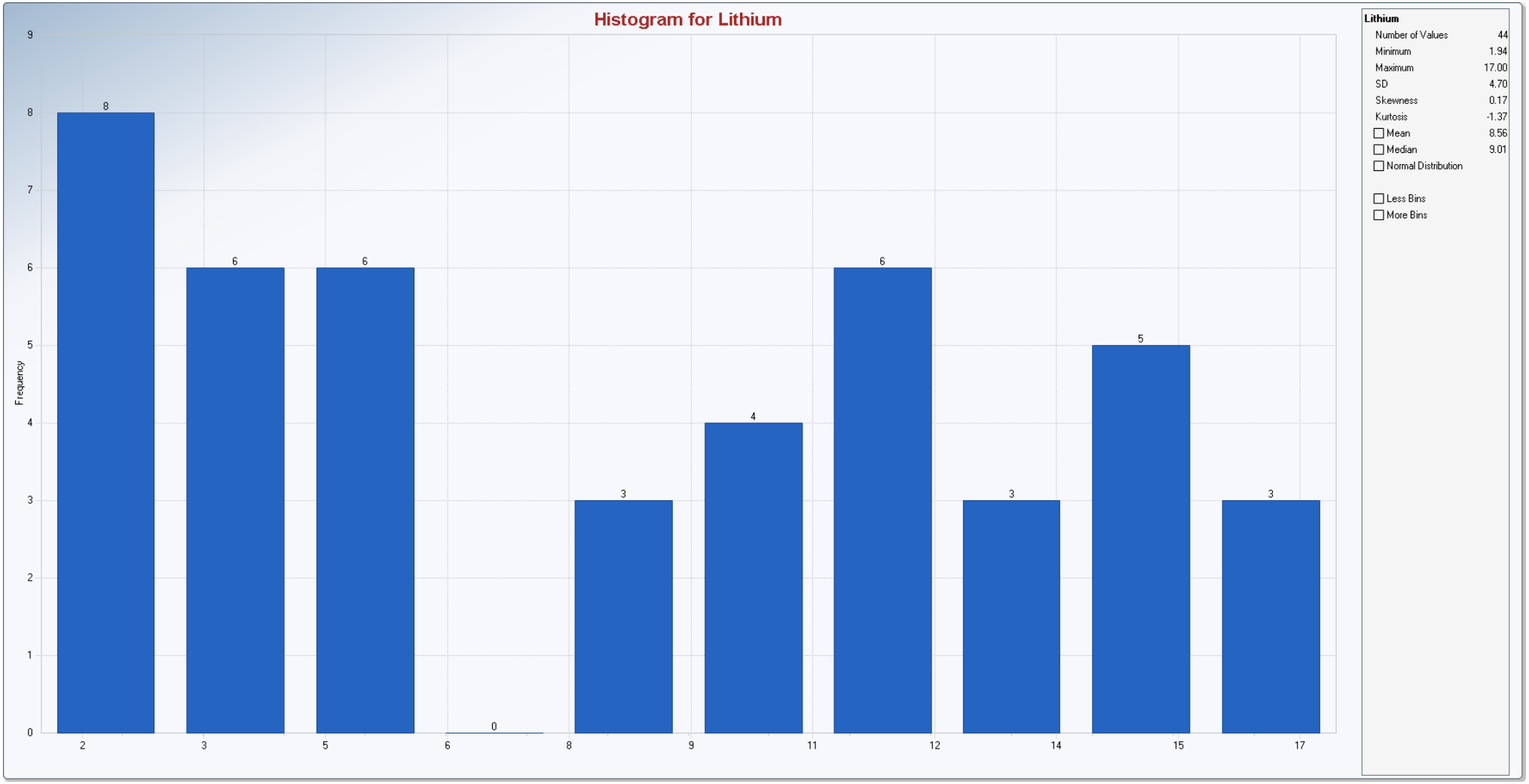

Histogram for Calcium
Frequency
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
30
6
3
1
0
0
2
1
0
1
0
13684
27367
41051
54734
68418
82102
95785
109469
123152
136836
Calcium
Number of Values 44
Minimum 164.00
Maximum 137,000.00
SD 30,724.67
Skewness 2.54
Kurtosis 6.18
Mean 17,942.61
Median 5,005.00
Normal Distribution
Less Bins
More Bins

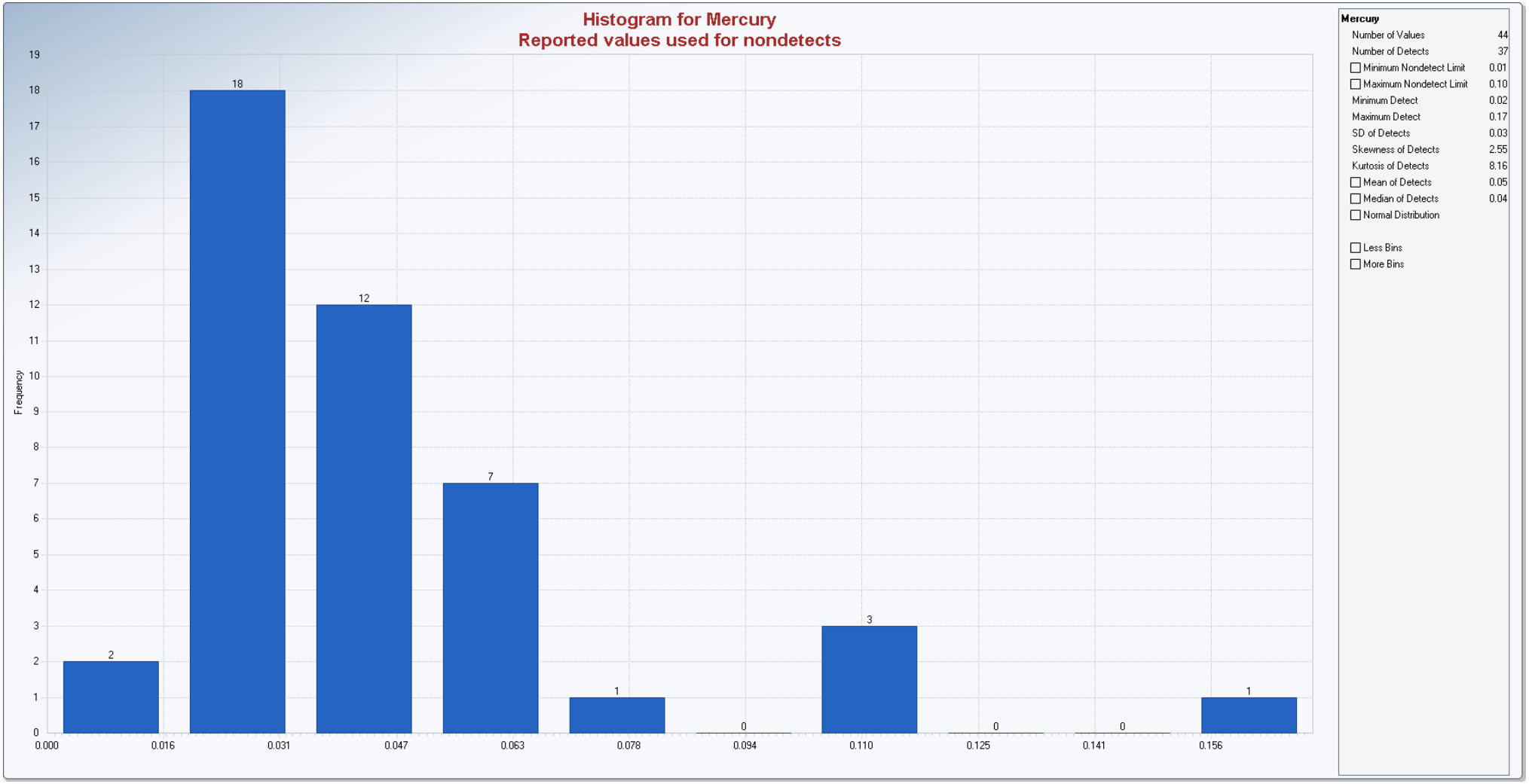

Histogram for Chromium
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
9
10
7
9
3
4
1
0
0
1
7
10
12
15
17
20
22
25
27
30
Chromium
Number of Values 44
Minimum 6.40
Maximum 31.20
SD 4.87
Skewness 1.23
Kurtosis 2.96
Mean 13.18
Median 12.10
Normal Distribution
Less Bins
More Bins

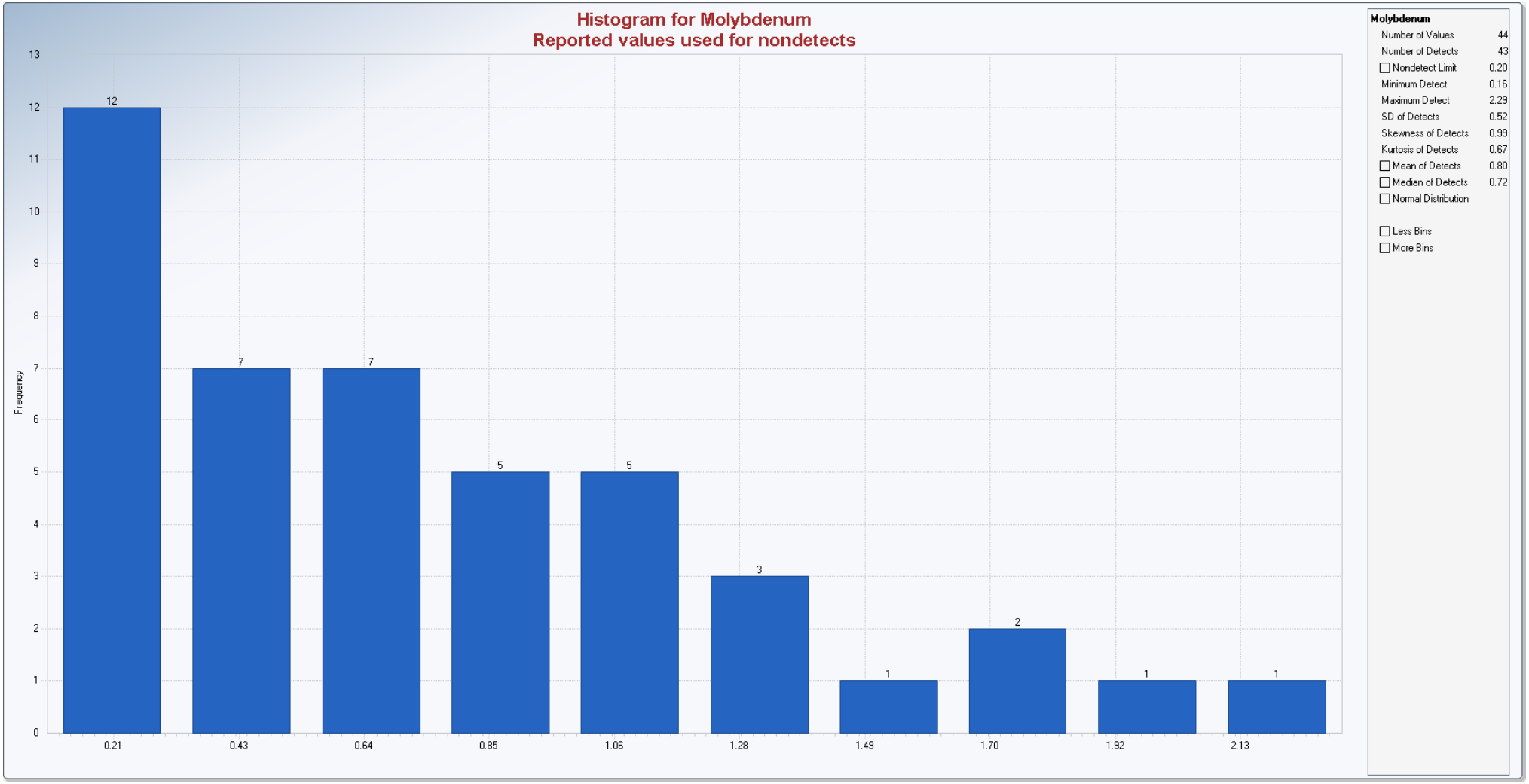

Histogram for Cobalt
Frequency
0
1
2
3
4
5
6
7
8
9
4
0
1
8
7
7
5
4
5
3
1
3
4
6
7
9
10
12
13
15
16
Cobalt
Number of Values 44
Minimum 1.44
Maximum 16.10
SD 3.67
Skewness -0.12
Kurtosis -0.28
Mean 9.30
Median 9.02
Normal Distribution
Less Bins
More Bins

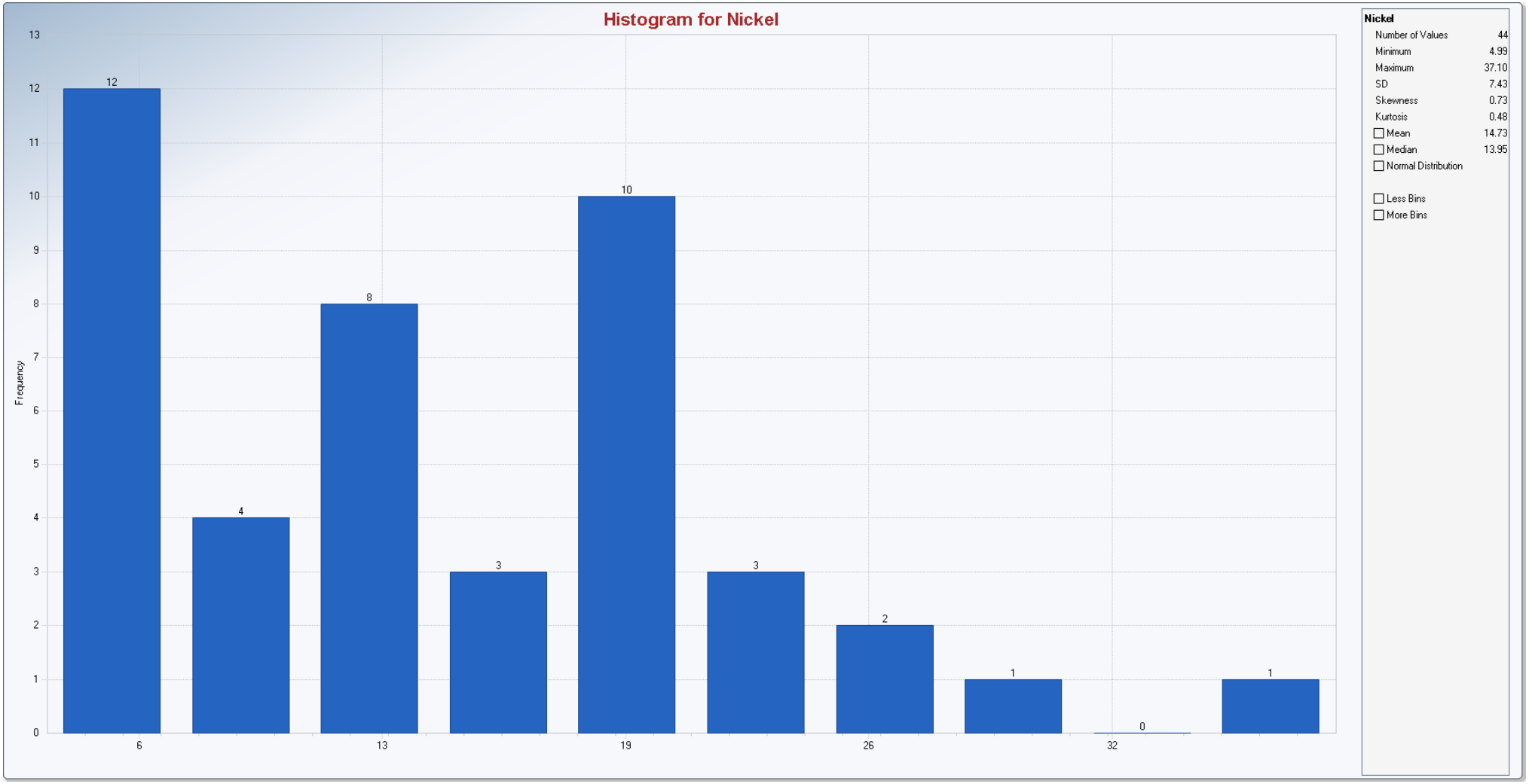

Histogram for Copper
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
5
13
10
6
1
2
3
1
1
2
6
7
9
11
13
15
17
19
21
22
Copper
Number of Values 44
Minimum 4.61
Maximum 23.30
SD 4.81
Skewness 1.27
Kurtosis 0.91
Mean 10.42
Median 8.96
Normal Distribution
Less Bins
More Bins

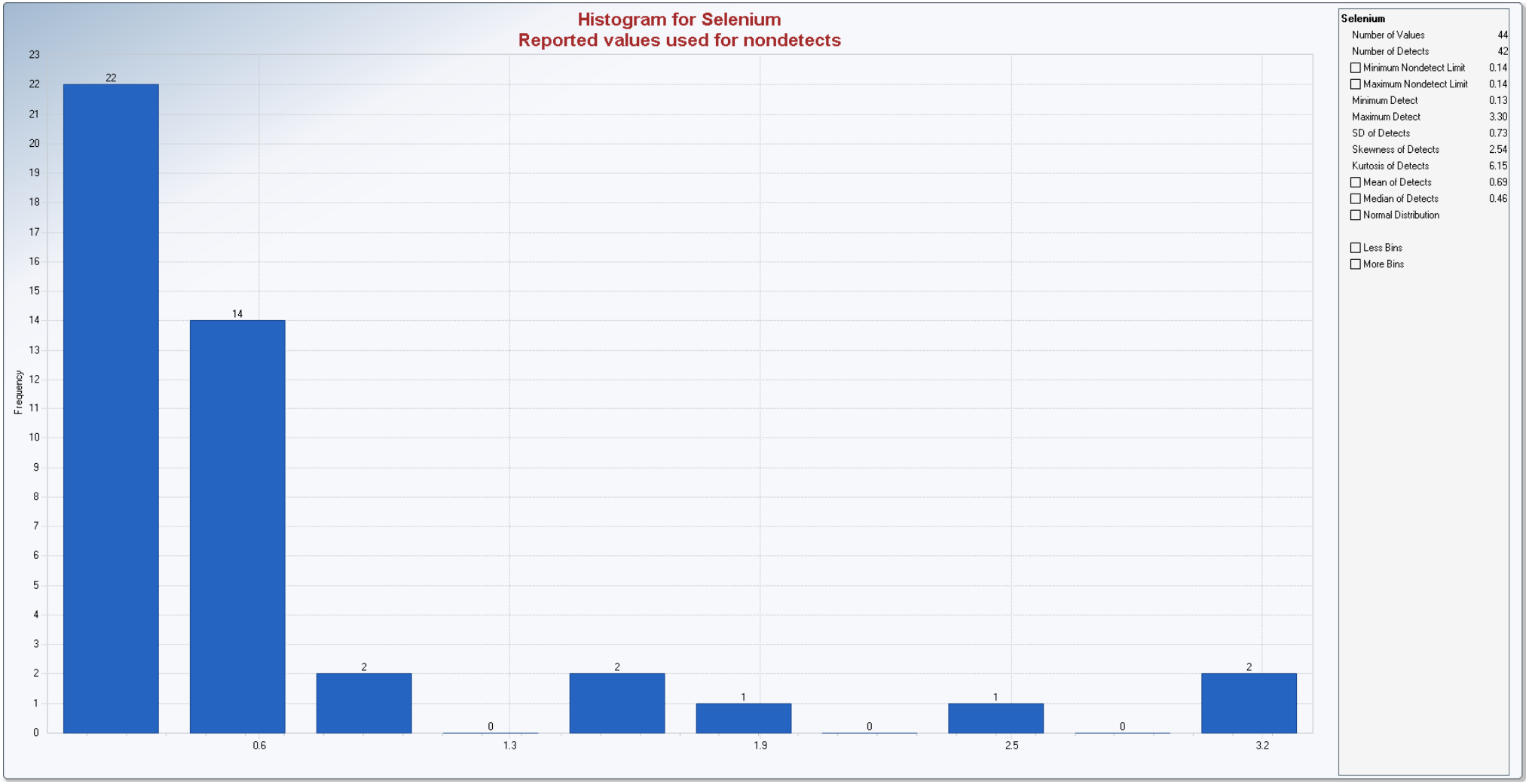

Histogram for Lead
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
12
6
6
11
10
2
3
0
3
1
2
5
8
11
13
16
19
21
24
27
29
Lead
Number of Values 44
Minimum 4.01
Maximum 30.80
SD 6.64
Skewness 1.11
Kurtosis 0.80
Mean 13.09
Median 11.95
Normal Distribution
Less Bins
More Bins

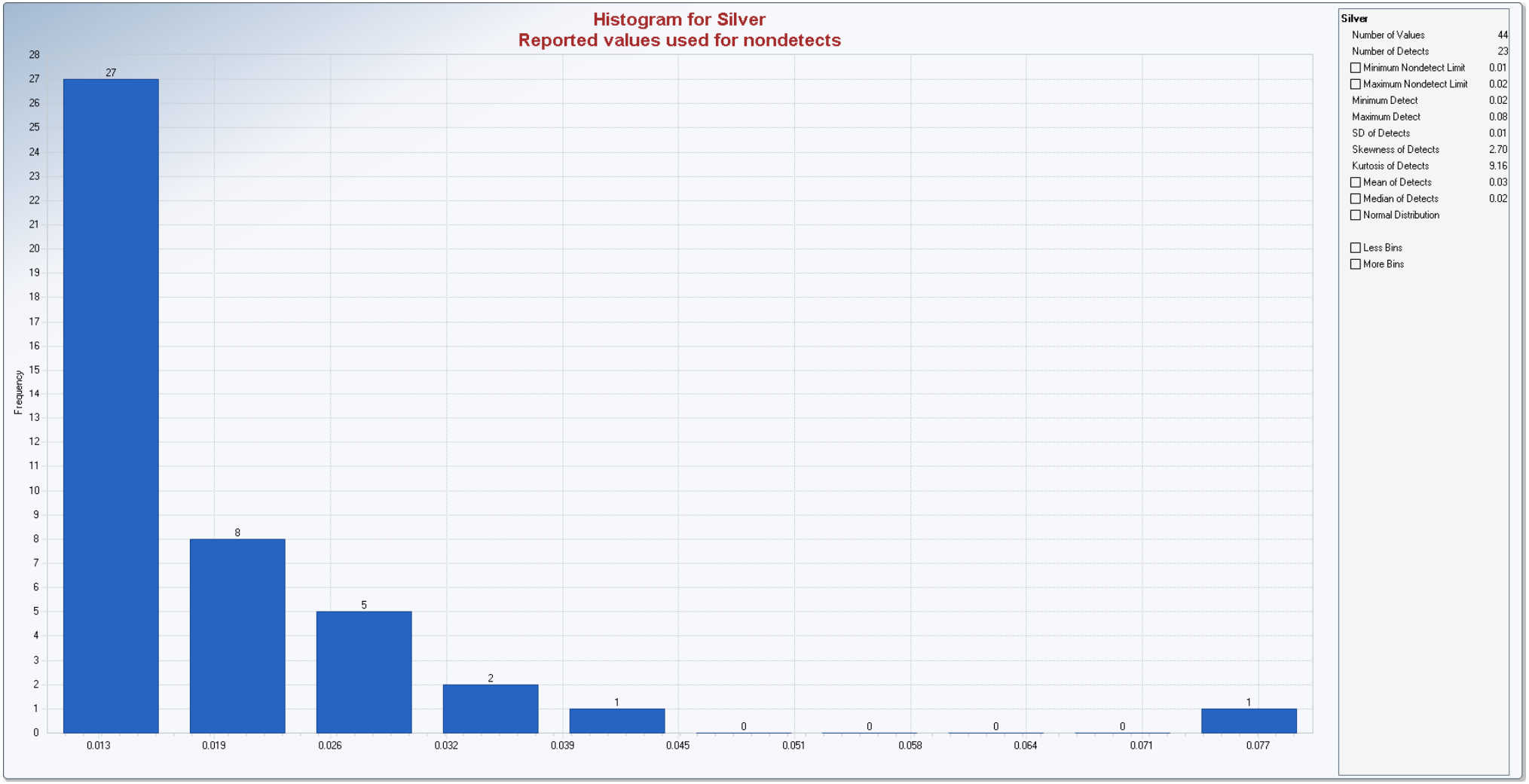

Histogram for Lithium
Frequency
0
1
2
3
4
5
6
7
8
9
8
6
6
0
3
4
6
3
5
3
2
3
5
6
8
9
11
12
14
15
17
Lithium
Number of Values 44
Minimum 1.94
Maximum 17.00
SD 4.70
Skewness 0.17
Kurtosis -1.37
Mean 8.56
Median 9.01
Normal Distribution
Less Bins
More Bins

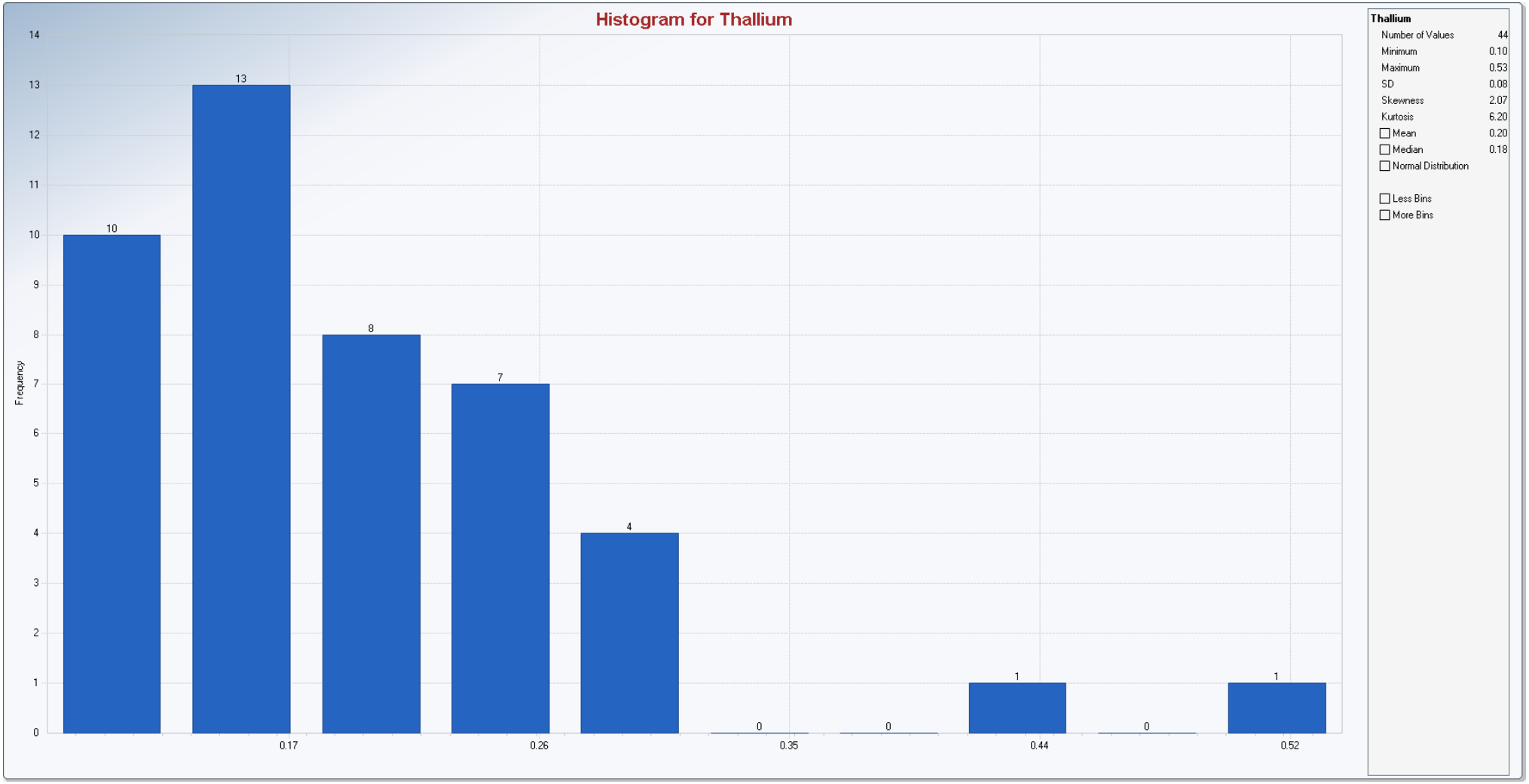

Histogram for Mercury
Reported values used for nondetects
Frequency
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
2
18
12
7
1
0
3
0
0
1
0.000
0.016
0.031
0.047
0.063
0.078
0.094
0.110
0.125
0.141
0.156
Mercury
Number of Values 44
Number of Detects 37
Minimum Nondetect Limit 0.01
Maximum Nondetect Limit 0.10
Minimum Detect 0.02
Maximum Detect 0.17
SD of Detects 0.03
Skewness of Detects 2.55
Kurtosis of Detects 8.16
Mean of Detects 0.05
Median of Detects 0.04
Normal Distribution
Less Bins
More Bins

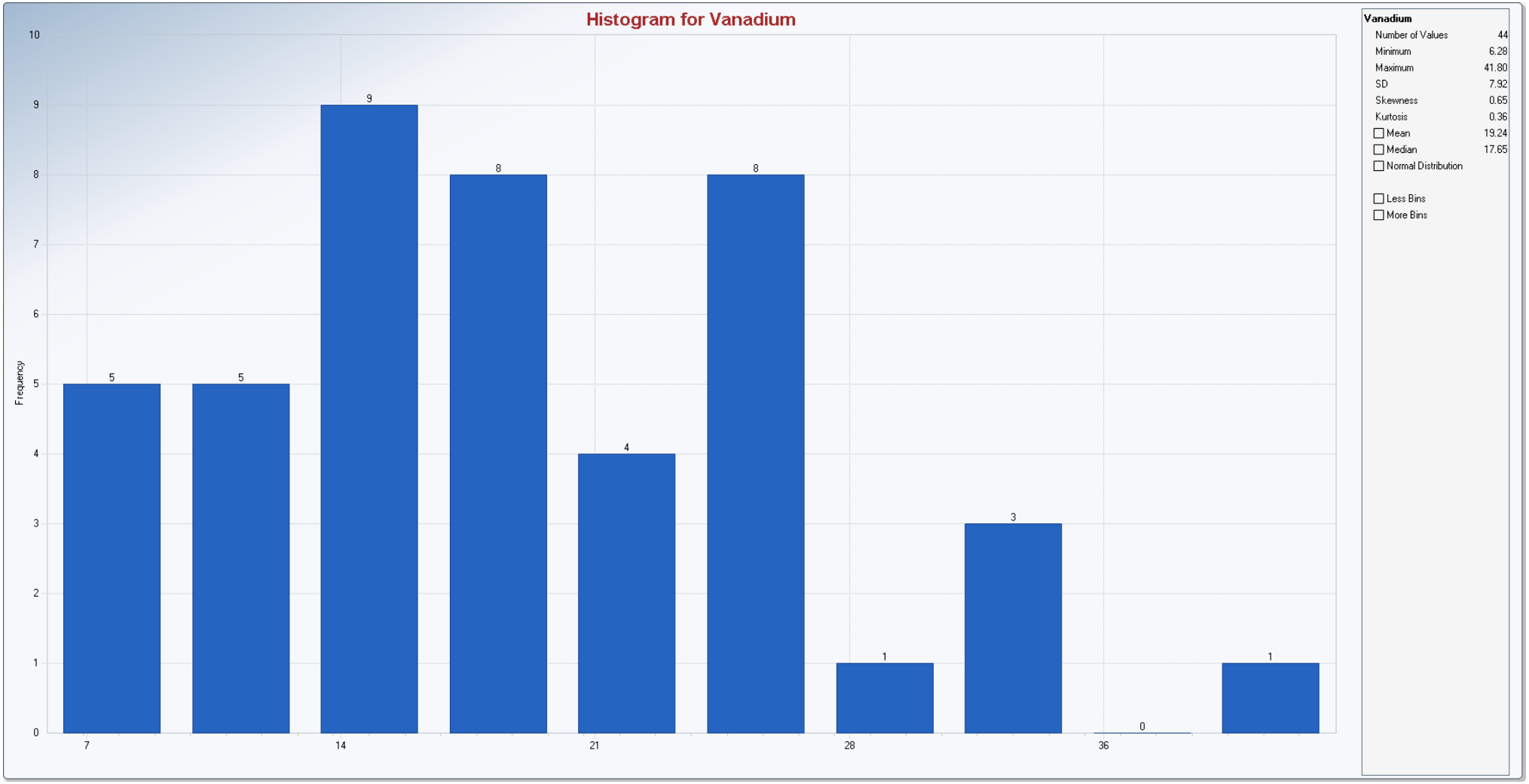

Histogram for Molybdenum
Reported values used for nondetects
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
12
13
12
7
7
5
5
3
1
2
1
1
0.21
0.43
0.64
0.85
1.06
1.28
1.49
1.70
1.92
2.13
Molybdenum
Number of Values 44
Number of Detects 43
Nondetect Limit 0.20
Minimum Detect 0.16
Maximum Detect 2.29
SD of Detects 0.52
Skewness of Detects 0.99
Kurtosis of Detects 0.67
Mean of Detects 0.80
Median of Detects 0.72
Normal Distribution
Less Bins
More Bins

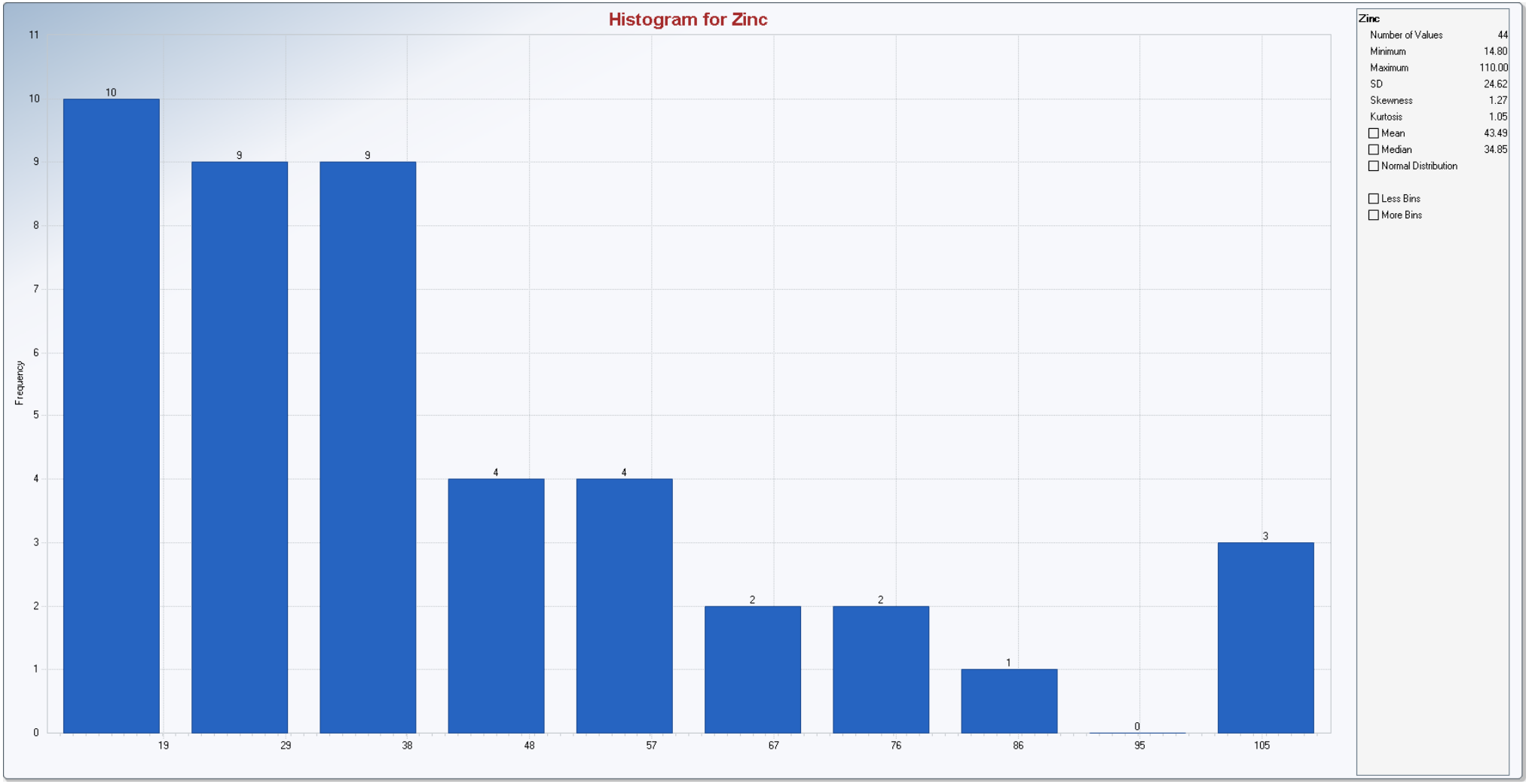

Histogram for Nickel
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
12
13
12
4
8
3
10
3
2
1
0
1
6
13
19
26
32
Nickel
Number of Values 44
Minimum 4.99
Maximum 37.10
SD 7.43
Skewness 0.73
Kurtosis 0.48
Mean 14.73
Median 13.95
Normal Distribution
Less Bins
More Bins


Histogram for Selenium
Reported values used for nondetects
Frequency
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
22
14
2
0
2
1
0
1
0
2
0.6
1.3
1.9
2.5
3.2
Selenium
Number of Values 44
Number of Detects 42
Minimum Nondetect Limit 0.14
Maximum Nondetect Limit 0.14
Minimum Detect 0.13
Maximum Detect 3.30
SD of Detects 0.73
Skewness of Detects 2.54
Kurtosis of Detects 6.15
Mean of Detects 0.69
Median of Detects 0.46
Normal Distribution
Less Bins
More Bins


Histogram for Silver
Reported values used for nondetects
Frequency
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
27
8
5
2
1
0
0
0
0
1
0.013
0.019
0.026
0.032
0.039
0.045
0.051
0.058
0.064
0.071
0.077
Silver
Number of Values 44
Number of Detects 23
Minimum Nondetect Limit 0.01
Maximum Nondetect Limit 0.02
Minimum Detect 0.02
Maximum Detect 0.08
SD of Detects 0.01
Skewness of Detects 2.70
Kurtosis of Detects 9.16
Mean of Detects 0.03
Median of Detects 0.02
Normal Distribution
Less Bins
More Bins


Histogram for Thallium
Frequency
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
10
13
8
7
4
0
0
1
0
1
0.17
0.26
0.35
0.44
0.52
Thallium
Number of Values 44
Minimum 0.10
Maximum 0.53
SD 0.08
Skewness 2.07
Kurtosis 6.20
Mean 0.20
Median 0.18
Normal Distribution
Less Bins
More Bins


Histogram for Vanadium
Frequency
10
9
8
7
6
5
4
3
2
1
0
5
5
9
8
4
8
1
3
0
1
7
14
21
28
36
Vanadium
Number of Values 44
Minimum 6.28
Maximum 41.80
SD 7.92
Skewness 0.65
Kurtosis 0.36
Mean 19.24
Median 17.65
Normal Distribution
Less Bins
More Bins


Histogram for Zinc
Frequency
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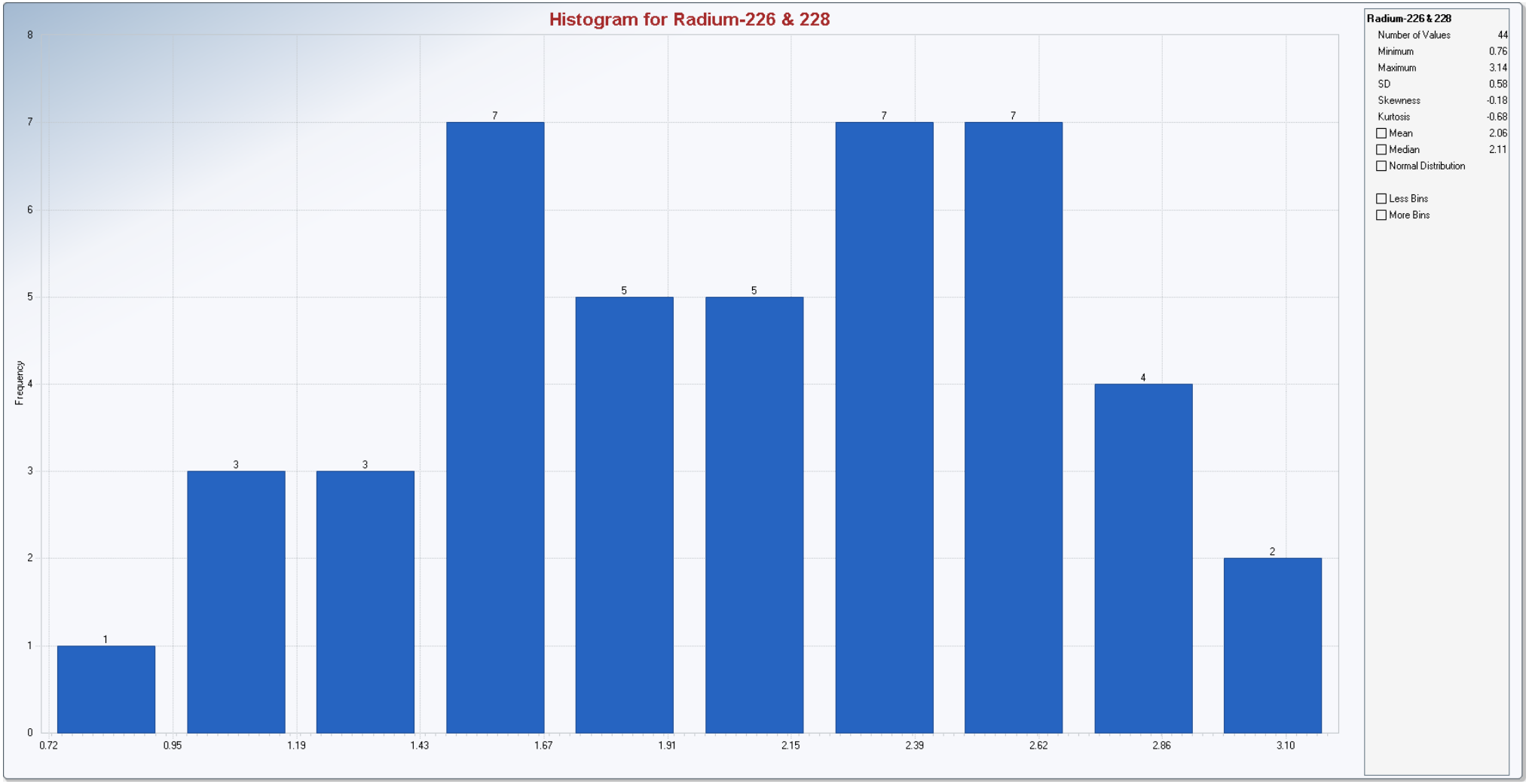
1
2
3
4
5
6
7
8
9
10
11
10
9
9
4
4
2
2
1
0
3
19
29
38
48
57
67
76
86
95
105
Zinc
Number of Values 44
Minimum 14.80
Maximum 110.00
SD 24.62
Skewness 1.27
Kurtosis 1.05
Mean 43.49
Median 34.85
Normal Distribution
Less Bins
More Bins


Histogram for Radium-226 & 228
Frequency
0
1
2
3
4
5
6
7
8
1
3
3
7
5
5
7
7
4
2
0.72
0.95
1.19
1.43
1.67
1.91
2.15
2.39
2.62
2.86
3.10
Radium-226 & 228
Number of Values 44
Minimum 0.76
Maximum 3.14
SD 0.58
Skewness -0.18
Kurtosis -0.68
Mean 2.06
Median 2.11
Normal Distribution
Less Bins
More Bins

APPENDIX C

Surface Water Dilution Attenuation Factor

APPENDIX C

SURFACE WATER DILUTION ATTENUATION FACTOR

This appendix describes the evaluation of the magnitude of dilution effects resulting from the mixing of groundwater that may flow from beneath the Ash Pond Complex (APC) area (including the Ash Pond A, Ash Pond E, Middle Pond A, Bottom Ash Pond, and Stilling Ponds B, C, and D) to surface water in the Cumberland River (**Figure C-1**), and describes the development of a dilution attenuation factor (DAF) between groundwater and surface water.

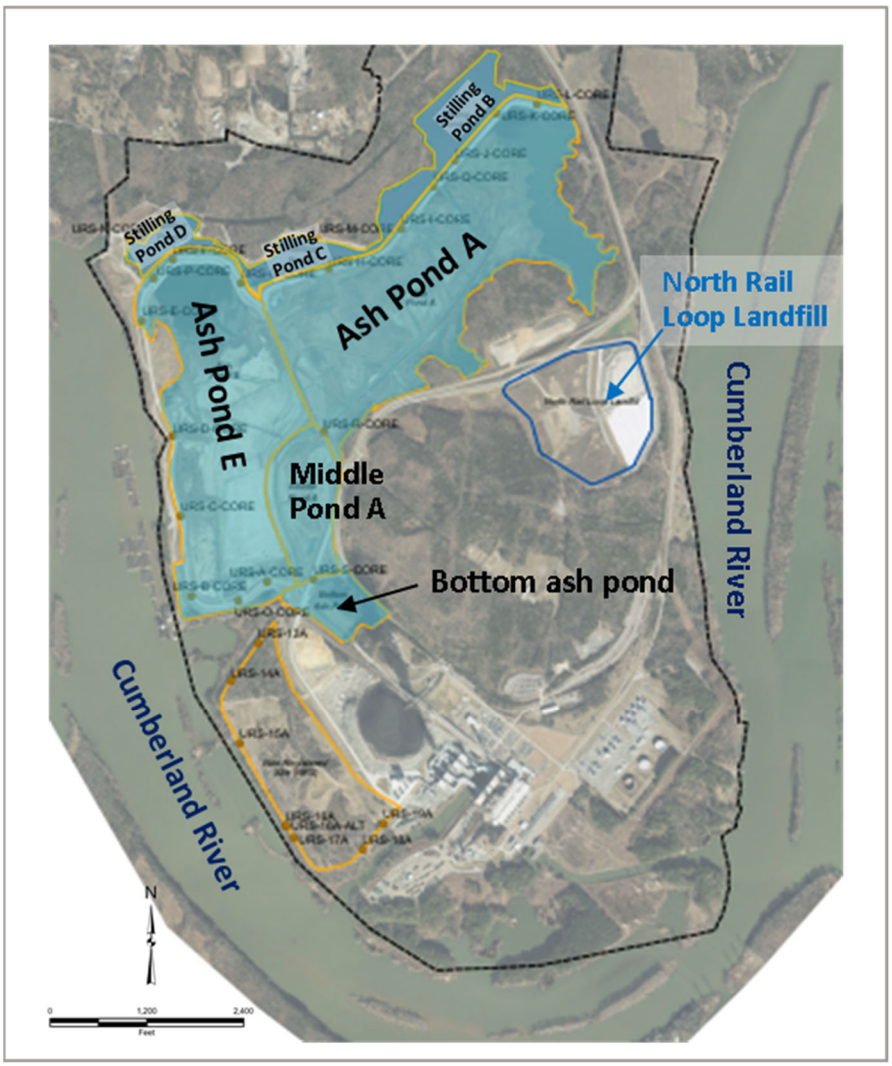


Figure C-1: *The extent of the Ash Pond Complex (blue shaded area) and the North Rail Loop Landfill Area*

Historically the constituents from the CCR material introduced into the APC area could be sorbed onto native aquifer solids along the flow pathways of the groundwater. Currently the planned closure strategy involves removal of CCR material from the APC area through excavation, potential excavation of an additional one foot of native soils, and the area regraded with imported clean soils. The excavation will result in a depression area below the typical stage of the Cumberland River (approximately elevation +445 feet Mean Sea Level [MSL]). The extent of the depression area in the APC is shown in **Figure C-2**.

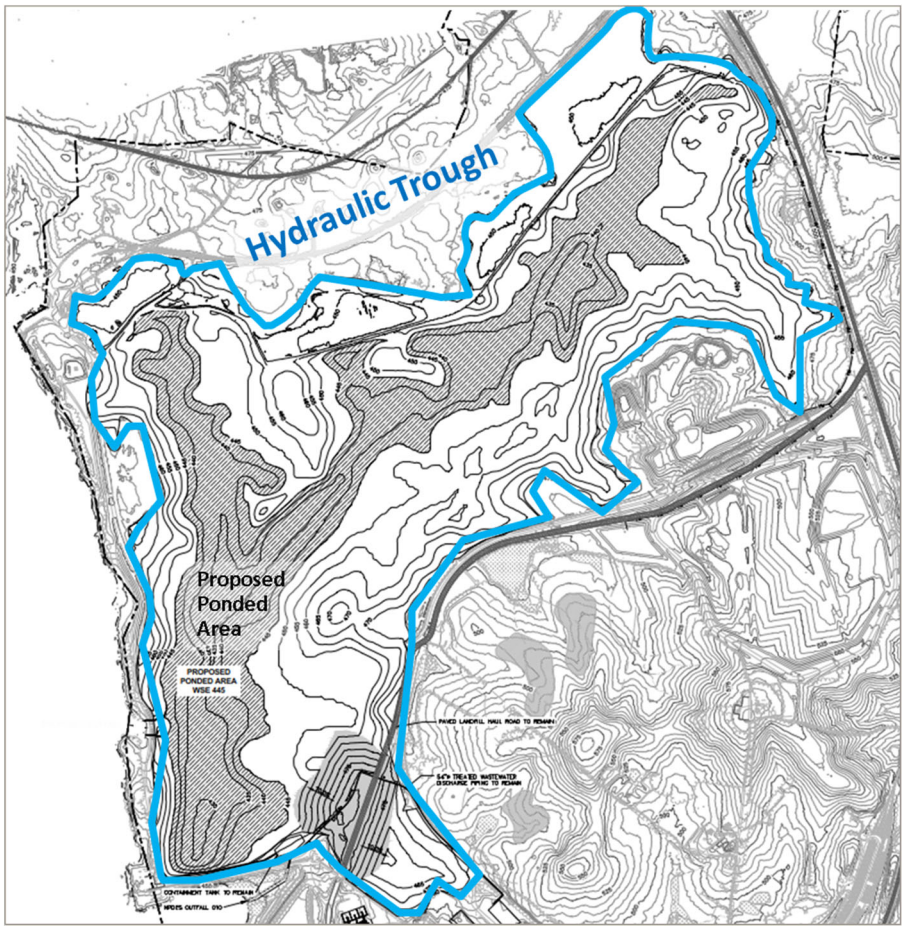


Figure C-2: *The approximate extent of the Ash Pond Complex (blue line) and the anticipated future ponded area (gray area) where the surface elevation after excavation is expected to be below elevation +445 feet MSL.*

Surface water inputs, such as precipitation in the APC area, runoff from areas adjacent to the APC, and potential groundwater seepage into the APC area are expected to result in water in the ponded area shown in **Figure C-2**. The future surface water elevation in the ponded area following excavation is expected to be similar to the stage of the Cumberland River (approximately +455 feet MSL) because water heads observed in the permeable hydraulic trough area (**Figure C-2**), adjacent to the northern side

of the APC, have been similar to the river elevation (TVA, 2017). Since the water level in the ponded area in the APC is expected to closely resemble the river stage, the ponded area can be assumed to behave like the river, acting as a sink for groundwater in the vicinity of the APC.

The Cumberland River is considered the dominant regional surface water feature in the region. It is a regional groundwater divide and a gaining stream (i.e., groundwater flows into the riverbed along its course). Groundwater at the GAF and surrounding vicinity is expected to flow towards the River.

After CCR material excavation, CCR constituents previously adsorbed onto post-excavation native aquifer solids could become a secondary constituent source to groundwater. The anticipated primary driving force responsible for constituent transport from the post-excavation aquifer solids to the River in the future (following excavation) is water movement through the groundwater flow pathway due to groundwater recharge resulting from surface infiltration and runoff in the vicinity of the APC area.

Previous characterizations (TVA, 2017) indicate limited communication between water in the ash ponds and groundwater beneath the ponds because the removal of ponded water from Ash Pond E did not result in the lowering of groundwater levels surrounding Ash Pond E. In addition, a hydrologic water balance study was conducted for the APC to assess whether there is a significant net imbalance of the water coming in and out of the APC (TVA, 2019). One primary goal of the study was to evaluate whether significant leakage of surface water in the APC occurred during the operation from January 2017 to June 2017. Based on two different measurement methods of inflow, the study determined a leakage rate between 0 and 2.08 million gallons per day (mgd), or 3.2 cubic feet per second (cfs), might occur during the study period. It is expected that the magnitude of the average water flow rate through the post-excavation native aquifer solids under the future APC conditions will be much less pronounced than the high-end leakage rate (2.08 mgd) estimated in 2017, because no process water input to the APC in the future. It has also been observed that, when the flow from the APC was eliminated, limited changes in groundwater levels occurred. This finding will be included in the Final Environmental Assessment Report.

The main shallow groundwater flow unit in the APC area is the Carters Limestone Aquifer, which overlies Lebanon Limestone Aquifer. Note that karst type features were found at the site and are especially prevalent in the north and northwest reaches of the site. Because of the presence of the karst features, aquifer permeability is expected to be very heterogenous. The magnitude of groundwater flow estimated using the observed hydraulic gradients and an assumed hydraulic conductivity field is expected to be subject to great uncertainty.

Estimation of Dilution and Attenuation Effects

The surface water dilution/attenuation factor (SW-DAF) is a factor that describes the mixing effects on constituent concentration anticipated in a surface water body that receives constituents from groundwater discharge. Since the Cumberland River nearly surrounds the GAF and is considered the

ultimate discharge end point for CCR-derived constituents in groundwater from the Ash Pond Complex, the site-specific SW-DAF can be estimated using the following formulas.

$$\text{SW-DAF} = Q_R \div Q_{IA} \quad (1)$$

where Q_R is the estimated representative river flow rate under low flow conditions and Q_{IA} is the estimated net infiltration (or groundwater recharge) rate over the APC area together with potential runoff and groundwater recharge from areas outside the APC.

1. Q_R – Flow of the Cumberland River near the Gallatin Fossil Plant

The Gallatin Fossil Plant is located on the north bank of the Cumberland River, approximately 24 miles upstream in the backwater of the Old Hickory Dam (**Figure C-3**). The Old Hickory Dam is used for "run of the river" type hydroelectric generation, regulating discharge to maximize flow through the turbines and to maintain a uniform upstream pool level rather than for storing water in a large reservoir (USACE, 2020a). Two upstream dams do impound reservoirs: the Cordell Dam on the Cumberland River and the Center Hill Dam on the Caney Branch River. The Old Hickory and Cordell Dams have associated shipping locks.

Flow of the Cumberland River at GAF is primarily controlled by operation of these three dams. **Figure C-4** shows the results of a 1-D hydrothermal flow model for a dry period followed by a flood event in 2018 (TVA, 2020). Although the effects of all three dams are seen, flow at GAF is similar to discharge at the Old Hickory Dam.

This high degree of engineered storage and flow regulation throughout the Cumberland River watershed has the effect of dampening the effects of extreme events such as droughts and floods. Because of this, recurrence interval statistics are less representative for establishing low-flow conditions. Instead, results from the hydrothermal flow model are used.

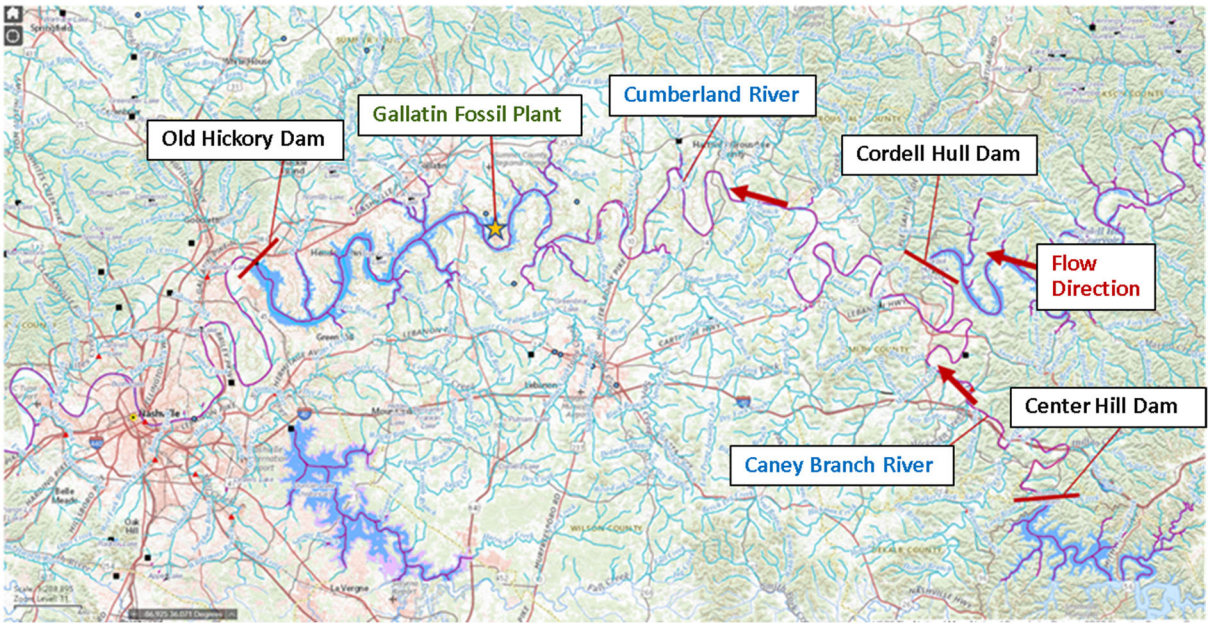


Figure C-3: *Configuration of dams and reservoirs affecting river flow at the Gallatin Fossil Plant (from https://www.usgs.gov/core-science-systems/national-geospatial-program/national-map)*

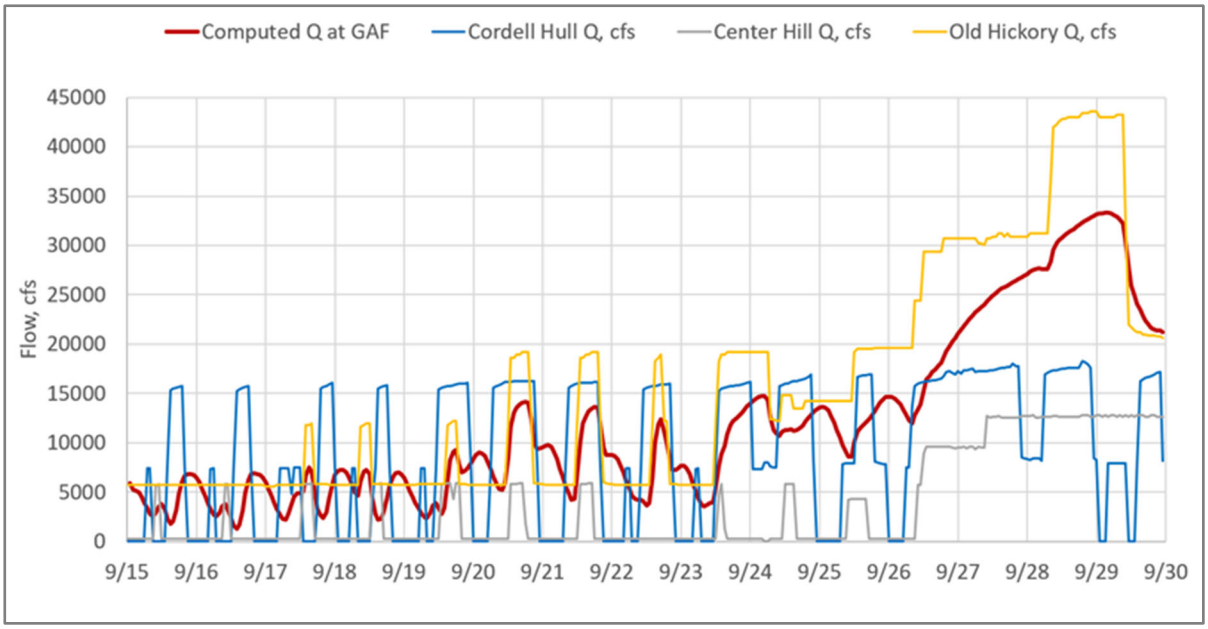


Figure C-4: *1-D Flow Model for the Cumberland River at GAF in September 2018 for a dry period (TVA, 2020).*

Low flow conditions occur during hot, dry summer months. During such times, hydroelectric power is used to meet peak demand in the late afternoon with corresponding episodic releases from the Center Hill and Cordell Hull Dams while a more constant flow is maintained at the Old Hickory Dam. **Table C-1** shows the precipitation data collected at Lebanon, Tennessee (9 miles away from the site) between 2000 and 2020. The month of September in 2019 is a drought month with the lowest September precipitation for the past 20 years. Results from the flow models during normal dam operations and a drought period in September 2019 can be considered as a representative low flow case (**Figure C-5**). The lowest average daily flow during this modeling period (9/21/2019 – 10/6/2019) is approximately 3000 cubic feet per second (cfs). This estimated low flow number is comparable with the historical discharge rate data collected at the Old Hickory Dam between 1979 and 2006 (**Figure C-6**). Therefore, 3000 cfs is selected as a representative $\boldsymbol{Q_R}$ for the Cumberland River at the plant location.

Note that the National Pollutant Discharge Elimination System (NPDES) permit for the plant estimated a 1Q10 low flow rate of 544.2 mgd (= 840 cfs) for the River. This low flow rate is significantly lower than the historical flow rates measured at the Old Hickory Dam downstream (**Figure C-6**). This 1Q10 flow rate can serve as a very conservative estimate of the $\boldsymbol{Q_R}$ for the Cumberland River at the plant location. As a reference for the comparison to the above low flow estimates, the USACE reports the mean daily flow of 8,359 cfs for the River near the plant (USACE, 2020).

Table C-1: **Monthly Total Precipitation for Lebanon, Tennessee between 2000 and 2020**
(data source: https://w2.weather.gov/climate/xmacis.php?wfo=ohx)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	4.66	3.17	4.40	5.87	4.99	2.60	3.00	4.33	3.29	0.43	5.40	4.98
2001	3.52	7.59	2.92	2.60	4.82	4.25	3.76	2.42	3.78	4.43	4.13	3.88
2002	5.58	2.27	8.21	3.38	6.81	2.20	4.36	3.03	5.16	4.58	2.89	5.69
2003	1.98	9.05	2.94	4.23	11.53	6.54	8.66	5.79	4.95	2.45	5.48	3.73
2004	8.24	5.59	5.67	4.79	9.26	6.34	4.13	M	4.72	2.23	5.23	M
2005	4.12	4.54	3.93	M	0.58	1.81	3.75	7.50	1.64	0.07	M	2.67
2006	6.79	M	M	M	M	M	3.38	M	M	3.05	M	2.89
2007	M	M	2.22	3.36	2.51	3.83	2.14	0.33	M	4.28	M	M
2008	1.96	3.67	4.58	M	4.75	0.92	M	1.42	M	3.47	1.94	M
2009	5.18	1.99	3.88	4.44	M	2.81	M	M	12.09	M	0.88	4.56
2010	4.33	3.04	2.71	2.55	11.88	M	M	10.78	0.89	2.28	M	M
2011	M	M	M	M	M	3.92	1.04	1.86	6.62	0.41	6.81	4.67
2012	M	M	4.00	1.25	M	1.81	10.92	5.69	5.84	4.45	2.14	5.11
2013	6.87	2.51	4.97	7.84	4.80	3.65	6.10	4.60	2.66	0.51	2.62	7.12
2014	2.73	M	3.80	7.18	3.44	4.19	M	M	2.45	9.93	3.60	3.89
2015	2.16	5.21	M	5.55	2.62	M	8.90	M	1.72	3.92	M	5.75
2016	M	6.04	2.94	M	3.58	M	M	M	M	0.10	M	7.40
2017	3.56	1.59	4.36	5.53	M	5.61	5.49	4.19	4.88	3.77	2.53	4.17
2018	1.63	M	5.47	6.49	4.24	4.86	2.95	3.78	7.55	5.67	6.11	5.67
2019	5.87	14.29	3.50	6.09	2.56	8.80	5.73	4.53	0.27	5.66	4.19	7.45
2020	6.13	7.89	7.49	6.67	M	M	M	M	M	M	M	M
Mean	4.43	5.23	4.33	4.86	5.22	4.01	4.95	4.30	4.28	3.25	3.85	4.98
Max	8.24 2004	14.29 2019	8.21 2002	7.84 2013	11.88 2010	8.80 2019	10.92 2012	10.78 2010	12.09 2009	9.93 2014	6.81 2011	7.45 2019
Min	1.63 2018	1.59 2017	2.22 2007	1.25 2012	0.58 2005	0.92 2008	1.04 2011	0.33 2007	0.27 2019	0.07 2005	0.88 2009	2.67 2005

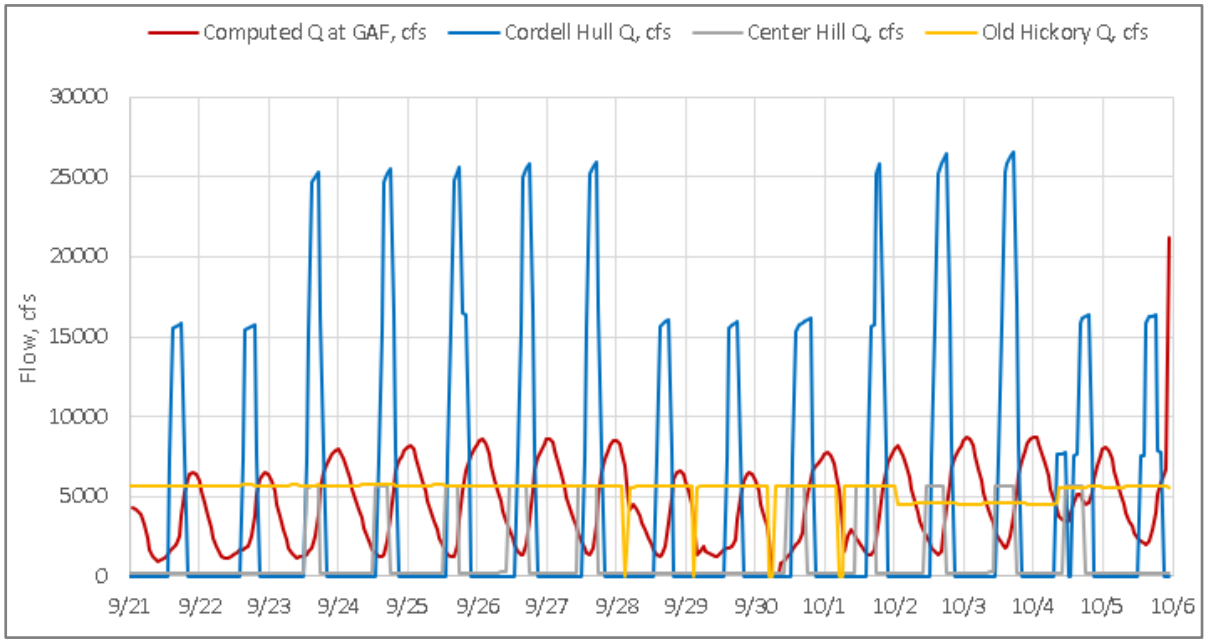


Figure C-5: *Results from the 1-D flow model representative of low flow conditions in 2019 (TVA, 2020).*

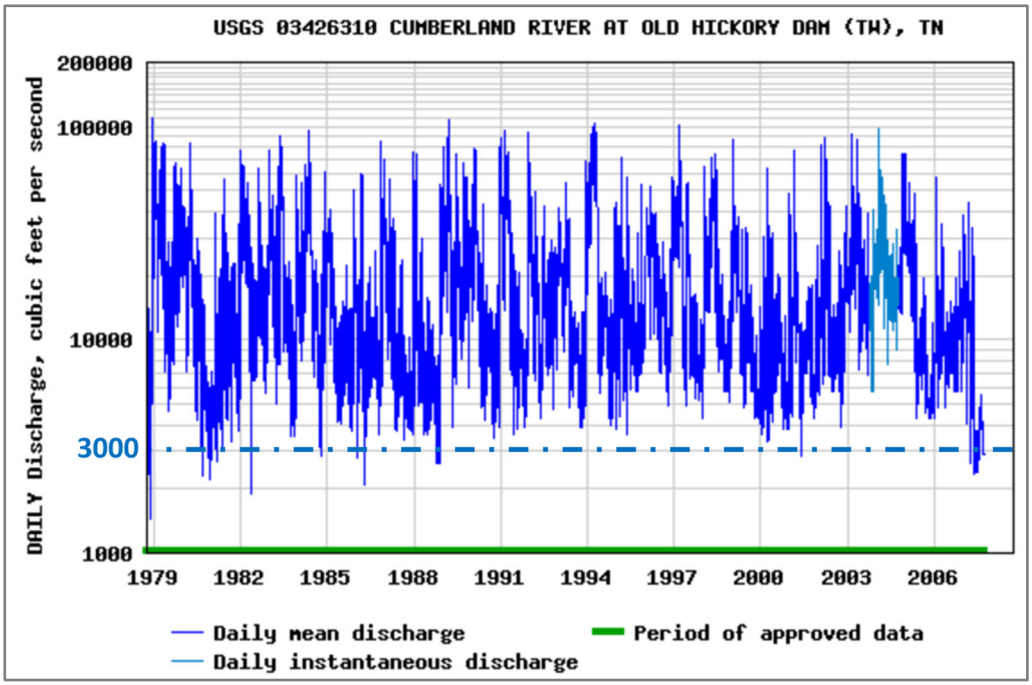


Figure C-6: *Historical data of the Cumberland River daily discharge rate measured at Old Hickory Dam. (data source: https://waterdata.usgs.gov/nwis)*

2. Q_{IA} – Infiltration and Runoffs into the APC Area

As described above, the magnitude of groundwater flow estimated using the observed hydraulic gradients and an assumed hydraulic conductivity field is expected to be subject to great uncertainty. However, the following general characteristics of groundwater flow and surface water flow interactions can be expected:

- Because the water level in the ponded area will closely resemble the river stage, the ponded area is assumed to behave like the River, acting as a sink for groundwater in the vicinity of the APC.

- Precipitation on the ponded area becomes part of surface water and is expected to have negligible interaction with the post-excavation aquifer solids in the subsurface.

- Precipitation outside the ponded area but within the APC (see the white area in **Figure C-7**), if not evaporated, is expected to become groundwater recharge percolating through the post-excavation aquifer solids that may have been impacted by CCR leachate in the past (**Figure C-8**).

- Precipitation on the North Loop Landfill area (**Figure C-7**) will be collected as runoff and transferred to the APC.

- Runoff originated from the areas outside and north of the APC (See numbered arrows 1 through 5 in **Figure C-7**, referred to here as "runoff streams") can be approximated using the StreamStat tool developed by the United States Geological Survey (USGS) (https://streamstats.usgs.gov/ss/). Note that a karst system and a hydraulic trough feature were found north of the APC. The hydrogeologic characterization data suggest that relatively high permeability and interconnectivity of the water bearing zones and the River (TVA, 2017; **Figure C-8**). The runoff streams 2 through 5 are considered as sinking streams, ending at sinkholes; therefore, they are expected to drain into the karst feature and flow through the hydraulic trough feature directly to the River before reaching the APC, unless there is too much runoff to drain through the karst system, which results in overflow and reaches the APC. As a conservative measure for the DAF estimate, the contributions of runoff streams 1 to 5 are assumed to reach the APC.

- Groundwater flow north of the APC will not interact with the aquifer solids beneath the APC because this groundwater flow is expected to be intercepted by the hydraulic trough, which directs the groundwater flow to the River (**Figure C-8**).

- Precipitation on the area south of the APC can also result in runoff and groundwater recharge, which may subsequently flow toward the APC. The USGS StreamStats tool was used to delineate the drainage units (**Figure C-7**). The yellow shaded drainage units are not likely to contribute water to flow through the post-excavation aquifer solids in the APC because (1) these units are partly covered by the Hermitage Formation and T-3 bentonite, which appear to considerably limit vertical infiltration of water (TVA, 2017), (2) runoff originated from these units are expected to

migrate directly toward the Cumberland River, and (3) groundwater flow in this area likely flow east, west, or south to the proximity to the River. To the contrary, although the purple area may also be covered by the Hemitage Formation and T3-bentonite, the resulting runoff may travel to surface karst features or where the low permeability cover soils is eroded, thereby becoming groundwater recharge and flowing toward the APC (**Figure C-8**).

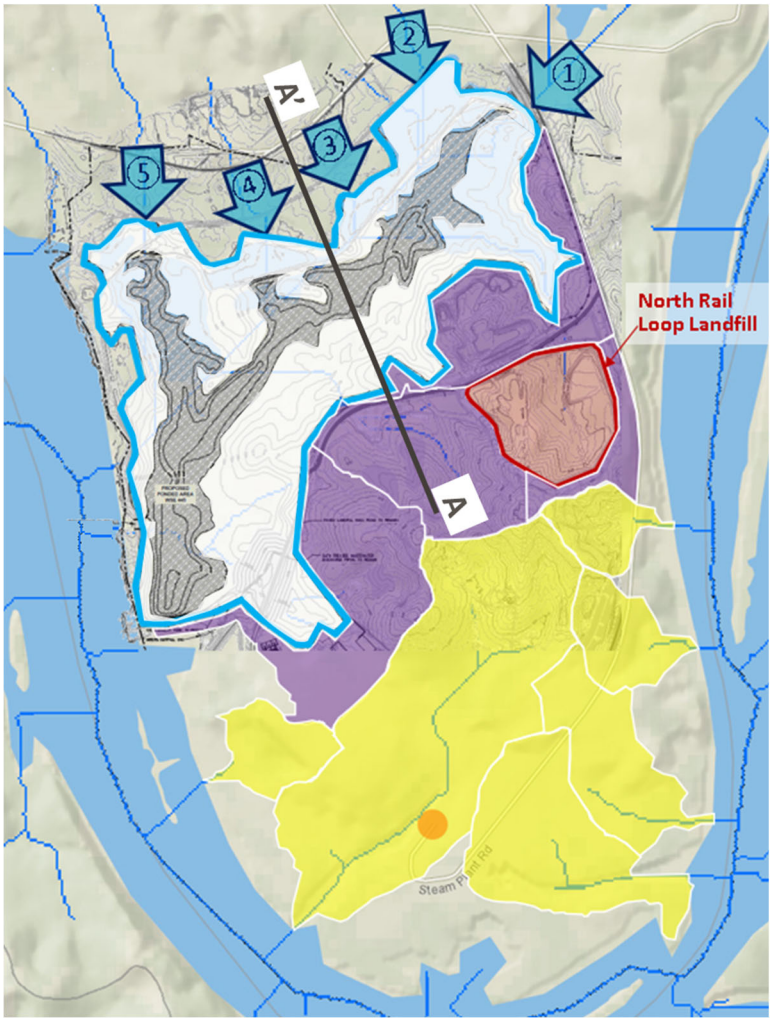


Figure C-7: *Schematics of conceptual water contribution sources in the vicinity of the APC. The gray area is the expected ponded area and the white area are the expected non-ponded area under future APC conditions. Runoff streams north of the APC are denoted by numbered arrows. The North Rail Loop Landfill area is expected to contribute runoff to the APC. The yellow area denotes various drainage units that are not likely to contribute surface and groundwater to the APC. The purple area denotes to the drainage units that may contribute groundwater recharge through the southern side of the APC. The water balance along the conceptual vertical cross-section A-A' is illustrated in Figure C-8.*

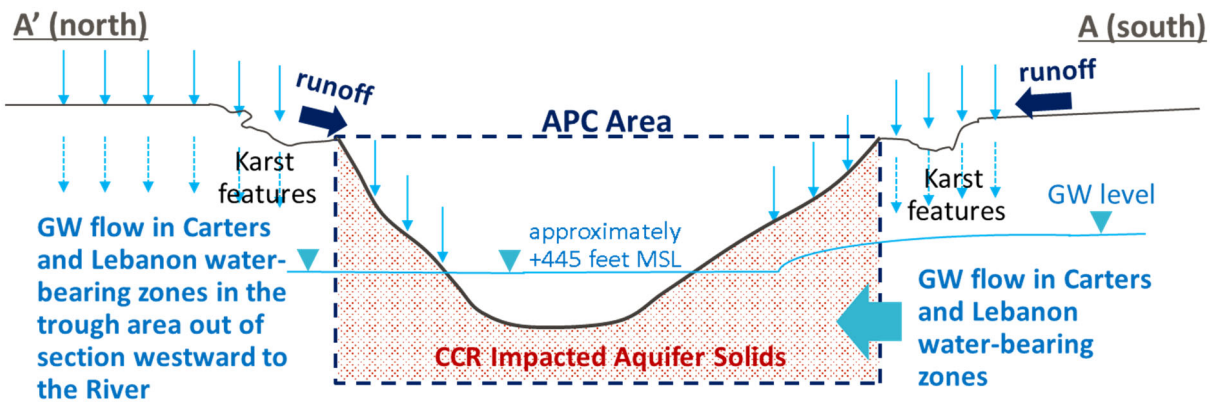


Figure C-8: *Conceptual vertical cross section view of water migration pathways in the vicinity of the APC under the future APC conditions.*

Infiltration Rate due to Direct Precipitation into the APC

The average annual precipitation in the vicinity of the plant is approximately 53 inches (TVA, 2017). The low-end estimated fraction of precipitation lost to evapotranspiration in the non-ponded area is approximately 50% (or 26.5 inches of average annual precipitation) (**Figure C-9**). The evaporation/evapotranspiration rate of the future ponded area is likely to be above 30 inches per year (**Figure C-10**). Therefore, conservatively assuming an average of 26 inches lost to evaporation/evapotranspiration annually and the rest of annual precipitation becomes groundwater recharge, which is approximately 27 inches (or 2.25 feet) annually.

The size of the non-ponded APC area (see the white area in Figure C-7) is approximately 13 x 10^6 square feet. Thus, the average annual groundwater recharge due to precipitation into the APC is 29 x 10^6 cubic feet per year (= 13 x 10^6 square feet x 2.25 feet annual infiltration) or 0.93 cfs. Note that, it is expected that a significant portion of precipitation not evaporated may directly flow to the ponded area in the form of runoff. Therefore, the method above to estimate the amount of water that may interact with the post-excavation aquifer solids through precipitation in the APC is representative of the average annual groundwater recharge rate in the APC area.

Runoff Transfer from the North Rail Loop Landfill Area

The size of the North Rail Loop Landfill area (see the area outlined in red in Figure C-7) is approximately 2.2 x 10^6 square feet. Assuming that 50% of precipitation that is not lost through evapotranspiration becomes runoff, which is subsequently captured by the surface drainage system for the area and then transferred to the APC, the average annual flow rate transferred to the APC is 5.0 x 10^6 cubic feet per year (= 2.2 x 10^6 square feet x 2.25 feet of precipitation [i.e., 50% of precipitation]) or 0.16 cfs. This estimated annual flow rate is 5.5 times higher than the amount of surface drainage for the area (= 0.9 x 10^6 cubic feet per year) estimated using stormwater modeling for the period between January 2017 and June 2017, as part of the water balance study reported (TVA , 2019). The comparison suggests that the

average annual runoff flow of 5.0 x 10^6 cubic feet per year or 0.16 cfs estimated here be conservative. All runoff water transferred to the APC is conservatively assumed to percolate through the post-excavation aquifer solids in the APC.

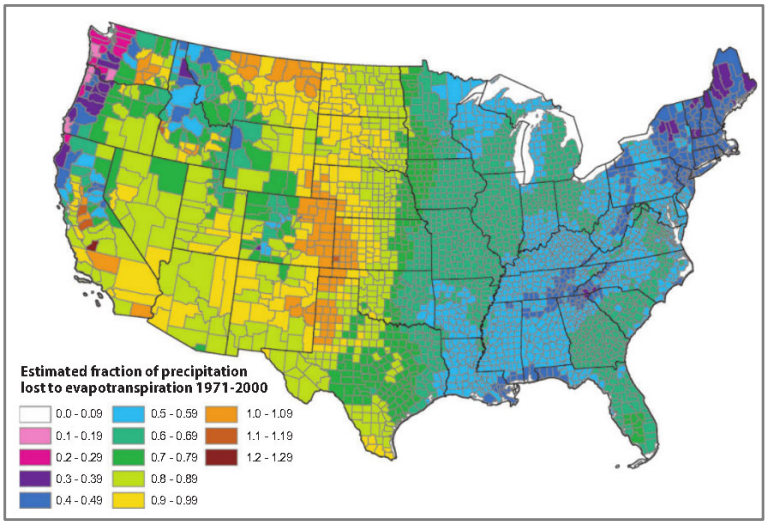


Figure C-9: *Estimated Mean Annual Ratio of Actual Evapotranspiration (ET) to Precipitation (P) for the Conterminous U.S. for the Period 1971-2000 (Sanford, W.E. and Selnick, 2013). (data source: https://onlinelibrary.wiley.com/doi/full/10.1111/jawr.12010)*

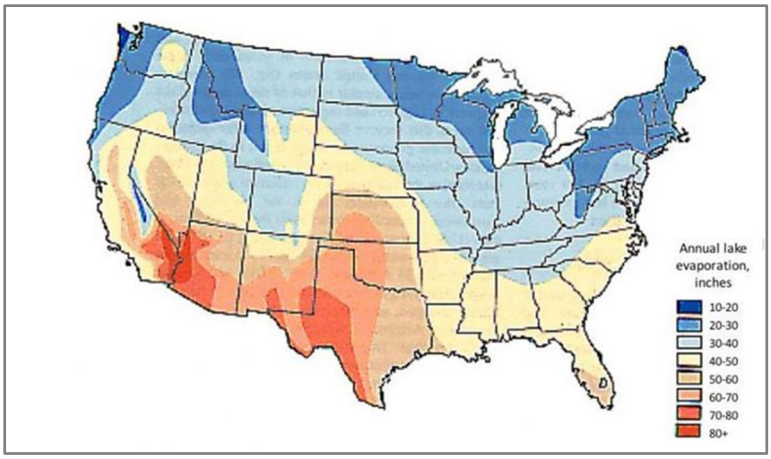


Figure C-10: *Mean annual lake evaporation in the conterminous United States, 1946-55. (data source: https://serc.carleton.edu/integrate/teaching_materials/food_supply/student_materials/905)*

<u>Potential Runoff Contribution from Areas North of the APC</u>

Based on the USGS StreamStat tool, five potential offsite runoff sources that may contribute water to the north of the APC are identified, as shown in **Figure C-7**. The StreamStat tool also produces various types of flow estimates that may be representative for each offsite runoff source based on their respective drainage area. The summer mean flow rate estimated by the tool is considered suitable for the purpose of this evaluation because of our interest in the period of the low flow conditions for the River. The results of the estimates are summarized in **Table C-2**. The total runoff rate is estimated to be 1.6 cfs. As described above, Runoff streams 2 through 5 are not likely to reach the APC because the karst and hydraulic trough features are present north of the APC. These streams are included to conservatively estimate the overall runoff input to the APC from the northern side. All runoff water is assumed to reach APC and percolate through the post- excavation aquifer solids in the APC.

Table C-2. Potential Offsite Runoff Contribution to the APC Area using StreamStat

Runoff Source	Estimated Summer Mean Flow Rate (cubic feet per second or cfs)
No. 1	1.3
No. 2	0.13
No. 3	0.01
No. 4	0.03
No. 5	0.08
Total	1.6

Potential Contribution from South of the APC

Precipitation on the purple area in Figure C-7 can contribute water to the APC. Although the purple area may be covered with impermeable soils, the resulting runoff may travel to nearby surface karst features or where the low permeability cover soils is eroded, thereby becoming groundwater recharge and flowing toward the APC (Figure C-8). The size of the purple area is approximately 13 x 10^6 square feet. The average annual groundwater recharge is estimated to be 29 x 10^6 cubic feet per year (= 13 x 10^6 square feet x 2.25 feet annual infiltration [50% of annual precipitation]) or 0.93 cfs.

Overall Q_{IA}

In summary, the average annual flow of the water that may pass through post-excavation aquifer solids in the APC is 3.6 cfs, which is the sum of the contributions from the following sources: precipitation inside the APC (0.93 cfs), runoff from the North Rail Loop Landfill area (0.16 cfs), Runoff inputs from the north of the APC (1.6 cfs), and the groundwater recharge input from the southern side of the APC (0.93 cfs.

3. SW-DAF for the Cumberland River

Based on the values of Q_R and Q_{IA} estimated above, two Surface Water Dilution Attenuation Factors that representative of low flow conditions of the Cumberland River are estimated. The first one is based on the Q_R value of 3000 cfs, which was obtained using the 1-D hydrothermal flow model results for a low flow period in 2019:

$$SW - DAF = \frac{Q_R}{Q_{IA}} = \frac{3000\ cfs}{3.6\ cfs} = \mathbf{830}$$

This SW-DAF value is a conservative (in terms of overestimating) estimate of groundwater discharge under the low flow conditions of the Cumberland River.

The second SW-DAF estimate is based on the Q_R value of 840 cfs, which is the 1Q10 value used in the plant NPDES permit:

$$SW - DAF = \frac{Q_R}{Q_{IA}} = \frac{840\ cfs}{3.6\ cfs} = \mathbf{230}$$

This SW-DAF value reflects the very low flow conditions of the Cumberland River and is a very conservative estimate.

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Attachment D – Interim Source Removal Process

Tennessee Valley Authority
1101 Market Street, BR 4A-C
Chattanooga, Tennessee 37402

Interim Source Removal Process

January 11, 2019

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1.0 PURPOSE AND SCOPE

This is an Interim Source Removal (ISR) Plan that addresses TVA's process for removal of coal combustion residuals (CCR) at locations where it is converting former ash disposal units to other industrial uses. The ISR Plan describes source removal activities and quality assurance activities in a general manner. Details such as planned limits of excavation, observation/verification point frequencies, personnel qualifications and forms of documentation will be established by the joint project team within project-specific Construction Quality Assurance (CQA) Plans.

The sequence of actions and compliance criteria for source removal within a CCR Unit are:

1. Establish geo-referenced 100-ft by 100-ft quality control (QC) grids that, as appropriate, will be further stratified by sections of inflow, middle and outflow (Section 2.1).

2. Excavate until visually observing the project area to be free of CCR (Section 2.2).

3. Perform composite soil sampling in accordance with the appropriate TVA Technical Instructions (TI) (Section 2.3).

4. Perform laboratory analysis for CCR Parameters (CCR Rule Appendix III [excluding anions] & IV, & Tennessee Department of Environment & Conservation (TDEC) Appendix I - copper, nickel, silver, vanadium, and zinc) and percent ash on the composite soil samples and related field and laboratory quality control samples in accordance with the ISR Quality Assurance Project Plan (QAPP) (Section 2.4).

5. Evaluate laboratory data quality in accordance with the TVA ISR QAPP. This involves comparing Level II verified laboratory results for the relevant CCR constituents to calculated site-specific soil screening levels (SSLs) (Section 2.5). The site-specific SSL calculations will be performed as specified in Section 4.8.5 of the November 2018 USEPA Regional Screening Levels (RSLs) - User's Guide (USEPA 2018). Results also will be compared to 95% Upper Tolerance Limits (UTLs) for nearby background soils, and to EPA's generic soil-to-water RSLs as described in the User's Guide. The percent ash results will serve as an additional confirmation of source removal, and also will be examined to evaluate the strengths of any relationships with individual CCR constituents that could be useful in future investigations.

6. If exposed soils exceed site-specific SSLs, over-excavate a minimum of 6 inches up to a maximum of one additional foot of native soil and re-sample for CCR constituents (Section 2.6).

7. Validated data (Level IV data packages) will be utilized in statistical analyses and, if needed, in any human health and ecological risk assessments (Section 2.7) performed under the 2015 TDEC Multisite Order.

2.0 SOURCE REMOVAL

Descriptions of ISR project personnel roles and associated responsibilities in addition to those presented in the CQA Plan are presented in the ISR QAPP.

The steps outlined below will be used to confirm CCR source removal sufficient to satisfy project-specific design criteria.

2.1 ESTABLISH GEO-REFERENCED QUALITY CONTROL GRID

The Contractor will establish a GPS-referenced 100-ft by 100-ft QC grid across the project area where accumulated CCR is present. If needed, these areas will be further stratified by sections of inflow, middle and outflow, which will be determined as appropriate for each site.

2.2 CCR REMOVAL

The Contractor will remove CCR in manageable portions of the project area such that the cleared area visually appears to be free of any non-native discolored areas or CCR deposits.

- The removal of CCR materials from the designated area(s) and the determination of non-CCR material shall be field-verified by visual observation and documented by the CQA team with photographs in the project records. The absence of CCR materials shall be determined by color and consistency of the exposed surface materials.
- Materials predominantly black or gray in color shall be deemed CCR materials, removed, and placed in designated areas for subsequent final disposal. Materials predominantly red or brown in color shall be deemed native soils and will be analyzed. If necessary, these areas will be considered cleared for over-excavation.
- A member of the CQA Team shall provide a one-foot by one-foot template to place at the center point of each grid. The template area should be photographed and geo-referenced with a hand-held GPS or similar device.

If the excavation encounters outcrop or pinnacles of bedrock, the Contractor will physically remove CCR materials from around those areas to the extent possible. If such features occur at a QC grid cell previously randomly-selected for sampling, the sampling will move to another adjacent grid cell and that change will be documented by the CQA team on red-lined drawings.

2.3 COMPOSITE SOIL SAMPLING

After source removal, sampling of the soil at the QC grid cells will use stratified (e.g. biased/weighted) random sampling methods performed in accordance with appropriate and

applicable TVA TIs and site-specific ISR QAPPs for analysis of CCR constituents and percentage of ash in native soils. Employing random stratified sampling recognizes the potential for differences in conditions due to the nature of settling ponds; therefore, the work area(s) may be divided into distinct sections such as inflow area, middle area, and outflow area.

As described in the TI, each selected grid cell will be subdivided into four quadrants. One composite sample will be collected that is comprised of equal portions of four representative grab samples from each quadrant (i.e., a four-point composite from each quadrant).

In accordance with the ISR QAPP and TVA TIs, collected composite samples and the associated field QC samples will be thermally preserved, packaged, and transported to the contracted laboratories for analysis.

If a random grid cell selected for sampling has saturated soils, samples will be collected from either a drier area within that QC cell or from an adjacent, drier cell. If this occurs TVA will red-line the grid provided to indicate where samples were taken, in the same manner as documentation of changes due to encountering rock outcroppings or pinnacles.

GPS coordinates will be recorded for each grab sample used to form a composite sample.

The frequency of the stratified random sampling of the QC grid cells for analysis of CCR Parameters and percentage of ash will be conducted as discussed in the following sections.

2.3.1 Sample Collection for analysis of CCR Parameters

Ten percent of the 100-ft by 100-ft QC grid cells will be sampled for analysis of CCR constituents in accordance with the TVA TIs. The sampling frequency within each area (e.g., inflow, middle, and outflow) will be proportional to the number of grids within that area.

2.3.2 Sample Collection for analysis of Percent Ash

Twenty percent of the 100-ft by 100-ft QC grid cells will be sampled for microscopic analysis of percentage of ash in accordance with the TVA TIs. The twenty percent of the grids sampled for percent ash analysis will include all grid cells sampled for CCR constituents. The sampling frequency within a section will be proportional to the number of grids within that section.

2.4 SAMPLE ANALYSIS

The collected soil samples will be shipped to the contracted laboratories for the analysis of CCR constituents and percentage of ash in soil in accordance with the ISR QAPP.

The percentage of ash will be analyzed by appropriate industry-standard polarized light microscopy (PLM) methods.

2.5 RESULTS EVALUATION

The analytical results for CCR constituents will be subjected to Level 2 data quality verification and Level 4 data validation assessments. Results will be compared against the following criteria:

- Site-specific 95% Upper Tolerance Limits (UTLS) for background soil concentrations,
- Site-specific SSLs calculated using the procedures and soil-to-water partition coefficients described in section 4.8 of the November, 2018 USEPA Regional Screening Levels (RSLs) - User's Guide (https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide).
- EPA's published generic Regional Screening Levels for *soil-to-groundwater*.

Calculated site-specific SSLs are based on either published drinking water Maximum Contaminant Levels (MCLs) or Protective Risk-based Groundwater concentrations (PRGs), taking into consideration exposure routes, dilution/attenuation factors specific to the situation being evaluated, and planned future site use (in this case, industrial).

The percent ash results will serve as an additional confirmation of source removal, and also will be examined to evaluate the strengths of any relationships with individual CCR constituents that could be useful in future investigations.

2.6 OVER-EXCAVATION

If a grid cell composite sample from the visually-clean surface does not meet site SSLs for CCR constituent concentrations, the native soil in the impoundment will be over-excavated by a minimum of 6 inches up to a maximum of one additional foot, and any QC grids that did not meet site SSLs will be re-sampled for CCR constituents. TDEC will be consulted for field verification prior to over-excavation.

Ground elevations after over-excavation will be documented via a field survey. The Contractor shall proceed with fill placement in a QC grid cell area after approval by the CQA Manager.

2.7 DATA VALIDATION

Level II data packages used for implementation decisions will be followed by Level IV data packages and data validation in accordance with the ISR QAPP. Validated data will be utilized in statistical analyses and, if needed, in human health and ecological risk assessments.

3.0 QUALITY ASSURANCE ACTIVITIES

The CQA Manager shall be responsible for CQA activities as discussed in the CQA Plan. Additionally, the following ISR-based QA activities shall be performed in accordance with relevant TIs and the ISR QAPP.

3.1 QUALITY ASSURANCE PROJECT PLAN

Samples will be collected, handled, transported, and analyzed in accordance with the ISR QAPP and relevant TVA TIs.

3.2 FIELD EQUIPMENT DECONTAMINATION

Equipment decontamination will be performed as directed by the CQA Plan. Manually powered field equipment will be decontaminated between sample events and locations in accordance with appropriate TVA TIs. Heavy equipment will be decontaminated, and documentation maintained, in accordance with applicable TIs and relevant best management practices (i.e. excavator buckets to be sprayed with water to remove accumulated materials between removal of CCR and over-excavation of native soils).

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Attachment E – Interim Source Removal Quality Assurance Project Plan

ENVIRONMENTAL STANDARDS

Setting the Standards for Innovative Environmental Solutions

QUALITY ASSURANCE PROJECT PLAN

TENNESSEE VALLEY AUTHORITY

SOURCE REMOVAL PROJECTS

Revision 0

January 2019

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2.0 QUALITY ASSURANCE PROJECT PLAN DESCRIPTION

2.1 Background

The primary goals of this Tennessee Valley Authority (TVA) Interim Source Removal (ISR) Quality Assurance Project Plan (QAPP) are to confirm that source removal objectives are met by TVA and contractors and to generate documented, high-quality, reliable analytical data. This document describes the quality assurance (QA) requirements for source removal activities conducted in accordance with TVA's policy for CCR Removal and Closure-by-Removal in compliance with the CCR Rule. This QAPP, along with the ISR and site-specific Construction Quality Assurance (CQA) plans, provides QA procedures and quality control (QC) measures to be applied to environmental sampling and analytical activities. This QAPP governs the quality aspects of the sampling and analytical activities of site-specific source removal activities.

This QAPP describes the QA implementation for ISR activities and identifies the obligations of the various entities responsible for generating environmental data. Details on the various sampling programs and quality objectives are presented in this QAPP, the ISR plan, and site-specific CQA plans. TVA Technical Instructions (TIs) will guide the specific activities performed under the site-specific CQA plans. The QAPP describes the generation and use of environmental data associated with source removal activities and applies to current and future sampling and monitoring programs associated with these projects.

2.2 Quality Assurance Program Organization, Management, and Responsibilities

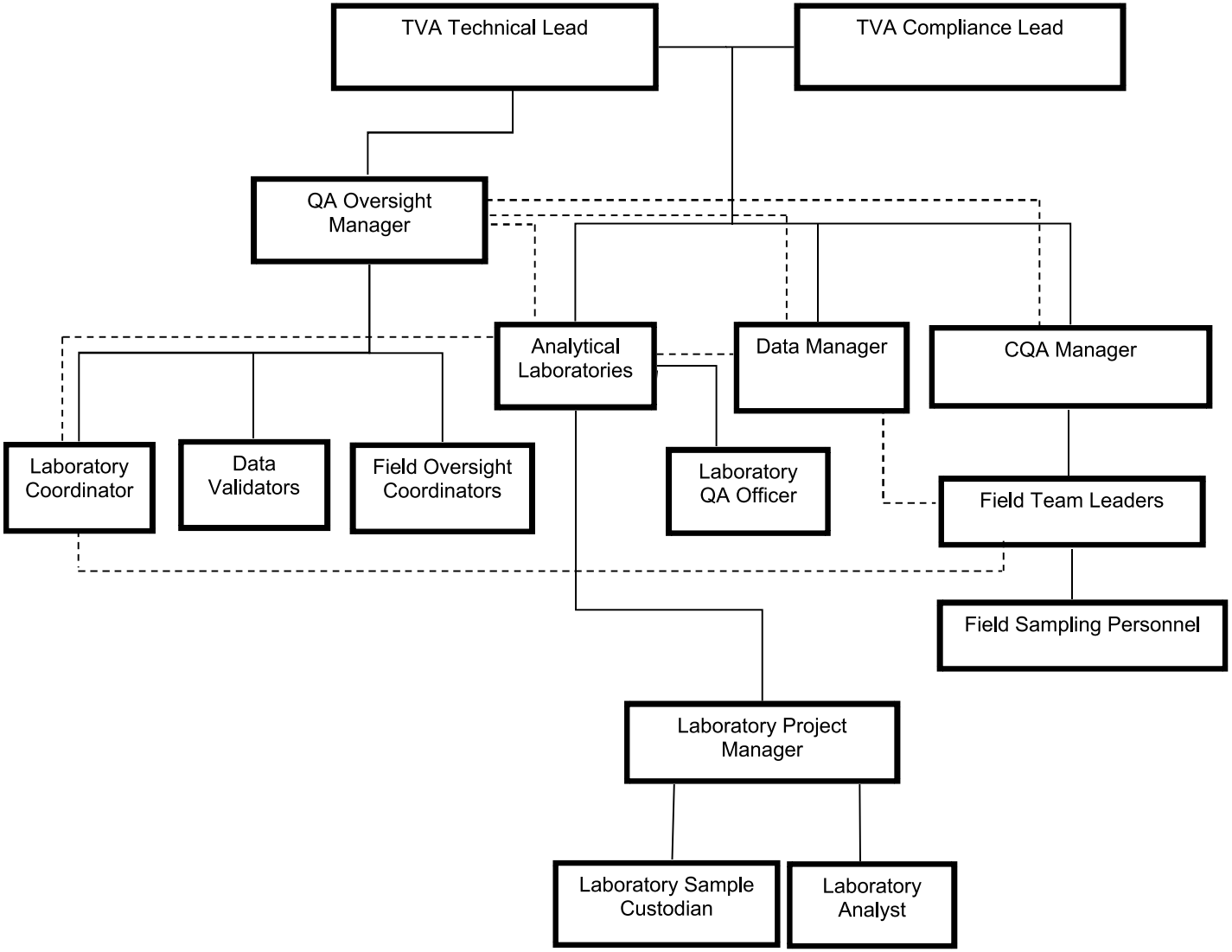
Successful implementation of a QA Program requires clear lines of reporting and authority, along with defined responsibilities for key individuals implementing and administrating the QA Program. This section describes the organizational structure, lines of authority, and responsibilities of key individuals accountable for the implementation and administration of the ISR and CQA plan requirements. Project activities are performed within the framework of the organization and functions described in this section.

The organizational structure showing relationships of individuals with key responsibilities is presented in Figure 2-1. The organizational structure in Figure 2-1 represents a subsection of the overall organizational structure for the project as directly related to implementation of the QAPP. The QA oversight consultant provides independent QA support to TVA including QA oversight of field and laboratory personnel. The organizational structure is designed to provide clear lines of responsibility and authority, regardless of the individuals filling particular roles. This organizational structure encompasses the following activities:

- Identifying lines of communication and coordination.
- Monitoring project schedules and performance.
- Managing technical resources.
- Providing periodic progress reports.
- Coordinating support functions such as laboratory analysis and data management.
- Rectifying deficiencies and issues that could impact data quality.

Field and laboratory personnel providing services in support of project efforts must perform work in compliance with the appropriate technical specifications for the activity.

Figure 2-1. Organization Chart and Lines of Communication for Interim Source Removal Activities



The sections below detail the roles and responsibilities for the positions involved in TVA source removal projects.

2.2.1 TVA Compliance Lead

The TVA Compliance Lead is responsible for the coordination and direction of source removal activities. The TVA Compliance Lead is ultimately responsible for design and implementation of projects. The TVA Compliance Lead interfaces with TVA Legal Counsel as necessary and provides reports to TVA Senior Management.

TVA Compliance Lead's responsibilities and duties include:

- Identifying lines of communication and coordination.
- Managing key technical resources.
- Providing periodic progress reports to TVA Senior Management.
- Reviewing and approving the strategy.
- Reviewing and approving quality objectives.
- Reviewing and approving ISR and site-specific CQA plans.
- Rectifying deficiencies and issues.
- Participating in meetings with Tennessee Department of Environment and Conservation (TDEC).
- Providing compliance support to TVA Technical Lead.

2.2.2 TVA Technical Lead

The TVA Technical Lead is responsible for providing technical guidance for source removal activities. The TVA Technical Lead directs the Investigation Project Manager and independent QA Oversight Manager and is ultimately responsible for design and implementation of source removal activities. The TVA Technical Lead interfaces with TVA Legal Counsel as necessary and provides reports to TVA Senior Management.

TVA Technical Lead's responsibilities and duties include:

- Developing and reviewing the strategy.
- Developing and reviewing quality objectives.
- Reviewing and approving ISR and site-specific CQA plans.
- Reviewing and analyzing overall task performance relative to planned QA requirements.
- Managing support functions such as laboratory analysis and data management.
- Rectifying deficiencies and issues.
- Providing technical support to the TVA Compliance Lead.
- Overseeing the budget.
- Monitoring project schedules and performance.

2.2.3 Construction Quality Assurance (CQA) Manager

The CQA Manager plans, coordinates, and oversees the performance of all source removal sample collection activities. The CQA Manager's responsibilities include:

- Developing site-specific CQA plans.
- Planning and coordinating Field Sampling Personnel for sampling events.
- Reviewing field logbooks for completeness, consistency, and accuracy.
- Managing and reviewing field sample Chain-of-Custody (COC) Records and associated documentation.
- Obtaining the appropriate field gear and supplies.
- Notifying management of situations requiring corrective action.
- Responding to, and implementing corrective action, as described in Section 15.0.

2.2.3.1 Field Team Leaders

The Field Team Leaders are the primary contacts in the field and are responsible for field activities, as listed below.

- Provide coordination and management of Field Sampling Personnel and subcontractors involved in field sampling.
- Submit analytical requests to the Laboratory Coordinator.
- Ensure Field Sampling Personnel are familiar with field procedures and that these procedures are followed to achieve the data objectives.
- Review field logbooks and field data sheets for completeness, consistency, and accuracy.
- Conduct QA review of field data and coordinate submittal of field data to the Data Manager.

2.2.3.2 Field Sampling Personnel

Field Sampling Personnel are responsible for the performance of field activities as required by the ISR and site-specific CQA plans and associated field TIs. Field Sampling Personnel document compliance with project requirements by recording field activities and observations in a field logbook at the time of the activity or observation. In addition, Field Sampling Personnel are responsible for collecting samples, submitting them to laboratories, and maintaining COC Records.

Field Sampling Personnel are responsible for field activities, including:

- Plan sampling events and interface with Laboratory Coordinator.
- Collect, label, and package samples.
- Ensure field procedures are followed to achieve the data objectives.
- Review field notebooks/logbooks for completeness, consistency, and accuracy.
- Provide coordination of sample delivery to project laboratories for analysis.

If there are problems encountered during any field activities, Field Sampling Personnel will inform the appropriate Field Team Leader and/or the Investigation Project Manager.

2.2.4 Analytical Laboratories

The functional roles for project analytical laboratories are described in this subsection. From the project perspective, the structure is designed to facilitate information exchange about planning, technical requirements, schedules, and QA measures among the laboratories, Investigation personnel, QA Oversight personnel, and TVA personnel. Project information exchange specifically includes sample identification; preservation procedures; sample container requirements; sample collection procedures; decontamination protocols; and sample labeling, packing, holding times, and shipping.

Although internal laboratory structures may differ depending on the specific contractor, key functional roles include division management, technical direction, subcontracting coordination, data review, and data management.

The responsibilities of the analytical laboratories include, but are not limited to:

- Preparing and analyzing samples in a manner consistent with the analytical request, the QAPP, and any applicable TVA TIs or other work instructions.
- Communicating with the QA Oversight Team.
- Adhering to the laboratory QA Program.
- Implementing QC procedures for each test parameter.
- Reviewing analytical results, including raw data, calculations, and laboratory logbooks.
- Monitoring proper documentation and maintenance records.
- Identifying and implementing training requirements for the laboratory analytical personnel.
- Identifying QA problems and recommending appropriate corrective action.
- Preparing status reports (progress, problems, and recommended solutions).
- Preparing reports documenting completion of corrective actions.
- Providing electronic data deliverables (EDDs) in a format consistent with project requirements.

Laboratories will be selected based on a number of factors including capability, capacity, and ability to generate quality data that meet project objectives. The primary contracted laboratories may subcontract samples for special studies or non-routine analyte lists. In the event that samples are subcontracted, the primary laboratory is responsible for ensuring that analyses conform to the QAPP requirements and the associated ISR and site-specific CQA plans. Data for subcontracted analyses will be reported through the primary contracted laboratory, which remains responsible for data quality.

The primary analytical laboratories expected to analyze samples associated with source removal activities are presented on Table 2-1.

Table 2-1. Analytical Laboratories for Interim Source Removal Projects

Parameter/ Sample Type	Laboratory	Facility Address	Laboratory Contact
Metals	TestAmerica Laboratories, Inc.	301 Alpha Drive Pittsburgh, PA 15237	Ms. Gail Lage (gail.lage@testamericainc.com)
Radiological Parameters		13715 Rider Trail North Earth City, MO 63045	
Percent Ash	R.J. Lee Group	50 Hochberg Road, Monroeville, PA 15146	Ms. Monica Carse (MCarse@rjleegroup.com)

2.2.4.1 Laboratory QA Officer

The Laboratory QA Officer ensures conformance with authorized policies, procedures, and sound laboratory practices as necessary. The Laboratory QA Officer will inform the Laboratory Project Manager of any non-conformances, introduce control samples into the sample train, and establish testing lots. In addition, the Laboratory QA Officer approves laboratory data before reporting or transmitting to permanent storage and is responsible for retention of supporting information such as control charts and other performance indicators to demonstrate that the systems that produced the data were in control. The Laboratory QA Officer also reviews results of internal QA audits and recommends corrective actions and schedules for their implementation.

The responsibilities of the Laboratory QA Officer include, but are not limited to:

- Administering the laboratory QA Program.
- Implementing QC procedures for each test parameter.
- Reviewing analytical results, including raw data, calculations, and laboratory logbooks.
- Monitoring proper documentation and maintenance of the records.
- Identifying and implementing training requirements for the laboratory analytical personnel.
- Overseeing QA implementation at the laboratory on a daily basis.
- Identifying QA problems and recommending appropriate corrective action.
- Preparing status reports (progress, problems, and recommended solutions).
- Preparing reports documenting completion of corrective actions.

2.2.4.2 Laboratory Project Manager

The Laboratory Project Manager is the primary contact for the Project Team at the analytical laboratory. A primary responsibility of the Laboratory Project Manager is to schedule analytical work within the laboratory, ensure that project-specific analytical requirements are communicated to staff, monitor analytical status/deadlines, approve laboratory reports, coordinate data revisions/corrections and re-submittal of data packages as necessary, and communicate sample preparation and analysis issues to the QA Oversight Manager and TVA Technical Lead on a real-time basis. The Laboratory Project Manager provides direction and support for laboratory administrative and technical project staff, interfaces with laboratory project

staff on technical issues, and performs QA oversight of analytical data. The Laboratory Project Manager contacts the QA Oversight Manager and TVA Technical Lead if, at any point, there is a need to deviate from the QAPP or other cited published materials. Any problems or inconsistencies identified at any time after laboratory sample receipt will be documented on a nonconformance report initiated by the Laboratory Project Manager and forwarded to the TVA Technical Lead and the Laboratory Coordinator.

The Laboratory Project Manager will provide sample receipt confirmations to the Laboratory Coordinator and Investigation Project Manager within 3 hours of sample login.

2.2.4.3 Laboratory Sample Custodian

The Laboratory Sample Custodian receives samples from TVA or its contractors, signs and dates COC Records, records the date and time of receipt, and records the condition of shipping containers and sample containers.

The Sample Custodian will verify and record agreement or non-agreement of information on sample custody documents. If there is non-agreement, the Sample Custodian will record the problems/inconsistencies for the case file and will inform the Laboratory Project Manager.

The Sample Custodian will also label sample containers with laboratory sample numbers, place sample containers and spent sample containers into the appropriate storage and/or secure areas, and monitor storage conditions.

2.2.4.4 Laboratory Analyst

The Laboratory Analyst is responsible for preparing and/or analyzing samples in accordance with this document and/or the applicable analytical methods. If there are problems encountered during sample preparation or analysis, the Laboratory Analyst will inform the Laboratory QA Officer and Laboratory Project Manager.

2.2.5 QA Functions

QA oversight activities will be performed by a third-party, independent contractor. The QA oversight consultant is an independent third-party QA organization and reports directly to the TVA Technical Lead.

2.2.5.1 QA Oversight Manager

The QA Oversight Manager develops, implements, and administers the overall QA Program for source removal activities. The QA Oversight Manager holds overall authority for the project QA and maintains that authority independently from the operational/production aspects of the project. The QA Oversight Manager also holds the authority to communicate at any level of the project organization in order to be effective.

The QA Oversight Manager’s responsibilities and duties include:

- Establish a documented quality system for the project.
- Identify QA problems through periodic auditing and validation procedures.

- Initiate, recommend, or provide solutions to QA problems through designated channels.
- Ensure that project activities, including processing of information, delivery of products, and installation or use of equipment, are reviewed in accordance with QA objectives.
- Ensure that deficiencies or non-conformances are corrected.
- Ensure that further processing, delivery, or use of deficient or non-conforming data is controlled until correction of the non-conformance, deficiency, or unsatisfactory condition has occurred.
- Review and analyze overall task performance with respect to planned requirements.
- Perform general oversight of corrective action processes.
- Initiate and direct internal audits, inspections, surveillances, and observation of quality-related activities.
- Serve as point of contact for audits, inspections, surveillances, data management, and observation activities.
- Ensure deficiencies and non-conformances are corrected.
- Maintain QA documentation and records, including this QAPP.

2.2.5.2 Laboratory Coordinator

The Laboratory Coordinator serves as a liaison between Field Team Leaders and the analytical laboratories for all work conducted under the source removal project. The Laboratory Coordinator's responsibilities include:

- Review analytical requests to verify consistency with the ISR and site-specific CQA plans.
- Submit analytical requests to the Laboratory Project Manager.
- Schedule sample submission and transportation (as needed).
- Review and approve laboratory bottleware orders.
- Review COC Records submitted to the laboratories and sample receipt documentation provided by the laboratories.
- Serve as the point of contact for questions and issues arising during laboratory analysis.

2.2.5.3 Data Validators

Data Validators are responsible for performing review and validation of project data generated by the laboratories in accordance with the QAPP and data specifications, producing data validation reports, and notifying the QA Oversight Manager of any specific issues or concerns.

2.2.5.4 Field Oversight Coordinators

Field Oversight Coordinators are independent from field sampling activities and work with the Field Team Leaders to ensure compliance with the QAPP, ISR and site-specific CQA plans, and associated TVA TIs. The Field Oversight Coordinators are responsible for training personnel involved in field sampling activities (if training is required), sample handling procedures, and sample custody as detailed in TIs and the ISR plan, and for periodically overseeing their performance of these functions. The Field Oversight Coordinators perform quality oversight of the Field Teams during sample collection and assess the procedures and performance of the Field Teams relative to the requirements in the QAPP, TIs, and ISR and site-specific CQA plans. As part of the quality oversight, the Field Oversight Coordinators will review COCs prior to submission of samples to the analytical laboratories.

2.2.6 Data Manager

The Data Manager is responsible for managing the project EQuIS™ database, which includes analytical data from laboratories and field data from the Field Team Leaders. The Data Manager is the main point-of-contact for data-related issues. The Data Manager is responsible for ensuring compliance with the QAPP and the Data Management Plan (DMP). The Data Manager or designee receives EDDs directly from the project laboratories after sample analysis and formats the deliverables such that they can be used during the validation/verification process. Field data is collected and submitted to the Data Manager from the Field Team Leader utilizing field EDDs and is loaded and managed in the project database. A complete description of the Data Manager's responsibilities and responsibilities of Data Management support staff is provided in the DMP.

3.0 PROJECT DESCRIPTION AND APPLICABILITY

The purpose of source removal activities is to remove CCR during the repurposing of ash ponds. Samples will be collected for CCR parameters during closure activities in accordance with the ISR and site-specific CQA plans. Analytical data collected during source removal activities may be used to evaluate site conditions under the plant-specific Environmental Investigation Plan (EIP), the Environmental Assessment Report (EAR), and the Corrective Action/Risk Assessment (CARA) plan.

To support the source removal objectives, a QA program has been implemented to ensure the environmental data generated for use in decision making is of high-quality and is legally defensible.

On behalf of TVA, Environmental Standards, Inc., an independent QA firm, has prepared this QAPP. The requirements of the QAPP are applicable to project environmental personnel, support staff, consultants, and subcontractors.

3.1 Purpose and Scope

The QAPP is intended to establish an overall environmental QA framework for site-specific source removal projects and to provide quantitative quality objectives for analytical data generated under the ISR and site-specific CQA plans. Requirements associated with sample analyses; data generation, reduction, and management; and results reporting are stipulated herein. Additional specific requirements are described in the ISR and site-specific CQA plans.

The scope of this document is to describe the QA requirements developed for site-specific source removal activities and to provide appropriate QA procedures and QC measures for the associated sampling and monitoring activities. The QAPP addresses the following items:

- Project organizational structure, roles, and responsibilities.
- QA objectives.
- Training requirements.
- Field and laboratory documentation requirements.
- Sample collection, handling, and preservation.
- COC procedures.
- Field and laboratory instrumentation and equipment calibration and maintenance.

- Preventive maintenance procedures and schedules.
- Laboratory procedures.
- Analytical methods requirements.
- Sample analysis, data reduction, validation, and reporting.
- QC sample types and frequency.
- QA performance and system audits.
- Data assessment procedures, including processing, interpretation, and presentation.
- Corrective actions.
- QA reports to management.

A general ISR plan and site-specific CQA plans describe sampling requirements that will provide data sufficient to address the objectives of each project. QC requirements and quantitative objectives for analytical data are presented in Attachment D of this QAPP.

3.2 Schedule

In general, the anticipated schedule of activities related to analytical data generated from chemical analyses is presented below.

- The laboratory will provide analytical results and EDDs to TVA within its standard turn-around time (TAT; approximately 10 business days for chemical analyses and approximately 40 days for radiological analyses) from sample receipt (or sooner when expedited TAT is requested).
- The QA oversight consultant will screen the EDD for acceptability to the database and complete the initial verification within 2 business days of EDD receipt and successful EDD loading. Verified data will be available to TVA and Investigation personnel for internal use and reporting.
- The laboratory will provide full data deliverable packages to TVA and the QA oversight consultant within its standard TAT (approximately 20 business days for chemical analyses and approximately 45 days for radiological analyses) from sample receipt.
- The QA oversight consultant will complete data validation as requested by TVA, generate reports following receipt of the complete data package, and add data validation qualifiers to the database as appropriate.

3.3 QAPP Distribution and Revision

The QAPP will be distributed to each consultant and contractor responsible for the collection, generation, and interpretation of field and analytical data. The TVA Technical Lead, QA Oversight Manager, or designee will be responsible for ensuring that necessary revisions are made so that the QAPP is up-to-date with actual practices and will ensure that revisions and updates are distributed to necessary users. The document control format used in the QAPP will identify the QAPP revision number and revision date. A revision history that identifies each revision and a summary of the revision will be maintained.

4.0 DATA QUALITY OBJECTIVES PROCESS

The Data Quality Objective (DQO) process is a series of planning steps based on a scientific method to ensure that the type, quantity, and quality of environmental data used in decision making are appropriate for the intended application. In general, DQOs provide a qualitative and quantitative framework around which data collection programs can be designed. The qualitative aspect of DQOs seeks to encourage good planning for field activities. The quantitative aspect of DQOs involves designing an efficient field activities that reduces the possibility of incorrect decision-making.

The DQO process is a tool employed during project planning to ensure that data generated from a project are appropriate and of sufficient quality to address the investigation objectives. TVA, its QA oversight consultant, and project personnel consider key components of the DQO process in developing the ISR and site-specific CQA plans to guide the data collection efforts for each source removal project.

5.0 SPECIAL TRAINING/CERTIFICATIONS

Field Sampling Personnel performing sample collection activities will be properly trained in equipment use and procedures necessary for each task prior to entering the field. Training will be conducted by TVA, the QA Oversight Consultant, the CQA Manager, and/or other subcontractors. Any proposed training not provided by the QA Oversight Consultant will be reviewed and approved by the Field Oversight Coordinator before training is conducted. Field Sampling Personnel training will be fully documented and the documentation will be maintained as part of the Project Record.

Individuals who plan to participate in field activities must have current health and safety training prior to commencement of sample collection activities. The Field Team Leader will verify that participants who arrive on site have provided evidence of health and safety training. It will be the responsibility of the Field Team Leader to ensure that Field Sampling Personnel understand and comply with the applicable requirements for their individual tasks.

Field Sampling Personnel will be trained on applicable field QC measures associated with a particular sampling program during program-specific training. Training received by Field Sampling Personnel will be documented. In addition, Field Sampling Personnel will receive training based on field oversight activities and additional training sessions on applicable project TIs.

Personnel who are responsible for performing laboratory analyses will be properly trained by the Laboratory Director or her/his designee to conduct the various laboratory analyses described in the QAPP. Each laboratory shall assure sufficient personnel with the necessary education, training, technical knowledge, and experience for their assigned functions. Laboratory personnel training will be documented in accordance with the laboratory's Quality Program requirements.

Data verification and validation will be conducted under the direction of the QA Oversight Manager, who will be experienced with the production, reporting, verification, and validation of analytical data.

Additional QA training will be conducted at the discretion of the TVA Technical Lead and the QA Oversight Manager. Generally, the need for QA training for project personnel will be identified through systems and performance audits and training will be conducted as part of the corrective action process. Any QA training provided to project personnel will be documented.

6.0 DOCUMENTATION AND RECORDS

Appropriate records will be maintained in a secure project file to provide adequate documentation of the entire data generation process, including field sampling and laboratory analysis. Field records will include maintaining field logs, field data sheets, and sample COC documentation. Field QC samples will be documented in both the field logbook and sample COC Records.

The Project File will be the central repository for documents relevant to sampling and analysis activities as described in the QAPP and in the ISR and site-specific CQA plans. The TVA Technical Lead has overall responsibility for maintenance of documentation associated with the project, including relevant records, correspondence, reports, logs, data, field records, pictures, subcontractor reports, analytical data, and data reviews. The file will include the following information, if generated:

- Field records.
- Field data and data deliverables.
- Photographs.
- Drawings.
- Sample logs.
- Laboratory data deliverables.
- Data validation reports.
- Field and laboratory audit reports.
- Reports (*e.g.,* progress reports, QA reports).
- Custody documentation.

Electronic and hardcopy data will be archived for a minimum of 10 years from the date of report. TVA will maintain a complete project file and will archive hardcopy and electronic data in accordance with TVA records retention rules as delineated by TVA's records management documents. Electronic or hardcopy data associated with source removal activities will not be discarded, deleted, or destroyed by any party without the written consent of TVA Legal Counsel.

6.1 Field Data Documentation

Field data collected during each source removal project will be evaluated for usability by conducting a QA review that includes checking the procedures used by field staff and comparing the data to previous measurements. Field QC samples will be used to verify that field measurements and sampling protocols have been observed and followed. The field data will be reviewed by the Field QA Oversight Coordinator or designee for the following:

- Compliance with TIs.
- Compliance with the ISR and CQA plans.
- Field equipment calibration method and frequency.
- Field calibration standard lot numbers and expiration dates.

- Date and time sampled.
- Preservation.
- Sampler collection procedures.
- COC Records.
- Date sample shipped.

The Field Team Leader or designee will be notified of any deviations from applicable TIs, the ISR plan, or site-specific CQA plan and will inform the TVA Technical Lead and the TVA Compliance Lead. The TVA Technical Lead and TVA Compliance Lead will review the deviations and either approve, as appropriate, or provide alternate direction on how to proceed. All deviations and actions related to those deviations will be documented in the field logbook during sampling and data collection operations.

The original COC Records will accompany samples to the analytical laboratories. Upon receipt and login of the samples at the laboratory, the remaining sections of the COC Record (such as description of the sample condition at the time of receipt, assigned laboratory identification number, and any special conditions) will be completed. The original COC Record will be archived at the analytical laboratory in accordance with the laboratory's document retention requirements and the requirements herein.

6.2 Laboratory Data Documentation

Analytical laboratories performing work on this project will retain records of the analytical data for a minimum of 10 years after project completion. Analytical data will not be disposed of without TVA's consent. In addition, laboratory data will be provided to TVA in hardcopy or approved electronic form. TVA will retain data in accordance with TVA records management requirements. Laboratory data will not be disposed of without specific approval from TVA Legal Counsel and the TVA Technical Lead.

6.2.1 Laboratory Data Reporting/Deliverable Package

Chemical analytical laboratories will report data at their standard TAT; generally, 10 business days from sample receipt at the laboratory for all chemical parameters. In some cases, expedited TATs are required. Results of sample chemical analyses are completed and results reported as a Level II report and EDD within 10 business days (refer to Attachment A for data deliverables requirements). Level IV data packages (refer to Attachment A for data deliverables requirements), in a hardcopy and/or electronic Adobe® Acrobat® portable document format (.pdf), will be submitted to TVA and the QA Oversight Consultant within approximately 20 business days from sample receipt at the laboratory. Radiological analysis results are completed and reported to TVA and the QA Oversight Consultant as a Level IV report and EDD within 45 business days.

Laboratories performing chemical analyses will be responsible for providing an EDD consistent with the DMP, as well as a Level II report and/or Level IV data package (see Attachment A). The deliverable package will contain final results (uncorrected for blanks and recoveries except where required by the referenced method), analytical method reference, sample results and detection limits, and results of field and laboratory QC samples. In addition, special analytical problems and/or any modifications of referenced methods will be noted in the Case Narrative of

the laboratory report/data package. The number of significant figures reported will be consistent with the limits of uncertainty inherent in the analytical method.

As a general statement:

- Concentrations for aqueous samples are expressed in terms of weight per unit volume (such as milligrams per liter [mg/L] or micrograms per liter [µg/L]).
- Concentrations for chemical analyses of solid samples are expressed in terms of weight per unit weight of sample (such as milligrams per kilogram [mg/kg] or micrograms per kilogram [µg/kg). Unless specifically directed otherwise, solid sample chemical analysis results will be reported on a dry-weight basis. The reporting basis for solid samples will be clearly indicated in the laboratory data package.
- Radiological activities are expressed in terms of picocuries per unit volume or weight (such as pCi/L or pCi/g). For solid samples, radiological activities are not corrected for sample moisture content.

Data will be reported in the units specified in the Method Analyte Groups (MAGs) to ensure consistent reporting among the contracted laboratories.

Chemical analytical data will be provide in the Level II report and Level IV data package formats presented in Attachment A. In general, the Level IV data package will include summary forms and raw data for calibrations, QC, and sample analyses. QC results reported will include a method blank, matrix spike/matrix spike duplicate (MS/MSD) samples, field QC samples, and laboratory control samples (LCSs). Sample chemical analyses data (both field and laboratory QC sample results) will also be provided in EDDs. The laboratory is responsible for reviewing the electronic data to ensure that these data are consistent with those presented in the laboratory report/data package. Data discrepancies between the EDD submission and laboratory report/data package, if any, will be reconciled at validation; the data validators will notify the contract laboratory and TVA so that the laboratory deliverables may be revised by the contract laboratory. In the event that revisions to Level II or Level IV data packages are required based on data validation, complete revised deliverables clearly stamped with revision number and date will be provided by the contract laboratory so that a final complete data package is archived for each sample submittal.

6.3 Recordkeeping

Written and/or electronic records generated during source removal activities, including but not limited to notes, logbooks, reports, draft and final documents, and forms, are maintained by the originator for inclusion in the project file as appropriate. In addition, electronic files, including but not limited to draft and final documents, and laboratory analytical reports are maintained as part of the electronic project file.

Chemical analytical data for this project will be reported in both an EDD and an analytical data package. An EarthSoft EQuIS database will be used for processing, storage, and reporting of all data generated during source removal activities. To maintain uniformity and consistency among analytical laboratories, the EDD format for the transfer of data associated with source removal activities will be a complex EDD specification compatible with EQuIS. A simple EDD specification may be substituted for laboratories that do not possess the capabilities to generate a complex EDD or for analyses for which automated data review is not applicable (*e.g.*, percent

ash analyses by polarized light microscopy). The EQuIS data transfer parameters are discussed further in the DMP. The EDD will be generated by the laboratories and will be used to facilitate loading the analytical data into the EQuIS Project Database.

Field data generated during the source removal project will also be stored in the EQuIS Project Database. A simple EDD specification will be utilized by the Field Team Leader (or designee) to submit field data to the EQuIS Project Database.

Analytical data packages will be prepared by the laboratory for sample analyses performed. A Limited data deliverable (Attachment A) in Adobe Acrobat .pdf and EQuIS EDD will be provided by the contract laboratory within the requested TAT for limited deliverables (approximately 10 business days from sample receipt for chemical analyses and approximately 21 business days from sample receipt for radiological analyses). Full deliverables (Attachment A) will be provided by the laboratory in an Adobe Acrobat .pdf electronic format for all analyses within the standard TAT (approximately 20 business days from sample receipt for chemical analyses and approximately 45 business days from sample receipt for radiological analyses).

6.4 Data Archival

Applicable electronic field and laboratory data collected during sampling will be archived electronically. Backup tapes containing databases and programs or software utilities will be maintained in a secure location. Hardcopy data, including but not limited to field logbooks, laboratory data deliverables, and data validation reports, will be archived in accordance with TVA's Document Control protocols. Formal records custody procedures will be maintained in accordance with TVA's Records Custody procedures.

7.0 SAMPLING PROCESS DESIGN

This section briefly outlines field activity procedures for source removal activities. Detailed discussions of field protocol are provided in the various TIs developed for the project. In addition, detailed descriptions of field activities are provided in the site-specific CQA plans.

Solid samples will be collected in association with source removal activities. These samples will be subject to a variety of chemical, radiological, and physical analyses to support the objectives outlined in the ISR and site-specific CQA plans.

Confirmatory sampling procedures will be conducted such that samples are representative of the media sampled and the resultant data can be compared to other data sets. Sampling schemes are designed to provide a statistically meaningful number of field sampling points and the rationale for the collection of these samples. A sufficient number of samples will be collected to adequately characterize the area and provide a sufficiently large data set such that statistical analyses can be performed. Field confirmatory sampling methods will be conducted in accordance with the ISR and site-specific CQA plans, and in accordance with TVA TIs that include equipment requirements and decontamination procedures to meet project objectives.

Rationales for specific sampling and analytical programs are addressed in the ISR and site-specific CQA plans. Sampling and monitoring activities are also subject to the requirements set forth in the TVA TIs and this QAPP. The site-specific CQA plans will describe specific sampling

and monitoring activities if QA requirements, more stringent than those presented herein, are required to meet project objectives.

The sampling design and planned execution of monitoring activities associated with source removal activities are described in site-specific CQA plans.

8.0 SAMPLING METHODS REQUIREMENTS

Descriptions of procedures for sampling, identification, packaging, and handling of project samples; decontamination of sampling equipment; and calibration and maintenance of sampling equipment (if applicable) are presented in the associated TIs and the site-specific CQA plans. An overview of sample identification, documentation, and custody as related to data collection activities is presented in Section 9.0.

8.1 Sample Containers, Preservation, and Holding Times

Sample container/media, preservation, and holding time requirements are presented Attachment D. Samples will be stored in accordance with the requirements set forth in the referenced analytical method and/or laboratory TIs.

Field samples will be contained and preserved in accordance with appropriate United States Environmental Protection Agency (US EPA) analytical method specifications. Sampling containers and preservatives will be provided by the laboratory. In most cases, the supplied sampling containers will be pre-preserved by the laboratory prior to shipment. For chemical analyses, sample containers provided will be new pre-cleaned I-Chem® Series 300 (or equivalent). Samples will be placed in individual pre-cleaned containers for shipment to the laboratory.

Sample container orders, when shipped by the laboratory, will include a packing list that details the number and type of bottles shipped, the bottle lot numbers, chemical preservatives, and the Packer's signature. The COC Records will be completed by Field Sampling Personnel and returned to the laboratory with the samples. Sample containers will be individually custody-sealed and placed inside the sample cooler. After the cooler is sealed, sampling personnel will attach signed/dated custody seals to the outside of the cooler as described in TVA *Sample Labeling and Custody* TI (ENV-TI-05.80.02).

Samples will be stored according to the applicable storage criteria from the time of collection until the time of analysis by the laboratory. Field Sampling Personnel will keep samples cold by placing ice in the coolers in which samples will be stored until delivery to the analytical laboratory personnel. After receipt of the samples, it is the laboratory's responsibility to store the applicable samples according to the applicable preservation conditions until preparation and analysis has been initiated.

Samples have a finite holding time (the time between sample collection, sample digestion, and sample analysis) to limit the potential for degradation of the analytes. The holding times for required analyses are measured from the verified time of sample collection. When possible, samples will be shipped by overnight carrier or delivered by same-day courier to minimize the time between collection and laboratory receipt.

8.2 Decontamination

Tools and equipment decontamination procedures are implemented to prevent cross-contamination of samples and to control potential inadvertent transport of hazardous constituents. Disposable sampling equipment will be utilized to the extent possible in an effort to limit the potential for cross-contamination. The non-disposable equipment will be decontaminated using the procedures described in the TVA *Field Sampling Equipment Cleaning and Decontamination* TI (ENV-TI-05.80.05) and/or the site-specific CQA plans.

9.0 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Field Sampling Personnel are responsible for the collection, description, documentation, labeling, packaging, storage, handling, and shipping of samples obtained in the field in accordance with the ISR and CQA plans and TVA TIs. These procecures and laboratory QA procedures ensure sample integrity from collection through laboratory analysis and data reporting. To demonstrate and document sample integrity aspects, information relative to the collected project samples will be described and thoroughly documented. Samples will be labeled, packaged, preserved, and shipped to the laboratories for analysis in appropriate sample containers, under the recommended temperature conditions with a COC Record documenting the time and day of sample collection.

Laboratory-supplied sample kits with custody seals, packing materials, sample containers, and preservatives will be used for project samples during sample collection and transport to the TVA-contracted laboratories. The sample containers and preservation requirements for samples collected under each investigation are presented in Attachment D to this QAPP.

COC Records will be assigned standardized identification numbers and task codes describing the intended purpose of the sampling event.

9.1 Sample Documentation

Field activity evidentiary files will be maintained by the project Field Team Leaders and Data Managers, and will include information that defines the Project in its entirety, including but not limited to:

- Field logbooks.
- Field data sheets.
- Raw data.
- QC information.
- COC Records.
- Airbills (when used) for sample shipments.
- Photographs.

Field documentation procedures are described in the *Field Record Keeping* TI (ENV-TI-05.80.03) and in the investigation-specific SAPs.

9.1.1 Chain-of-Custody Record

A primary consideration for environmental data is the ability to demonstrate that samples have been obtained from specific locations and have reached the laboratory without alteration. Evidence of collection, shipment, laboratory receipt, and laboratory custody while samples are in the laboratory's possession will be documented by maintaining a COC that records each sample and the individuals responsible for sample collection, shipment, and receipt at the project laboratory. Samples that are collected will be accompanied by a COC Record. An example COC Record is included in Attachment C. The following information will be recorded on the COC Record:

- Project name and number.
- Name of Sampler.
- Sample identifier/name, location, date and time collected, and sample type.
- Analyses requested.
- Special instructions and/or sample hazards, if applicable.
- Signature of Sampler in the designated blocks, including date, time, and company.
- Sample condition (including temperature) upon receipt as reported by the analytical laboratory.
- Signature of the laboratory receipt personnel in the designated blocks, including date, time, and company affiliation.

Original COC Records are transferred to the analytical laboratories such that sample custody is maintained through analysis and reporting. Copies of COC Records are maintained on site by the Field Team Leaders. Duplicates of COC Records are retained by the TVA Technical Lead and .pdf versions of COC Records are maintained by the Data Management Team as part of the Project File.

COC Records will reference defined MAGs to communicate sample analysis requirements to the analytical laboratories. MAGs identify the required analytical methods, parameter lists, and reporting units to ensure consistent reporting of data among multiple laboratories. In addition, MAGs enable automated data completeness evaluation and data verification upon receipt of electronic data. An overview of the data management process is provided in Section 14.0.

For samples collected for chemical, optical, or radiological analyses, field COCs are provided to the QA Oversight Consultant's Data Manager by the Field Sampling Team performing the sample collection. EQuIS field sample EDDs are subsequently created to facilitate completeness review upon laboratory submittal of the associated analytical data.

9.1.2 Sample Custody in the Field

The purpose of sample custody procedures is to document the history of samples (and sample digestates) from the time of sample collection through shipment and sample receipt, analysis, and disposal. A sample is considered to be in one's custody if one of the following conditions applies:

- The sample is in an individual's actual possession.
- The sample is in view after being in an individual's physical possession.

- It was in the physical possession of an investigator and then they secured it to prevent tampering; and/or
- It is placed in a designated secure area.

Each individual Field Sampler is responsible for the care and custody of the samples he/she collects until the samples are properly transferred to temporary storage or are shipped to the laboratory. The following COC procedures will be followed for samples submitted to the laboratory for analyses:

- Each individual Field Sampler is responsible for the care and custody of samples he/she collects until the samples are properly transferred (relinquished on the COC by Field Sampling Personnel) to another person ("acceptor" of the samples) or are shipped to the laboratory.
- A COC Record will be completed at the time of sample collection by the Field Sampling Personnel for each batch of samples submitted to the laboratory in accordance with the *Sample Labeling and Custody* Technical Instruction (ENV-TI-05.80.02). Field sampling logs may be used in the place of formal COCs in the field.
- If multiple coolers are needed, one COC Record will accompany each cooler that contains the samples identified on the COC.
- Sample coolers will be packed and sealed with custody seals for transport from field and shipment to laboratory in accordance with the *Handling and Shipping of Samples* Technical Instruction (ENV-TI-05.80.06).
- Each time a sample batch is transferred (Field Sampling Personnel relinquish custody to the laboratory or other Sampling Team personnel), signatures of the individuals relinquishing and receiving the sample batch, as well as the date and time of transfer, will be documented on the COC or courier documentation form. Note that commercial courier custody is tracked by commercial courier records and not by COC.
- A copy of the carrier air bill will be retained as part of the permanent COC documentation record.
- The laboratory will record the condition of the sample containers, and cooler temperature upon receipt, and record this information on a combination of sample receipt documentation including a sample receipt confirmation checklist and the COC. Documentation of sample preservation checks (where applicable) will be recorded in the sample preparation documentation.

Changes or corrections to the information documented by the COC Record (including, but not limited to, field sample identification [ID] or requested analyses) must be changed by marking through the incorrect information with a single strike through line and, dating, and initialing the change in accordance with the *Field Record Keeping* Technical Instruction (ENV-TI-05.80.03). If the request for a change or correction comes from the Field Team after the COC Records have been relinquished to the laboratory, a copy of the COC Record will be revised, initialed, and forwarded to the laboratory, where the revised version will supersede the original COC Record. This record will be used to document sample custody transfer from the sampler to the laboratory and will become a permanent part of the Project File.

Sample coolers with appropriate custody seals will be shipped to the contract laboratory in a timely fashion to ensure proper thermal preservation and meet analytical method holding times.

9.2 Sample Packaging and Shipment

Samples will be packed and shipped to the laboratory in accordance with applicable U.S. Department of Transportation (US DOT) regulations, consulting corporate guidelines, and International Air Transport Association (IATA) standards (as detailed in the most current edition of *IATA Dangerous Goods Regulations* for hazardous materials shipments), as applicable.

Samples that are to be stored at a temperature < 6 degrees Celsius (°C) (not frozen) will be placed on wet ice within 15 minutes of sample collection and packaged with additional wet ice for shipment to the analytical laboratory.

9.3 Sample Custody in the Laboratory

The following subsections describe the COC procedures associated with sample receipt, storage, tracking, and documentation by the laboratory.

9.3.1 Sample Receipt

A designated Laboratory Sample Custodian will be responsible for samples received at the laboratory. The Laboratory Sample Custodian will be familiar with custody requirements and the potential hazards associated with environmental samples. In addition to receiving samples, the Laboratory Sample Custodian will also be responsible for documenting sample receipt, maintaining samples at < 6°C during the sample login process, storage at < 6°C before and after sample analysis, and the proper disposal of samples. Upon sample receipt, the Sample Custodian will:

- Inspect the sample containers for integrity and ensure that custody seals are intact on the shipping coolers. The temperature of the samples upon receipt and the presence of leaking or broken containers will be noted on the COC Record/sample receipt forms.
- Sign (with date and time of receipt) the COC/sample analysis request forms, thereby assuming custody of the samples and assign the laboratory sample ID numbers.
- Compare the information of the COC Record/sample receipt with the sample labels to verify sample identity. Any inconsistencies will be resolved through the Laboratory Coordinator before sample analysis proceeds.
- Store samples in accordance with Section 9.3.2.

The QA Oversight Manager and Laboratory Coordinator must be notified immediately via email or documented telephone call when samples are received broken or improperly preserved. Samples received in a condition that may potentially impact results will be placed on hold pending direction from the QA Oversight Manager or Laboratory Coordinator. In the event that aqueous samples for metals analyses are received at pH > 2, acid preservative will be added in the originally received sample bottleware by the laboratory and the pH of the samples will be allowed to equilibrate in the originally received bottleware for a minimum of 24 hours prior to digestion. Sample preservation and equilibration will be fully documented via laboratory logbooks.

9.3.2 Sample Storage

Analytical samples will be stored in a locked facility and maintained within the appropriate temperature range as specified in US EPA SW-846 Chapter 3, or Table II of 40 CFR 136.3 sample storage requirements. The temperature will be monitored and recorded daily by laboratory personnel.

Required sample storage conditions are presented in Attachment D of this QAPP.

9.3.3 Sample Tracking

Each sample will receive a unique laboratory sample ID number at the laboratory when the sample is logged into the laboratory information management system (LIMS).

Sample preparation/digestion records will be generated to fully document sample handling prior to analysis. Laboratory data will be entered on the sample digestion form and permanently recorded in a laboratory logbook.

The laboratory will maintain a sample tracking system that documents the following:

- Organization/individual who performed sample analyses.
- Date of sample receipt, extraction or digestion, and analysis.
- Names of Analysts.
- Sample preparation procedures.
- Analytical methods used to analyze the samples.
- Calibration and maintenance of instruments.
- Deviations from established analytical procedures, if applicable.
- QC procedures used to ensure that analyses were in control during data generation (instrument calibration, precision checks, method standards, method blanks, *etc*.).
- Procedures used for the calculation of precision and accuracy for the reported data.
- Statement of quality of analytical results.

9.4 Sample Archive

Upon request, unused portions of samples may be requested by TVA from the laboratory for archival. Archived samples will be shipped under COC and relinquished to the TVA Technical Lead or designee. The sample archive will be equipped to properly maintain thermal preservation of the samples and will be locked or in an access controlled locations such that sample custody is maintained.

Unused portions of samples collected in association with source removal activities may be returned to TVA for archive or disposal or may be disposed of by the contract laboratories. Archived samples will be cataloged and stored in an organized manner. In the event that project objectives are not met for a sample, any remaining portion with preparation/analytical holding time remaining may be retrieved and submitted to a TVA contracted laboratory for additional analysis.

10.0 ANALYTICAL METHODS REQUIREMENTS

Analytical methods cited in this QAPP reference US EPA's *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846); US EPA Clean Water Act Test Methods; *Standard Methods for the Examination of Water and Wastewater*. These and potentially other methods, constituents, and reporting limits for samples collected under this plan are presented in Attachment D of this QAPP. Analytical methods will be selected based on the ability to detect constituents of concern at reporting limits sufficient to meet project requirements and quality objectives for precision, accuracy, and sensitivity.

10.1 Field Analysis

Field analyses will be conducted in accordance with the associated field sampling TIs and/or published field method as applicable. The results from field analysis are reviewed and stored electronically.

Detailed descriptions of field monitoring activities, the field analytical equipment, and the sampling equipment utilized to perform the field activities are provided in the plant-specific Source Removal and CQA plans and/or in the associated TVA TIs.

10.2 Laboratory Analysis

To support the objectives of source removal activities, the collected samples will be tested for the methods, constituents, and reporting limits presented in Attachment D of this QAPP. Individual sample reporting limits may vary from the laboratory's routinely reported limits; this variance may be a result of dilution requirements, sample weight or volume used to perform the analysis, dry-weight adjustment for solid samples, the presence of analytical background contaminants, or other sample-related or analysis-related conditions. Additional analytical needs may be identified based on future project needs. As such, the QAPP, ISR plan, and site-specific CQA plan will be modified to document the appropriate QC requirements associated with the additional analyses.

The reporting limits indicated in Attachment D represent the maximum reporting limits (not adjusted for sample weight/volume, dilution factors, and percent moisture for non-aqueous samples).

All analytical methods performed by the TVA-contracted laboratory must have valid method detection limit (MDL) studies and MDL verifications by matrix type, by preparation method, and by analytical method. MDL studies must include all preparatory and analytical processes used for the preparation and analysis of investigative samples. Formal MDL evaluations must be performed at the frequency dictated by the current US EPA-promulgated procedures or the current The NELAC Institute (TNI) laboratory accreditation standard or the frequency dictated below, whichever is more frequent. TVA's contracted laboratories will conduct MDL studies in accordance with the current TNI laboratory accreditation standard as described below.

The initial MDL study shall include a minimum of seven spiked replicates prepared and analyzed in a minimum of three separate batches, spaced over the course of three separate calendar days. If an MDL is to be determined over more than one instrument, each instrument must have at least two analyses on two different calendar days. For an analyte to be considered

detected during an MDL study it must meet the analytical method's qualitative identification criteria without any manual searching routines. Only analyses associated with acceptable initial calibration, continuing calibration, and batch QC can be used. The MDL based on spiked replicates will be calculated as follows:

$$MDL_s = t_{(n-1,1-\alpha=0.99)} S$$

Where: MDL_s = MDL based on analysis of replicate spikes,
t = Students 99th percentile single-tailed t-value and
S = the sample standard deviation of the replicate analyses.

If the calculated MDL_s for any analyte is less than 10% the concentration of the spiked concentration, repeat the study for that analyte at a lower spike concentration. If the calculated MDL_s is higher than the spiked concentration, the study must be repeated at a higher spike concentration from the original study.

In addition to the spiked samples, an MDL will be determined using method blank results (MDL_b). The initial MDL_b determined using the method blanks will be a minimum of seven method blanks prepared and analyzed in at least three separate batches, spaced over the course of three separate calendar days. If an MDL_b is to be determined over more than one instrument, each instrument must have at least two analyses on two different calendar days. For an analyte to be considered detected during an MDL study it must meet the analytical method qualitative identification criteria without any manual searching routines. Only analyses associated with acceptable initial calibration, continuing calibration, and batch QC can be used.

If the analytical system for which the MDL_b is being determined gives numeric results for every analysis, the MDL_b will be calculated as follows:

$$MDL_b = \overline{X} + t_{(n-1,1-\alpha=0.99)} S$$

Where: $\overline{X}$ = the mean of the method blank results,
t = Students 99th percentile single-tailed t-value and
S = the sample standard deviation of the replicate analyses.

If the analytical system for which the MDL_b is being determined gives censored results or otherwise gives numeric results for some, but not all method blanks:

- If fewer than 101 numeric method blank results are available, set the MDL_b to the highest method blank result.

- If more than 100 numeric method blank results are available, set the MDL_b to the level that is no less than the 99th percentile of the method blank results.

MDL_s and MDL_b must be compared and the higher value utilized for MDL reporting.

The MDL is to be verified annually through the quarterly analysis of standards spiked at the same concentration used to determine MDL_s. For verification analyses for a pooled MDL for more than one instrument, each instrument must have at least two analyses, prepared in different batches and analyzed on separate days. MDL verification analyses must meet the analytical method qualitative identification criteria, again without any manual searching routines.

Only analyses associated with acceptable initial calibration, continuing calibration, and batch QC can be used.

On an annual basis, the MDL calculation is to be repeated using the results from the quarterly spiked samples and method blanks. The resulting MDL is to be compared to the initially derived MDL. If the repeated MDL is within a factor of 0.5 to 2.0 of the existing MDL, and fewer than 3% of the method blank results have numerical results above the existing MDL, then the initially derived MDL may be left unchanged. Otherwise, adjust the MDL to the new repeated MDL.

To add a new instrument, the new instrument must have at least two spike analyses and at least two method blanks. The new spike results would be combined with the existing results and a new MDL_s would be calculated. If the new MDL_s is within a factor of 0.5 to 2.0 of the existing MDL, then the initially derived MDL_s may be left unchanged. If all method blank analyses are below the existing MDL and the MDL_s meets the criteria described above, the MDL may be left unchanged. Otherwise, adjust the MDL to the new MDL. Once 6-months of blank data have been generated on a new instrument, MDLs will be evaluated to assess the need for adjustment.

The laboratory will perform a percent moisture analysis on solid samples where possible. Chemical analysis results for solid samples will be reported on a dry-weight basis unless specifically requested otherwise. Radiological activities and physical/optical analysis results will not be corrected for sample moisture. The reporting basis (wet-weight, dry-weight, *etc*.) will be maintained as an attribute of the result in the database.

11.0 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

This section describes the data objectives and associated data quality indicators used for source removal projects. QA procedures are designed to ensure high quality for all environmental data associated with source removal projects.

The subsections below provide an introduction to QA objectives and protocols and set forth minimum requirements for source removal activities. Specific quantitative QA objectives for this project are presented in Attachment D.

11.1 General

There are four levels of data quality that have been developed for this project. The data quality levels defined below provide general indications of measurement defensibility. The data quality level of a particular measurement is used to determine whether that measurement is sufficient to meet the program-specific DQOs.

Field Screening – This level is characterized by the use of portable analytical instruments (such as temperature probe) which can provide real-time data to assist in the optimization of sampling locations and health and safety support. Data can be generated regarding the presence or absence of certain contaminants at sampling locations.

Field Analyses – This level is characterized by the use of portable analytical instruments, which can be used on site (such as Hydrolab® instrument) or in a mobile laboratory stationed near a site. Depending on the types of contaminants,

sample matrix, and personnel skills, qualitative and quantitative data can be obtained.

Screening Data with Definitive Confirmation – These data are generated by rapid, less precise methods of analysis with less rigorous sample preparation. Sample preparation steps may be restricted to simple procedures such as dilution with a solvent, instead of elaborate extraction/digestion and cleanup. Screening data provides analyte identification and quantitation, although the quantitation may be relatively imprecise. At least 10% of the screening data will be confirmed using appropriate analytical methods and QA/QC procedures and criteria associated with definitive data. Screening data without associated confirmation data is not considered to be data of known quality.

Definitive Data – These data are generated using rigorous analytical methods, such as approved US EPA reference methods. Data are analyte-specific, with confirmation of analyte identity and concentration. These methods produce tangible raw data (such as chromatograms, spectra, or digital values) in the form of paper printouts or computer-generated electronic files. Data may be generated by an on-site or off-site laboratory, as long as the QA/QC requirements are satisfied. To be definitive, either the analytical or total measurement error must be determined.

Field Screening data will be obtained with portable instruments, such as conductivity meters, temperature probes, and may be used for health and safety and field operational monitoring. In addition, these instruments and field test kits may be used to produce Field Analysis data to determine where to collect a sample to assess impacts and identify which samples are to be designated for laboratory confirmation analyses.

Field pH measurements for soil samples will be conducted using pH kits or equivalent with confirmation samples submitted to the fixed-base analytical laboratory for definitive analysis.

Attainment of qualitative data indicators is assessed by monitoring QA measures, such as accuracy, precision, representativeness, comparability, and completeness, as discussed in Section 19. Specific qualitative criteria for the chemical analyses to be performed in association with source removal activities are presented in Attachment D. The objectives associated with accuracy and precision of laboratory results are assessed through an evaluation of the results of QC samples. The accuracy of field measurements will be assessed by calibration, as described in the associated field TIs.

11.2 Field and Laboratory Quality Control Samples

The quality of data collected in the field will be controlled, monitored, and verified by maintaining site logs, by documenting field activities, and by collecting and analyzing of QC samples concurrently with investigative samples. Field and laboratory QC samples will be used to assess accuracy and precision for chemical analyses to gauge both field and laboratory activities. Further discussion and equations for determining precision and accuracy may be found in Section 19. In addition, specific requirements for comparability, completeness, and representativeness of field and laboratory QC samples may be found in Section 19. QC

samples will be used to assess laboratory performance and gauge the likelihood of cross-contamination associated with both field and laboratory activities.

The subsections below apply to chemical analyses performed on aqueous and solid samples associated with source removal activities.

QC samples will be collected and analyzed in conjunction with samples designated for laboratory analysis. The QC checks that may be instituted by field and laboratory personnel may include, but not be limited to, the following:

- Equipment Rinsate Blanks.
- Field Blanks.
- Field Duplicate Samples.
- MS/MSD Samples.
- Laboratory Method Blanks.
- Laboratory Control Samples/Laboratory Control Sample Duplicates (LCS/LCSDs).
- Laboratory Duplicate (LD) Samples.

These types of QC samples are discussed in the following subsections. Field QC samples will be submitted to the laboratory using the same information as the associated investigative samples.

Field QC samples will be collected at the frequency specified in Table 11-1. Laboratory QC samples will be analyzed at the frequency specified in the associated laboratory SOPs and referenced analytical methods. The analysis frequencies specified below are considered the minimum required frequencies; program-specific Work Plans and/or SAPs and/or TIs may require more frequent collection of field QC samples.

Table 11-1. Field Quality Control Sample Minimum Frequency

Field QC Sample	Solids Sampling Frequency
Equipment Rinsate Blank	1 per 20 field samples; minimum of 1 per sampling event
Field Duplicate[a]	1 per 20 field samples; minimum of 1 per sampling event
MS/MSD or Laboratory Duplicate[b]	1 per 20 field samples; minimum of 1 per sampling event

N/A Not Applicable

[a] True field duplicate samples are not feasible for whole ash/sediment cores (depending on volume recovered); consequently, co-located samples will be collected when possible.

[b] Laboratory duplicate analyses will be performed in lieu of MS/MSD for parameters not amenable to spiking.

11.2.1 Equipment Rinsate Blanks

Collection and analysis of equipment rinsate blanks are performed to assess the efficiency of field equipment decontamination procedures in preventing cross-contamination between samples. Laboratory-supplied analyte-free reagent water will be poured into/through/over clean (decontaminated) sampling equipment used in the collection of investigative samples and subsequently collected into prepared sample bottles. For Vibecore® sampling and other sediment/soil core sampling, analyte-free reagent water will be poured through the solid-wall tubing used for sample collection (typically Lexan® tubing). The rinsate blank will be analyzed for the same parameters as the investigative samples.

11.2.2 Field Duplicate Samples

Field duplicate samples are used to check for sampling and analytical error, reproducibility, and homogeneity. For soil samples, the duplicate will be obtained by collecting a sample from an area adjacent to the routine sample (that is, co-located sample), or by collecting a separate aliquot of homogenized soil from within the same core, whichever is more appropriate for the type of sample/sampling technique (surface or subsurface sediment sample). Duplicates will be analyzed for the same parameters as the associated investigative samples.

11.2.3 Matrix Spike/Matrix Spike Duplicate

MS/MSD samples are investigative samples to which known amounts of compounds are added in the laboratory before extraction/digestion and analysis. The recoveries for spiked analytes can be used to assess how well the method used for analysis recovers target analytes in the site-specific sample matrix, a measure of accuracy. Additionally, the relative percent difference (RPD) between the results of the MS and MSD provide a measure of precision. In the event that sufficient sample volume to perform MS/MSD analyses is not provided, the laboratory may substitute LCS/LCSD analyses (see Section 11.2.5).

For parameters that are not amenable to spiking, a laboratory duplicate (see Section 11.2.6) will be used to demonstrate matrix-specific precision.

11.2.4 Laboratory Method Blanks

Method blanks consist of analyte-free materials (such as reagent water) and reagents (such as sodium sulfate) that are prepared in the same manner as the associated samples (digested, extracted, *etc*.) and that are analyzed and reported in the same manner as the associated investigative samples. Laboratory method blanks will be performed as indicated in the analytical method and in the associated laboratory SOPs.

11.2.5 Laboratory Control Samples/Laboratory Control Sample Duplicates

An LCS is a sample of laboratory certified material that is fortified (spiked) with the analytes of interest or a certified reference material that is prepared and analyzed in the same manner as investigative samples. The LCS must be from a source that is different from the source of the initial calibration standards (that is, second-source). LCS data are used to monitor analytical accuracy and laboratory performance. LCSs are prepared and analyzed with each preparation batch of 20 (or less) field samples. In the event that insufficient sample volume to perform MS/MSD analyses (Section 11.2.4) is received, an LCSD will be prepared to assess laboratory

precision. LCS will be performed at a minimum frequency of 1 per batch of 20 (or fewer) field samples or as required by the referenced analytical method and as specified in the associated laboratory SOPs.

11.2.6 Laboratory Duplicate Samples

A LD sample is obtained by splitting a field sample into two separate aliquots and performing separate preparation and analysis on the respective aliquots if a field collected sample is not designated as a LD sample. The analysis of laboratory duplicate samples monitors precision; however, precision may be affected by sample homogeneity, particularly in the case of solid samples. Laboratory duplicates will be analyzed and reported with every batch of 20 (or fewer) field samples. MSDs (see Section 11.2.3) may be substituted for laboratory duplicates for inorganic analyses. The laboratory will utilize a project sample for the laboratory duplicate in every batch that includes project samples.

12.0 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

12.1 Field Equipment

Equipment failure will be minimized by routinely inspecting field equipment to ensure that it is operational and by performing preventive maintenance procedures. Field sampling equipment will be inspected prior to sample collection activities by the Field Sampling Personnel and necessary repairs will be made prior to use of the sampling equipment. Routine preventive maintenance procedures, at a minimum, will include removal of foreign debris from exposed surfaces of the sampling equipment, storage of equipment in a cool dry place protected from the elements, inspections of the equipment each day prior to use, and verification of instrument calibrations as described in Section 13.0.

Field equipment, instruments, tools, gauges, and other items requiring preventive maintenance will be obtained from a contracted equipment supplier. All equipment will be serviced in accordance with the manufacturer's specified recommendations or written procedure based on the manufacturer's instructions or recommendations. Maintenance will be performed in accordance with the schedule specified by the manufacturer to minimize the downtime of the measurement system. Maintenance work will be performed by qualified personnel.

Field equipment will be maintained in good working order to minimize downtime while fieldwork is in progress. Field equipment will be maintained under service contract for rapid instrument repair or provision of backup instruments in the case of instrument failure.

Non-routine maintenance procedures require field equipment be inspected prior to initiation of fieldwork to determine whether or not the equipment is operational. If not operational, the equipment will be serviced or replaced by a contracted equipment provider. Batteries will be fully charged or new, as applicable.

The ability to collect valid samples requires that field equipment be appropriately cleaned and maintained. The elements of an effective maintenance program are identified below.

- Pre-cleaned or certified-clean equipment.

- Spare parts or service contract for equipment repair or replacement.
- Contingency plan.
- Maintenance and repair of non-dedicated equipment.

12.2 Supplies and Consumables

Field supplies and consumable items (including, but not limited to, pre-cleaned containers, preserved containers, tubing, and filters) will be inspected upon receipt. Certificates of cleanliness for consumables provided by the laboratory will be retained on file at the laboratory. Chemical preservatives provided in pre-preserved containers will be certified by the laboratory prior to use. Certificates of cleanliness for supplies and lot numbers of supplies obtained by the Field Team will be retained by Investigation personnel as part of the project records. All supplies and consumable materials will be certified clean to levels sufficient to meet data objectives for the associated investigation.

12.3 Laboratory Equipment

The ability to generate valid analytical data requires that analytical instrumentation be properly maintained. The laboratory will be responsible for appropriate maintenance for major instruments. The elements of an effective maintenance program are identified below and discussed in the following subsection:

- Instrument maintenance logbooks.
- Instrument maintenance and repair.
- Available spare parts.
- Contingency plans.

Periodic preventive maintenance is required for sensitive equipment. Instrument manuals will be kept on file for reference when equipment needs repair. The troubleshooting sections of factory manuals may be used to assist personnel perform maintenance tasks.

Major instruments in the laboratory are covered by annual service contracts with manufacturers or other qualified personnel (internal or external). Under these agreements, regular preventive maintenance visits are made by trained service personnel. Maintenance is documented and maintained in permanent records by the individual responsible for each instrument.

The calibration and maintenance sections of the laboratories' SOPs will establish the schedule for servicing critical items to minimize the downtime of the measurement system. The laboratory will adhere to the maintenance schedule and will promptly arrange any necessary service. Qualified personnel will perform required service.

12.3.1 Instrument Maintenance Logbooks

In the laboratory, each analytical instrument will be assigned an instrument logbook. Maintenance activities will be recorded in the instrument logbook and the information entered will include:

- Date of service.
- Person performing the service.

- Type of service performed and reason for service.
- Replacement parts installed (if applicable).
- Miscellaneous information.

If service is performed by the manufacturer or its representative, a copy of the service record will be inserted into the page immediately following the logbook page where the above-cited information has been entered.

12.3.2 Instrument Calibration and Maintenance

An overview of the routine calibration procedures used for analytical instrumentation is presented in Section 13.0. Preventive maintenance and calibration by manufacturer service representatives will be provided on a routine basis.

In addition to maintenance by manufacturer service representatives, procedures for routine maintenance in accordance with manufacturer specifications for each analytical instrument will be followed by the laboratory. These procedures will include maintaining inventories of spare parts used routinely (such as spare torches for inductively coupled plasma/mass spectrometry [ICP/MS] instruments). Instrument operators have the responsibility to ensure that an acceptable inventory of spare parts is maintained.

Instrument calibration and maintenance procedures will be conducted in accordance with the laboratory's QA Program and the specific calibrations sections of the laboratory's analytical SOPs.

13.0 INSTRUMENT CALIBRATION AND FREQUENCY

This section provides the requirements for calibration of measuring and test equipment/instruments used in field sampling and laboratory analysis. The calibration procedures stipulated in the QAPP are designed to ensure that field equipment and instrumentation are calibrated to operate within manufacturer specifications and that the required traceability, sensitivity, and precision of the equipment/instruments are maintained. Measurements that affect the quality of an item or activity will be taken only with instruments, tools, gauges, or other measuring devices that are accurate, controlled, calibrated, adjusted, and maintained at predetermined intervals to ensure the specified level of precision and accuracy.

In general, instrument calibration will be conducted in accordance with manufacturer's recommendations, method requirements, and field TIs or laboratory SOPs.

It is not anticipated that any field measurements will be collected in association with source removal activities.

13.1 Field Equipment Calibration and Procedures

All field analytical equipment used to conduct monitoring will be calibrated/standardized daily prior to use. The calibration/standardization procedures for field instrumentation are described in the calibration section of the applicable field TIs. The calibration/standardization acceptance criteria for field instruments are provided in the applicable TVA TIs.

Personnel performing instrument calibrations/standardizations shall be trained in its proper operation and calibration. Records of instrument calibration/standardization will be maintained by the Field Team Leader and will be subject to audit by the Field Oversight Coordinator or designee. The Field Team Leader will maintain copies of the instrument manuals on site.

The calibration records will include documentation of the following information:

- Instrument name and identification number.
- Name of person performing the calibration.
- Date of calibration.
- Calibration points.
- Results of the calibration.
- Manufacturer lot number of the calibration standards.
- Expiration dates for the calibration standards, when applicable.

Field equipment will be properly inspected, charged, and in good working condition prior to the beginning of each working day. Prior to the start of each working day, the Field Team Leader will inspect equipment to ensure its proper working condition. If equipment is not in the proper working condition, the Field Team Leader must repair or replace the equipment prior to the start of field activities. Field equipment and instruments will be properly protected against inclement weather conditions during the field work. At the end of each working day, field equipment and instruments will be properly decontaminated, taken out of the field, and appropriately placed for overnight storage and/or charging.

Field-collected pH measurements for solid samples will be considered field screening data. Field pH measurements for solid samples will be conducted using pH test kits or equivalent; samples will be subsequently submitted to a fixed-base laboratory for definitive pH analysis.

Calibration checks may suggest the need for maintenance or calibration by the manufacturer. Field instruments that do not meet the calibration requirements will be taken out-of-service until acceptable performance can be verified. Maintenance will be performed when the instrument will not adequately calibrate. Maintenance of field equipment will be noted in an instrument logbook or field notebook.

Field equipment calibration is addressed in greater detail in the TIs associated with each field investigation or monitoring activity.

13.2 Laboratory Equipment Calibration

Instruments and equipment used in the laboratory will be controlled by a formal calibration program as described in the laboratory's Quality Assurance Manual. The program will verify that the equipment has the proper calibration range, accuracy, and precision to generate data comparable with specific requirements. Calibration will be performed by laboratory personnel experienced in the referenced methods for the analysis of project samples for the constituents of concern.

Instrument calibration procedures and corrective actions are described in the calibration section of the associated laboratory SOP. At a minimum, laboratory instrument calibration will be performed in accordance with the associated technical and quality control requirements specified in the method applicable to the ISR plan and associated site-specific CQA plan.

The laboratory will provide all data and information to demonstrate that the analytical system was properly calibrated at the time of analysis, including: calibration method, required frequency, source of standards, response factors, linear range, check standards, and applicable control limits, as part of the data deliverables.

Before any instrument is used as a measuring device, the instrument's response to reference materials must be determined. The manner in which various instruments are calibrated is dependent on the particular type of instrument and its intended use. Preparation of reference materials used for calibration will be documented in a laboratory notebook.

The two types of laboratory instrument calibration are initial calibration and continuing calibration verification. Initial calibration procedures establish the calibration range of the instrument. Typically, multiple analyte concentrations are used to establish the calibration range and calibration data. The laboratory evaluates the resulting calibration data as detailed in the calibration section of the associated SOP.

Continuing calibration verification usually measures the instrument's response to fewer calibration standards and requires instrument response to fall within certain limits of the initial measured instrument response. Continuing calibration verification may be used within an analytical sequence to verify stable calibration throughout the sequence and/or to demonstrate that instrument response did not drift during a period of non-use of the instrument.

The QA measures in the calibration section of the associated laboratory SOP will be used for calibration, calibration verification, and subsequent sample analyses. In addition, the following procedures will be used for the calibration of balances and thermometers.

Laboratory balances will be calibrated and serviced annually by a certified contractor. Balances will undergo a calibration check prior to use each day using multiple S-Class or equivalent class weights that bracket the usage range. A record of calibrations and daily checks will be documented.

Oven and refrigerator thermometers will be calibrated annually against a National Institute of Standards and Technology- (NIST-) certified thermometer in the range of interest. Annual calibrations will be documented. Daily oven and refrigerator readings will be recorded. Thermometers must be tagged with any applicable correction factors.

Records will be maintained as evidence of required calibration frequencies, and equipment will be marked suitably to indicate calibration status. If marking on the equipment is not possible, records traceable to the equipment will be readily available for reference.

14.0 DATA MANAGEMENT

Data generated and used in association with source removal activities will be managed in accordance with the DMP. Consolidated management of data related to the Order will ensure that environmental data associated with the project are appropriately maintained and accessible to data end users. The Data Management Plan will provide a basis for supporting a full technical data management business cycle from pre-planning of sampling events to reporting and analysis with a particular emphasis on ensuring completeness, data usability, and most importantly defensibility of the data.

Data generated from collection events will be consolidated in the single EQuIS database. The EQuIS database will implement QA procedures at each step in the data transfer process to ensure that a complete, correct data set is maintained. A detailed description of the various elements of the data management program is presented in the DMP. In addition, the DMP describes sample planning and tracking process and details the flow of field and laboratory data into the project database. Finally, the DMP describes the process by which errors in data already reported in the project database are rectified and how those changes are managed and documented.

15.0 ASSESSMENTS AND RESPONSE ACTIONS

The primary goal of the QAPP is to ensure that project data objectives are met and that defensible, high-quality, analytical data are generated for use decision-making processes. The QAPP includes systems and performance audits to ensure that established QA procedures are properly implemented.

The QAPP will be distributed to each consultant and contractor responsible for the collection, generation, and interpretation of field and analytical data. The QA Oversight Manager or designee will be responsible for ensuring that necessary revisions are made so that the QAPP is up-to-date with actual practices and will ensure that revisions and updates are provided to everyone on the distribution list. The document control format used in the QAPP will identify the QAPP revision number and revision date. A revision history that identifies each revision and a summary of the revision will be maintained.

15.1 Field Activities

Field QA will include (but not be limited to) the following:

- Instrument calibration.
- Documentation of sample collection and field conditions.
- Adherence to COC procedures.
- Adherence to the QAPP, ISR and site-specific CQA plans, and associated TVA TIs.
- Collection of field QC samples.

The QA review for usability of objective field data will be performed at two levels. For the first level, data will be reviewed at the time of collection to ensure the ISR and site-specific CQA plans and TVA TIs were followed. For the second level, after data reduction to table format or arrays, the data will be reviewed for inconsistent values.

Any inconsistencies identified during data review will be investigated by the Field Team Leader. When possible, the Field Team Leader will seek clarification from the Field Sampling Personnel responsible for collecting the data. Resolution of discrepancies will be documented using the corrective action process detailed in Section 16.4.

Field data will be reviewed for reasonableness and completeness. In addition, random checks of sampling and field conditions will be made to check recorded data at the time of sampling to confirm the recorded observations. Whenever possible, peer review will also be incorporated into the QA review process in order to maximize consistency among Field Sampling Personnel.

Any observed discrepancies between the COC Record and the samples received will be documented by the laboratory, then the TVA Technical Lead, QA Oversight Manager, and Field Team Leader will be contacted for resolution.

The field COC Record information will be initially keyed into and maintained in the laboratory's database. A copy of the laboratory's COC Record, referred to as sample receipt confirmation, will be sent to the QA Oversight Manager and Data Manager following sample login for verification of properly entered and COC Record requests and information such as sample identification numbers, analyses requested, and the quantity of samples. In case of discrepancies between the COC Record and the sample receipt confirmation, the appropriate revisions will be communicated to the laboratory for the appropriate COC Record corrections. Corrected information on the COC Record will be recorded into the project data management system.

15.2 Laboratory Analysis

Internal laboratory QA will consist of the following:

- Instrument performance checks.
- Instrument calibration and calibration verification.
- Retrieval of documentation pertaining to instrument standards, samples, and data.
- Adherence to the QAPP and the associated laboratory SOPs.
- Documentation of sample preservation, transport, and analytical methodology.
- Adherence to the analytical methodology (at a minimum).
- Analysis of QC samples (discussed in Section 11.2).

The samples received by the laboratory will be handled in accordance with internal laboratory QC procedures. The laboratory's deliverables, on submission to Data Validators, will be verified and/or validated with guidance from the National Functional Guidelines. Data package completeness will be assessed and missing or incomplete information will be obtained from the laboratory. Any incorrect data will be corrected. Data usability will be evaluated and appropriate qualifiers will be added to the database. Any data deemed unreliable by data validation efforts due to imprecision, holding time exceedances, and failure of relevant QC measures will be qualified appropriate and/or not utilized for the project.

15.2.1 Data Reduction

Data reduction is performed by the individual Analysts and consists of calculating concentrations in samples from the raw data obtained from the measuring instruments. Data reduction complexity is dependent upon the specific method and the number of discrete operations (extractions/digestion, dilutions, and levels/concentrations) involved in obtaining a sample that can be measured.

For analytical methods, sample response will be applied to the average response factor or the regression line to obtain an initial raw result, which will then be factored into equations to obtain the estimate of the concentration in the original sample. Rounding will not be performed until after the final result has been obtained to minimize rounding errors; results will not normally be expressed in more than three significant figures.

Copies of raw data and calculations used to generate the final results will be retained on file to allow reconstruction of the data reduction process at a later date.

The laboratory data reduction process is described in detail in the associated laboratory SOPs.

15.2.2 Laboratory Data Review

System reviews are performed at all levels. The individual analyst continuously reviews the quality of data through calibration checks, QC sample results, and performance evaluation (PE) samples. These reviews will be performed prior to submission to the Laboratory Project Manager or designee.

Criteria for analytical data review/verification include checks for internal consistency, transmittal errors, laboratory protocol, and laboratory QC. QC sample results and information documented in field notes will be used to interpret and evaluate laboratory data. The Laboratory QA Department will independently conduct a complete review of selected reports to confirm analytical results.

The laboratory will complete data verification procedures, including:

- Verifying analyses requested were analyses performed.
- Preliminary data proofing for inconsistencies; investigation and corrections, where possible.
- Reviewing laboratory data sheets for reporting/detection limits, holding times, surrogate recovery performance, and spike recovery performance.
- Double-checking computerized data entry, if applicable.

The Laboratory Project Manager or designee will review data for consistency and reasonableness with other generated data and determine whether project requirements have been satisfied. Selected hardcopy output of data will be reviewed to ensure that results have been interpreted correctly. Unusual or unexpected results will be reviewed, and a determination will be made as to whether the analyses should be repeated. In addition, the Laboratory Project Manager or designee may recalculate selected results to verify the calculation procedure.

The Laboratory QA Officer will independently conduct a review of the Project data to determine project requirements have been met. Discrepancies will be reported to the Laboratory Project Manager or designee for resolution.

Prior to final review/signoff by the Laboratory Project Manager or designee, the laboratory personnel will verify that the report deliverable is complete and in proper format, screen the report for compliance to laboratory and QAPP requirements, and ensure that the Case Narrative addresses any noted deficiencies. The Laboratory Project Manager or designee will perform the final laboratory review prior to reporting the results to the QA Oversight Consultant and TVA. Any discrepancy noted during laboratory review that results in sample reanalysis or data correction must be documented using the corrective action procedure addressed in Section 16.4.

15.3 Performance and System Audits

Laboratories performing analyses of samples associated with source removal activities will be subjected to system and performance audits under TVA's laboratory management program. These audits will be conducted as described in Sections 15.3.1 and 15.3.2.

Internal audits will be initiated by the QA Oversight Manager at the discretion of the TVA Technical Lead. Internal audits may be conducted based upon issues identified during various other assessment activities. The internal systems and performance audits will be planned and conducted by the QA Oversight Manager or designee or other appropriate QA Program personnel with the experience and competency to perform the audits/assessments. As part of the planning process for conducting internal audits, internal audits or assessments will first be scheduled. Next, the Audit Team will be identified, and the pertinent documentation and procedures relevant to the audit will be obtained and reviewed by the Audit Team. Internal audits may be announced or unannounced. The Audit Team members will hold a minimum of a Bachelor's degree in a scientific discipline and have 5 or more years of QA and on-site laboratory auditing experience. As indicated in Section 2.0, the QA Oversight Manager holds overall authority for the project QA Program and maintains that authority independently from the operational/production aspects of the project.

Documentation of systems and performance audits and any resulting corrective actions will be maintained as part of the Project File. Audit documentation will be reported to the TVA Technical Lead.

15.3.1 Performance Audits

Performance audits are quantitative evaluations of data quality produced by a particular activity or function. Performance audits of the participating laboratories performing chemical analyses of project samples may be conducted through the submission and analysis of performance evaluation samples.

The QA Oversight Manager or designee will coordinate the manufacture and submission of performance audit samples to the laboratory. A TNI-approved performance testing sample provider will be used to obtain the performance evaluation samples. PE sample studies will be conducted at the discretion of the TVA Technical Lead for TVA contract laboratories analyzing solid samples associated with source removal activities. The performance evaluation sample

matrices and requested analytes will be determined based on the nature of the work performed by that laboratory for the project.

Upon receipt of results from the performance evaluation study analyses, the QA Oversight Manager or designee will evaluate the data relative to the certified “true values” and will prepare a comprehensive report (including a discussion of non-analytical issues, such as data package preparation and presentation). If multiple laboratories are included in the performance evaluation study, a statistical evaluation of the results will be performed and a simple fencepost test will be conducted for each analyte to determine outliers; a set of warning limits and acceptance limits (based on the set of data excluding outliers) will be generated for the analytes. The performance evaluation study report will contain a detailed account of any results that are outside of the established acceptance limits. Laboratories will be contacted to explain discrepancies between the reported concentrations and the “known” (true) concentrations of the analytes in the performance evaluation samples and to provide corrective actions in accordance with the corrective action process described in Section 16.4. Performance evaluation sample documentation, inclusive of corrective action responses, will be maintained as part of the Project File.

15.3.2 System Audits

System audits entail on-site observation and evaluation of participating laboratories and field sampling activities for compliance with the QAPP TIs, and/or project-specific Work Plans and/or SAPs. Prior to conducting an on-site audit, the Auditor will conduct a thorough examination of procedures and records. These on-site audits will also include verification of effectiveness of implemented corrective actions.

The system audits will address both field and laboratory activities, including a review of personnel qualifications, equipment, documentation, sampling techniques, analytical methods, and adherence to QA procedures. Each laboratory has its own QA Plan; therefore, the laboratory audit activities under the QAPP will entail a general review of laboratory QA practices.

Systems audits of laboratories conducting chemical analyses of project samples will be performed by the QA Oversight Manager or designee. Field audits will be conducted by the Field Oversight Coordinator or designee.

On-site audits of laboratories analyzing samples associated with source removal activities will be conducted at the discretion of the TVA Technical Lead. Each laboratory will be audited on an annual basis or more frequently as directed by the TVA Technical Lead. Field activities will be subjected to assessments and/or surveillances on a regular basis as new Field Sampling Personnel, new procedures, or new sampling activities are performed. In addition, the Field Oversight Coordinator may observe sampling events as appropriate given the sensitivity of the samples collected.

15.4 Feedback and Corrective Action

In general, feedback and corrective action processes for source removal activities will be conducted in accordance with TVA’s *Corrective Action Program*. TVA’s Corrective Action Program includes various pathways depending on the nature and severity of the issue identified.

Issues will be resolved using the lowest-level pathway that adequately identifies and addresses the cause of the non-conformance or deficiency and prevents recurrence.

15.4.1 Feedback Mechanism

There are mechanisms within the project structure that allow for the identification, feedback, and control of any non-conformances or deficiencies. In general, the technical personnel involved with the project are responsible for reporting suspected technical non-conformances through standard communication channels established by the organizational structure. In the same manner, project personnel are responsible for reporting suspected QA non-conformances.

Feedback will be provided to laboratory personnel and the field team by the TVA Technical Lead, QA Oversight Manager, and/or Investigation Project Manager. Laboratories may receive feedback based on systems and performance audits and ongoing data validation. In addition, laboratories may provide feedback to the QA Oversight Manager. Documentation of feedback will be maintained in the Project File.

15.4.2 Corrective Action for Field Activities

Field Sampling Personnel have the initial responsibility to monitor the quality of field measurements and observations. The Field Team Leader is responsible for verifying that QC procedures are followed. This responsibility requires the Field Team Leader to assess the correctness of field methods and the ability to meet QA objectives. If a problem occurs that might jeopardize the integrity of the project or that might cause a specific QA objective not to be met, the Field Team Leader will notify the TVA Technical Lead and QA Oversight Manager. An appropriate corrective action will then be determined and implemented. The Field Team Leader will document the problem, the corrective action, and the results. A copy of the documentation form will be provided to the TVA Technical Lead.

Field auditing is a recognized technique for evaluating the performance of Field Sampling Personnel and assessing how team performance may affect data quality. Field audits will be conducted by the Field Oversight Coordinator to ensure that sampling, handling, and transportation to project laboratories provide assurance that such procedures meet QA protocols and that field documentation is sufficient to produce data of satisfactory quality, to provide a “defense” in the event that field procedures are called into question, and to identify ways to reduce sampling costs. Field audits will be conducted at a minimum of once (for one-time field collection activity) per plant or as directed by the TVA Technical Lead to verify that corrective actions have been implemented if deficiencies were identified in prior field audits or as requested by the TVA Technical Lead.

15.4.3 Laboratory Corrective Action

Corrective action within the laboratory will be performed in accordance with the laboratory’s formal QA Program.

The laboratory has the responsibility to monitor the quality of the analytical system and to provide a corrective action process adequate to address problems encountered in laboratory analysis of samples. The laboratory will verify that QC procedures are followed and that the analytical results of QC samples are within the acceptance criteria. The verification requires that the laboratory assess the correctness of the following items, as appropriate:

- Sample preparation procedure.
- Initial calibration.
- Calibration verification.
- Method blank result.
- LCS.
- LD analysis.
- Fortified sample result.
- Internal standard performance.

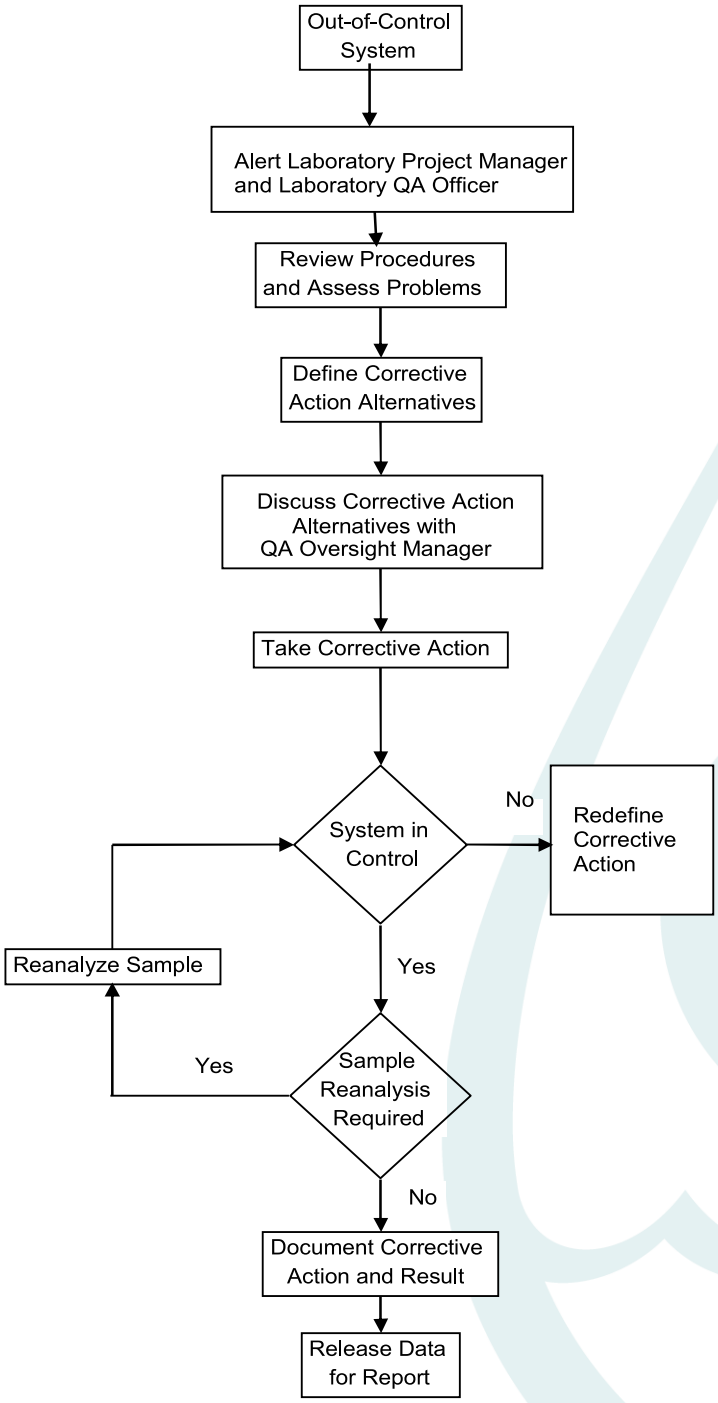
If the assessment reveals that the QC acceptance criteria are not met, the laboratory must immediately evaluate the analytical system and correct the problem. The Laboratory Analyst will notify the Laboratory Project Manager and Laboratory QA Officer of the problem and, if possible, will identify potential causes and suggest correct action.

When the appropriate corrective action measures have been implemented and the analytical system is determined to be “in control,” the Laboratory Analyst will document the problem, the corrective action taken, and resultant data demonstrating that the analytical system is in control. Copies of the documentation will be provided to the Laboratory Project Manager and the Laboratory QA Officer.

Data generated concurrently with an out-of-control system will be evaluated for usability relative to the nature of the deficiency. If the deficiency does not adversely impact the usability of the results, data will be reported and the deficiency will be addressed in the Case Narrative. If sample results are adversely impacted, the Laboratory Project Manager will be notified and appropriate corrective action (such as reanalysis) will be taken.

Figure 15-1 presents the pathway for corrective actions.

Figure 15-1. Critical Path for Laboratory Corrective Action



16.0 REPORTS TO MANAGEMENT

The QA activities performed by laboratories conducting analyses of samples associated with source removal activities will be monitored by the TVA Technical Lead and the QA Oversight Manager.

Communication among TVA, QA personnel, the Field Team Leader, and laboratory personnel is important to ensure that problems are remedied and that solutions are documented in an informed and timely manner.

After the completion of a performance and systems audit, the QA Oversight Manager will submit an audit report to the TVA Technical Lead. This audit report will include a list of observed field activities, a list of reviewed documents, and any observed deficiencies. The TVA Technical Lead and QA Oversight Manager or designee will meet with the laboratory Project Managers of any area with observed deficiencies to review the audit findings, confirm the observations, and resolve misunderstandings. In the event that inadequacies are identified, corrective actions will be undertaken as outlined in Section 16.4.

16.1 Field QA Reports

The Field Team Leader and Investigation Project Manager will provide the TVA Technical Lead with routine field progress reports. Compiled field data sets will be provided to the Data Manager for inclusion in the project EQuIS database. The TVA Technical Lead and QA Oversight Manager or designee will be immediately notified about field QA situations that require corrective action. Corrective action will be performed and documented in accordance with the protocol set forth in Section 16.4.

16.2 Laboratory QA Reports

The Laboratory QA Officer may provide periodic summary reports specific to the project to the QA Oversight Manager. These reports may summarize QA activities for the reporting period, including results of performance audits (external and internal), results of system audits (external and internal), summaries of corrective action to remedy out-of-control situations, and recommendations for revisions of laboratory procedures to improve the analytical systems. The Laboratory Project Manager will notify the QA Oversight Manager and Laboratory Coordinator about laboratory QA situations that appear to systematically impact data quality.

The Laboratory QA Officer will immediately notify the QA Oversight Manager and the Laboratory Coordinator of any laboratory QA situations that require corrective action and ascertain if such measures meet the DQOs of the project. Corrective action will be performed and documented in accordance with the protocol set forth in Section 16.4 or internal laboratory corrective action tracking system, as appropriate.

16.3 Internal Performance and System Audit/Assessment Reports

Documentation of systems and performance audits and any resulting corrective actions will be maintained as part of the Project File. Audit documentation will be reported to the TVA Technical Lead.

17.0 DATA REVIEW, VERIFICATION, AND VALIDATION

The Data Validators will verify or validate data generated by the laboratories for chemical analyses of project samples. Any issues observed during data validation will be brought to the attention of the QA Oversight Manager and TVA Technical Lead; the Laboratory Project Manager will be contacted to determine and implement an appropriate corrective action.

The purpose of analytical data verification and validation is to ensure data completeness, correctness, and method compliance/conformance, and identify data quality, including unusable data that would not be sufficient to support environmental decisions. In addition to the laboratory QA review, the data presented in Level IV data packages will be verified and validated by The QA Oversight Consultant for the following:

- Compliance with requested testing requirements.
- Completeness.
- Reporting accuracy (including hardcopy to EDD).
- Confirmation of receipt of requested items.
- Traceability, sensibility, and usability of the data.

In addition to the above criteria, data will be validated with guidance from the following documents:

- US EPA CLP National Functional Guidelines (NFG) for Inorganic Data Review (October 2004);
- US EPA Region 4 Data Validation SOPs for CLP Inorganic Data by Inductively Coupled Plasma – Atomic Emission Spectroscopy (September 2011);
- US EPA Region 4 Data Validation SOPs for CLP Mercury Data by Cold Vapor Atomic Absorption (September 2011);
- US EPA Region 4 Environmental Investigations SOPs and Quality Assurance Manual (November 2001).

It should be noted that data validation guidelines specified above were developed for work conducted under the US EPA Contract Laboratory Program; therefore, these guidelines are not completely applicable to the Clean Water Act (CWA) and SW-846 methods referenced for source removal activities. Professional judgment will be used as necessary to adapt the guidelines for use in evaluating usability of data generated in accordance with CWA and SW-846 methodology.

Analytical data from off-site, commercial laboratories will be qualified with guidance from the National Functional Guidelines previously referenced. The data validation qualifiers listed below will be used for project samples:

- Inorganic Data Validation Qualifiers

U*	This result should be considered “not detected” because it was detected in a rinsate blank or laboratory blank at a similar level.
R	Unreliable positive result; analyte may or may not be present in sample.
UR	Unreliable reporting or detection limit; analyte may or may not be present in sample.
J	Quantitation is approximate due to limitations identified during data validation.
UJ	This analyte was not detected, but the reporting or detection limit may or may not be higher due to a bias identified during data validation.

The EDD and Full data packages for data generated from the chemical analysis of project samples will summarize the deviations from approved protocols and significant data findings in the Case Narratives. Analytical reports will be submitted to TVA and the QA Oversight Consultant as separate documents and will be transmitted in an electronic (.pdf and EDD) and/or hardcopy formats. The QA Oversight Consultant will maintain a database of TVA data for data validation and/or verification. The QA Oversight Consultant will complete data validation and generate reports for TVA. Data validation and project reports will be submitted to the TVA Technical Lead. Electronic validated data will be submitted upon approval from the TVA Technical Lead. The DMP details the process for appending data qualifiers in the EQuIS database and submitting verified and validated data to data users.

In addition to the validation qualifiers, qualifier reason codes will be maintained in the database. The reason codes below will be used to describe the usability issue(s) associated with results qualified during data review. Additional reason codes may be added as needed to address recurring usability issues.

Reason Code	Explanation
BE	Equipment blank contamination. The result should be considered “not-detected.”
BF	Field blank contamination. The result should be considered “not-detected.”
BL	Laboratory blank contamination. The result should be considered “not-detected.”
BN	Negative laboratory blank contamination.
C	Initial and/or continuing calibration issue, indeterminate bias.
C+	Initial and/or continuing calibration issue. The result may be biased high.
C-	Initial and/or continuing calibration issue. The result may be biased low.
FD	Field duplicate imprecision.
FG	Total versus Dissolved Imprecision.
H	Holding time exceeded.
I	Internal standard recovery outside of acceptance limits.
L	LCS and LCSD recoveries outside of acceptance limits, indeterminate bias.
L+	LCS and/or LCSD recoveries outside of acceptance limits. The result may be biased high.
L-	LCS and/or LCSD recoveries outside of acceptance limits. The result may be biased low.
LD	Laboratory duplicate imprecision.
LP	LCS/LCSD imprecision.
M	MS and MSD recoveries outside of acceptance limits, indeterminate bias.
M+	MS and/or MSD recoveries outside of acceptance limits. The result may be biased high.
M-	MS and/or MSD recoveries outside of acceptance limits. The result may be biased low.
MP	MS/MSD imprecision.
P	Post-digestion spike recoveries outside of acceptance limits, indeterminate bias.
P+	Post-digestion spike recovery outside of acceptance limits. The result may be biased high.
P-	Post-digestion spike recovery outside of acceptance limits. The result may be biased low.
Q	Chemical preservation issue.
R	RL standards outside of acceptance limits, indeterminate bias.
R+	RL standard(s) outside of acceptance limits. The result may be biased high.
R-	RL standard(s) outside of acceptance limits. The result may be biased low.
RL	Positive result reported between the MDL and QL.

Reason Code	Explanation
S	Radium-226+228 flagged due to reporting protocol for combined results.
SD	Serial dilution imprecision.
T	Temperature preservation issue.
X	Percent solids < 50%.
Y+	Chemical yield outside of acceptance limits. The result may be biased high.
Y-	Chemical yield outside of acceptance limits. The result may be biased low.
Z	ICP/MS interference.
ZZ	Other.

18.0 VERIFICATION AND VALIDATION METHODS

The overall QA objective for field activities, laboratory analyses, and data assessment is to produce data of sufficient and known quality to support the program-specific objectives and to produce high-quality, legally defensible data.

This data assessment activity is an ongoing coordinated process with data production and is intended to ensure that data produced during the project are acceptable for use in subsequent evaluations. Both statistical and qualitative evaluations will be used to assess the quality of the data. The primary evaluation of the data will be based upon the control samples. The blank samples will be used to evaluate whether or not the laboratory and/or field sample handling represent a possible source of sample contamination. Duplicate sample results will be used to evaluate data precision.

All data submitted to the project EQuIS database will undergo data verification. Analytical data will be available for preliminary internal use after verification. Initially, 100% of all chemical and physical analysis data will be reported in fully documented (Level IV) data packages for independent data validation. Once a data stream has reached the point that QA finds relatively few issues occurring, that percentage may be reduced to lower levels. If after the percentage of full data validation has decreased, a trend in frequency of reporting issues, method non-compliances, or data usability issues is identified, data validation will be conducted for specific data points, or the full data validation percentage may be increased until the issues have been minimized to a reasonable frequency.

Data verification includes the review of laboratory deliverables for completeness, correctness, and compliance with applicable methods. The validation of data presented in a Level IV data package includes the review of commercially-available raw data and associated QC summary forms for compliance with the applicable methods and for data usability with respect to the appropriate guidance documents. The nature and extent of the data package available for review is dependent on the analytical method used (such as US EPA methods, SW-846, *etc*.) and the reporting and deliverables requirements defined in QAPP and program-specific SAPs. After completion of either Full or Limited data validation, a QA report will be prepared. The QA report will address QAPP and method non-compliance issues, reporting errors, data usability issues, and include summary tables with qualified sample results. The QA report will also address laboratory calculation errors (*i.e*., the reported value is more than 10% different than

the value calculated from the raw data by the data validator). The summary tables will include reported sample results and the associated data qualifiers. The QA report will be fully supported by photocopied pages of the laboratory data showing deficiencies identified in the review, as an appendix to the report.

The data produced during the sampling tasks included in the field investigation will be compared with the defined QA objectives and criteria for precision, accuracy, representativeness, completeness, and comparability (PARCC) and sensitivity. The primary goal of these procedures is to ensure that the data reported are representative of actual conditions at the Site.

Standard procedures are used so that known and acceptable levels of PARCC are maintained for each data set. Descriptions of these criteria are presented in the following subsections.

Specific quantitative QA objectives for chemical analyses associated with source removal activities are presented in Attachment D of this QAPP.

18.1 Precision

The degree of agreement between the numerical values of a set of duplicate samples performed in an identical fashion constitutes the precision of the measurement.

During the collection of data using field methods and/or instruments, precision is checked by reporting measurements at one location and comparing results. For example, soil measurements are taken in pairs at a certain point and depth and the values compared. The measurements are considered sufficiently precise only if the values are within a specified percentage of each other.

Analytical precision for non-radiological parameters is calculated by expressing, as a percentage, the RPD between results of analyses of duplicate samples for a given analyte. Precision is expressed as an RPD when both results are greater than 5× the reporting limit as calculated by the following formula:

$$RPD = abs\left[\frac{\mathrm{A} - \mathrm{B}}{\left(\frac{A+B}{2}\right)}\right] \times 100$$

Where: A = Value of original sample
B = Value of duplicate sample
Abs = Absolute Value

When at least one result is less than 5× the reporting limit, the difference between the results is used to evaluate precision.

Analytical precision for radiological analyses is calculated as the relative error ratio (RER) using the following formula:

$$RER = abs\left[\frac{ACT_s - ACT_d}{\sqrt{(TPU_s)^2 + (TPU_d)^2}}\right]$$

Where: Abs = Absolute Value

ACT_s = Sample Activity
ACT_d = Duplicate Activity
TPU_s = Total Propagated Uncertainty of Sample
TPU_d = Total Propagated Uncertainty of Duplicate

Specific precision and difference objectives for field duplicate samples and laboratory duplicate samples (including MSDs) are presented in Attachment D of this QAPP.

18.2 Accuracy

Accuracy is the degree of agreement of a measurement, X, with an accepted reference or true value, T. Accuracy is usually expressed as the difference between the two values, X-T, or the difference as a percentage of the reference or true value, 100(X-T)/T; accuracy is also sometimes expressed as a ratio X/T. Accuracy, which is a measure of the bias in a system, is assessed by means of reference samples and percent recoveries. Error may arise due to personal, instrumental, or method factors.

The two types of analytical check samples used are LCSs and MSs. Analytical accuracy is expressed as the percent recovery (%R) of an analyte that has been added to the control sample or a standard matrix (such as blank soil) at a known concentration prior to analysis.

The formula used to calculate accuracy for the LCS is:

$$\%\,R = \left(\frac{A_T}{A_F}\right) \times 100$$

Where: A_T = Total concentration of the analyte measured or recovered
A_F = Concentration of the analyte spiked

When calculating accuracy for the MS analysis, a correction for background concentration found in the unspiked sample must be made. MS recovery is calculated using the following formula:

$$\%\,R = \left(\frac{A_T - A_O}{A_F}\right) \times 100$$

Where: A_T = Concentration of the analyte measured or recovered
A_0 = Unspiked concentration of the analyte
A_F = Concentration of the analyte spiked

In general, the accuracy objectives are based on the requirements set forth in the referenced analytical method and in Attachment D of this QAPP.

18.3 Representativeness

Representativeness expresses the degree to which sample data are accurate and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter associated with the proper design of the sampling program. The representativeness criterion can, therefore, be met through the proper selection of sampling locations, the collection of a sufficient number of samples and the use of standardized sampling procedures (*viz*., TVA TIs) to describe sampling techniques and the rationale used to select sampling locations to ensure representativeness of the sample data.

Representativeness will also be measured by the collection of field duplicates or co-located samples, as appropriate given the sample matrix. Comparison of the analytical results of field duplicates will provide a direct measure of individual sample representativeness.

18.4 Completeness

Completeness is a measure of the degree to which the amount of sample data collected meets the needs of the sampling program and is quantified as the relative number of analytical data points that meet the acceptance criteria (including accuracy, precision, and any other criteria required by the specific analytical method used). Completeness is defined as a comparison between actual numbers of usable data points expressed as a percentage of expected number of points.

Difficulties encountered while handling samples in the laboratory, as well as unforeseen complications regarding analytical methods, may affect completeness during sample analysis. The minimum goal for completeness is 90%; the ability to exceed this goal is dependent on the applicability of the analytical methods to the sample matrix analyzed. If data cannot be reported without qualifications, project completion goals may still be met if the qualified data (data of known quality, even if not perfect) are suitable for specified project goals. Percent completeness will be expressed as the ratio of the total number of usable results relative to the total number of analytical results. The total number of usable analytical results will be total number of results minus any results deemed unusable (or rejected) at validation.

18.5 Comparability

Comparability is a qualitative parameter used to express the confidence with which one data set can be compared with another. The comparability of the data, a relative measure, is influenced by sampling and analytical procedures. By providing specific protocols for obtaining and analyzing samples, data sets will be comparable regardless of who collects the sample or who performs the sample analysis.

The laboratory will be responsible providing the following controls to allow assessment of comparability:

- Adherence to current, standard US EPA-approved methodology for sample preservation.
- Compliance with holding times and analysis consistent with QAPP.
- Consistent reporting units for each parameter of similar matrices.

- US EPA-traceable or NIST-traceable standards, when applicable.

19.0 RECONCILIATION OF DATA TO PROJECT OBJECTIVES

The QA Oversight Manager, in conjunction with the TVA Technical Lead, will determine whether field and validated analytical data or data sets meet the requirements necessary for decision-making. The results of measurements will be compared to the objectives set forth in the ISR and site-specific CQA plans.

Generally, data assessment begins with verification and validation of project data to ensure that the sampling and analysis protocols specified in the associated TVA TIs and site-specific CQA plans were followed, and that the measurement systems were performed in accordance with the criteria specified in these documents and this QAPP. Data limitations identified during data verification and validation are communicated to the project team via reports and qualification in the project database.

Following data assessment, statistical analysis is performed to determine if the investigation and project objectives were achieved. As data are evaluated, anomalies in the data or data gaps may become apparent to the data users. Data that do not meet the data users' needs will be identified and appropriately noted so that decision-makers are aware of data limitations.

Data that are determined not to meet the investigation and project objectives may be used qualitatively or may be rejected depending on the program-specific requirements and the intended use of the data. The TVA Technical Lead, with the support of the QA Oversight Manager or designee and Data Validators, will assist data end users in evaluating data limitations identified and determining whether data are acceptable for their intended use.

20.0 REFERENCES

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US EPA. 40 CFR Part 136, *Final Methods Update Rule*, March 2008.

ATTACHMENT A

DATA PACKAGE DELIVERABLE REQUIREMENTS

Required Data Deliverables Elements

All Sample Data Packages will include data for analyses of all samples in one sample delivery group (SDG), including field samples, reanalyses, secondary dilutions, blanks, laboratory control samples (LCS), laboratory control sample duplicates (LCSD), matrix spikes (MS), matrix spike duplicates (MSD), and/or laboratory duplicates. A fraction-specific unit is not a required deliverable if the analysis of that fraction was not required for samples in the SDG. The Sample Data Package must be complete before submission and must be consecutively paginated. The Sample Data Package will be arranged in the following order:

- Cover Letter/Letter of Transmittal signed by Technical Project Manager or designee
- Title Page
- Table of Contents
- SDG Narrative

The SDG Narrative will be clearly labeled "SDG Narrative" and will contain laboratory name; SDG number; TVA sample identifications; laboratory sample numbers; and detailed documentation of any QC, sample, shipment, and/or analytical problems encountered in processing (preparing and analyzing) the samples reported in the data package. A glossary of qualifier codes used in the SDG must also be provided.

The laboratory must also include reference to preparation and analytical methods performed and applicable project documents (*e.g.,* approved work plans), any problems encountered, both technical and administrative, corrective actions taken and resolution, and an explanation of all flagged edits (*i.e*., exhibit edits) on quantitation reports (including results flagged due to storage blank contamination).

The SDG Narrative must be signed and dated by the Laboratory Manager or designee. The SDG Narrative must include a statement or statements relative to compliance with this document and any applicable project documents and description of any deviations from these documents:

- Field and Internal (Laboratory) Chain-of-Custody Records
- Sample Receipt Documentation Log, and all Project Correspondence

Copies of both the external and internal Chain-of-Custody Records for all samples within the SDG must be included in the deliverables. The Chain-of-Custody Records will list all temperature and pH measurements for all samples requiring pH adjustment for preservation.

A.1 Inorganic and General Chemistry Deliverables Requirements

The following subsections provide detailed requirements for the information presented on each of the deliverables elements referenced in Table A-1. In the event that certain required information is not included on a particular form, the laboratory will provide additional documentation (e.g., preparation logs or analytical runlogs) to ensure that the minimum required level of documentation is supplied.

A.1.1 Target Analyte Results Summaries

Target analyte results summaries are required for all MS/MSD samples, laboratory duplicate samples, LCS/LCSDs, and preparation blanks and will be arranged in increasing alphanumeric order by laboratory sample number.

The target analyte results summary must include:

- SDG Number
- TVA sample number
- laboratory sample identifier
- matrix of the TVA sample
- date of sample collection
- sample percent solids (if applicable)
- name and CAS number for each target analyte
- concentration or project-required detection limit (PRDL) for each target analyte
- any applicable flags for target analyte results (e.g., “U” to designate a “not-detected” result)
- concentration units

A.1.2 Initial and Continuing Calibration Verification Summary

The initial and continuing calibration verification summaries will be arranged in chronological order, by instrument and must include:

- SDG number
- names for all target analytes
- instrument identifier

- start and end dates and times of the analytical sequence
- true concentrations for all target analytes for the ICV and CCV standards
- observed concentrations for all target analytes for each ICV and CCV analyses
- calculated percent recoveries for all target analytes for each ICV and CCV analyses
- control limits for ICV and CCV
- percent recoveries
- concentration units

A.1.3 PRDL Standard Summary

The PRDL standard summaries will be arranged in chronological order, by instrument and must include the following:

- SDG number
- names for all target analytes
- instrument identifier
- dates and times for the PRDL standard analyses
- true concentrations for all target analytes
- observed concentrations for all target analytes for each PRDL standard analysis
- calculated percent recoveries for all target analytes for each PRDL
- standard analysis
- control limits for PRDL standard recoveries
- concentration units

A.1.4 Initial and Continuing Calibration Blank Summary

The initial and continuing calibration blank summaries will be arranged in chronological order, by instrument and must include the following:

- SDG number

- names for all target analytes
- instrument identifier
- start and end dates and times of the analytical sequence
- observed concentration or PRDL for each target analyte for each initial calibration blank (ICB) or continuing calibration blank (CCB) analysis
- acceptance limits for ICB and CCB analyses
- concentration units

A.1.5 Preparation Blank Analytical Summary

The preparation blank analytical summaries will be arranged in chronological order, by instrument and must include:

- SDG number
- preparation blank sample identifier
- names for all target analytes
- instrument identifier
- observed concentration or PRDL for each target analyte
- acceptance limits
- concentration units

A.1.6 ICP and/or ICP/MS Interference Check Sample Summary

The ICP and/or ICP/MS interference check sample summaries will be arranged in chronological order, by instrument and must include:

- SDG number
- names for all target analytes
- instrument identifier
- dates and times for the ICP interference check standard analyses
- true concentrations for all target analytes
- observed concentrations for all target analytes observed in each ICP

interference check standard analysis

- calculated percent recoveries for all target analytes for each ICP interference check standard analysis
- control limits for ICP interference check standard recoveries
- concentration units

A.1.7 Matrix Spike /Matrix Spike Duplicate Summary

The MS/MSD summaries will be arranged in alphanumeric order by laboratory sample number and must include:

- SDG number
- TVA sample number for the spiked sample
- percent solids for the TVA sample (if applicable)
- names for all target analytes
- analyte concentration observed in the non-spiked sample aliquot
- true concentrations for all target analytes in the spike solutions
- observed concentrations for all target analytes in the spike sample/spike sample duplicate analyses
- calculated percent recoveries for all target analytes
- control limits for spike sample/spike sample duplicate recoveries
- calculated RPD between spike sample/spike sample duplicate results
- RPD limit for each analyte
- concentration units

A.1.8 Post-Digestion Spike Sample Recovery Summary (if applicable)

The post-digestion spike sample recovery summaries will be arranged in alphanumeric order by laboratory sample number and must include:

- SDG number
- TVA sample number for the post-digestion spike parent sample

- percent solids for the TVA sample (if applicable)
- names for all target analytes
- analyte concentration observed in the non-spiked sample aliquot
- true concentrations for all target analytes in the post-spike solution
- observed concentrations for all target analytes in the post-spike sample analysis
- calculated percent recoveries for all target analytes
- control limits for post-spike sample recoveries
- concentration units

A.1.9 Duplicates Precision Summary

The duplicate precision summaries will be arranged in alphanumerical order by TVA sample number and must include:

- SDG number
- TVA sample number for the duplicate sample
- percent solids for the TVA sample (if applicable)
- names for all target analytes
- analyte concentration observed in the original sample aliquot
- observed concentrations for all target analytes in the duplicate sample analysis
- calculated RPD for all target analytes
- control limits for RPD
- concentration units

A.1.10 LCS/LCSD Recovery Summary

The LCS/LCSD recovery summaries will be arranged in chronological order, by instrument and must include:

- SDG number

- LCS/LCSD identification number
- names for all target analytes
- true concentrations for all target analytes in the LCS/LCSD solution
- observed concentrations for all target analytes in the LCS/LCSD analysis
- calculated percent recoveries for all target analytes
- control limits for LCS/LCSD recoveries
- concentration units
- RPD between LCS/LCSD results
- RPD limit for each analyte

A.1.11 Standard Addition Results Summary (where applicable) must include:

- SDG number
- TVA sample number for the sample that underwent the standard additions procedure
- names for all target analytes
- analyte concentration or absorbance observed in the non-spiked sample aliquot
- true concentrations for all target analytes for each standard addition analysis
- observed concentration or absorbance for each standard addition analysis
- calculated concentration for each target analyte
- calculated correlation coefficient for each target analyte
- concentration units

A.1.12 ICP and/or ICP/MS Serial Dilution Summary

The ICP and/or ICP/MS serial dilution summaries will be arranged in alphanumeric order by laboratory sample number and must include:

- SDG number
- TVA sample number for the ICP serial dilution sample
- names for all target analytes
- analyte concentration observed in the original sample aliquot
- observed concentrations for all target analytes in the ICP serial dilution analysis
- calculated RPD for all target analytes
- control limits for RPD
- concentration units

A.1.13 PRDL and MDL Summary

The PRDL and MDL summaries will be arranged in chronological order, by instrument and must include:

- SDG number
- instrument identifier
- date the MDL determination was performed
- names for all target analytes
- determined MDL for all target analytes
- PRDL for all target analytes
- concentration units

A.1.14 ICP Interelement Correction Factors Summary

The ICP interelement correction factors summaries will be arranged in chronological order, by instrument and must include:

- SDG number
- instrument identifier

- date the ICP interelement correction factors determination was performed
- names for all target analytes
- determined ICP interelement correction factors concentrations for all target analytes
- concentration units

A.1.15 ICP and/or ICP/MS Linear Range Summary

The ICP and/or ICP/MS linear range summaries will be arranged in chronological order, by instrument and must include:

- SDG number
- instrument identifier
- date the ICP linear range determination was performed
- names for all target analytes
- determined ICP linear range concentrations for all target analytes
- concentration units

A.1.16 Preparation Logs

- TCLP or SPLP Preparation Logs (if TCLP or SPLP extraction was performed)
- TVA sample and QC sample digestion logs

A.1.17 Analytical Sequence Form

The analytical sequence forms will be arranged in chronological order, by analyte, by instrument and must include:

- SDG number
- instrument identifier
- TVA sample numbers associated with the sequence
- QC sample identifiers associated with the sequence
- analysis date and time for each TVA sample and QC sample associated with the sequence

- identification of all target analytes reported from each TVA sample and
- QC sample analysis
- dilution factor for each TVA sample and QC sample analysis
- start and end dates and times for the sequence

A.1.18 ICP/MS Additional Forms

ICP/MS Data Packages will include the following forms in addition to the requirements listed above.

- ICP/MS Tune Summary
- ICP/MS Internal Standards Relative Intensity Summary

A.1.19 Raw Data for Metals/Mercury

- For each reported value, the laboratory will provide all raw data used to obtain that value. This requirement applies to all required QA/QC measurements and instrument standardization as well as all sample analysis results. This statement does not apply to the Quarterly Verifications Parameters submitted as part of each data package. Raw data must contain all instrument readouts used for the sample results. Each exposure or instrumental reading must be provided, including those readouts that may fall below the PRDL. All ICP, ICP/MS, and AA instruments must provide a legible hardcopy of the direct real-time instrument readout (e.g., strip-charts, printer tapes, etc.). A photocopy of the instrument's direct sequential readout must be included. A hardcopy of the instrument's direct instrument readout for cyanide must be included if the instrumentation has the capability.
- Raw data must include instrument calibration and calibration curves/equations.

A.1.20 Raw Data for General Chemistry Parameters

- For each reported value, the laboratory will provide all raw data (instrument printouts or logbook pages) used to obtain that value. This requirement applies to all required QA/QC measurements and instrument standardization, as well as all sample analysis results. Raw data must contain all instrument readouts/logbooks pages used for the sample results. Each exposure or instrumental reading must be provided, including those readouts/logbook pages that may fall below the quantitation limit. A photocopy of the instrument's direct sequential readout must be included if the instrumentation has the capability.

- Raw data must include instrument calibration and calibration curves/equations as applicable.

- Wet Chemistry Preparation Logs (by parameter)

Table A-1: Required Deliverables for Inorganic and General Chemistry Analyses

	Section	ICP/MS Metals	Mercury	General Chemistry Parameters
Cover Letter/Letter of Transmittal	n/a	X	X	X
Case Narrative	n/a	X	X	X
Field and Internal (Laboratory) COC Records	n/a	X	X	X
Sample Receipt Documentation Log	n/a	X	X	X
Project Correspondence	n/a	X	X	X
Target Analyte Results Summary	A.1.1	X	X	X
ICP/MS Tune Summary	A.1.18	F		
Initial Calibration Summary	A.1.19 A.1.20	F	F	F
Initial and Continuing Calibration Verification (ICV/CCV) Summary	A.1.2	F	F	F
PRDL Standard Summary	A.1.3	F	F	
Initial and Continuing Calibration Blank Summary	A.1.4	F	F	F[A]
Preparation Blank Summary	A.1.5	X	X	X
Interference Check Sample Summary	A.1.6	F		
MS/MSD Duplicate Summary	A.1.7	X	X	X[A]
Post-Spike Sample Recovery Summary	A.1.8	F	F	
Duplicates Precision Summary	A.1.9	X	X	X
LCS/LCSD Recovery Summary	A.1.10	X	X	X
ICP and/or ICP/MS Serial Dilution Summary	A.1.12	F		
PRDL and MDL Summary	A.1.13	F	F	F[A]
Standard Additions Summary	A.1.11	F[A]	F[A]	
ICP Interelement Correction Factors Summary	A.1.14	F		
ICP and/or ICP/MS Linear Range Summary	A.1.15	F		
ICP/MS Internal Standards Relative Intensity Summary	A.1.18	F		
TCLP or SPLP Preparation Logs	A.1.16	F[A]	F[A]	
Digestion Logs	A.1.16	F	F	
General Chemistry Preparation Logs	A.1.20			F
Analytical Sequence Form	A.1.17	F	F	F
Raw Data	A.1.19	F	F	F

Notes:
X Required element for all deliverables Levels
F Required additional element for full deliverables (in addition to elements required for all deliverables levels)
[A] Required element for associated deliverable level when applicable to the analyses performed

A.2 Radiological Deliverables Requirements

The following subsections provide detailed requirements for the information presented on each of the deliverables elements referenced in Table A-2. In the event that certain required information is not included on a particular form, the laboratory will provide additional documentation (e.g., preparation logs or analytical runlogs) to ensure that the minimum required level of documentation is supplied.

The radiological data will be arranged in the following order by individual parameter requested for the samples in the SDG.

A.2.1 Target Analyte Results Summaries: Target analyte results summaries are required for all samples and will be arranged in increasing alphanumeric order by TVA sample number. The target analyte results summary must include the following:

- SDG Number
- TVA sample number
- laboratory sample identifier
- matrix of the TVA sample
- date of sample collection
- date of sample analysis
- sample activity, uncertainty, and the sample-specific minimum detectable concentration (MDC). The sample-specific MDC will be based on the background of the detector that the sample was counted on. The sample activity (positive or negative), uncertainty, and sample-specific MDC will be reported for positive and “not-detected” results
- any applicable flags for target analyte results (e.g., “U” to designate a “not-detected” result)
- concentration units

A.2.2 Chemical Yield (Tracer/Carrier) Recovery Summary that must include the following:

- SDG number
- TVA sample number
- Method blank sample number
- Laboratory Duplicate sample number
- LCS identification number
- LCSD identification number (if performed)
- percent recovery for all tracers/carriers
- applicable recovery limits for each tracer/carrier

A.2.3 Method Blank Summary: The method blank summaries will be arranged in chronological order, by instrument and method and must include the following:

- SDG number
- names for all target analytes
- observed activity, uncertainty, and MDC for each target analyte for each method blank analysis
- concentration units

A.2.4 Duplicates Precision Summary: The duplicate precision summaries will be arranged by instrument and method and must include the following:

- SDG number
- TVA sample number for the duplicate sample
- names for all target analytes
- analyte activity, uncertainty, and MDC observed in the original sample aliquot
- observed activity, uncertainty, and MDC for all target analytes in the duplicate sample analysis
- calculated RPD/Replicate Error Ratio (RER) for all target analytes
- control limits for RPD/RER

- concentration units

A.2.5 LCS Recovery Summary: The LCS recovery summaries will be arranged by instrument and method and must include the following:

- SDG number
- LCS identifier
- names for all target analytes
- true concentrations for all target analytes in the LCS solution
- observed concentrations for all target analytes in the LCS analysis
- calculated percent recoveries for all target analytes
- control limits for LCS recoveries
- concentration units

A.2.6 Calibration Verification Summary: The calibration verification summaries will be arranged by instrument and method and must include the following:

- SDG number
- names for all target analytes
- instrument identifier
- date the calibration verification was performed. For each method and analyte, the Contracted Laboratories will provide Calibration Verification summaries that include or bracket the analysis dates of the field and QC samples.
- acceptance limits for the calibration verification
- the following calibration verification summaries will be provided for Gas Flow Proportional Counter data

    a. Efficiency Checks
    b. Background Checks

- the following calibration verification summaries will be provided for Alpha Spectroscopy data

    a. Energy Calibration Checks
    b. Efficiency Checks
    c. Background Checks

d. Resolution (FWHM) Checks

- the following calibration verification summaries will be provided for Alpha Scintillation data

  a. Daily Instrument Performance Checks
  b. Background Checks

A.2.7 Raw Data

For each reported value, the Contracted Laboratories will provide all raw data (instrument printouts) used to obtain that value. This applies to all required QA/QC measurements (including tracer/carrier recoveries) as well as all sample analysis results. Raw data must contain all instrument readouts and worksheets used for the sample results. An exhibit work sheet per method (including example calculations showing how sample activity, total propagated uncertainty [TPU] and minimum detectable activity [MDA] are calculated) will be provided.

A.2.8 Preparation Logs (by method)

A.2.9 Traceability Documents (by method)

Table A-2: Required Deliverables for Radiological Analyses

	Section	**Radiological Parameters**
Cover Letter/Letter of Transmittal	n/a	X
Case Narrative	n/a	X
Field and Internal (Laboratory) COC Records	n/a	X
Sample Receipt Documentation Log	n/a	X
Project Correspondence	n/a	X
Target Analyte Results Summary	A.2.1	X
Chemical Yield (Tracer/Carrier) Recovery Summary	A.2.2	X
Method Blank Summary	A.2.3	X
Duplicates Precision Summary	A.2.4	X
LCS Recovery Summary	A.2.5	X
Calibration Verification Summary	A.2.6	X
Preparation Logs	A.2.8	X
Traceability Documents	A.2.9	X
Raw Data	A.2.7	F

Notes:
X Required element for all deliverables levels
F Required additional element for full deliverables (in addition to elements required for all deliverables levels)

ATTACHMENT B

SAMPLING PROCEDURES LIST

The TVA Technical Instructions (TIs) associated with Interim Source Removal activities are identified on Table B-1. Current versions of these documents are maintained on TVA's Accellion Workspace.

Table B-1: Applicable TIs

Document Number	**Document Title**
ENV-TI-05.80.02	*Sample Labeling and Custody*
ENV-TI-05.80.03	*Field Record Keeping*
ENV-TI-05.80.04	*Field Sampling Quality Control*
ENV-TI-05.80.05	*Field Sampling Equipment Cleaning and Decontamination*
ENV-TI-05.80.06	*Handling and Shipping of Samples*
EMA-TI-05.80.42	*Soil Sample Compositing*

ATTACHMENT C

EXAMPLE CHAIN OF CUSTODY RECORD

CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed and accurate.

Page: ____ of ____
Cooler # ____ of ____

COC #

Task

Required Ship to Lab:		Required Project Information:		Required Sampler Information:			
Lab Name:		Site ID #:		Sampler		TAT: Standard	Rush	Mark One
Address:	#N/A	Project #	#N/A	Sampling Company			
				Address:			
		Site Address	#N/A	City/State	Phone #:		
Lab PM:	#N/A	City	#N/A	State, Zip	#N/A	Reimbursement project?	Non-reimbursement	Mark one
Phone/Fax:	#N/A	Site PM Name	#N/A	Send EDD to			
Lab PM email	#N/A	Phone/Fax:		CC Hardcopy report to			
Applicable Lab Quote #:		Site PM Email:		CC Hardcopy report to			

ITEM #	SAMPLE ID Samples IDs MUST BE UNIQUE	SAMPLE LOCATION	Sample Depth Depth Unit: Start Depth	End Depth	MATRIX CODE	G=GRAB C=COMP	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	#OF CONTAINERS	Comments/Lab Sample I.D.	Filtered	Preserve	Analysis
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														

Additional Comments/Special Instructions:

RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	Sample Receipt Conditions			
							Y / N	Y / N	Y / N
							Y / N	Y / N	Y / N
							Y / N	Y / N	Y / N
							Y / N	Y / N	Y / N

SHIPPING METHOD: (mark as appropriate)	SAMPLER NAME AND SIGNATURE				Temp In 0C	Samples on Ice?	Sample Intact?	Trip Blank?
UPS COURIER \ FEDEX	PRINT Name of SAMPLER:							
US MAIL	SIGNATURE of SAMPLER:		Date:					

ATTACHMENT D

QUALITY CONTROL REQUIREMENTS

NATIVE SOIL SAMPLING

Table D-1. Sample Containers, Mass, Preservation, and Holding Time Requirements

Matrix	Parameter(s)	Container Type	Recommended Sample Mass/Volume	Preservation	Holding Time
Solid	Metals	4-oz glass	5 g	Cool to < 6°C	180 days
	Mercury				28 days
	pH				NA*
	Radiological Parameters	16-oz glass	20 g	NA	180 days
	Percent Ash	4-oz glass	5 g	NA	NA
Aqueous Blanks	Metals	250-mL HDPE	250 mL	HNO_3 to pH < 2 Cool to < 6°C	180 days
	Mercury				28 days
	Radiological Parameters	3× 1-L HDPE	3000 mL	HNO_3 to pH < 2	180 days

*Holding time for soil pH samples is 15 minutes following creation of soil paste.

Notes:

oz - ounce
g - grams
mL - milliliter
L - liter
HDPE - High Density Polyethylene
NA - Not applicable

Table D-2: Analytes, Methods, and Reporting Limits – Solid Matrices

Parameter	CAS No.	Method	Reporting Limit[1]	Units
Antimony	7440-36-0	SW-846 6020A	0.200	mg/kg
Arsenic	7440-38-2	SW-846 6020A	0.100	mg/kg
Barium	7440-39-3	SW-846 6020A	1.00	mg/kg
Beryllium	7440-41-7	SW-846 6020A	0.100	mg/kg
Boron	7440-42-8	SW-846 6020A	8.0	mg/kg
Cadmium	7440-43-9	SW-846 6020A	0.100	mg/kg
Calcium	7440-70-2	SW-846 6020A	50.0	mg/kg
Chromium	7440-47-3	SW-846 6020A	0.200	mg/kg
Cobalt	7440-48-4	SW-846 6020A	0.0500	mg/kg
Copper	7440-50-8	SW-846 6020A	0.200	mg/kg
Lead	7439-92-1	SW-846 6020A	0.100	mg/kg
Lithium	7439-93-2	SW-846 6020A	0.500	mg/kg
Mercury	7487-94-7	SW-846 7471B	0.0330	mg/kg
Molybdenum	7439-98-7	SW-846 6020A	0.500	mg/kg
Nickel	7440-02-0	SW-846 6020A	0.100	mg/kg
Selenium	7782-49-2	SW-846 6020A	0.500	mg/kg
Silver	7440-22-4	SW-846 6020A	0.100	mg/kg
Thallium	7440-28-0	SW-846 6020A	0.100	mg/kg
Vanadium	7440-62-2	SW-846 6020A	0.100	mg/kg
Zinc	7440-66-6	SW-846 6020A	0.500	mg/kg
Radium-226	13982-63-3	EPA 901.1	1.00	pCi/g
Radium-228	15262-20-1	EPA 901.1	1.00	pCi/g
Radium-226+228	RA226/228	CALC	1.00	pCi/g
Percent Ash	%ASH	R.J. Lee SOP OPT23.02	1	%
pH	PH	SW-846 9045D Modified	0.1	pH units

Notes:

CAS No. - Chemical Abstracts Service registry number
mg/kg - milligrams per kilogram
pCi/g - picoCuries per gram
CALC - Parameter determined by calculation.

1 Samples will be reported on a dry-weight basis; sample-specific reporting limits will vary based on sample mass, dilution factors, and percent moisture.

Analyte/ Parameter Group	Method	Equipment Rinsate Blank, Field Blank, Method Blank	LCS Accuracy (% R)	MS/MSD Accuracy (% R)	LCS/LCSD Precision (RPD)	MS/MSD Precision (RPD)	Laboratory Duplicate Precision (RPD)	Field Duplicate Precision[1]
Metals	SW-846 6020A	< RL	80-120	75-125	35	35	35	RPD < 35% difference < 2× the RL
Mercury	SW-846 7471B	< RL	80-120	75-125	35	35	35	RPD < 35% difference < 2× the RL
Radium-226	EPA 901.1	< RL	75-125	NA	RER < 2	NA	RER < 2	RER < 2
Radium-228	EPA 901.1	< RL	75-125	NA	RER < 2	NA	RER < 2	RER < 2
Percent Ash	R.J. Lee SOP OPT23.02	< RL	NA	NA	NA	NA	±10%	RPD < 35% difference < 2× the RL

Notes:

[1] When both field duplicate results are > 5× the RL, the RPD must be < 20%. When at least one result is < 5× the RL, the difference must be < the RL

LCS - Laboratory Control Sample
LCSD - Laboratory Control Sample Duplicate
MS/MSD - Matrix Spike/Matrix Spike Duplicate
NA - Not Applicable
RPD - Relative Percent Difference
RER - Relative Error
RL - Reporting Limit
%R - Percent Recovery

Attachment E – Fugitive Dust Control Plan

CCR FUGITIVE DUST CONTROL PLAN

GALLATIN FOSSIL PLANT
COAL COMBUSTION PRODUCTS
GALLATIN, TENNESSEE

Prepared by:

TENNESSEE VALLEY AUTHORITY
1101 Market Street
Chattanooga, TN 37402-2801

December 13, 2019 (Amended)

Revision or Change Number	Date Placed in Operating Record	Affected Page Numbers	Description of Revision/Change
0	10/19/15	All	Initial Plan
1	12/15/17	1	Facility updates in Sections 1.1 and 2.0.
2	12/13/19	1	Facility updates in Section 1.1.

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CERTIFICATION

I certify that this plan meets the requirements of 40 CFR 257.80, Final Rule: Disposal of Coal Combustion Residuals from Electric Utilities.

Signature

December 13, 2019
Date

JASON CURTSINGER
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 117971
STATE OF TENNESSEE
12/13/19

1.0 OVERVIEW

This CCR Fugitive Dust Control Plan (Plan) provides a program for minimizing fugitive dust events originating from day-to-day operations for Coal Combustion Residuals (CCR) management at the Gallatin Fossil Plant (GAF or Site) of the Tennessee Valley Authority (TVA), located in Gallatin, Tennessee. This document provides measures to effectively minimize CCR from becoming airborne from CCR units, CCR piles, roads, and other CCR management activities. This plan has been developed in accordance with 40 CFR 257.80, Final Rule: Disposal of Coal Combustion Residuals from Electric Utilities.

1.1 Facility Description

GAF is a fossil-fueled, steam-electric generating plant operated by TVA that has four coal-fired generating units. It is located south of Gallatin, Sumner County, Tennessee on Steam Plant Road. CCR materials generated by the power generating station are processed and placed into the North Rail Loop Landfill (NRLL).

2.0 FUGITIVE DUST CONTROL MEASURES

Fugitive dust will be controlled primarily through the conditioning and wetting of CCR material and associated CCR management activities as these methods have been historically effective and appropriate at the Site. In accordance with the GAF Title V Operating Permit, there will be no visible fugitive dust emissions leaving the Site's property boundary.

The Construction Contractor manages dust suppression around the site through the application of water using water trucks. The water filling station is located on the southwest corner of the maintenance building (U Building) near the power plant. CCR placed in lifts at the NRLL and wetted to a moisture content that will prevent wind dispersal, but will not result in free liquids. The conditioned CCR will be compacted in accordance with the procedures outlined in the Site's Operations and Maintenance Manual.

The Construction Contractor will strictly manage the haul routes and traffic patterns to ensure that traffic is concentrated to common routes and use construction barrels to prevent light vehicle traffic from entering any nonessential areas. Since CCR materials typically harden and stabilize with time after placement, it is anticipated that completed areas will not require continued water application to prevent fugitive dust dispersion. However, the Construction Contractor will monitor all surfaces and apply additional water as necessary to control fugitive dust across any exposed CCR material.

Other dust control measures that may be utilized in combination with the current measures, on an as needed basis include:

- Berms constructed as wind breaks
- Intermediate soil cover
- Chemical dust suppressants
- Sweeping of haul roads
- Limiting material drop heights
- Mobilization and use of additional water trucks

3.0 RECORD KEEPING

This Plan and the following associated documents will be placed in the Site's operating record once completed, and proper notification will be provided to the State Director. The following documents will also be made publically available on the Site's "CCR Rule Compliance Data and Information" website.

3.1 Citizen Input

Citizens can provide input and submit complaints/concerns relative to fugitive dust by calling 1-844-TVA-DUST (882-3878). Comments will be logged and submitted to TVA's Coal Combustion Product Management (CCPM) Group for review and response. Upon receipt, appropriate CCPM Management personnel will investigate the complaint/concern and implement any additional dust control measures

required. Examples of additional dust control measures which may be considered for implementation are described in Section 2.0. Upon completion, the results of the investigation and a description of any associated corrective measures employed by the site will be added to the log.

3.2 Annual CCR Fugitive Dust Control Report

A CCR Fugitive Dust Control Report will be prepared annually to provide a summary of dust control activities for the reporting year. The report will include a description of the actions taken to control CCR fugitive dust on Site, a record of all reported citizen complaints/concerns, and a summary of any necessary corrective measures taken.

4.0 ASSESSMENT OF CCR FUGITIVE DUST CONTROL PLAN

This Plan will be evaluated annually in conjunction with preparation of the annual CCR Fugitive Dust Control Report. Operating personnel at the Site have been instructed to record any evidence of fugitive dust events or deficiencies in the current fugitive dust control measures as well as report such issues to the TVA Field Supervisor. Evaluation of plan effectiveness will include a review of the Construction Contractor and TVA observation reports and any reported public complaints/concerns. Any necessary amendments or revisions required to rectify noted issues will be incorporated into the updated Plan.

Attachment F – Engineering Calculations

F.1 – Temporary Excavation Slope Stability Calculations

1 PURPOSE

On June 13, 2019 the Tennessee Valley Authority (TVA) entered into an agreement with the Tennessee Department of Environment and Conservation (TDEC) to close the Ash Pond Complex (APC) located at the Gallatin Fossil Plant (GAF) located near Gallatin, Sumner County, Tennessee. The APC consists of the Bottom Ash Pond, Middle Pond A, Ash Pond A, Ash Pond E, and Stilling Ponds B, C, and D. TVA is proposing to excavate the CCR from the APC and place the material within a dedicated expansion to the existing Rail Loop disposal facility, referred to as the South Rail Loop (SRL) landfill. As excavation with the APC progresses, temporary slopes will be cut in the CCR as various areas reach different excavation depths.

As noted in the Removal Plan, many different slope and dewatering scenarios may be found acceptable. Proposed dewatering and slope configurations will depend on the contractor's proposed means and methods for CCR removal and phasing. The means and methods of achieving excavation grades and a particular dewatered state are not dictated in the Removal Plan or this package. Slope conditions will be re-evaluated based on the contractor's proposed means and methods for CCR removal and phasing.

The purpose of this package is to evaluate the stability of example temporary slopes to verify that reasonable slope geometries can be achieved that ensure the safety of the workers and efficient progress in excavation of the CCR.

Two example slope geometries were proposed based on the anticipated dewatering approaches to be taken by the contractor i.e. passive dewatering (e.g. rim ditches, gravity draining) or active dewatering (e.g. well points and pumping).

The following sections summarize the methods, cross sections analyzed, cases analyzed, material properties, results and conclusions.

2 METHODOLOGY

2.1 Slope Stability Analysis

CCR slope stability analyses were performed using Spencer's method (Spencer, 1967), as implemented in the software, SLOPE/W (GEOSLOPE, 2019). Spencer's method was used because it satisfies vertical and horizontal force equilibrium and moment equilibrium. SLOPE/W was used to generate potential slip surfaces, calculate the factor of safety for each surface, and identify the critical surface i.e. the surface with the lowest calculated FS. Information that is required to perform he analyses includes:

- Slope geometry;

- Subsurface stratigraphy;
- Material properties; and
- Groundwater conditions.

Details regarding this information is provided in subsequent sections.

2.2 Target Factor of Safety

The United States Army Corps of Engineers (USACE) provided guidance for selection of suitable target FS in the Slope Stability Engineering Manual (USACE, 2003). The Engineering Manual recommends an FS of 1.5 and 1.3 for long term and temporary conditions, respectively. CCR excavation within the APC is considered a temporary condition, therefore a target FS of 1.3 was selected.

3 CROSS SECTIONS ANALYZED

As noted in Section 1, two theoretical, example cross sections were analyzed – one for passive and active dewatering controls and shown in **Figure 1** and **Figure 2**, respectively. The drawings are also provided as details in the Removal Plan Drawings provided as Attachment A to the Removal Plan. A summary of the geometries is presented in **Table 1**.

In both cases, it was assumed that the CCR excavation is approaching completion and that 50 feet of CCR remains in place. Bedrock was assumed to underlie the CCR.

4 CASES ANALYZED

The two cross sections were analyzed under both drained and undrained conditions for both active and passive dewatering. In the undrained cases, the materials were assumed to be drained above the phreatic surface and undrained below. A minimum slip surface depth of 3 feet was applied to the active dewatering case to eliminate surficial raveling type slip surfaces.

5 MATERIAL PROPERTIES

Slope stability analyses were previously performed at GAF as part of Initial Static Safety Factor Assessment (AECOM, 2016) and Structural Stability Assessment (AECOM, 2018). Material properties used in the analyses presented herein were selected based on the most conservative values presented in the previous analyses. A summary of the material properties used in these analyses is presented in **Table 2**. A detailed discussion of the laboratory and/or in-situ testing, data reduction, and interpretation can be found in the Initial Static Safety Factor Assessment

(AECOM, 2016) and Structural Stability Assessment (AECOM, 2018), relevant excerpts are provided in **Attachment A** and **Attachment B**, respectively.

6 RESULTS

The calculated FS for the passive dewatering conditions was 2.57 and 1.73 for the drained and undrained case, respectively. The calculated FS for the active dewatering conditions was 2.50 and 2.22 for the drained and undrained case, respectively. A summary of the calculated FS is provided in **Table 3**. SLOPE/W outputs for each case are provided in **Figure 3** through **Figure 6**.

7 CONCLUSIONS

Given the assumptions presented herein, the calculated FS meet the required target FS (i.e. FS ≥ 1.3) for both passive and active dewatering methods under drained and undrained conditions. Note that means and methods of achieving a particular dewatered state are not dictated herein and slope conditions will be re-evaluated based on the contractor's proposed means and methods for CCR removal and phasing.

8 REFERENCES

AECOM (2016), "Initial Safety Factor Assessment, Geotechnical Exploration Report, TVA Gallatin Fossil Plant", 7 October 2016.

AECOM (2018), "Structural Stability Assessment (Rev 0), Non-Registered Site, Stilling Pond C and Stilling Pond D, Ash Pond Complex (Bottom Ash Pond, Middle Pond A, Ash Pond A, and Ash Pond E), Tennessee Valley Authority, Gallatin Fossil Plant, Gallatin, Sumner County, Tennessee", 5 March 2018.

GEOSLOPE International Ltd. (2019), GeoStudio 2019 – SLOPE/W, Calgary, Alberta.

Spencer, E. (1967), "A Method of Analysis of the Stability of Embankments Assuming Parallel Inter-Slice Forces", Geotechnique, Vol. 17, No. 1, pp. 11-26.

USACE (2003), "Engineering and Design: Slope Stability Engineering Manual", EM 1110-2-1902, 31 October 2003.

TABLES

Table 1. Example Temporary CCR Excavation Slope Scenarios

	Passive Dewatering	Active Dewatering
Slope (horizontal : vertical)	10H:1V	5H:1V
Maximum Vertical Slope Height (ft)	20	10
Minimum Equipment Setback from Edge of Crest (ft)	100	100
Minimum Dewatering Depth Below Toe (ft)	5	5
Minimum Dewatering Depth Below Slope (ft)	5	Varies
Minimum Dewatering Depth Below Crest (ft)	5	15

Table 2. Summary of Material Properties

	Material Property	CCR	Bedrock
Drained[1]	Cohesion, c' (psf)	0	Modelled as infinite strength layer
	Friction Angle, ϕ' (degrees)	26	
Undrained[2]	Shear Strength Ratio, τ/σ	0.32	
	Unit Weight, γ (pcf)[2]	90	

Notes:

[1] Drained material properties obtained from Initial Static Safety Factor Assessment (AECOM, 2016).

[2] Undrained material properties and unit weight obtained from Structural Stability Assessment (AECOM, 2018).

Table 3. Summary of Calculated Factors of Safety

	Calculated Factor of Safety	
Dewatering Method	Drained	Undrained
Passive	2.57	1.73
Active	2.50	2.22

FIGURES

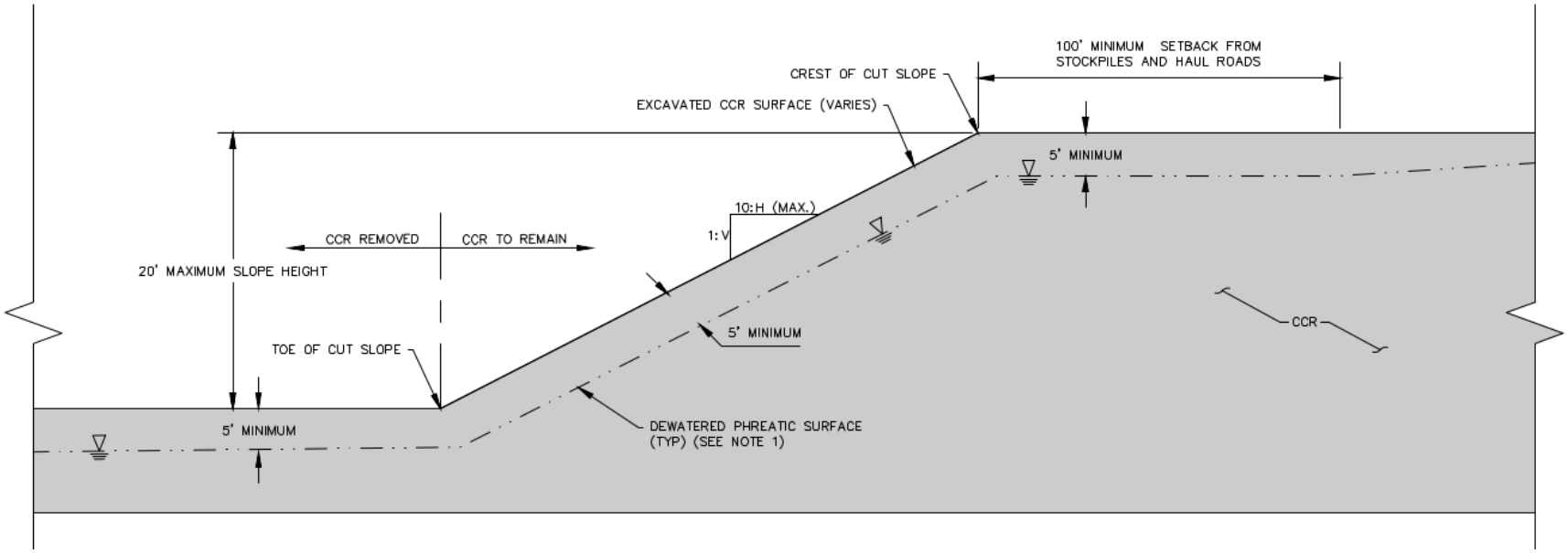

Figure 1. Passive Dewatering – Proposed Slope Geometry

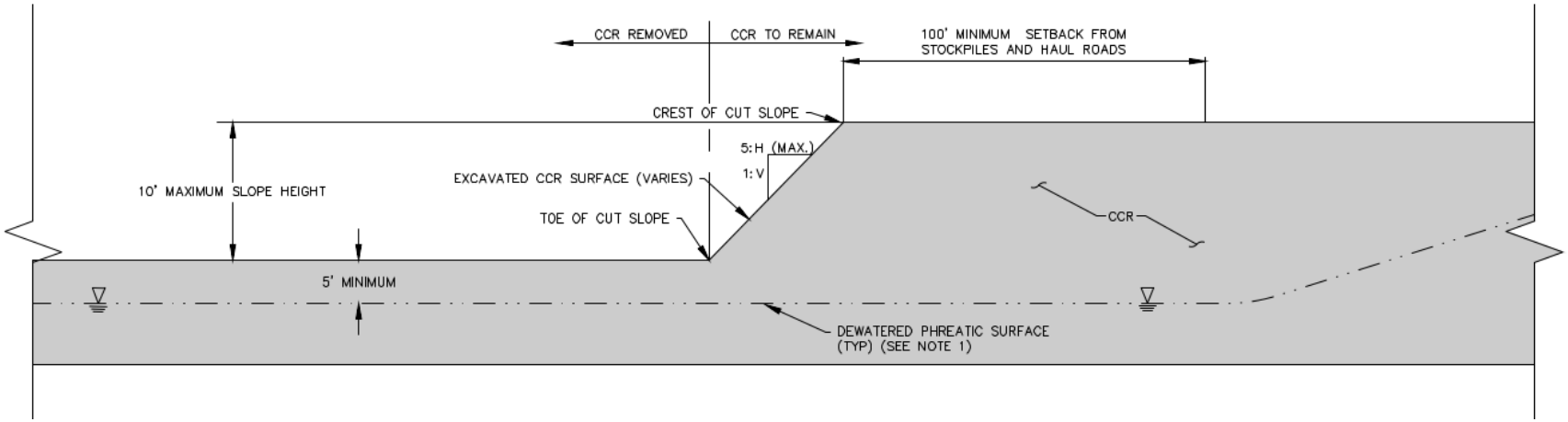

Figure 2. Active Dewatering – Proposed Slope Geometry

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Bedrock			
	CCR - Drained	90	0	26

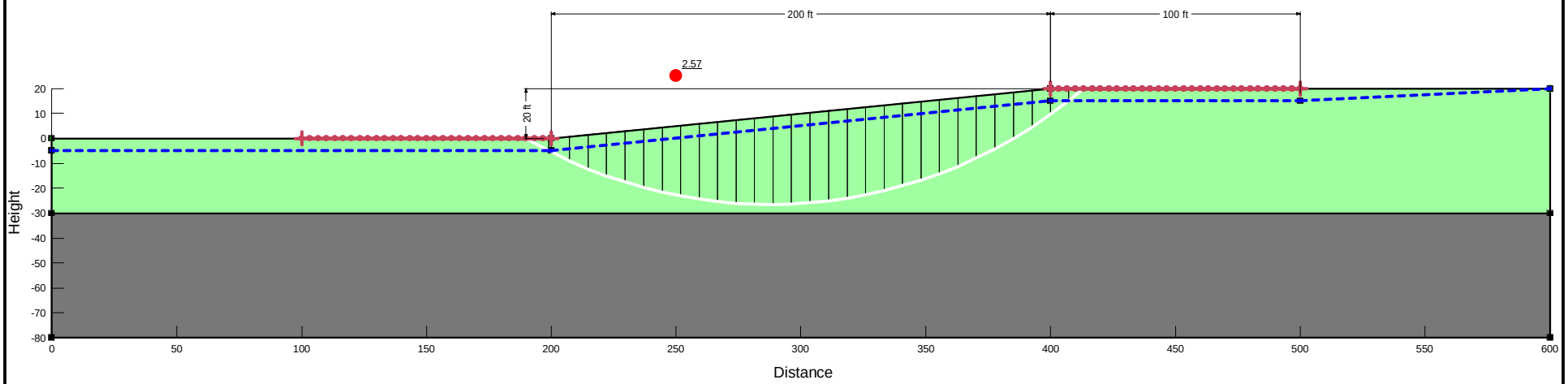

Figure 3. Calculated Factor of Safety - Passive Dewatering, Drained Conditions

Color	Name	Unit Weight (pcf)	Minimum Strength (psf)	Tau/Sigma Ratio	Cohesion' (psf)	Phi' (°)
	Bedrock					
	CCR - Drained	90			0	26
	CCR - Undrained	90	0	0.32		

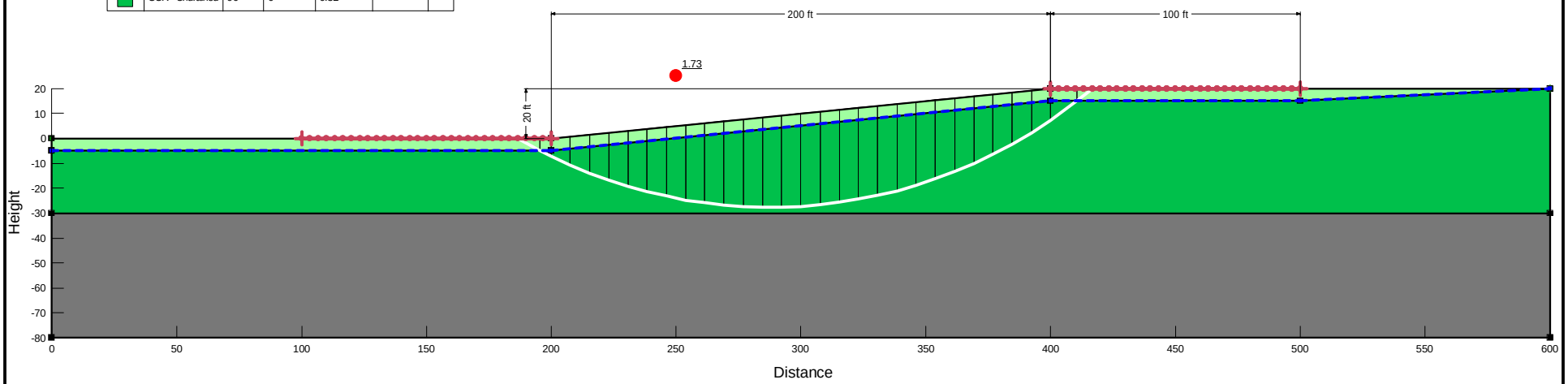

Figure 4. Calculated Factor of Safety - Passive Dewatering, Undrained Conditions

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Bedrock			
	CCR - Drained	90	0	26

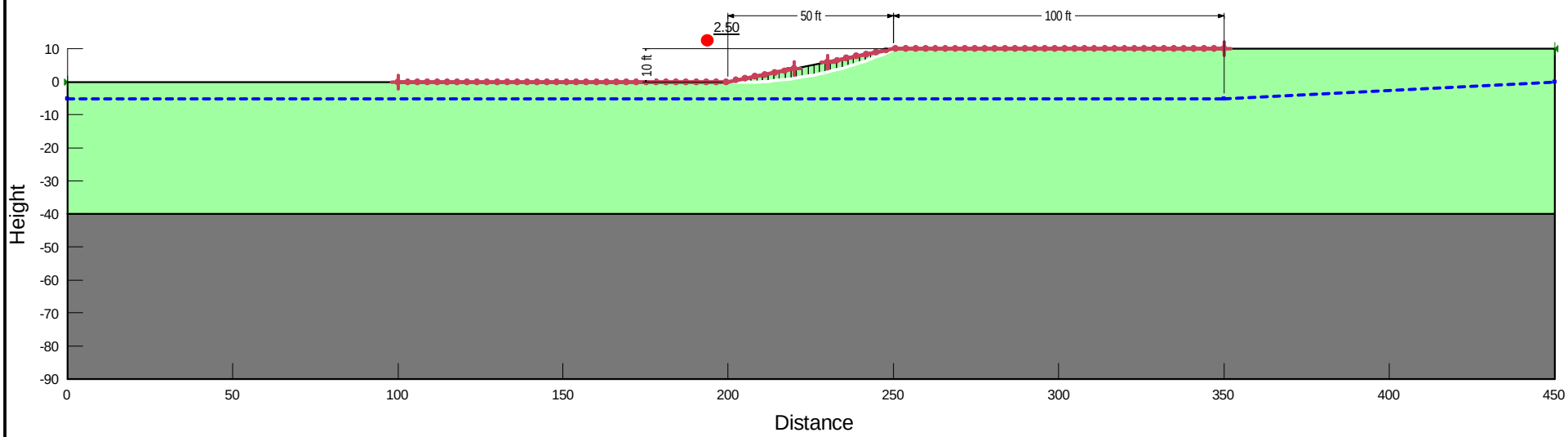

Figure 5. Calculated Factor of Safety - Active Dewatering, Drained Conditions

Color	Name	Unit Weight (pcf)	Minimum Strength (psf)	Tau/Sigma Ratio	Cohesion' (psf)	Phi' (°)
	Bedrock					
	CCR - Drained	90			0	26
	CCR - Undrained	90	0	0.32		

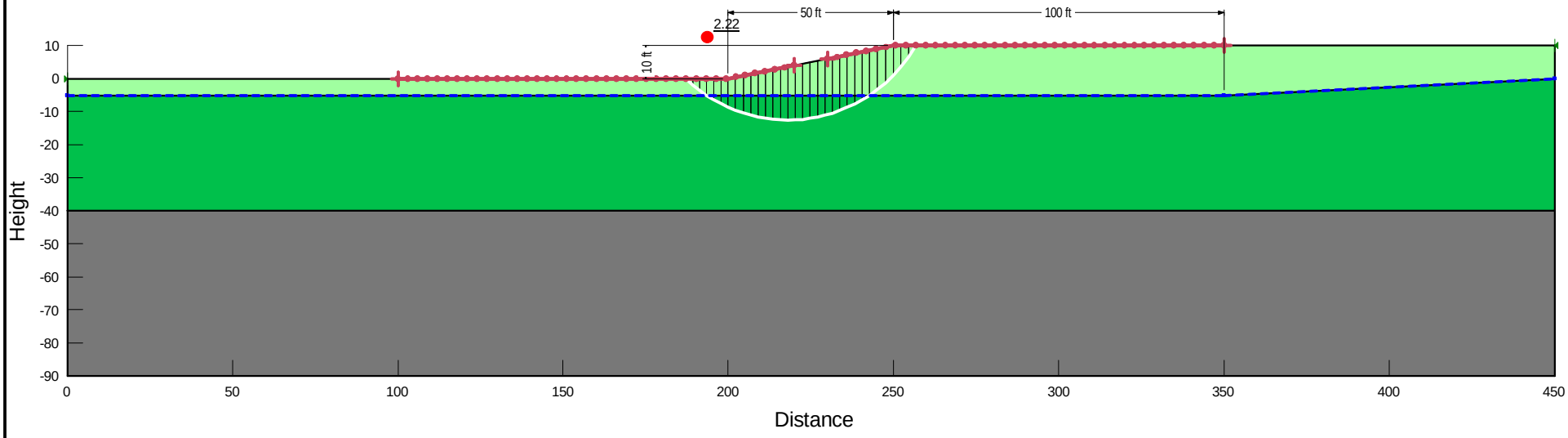

Figure 6. Calculated Factor of Safety - Active Dewatering, Undrained Conditions

ATTACHMENTS

Attachment A – Excerpts from Initial Static Safety Factor Assessment (AECOM, 2016)

COAL COMBUSTION PRODUCT DISPOSAL PROGRAM

TVA GALLATIN FOSSIL PLANT – SUMNER COUNTY, TENNESSEE

ASH POND A AND E DIKES GEOTECHNICAL SITE EVALUATION REPORT (REV. 0)

Prepared for

Tennessee Valley Authority
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February 21, 2014

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LIST OF ACRONYMS

ASTM	American Society for Testing and Materials
ATV	All-Terrain Vehicle
bpf	Blows per foot
CU	Consolidated Undrained Triaxial Test
CCP	Coal Combustion Products
CPT	Cone Penetration Test
DS	Direct Shear
DMT	Marchetti Dilatometer Test
°	Degrees
FS	Factor of Safety
ft bgs	Feet below ground surface
GAF	Gallatin Fossil Plant
LL	Liquid Limit
N-value	Standard Penetration Resistance
NAD27	North American Datum of 1927
NGVD 29	National Geodetic Vertical Datum of 1929
PI	Plasticity Index
PL	Plastic Limit
pcf	Pounds per cubic foot
psf	Pounds per square foot
RQD	Rock Quality Designation
SPT	Standard Penetration Test
TSF	Tons per square foot
TVA	Tennessee Valley Authority
USCS	Unified Soil Classification System
WCF	Widows Creek Fossil Plant

SUMMARY

URS completed a subsurface investigation and static slope stability evaluation to develop recommendations for remediating maintenance-type, sloughing slope stability at the divider and perimeter dikes at Ash Ponds A and E at the Gallatin Fossil Plant (GAF) in Gallatin, Tennessee. Information gathered through the subsurface investigation, completed in April and May of 2012, was used to supplement data collected by Stantec and Mactec in 2010 and 2004, respectively. Previous analyses by Stantec found that the perimeter and divider dikes of Ponds A and E exhibited deficient factors of safety (FS) against maintenance-type sloughing/slope stability.

Geotechnical investigation activities included a review of site documents and previous site investigations, geotechnical drilling through overburden material, in-situ testing consisting of static cone penetration tests (CPT) and Marchetti dilatometer tests (DMT), laboratory testing of representative soil samples, piezometer installation, and groundwater data measurements. Field activities were performed between April 24 and May 3, and May 14, 15, and 17, 2012. A total of fourteen (14) exploratory borings, nineteen (19) CPT soundings, and thirteen (13) DMT soundings were performed along the top and toe of slope of the perimeter and divider dikes of GAF Ponds A and E. The 14 borings were completed as stand-pipe piezometers upon completion of drilling activities.

A laboratory testing program was performed on representative samples obtained during drilling activities. Thirty-one (31) split spoon jar soil samples and eight (8) Shelby tube soil samples were sent to Tri-State Testing Services, in Memphis, Tennessee, and Geotechnics, Inc., in Raleigh, North Carolina for testing. The laboratory testing program included 79 index tests, 1 consolidated undrained triaxial, 1 direct shear, and 3 permeability tests performed on select soil samples.

Based on the field-collected data, the subsurface stratigraphy at Ash Ponds A and E is generally divided into three areas. Subsurface soils along the Ash Pond A divider dike generally consist of bottom ash dikes underlain by hydraulically sluiced fly ash and residual clay. The northern portion of Ash Pond E dikes generally consist of interbedded bottom ash fill and clay fill underlain by sluiced ash and residual clay deposits. Within the southern portion of Ash Pond E the subsurface profile generally consist of a clay dike underlain by bottom ash fill and sluiced fly ash. Residual clay was encountered beneath the ash materials in this portion of the site. Overburden soils at both Ash Ponds A and E were underlain by limestone bedrock.

Thirteen (13) slope stability cross-sections were analyzed using GeoStudio 2007 SLOPE/W and SEEP/W and the resulting static factors of safety were compared to the target value of 1.5. Seismic analyses were not included in the scope of work for this project. Stability results of existing conditions indicate that the divider and perimeter dikes at Ash Ponds A and E meet requirements for global stability at the majority of cross-sections, confirming the results of previous analyses. The only exception being cross-section K which has a global factor of safety of 1.4. The results also indicate that sections of the divider dike between Ash Pond A and the Stilling Ponds are deficient for maintenance stability and require remediation to improve factors of safety to 1.5. The Pond E dikes were found to have adequate factors of safety for maintenance stability and no remediation is recommended.

URS considered three alternatives for improving maintenance and global stability factors of safety for the divider dike between Ash Pond A and the Stilling Ponds. These alternatives included lowering operating levels in Pond A and flattening the downstream slopes of the dike to 2H:1V or 2.5H:1V. These options would maintain a minimum 25 to 30-ft wide dike crest to preserve desired traffic flow on the Pond A divider dike. In locations where slope cutting cannot maintain the above dike crest widths, fill material will be placed along the existing downstream slope to create the required grade. In addition, URS also considered two options for surfacing the flattened slopes with a vegetative cover and rip rap.

Based upon the results of our analysis, URS recommends that the entire length of the Pond A divider dike be remediated by flattening and vegetating the downstream slope to 2.5H:1V. The limits of this improvement should extend from the northeast point of Ash Pond E where the Pond E divider dike intersects the Pond A divider dike, up to the northeastern point of Ash Pond A, along the divider dike. A 10 foot wide Rip Rap bench is also to be constructed at the toe of the slope to allow for safe access and construction at the toe of the slope in the existing Stilling Pond. The bench would also provide long-term safe access to the toe of the dike during future maintenance and inspection. The proposed remediation will meet all project objectives discussed in the report including providing acceptable factors of safety, allowing for current pond operating levels, meeting the Programmatic Document, reducing future maintenance and facilitating future closure.

As a measure for finalizing the geotechnical analysis, URS has evaluated the stability of the dikes under interim construction conditions for the preferred remediation alternative. The results of this analysis indicate that acceptable factors of safety for short-term construction loading are maintained when construction equipment operates no closer than 2 feet from the edge of the dike crest.

1.0 INTRODUCTION

URS was retained by TVA to perform subsurface investigation and static slope stability analysis of perimeter and divider dike slopes at Ash Ponds A and E of the Gallatin Fossil Plant (GAF). Services were provided in accordance with URS' proposal titled *Proposal for Supplemental Exploration, Instrumentation and Work Plan* dated September 22, 2011 and accepted by TVA with issuance of TVA Purchase Order 386800-1 on March 31, 2012.

This *Geotechnical Site Evaluation Report* presents the results of our evaluation and provides discussion of alternatives for improving the maintenance slope stability and maintaining the global slope stability at the Ash Pond Complex while meeting TVA programmatic and GAF operation objectives.

1.1 SITE LOCATION AND FACILITY DESCRIPTION

The GAF facility is located at 1499 Steam Plant Road in Sumner County, Tennessee on the north bank of the Cumberland River, approximately four miles southeast of the center of the City of Gallatin. The plant occupies the Odom's Bend peninsula, which is surrounded to the east, west, and south by the Cumberland River. Plant facilities are located on the south portion of the peninsula. The Ash Pond Complex comprises approximately 476 acres and is situated north of the fossil plant facilities.

1.2 OPERATIONAL HISTORY

The GAF plant has been in operation since 1959, and currently consists of four coal-fired electric generating units with a net capability of 976 megawatts. Four combustion turbine generating units were installed in the early 1970's, and another four in 2000, to add additional electricity generation capacity during peak demand. In a typical year, GAF consumes approximately four million tons of coal which yield approximately 235,000 tons of fly and bottom ash coal combustion products (CCPs) annually but has varied historically based on consumer demand.

The main ash ponds were commissioned in 1970. These ponds discharge to a series of stilling ponds which clarify ash-transport water prior to being discharged into the Cumberland River through NPDES Outfall 001.

1.3 ASH POND COMPLEX FEATURES

The Ash Pond/Stilling Pond Complex at GAF is comprised of Ash Pond A, Ash Pond E, and a series of stilling ponds, Ponds B, C, and D. Each of the ponds is surrounded by perimeter containment dikes. Divider dikes separate Pond A from Pond E and these two ash ponds from the Stilling Ponds. Ash Pond A encompasses 248 acres, Ash Pond E 167 acres, and a series of stilling ponds, Ponds B, C, and D, comprise 61 acres. Ash Pond A is situated northeast of Ash Pond E, with Stilling Ponds B, C, and D located to the north of both Ash Ponds A and E, as shown on **Drawing 10W277-02** in **Attachment E**.

1.3.1 ASH POND A

Ash Pond A is located in the northeast corner of the GAF complex. Divider dikes, constructed of bottom ash, separate Ash Pond A from the Stilling Pond Complex to the north and Ash Pond E to the west. Originally developed for bottom ash management, Ash Pond A currently receives all sluiced ash generated at the GAF plant. The fly ash sluicing stream, formerly directed to Ash Pond E, was recently rerouted to Ash Pond A to improve overall water quality delivered to the Stilling Pond Complex.

1.3.2 ASH POND E

Ash Pond E, formerly identified as Fly Ash Pond E, is located in the northwest corner of the GAF. Until recently, this pond received sluiced fly ash from the GAF Plant. Fly Ash and bottom ash sluicing streams have since been consolidated into Ash Pond A. Ash Pond E receives storm water runoff from the coal pile runoff ditch and the coal unloading facility and non-ash process flow from the GAF Plant.

1.3.3 STILLING POND COMPLEX

The Stilling Pond Complex is located on the north side of Ash Pond A and Ash Pond E. The Stilling Pond Complex consists of three separate stilling ponds, designated as Stilling Ponds B, C, and D, which are connected by narrow channels. Stilling Pond B receives the ash-sluicing stream from Ash Pond A and Stilling Pond C receives wastewater streams from Ash Pond E. After passing through the series of stilling ponds, effluent is discharged at NPDES Outfall 001 from Stilling Pond D into the Cumberland River.

1.4 PROJECT BACKGROUND

In 2010, Stantec completed an extensive geotechnical exploration and slope stability evaluation of the Ash Pond/Stilling Pond Complex at GAF and issued both Draft and Final Geotechnical Reports. The purpose of their work was to explore existing site conditions along the ash pond dikes and evaluate current stability characteristics. Stantec concluded from their 2010 exploration that the pond dikes provided acceptable factors of safety (1.5 or greater) for global stability, but exhibited deficient factors of safety (FS) against maintenance-type sloughing/slope stability in some areas. These areas were along the divider dike between Pond A and Stilling Ponds B and C, and along the toe of the Pond E north dike adjacent to Stilling Pond D. The results of Stantec's slope stability analysis are presented in **Table 1-1** below, and the associated cross section locations in **Drawing 10W277-02** of **Attachment E**:

Table 1-1: Slope Stability Results (Stantec, 2010)

Section	Global FS	Maintenance FS
B	1.5	>1.5
C	1.6	>1.5
F	2.0	1.1
G	2.2	1.5
H	1.5	1.4
J	1.5	1.2
K	1.5	1.2

The dike slopes around the Ash Pond Complex, principally at Pond A, are moderately steep, with slopes ranging from 2.5H:1V to 1.5H:1V. As such, TVA's RHO&M group has expended significant efforts in maintaining the slopes following storm/wet weather events. The RHO&M group has requested permission to flatten the slopes along the Pond A divider dike. However, Stantec's prior analysis and parameters result in lower global factors of safety (less than 1.5) when removing soil from the slopes.

A review of Stantec's Draft Geotechnical Report for the facility was conducted by URS and a Technical Memorandum was issued on May 5, 2010, which identified areas in the report that warranted additional clarification. As a result, Stantec revised the report and issued a final report on May 27, 2012. URS has supplemented that report with the exploration and evaluation presented herein.

In April and May of 2012, URS executed a geotechnical investigation consisting of soil borings, cone penetration testing, and Marchetti dilatometer testing, along the top and toe of slope of the perimeter and divider dikes of Ponds A and E. Borings were converted into stand-pipe piezometers upon completion of drilling activities and have been incorporated into the monthly instrumentation monitoring program. Water level readings in the newly installed piezometers at Ash Ponds A and E have been recorded since July 2012 and subsequently used in the slope stability analyses. Boring locations and instrumentation of the dikes are depicted in **Drawings 10W277-02** and **-03** in **Attachment E**, respectively.

1.5 Objective and Purpose

The objective of this project was to develop remediation alternatives for increasing the maintenance slope stability factors of safety at the divider and perimeter dikes at Ash Ponds A and E. Additional project objectives are presented below:

- Maintain Minimum Stability FS of 1.5 for Global and Maintenance Surfaces.

- Meet Programmatic Document Requirements.
- Reduce Potential for Erosion and Maintenance (Short-Term).
- Facilitate Future Closure (Long-Term).

Several alternatives were considered to accomplish the above objectives, some of which included flattening the dike slopes and lowering the ash pond pool elevations. The following sections discuss the subsurface exploration and slope stability evaluation and presents alternatives for improving the maintenance slope stability.

2.0 FIELD EXPLORATION ACTIVITIES

The geotechnical field exploration program was undertaken during April and May 2012, with the objective of completing in-situ testing to determine the mechanical characteristics (strength and stiffness) of the soil and the subsurface stratigraphy; and recover samples for inspection and laboratory testing.

2.1 SUBSURFACE EXPLORATION

Subsurface conditions were evaluated by advancing fourteen (14) exploratory borings, and in-situ testing activities that included nineteen (19) static cone penetration test soundings (CPT), and thirteen (13) flat plate Marchetti dilatometer test soundings (DMT) along the top and toe of slope of the perimeter and divider dikes of GAF Ponds A and E, as shown on **Drawing 10W277-02 in Attachment E**. Exploration activities were conducted between April 24 and May 3, and May 14, 15, and 17, 2012. Boring and in-situ testing locations were selected to verify and supplement information presented in Stantec's 2010 Report. Borings were converted into stand-pipe piezometers upon completion of drilling activities.

2.1.1 SUBSURFACE BORINGS

The soil borings performed for the field exploration were drilled on April 24 thru May 3, and May 14, 15, and 17, 2012 by URS's subcontractor Tri-State Testing Services (Tri-State). A CME 550, track-mounted drill rig was used to drill fourteen (14) borings in conjunction with 4-1/4 inch, inner diameter, continuous flight, hollow-stem augers. A URS geotechnical engineer was on-site during all drilling operations, to monitor and direct the drilling subcontractor, and to visually classify and log soil and rock formations encountered during the investigation. Due to difficult access, advancement of boring URS-12B required the use of a 7822 DT Geoprobe. The Geoprobe was operated by Tri-State Drilling on May 14 and 15, 2012. Boring locations were located and staked in the field by URS prior to the commencement of field activities.

Soil and rock samples were collected from the borings for visual classification and testing. Samples were obtained by Standard Penetration Testing (SPT) with a split-spoon sampler in general accordance with ASTM D 1586. In addition, samples of fine-grained soils were obtained by undisturbed sampling techniques using Shelby Tubes, in general accordance with ASTM D 1587, or hydraulically operated stationary piston samplers, in general

accordance with ASTM D 6519. Where applicable, a pocket penetrometer was used in the field to measure unconfined compressive strength of the cohesive soils. A complete set of boring logs, including soil and rock descriptions, types of sampling, monitoring well installation, and laboratory test results, is provided in **Attachment A**.

Table 2-1: Boring Summary

Boring/ Piezometer No.	Pond Location/ Cross-Section	Northing (ft)	Easting (ft)	Ground Surface Elevation (NGVD 29)	Boring Terminati on Depth (ft)
URS-1b	Pond A/ L-L'	709170.02	1882484.43	459.8	19.2
URS-2b	Pond A/ J-J'	708353.18	1881435.67	473.8	22.6
URS-K-2b	Pond A/ K-K'	708952.57	1881959.80	474.7	52.9
URS-3a	Pond A/ Q-Q'	708061.04	1881150.40	474.7	23.5
URS-4b	Pond A/ I-I'	707518.78	1880739.20	474.3	25.0
URS-5b	Pond A/ H-H'	706980.73	1879812.24	472.6	48.1
URS-6b	Pond E/ G-G'	706876.29	1878741.41	464.3	20.9
URS-8b	Pond E/ F-F'	707141.99	1877803.25	475.7	40.0
URS-9b	Pond E/ P-P'	706879.05	1877572.38	475.8	31.5
URS-9c	Pond E/ P-P'	706906.86	1877543.69	463.2	25.1
URS-10b	Pond E/ C-C'	703827.37	1877881.93	456.0	43.0
URS-11a	Pond E/ O-O'	702757.09	1878642.83	477.8	52.1
URS-11b	Pond E/ O-O'	702709.90	1878657.40	459.5	33.4
URS-12b	Pond E/ A-A'	702956.94	1879038.85	461.3	32.1

2.1.2 CPT AND DMT SOUNDINGS

CPT and DMT soundings were advanced on April 24 thru May 3, 2012 by URS's subcontractor ConeTec, Inc. Nineteen (19) static CPT soundings were performed in accordance with ASTM D3441, and thirteen (13) DMT soundings were completed in accordance with ASTM D6635, as part of URS' subsurface investigation. Concurrently, four (4) CPT soundings (GAF-B-1A, GAF-B-1B, GAF-K-1A, and GAF-K-1B) were conducted on April 24, 2012, by ConeTec as part of GeoComp's seismic site study. The in-situ tests were performed with a track-mounted rig equipped with a hydraulic push ram.

The DMT device consists of a high strength flat 15 mm-thick stainless steel blade instrumented with a circular flexible membrane along one side. The blade was affixed to a series of steel rods and hydraulically pushed into the ground and readings recorded at approximately 1-foot depth intervals. DMT soundings ranged in depth from 6.0 to 67.0 ft bgs. The DMT soundings were principally performed both to provide in-situ measurements of soil strength (shear strength and stiffness), as well as provide indications of the state of stress of the in-situ soils. Results of the DMT soundings are presented in **Attachment C**.

CPT soundings were conducted by hydraulically pushing steel rods equipped with a 15 cm^2 cone equipped with a friction mantle and pore pressure transducer into the subsurface at a rate of approximately 2 cm/second. CPT soundings ranged in depth from 19.0 to 56.9 ft bgs. Continuous measurements of tip and side resistance and pore pressure were recorded during advancement. Additionally, measures of in-situ pore pressure dissipation (PPD) were taken at select depths/subsurface layers in some of the CPT soundings. The CPT has a well-documented record of effectiveness in evaluating subsurface stratigraphy (comparing CPT signatures of cone tip resistance, q_c, sleeve friction, f_s, and dynamic pore pressure, u, from sounding to sounding). The soundings also provide an indication of the strength of the soils, correlating tip resistance with laboratory measured strength. CPT sounding results are presented in **Attachment B.**

Cuttings were not generated during the CPT and DMT soundings. As such, test holes were grouted up to the ground surface upon completion of testing. CPT and DMT tests were conducted to the depths presented in **Table 2-2,** below.

Table 2-2: CPT/ DMT Soundings Summary

CPT/DMT Number	Pond Location/ Cross-Section	CPT Test	CPT Termination Depth (ft)	DMT Test	DMT Termination Depth (ft)
URS-1a	Pond A/ L-L'	X	32.8	X	32.0
URS-1c	Pond A/ L-L'	-	-	X	16.0
GAF-K-1A	Pond A/ K-K'	X	12.0	-	-
GAF-K-1B	Pond A/ K-K'	X	26.9	-	-
URS-2a	Pond A/ J-J'	X	29.4	X	22.0
URS-3b	Pond A/ Q-Q'	X	20.2	-	-
URS-4a	Pond A/ I-I'	X	24.4	-	-
URS-5a	Pond A/ H-H'	X	47.6	X	43.0
URS-6a	Pond E/ G-G'	X	19.0	-	-
URS-6c	Pond E/ G-G'	X	50.4	X	28.0
URS-7	Pond E	X	29.7	-	-
URS-7a	Pond E	X	30.7	-	-
URS-8a	Pond E/ F-F'	X	35.6	X	35.5
URS-8c	Pond E/ F-F'	X	37.6	X	35.2
URS-9a	Pond E/ P-P'	X	25.6	X	9.0
URS-9d	Pond E/ P-P'	X	25.0	-	-
URS-9e	Pond E/ P-P'	-	-	X	20.0
URS-10a	Pond E/ C-C'	X	56.9	-	-
URS-10c	Pond E/ C-C'	X	45.8	X	67.0
GAF-B-1A	Pond E/ B-B'	X	52.5	-	-
GAF-B-1B	Pond E/ B-B'	X	33.1	X	34.0
URS-11c	Pond E/ O-O'	X	52.3	-	-
URS-11d	Pond E/ O-O'	X	37.4	X	33.5
URS-12a	Pond E/ A-A'	X	44.5	-	-
URS-12c	Pond E/ A-A'	X	23.5	X	6.0

2.2 Laboratory Testing

Laboratory testing was performed on representative samples of the soils at Ash Ponds A & E. Soil samples selected for laboratory testing were sent to Tri-State Testing Services, in Memphis, Tennessee, and Geotechnics, Inc., in Raleigh, North Carolina. Soil samples obtained from SPT sampling during drilling were placed in jars, sealed at the site, and selected on-site for laboratory testing. The undisturbed Shelby tube samples were sealed in wax, covered with water-tight tape, and transported for testing. A total of thirty-one (31) jar samples and eight (8) Shelby tube samples were sent for testing. Material samples were evaluated using the types and numbers of laboratory tests presented in **Table 2-3**, below:

Table 2-3: Laboratory Test Program Summary

Test	Method	Number of Tests
Natural Moisture Content	ASTM D 2216	41
Atterberg Limits	ASTM D 4318	18
Grain Size - Sieve	ASTM D 422	20
Permeability (Undisturbed)	ASTM D 5084	3
Consolidated Undrained Triaxial (Undisturbed)	ASTM D 2850	1
Direct Shear (Undisturbed)	ASTM D 3080	1

Results of laboratory tests are presented in **Attachment D** and incorporated onto the boring logs.

3.0 Field Exploration Findings

3.1 Geologic Setting

The Gallatin Fossil Plant is located within the Nashville Dome. Bedrock of the Nashville Dome nearest the surface generally consists of Ordovician limestones, dolomites, and shales, while the surrounding highland Rim region generally consists of less-weathered Silurian, Devonian, and Mississippian limestones, cherts, shales, and sandstones. Soil deposits in this region generally consist of alluvial clay, silt, and sand, and residual clay. Bedrock stratigraphy beneath the site soils from youngest to oldest, consists of the Bigby-Cannon Limestone, Hermitage Formation, Carters Limestone, and Lebanon Limestone.

These strata are separated by erosional unconformities. The most recognizable geologic contacts occurring in this sequence are the Hermitage/Carters contact and the Upper/Lower Carters contact.

The most prominent surface drainage feature in the region is the westward-flowing Cumberland River, which has cut an open valley profile and deposited a floodplain averaging approximately 3,000 feet in width. The Cumberland River is characterized by its pronounced meanders. The regions bordering the river are maturely dissected by a complex system of tributaries.

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. Both the Stones River Group and the Nashville Group are included in this stratigraphic interval. 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. 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.

Karst features have been identified at various locations across the GAF site. Karst is a type of topography caused by dissolution of rock and is characterized by sinkholes, closed depressions, bedrock pinnacles and cutters, caves and sinking streams, and underground drainage, which are formed by dissolving of carbonate rock, primarily limestone or dolomite (US EPA, 2002). The presence of karst features has not been investigated as part of this study at the Ash Pond Complex. Investigations of karst potential at the Ash Ponds are anticipated as part of future pond closure activities.

3.2 SUBSURFACE CONDITIONS

The results of the field exploration, laboratory testing program, and review of historical geotechnical studies were used to refine existing cross-sections and develop new cross-sections at Ash Ponds A and E. The work by URS disclosed subsurface conditions consistent with those reported by Stantec in 2010. In general, the subsurface conditions at Ash Pond A consist of initial and raised bottom ash dikes underlain by hydraulically sluiced fly ash and residual clay. Soil deposits at Ash Pond A are underlain by limestone bedrock. The soil deposits encountered at Ash Pond E generally consist of a clay dike underlain by sluiced fly ash and bottom ash. The ash materials at Ash Pond E were underlain by residual clay and limestone bedrock at each boring location. Soil deposits encountered during the field exploration are described below and are depicted on the cross-sections presented in **Attachment E**.

3.2.1 BOTTOM ASH DEPOSITS

Bottom ash fill material is encountered within a majority of the dikes at the Ash Pond Complex. The bottom ash is classified as USCS silty sand (SM) and sand with silt (SP-SM, and SW-SM). Bottom ash encountered within the soil borings was described as moist, black and dark brown, with varying amounts of gravel and silt. The initial and raised dikes at Ash Pond A were constructed entirely of the bottom ash material. At Ash Pond E, deposits of bottom ash fill were encountered interbedded within the clay dike, and underlying the dike.

At Ash Pond A the relative density of bottom ash deposits was loose to very dense, based upon SPT N-values, CPT, and DMT results. Moreover, zones of very dense, cemented

material were encountered near cross-sections Q-Q' and I-I'. Bottom ash deposits encountered within dikes at Ash Pond E exhibited loose to very dense relative densities, based upon SPT N-values and in-situ test results. Natural moisture contents in the bottom ash ranged from 7.2% to 45.7%, with an average of 21.1%.

3.2.2 Sluiced Fly Ash Deposits

Hydraulically placed fly ash deposits classified as wet, gray and black silty sand (SM), clayey sand (SC), and sandy silt (ML), were encountered at each exploration location. Varying amounts of gravel were noted in the representative samples. The thickness of the sluiced fly ash deposits ranged from 4 to 18 ft, with an average thickness of 7.7 ft.

SPT N-values and in-situ test results indicate that the sluiced ash materials have a very loose to medium dense consistency. Natural moisture content results in this deposit ranged from 12.6% to 91.5%, with an average of 34%.

3.2.3 Clay Dike Deposits

The clay dike at Ash Pond E is constructed primarily out of red-brown, moist, sandy lean clay (CL) and sandy silt (ML). Trace amounts of sand and gravel were encountered in the clay samples. Localized deposits of bottom ash were encountered near the crest of the dike and beneath the dike material at some locations. In general, the clay dike at Ash Pond E is underlain by sluiced fly ash.

The clay dike material exhibited consistencies of stiff to very stiff, based upon SPT N-values, pocket penetrometer, and in-situ test results. Results of moisture content tests conducted on samples of the dike material ranged from 8.9% to 22%, with an average moisture content of 15.2%.

3.2.4 Residual Clay Deposits

Beneath the dike and ash materials was encountered a deposit of moist, yellow to red-brown residual clay material having USCS classification of lean clay (CL) and fat clay (CH). Trace amounts of gravel and sand materials were noted in the representative samples. The residual clay deposit is present across the site, with the exception of areas near cross-section Q-Q'. The thickness of this deposit varies across the site, ranging from less than 5 ft to 41 ft.

SPT-N values, pocket penetrometer, and in-situ test results indicate a medium stiff to stiff consistency, with few occurrences of soft to very stiff zones. Natural moisture content results in this deposit ranged from 18.5% to 37.5%, with an average of 24.9%. Results of Atterberg limits testing included liquid limits from 29 to 72, plastic limits from 17 to 35, and plasticity indices from 10 to 57.

3.2.5 LIMESTONE BEDROCK

The residual and dike soils are underlain by limestone bedrock. The depth to top of bedrock varies across the site, as indicated by auger refusal and CPT and DMT sounding refusal. At Ash Pond A the top of bedrock elevations ranged from approximately El. 421.5 to El. 451.2, according to refusal. Top of apparent bedrock elevations at Ash Pond E ranged from approximately El. 408 to El. 444, based upon boring refusal. Based upon the information gathered in the subsurface exploration, the top of rock appears to vary along the alignment of the dike, and across the width of the dikes.

Rock was not cored as part of the URS subsurface exploration, however, according to information gathered by Stantec in 2010; bedrock generally consists of gray, thin bedded, weathered limestone.

3.3 GROUNDWATER CONDITIONS

Groundwater levels were observed and measured during and immediately after drilling. Each boring was subsequently converted into a stand-pipe piezometer. At Ash Pond A groundwater was encountered at depths ranging from 7.7 to 17.5 ft bgs. The groundwater elevation along the lower dike road at Ash Pond E was encountered at depths ranging from 3.5 to 12.0 ft bgs. Groundwater depths along the upper dike road ranged from 20.2 to 22.6 ft bgs. Table 3-1 tabulates the groundwater levels measured by URS during the soil borings.

Table 3-1: Groundwater Levels Measured by URS At the Time of Drilling

Boring No.	Pond Location/ Cross-Section	Date	Depth (ft)	Elevation (NGVD 29)
URS-1b	Pond A/ L-L'	4/29/12	2.2	457.6
URS-2b	Pond A/ J-J'	5/17/12	10.2	463.6
URS-K-2b	Pond A/ K-K'	4/30/12	7.7	467.0
URS-3a	Pond A/ Q-Q'	5/1/12	17.5	457.2
URS-4b	Pond A/ I-I'	5/1 – 5/2/12	17.5	456.8
URS-5b	Pond A/ H-H'	4/27 – 4/28/12	10.5	462.1
URS-6b	Pond E/ G-G'	4/24/12	8.0	456.3
URS-8b	Pond E/ F-F'	4/25/12	22.6	453.1
URS-9b	Pond E/ P-P'	4/25/12	20.2	455.6
URS-9c	Pond E/ P-P'	4/24/12	7.5	455.7
URS-10b	Pond E/ C-C'	4/26 – 4/27/12	12.0	444.0
URS-11a	Pond E/ O-O'	5/2/12	22.2	455.6
URS-11b	Pond E/ O-O'	5/3/12	3.4	456.1
URS-12b	Pond E/ A-A'	5/14 – 5/15/12	3.8	457.5

A total of 6 piezometers (URS-1b, URS-2b, URS-3a, URS-4b, URS-5b, URS-K-2b) and 6 vibrating wire piezometers (GAF-K-2a(3), GAF-K-2b(3)) were installed at Ash Pond A, and a total of 8 piezometers (URS-6b, URS-8b, URS-9b, URS-9c, URS-10b, URS-11a, URS-11b, URS-12b) and 6 vibrating wire piezometers (GAF-B-2a(3), GAF-B-2b(3)) were installed at Ash Pond E in April and May, 2012 by URS and GeoComp Corporation. The vibrating wire piezometers were installed by GeoComp as part of a separate seismic study and data from these piezometers is included for reference purposes. The piezometers were constructed of 2-inch inside diameter (ID) polyvinyl chloride (PVC) flush threaded casing with either a 5-foot or 2-foot long screen that is 0.010-inch machine slotted. Prior to installation of the screen and casing at each location, the borehole was backfilled with bentonite pellets up to a minimum of 2-feet below the screen tip. Filter pack of 20/30 high silica sand and bentonite pellets was used as a seal. Piezometer completions consist of Sonotube concrete pads with four (4) yellow bollards and above-ground galvanized steel casing. Piezometer locations were surveyed by TVA Surveying upon completion of installation. A summary of the Piezometer installation information is presented in **Table 3-2**.

Table 3-2: Summary of Piezometer Installation

Boring/ Piezometer No.	Pond Location/ Cross-Section	Top of PVC Elevation (NGVD 29)	Piezometer Screen Interval (ft bgs)	Piezometer Tip Elevation (NGVD 29)
URS-1b	Pond A/ L-L'	462.91	2.3 – 4.8	455.0
URS-2b	Pond A/ J-J'	477.19	8.4 – 13.4	460.4
URS-K-2b	Pond A/ K-K'	477.99	8.2 – 13.2	461.5
GAF-K-2a-25'	Pond A/ K-K'	476.15	10.7	464.0
GAF-K-2a-30'	Pond A/ K-K'	476.15	19.7	455.0
GAF-K-2a-35'	Pond A/ K-K'	476.15	21.7	453.0
GAF-K-2b-30'	Pond A/ K-K'	476.81	12.2	463.1
GAF-K-2b-35'	Pond A/ K-K'	476.81	22.2	453.1
GAF-K-2b-50'	Pond A/ K-K'	476.81	25.2	450.1
URS-3a	Pond A/ Q-Q'	478.20	13.5 – 18.5	456.2
URS-4b	Pond A/ I-I'	477.64	14.25 – 19.25	455.1
URS-5b	Pond A/ H-H'	476.08	13.5 – 18.5	454.1
URS-6b	Pond E/ G-G'	467.59	5.0 – 10.0	454.3
URS-8b	Pond E/ F-F'	479.01	20.3 – 25.3	450.4
URS-9b	Pond E/ P-P'	479.32	17.7 – 22.7	453.1
URS-9c	Pond E/ P-P'	466.53	4.0 – 9.0	454.2
URS-10b	Pond E/ C-C'	459.09	11.9 – 16.9	439.1
GAF-B-2a-25'	Pond E/ B-B'	476.90	21.7	454.8
GAF-B-2a-45'	Pond E/ B-B'	476.90	31.7	444.8
GAF-B-2a-55'	Pond E/ B-B'	476.90	41.7	434.8
GAF-B-2b-15'	Pond E/ B-B'	459.87	6.31	452.9
GAF-B-2b-25'	Pond E/ B-B'	459.87	17.32	441.9
GAF-B-2b-35'	Pond E/ B-B'	459.87	27.32	431.9
URS-11a	Pond E/ O-O'	481.42	20.0 – 25.0	452.8
URS-11b	Pond E/ O-O'	463.10	2.8 – 5.3	454.2
URS-12b	Pond E/ A-A'	464.41	5.2 – 10.2	451.1

Piezometers have been incorporated into the monthly instrumentation monitoring program. Water level readings in the newly installed piezometers at Ash Ponds A and E have been recorded since July 2012 and subsequently used in the slope stability analyses. Water levels recorded at the Ash Pond Complex between September 2009, and December 2013 are included in **Attachment F**. Boring locations and instrumentation of the dikes are depicted in **Drawings 10W277-02** and **-03** in **Attachment E**, respectively.

4.0 IN-SITU AND LABORATORY TESTING RESULTS

4.1 IN-SITU TESTING RESULTS

Results of CPT and DMT soundings may be correlated to estimate a number of shear strength and index properties of in-situ materials.

4.1.1 CPT

Shear Strength:
The undrained shear strength of clay deposits can be estimated from CPT data, relating cone tip resistance (q_c) to undrained shear strength (c_u) using the following equation.

$$c_u = (q_c - \sigma'_{vo}) / N_k$$

where,

q_c = cone tip resistance,
σ'_{vo} = the total overburden stress at the test depth, and
N_k = the plasticity dependent cone factor, increasing with decreasing plasticity.

Friction Angle:
CPT is used to estimate the peak friction angle (Φ'_P) of sandy deposits by relating the friction angle to the cone resistance. The relationship below estimates the friction angle of sand materials.

$$\Phi'_P = arctan[0.1 + 0.38 \cdot log(q_t / \sigma'_{vo})]$$

where,

σ'_{vo} = effective overburden stress,
q_t = cone tip resistance.

CPT sounding results estimate a number of other material properties for both sandy and clayey soils such as unit weight, SPT N-values, over-consolidation ratio (OCR), and constrained modulus (M), based upon empirical correlations. **Attachment B** presents the results of CPT soundings for the GAF Ash Pond Complex.

4.1.2 DMT

Shear Strength:
The Marchetti flat plate dilatometer can be used to estimate the undrained shear strength (c_u) of clayey soil by the following relationship.

$$c_u = 0.22\ \sigma'_{vo}(\ K_D/2)^{1.25}$$

where,

σ'_{vo} = effective overburden stress,
K_D = horizontal stress index, calculated as the corrected dilatometer reading, effective overburden stress

The DMT data is also correlated to provide properties in clayey soils such as OCR, coefficient of lateral earth pressure at rest (K_o), and unit weight. Results of DMT soundings are provided in **Attachment C**.

4.2 Laboratory Testing Results

Laboratory testing of samples gathered during soil boring activities was performed to determine soil index properties, and to estimate shear strength, and hydraulic conductivity parameters.

4.2.1 Index Testing

The results of index testing completed on samples of ash and clay materials collected during soil boring activities is presented in **Table 4-1** below. Complete index test results are provided in **Attachment D**.

Table 4-1: Results of Index Testing by URS

Boring No.	Pond Location/ Cross-Section	Sample No.	Depth (ft)	Geologic Description	Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Finer than #200 Sieve (%)
URS-1b	Pond A/ L-L'	SS-2	1.8-3.3	Initial Bottom Ash Dike	18.8	-	-	-	SM	37
URS-1b	Pond A/ L-L'	T-1	8.1-10.0	Initial Bottom Ash Dike	37.2	-	-	-	SM	47
URS-1b	Pond A/ L-L'	SS-8a	17.7-18.5	Residual Clay	19.5	29	16	13	CL	-
URS-2a	Pond A/ J-J'	T-1	23.9-25.9	Sluiced Ash	24.7	45	21	24	CL	-
URS-2b	Pond A/ J-J'	SS-3	4.5-5.6	Raised Bottom Ash Dike	19.5	-	-	-	SM	32
URS-2b	Pond A/ J-J'	SS-7	14.3-15.8	Initial Bottom Ash Dike	20.7	-	-	-	SM	33
URS-K-2b	Pond A/ K-K'	SS-4	7.3-8.8	Raised Bottom Ash Dike	26.5	-	-	-	SM	-
URS-K-2b	Pond A/ K-K'	SS-11	10.8-12.2	Sluiced Ash	23.4	37	17	20	SC	30
URS-3a	Pond A/ Q-Q'	SS-4	7.1-8.6	Raised Bottom Ash Dike	11.0	-	-	-	SM	45
URS-3a	Pond A/ Q-Q'	SS-8	17.1-18.6	Sluiced Ash	42.1	-	-	-	SM	35
URS-4b	Pond A/ I-I'	SS-3	4.1-5.6	Raised Bottom Ash Dike	7.2	-	-	-	SM	33
URS-4b	Pond A/ I-I'	SS-6	12.2-13.7	Raised Bottom Ash Dike	9.6	-	-	-	SM	36
URS-4b	Pond A/ I-I'	T-1	16.3-18.3	Sluiced Ash	12.6	-	-	-	SM	35
URS-5b	Pond A/ H-H'	SS-9	18.0-19.5	Sluiced Ash	91.5	-	-	-	SP-SM	18
URS-5b	Pond A/ H-H'	T-1	23.8-25.5	Sluiced Ash	22.8	-	-	-	SM	19.8
URS-5b	Pond A/ H-H'	SS-12	27.0-28.5	Sluiced Ash	39.1	-	-	-	ML	-
URS-5b	Pond A/ H-H'	SS-14	32.8-34.3	Residual Clay	31.1	55	23	32	CH	-
URS-5b	Pond A/ H-H'	SS-17	39.7-41.2	Residual Clay	25.3	72	35	37	MH	-
URS-6b	Pond E/ G-G'	SS-3	5.0-6.5	Bottom Ash Fill	17.7	-	-	-	SM	38
URS-6b	Pond E/ G-G'	SS-6	12.5-14.0	Residual Clay	25.9	54	23	31	CH	-
URS-8a	Pond E/ F-F'	T-2	23.8-25.8	Residual Clay	21.5	48	21	27	CL	-
URS-8b	Pond E/ F-F'	SS-4	7.7-9.2	Clay Dike Fill	22.0	48	34	14	ML	-
URS-8b	Pond E/ F-F'	SS-12	27.0-28.5	Bottom Ash Fill	21.5	-	-	-	SP-SM	30
URS-9c	Pond E/ P-P'	SS-5	10.0-11.5	Residual Clay	18.5	38	21	17	CL	-
URS-9c	Pond E/ P-P'	SS-8	16.9-18.4	Residual Clay	25.0	85	28	57	CH	-
URS-10b	Pond E/ C-C'	SS-7	14.0-15.5	Residual Clay	21.4	50	19	31	CH	-
URS-10b	Pond E/ C-C'	SS-9b	19.7-20.7	Residual Clay	26.9	-	-	-	SM	32
URS-10b	Pond E/ C-C'	SS-12	26.3-27.8	Residual Clay	28.0	67	25	42	CH	-
GAF-B-1a	Pond E/ B-B'	T-1	37.5-39.0	Residual Clay	21.1	35	17	18	CL	-
GAF-B-1b	Pond E/ B-B'	T-1	14.6-16.6	Sluiced Ash	28.0	-	-	-	ML	94
URS-11a	Pond E/ O-O'	SS-5	9.1-10.6	Clay Dike Fill	8.9	42	24	18	CL	-

Table 4-1 Continued

Boring No.	Pond Location/ Cross-Section	Sample No.	Depth (ft)	Geologic Description	Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Finer than #200 Sieve (%)
URS-11a	Pond E/ O-O'	SS-9	19.1-20.6	Sluiced Ash	18.4	-	-	-	SM	31
URS-11a	Pond E/ O-O'	SS-13a	30.2-31.5	Bottom Ash Fill	45.7	NP	NP	NP	-	93
URS-11a	Pond E/ O-O'	SS-13b	30.2-31.5	Residual Clay	26.3	29	19	10	CL	85
URS-11a	Pond E/ O-O'	T-1	33.4-35.7	Residual Clay	22.6	52	20	32	CH	-
URS-12b	Pond E/ A-A'	SS-2	2.3-3.8	Clay Dike Fill	14.7	31	20	11	CL	-
URS-12b	Pond E/ A-A'	SS-4	8.0-9.5	Bottom Ash Fill	17.3	-	-	-	SC	29
URS-12b	Pond E/ A-A'	SS-9	22.8-24.3	Residual Clay	21.8	56	23	33	CH	-
URS-12b	Pond E/ A-A'	SS-11	28.6-30.1	Residual Clay	37.5	-	-	-	MH	88

Index tests assigned by Stantec and Mactec in 2010 and 2004, respectively, were conducted primarily on samples of fine-grained materials gathered from deposits of the clay dike and residual clay. As such, few tests were conducted on samples of bottom ash or sluiced fly ash deposits. The testing performed by URS, and presented in Table 4-1, was intended to supplement these original test results and provide additional test data on the ash materials. **Table 4-2** presents results of index testing reported by Stantec in 2010.

Table 4-2: Results of Index Testing Reported by Stantec

Boring No.	Pond Location/ Cross-Section	Depth (ft)	Geologic Description	Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Finer than #200 Sieve (%)
MACTEC-B-3	Pond A/ H-H'	7.5-9.5	Ash	47.6	-	-	-	ML	91
MACTEC-B-8	-	22.0-23.5	Native Clay	26.1	51	20	31	CH	91
MACTEC-B-13	-	15.0-17.0	Ash	33.8	-	-	-	ML	99
MACTEC-B-13	-	25.0-27.0	Native Clay	32.5	78	30	48	CH	86
STN-A-2	Pond A/ H-H'	35.0-39.5	Native Clay	-	53	18	35	CH	80
STN-A-3	Pond A/ I-I'	9.0-13.5	Raised Bottom Ash	-	NP	NP	NP	SM	14
STN-A-6	Pond A/ J-J'	29.1-29.5	Native Clay	-	60	19	41	CH	86
STN-A-7	Pond A/ K-K'	30.0-34.5	Native Clay	-	43	16	27	CL	62
STN-A-10	Pond A/ L-L'	15.0-19.5	Sluiced Ash	-	NP	NP	NP	SM	35
STN-E-2	Pond E/ A-A'	4.5-9.0	Clay Dike Fill	-	33	16	17	CL	56
STN-E-3	Pond E/ A-A'	4.5-9.0	Sluiced Ash	-	NP	NP	NP	SM	28
STN-E-3	Pond E/ A-A'	25.5-30.0	Native Clay	-	54	18	36	CH	76
STN-E-4	Pond E/ B-B'	34.5-39.0	Sluiced Ash	-	NP	NP	NP	ML	92
STN-E-4S	Pond E/ B-B'	5.0-5.5	Clay Dike Fill	19.9	42	18	24	CL	56
STN-E-8	Pond E/ C-C'	31.5-33.0	Native Clay	31	25	13	12	CL	51
STN-E-8	Pond E/ C-C'	41.6-42.1	Native Clay	19.8	27	13	14	GC	30
STN-E-8	Pond E/ C-C'	50.2-50.7	Native Clay	29.1	47	22	25	CL	78
STN-E-9	Pond E/ C-C'	5.8-6.3	Native Clay	18.6	31	14	17	CL	69
STN-E-9	Pond E/ C-C'	34.0-38.5	Native Clay	-	34	15	19	CL	62
STN-E-10S	Pond E/ D-D'	5.3-5.8	Clay Dike Fill	18.1	38	16	33	CL	76
STN-E-10S	Pond E/ D-D'	25.0-26.7	Native Clay	-	-	-	-	CL	-
STN-E-11	Pond E/ D-D'	3.0-7.5	Clay Dike Fill	-	45	18	27	CL	61
STN-E-12	Pond E/ D-D'	10.3-10.8	Native Clay	22.7	46	20	26	CL	67
STN-E-13	Pond E/ E-E'	16.5-21.0	Native Clay	-	77	26	51	CH	91
STN-E-13S	Pond E/ E-E'	20.0-25.5	Native Clay	-	-	-	-	CH	-
STN-E-14S	Pond E/ E-E'	2.0-2.5	Clay Dike Fill	20	38	19	19	CL	77
STN-E-15	Pond E/ E-E'	11.5-16.0	Native Clay	-	65	20	45	CH	81
STN-E-16	Pond E/ F-F'	18.0-22.5	Bottom Ash Fill	-	NP	NP	NP	SM	35
STN-E-16S	Pond E/ F-F'	36.0-36.5	Native Clay	25.2	34	16	18	CL	97
STN-E-16S	Pond E/ F-F'	5.6-6.1	Clay Dike Fill	27.9	52	19	33	CH	76
STN-E-17	Pond E/ F-F'	4.5-9.0	Clay Dike Fill	-	47	19	28	CL	84
STN-E-18	Pond E/ F-F'	22.5-27.0	Native Clay	-	34	14	20	CL	86
STN-E-20	Pond E/ G-G'	4.5-9.0	Clay Dike Fill	-	54	18	36	CH	71
STN-E-20S	Pond E/ G-G'	4.0-7.1	Clay Dike Fill	-	-	-	-	CH	-
STN-E-21S	Pond E/ G-G'	11.6-12.1	Native Clay	26	41	17	24	CL	81

4.2.2 HYDRAULIC CONDUCTIVITY

Hydraulic conductivity tests were conducted in general accordance with ASTM D 5084, on undisturbed samples of ash material, in order to estimate the permeability of in place ash materials. Permeability test results were used in preliminary slope stability analyses to predict phreatic conditions within the dikes at Ash Pond A and Ash Pond E. **Table 4-3** presents the results of hydraulic conductivity tests performed on undisturbed samples from Ash Ponds A and E.

Table 4-3: Results of Permeability Testing on Ash Samples by URS

Boring No.	Pond Location/ Cross-Section	Sample No.	Depth (ft)	Geologic Description	USCS Classification	Permeability (cm/sec)
GAF-B-1b	Pond E/ B-B'	T-1	14.6-16.6	Sluiced Ash	ML	1.2×10^{-5}
URS-4b	Pond A/ I-I'	T-1	16.3-18.3	Sluiced Ash	SM	3.8×10^{-3}
URS-5b	Pond A/ H-H'	T-1	23.8-25.5	Sluiced Ash	SM	6.5×10^{-6}

Stantec presented results of permeability tests conducted on samples of lean clay (CL), fat clay (CH), and silt (ML) material in their 2010 Report. **Table 4-4** presents the results reported by Stantec in 2010.

Table 4-4: Results of Permeability Testing on Clay Samples Reported by Stantec

Boring No.	Pond Location/ Cross-Section	Depth (ft)	Geologic Description	USCS Classification	Permeability (cm/sec)
STN-A-6	Pond A/ J-J'	29.1-29.5	Native Clay	CH	9.07×10^{-8}
STN-E-8	Pond E/ C-C'	50.2-50.7	Native Clay	CL	1.38×10^{-8}
STN-E-9	Pond E/ C-C'	5.8-6.3	Native Clay	CL	4.70×10^{-8}
STN-E-10S	Pond E/ D-D'	5.3-5.8	Clay Dike Fill	CL	1.02×10^{-7}
STN-E-12	Pond E/ D-D'	10.3-10.8	Native Clay	CL	3.01×10^{-7}
STN-E-13S	Pond E/ E-E'	20.0-25.5	Native Clay	CH	2.33×10^{-8}
STN-E-15	Pond E/ E-E'	11.5-16.0	Native Clay	CH	1.36×10^{-8}
MACTEC-B-13	-	15.0-17.0	Ash	ML	2.78×10^{-5}

4.2.3 SHEAR STRENGTH

A direct shear and a consolidated-undrained triaxial test were performed on undisturbed samples of the sluiced fly ash to supplement the field data obtained and to estimate the soil strength. Direct shear and consolidated-undrained triaxial testing was conducted by Geotechnics and the results are presented in Table 4-5, below.

Table 4-5: Results of Shear Strength Testing on Sluiced Ash by URS

Boring Number	Shear Strength Test	Geologic Description	Shear Strength	
			Effective Cohesion, c' (psf)	Effective Internal Friction Angle, ϕ' (deg.)
URS-5b (23.8-25.5 ft bgs)	Direct Shear (DS)	Sluiced Ash	0	26.4
GAF-B-1b (14.6-16.6 ft bgs)	Consolidated Undrained Triaxial (CU)	Sluiced Ash	167	31.38

A summary of triaxial shear tests conducted by Stantec and Mactec are presented in **Table 4-6**. Shear strength test results reported by Stantec in 2010 are primarily for samples of lean and fat clay deposits from Ash Pond E.

Table 4-6: Results of Shear Strength Testing Reported by Stantec

Boring Number	Pond Location/ Cross-Section	Sample Depth (feet)	Geologic Description	USCS Classification	Triaxial Shear Testing			
					Φ (Degrees)	c (psf)	Φ' (Degrees)	c' (psf)
MACTEC-B-3	Pond A/ H-H'	7.5-9.5	Ash	ML	18.3	1770	24.4	1280
MACTEC-B-13	-	15.0-17.0	Ash	ML	38.5	2640	35.5	0
MACTEC-B-13	-	25.0-27.0	Native Clay	CH	11.3	370	14.2	210
MACTEC-B-8	-	22.0-23.5	Native Clay	CH	14.2	1520	22.9	1000
STN-E-4S	Pond E/ B-B'	5.0-5.5	Clay Dike Fill	CL	-	-	17.6	740
STN-E-8	Pond E/ C-C'	41.6-42.1	Native Clay	GC	-	-	26.6	360
STN-E-9	Pond E/ C-C'	5.8-6.3	Native Clay	CL	-	-	28.8	640.0
STN-E-10S	Pond E/ D-D'	25.0-26.7	Native Clay	CL	-	-	37.1	70
STN-E-13S	Pond E/ E-E'	20.0-25.5	Native Clay	CH	-	-	18.4	700
STN-E-15	Pond E/ E-E'	11.5-16.0	Native Clay	CH	-	-	26.3	380
STN-E-14S	Pond E/ E-E'	2.0-2.5	Clay Dike Fill	CL	-	-	21.5	480
STN-E-16S	Pond E/ F-F'	5.6-6.1	Clay Dike Fill	CH	-	-	22	340
STN-E-16S	Pond E/ F-F'	36.0-36.5	Native Clay	CL	-	-	34.3	160
STN-E-20S	Pond E/ G-G'	4.0-7.1	Clay Dike Fill	CH	-	-	25.5	460
STN-E-20	Pond E/ G-G'	4.5-9.0	Clay Dike Fill	CH	-	-	25.5	460
STN-E-21S	Pond E/ G-G'	11.6-12.1	Native Clay	CL	-	-	34.1	260
STN-D-1S		2.6-6.5	Clay Dike Fill	CH	-	-	23.3	940

5.0 SLOPE STABILITY ANALYSES

5.1 GENERAL

Static stability analyses at the Pond A and E dikes were performed using GeoStudio 2007 SLOPE/W and SEEP/W Version 7.17, Build 4921. Spencer's procedure for limit equilibrium analysis of sliding soil mass was utilized for the stability analysis. An "Entry and Exit" slip surface was defined for producing failure curves in order to evaluate both global and maintenance failures. By setting "Entry and Exit" boundary conditions to specific bounds the user is able to analyze various failure modes. The procedure was "optimized" in order to locate the lowest factor of safety (FS) computed in a given run. The factor of safety (FS) calculated by the Spencer procedure uses the following definition:

$$FS = \frac{\text{shear strength of the soil (resisting force)}}{\text{shear stress required for equilibrium (driving force)}}$$

Thirteen (13) slope stability models were developed in order to evaluate static dike stability for maintenance-type (a localized veneer or slough failure) and global slope stability safety factors under existing and alternative remediation systems. Seven models were initially inherited from Stantec Inc., developed as part of the Report of Geotechnical Exploration and Slope Stability Evaluation, issued in May, 2010. GeoStudio models for cross-sections B, C, F, G, H, J, and K, were inherited from Stantec and subsequently modified based upon geotechnical exploration results. The cross-section geometry, stratigraphy, material properties, and boundary conditions were updated to complete the stability analyses. Additionally, URS developed six (6) new models to assist in assessing the Ash Pond Complex site slope stability. The new models generated by URS are located at cross-sections A, I, L, O, P, and Q. The new models were developed using the site geometry, material properties, and boundary conditions determined from the field exploration, laboratory testing, and review of historical data. See **Drawing 10W277-02** in **Attachment E** for locations of each cross-section analyzed.

The existing Ash Pond Complex dikes have been in place for several years and are assumed to be in static equilibrium and under effective stress conditions. For this reason, static slope stability analyses were performed at each cross-section using effective strength parameters. In addition, a total strength analysis was completed using conservative total strength properties in order to verify that stability factors of safety are acceptable under total stress conditions. The results of these analyses indicate that under total stress conditions the dikes exhibit similar stability safety factors as computed for effective stress conditions.

Seismic related analyses and evaluations of the slopes were not performed as part of the work scope. We understand that these analyses are being performed under a separate project by other consultants. Based upon preliminary seismic information provided by TVA, we understand that the

Pond Complex dikes currently provide acceptable seismic factors of safety and that remediation for seismic purposes is not anticipated.

5.2 PHREATIC SURFACE

Based on design guidelines from USACE and the Master Programmatic Document, Version 1, preliminary seepage analyses were conducted using hydraulic parameters developed from results of CPT pore pressure dissipation and laboratory testing, and the predicted phreatic surface was evaluated. The predicted phreatic surface from SEEP/W was used for comparison with the monthly piezometer readings from the Instrumentation Program and indicates that the phreatic surface predicted in SEEP/W is lower than the piezometric surface developed from the monthly readings. As such, the most conservative approach for the slope stability analysis involved inputting the phreatic surface interpolated from the piezometer monthly readings as a piezometric line in SLOPE/W, rather than importing the phreatic surface and porewater pressures predicted by SEEP/W directly into SLOPE/W. This approach is consistent with that implemented to develop threshold values as part of the Instrumentation Program, and utilizes current and historical data obtained from each of the piezometers located across the site.

In the stability models, the upstream piezometric surface was set equal to the Ash Pond normal pool elevations and the downstream piezometric surface was set equal to the Stilling Pond normal pool elevations. Within the Ash Pond dikes, the water surface at piezometer locations was set equal to the historical high water level, as measured in the monthly piezometer readings. Where piezometer data was not available, the piezometer water level was interpolated based upon piezometer levels at adjacent cross-sections. **Table 5-1** presents piezometric levels used in the stability analysis, as well as those measured between October and December 2012, which were the most current readings at the time of the analyses. Additional piezometer water levels measured through December 2013 have been incorporated into **Attachment F**. URS reviewed the new piezometer level measurements and does not believe the previously completed stability analyses require revising or updating.

Table 5-1: Piezometric Levels Used in Stability Models

Piezometer No.	Pond Location/ Cross-Section	Oct 2012 W.L.	Nov 2012 W.L.	Dec 2012 W.L.	Value used in Analysis (ft)
STN-A-1	Pond A/ H-H'	457.16	456.99	456.98	**457.21**
URS-5b	Pond A/ H-H'	461.93	461.03	461.12	**462.06**
URS-4b	Pond A/ I-I'	456.99	456.85	456.84	**457.03**
STN-A-5	Pond A/ J-J'	458.79	458.51	458.47	**459.26**
URS-2b	Pond A/ J-J'	462.03	461.56	461.73	**463.08**
URS-K-2b	Pond A/ K-K'	468.9	468.78	468.79	**469.02**
GAF-K-2a-25	Pond A/ K-K'	469.25	468.8	468.86	**469.02**
GAF-K-2a-30	Pond A/ K-K'	463.24	462.95	463.19	**469.02**
GAF-K-2a-35	Pond A/ K-K'	462.99	462.7	462.77	**469.02**
GAF-K-2b-30	Pond A/ K-K'	465.13	464.77	464.81	**461.5**
GAF-K-2b-35	Pond A/ K-K'	459.2	458.95	459.04	**461.5**
GAF-K-2b-50	Pond A/ K-K'	459.3	458.98	459.00	**461.5**
STN-A-9	Pond A/ L-L'	463.47	463.12	462.93	**463.94**
URS-1b	Pond A/ L-L'	457.82	457.73	457.66	**457.8**
URS-3a	Pond A/ Q-Q'	459.8	459.46	459.32	**460.25**
STN-E-2	Pond E/ A-A'	461.1	460.79	461.14	**461**
URS-12b	Pond E/ A-A'	458.39	458.13	458.66	**458.16**
STN-E-6	Pond E/ B-B'	453.86	452.91	453.03	**453.83**
GAF-B-2a-25	Pond E/ B-B'	456.04	455.14	455.08	**458**
GAF-B-2a-45	Pond E/ B-B'	454.51	453.63	453.65	**458**
GAF-B-2a-55	Pond E/ B-B'	451.39	450.68	450.75	**458**
GAF-B-2b-15	Pond E/ B-B'	455.64	454.4	454.46	**451.2**
GAF-B-2b-25	Pond E/ B-B'	449.95	448.95	449.04	**451.2**
GAF-B-2b-35	Pond E/ B-B'	444.98	443.93	443.99	**451.2**
STN-E-8	Pond E/ C-C'	459.59	458.86	459.26	**459.5**
URS-10b	Pond E/ C-C'	448.51	448.48	448.57	**448.54**
STN-E-18	Pond E/ F-F'	456.31	456.24	456.25	**456.36**
URS-8b	Pond E/ F-F'	456.79	456.67	456.67	**456.77**
STN-E-20	Pond E/ G-G'	457.46	457.27	457.16	**457.74**
URS-6b	Pond E/ G-G'	456.96	456.76	456.75	**457.15**
URS-11a	Pond E/ O-O'	457.93	457.56	457.77	**458.02**
URS-11b	Pond E/ O-O'	457.99	457.65	457.82	**458**
URS-9b	Pond E/ P-P'	456.42	456.33	456.27	**456.41**
URS-9c	Pond E/ P-P'	456.38	456.3	456.25	**456.45**

In general, water level values used in the analysis are higher than historically measured values. At vibrating wire piezometers GAF-B-2b-15 and GAF-K-2b-30 the analysis value is lower than historical high readings, but is higher than those values recorded for deeper transducer depth intervals at the same location.

5.3 Global & Maintenance Stability Analysis

Each of the stability cross-sections were analyzed for global stability, defined as a slip surface that would pass from the far half of the top of dike (crest nearest the Ash Pond) to the downstream toe of the dike. The resulting factor of safety slip surface encompasses the majority of the dike. Existing conditions, as well as remediation alternative conditions were modeled utilizing a similar failure surface.

Slope stability models were analyzed for maintenance stability using assigned entry and exit points limited to the crest and toe of the dike slope, resulting in a localized veneer or slough failure. Maintenance slope stability was evaluated at each section, for effective stress and total stress conditions.

5.4 Material Properties

Following the geotechnical field investigation, URS assembled the available geotechnical data from Stantec, Mactec, and the URS field exploration, and reviewed the material properties results in order to select the strength parameters used in the stability analyses. Material properties were obtained from in-situ and laboratory testing, in addition to soil borings, performed between 2004 and 2012.

5.4.1 Shear Strength Parameters

Material property values for cohesion (c), unit weight (Gamma, γ), and angles of internal friction (Phi, ϕ) originally selected by Stantec were reviewed and revised by URS. Effective and total stress properties were developed by comparing SPT, CPT, DMT, and laboratory test results, and employing engineering judgment and local experience. Values for shear strength, unit weight, and angle of internal friction were estimated for each soil horizon using empirical correlations or laboratory test results and then each parameter was selected by comparing the results.

Drained strength parameters for bottom ash materials were updated using results from the CPT and DMT soundings. Friction angle results correlated from CPT and DMT data in the Raised Bottom Ash Dike material ranged from approximately 31 to 51 degrees, with a median value of 38 degrees. A plot of the friction angle data for the Raised Bottom Ash Dike is presented in **Figure 5-1**. The Initial Bottom Ash Dike angles of internal friction ranged from approximately 30 to 40 degrees, based upon CPT and DMT sounding results. A median value of 35 degrees was selected for the stability analysis. **Figure 5-2** compares the data for angle of internal friction in the Initial Bottom Ash Dike. URS reviewed the friction angle parameters used by Stantec for Bottom Ash Fill and conservatively increased the value at select cross-sections based upon in-situ testing results. Within the Bottom Ash Fill deposits, friction angle results ranged from 30 to 49 degrees. URS selected friction angles near the lower bounds of the testing results, to account for correlation deviations in

coarse-grained materials. The CPT and DMT results for friction angle in the Bottom Ash Fill deposits are presented in **Figure 5-3**, below. Based upon laboratory testing, the majority of bottom ash material sampled is coarse-grained and cohesion-less material, cohesion was thus set equal to zero for all analyses. The remaining material property, unit weight, for bottom ash dike and bottom ash fill materials were carried over from Stantec's analysis. The bottom ash material is primarily comprised of sand and gravel and will not develop significant pore pressures under short-term saturated conditions. For this reason, undrained strength properties of these deposits do not differ from drained parameters.

Figure 5-1: Friction Angle - Raised Bottom Ash Dike CPT and DMT Results

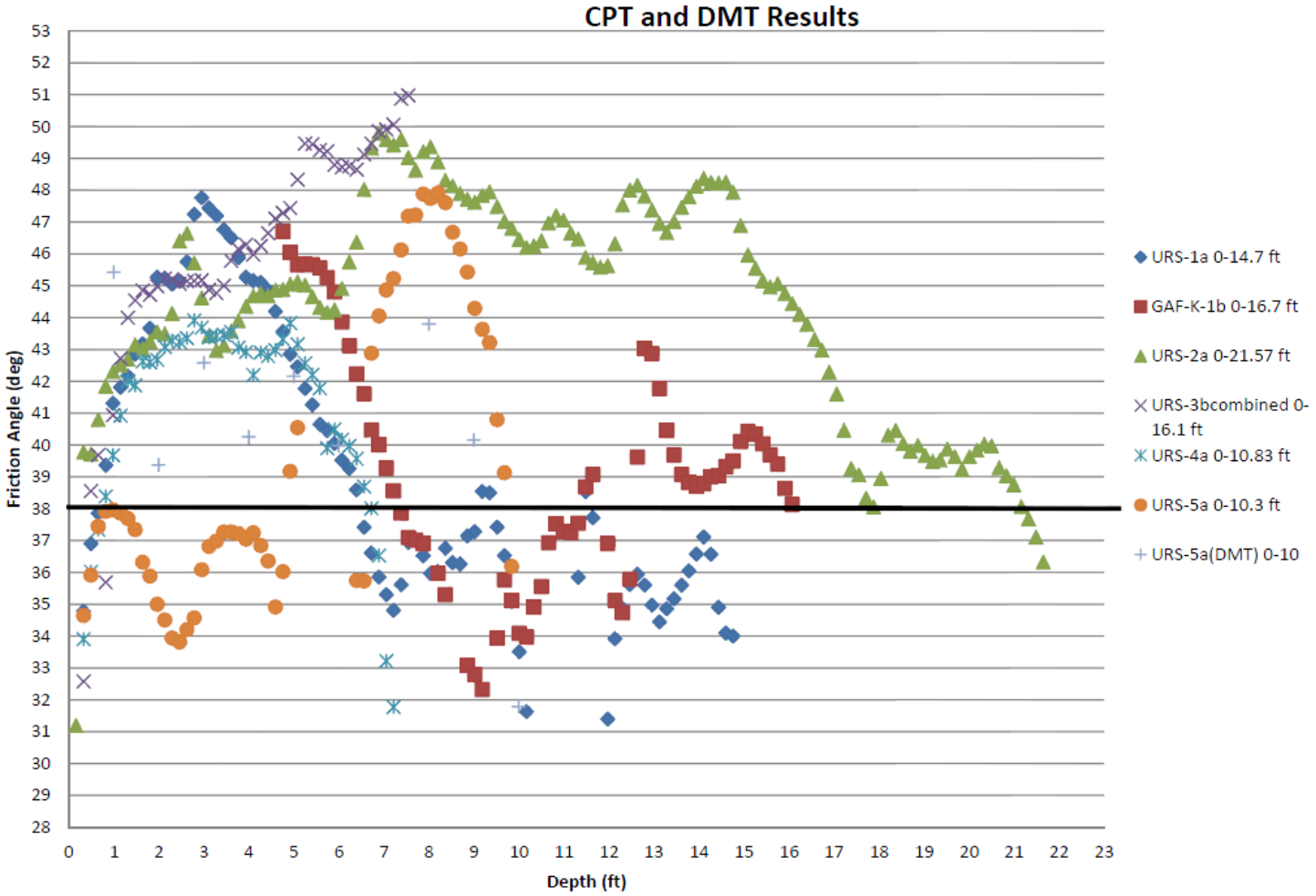


Figure 5-2: Friction Angle - Initial Bottom Ash Dike CPT and DMT Results

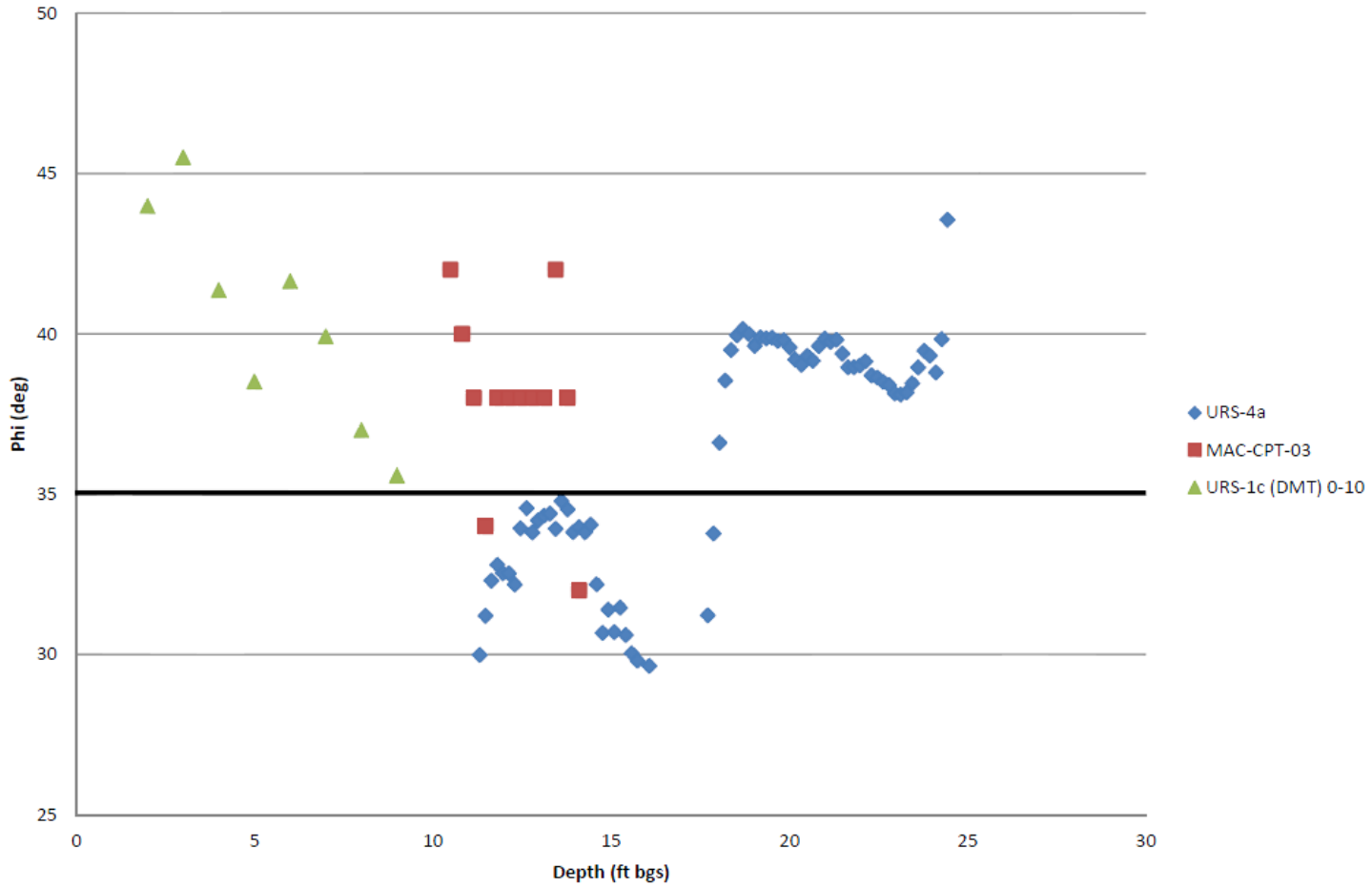
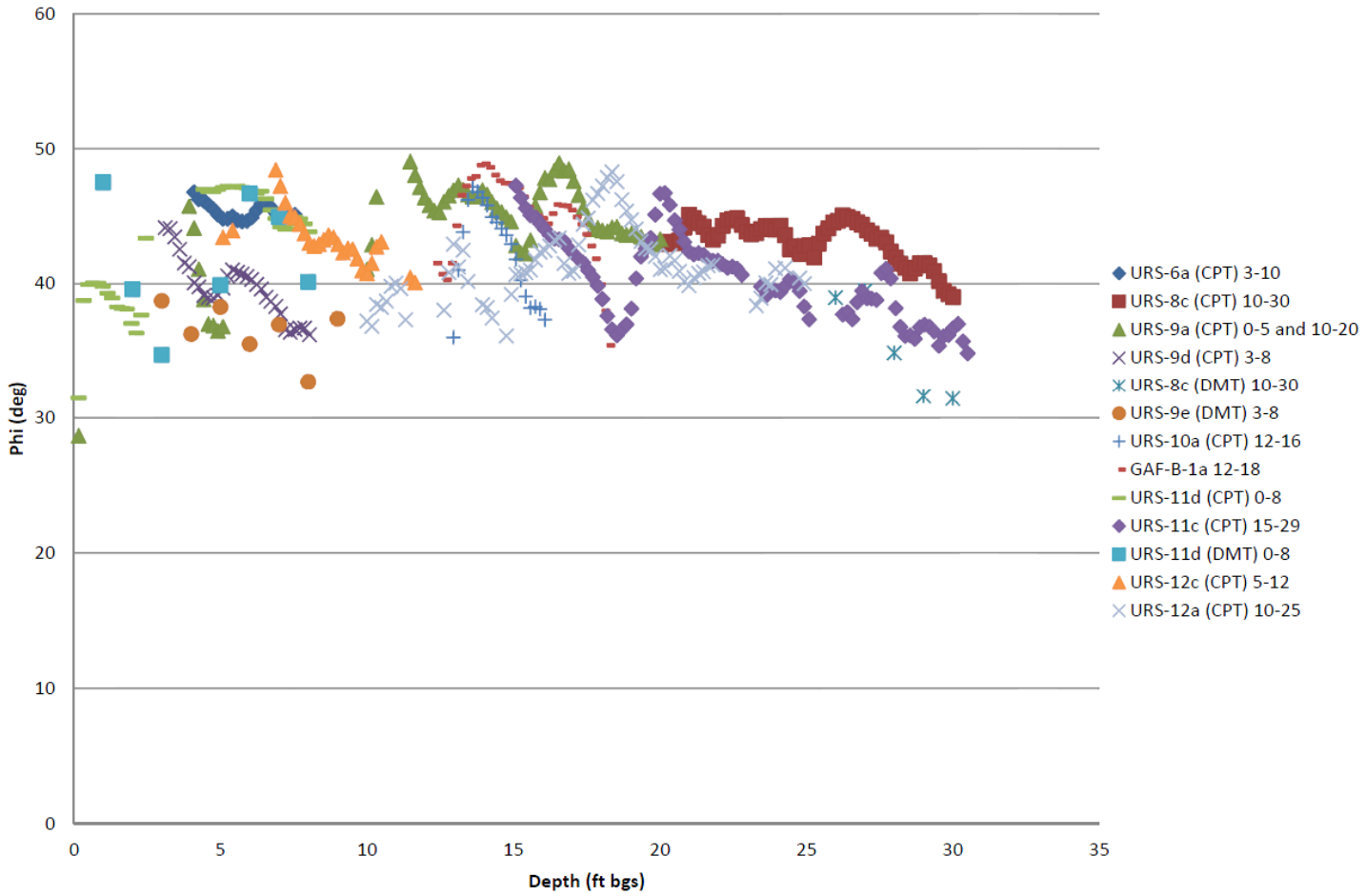
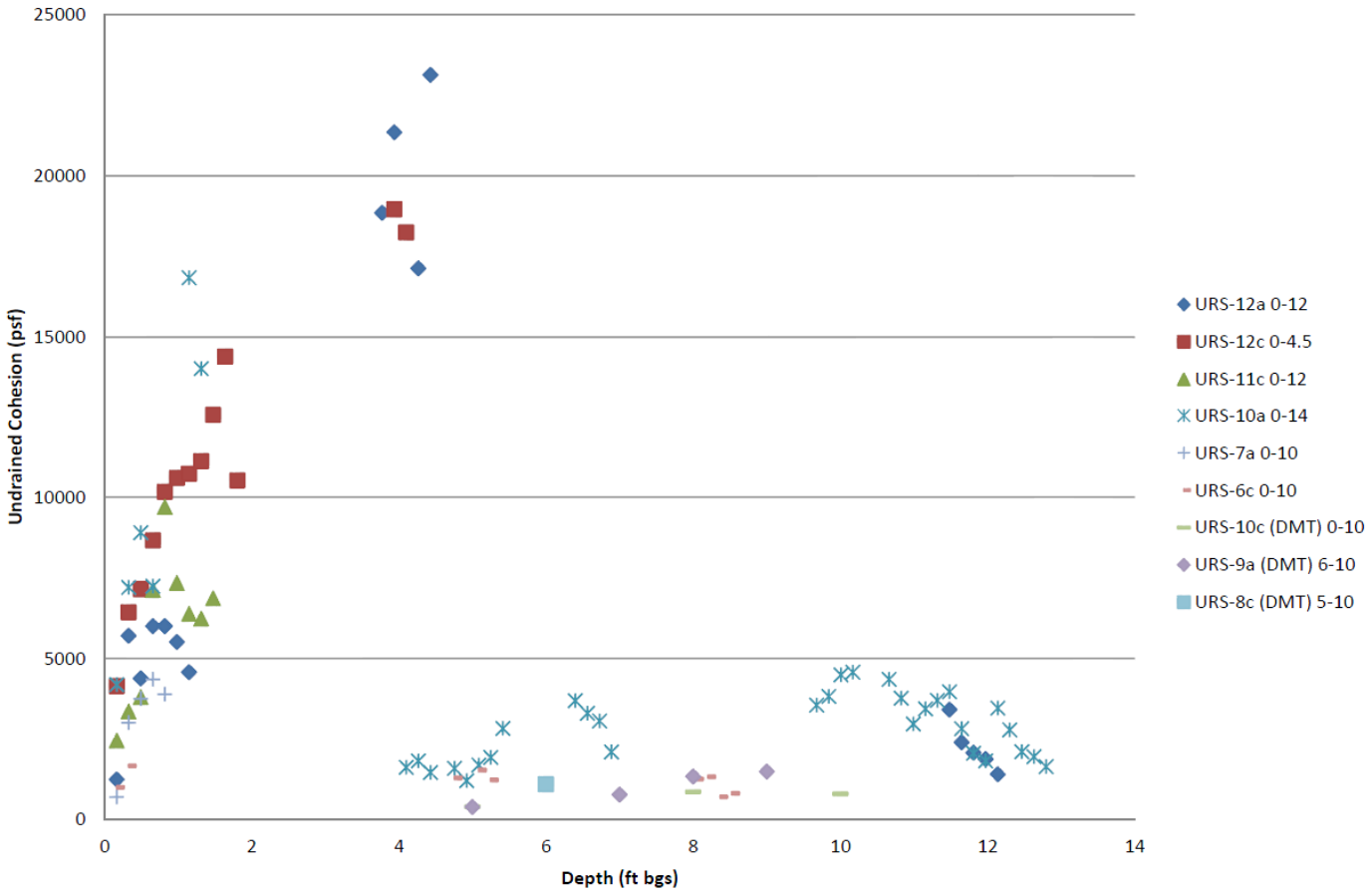


Figure 5-3: Friction Angle - Bottom Ash Fill CPT and DMT Results



The clay dike materials encountered at Ash Pond E had cohesion values ranging from approximately 700 to 23000 psf for undrained conditions, based upon CPT and DMT sounding results. A conservative value of 1500 psf was selected. Refer to **Figure 5-4** for the results of CPT and DMT testing in this material. Drained shear strength properties in the clay dike deposits were increased from a 22 degree friction angle to a 28 degree friction angle as a result of in-situ testing that suggested increased shear strengths in the clay dike. The drained parameters used in the stability analysis for residual clay were modeled with the same values as specified by Stantec, based upon their laboratory test results.

Figure 5-4: Cohesion - Pond E Clay Dike CPT and DMT Results



Sluiced ash material properties for drained conditions were evaluated by comparing consolidated-undrained triaxial and direct shear test results obtained during the subsurface exploration with values specified by Stantec. Following comparison, the drained strength values for angle of internal friction and cohesion reported by Stantec were deemed appropriate for use in the slope stability analysis.

The slope stability analyses were undertaken employing the effective and total stress soil strength parameters listed in **Table 5-2**.

Table 5-2: Material Properties for Slope Stability Analysis

Material	Unit Weight, γ (pcf)	URS Drained Parameters		URS Undrained Parameters		Stantec Drained Parameters		
		Cohesion, c' (psf)	Friction Angle, ϕ' (deg.)	Cohesion, c (psf)	Friction Angle, ϕ (deg.)	Unit Weight, γ (pcf)	Cohesion, c' (psf)	Friction Angle, ϕ' (deg.)
Raised Bottom Ash Dike	105	0	38	0	38	105	0	34
Initial Bottom Ash Dike	105	0	35	0	35	105	0	33
Bottom Ash Fill	105	0	30-34	0	30-34	100	0	34
Sluiced Ash	85	0	26	400	0	85	0	26
Residual Clay	125	200	27	1000	0	125	200	27
Pond E Clay Dike	125	200	28	1500	0	125	200	22

6.0 STABILITY ANALYSIS RESULTS

6.1 SUMMARY OF ASH POND COMPLEX DIKE STABILITY

The existing dike configurations at Ash Ponds A and E were analyzed at the thirteen (13) selected cross-sections, in conjunction with the strength parameters presented in Table 5-2, and phreatic conditions modeled based upon piezometer water level readings. Global and maintenance-type failure analyses were conducted for drained and undrained strength conditions. **Attachment G** contains GeoStudio slope stability outputs for each section analyzed.

6.1.1 GLOBAL STABILITY RESULTS

In most cases, the resulting global factors of safety are on the order of 1.5 or greater. A global factor of safety less than 1.5 was computed at cross-section K of Ash Pond A. The resulting factor of safety at this section was 1.4, which is marginally lower than the target value of 1.5. In all other cases, the factor of safety for global conditions was acceptable. Total Stress Analyses were also completed to verify that the undrained strength of the clay materials and sluiced ash would meet a minimum factor of safety of 1.5. Results of these analyses were similar to those for drained conditions.

6.1.2 MAINTENANCE STABILITY RESULTS

The results of the slope stability analyses indicate that the existing dike configuration at five (5) sections at Ash Pond A have unacceptable maintenance stability factors of safety. Cross-section K has the lowest stability factors of safety for existing conditions, with maintenance FS of 1.1 and global FS of 1.4. As such, Section K was considered the critical cross-section and was used to evaluate remediation alternatives (See discussion in Section 7 of this report). Maintenance stability analyses at Ash Pond E resulted in factors of safety in excess of 1.5. Therefore, remediation alternatives were not evaluated for sections around Ash Pond E.

Table 6-1 summarizes the stability of the embankment sections analyzed by URS, comparing these results with those reported by Stantec in 2010. The results of the URS slope stability analyses are presented on each stability cross-section in **Attachment E.**

Table 6-1: Summary of URS Stability Analysis Results

Location	Section	Failure Type	Existing FS Drained	Existing FS Undrained	Stantec Stability Analysis Results 2010
Ash Pond A	L	Global	1.9	2.0	NA
		Maintenance	1.6	1.7	NA
	K	Global	1.4	1.4	1.5
		Maintenance	1.1	1.1	1.2
	J	Global	1.5	1.5	1.5
		Maintenance	1.3	1.3	1.2
	Q	Global	1.5	1.6	NA
		Maintenance	1.3	1.6	NA
	I	Global	1.5	1.5	NA
		Maintenance	1.2	1.2	NA
	H	Global	1.5	1.5	1.5
		Maintenance	1.1	1.1	1.4
Ash Pond E	G	Global	2.9	2.9	2.2
		Maintenance	2.8	2.9	1.5
	F	Global	2.3	2.0	2.0
		Maintenance	2.6	2.7	1.1
	P	Global	2.8	3.3	NA
		Maintenance	2.4	3.2	NA
	C	Global	2.0	1.6	1.5
		Maintenance	1.9	1.8	1.6
	B	Global	1.9	1.5	1.5
		Maintenance	1.9	2.6	1.5
	O	Global	2.1	1.9	NA
		Maintenance	2.0	2.4	NA
	A	Global	2.2	2.6	NA
		Maintenance	2.0	2.5	NA

7.0 REMEDIATION ALTERNATIVES

To address reduced maintenance and global stability factors of safety at the Ash Pond A divider dike, remediation alternatives were modeled and evaluated in SLOPE/W to assess their impact on the factors of safety. As the critical section having the lowest maintenance and global factors of safety, stability section K was used to assess each alternative. The same strength parameters used in the analyses for existing conditions were used in the alternatives evaluation. Where applicable, two additional material types were included in the remediation alternative's analysis; Rip Rap and Recompacted Bottom Ash Fill. Material properties for Rip Rap were selected based upon site experience and are consistent with similar slope stability evaluations performed at the WCF site. Compacted Bottom Ash Fill was modeled using strength parameters similar to those used for Bottom Ash Fill in the existing condition analyses. A discussion of the alternatives considered follows:

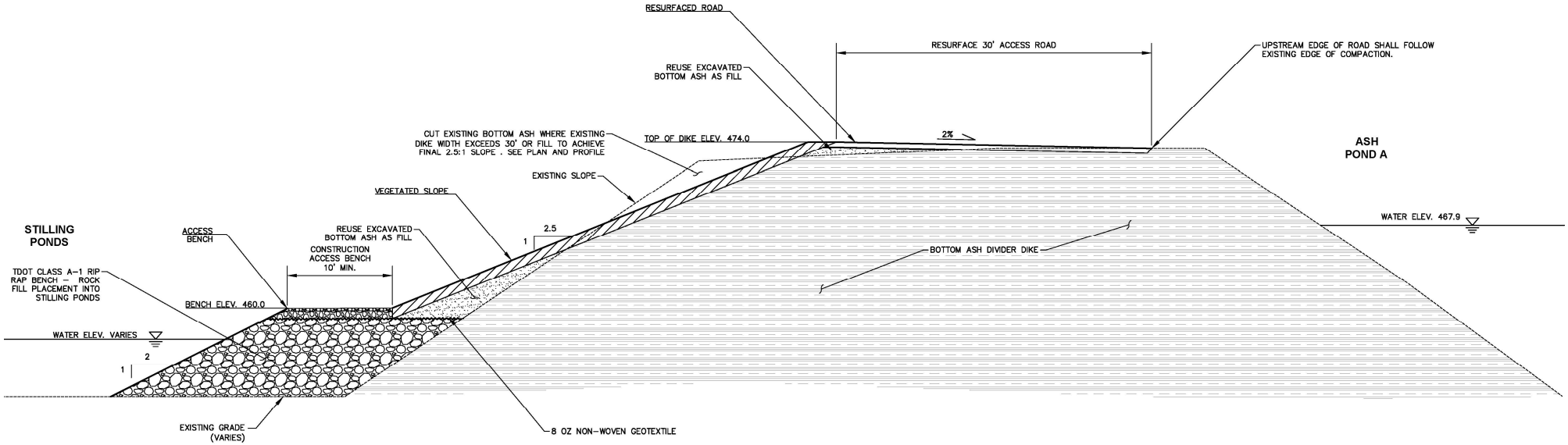
Lower Pond A Pool Levels – The lowering of the Pond A pool levels as part of the Pond A Spillway upgrade project was evaluated as a potential for remediating the low factors of safety. The slope stability analysis indicates that lowering of the planned pool elevations will not raise maintenance factors of safety to 1.5. Therefore, this alternative was not considered as a suitable remediation alternative; however, once implemented, this condition will result in increased global factors of safety for the other alternatives presented below.

Flatten Slope to 2:1 – This alternative includes flattening the downstream slope (Stilling Pond side) of the divider dike at Ash Pond A by cutting back the existing slope to a final grade of 2H:1V. At each section along the Pond A divider dike this alternative would maintain a minimum dike roadway width between 25 and 30 ft after constructing the 2:1 slope. However, this alternative is also not sufficient to raise the maintenance factors of safety to 1.5 at the critical sections and therefore, this option was not considered further.

Flatten Slope to 2.5:1 – This alternative includes flattening the downstream slope (Stilling Pond side) of the divider dike at Ash Pond A by cutting back or filling the existing slope to a final grade of 2.5H:1V. This option would be designed to maintain the existing minimum dike roadway width of approximately 30 ft. The results of the stability analysis indicate that the 2.5:1 flattened slope will raise factors of safety to 1.5 or greater. **Figure 7-1** depicts a typical detail of the 2.5:1 slope remediation alternative. This alternative is therefore considered the preferred approach for remediating the Ash Pond A dike and has been selected by TVA.

As part of the selected flattened slope alternative, a 10 foot wide Rip Rap bench is also to be constructed at the downstream toe of slope. The bench is recommended to allow for safe access and construction at the toe of the dike as well as facilitate future maintenance and inspection.

Figure 7-1: 2.5H:1V Flattened Slope Typical Detail



7.1 Selected Alternative Analysis Results

Results of the selected alternative stability analysis indicate that grading the steep slopes at Ash Pond A to a slope of 2.5:1 will increase the maintenance and global factors of safety to 1.5 or higher. At cross-sections K, J, and I, achieving a final slope of 2.5:1 will require placing fill material on the downstream slopes in order to sustain required dike widths for traffic flow. The remaining sections at Pond A will be cut and graded to a final slope of 2.5:1. In addition to critical section K, stability section H was analyzed using a 2.5:1 cut slope, in order to verify that a cut slope of 2.5:1 results in sufficient factors of safety. The stability analysis results indicate that acceptable factors of safety can be achieved when the slope is either graded by placing bottom ash fill material, or by cutting the existing slope to desired final grades. **Table 7-1** presents the factor of safety results for critical sections K and H, when the slope is filled, or cut, respectively. The remaining sections are expected to have global and maintenance factors of safety in excess of 1.5.

Table 7-1: Stability Results for 2.5:1 Slope Alternative

Location	Section	Failure Type	FS Fill/Cut Slope of 2.5:1
Ash Pond A	K	Global	2.0
		Maintenance	1.6
	H	Global	1.9
		Maintenance	1.7

Refer to **Attachment H** for slope stability model outputs for the 2.5:1 slope selected alternative.

7.1.1 Interim Construction Analysis Results

As part of the stability analysis for the selected reconstructed 2.5H:1V dike slope alternative, an evaluation of the temporary construction conditions was performed in order to verify that sufficient slope stability will be maintained during construction. The critical slope stability case during interim construction occurs when equipment is situated at the edge of the downstream slope crest and works to grade the existing slope to final proposed grades. Based upon the proposed construction sequence, the rip rap construction bench will be constructed prior to the start of slope grading. As such, a slope stability model was developed where the rip rap construction bench has been constructed to final proposed grades but the existing downstream slope has not been altered from its existing condition.

The interim construction analysis evaluated three loading scenarios which represented construction equipment working on the crest of the dike, as described above. Each piece of equipment was modeled by applying a representative surcharge load near the edge of the crest of the dike and oriented based upon the direction the equipment would be

seated. The applied surcharge loads correspond to the following construction equipment typically used at TVA facilities:

- CAT 324E HEX Long Reach Excavator; and
- CAT 740 Articulated Dump Truck fully loaded.

The CAT 324E Excavator was modeled as two separate surcharge loads in order to represent the two directions the equipment may be situated and work on the dike crest. The first loading condition corresponds to a CAT 324E Excavator seated with tracks parallel to the existing road. In this case two strip surcharge loads are applied at the crest of the downstream slope, simulating the equipment tracks. The second loading condition corresponds to a CAT 324E Excavator seated with tracks perpendicular to the existing road. One strip surcharge load was modeled in this case, simulating the total surcharge load from the weight of the excavator distributed over the length of the track. In a similar way, the fully loaded CAT 740 Articulated Dump truck was modeled as a single strip surcharge load oriented perpendicular to the existing road and for potential scenarios such as parking parallel to the slope. The corresponding slope stability results are considered conservative because SlopeW assumes the equipment is infinitely wide along the length of the dike. The load cases as they were applied in SlopeW are as follows:

Load Case 1: No equipment loading on the crest of the dike

Load Case 2: CAT 324E HEX Long Reach Excavator seated parallel to the road; modeled with two surcharge loads

Load Case 3: CAT 324E HEX Long Reach Excavator seated perpendicular to the road; modeled with one surcharge load

Load Case 4: CAT 740 Articulated Dump Truck fully loaded seated perpendicular to the road and parallel to the slope; modeled with one surcharge load.

The slope stability models were also used to determine where equipment could safely operate in relation to the dike crest edge during construction and maintain stability of the slopes. Each equipment load was applied at the very edge of the dike crest and then incrementally moved away from the edge until the stability factor of safety exceeded the target factor of safety for temporary construction conditions of 1.3. Results of the analysis indicate that a CAT 324E Excavator may operate on the very edge of the dike crest (0 ft set back) while maintaining a temporary construction stability factor of safety of 1.3. Conversely, the analysis indicates that operating the fully loaded CAT 740 Articulated Dump truck right at the edge of the crest of the dike will result in factors of safety slightly below the target value. Therefore, URS recommends that fully loaded dump trucks be positioned to sit no closer than 2 feet from the downstream edge of the crest of the dike. The critical factor of safety computed for this configuration is 1.3, which is equal to the target value

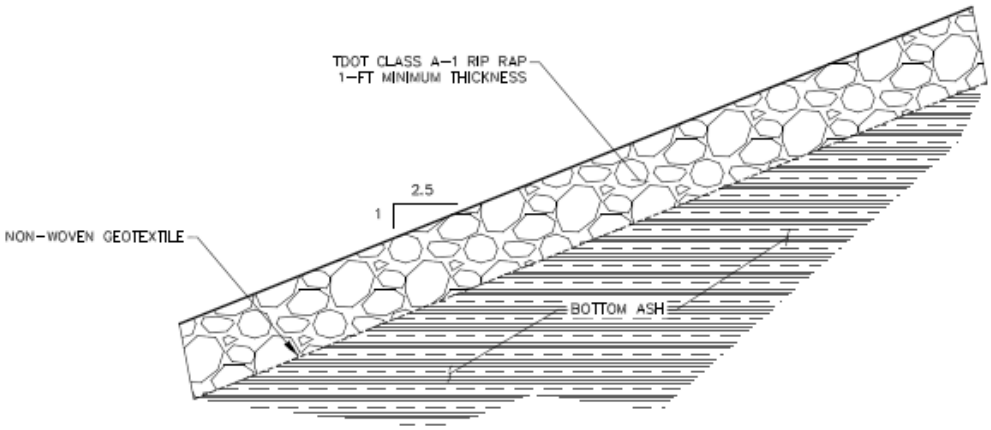
given in the Programmatic Document. Refer to Attachment H for slope stability model outputs for the interim construction slope stability evaluation completed for the selected reconstructed 2.5H:1V dike slope alternative.

7.2 FLATTENED SLOPE FACING OPTIONS

Two options were considered for the final surface of the reconstructed 2.5:1 dike slope. These options are introduced below.

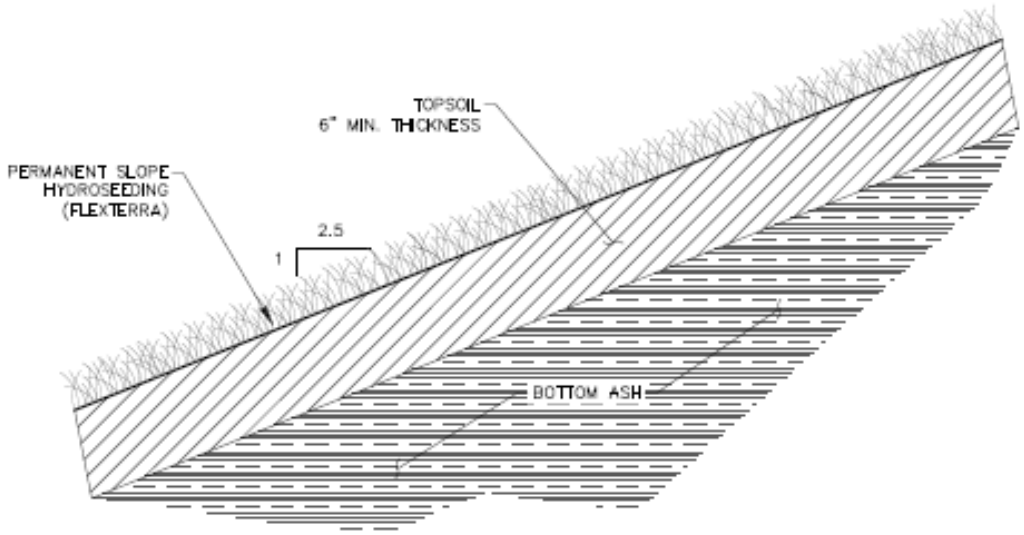
Option 1: Rip Rap Slope Facing – Consists of placing a non-woven geotextile on the reconstructed 2.5:1 bottom ash slope and overlaying with 1 foot of TDOT Class A-1 Rip Rap as shown on **Figure 7-2**, below.

Figure 7-2: Option 1 Typical Detail



Option 2: Vegetated Slope Facing – Consists of placing a 6 inch thick layer of topsoil on the reconstructed 2.5:1 bottom ash slope and surfacing with erosion control matting and seed and mulchas shown on **Figure 7-3**, below.

Figure 7-3: Option 2 Typical Detail



Based upon the results or our evaluation, the vegetated slope facing option is anticipated to provide the most construction friendly and closure ready surface for the future closure of Ash Pond A. Therefore, the vegetated slope facing was selected by TVA for the slope facing option.

7.3 ADDITIONAL CONSIDERATIONS

As part of the stability analyses, URS considered the impact future projects at Ash Pond A will have on long-term slope stability and how the selected remediation alternative will function after implementation of those projects. Additionally, analysis of the ½ Probable Maximum Precipitation event was completed and a discussion of the results follows:

<u>½ Probable Maximum Precipitation (1/2-PMP) Event</u> – The ½-PMP storm event was analyzed in SLOPE/W using a high water elevation in Pond A of 472.66 ft, and downstream Stilling Pond water elevation of 462 ft, in conjunction with a 2.5:1 flattened slope and rip rap bench at Section K, and the resulting factors of safety were 1.3 and 1.6, for maintenance and global stability, respectively. These factors of safety are considered acceptable for a temporary, extreme event. Slope stability results for this analysis are presented in **Attachment H**.

<u>Pond A Spillway Replacement Project</u> – The Pond A spillway was designed to lower the elevation in Pond A by 2 ft, resulting in a final pool elevation of approximately 467.9. On November 3, 2013 the Pond A water level was lowered to El. 467.9 and has been operating in this range since. Lowering the pond water level will improve overall global stability, but will have little effect on the maintenance stability, which is primarily controlled by water levels in the downstream Stilling Pond. By inspection, the proposed Pond A Spillway Project will result in higher global factors of safety and minimal or no change in the maintenance stability. Preliminary analysis of lowered Pond A levels was completed and the results are included in Attachment H.

Ash Pond Closure – The preliminary Ash Pond Closure Plan includes closure grades of a minimum 3% design slope within the dike containment area of Ash Pond A. The recommended dike improvement at Ash Pond A is anticipated to be sufficient to maintain acceptable maintenance and global factors of safety upon completion of final closure. Due to the existing high stability factors, any reductions in dike stability as a result of final closure are expected to remain at or above 1.5 for maintenance and global conditions.

It is also TVA's objective for each slope surfacing option presented in 7.2 above to facilitate final closure of Ash Pond A and the associated ash dikes. Currently there are no regulations requiring the closure of embankments constructed of CCP materials. However, anticipated changes to US EPA regulations governing CCP materials are pending. As such, each option was evaluated with respect to its ability to facilitate final closure.

8.0 CONCLUSIONS

Computed factors of safety for global stability along the divider and perimeter dikes of Ash Pond A were 1.5 or higher at the majority of cross-sections, confirming the results of previous analyses. The only exception being cross-section K which has a global factor of safety of 1.4. These stability results also indicate that existing conditions at Ash Pond E maintain acceptable factors of safety. For that reason, no additional improvements are required along the Ash Pond E perimeter dikes.

Based upon the results of our analysis, URS recommends and TVA has selected to remediate the entire length of the Pond A divider dike by flattening and vegetating the downstream slope to 2.5H:1V. The limits of this improvement should extend from the northeast point of Ash Pond E where the Pond E divider dike intersects the Pond A divider dike, up to the northeastern point of Ash Pond A, along the divider dike. A 10 foot wide Rip Rap bench is also to be constructed at the toe of the slope to allow for safe access and construction at the toe of the slope in the existing Stilling Pond. The bench would also provide long-term safe access to the toe of the dike during future maintenance and inspection. The proposed remediation will meet all project objectives discussed in the report including providing acceptable factors of safety, allowing for current pond operating levels, meeting the Programmatic Document, reducing future maintenance and facilitating future closure.

In addition, URS recommends and TVA has selected to have that the Pond A flattened slope covered with topsoil and vegetated. This option will meet all project objectives discussed above including providing acceptable factors of safety, allowing for current pond operating levels, meeting the Programmatic Document, reducing future maintenance and facilitating future closure.

9.0 REFERENCES

- MACTEC Engineering and Consulting, Inc., 2004. *Report of Geotechnical Exploration, Ash Disposal Area and Potential On-site and Off-site Borrow Areas, Gallatin Fossil Plant, Gallatin, Tennessee.* October 14, 2004.
- Mayne, Paul W, 2006. *Undisturbed Sand Strength from Seismic Cone Tests.* The 2006 James K. Mitchell Lecture.
- US EPA, 2002, *A Lexicon of Cave and Karst Terminology with Special Reference to Environmental Karst Hydrology*. U.S. Environmental Protection Agency EPA/600/R-02/003, Compiled by M.S. Field, 214 p.
- Stantec Consulting Services Inc., 2010. *Report of Geotechnical Exploration and Slope Stability Evaluation, Ash Pond/ Stilling Pond Complex, Gallatin Fossil Plant – Gallatin, Tennessee*. May 27, 2010.

Attachment B – Excerpts from Structural Stability Assessment (AECOM, 2018)

Attachment 2.C – CCR Material Characterization

Calculation Notes AECOM

Subject: CCR Material Characterization

Project Name: TVA GAF EIP

By: Matt Nanak Date: 06/06/2017

Project No: 60513955

Checked By: Lucas Carr Date: 06/06/2017

Task No.: 6

Objective

Develop drained and undrained shear strength and unit weight parameters values for the CCR material at the Gallatin Fossil Plant (GAF) in Gallatin, TN. The shear strength parameters will be used in static and seismic slope stability analyses for the Non-Registered Site (NRS) at GAF.

Procedure

The procedure for developing the drained and undrained shear strength and unit weight design values is described below. In general, the procedure involved analyzing laboratory testing data performed on samples of CCR collected by AECOM in 2016 and 2017. The samples were collected from the 5 active and inactive CCR units at GAF, including Ash Pond A, Ash Pond E, Middle Pond A, the Bottom Ash Pond, and the Non Registered Site (NRS). Samples of CCR for strength and permeability testing were collected at each CCR unit using relatively undisturbed Shelby tube sampling techniques. The collected samples were sealed in the field using O-ring packers transported to AECOM's laboratory testing subcontractor (GeoTesting Express [GTX]) for laboratory testing. Although a wide range of physical laboratory tests were performed by GTX, data utilized for this material characterization was limited to data from the following strength and permeability tests:

- Direct Shear (ASTM D 3080) – 30 specimens
- Isotropically Consolidated Undrained Triaxial Shear (ASTM D 4767) – 30 specimens
- Static Consolidated Undrained Direct Simple Shear (ASTM D 6528) – 2 specimens
- Cyclic Consolidated Undrained Direct Simple Shear (ASTM D 6528) – 10 specimens
- Flexible Wall Permeability (ASTM D 5084) – 10 specimens

Drained Shear Strength Characterization

GTX performed isotropically consolidated undrained (CIU) triaxial tests with pore pressure measurements on 10 separate Shelby tube samples (30 total test specimens), with effective confining stresses ranging from 4 to 33 psi. The results of the CIU triaxial tests were plotted on a p'-q plot. The use of p'-q plots allows the failure stress of each triaxial test specimen to be shown as a single point on a plot, using equations based on equations from Holtz and Kovacs (1981), which are also presented below[1]. Failure stresses were defined using the maximum ratio of principal effective stresses during the triaxial test (σ'_1/σ'_3, or peak obliquity), as recommended in Appendix D of United States Army Corps of Engineers (USACE) Engineer Manual (EM) 1110-2-1902 (2003). However, in order to reduce the potential effects of strain compatibility, failure was limited to 10% strain (e.g if peak obliquity occurred above 10% strain, failure was assumed to correspond to the stresses acting on the specimen at 10% strain). Note

[1] The notation in the equations for horizontal and vertical stress has been modified to s_1 and s_3 instead of s_v and s_h, respectively. For a triaxial compression test, $s_1 = s_v$ and $s_3 = s_h$.

that all but one of the specimens met failure prior to 10% strain, with an average strain at peak obliquity of 3%.

$$q = \frac{\sigma_1 - \sigma_3}{2}$$ (based on Eqn. 10-18 from Holtz and Kovacs, 1981)

$$p = \frac{\sigma_1 + \sigma_3}{2}$$ (based on Eqn. 10-19 from Holtz and Kovacs, 1981)

$$p' = p - u$$ (Eqn. from page 474 of Holtz and Kovacs, 1981)

where:

σ_1 = vertical stress

σ_3 = horizontal stress

u = excess pore water pressure

Using the p'-q plot, the design shear strength envelope was represented using a stress ratio at failure line (K_f). The K_f line is drawn at an angle of Ψ and a y-intercept of a', which can be converted to a Mohr-Coulomb f ' and c' failure envelope using sin f ' = tan Ψ and c' = a'/cos f (Eqn. 10-24 and 10-25, respectively, Holtz & Kovacs, 1981). The design shear strength envelope was selected so approximately two-thirds of the specimens failed above the design envelope, while the remaining one-third failed below the design envelope, in order to provide a representative lower-bound design shear strength. Based on this analysis, the CCR has been characterized as a cohesionless (c' = 0 psf) material as the testing data did not indicate the presence of effective cohesion.

The effective stress data from CIU testing is presented in Figure 1. The design drained strength parameters are f '= 42 degrees and c' = 0 psf. The data did not indicate a significant variability in drained CCR strength between CCR in each of the 5 CCR units, therefore a single design value was selected for the site and will be used for slope stability analysis at the NRS. Tabulated CIU test data and a large-scale p'-q plot are presented in the attachments.

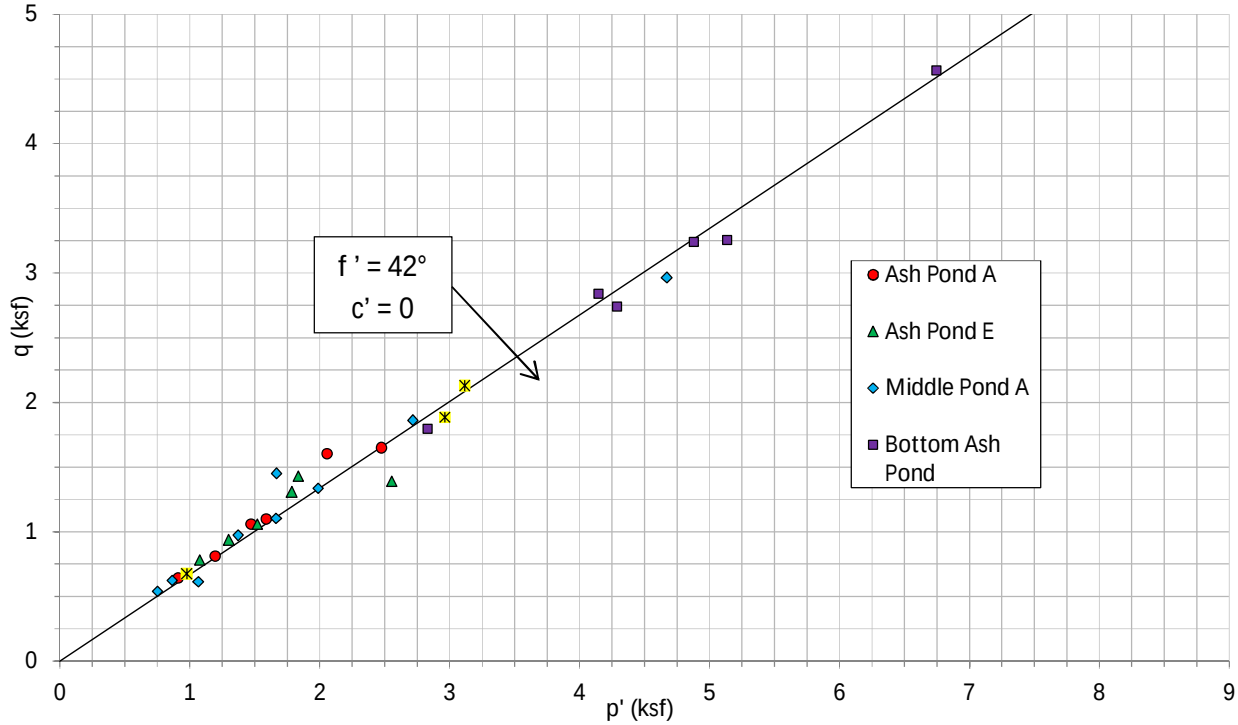


Figure 1: p'-q Plot of Effective Stress Data from CIU Testing

In addition to the CIU tests, AECOM performed direct shear (DS) tests on 10 separate Shelby tube samples (30 total test specimens), with normal stresses ranging from 1 to 45 psi. The results of the DS tests were plotted as effective normal stress versus shear stress as failure. Failure was defined as the maximum shear stress during testing, limited to 10% strain. The plot of the DS results, presented in Figure 2, shows that the data falls on a failure envelope corresponding to f '= 44 degrees and c' = 0 psf, which is higher than the CIU design drained shear strength of f '= 42 degrees and c' = 0 psf. The design drained strength for the CCR was selected as f ' = 42 degrees in order to use the more conservative value from the CIU and DS data.

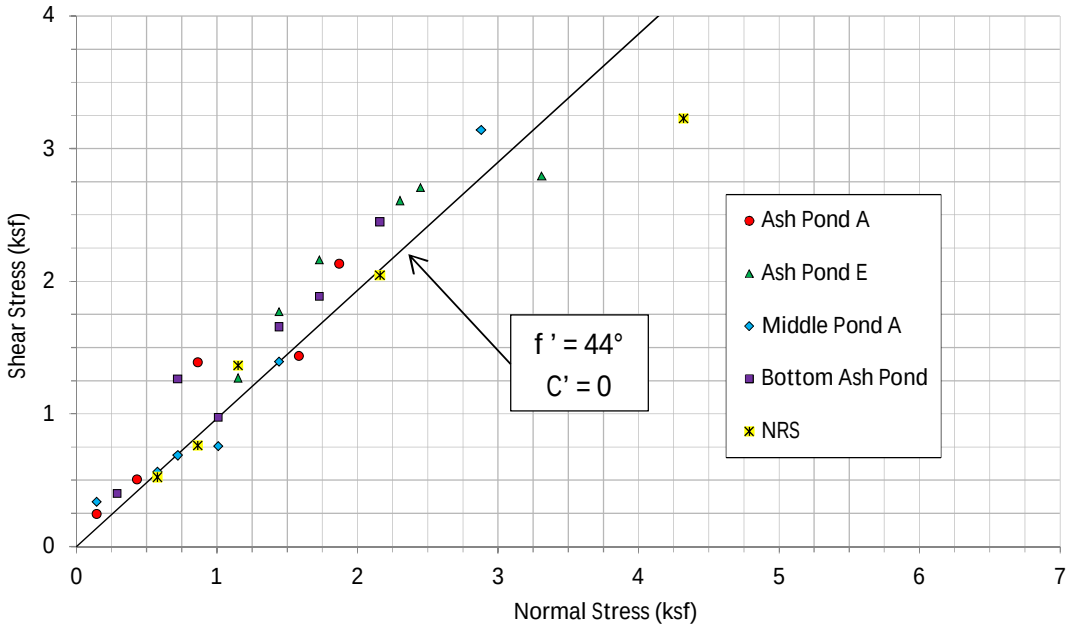


Figure 2: Effective Normal and Shear Stress Data from DS Testing

Undrained Shear Strength Characterization

In addition to the CIU testing, GTX also performed static direct simple shear (SDSS) tests on 2 specimens of CCR from the site. Undrained shear strength of the CCR was evaluated using both SDSS and CIU strength tests, as these tests consisted of shearing the CCR in an undrained manner (constant volume and no drainage during shear). Data from direct shear tests were not used in the undrained shear strength characterization as the direct shear test is conducted in a fully drained manner (the sample is allowed to change in volume and drain during shear) and therefore the direct shear test does not measure undrained shear strength. The undrained shear strength of the CCR was modeled using a ratio of undrained shear strength to effective consolidation stress on the failure plane, prior to the start of shear[2] (S_u/s'_{fc}). This type of characterization was selected as most of the CCR at GAF was recently wet-sluiced into the CCR units, and is therefore assumed to behave as a normally-consolidated material during undrained shear due to the absence of any past stresses that would have overconsolidated the CCR beyond the current insitu stress. Based on the method of CCR placement as well as AECOM's experience with CCR, this means that the shear strength of the CCR can be normalized as a function of

[2] Consolidation stress on the failure plane, prior to the start of shearing, is known for both CIU and SDSS testing. The consolidation stress on the failure plane is equal to the specimen consolidation stress. For the CIU specimens, this is because they are isotropically consolidated to a uniform stress within the samples. For SDSS specimens, this is because they are vertically consolidated to a known stress on the horizontal failure plane.

consolidation stress on the failure plane. Therefore the S_u/s'_{fc} characterization was selected for the undrained strength of the CCR.

Undrained shear strength data from CIU testing was developed using a derivation developed by AECOM that relates shear stress on the failure plane at failure (τ_{ff}) to the consolidation stress prior to triaxial shear (s'_{fc}). The derivation relies on calculating an effective friction angle (f ') for each individual CIU test specimen, which varies slightly from the overall design f ' of 42 degrees for the CCR at the site. In order to calculate the effective friction angle, failure for each CIU specimen was defined using peak deviator stress ($s'_1 - s'_3$), limited to 15% strain, per USACE EM 1110-2-1902 (2003). The stress conditions at failure were then used to calculate an effective friction angle for each specimen, which was then used in conjunction with the effective principal stresses at failure to calculate τ_{ff}. A plot was then prepared relating t_{ff} (y-axis) to the effective consolidation pressure for each triaxial test specimen (x-axis), which is shown in Figure 4. It should be noted that s'_{fc} is equal to the consolidation stress of the CIU specimen (s'_{3c}), as the isotropic consolidation stress results in a uniform stress within the specimen prior to shear.

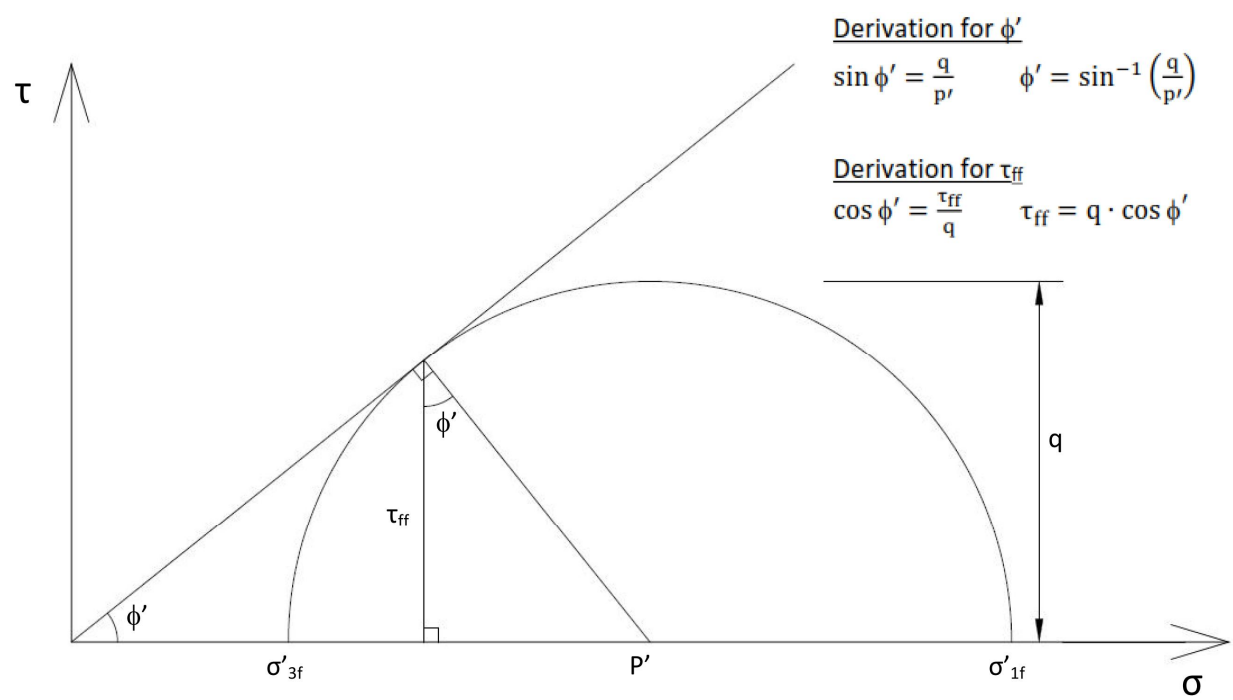


Figure 3: Derivation of t_{ff} from p-q data

In addition to the CIU triaxial tests previously discussed, AECOM performed SDSS tests on 2 separate Shelby tube samples (2 total test specimens), with an effective confining stress of 15 psi. In order to be consistent with the CIU data, failure for the SDSS test specimens was defined using peak shear stress (t_{ff})

limited to 15% strain. Because the SDSS directly measures shear stress on the failure plane at failure, τ_{ff} was plotted versus the specimen consolidation stress for the SDSS tests (σ'_{fc} = 15 psi). A plot of the SDSS failure envelope is presented in Figure 5.

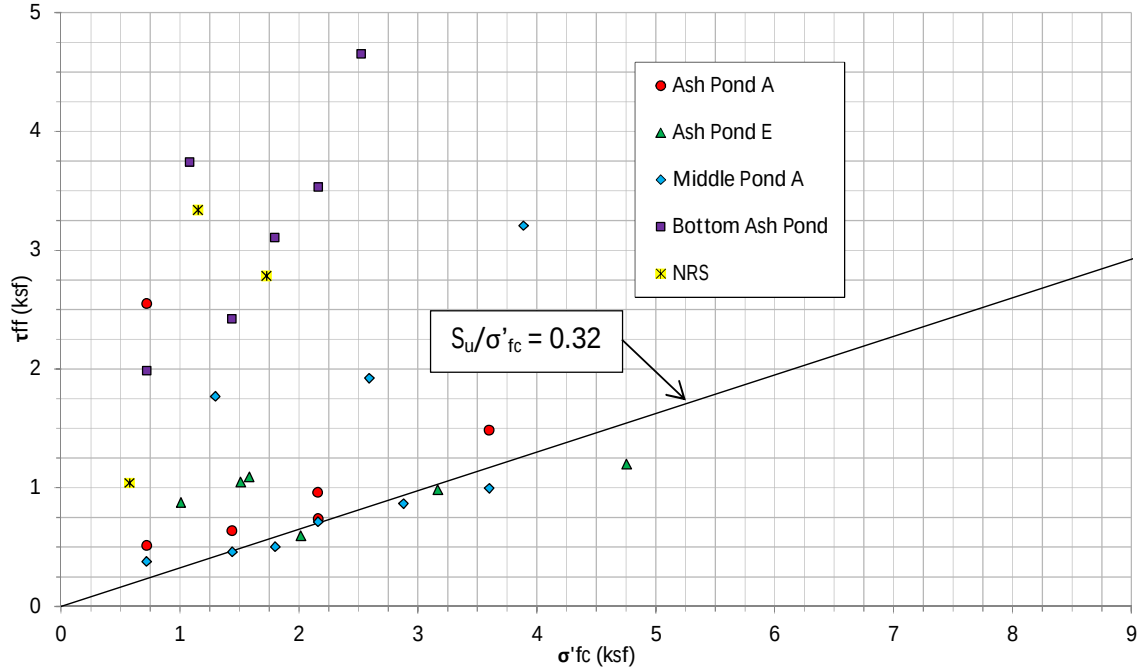


Figure 4: Undrained Strength Characterization from CIU Data

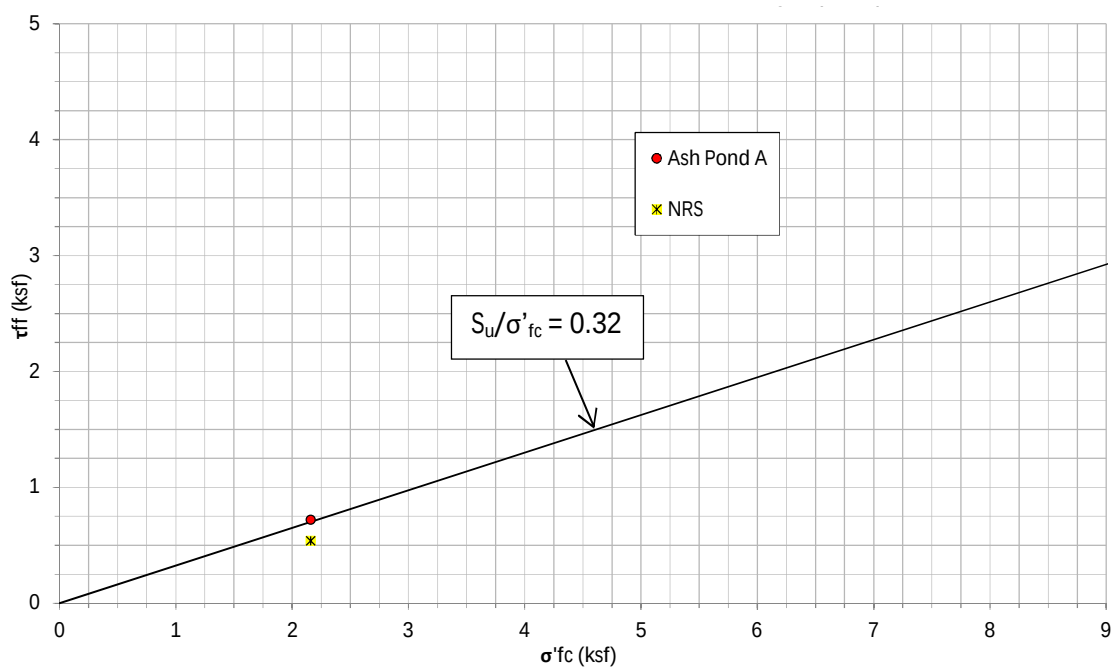


Figure 5: Undrained Strength Characterization from SDSS Data

For the CIU data, values of t_{ff}-s'_{fc} were found to exhibit a significant amount of scatter, with tests from the NRS and Bottom Ash Pond showing high undrained shear strengths (when plotted as a function of consolidation stress), while tests from Middle Pond A exhibiting moderate scatter and Ash Pond A and Ash Pond E showed relatively consistently and lower undrained shear strengths, that followed t_{ff}/s'_{fc} of approximately 0.32. This is likely due to the presence of significant quantities of bottom ash within specimens from the NRS and Bottom Ash Pond. The bottom ash is typically gravel-like in gradation, and therefore resulted in the development of high negative pore pressures during shear, which significantly increases the effective stress in the specimen at failure. However, all CCR units at the site are likely to have variations within the spatial extents of bottom ash and fly ash. Therefore, a lower-bound t_{ff}/s'_{fc} ratio of 0.32 was selected as the design shear strength for the CCR, primarily based on the results of CIU tests form Middle Pond A and Ash Pond E. SDSS tests performed on specimens of CCR form Ash Pond A and the NRS indicated that a similar t_{ff}/s'_{fc} ratio is reasonable, so the ratio of 0.32 was selected as the lower-bound design ratio for all CCR at the site.

Unit Weight Characterization

Total (moist, or in-situ) unit weight test data was collected from 30 CIU test specimens, 30 DS test specimens, 10 cyclic direct simple shear (CDSS) test specimens, 2 SDSS test specimens, and 10 permeability test specimens collected at each of the 5 CCR units at GAF. Collected total unit weight data

ranged from 60 pcf to 125 pounds per cubic foot (pcf) with an average unit weight of 90 pcf and a standard deviation of 12.5 pcf. The large variation of total unit weights is likely due to the variable historic coal combustion processes as well as intermingling of various types of CCR (mixed fly ash and bottom ash). Trends in unit weight were not identified for any of the 5 CCR units, and therefore a single mean design value of 90 pcf was selected for the entire site. Tabulated data of the collect total unit weight data is presented in the attachments, and is shown graphically in Figure 6.

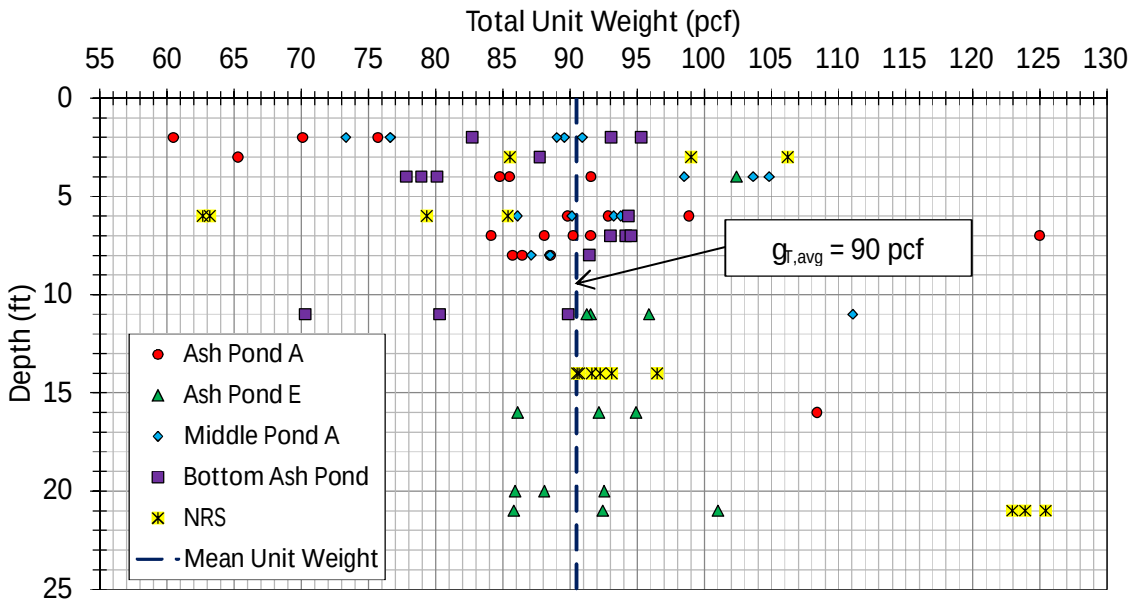


Figure 6: Collected Total Unit Weight Data

Results

Based on the evaluation described above, AECOM has developed design drained and undrained shear strength values and a unit weight for the CCR material within the 5 CCR units at GAF. AECOM's analysis did not identify significant trends in values for each CCR unit, and therefore a single set of design values has been assigned for all 5 CCR units. The design values are summarized in Table 1.

Table 1: Design Strength Properties

Material	Total Unit Weight (pcf)	Drained Strength (Effective Stress)		Undrained Strength (Total Stress)
		f ' (deg)	c' (psf)	t_{ff}/σ'_{fc}
CCR	90	42	0	0.32

References

Duncan, J.M., Wright, S.G., (2005), *Soil Strength and Slope Stability*, 2005.

Holtz, R.D., Kovacs, W.D., (1981), *An Introduction to Geotechnical Engineering*, 1981.

U.S. Army Corps of Engineers (USACE) (2003), *Engineering and Design: SLOPE STABILITY*, Engineering Manual No. 1110-2-1902, October 31, 2003

Attachments

Attachment 1: CIU Tests Data Reduction
Attachment 2: DS Tests Data Reduction
Attachment 3: CIU and SDSS Undrained Strength Data Reduction
Attachment 4: Total Unit Weight Calculation

Calculation Notes AECOM

Subject: CCR Material Characterization

Project Name: TVA GAF EIP

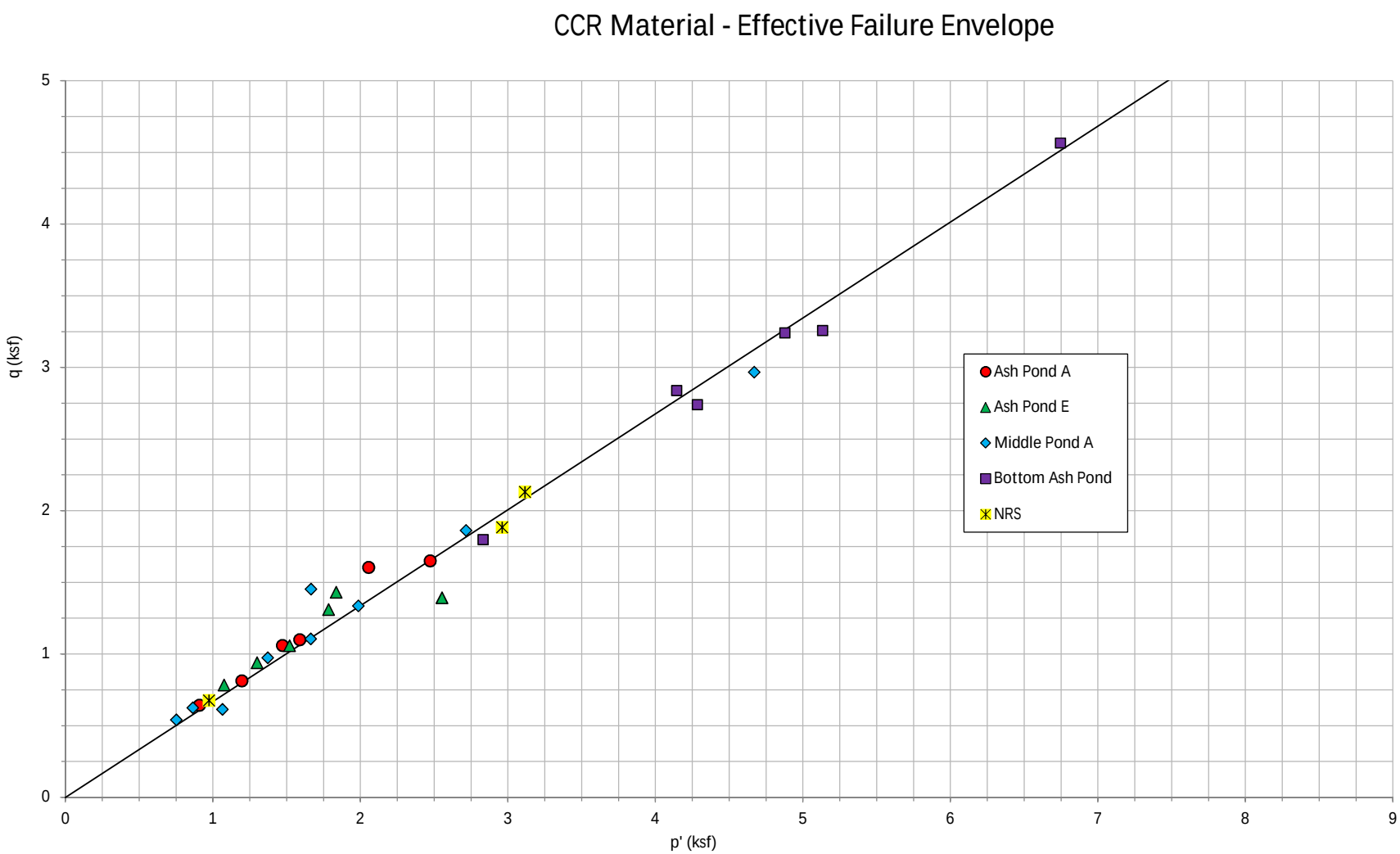
By: Matt Nanak Date: 06/06/2017

Project No: 60513955

Checked By: Lucas Carr Date: 06/06/2017

Task No.: 6

Attachment 1: CIU Tests Data Reduction



Mohr-Coulomb Space		Conversion Equations	p'-q Space	
c' (psf) =	0	a' = c' * cos(Φ')	a' (ksf) =	0.00
Φ' (°) =	42	Ψ' = atan(sin(Φ'))	Ψ' (°)=	33.8

TVA Gallatin	**CIU Test Data Reduction**	AECOM	**Figure**
Gallatin, TN	**CCR Materials**		**A1**
60513955	**All Ponds**		

PROJECT NAME:	TVA Gallatin
PROJECT LOCATION:	Gallatin, TN
POND NAME:	All Ponds
SECTION:	All Sections
MATERIALS:	CCR Materials
PROJECT NUMBER:	60513955
WORK TITLE:	CIU Tests Data Reduction

AECOM

Summary of Results				
Material	Effective Strength Parameters		Rapid Drawdown Strength Parameters	
	c' (psf)	Φ' (°)	c (psf)	Φ (°)
CCR	0	42	0	19

Revision Log					
Rev. No.	Rev By:	Date:	Chck By:	Date:	Description of Revision
0	MJN	4/5/2017	LPC	4/5/2017	Entered data
1	MJN	4/6/2017	LPC	4/6/2017	Added data point for GAP070
2	MJN	4/17/2017	LPC	4/18/2017	Added data for GAP039
3	MJN	4/18/2017	LPC	4/19/2017	Added data for GAP062 3-5
4					

Boring	Sample Depth (ft)	Pond	e@Failure (%)	$s_3'_c$ (psi)	Peak Obliquity	s_3' (psi)	s_1' (psi)	Δu (psi)	p' (psi)	q (psi)	p (psi)	Ash Pond A p' (ksf)	Ash Pond A q (ksf)	Ash Pond A p (ksf)	Ash Pond E p' (ksf)	Ash Pond E q (ksf)	Ash Pond E p (ksf)	Middle Pond A p' (ksf)	Middle Pond A q (ksf)	Middle Pond A p (ksf)	Bottom Ash Pond p' (ksf)	Bottom Ash Pond q (ksf)	Bottom Ash Pond p (ksf)	NRS p' (ksf)	NRS q (ksf)	NRS p (ksf)
GAP061	7-9	Ash Pond A	1.85	5.0	5.78	1.86	10.77	3.14	6.31	4.45	9.45	0.91	0.64	1.36	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			2.28	10.0	5.20	2.68	13.94	7.30	8.31	5.63	15.62	1.20	0.81	2.25	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			1.34	15.0	6.11	2.88	17.58	12.12	10.23	7.35	22.36	1.47	1.06	3.22	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GAP062	7-9	Middle Pond A	1.35	10.0	6.16	1.68	10.34	8.22	6.01	4.33	14.33	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.87	0.62	2.06	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			1.90	15.0	5.84	2.79	16.29	12.21	9.54	6.75	21.75	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.37	0.97	3.13	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			2.02	25.0	5.08	4.54	23.07	20.46	13.81	9.26	34.26	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.99	1.33	4.93	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GAP063	10-12	Ash Pond E	2.60	7.0	5.57	3.22	17.90	3.80	10.56	7.34	14.34	#N/A	#N/A	#N/A	1.52	1.06	2.06	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			5.15	10.5	6.18	2.51	15.54	7.98	9.03	6.51	17.00	#N/A	#N/A	#N/A	1.30	0.94	2.45	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			3.50	14.0	6.33	2.04	12.91	11.94	7.47	5.43	19.43	#N/A	#N/A	#N/A	1.08	0.78	2.80	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GAP064	5-7	Middle Pond A	3.80	5.0	6.04	1.49	8.98	3.51	5.23	3.75	8.75	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.75	0.54	1.26	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			3.73	12.5	3.71	3.14	11.66	9.34	7.40	4.26	16.76	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.07	0.61	2.41	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			2.15	20.0	4.94	3.89	19.23	16.11	11.56	7.67	27.67	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.66	1.10	3.98	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GAP065	20-22	Ash Pond E	4.00	11.0	6.49	3.31	21.48	7.70	12.40	9.08	20.08	#N/A	#N/A	#N/A	1.78	1.31	2.89	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			7.45	22.0	8.02	2.83	22.68	19.14	12.76	9.93	31.93	#N/A	#N/A	#N/A	1.84	1.43	4.60	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			10	33.0	3.39	8.08	27.40	24.94	17.74	9.66	42.68	#N/A	#N/A	#N/A	2.55	1.39	6.15	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GAP068	1-3	Bottom Ash Pond	2.28	5.0	4.47	7.19	32.15	-2.20	19.67	12.48	17.48	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	2.83	1.80	2.52	#N/A	#N/A	#N/A
			4.43	10.0	4.54	10.75	48.78	-0.76	29.77	19.02	29.00	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	4.29	2.74	4.18	#N/A	#N/A	#N/A
			3.64	15.0	4.47	13.05	58.27	1.95	35.66	22.61	37.61	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	5.14	3.26	5.42	#N/A	#N/A	#N/A
GAP068	10-12	Bottom Ash Pond	2.95	7.5	5.34	9.09	48.49	-1.59	28.79	19.70	27.20	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	4.15	2.84	3.92	#N/A	#N/A	#N/A
			6.00	12.5	4.95	11.39	56.38	1.06	33.89	22.50	34.99	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	4.88	3.24	5.04	#N/A	#N/A	#N/A
			5.00	17.5	5.18	15.16	78.56	2.36	46.86	31.70	49.22	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6.75	4.57	7.09	#N/A	#N/A	#N/A
GAP070	5-7	Ash Pond A	1.05	5.0	8.08	3.15	25.41	1.85	14.28	11.13	16.13	2.06	1.60	2.32	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			1.73	15.0	5.48	3.41	18.67	11.57	11.04	7.63	22.62	1.59	1.10	3.26	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			3.33	25.0	5.00	5.73	28.64	19.27	17.19	11.45	36.44	2.47	1.65	5.25	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GAP039	2-4	NRS	3.98	4.0	5.49	2.09	11.47	1.91	6.78	4.69	8.69	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.98	0.68	1.25
			3.08	8.0	4.49	7.49	33.65	0.50	20.57	13.08	21.08	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	2.96	1.88	3.04
			2.45	12.0	5.32	6.85	36.43	5.05	21.64	14.79	26.79	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	3.12	2.13	3.86
GAP062	3-5	Middle Pond A	1.55	9.0	14.46	1.50	21.65	7.50	11.58	10.08	19.08	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.67	1.45	2.75	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			1.55	18.0	5.35	5.94	31.80	12.06	18.87	12.93	30.93	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	2.72	1.86	4.45	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			2.32	27.0	4.48	11.84	53.02	15.16	32.43	20.59	47.59	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	4.67	2.96	6.85	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

Calculation Notes AECOM

Subject: CCR Material Characterization

Project Name: TVA GAF EIP

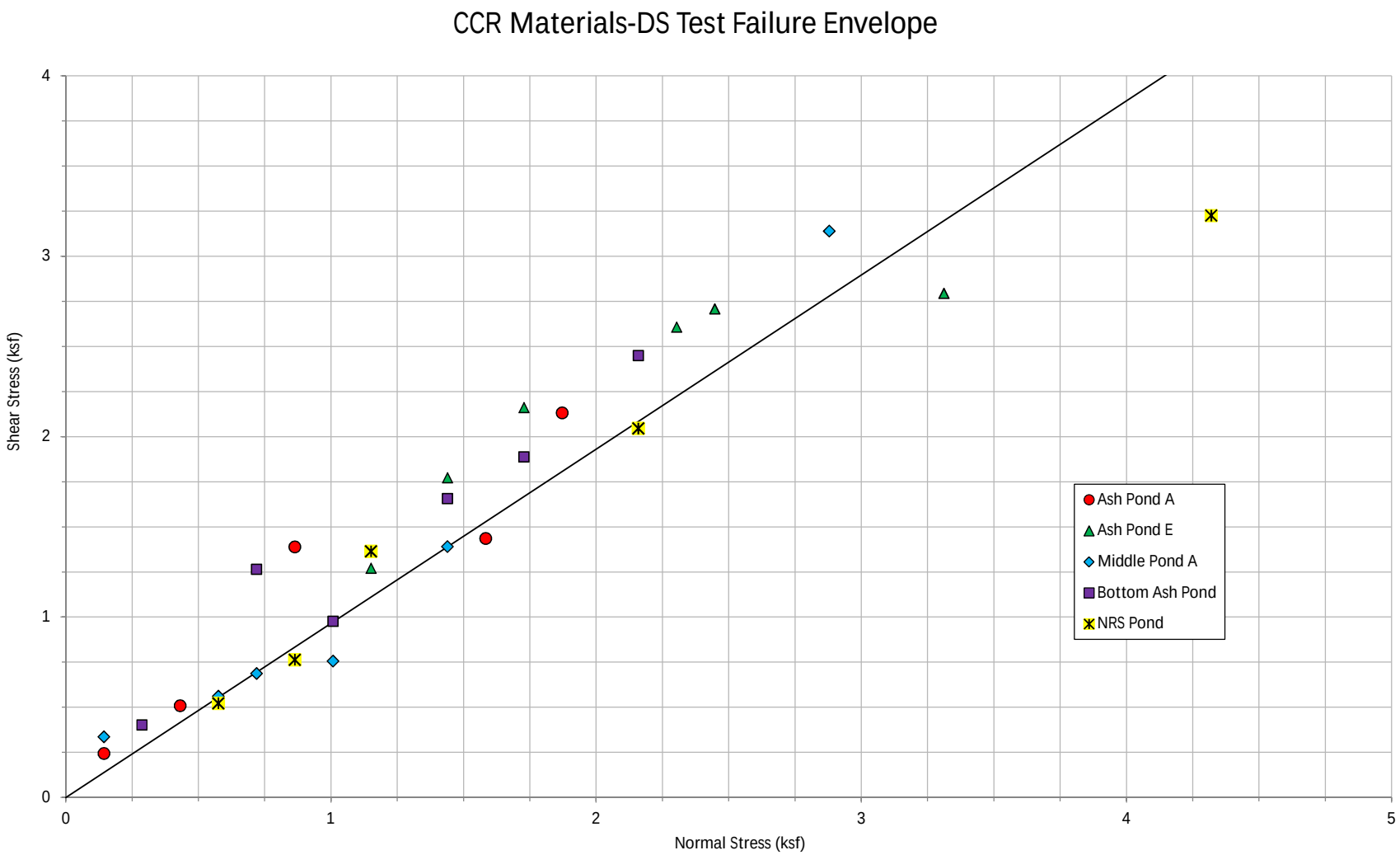
By: Matt Nanak Date: 06/06/2017

Project No: 60513955

Checked By: Lucas Carr Date: 06/06/2017

Task No.: 6

Attachment 2: DS Tests Data Reduction



Mohr-Coulomb Space	
c' (psf) =	0
Φ' (°) =	44

TVA Gallatin	**DS Test Data Reduction**	AECOM	**Figure**
Gallatin, TN	**CCR Materials**		**A2**
60513955	**All Ponds**		

PROJECT NAME:	TVA Gallatin
PROJECT LOCATION:	Gallatin, TN
POND NAME:	All Pond
SECTION:	All Sections
MATERIALS:	CCR Materials
PROJECT NUMBER:	60513955
WORK TITLE:	DS Test Data Reduction

AECOM

Revision Log

Rev. No.	Revised By:	Date:	Checked By:	Date:	Description of Revision
0	MJN	4/5/2017	LPC	4/5/2017	Entered data

Summary of Results		
Material	Effective Strength Parameters	
	c' (psf)	Φ' (°)
CCR	0	44

Boring	Sample Depth (ft)	Pond	Normal Stress (psi)	Max Shear (psi)	Strain @ Failure (%)	NRS Pond		Middle Pond A		Ash Pond E		Ash Pond A		Bottom Ash Pond	
						Normal (ksf)	Shear (ksf)	Normal (ksf)	Shear (ksf)	Normal (ksf)	Shear (ksf)	Normal (ksf)	Shear (ksf)	Normal (ksf)	Shear (ksf)
GAP039	5-7	NRS Pond	4	3.6	2.377	0.58	0.52	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			6	5.3	9.996	0.86	0.76	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			8	9.5	9.972	1.15	1.36	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GAP042	20-22	NRS Pond	15	14.2	6.812	2.16	2.04	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			30	22.4	4.132	4.32	3.23	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			45	28.3	4.600	6.48	4.08	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GAP062	1-3	Middle Pond A	5	4.8	6.644	#N/A	#N/A	0.72	0.69	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			10	9.7	3.621	#N/A	#N/A	1.44	1.39	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			20	21.8	9.740	#N/A	#N/A	2.88	3.14	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GAP063	15-17	Ash Pond E	8	8.8	10.000	#N/A	#N/A	#N/A	#N/A	1.15	1.27	#N/A	#N/A	#N/A	#N/A
			12	15.0	3.068	#N/A	#N/A	#N/A	#N/A	1.73	2.16	#N/A	#N/A	#N/A	#N/A
			16	18.1	9.140	#N/A	#N/A	#N/A	#N/A	2.30	2.61	#N/A	#N/A	#N/A	#N/A
GAP064	1-3	Middle Pond A	1	2.3	7.512	#N/A	#N/A	0.14	0.34	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			4	3.9	1.257	#N/A	#N/A	0.58	0.56	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			7	5.2	9.316	#N/A	#N/A	1.01	0.75	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GAP061	3-5	Ash Pond A	1	1.7	2.485	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.14	0.24	#N/A	#N/A
			6	9.6	7.836	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.86	1.39	#N/A	#N/A
			11	10.0	9.776	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.58	1.43	#N/A	#N/A
GAP065	19-21	Ash Pond E	10	12.3	4.096	#N/A	#N/A	#N/A	#N/A	1.44	1.77	#N/A	#N/A	#N/A	#N/A
			17	18.8	9.180	#N/A	#N/A	#N/A	#N/A	2.45	2.71	#N/A	#N/A	#N/A	#N/A
			23	19.4	4.232	#N/A	#N/A	#N/A	#N/A	3.31	2.79	#N/A	#N/A	#N/A	#N/A
GAP068	3-5	Bottom Ash Pond	2	2.8	8.064	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.29	0.40
			7	6.8	10.000	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.01	0.97
			12	13.1	9.396	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.73	1.89
GAP069	6-8	Bottom Ash Pond	5	8.8	4.328	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.72	1.26
			10	11.5	9.924	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.44	1.66
			15	17.0	8.612	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	2.16	2.45
GAP070	1-3	Ash Pond A	3	3.5	9.940	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.43	0.51	#N/A	#N/A
			13	14.8	9.940	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.87	2.13	#N/A	#N/A
			33	28.8	9.972	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	4.75	4.15	#N/A	#N/A

Calculation Notes AECOM

Subject: CCR Material Characterization

Project Name: TVA GAF EIP

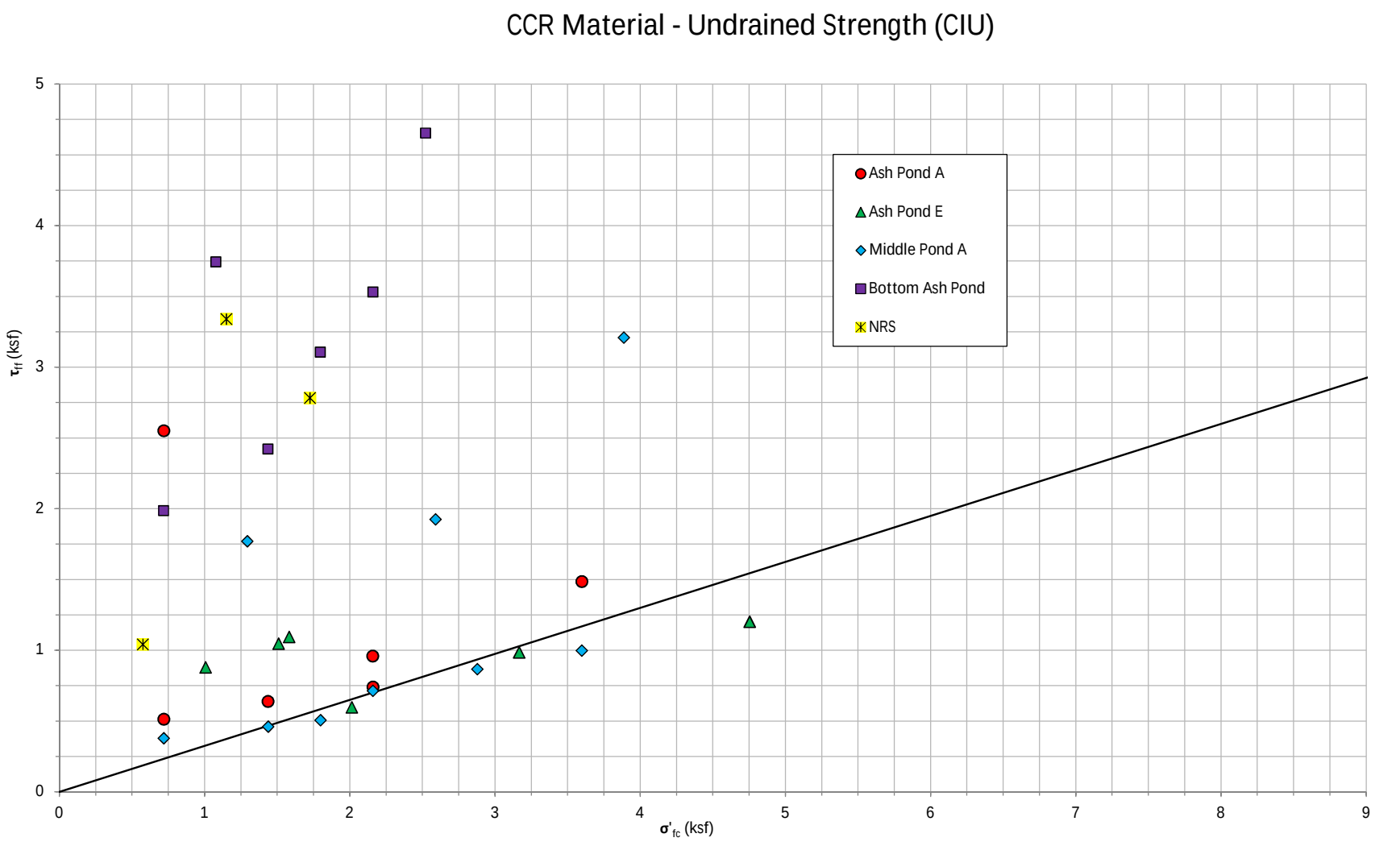
By: Matt Nanak Date: 06/06/2017

Project No: 60513955

Checked By: Lucas Carr Date: 06/06/2017

Task No.: 6

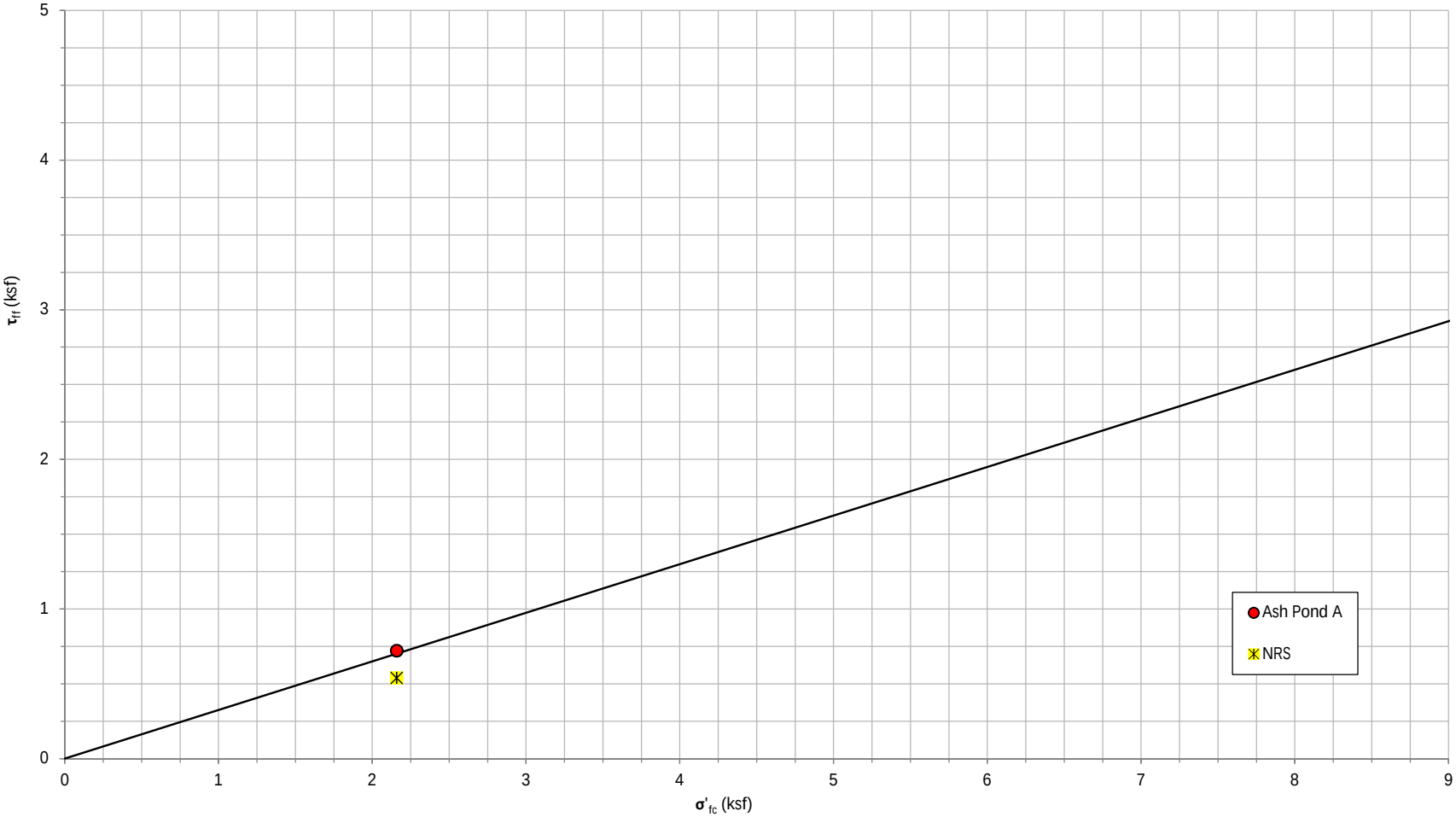
Attachment 3: CIU and SDSS Undrained Strength Data Reduction



Mohr-Coulomb Space	
S_u/σ'_{fc}	0.32

TVA Gallatin	**Undrained Strength Characterization**	AECOM	**Figure**
Gallatin, TN	**CCR Materials**		**A3**
60513955	**All Ponds**		

CCR Material - Undrained Strength (SDSS)



Mohr-Coulomb Space	
S_u/σ'_{fc}	0.32

TVA Gallatin	**Undrained Strength Characterization**	AECOM	**Figure**
Gallatin, TN	**CCR Materials**		**A4**
60513955	**All Ponds**		

PROJECT NAME:	TVA Gallatin
PROJECT LOCATION:	Gallatin, TN
POND NAME:	All Ponds
SECTION:	All Sections
MATERIALS:	CCR Materials
PROJECT NUMBER:	60513955
WORK TITLE:	Undrained Strength Characterization

AECOM

Summary of Results		
Material	Undrained Strength Parameters	
	S_u/σ'_{fc} (CIU)	S_u/σ'_{fc} (SDSS)
CCR	0.32	0.32

Revision Log

Rev. No.	Rev By:	Date:	Chck By:	Date:	Description of Revision
0	MJN	4/17/2017			Modified spreadsheet for characterization
1	MJN	4/18/2017	LPC	4/19/2017	Revised per comments
2					
3					
4					

Boring	Sample Depth (ft)	Pond	e@Failure (%)	$s_3'_c$ (psi)	Peak Deviator Stress (psi)	Δu (psi)	p' (psi)	q (psi)	f ' (deg)	σ'_{fc} (psi)	τ_{ff} (psi)	Ash Pond A		Ash Pond E		Middle Pond A		Bottom Ash Pond		NRS	
												σ'_{fc} (ksf)	τ_{ff} (ksf)	σ'_{fc} (ksf)	τ_{ff} (ksf)	σ'_{fc} (ksf)	τ_{ff} (ksf)	σ'_{fc} (ksf)	τ_{ff} (ksf)	σ'_{fc} (ksf)	τ_{ff} (ksf)
GAP061	7-9	Ash Pond A	5.67	5.0	9.78	2.77	7.13	4.89	43.3	5.00	3.56	0.72	0.51	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			4.43	10.0	11.85	7.01	8.92	5.92	41.6	9.99	4.43	1.44	0.64	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			1.21	15.0	14.75	12.11	10.27	7.38	45.9	15.01	5.13	2.16	0.74	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GAP062	7-9	Middle Pond A	2.63	10.0	8.90	8.06	6.39	4.45	44.1	10.00	3.19	#N/A	#N/A	#N/A	#N/A	1.44	0.46	#N/A	#N/A	#N/A	#N/A
			2.63	15.0	13.83	12.01	9.90	6.92	44.3	15.00	4.95	#N/A	#N/A	#N/A	#N/A	2.16	0.71	#N/A	#N/A	#N/A	#N/A
			1.59	25.0	18.55	20.37	13.92	9.27	41.8	25.00	6.91	#N/A	#N/A	#N/A	#N/A	3.60	1.00	#N/A	#N/A	#N/A	#N/A
GAP063	10-12	Ash Pond E	10.33	7.0	16.29	2.86	12.29	8.15	41.5	7.00	6.10	#N/A	#N/A	1.01	0.88	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			12.30	10.5	18.57	4.87	14.91	9.29	38.5	10.49	7.26	#N/A	#N/A	1.51	1.05	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			8.67	14.0	11.66	11.56	8.27	5.83	44.8	14.00	4.14	#N/A	#N/A	2.02	0.60	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GAP064	5-7	Middle Pond A	3.73	5.0	7.50	3.51	5.25	3.75	45.7	5.00	2.62	#N/A	#N/A	#N/A	#N/A	0.72	0.38	#N/A	#N/A	#N/A	#N/A
			4.25	12.5	8.56	9.34	7.44	4.28	35.1	12.50	3.50	#N/A	#N/A	#N/A	#N/A	1.80	0.50	#N/A	#N/A	#N/A	#N/A
			1.33	20.0	15.85	15.77	12.16	7.92	40.7	20.00	6.01	#N/A	#N/A	#N/A	#N/A	2.88	0.87	#N/A	#N/A	#N/A	#N/A
GAP065	20-22	Ash Pond E	13.70	11.0	20.75	6.18	15.21	10.37	43.0	11.00	7.58	#N/A	#N/A	1.58	1.09	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			3.40	22.0	20.76	18.60	13.78	10.38	48.9	22.00	6.83	#N/A	#N/A	3.17	0.98	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			6.88	33.0	19.67	24.34	18.53	9.84	32.1	33.02	8.34	#N/A	#N/A	4.75	1.20	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GAP068	1-3	Bottom Ash Pond	5.90	5.0	34.94	-5.97	28.43	17.47	37.9	5.00	13.78	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.72	1.98	#N/A	#N/A
			8.70	10.0	42.94	-3.04	34.52	21.47	38.5	9.99	16.81	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.44	2.42	#N/A	#N/A
			8.86	15.0	59.96	-7.10	52.08	29.98	35.1	15.00	24.51	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	2.16	3.53	#N/A	#N/A
GAP068	10-12	Bottom Ash Pond	13.61	7.5	68.28	-11.00	52.64	34.14	40.4	7.50	25.99	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.08	3.74	#N/A	#N/A
			14.68	12.5	55.66	-3.71	44.04	27.83	39.2	12.49	21.57	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.80	3.11	#N/A	#N/A
			12.40	17.5	82.94	-7.19	66.18	41.47	38.8	17.52	32.32	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	2.52	4.65	#N/A	#N/A
GAP070	5-7	Ash Pond A	7.45	5.0	47.55	-6.86	35.63	23.77	41.9	5.00	17.71	0.72	2.55	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			5.93	15.0	17.50	10.26	13.48	8.75	40.5	14.99	6.66	2.16	0.96	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
			7.80	25.0	26.42	17.10	21.12	13.21	38.7	24.99	10.31	3.60	1.48	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GAP039	2-4	NRS	15.00	4.0	18.39	-1.65	14.85	9.19	38.3	4.00	7.22	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.58	1.04
			10.65	8.0	56.45	-13.25	49.47	28.23	34.8	8.00	23.18	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.15	3.34
			12.75	12.0	49.43	-2.90	39.60	24.71	38.6	12.00	19.31	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.73	2.78
GAP062	3-5	Middle Pond A	10.68	9.0	33.66	1.21	24.63	16.83	43.1	9.00	12.29	#N/A	#N/A	#N/A	#N/A	1.30	1.77	#N/A	#N/A	#N/A	#N/A
			9.30	18.0	33.58	7.12	27.69	16.79	37.3	18.00	13.35	#N/A	#N/A	#N/A	#N/A	2.59	1.92	#N/A	#N/A	#N/A	#N/A
			14.78	27.0	53.76	5.94	47.99	26.88	34.1	27.00	22.27	#N/A	#N/A	#N/A	#N/A	3.89	3.21	#N/A	#N/A	#N/A	#N/A
GAP042	13-15	NRS	15.00	-	-	-	-	-	-	15	3.739	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	2.16	0.54
GAP070	6-8	Ash Pond A	15.00	-	-	-	-	-	-	15	5.004	2.16	0.72	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

Calculation Notes AECOM

Subject: CCR Material Characterization

Project Name: TVA GAF EIP

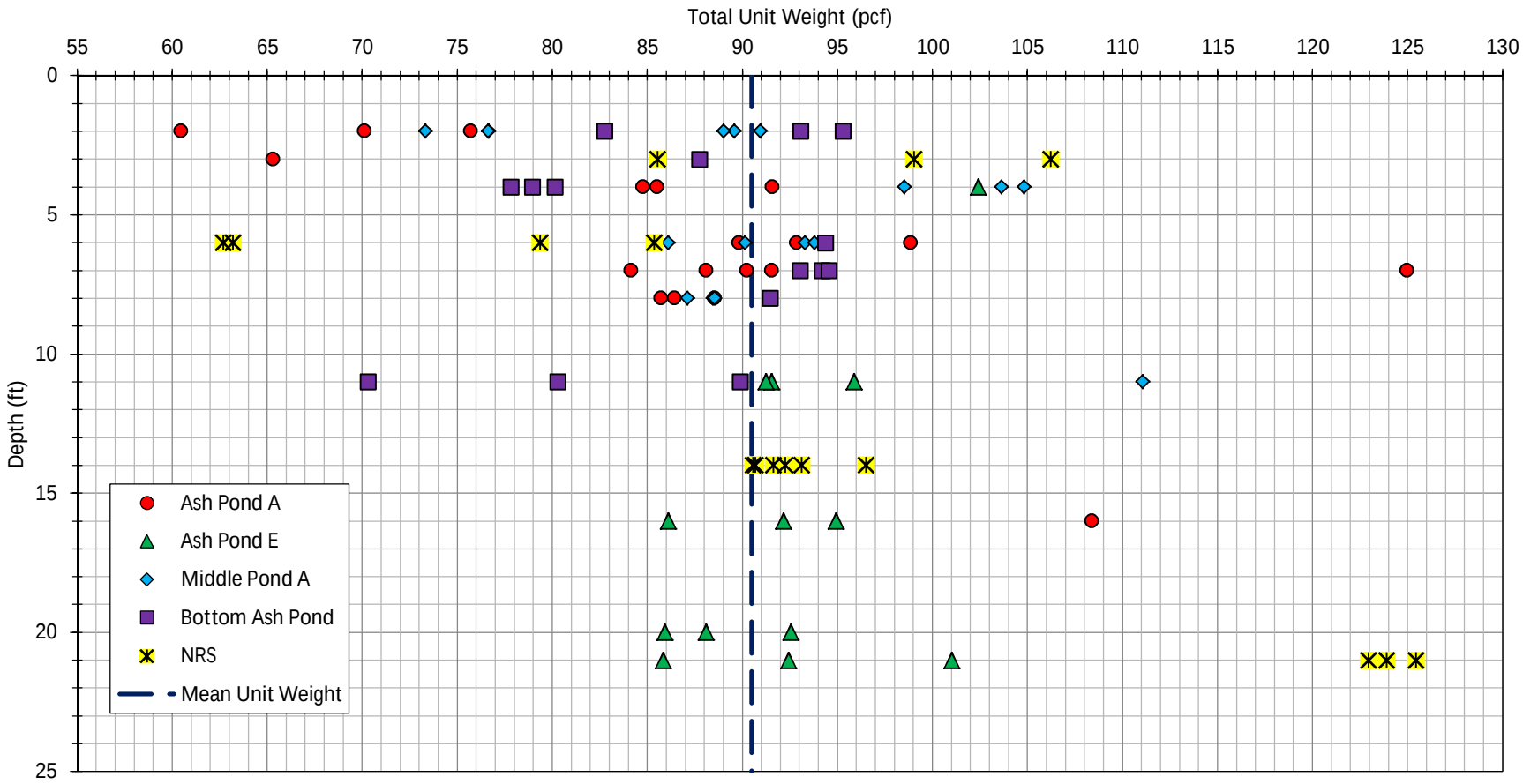
By: Matt Nanak Date: 06/06/2017

Project No: 60513955

Checked By: Lucas Carr Date: 06/06/2017

Task No.: 6

Attachment 4: Total Unit Weight Calculation



Mean Unit Weight	90
Standard Deviation	12.5

Max Unit Weight	125
Min Unit Weight	60

TVA Gallatin	**Total Unit Weight Calculation**	AECOM	**Figure**
Gallatin, TN	**CCR Materials**		**A5**
60513955	**All Ponds**		

PROJECT NAME:	TVA Gallatin
PROJECT LOCATION:	Gallatin, TN
POND NAME:	All Ponds
SECTION:	All Sections
MATERIALS:	CCR Materials
PROJECT NUMBER:	60513955
WORK TITLE:	Total Unit Weight Calculation

AECOM

Total Unit Weight Statistical Data	
Mean	90
Max	125
Min	60
Std Dev	12.5

Revion Log

Rev. No.	Rev By:	Date:	Chck By:	Date:	Description of Revision
0	MJN	4/5/2017			Developed Sheet/Entered data
1	MJN	4/17/2017	LPC	4/17/2017	Added data: CIU GAP039, CDSS, SDSS
2	MJN	4/18/2017	LPC	4/19/2017	Added data: Perm, DS GAP069, CIU GAP062
3					
4					

	Boring ID	Sample Depth ft	Pond	Dry Unit Weight pcf	Moisture Content w%	Total Unit Weight pcf	Ash Pond A Depth ft	Ash Pond A γ_t pcf	Ash Pond E Depth ft	Ash Pond E γ_t pcf	Middle Pond A Depth ft	Middle Pond A γ_t pcf	Bottom Ash Pond Depth ft	Bottom Ash Pond γ_t pcf	NRS Depth ft	NRS γ_t pcf
From CIU Tests	GAP061	7-9	Ash Pond A	40.9	109.6	86	8	86	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				42	105.8	86	8	86	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				46	92.5	89	8	89	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	GAP062	7-9	Middle Pond A	47.1	87.8	88	#N/A	#N/A	#N/A	#N/A	8	88	#N/A	#N/A	#N/A	#N/A
				47.2	84.6	87	#N/A	#N/A	#N/A	#N/A	8	87	#N/A	#N/A	#N/A	#N/A
				46.4	90.8	89	#N/A	#N/A	#N/A	#N/A	8	89	#N/A	#N/A	#N/A	#N/A
	GAP063	10-12	Ash Pond E	61.6	48.6	92	#N/A	#N/A	11	92	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				45.6	110.3	96	#N/A	#N/A	11	96	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				46.3	97.1	91	#N/A	#N/A	11	91	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	GAP064	5-7	Middle Pond A	54.9	64.2	90	#N/A	#N/A	#N/A	#N/A	6	90	#N/A	#N/A	#N/A	#N/A
				54.3	71.8	93	#N/A	#N/A	#N/A	#N/A	6	93	#N/A	#N/A	#N/A	#N/A
				55.6	68.7	94	#N/A	#N/A	#N/A	#N/A	6	94	#N/A	#N/A	#N/A	#N/A
	GAP065	20-22	Ash Pond E	62	49.1	92	#N/A	#N/A	21	92	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				47.9	79.2	86	#N/A	#N/A	21	86	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				67.9	48.8	101	#N/A	#N/A	21	101	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	GAP068	1-3	Bottom Ash Pond	54.9	50.7	83	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	2	83	#N/A	#N/A
				62.9	51.5	95	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	2	95	#N/A	#N/A
				57.7	61.3	93	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	2	93	#N/A	#N/A
	GAP068	10-12	Bottom Ash Pond	43	63.5	70	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	11	70	#N/A	#N/A
				54.4	47.6	80	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	11	80	#N/A	#N/A
				62.9	42.9	90	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	11	90	#N/A	#N/A
	GAP070	5-7	Ash Pond A	65.3	51.4	99	6	99	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				49.9	80	90	6	90	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				54.2	71.3	93	6	93	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	GAP039	2-4	NRS	75.1	13.9	86	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	3	86
				82.6	19.9	99	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	3	99
				82.4	28.9	106	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	3	106
	GAP062	3-5	Middle Pond A	59.6	65.3	99	#N/A	#N/A	#N/A	#N/A	4	99	#N/A	#N/A	#N/A	#N/A
				67.0	54.7	104	#N/A	#N/A	#N/A	#N/A	4	104	#N/A	#N/A	#N/A	#N/A
				72.0	45.6	105	#N/A	#N/A	#N/A	#N/A	4	105	#N/A	#N/A	#N/A	#N/A
From DS Tests	GAP039	5-7	NRS	49.3	61	79	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6	79
				45.1	39	63	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6	63
				50.2	25.9	63	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6	63
	GAP042	20-22	NRS	104.2	18.9	124	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	21	124
				101.7	20.9	123	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	21	123
				107.3	16.9	125	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	21	125
	GAP062	1-3	Middle Pond A	50.4	45.5	73	#N/A	#N/A	#N/A	#N/A	2	73	#N/A	#N/A	#N/A	#N/A
				51.1	50	77	#N/A	#N/A	#N/A	#N/A	2	77	#N/A	#N/A	#N/A	#N/A
				52.2	46.8	77	#N/A	#N/A	#N/A	#N/A	2	77	#N/A	#N/A	#N/A	#N/A
	GAP063	15-17	Ash Pond E	54.7	68.5	92	#N/A	#N/A	16	92	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				56.6	67.7	95	#N/A	#N/A	16	95	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				46.3	86	86	#N/A	#N/A	16	86	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	GAP064	1-3	Middle Pond A	59.1	51.6	90	#N/A	#N/A	#N/A	#N/A	2	90	#N/A	#N/A	#N/A	#N/A
				54	68.4	91	#N/A	#N/A	#N/A	#N/A	2	91	#N/A	#N/A	#N/A	#N/A
				52	71.2	89	#N/A	#N/A	#N/A	#N/A	2	89	#N/A	#N/A	#N/A	#N/A
	GAP061	3-5	Ash Pond A	56	52.7	86	4	86	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				56	63.5	92	4	92	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				60	41.3	85	4	85	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	GAP065	19-21	Ash Pond E	54.9	68.6	93	#N/A	#N/A	20	93	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				51.8	65.9	86	#N/A	#N/A	20	86	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				52.1	69.1	88	#N/A	#N/A	20	88	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	GAP068	3-5	Bottom Ash Pond	65.4	20.7	79	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	4	79	#N/A	#N/A
				65.2	22.9	80	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	4	80	#N/A	#N/A
				64.9	19.9	78	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	4	78	#N/A	#N/A
	GAP069	6-8	Bottom Ash Pond	70.8	31.4	93	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	7	93	#N/A	#N/A
				67.9	38.7	94	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	7	94	#N/A	#N/A
				65.3	44.8	95	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	7	95	#N/A	#N/A
	GAP070	1-3	Ash Pond A	48.6	55.8	76	2	76	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				38.3	57.9	60	2	60	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				44.1	59	70	2	70	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
From CDSS Tests	GAP070	6-8	Ash Pond A	52.4	74.7	92	7	92	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				48.8	72.4	84	7	84	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				58.5	61.4	94	7	94	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				52.5	71.9	90	7	90	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
				89.4	39.8	125	7	125	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	GAP042	13-15	NRS	87.8	9.9	96	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	14	96
				83.0	9.1	91	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	14	91
				83.9	9.2	92	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	14	92
				81.7	11.0	91	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	14	91
				83.5	10.5	92	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	14	92
From SDSS Tests	GAP042	13-15	NRS	83.9	11	93	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	14	93
	GAP070	6-8	Ash Pond A	59.2	48.8	88	7	88	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
From Perm Tests	GAP061	15-17	Ash Pond A	80.0	35.5	108	16	108	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	GAP070	2-4	Ash Pond A	50.9	28.3	65	3	65	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	GAP063	3-5	Ash Pond E	77.7	31.8	102	#N/A	#N/A	4	102	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	GAP065	25-27	Ash Pond E	81.6	31.9	108	#N/A	#N/A	26	108	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	GAP039	5-7	NRS	59.7	43.0	85	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6	85
	GAP068	7-9	Bottom Ash Pond	73.7	24.1	91	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	8	91	#N/A	#N/A
	GAP069	2-4	Bottom Ash Pond	69.7	25.9	88	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	3	88	#N/A	#N/A
	GAP064	10-12	Middle Pond A	79.9	39.0	111	#N/A	#N/A	#N/A	#N/A	11	111	#N/A	#N/A	#N/A	#N/A
	GAP062	5-7	Middle Pond A	41.2	109.0	86	#N/A	#N/A	#N/A	#N/A	6	86	#N/A	#N/A	#N/A	#N/A
	GAP068	5-7	Bottom Ash Pond	60.6	55.7	94	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6	94	#N/A	#N/A

F.2 – Storm Water Calculations

1 PURPOSE

The purpose of this report is to detail existing conditions of the Ash Pond Complex (APC) at the Tennessee Valley Authority's (TVA) Gallatin Fossil Plant (GAF).

2 SITE AND PROJECT DESCRIPTION

GAF is located on approximately 1,950 acres of land situated on the north bank of the Cumberland River in north-central Tennessee at 1499 Steam Plant Road, Gallatin, Sumner County. The APC covers an area of approximately 435 acres and contains approximately 11.9 million cubic yards (cy) of coal combustion residuals (CCR). The APC consists of the Bottom Ash Pond, Middle Pond A, Ash Pond A, Ash Pond E, and Stilling Ponds B, C, and D as shown in **Figure 1.**

An existing conditions hydrology model was created as part of the draft submittal for the APC. The model includes all watersheds that currently drain into the APC and provides hydrologic data and stormwater volumes for the 24-hr/25-year storm event. Refer to **Figure 2** for a depiction of the existing watersheds.

The following sections summarize the existing infrastructure and results of the hydrology modeling.

3 EXISTING HYDROLOGY

The APC watershed consists of approximately 4,000 acres, most of which are located outside the TVA GAF property boundary. Because all plant flows were directed to a treatment facility as of June 2019, the only water still entering the APC is stormwater. Refer to **Attachment A**, the HydroCAD model routing diagram for a depiction of the flow network.

3.1 Ash Pond A

All drainage areas that flow into Ash Pond A are denoted with an "A" subcatchment label. Ash Pond A watershed, labeled A1, consists of 320 acres of CCR, forested areas, and water surface; this watershed includes Ash Pond A, Middle Pond A, and the Bottom Ash Pond. The flow path is generally towards the northeast boundary between Pond A and Stilling Pond B, where the Ash Pond A spillway is located. Ash Pond A, and the associated storage volume, is labeled Pond A in the model.

Other areas that flow to Ash Pond A are West Rail Loop 1 and 2, labeled A3 and A2. These are heavily forested areas that drain to low areas on the south side of the Haul Road with a combined acreage of 123 acres. West Rail Loop 1, A3, drains to a low area labeled PA3; West Rail Loop 2, A2, drains to a low area labeled PA2. From the low areas, stormwater is conveyed under the Haul Road through culverts. Refer to **Section 4** for a list of all APC culverts. The flow path from West Rail Loop 1 and 2 is generally to the north where it joins with the Ash Pond A flow path.

3.2 Stilling Pond B/C

All drainage areas that flow directly into Stilling Pond B/C are denoted with a "BC" subcatchment label. Stilling Ponds B/C are combined as one waterbody because there is no outlet structure between them, and they operate as one pool. Stilling Pond B/C watershed, labeled BC1, consists of 99 acres of water surface, forested areas, roads, and grass. The flow path is generally towards the west where the spillway into Stilling Pond D is located. Stilling Pond B/C, and the associated storage volume, is labeled Pond BC in the model. Refer to **Section 5** for more information on existing spillway structures.

The North Rail Loop Landfill (NRL) stormwater drains to two sediment basins and is then pumped to Stilling Pond B. The NRL watersheds, labeled as BC2 and BC3, consist of 90 acres of landfill vegetated cover. Watershed NRL 1, labeled BC2, drains to a sediment basin labeled PBC2; watershed NRL 2, labeled BC3, drains to a sediment basin labeled PBC3. The flow path of the forcemain from the sediment basins is to the north, between Ash Pond A and Steam Plant Road.

The farmland north of GAF is the largest watershed into the APC. The northernmost farmland watershed, labeled BC4, consists of 2315 acres of row crops. This watershed drains to a large low area, labeled PBC4, and from there it flows through a grate inlet and to a culvert under Steam Plant Road to discharge into Stilling Pond B/C.

To the south of BC4, there is a 559-acre watershed of row crops and woods labeled BC5. This watershed drains to a pond north of Stilling Pond B/C labeled PBC5. This pond is connected to Stilling Pond B/C by several culverts.

To the south of BC5, there is an 82-acre watershed of row crops and woods labeled BC6. This watershed drains to the lowlands north of Stilling Pond B/C. The lowlands are labeled as PBC6 in the model and overtop an earthen embankment to flow into Stilling Pond B/C.

3.3 Ash Pond E

The drainage area that flows to Ash Pond E is labeled E1. This watershed consists of 146 acres of CCR and water surface. The flow path is generally towards the north boundary between Ash Pond

E and Stilling Pond C, where the Ash Pond E spillway is located. Ash Pond E, and the associated storage volume, is labeled Pond E.

3.4 Stilling Pond D

All drainage areas that flow directly to Stilling Pond D are denoted with "D" subcatchment label. Stilling Pond D watershed, labeled D1, consists of 89 acres of water surface, forested areas, roads, and grass. The flow path is generally towards the west boundary between Stilling Pond D and the Cumberland River, where the Stilling Pond D spillway is located (Outfall 001). Stilling Pond D, and the associated storage volume, is labeled Pond D in the model.

The second drainage area that discharges directly into Stilling Pond D is row crops and woods to the north of Stilling Pond D, labeled D2. This 230-acre watershed flows to a low area labeled PD2. From there it overflows into a series of channels that connect directly to the Cumberland River, labeled 1R and 2R. This low area can overtop into Stilling Pond D as well, but only occurs during high rainfall.

4 EXISTING CULVERTS AND SPILLWAY STRUCTURES

Refer to **Table 1** for a summary of all stormwater culverts and spillway culverts at the APC; the culvert labels correspond to the labels on **Drawing 10W272-02**.

Table 1. APC Stormwater Culverts and Ash Pond Spillway Culverts

10W272-02 Label	HydroCAD Node	Culvert Size (in)	No. of Pipes	Inlet Invert	Outlet Invert
C1	PA3	24	4	469.7	468.57
C2	PA2	36	3	473.42, 473.30, 473.29	472.25, 472.16, 471.53
C3	PBC2	24	2	475.99, 485.95	473.86, 474.64
C4	PBC3	24	2	476.03, 485.45	473.72, 474.40
C5	PBC4	42	1	450.0	450.0
C6	PBC5	64x43 arch	2	457.0	456.07
C7	PBC5	24	1	452.0	451.8
Spillway	Pond A	30	3	451.5	451.0
Spillway	Pond D	36	4	447.53	447.0
Spillway	Pond D	36	4	448.48	447.0
Spillway	Pond E	30	2	455.0	454.0

4.1 Ash Pond A Spillway

Details for the Ash Pond A spillway structure and siphons are located on **Drawing 10W272-14**. Morning glory spillways connect to three culverts that discharge to Stilling Pond B under the access road. There is also a siphon system in place for additional drawdown.

4.2 Stilling Pond B & C Spillway

The discharge structure between Stilling Pond C and Stilling Pond D is a rock check dam, modeled as a broad crested weir. There are no engineering details of this overflow structure included in the APC drawings.

4.3 Ash Pond E Spillway

A detail for the Ash Pond E spillway structure is located on **Drawing 10W272-14**. Skimmer plates are connected to riser structures that discharge to two culverts under the access road into Stilling Pond C.

4.4 Stilling Pond D Spillway

Details for the Ash Pond D primary and secondary spillway structure are located on **Drawing 10W272-15**. The primary spillway includes skimmer plates connected to an outlet structure that discharges to four culverts under the access road and then the Cumberland River. The secondary spillway consists of morning glory spillways connected to four culverts that discharge under the access road to the Cumberland River. The secondary spillway is for additional discharge capacity during large storm events.

5 PROCEDURE

The AutoCAD Civil 3D software package was used to assess existing site grading and subsequently to determine drainage areas, volumes, and other site geometry. HydroCAD (10.00-22) modeling software was used to conduct the hydrologic and hydraulic calculations for this analysis with inputs based on the site geometry, rainfall data, and other design assumptions.

The model was used to generate surface water volumes and peak water surface elevations for existing conditions of the APC for the 24-hr/25-year storm event.

6 NOTES/ASSUMPTIONS

The following is a list of key notes and assumptions made in completing this analysis.

- Within the HydroCAD program, the runoff was calculated using the SCS TR-20 method.
- Runoff curve numbers (CN) used in the analysis were as follows:
  - 73 for wooded areas,
  - 74 for landfill vegetated cover and grassed slopes,
  - 79 for row crops,
  - 82 for roads with grassed shoulders,
  - 95 for ash surface (CCR), and
  - 98 for water surface.
- The time of concentration was calculated using the Curve Number Method in HydroCAD which takes inputs for each drainage area of the longest hydraulic flow path and average land slope.

7 SUMMARY OF RESULTS

The results of the existing conditions are summarized in **Table 2** (see also **Attachment B** for the HydroCAD output report).

Table 2. Existing Hydrology Results

	Ash Pond A	Ash Pond E	Stilling Pond B/C	Stilling Pond D
Starting WSE (ft)	453.0	449.0	456.0	456.0
Lowest Spillway Invert (ft)	463.62	459.42	456.0	456.0
Peak WSE (ft)	463.45	455.49	457.23	457.17
Primary Spillway Peak Flow (cfs)	0	0	161.14	116.93
Secondary Spillway Peak Flow (cfs)	n/a	n/a	n/a	44.30
Total Volume Inflow (af)	159	64	196	200
Total Volume Inflow (MG)	51.8	20.9	63.9	65.2
Total Volume Outflow (af)	0	0	195	199
Total Volume Outflow (MG)	0	0	63.5	64.8

8 ATTACHMENTS

Figures:

Figure 1: Site Map

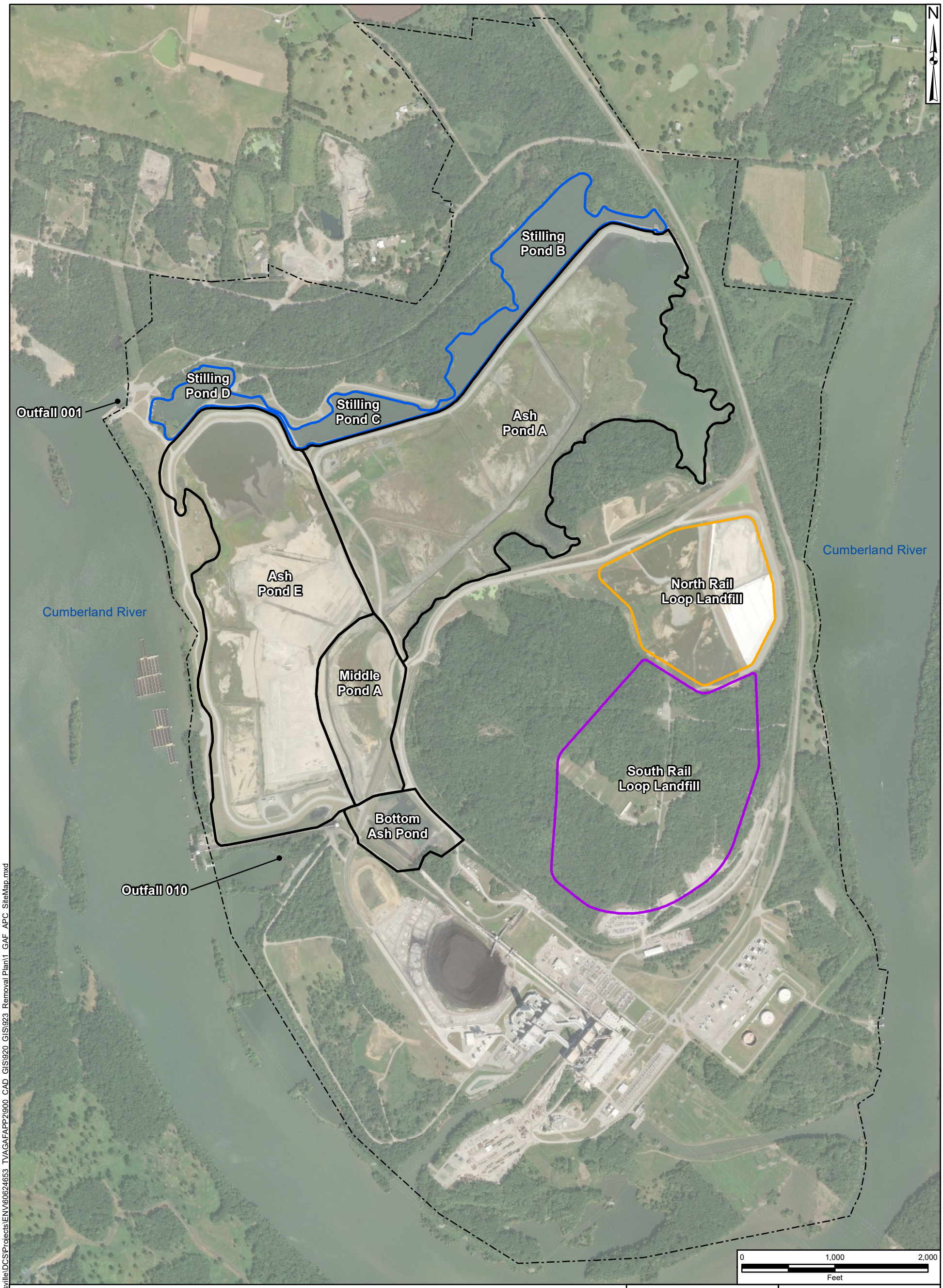
Figure 2: Watershed Map: Existing Conditions

Attachments:

Attachment A: HydroCAD Routing Diagram

Attachment B: HydroCAD report for 24-hour, 25-year storm

FIGURES



LEGEND

- North Rail Loop Landfill
- South Rail Loop Landfill
- Ash Ponds
- Stilling Ponds
- TVA Gallatin Fossil Plant Property Boundary (Approximate)

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

AECOM

Figure 1

SITE MAP

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
J.COLLEY	D.SKEGGS	-	REV. 0

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
FEB 2020	FOSSIL AND HYDRO ENGINEERING

Document Path: \\morrisville.na.aecomnet.com\Morrisville\DCS\Projects\ENV\60624653_TVAGAFAPP2\900_CAD_GIS\920_GIS\923_Removal Plan\1_GAF_APC_SiteMap.mxd

LEGEND

XX SUBCATCHMENT NO.

WATERSHED BOUNDARY

TIME OF CONCENTRATION FLOWPATH

APPROXIMATE POND AREA

0 750 1,500

SCALE: 1"=1,500"

AECOM

GALLATIN FOSSIL PLANT

TENNESSEE VALLEY AUTHORITY

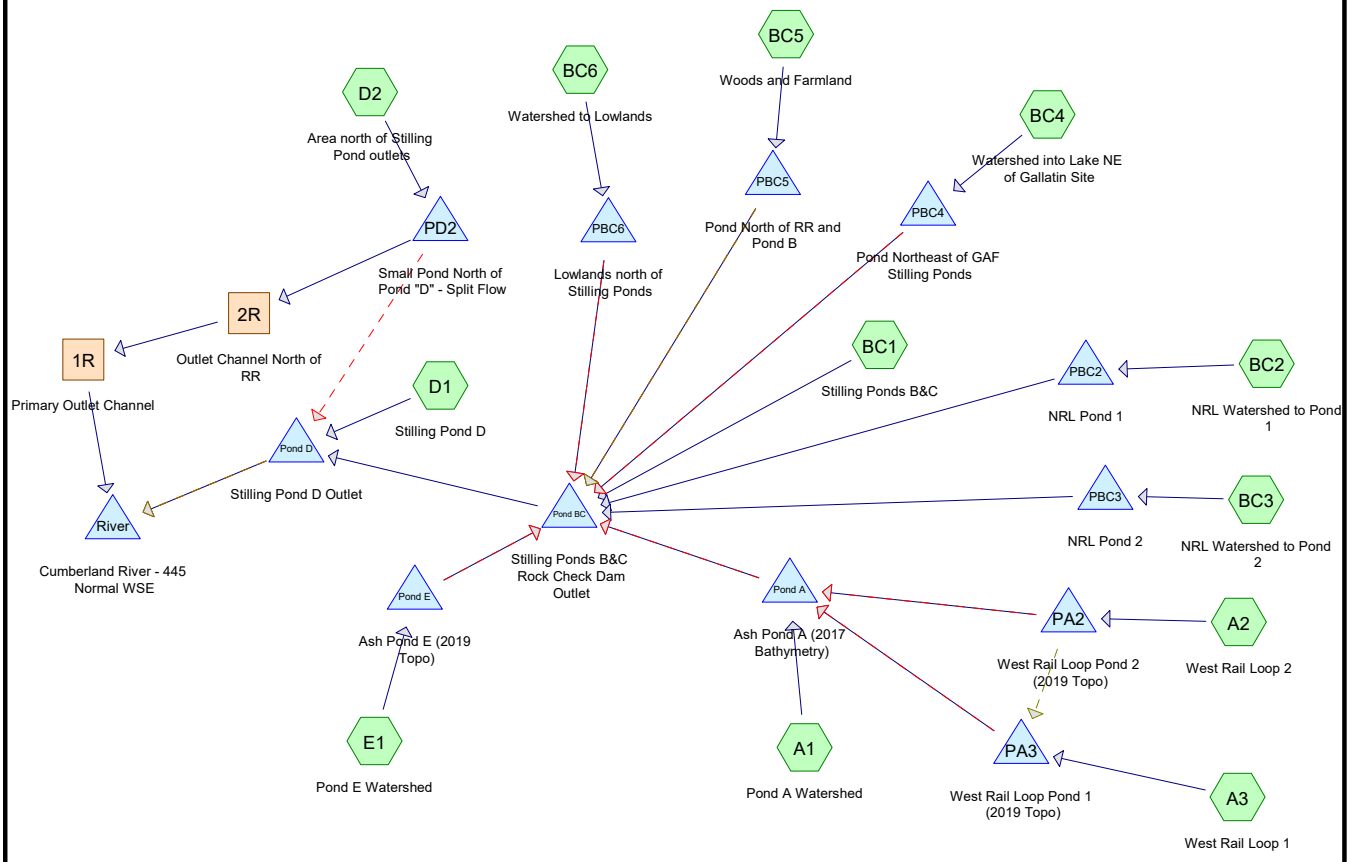
GAF POND COMPLEX WATERSHED EXISTING CONDITIONS

DRAWN BY:	CHECKED BY:	PROJECT No:	DATE:	FIGURE No:
RLP	DES	60624653	06/2020	2

C:\Users\rebekah.pomohaci\Documents\Project Files\60624653_TVAGAFAPP2\400_Technical\GAF Tributary Boundaries_Updated.dwg User:Rebekah.Pomohaci Jun 17, 2020 – 11:36am

ATTACHMENTS

Attachment A
HydroCAD Routing Diagram



Subcat Reach Pond Link

Routing Diagram for Ash Pond Complex Hydrology_Existing
Prepared by AECOM, Printed 6/23/2020
HydroCAD® 10.00-22 s/n 05704 © 2018 HydroCAD Software Solutions LLC

Attachment B
HydroCAD 24-hr/25-yr Storm Event

Summary for Subcatchment A1: Pond A Watershed

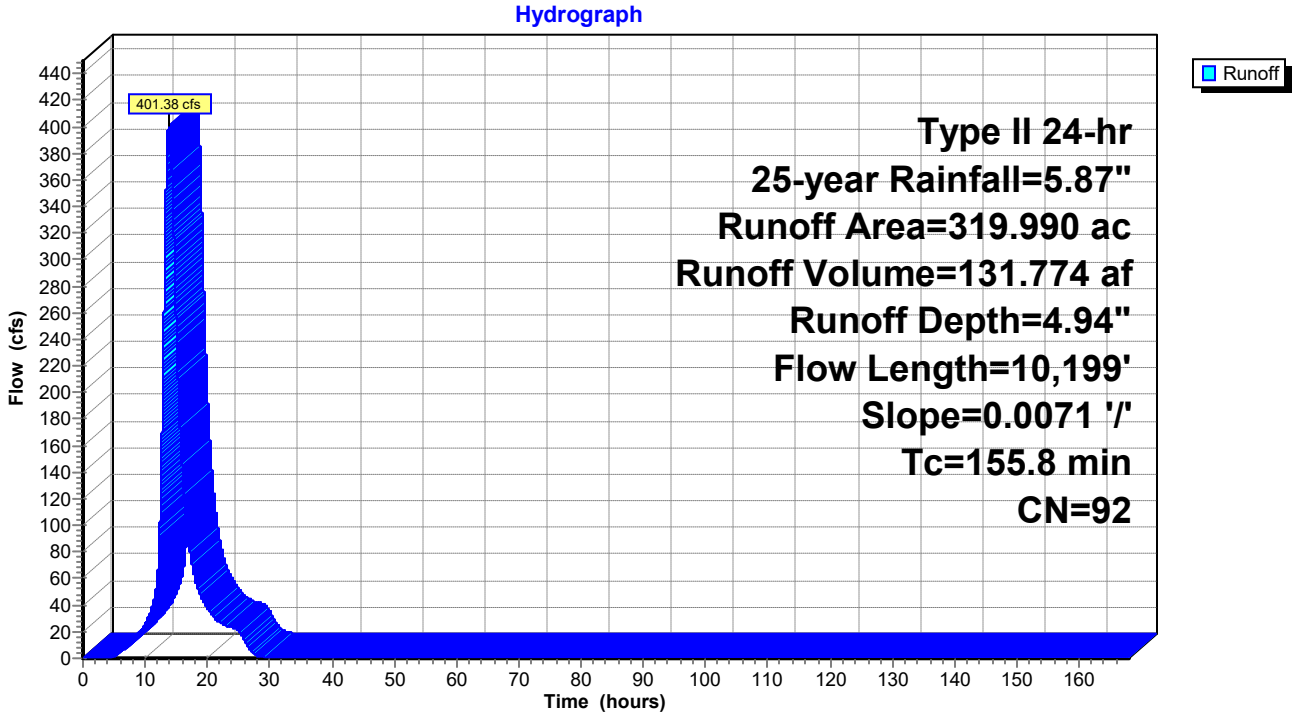
Runoff = 401.38 cfs @ 13.85 hrs, Volume= 131.774 af, Depth= 4.94"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=5.87"

	Area (ac)	CN	Description
*	244.680	95	Ash Surface
	47.390	73	Woods, Fair, HSG C
*	27.920	98	Pond A WS elev 494
	319.990	92	Weighted Average
	292.070		91.27% Pervious Area
	27.920		8.73% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
155.8	10,199	0.0071	1.09		**Lag/CN Method, Overland flow**

Subcatchment A1: Pond A Watershed



Summary for Subcatchment A2: West Rail Loop 2

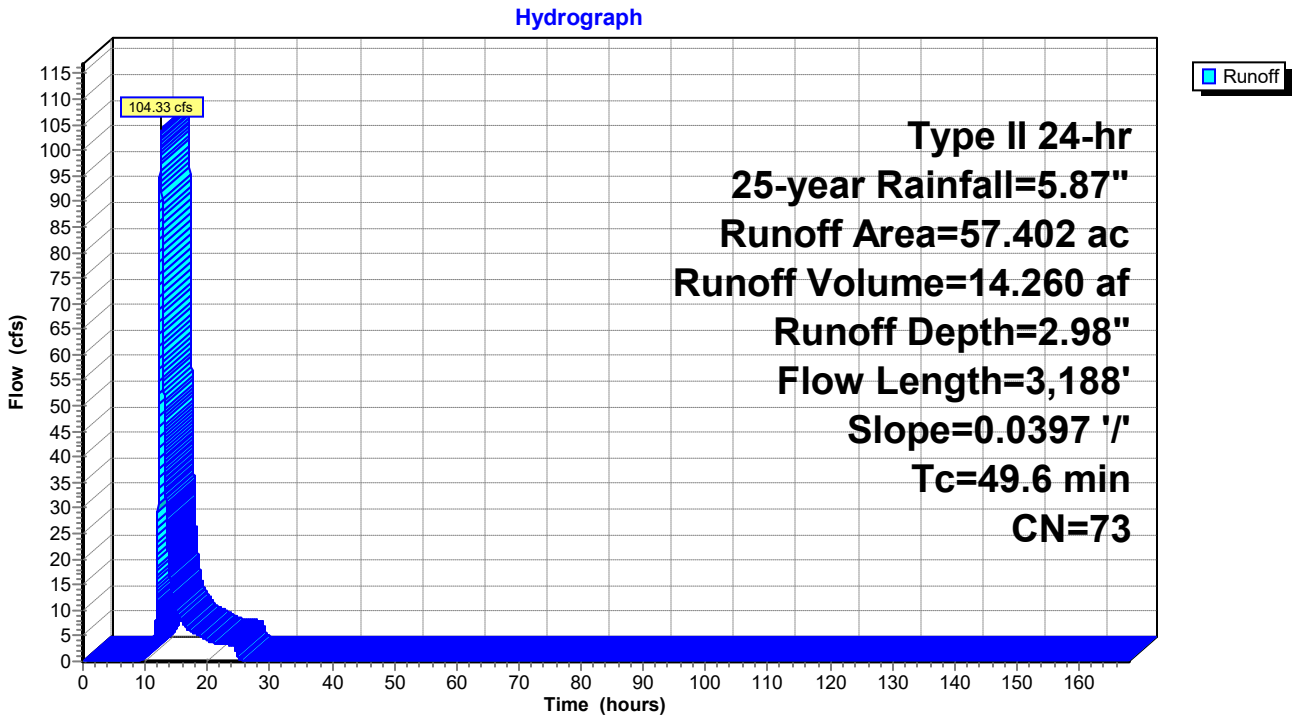
Runoff = 104.33 cfs @ 12.51 hrs, Volume= 14.260 af, Depth= 2.98"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=5.87"

Area (ac)	CN	Description
57.402	73	Woods, Fair, HSG C
57.402		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
49.6	3,188	0.0397	1.07		**Lag/CN Method,**

Subcatchment A2: West Rail Loop 2



Summary for Subcatchment A3: West Rail Loop 1

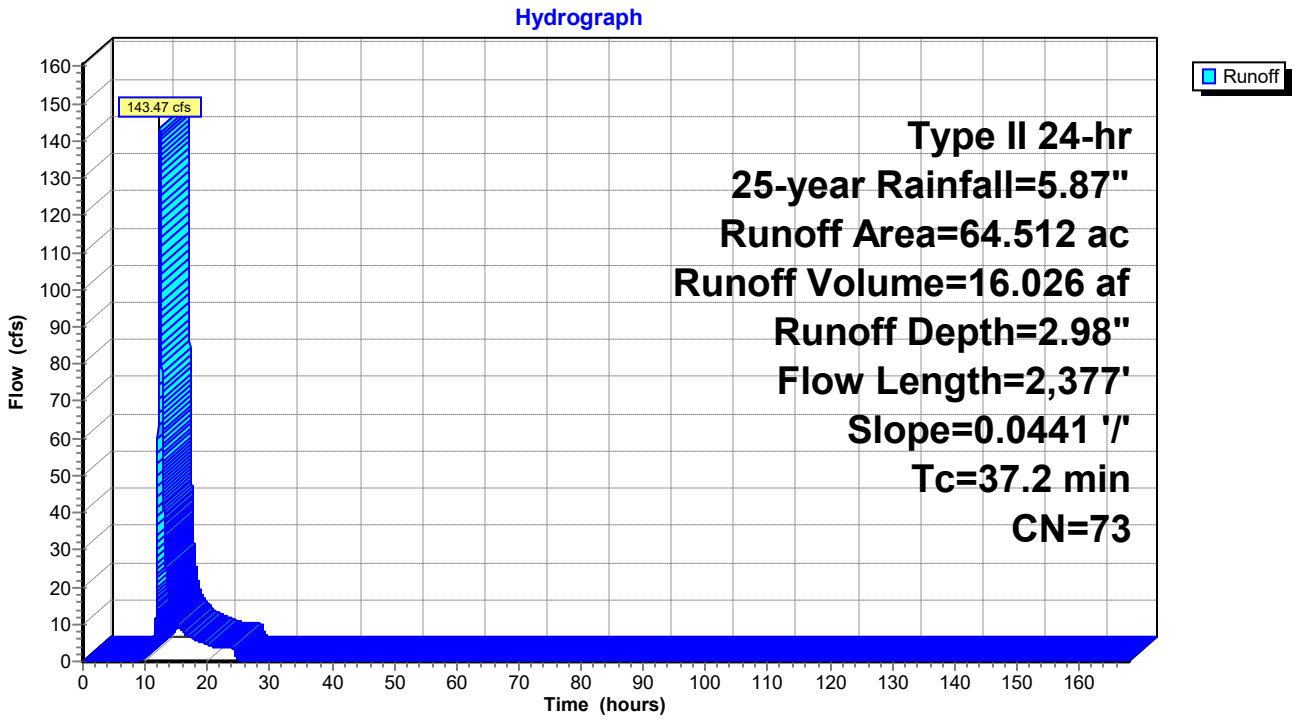
Runoff = 143.47 cfs @ 12.35 hrs, Volume= 16.026 af, Depth= 2.98"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=5.87"

Area (ac)	CN	Description
64.512	73	Woods, Fair, HSG C
64.512		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
37.2	2,377	0.0441	1.07		**Lag/CN Method,**

Subcatchment A3: West Rail Loop 1



Summary for Subcatchment BC1: Stilling Ponds B&C

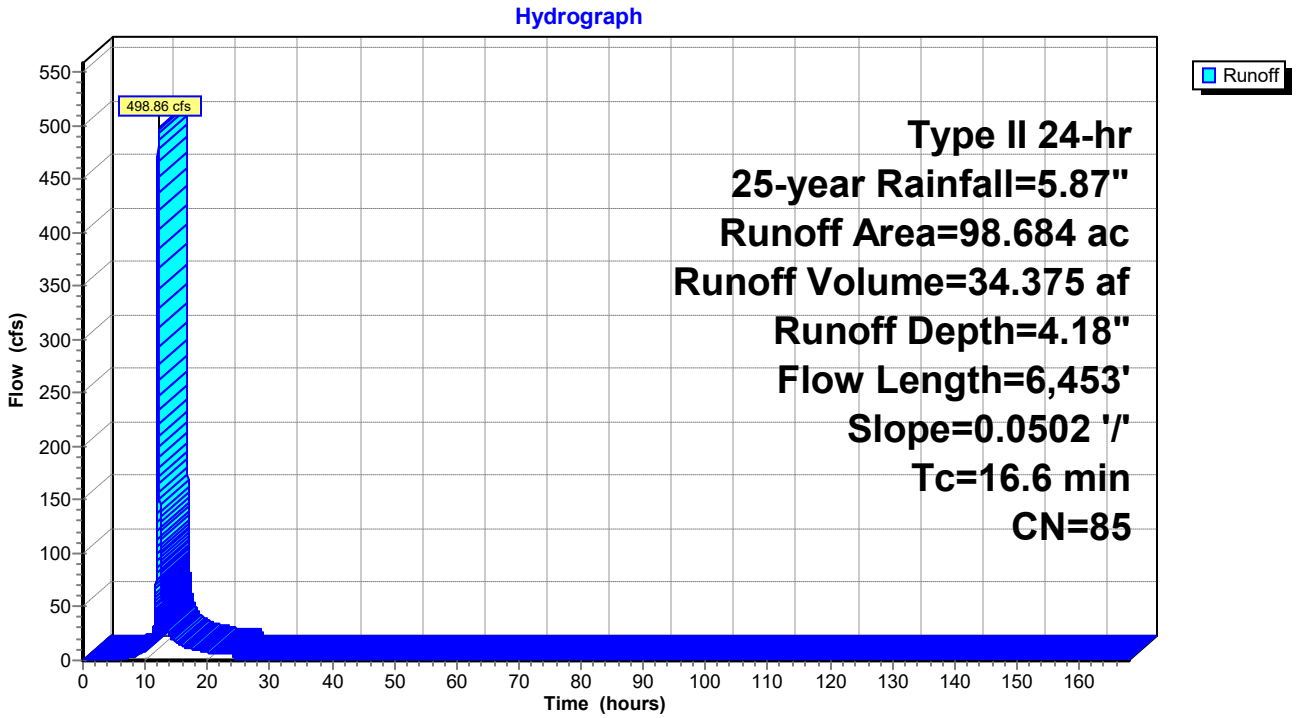
Runoff = 498.86 cfs @ 12.08 hrs, Volume= 34.375 af, Depth= 4.18"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=5.87"

	Area (ac)	CN	Description
*	39.414	98	Water Surface
*	16.910	82	Roads/Grass
	42.360	73	Woods, Fair, HSG C
	98.684	85	Weighted Average
	59.270		60.06% Pervious Area
	39.414		39.94% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.7	5,855		12.69		**Lake or Reservoir,** Mean Depth= 5.00'
8.9	598	0.0502	1.12		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
16.6	6,453	Total			

Subcatchment BC1: Stilling Ponds B&C



Summary for Subcatchment BC2: NRL Watershed to Pond 1

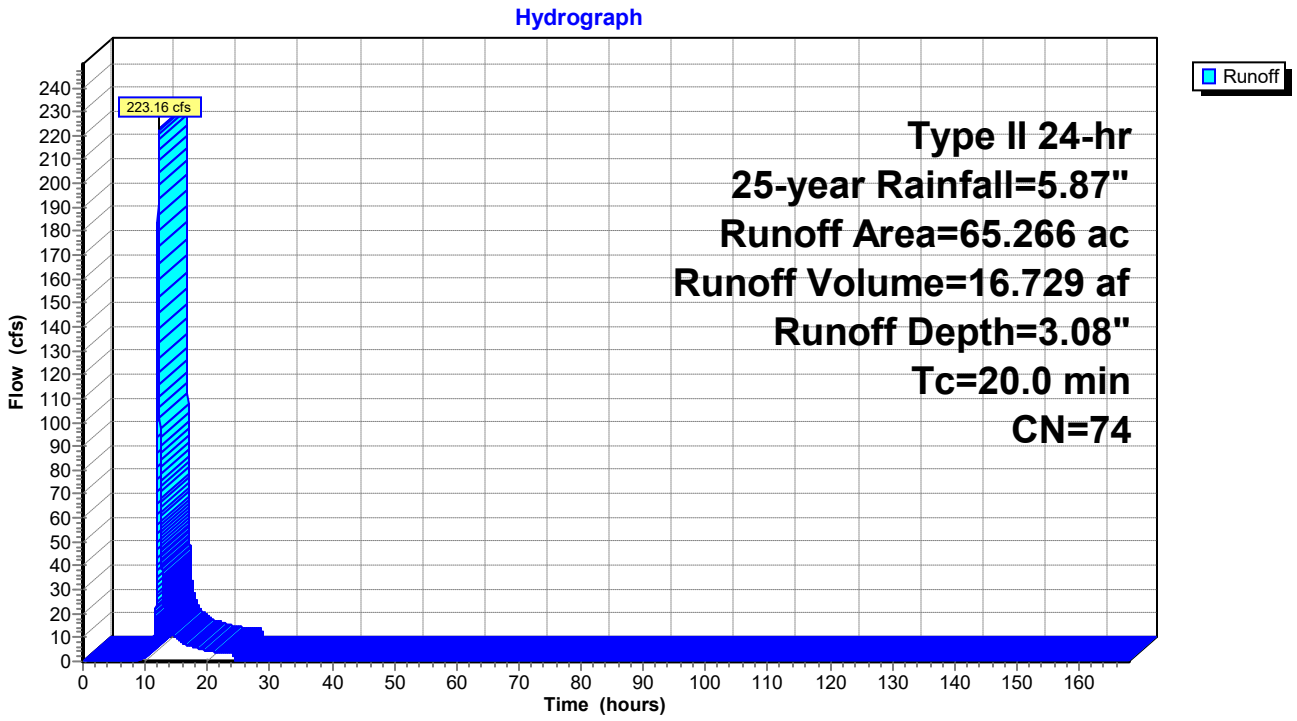
Runoff = 223.16 cfs @ 12.13 hrs, Volume= 16.729 af, Depth= 3.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=5.87"

	Area (ac)	CN	Description
*	65.266	74	landfill
	65.266		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.0					**Direct Entry,**

Subcatchment BC2: NRL Watershed to Pond 1



Summary for Subcatchment BC3: NRL Watershed to Pond 2

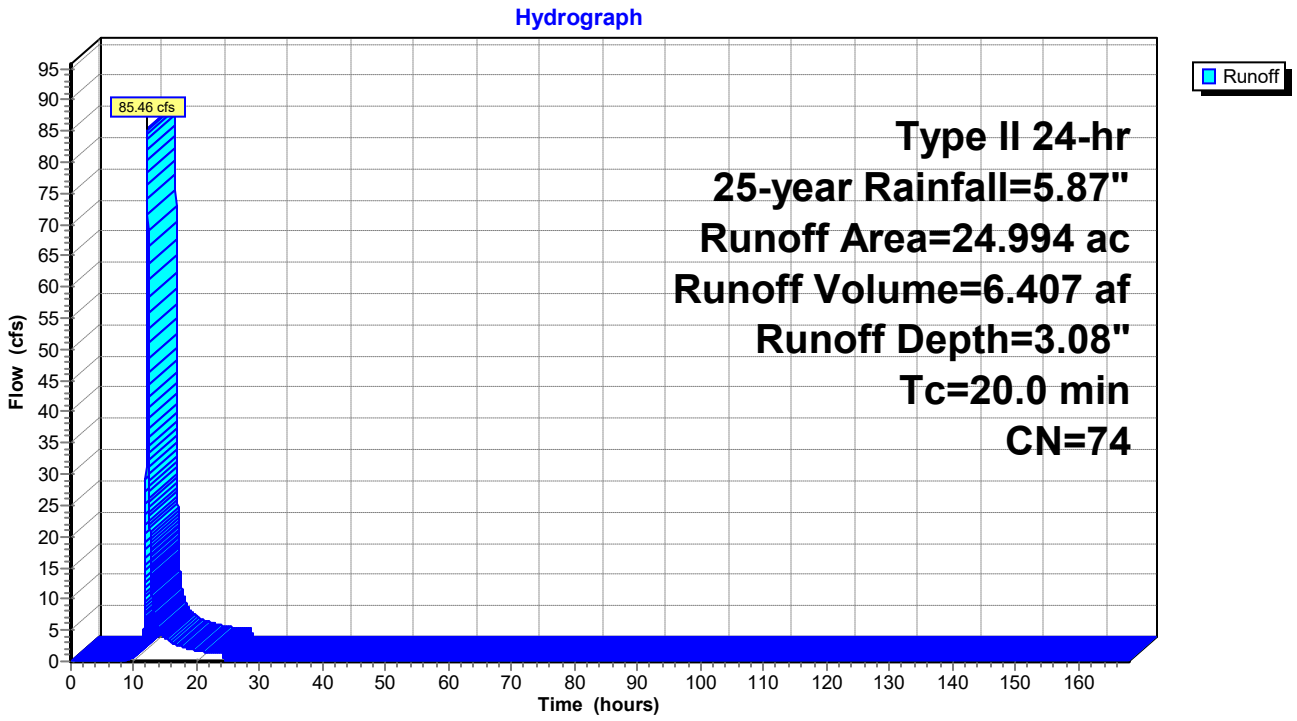
Runoff = 85.46 cfs @ 12.13 hrs, Volume= 6.407 af, Depth= 3.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=5.87"

	Area (ac)	CN	Description
*	24.994	74	landfill
	24.994		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.0					**Direct Entry,**

Subcatchment BC3: NRL Watershed to Pond 2



Summary for Subcatchment BC4: Watershed into Lake NE of Gallatin Site

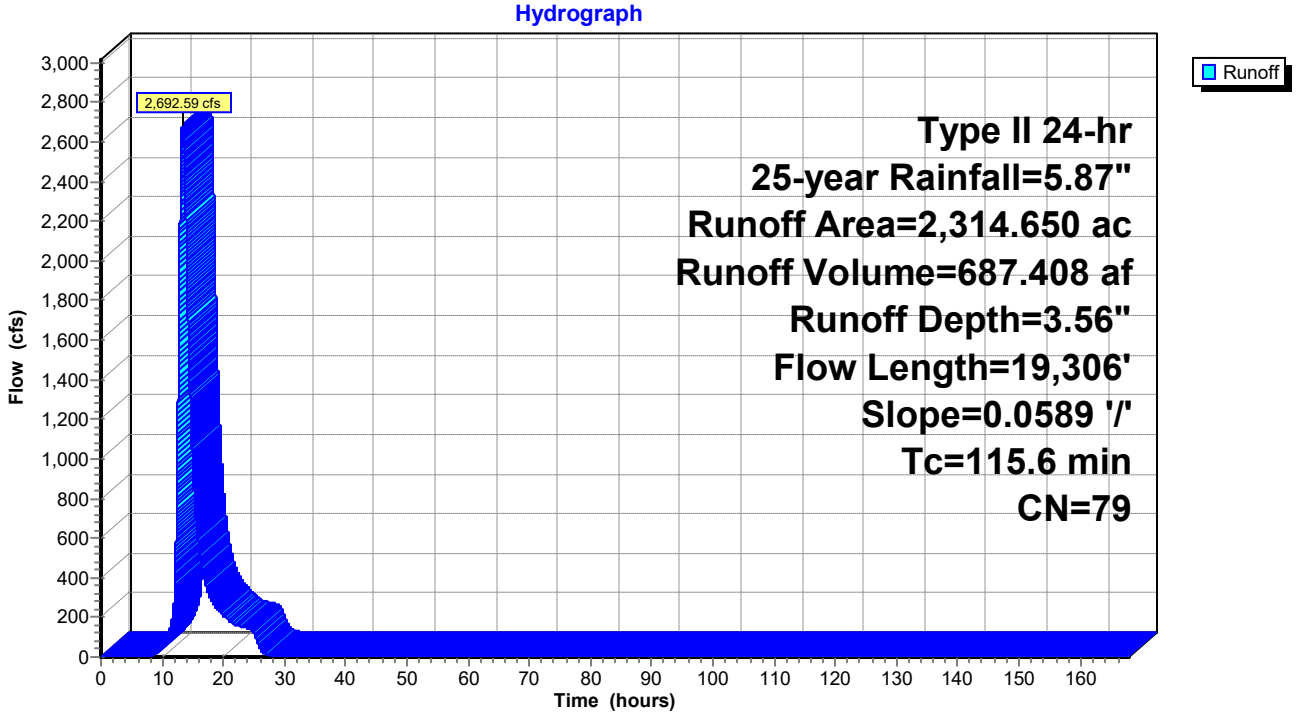
Runoff = 2,692.59 cfs @ 13.36 hrs, Volume= 687.408 af, Depth= 3.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=5.87"

Area (ac)	CN	Description
2,314.650	79	Row crops, C&T + CR, Poor, HSG C
2,314.650		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
109.3	13,656	0.0589	2.08		**Lag/CN Method, Upper**
6.3	5,650		15.01		**Lake or Reservoir, Offsite Lake**
					Mean Depth= 7.00'
115.6	19,306	Total			

Subcatchment BC4: Watershed into Lake NE of Gallatin Site



Summary for Subcatchment BC5: Woods and Farmland

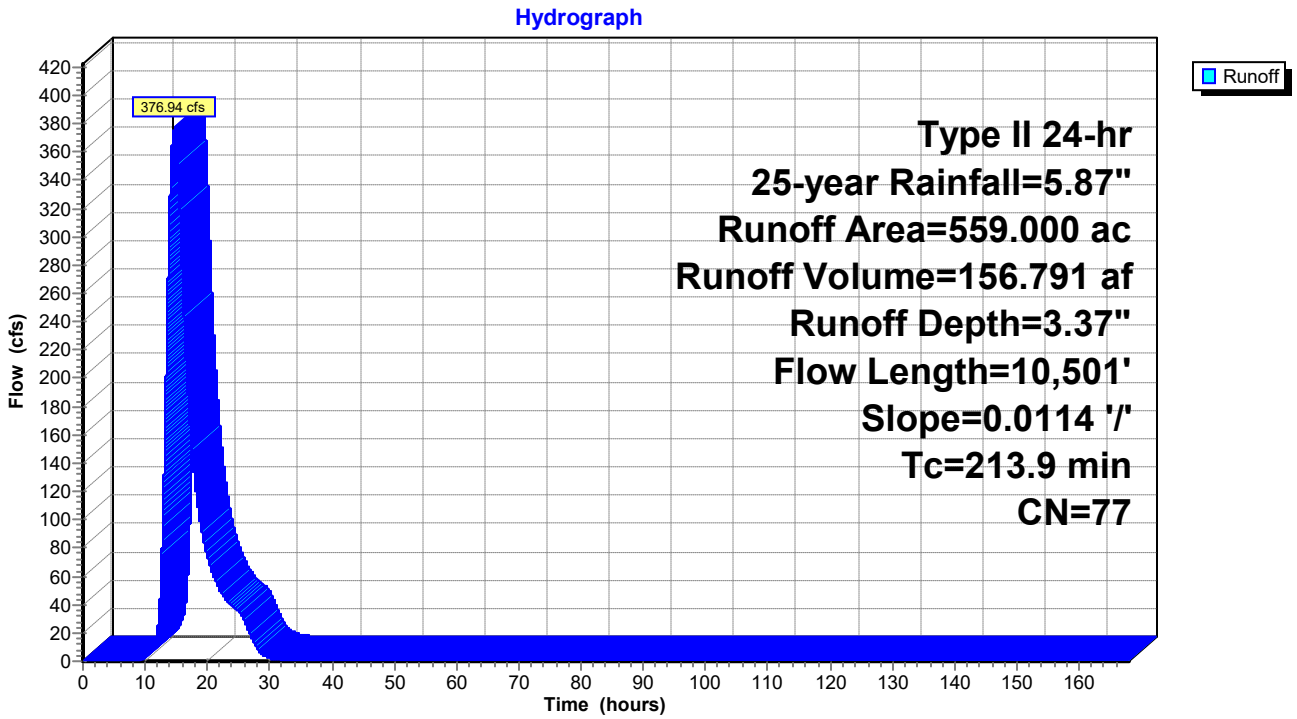
Runoff = 376.94 cfs @ 14.51 hrs, Volume= 156.791 af, Depth= 3.37"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=5.87"

	Area (ac)	CN	Description
*	400.000	79	Row crops, C&T + CR, Poor, HSG C
	159.000	73	Woods, Fair, HSG C
	559.000	77	Weighted Average
	559.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
213.9	10,501	0.0114	0.82		**Lag/CN Method,**

Subcatchment BC5: Woods and Farmland



Summary for Subcatchment BC6: Watershed to Lowlands

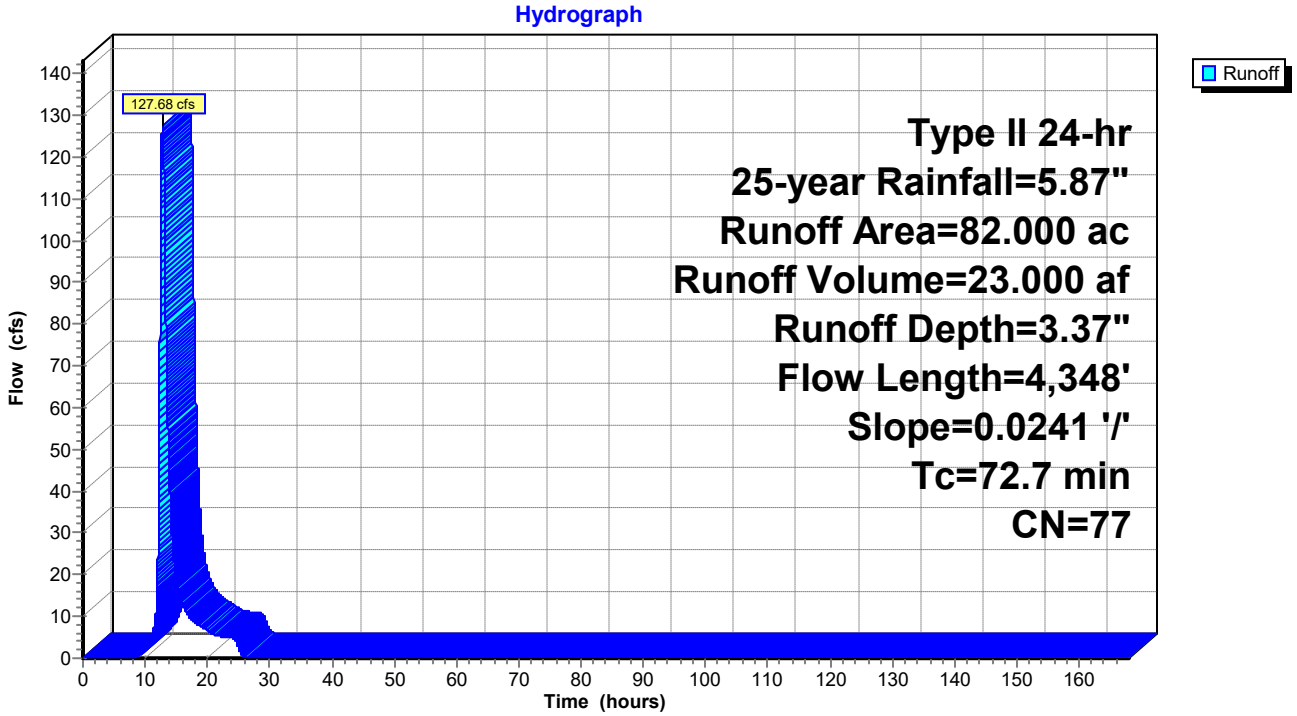
Runoff = 127.68 cfs @ 12.77 hrs, Volume= 23.000 af, Depth= 3.37"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=5.87"

Area (ac)	CN	Description
30.000	73	Woods, Fair, HSG C
52.000	79	Row crops, C&T + CR, Poor, HSG C
82.000	77	Weighted Average
82.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
72.7	4,348	0.0241	1.00		**Lag/CN Method,**

Subcatchment BC6: Watershed to Lowlands



Summary for Subcatchment D1: Stilling Pond D

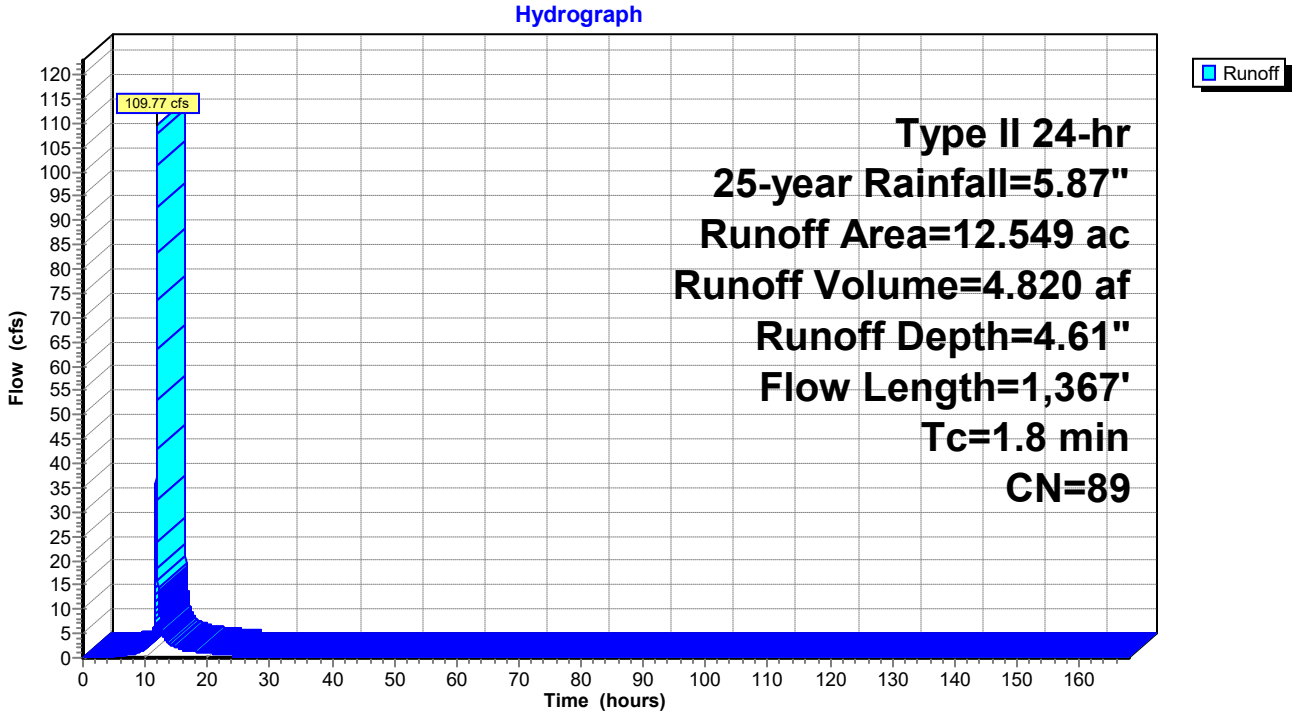
Runoff = 109.77 cfs @ 11.92 hrs, Volume= 4.820 af, Depth= 4.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=5.87"

	Area (ac)	CN	Description
*	7.142	98	Water Surface
*	2.986	82	Roads/Grass
	2.421	73	Woods, Fair, HSG C
	12.549	89	Weighted Average
	5.407		43.09% Pervious Area
	7.142		56.91% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.8	1,367		12.69		**Lake or Reservoir,** Mean Depth= 5.00'

Subcatchment D1: Stilling Pond D



Summary for Subcatchment D2: Area north of Stilling Pond outlets

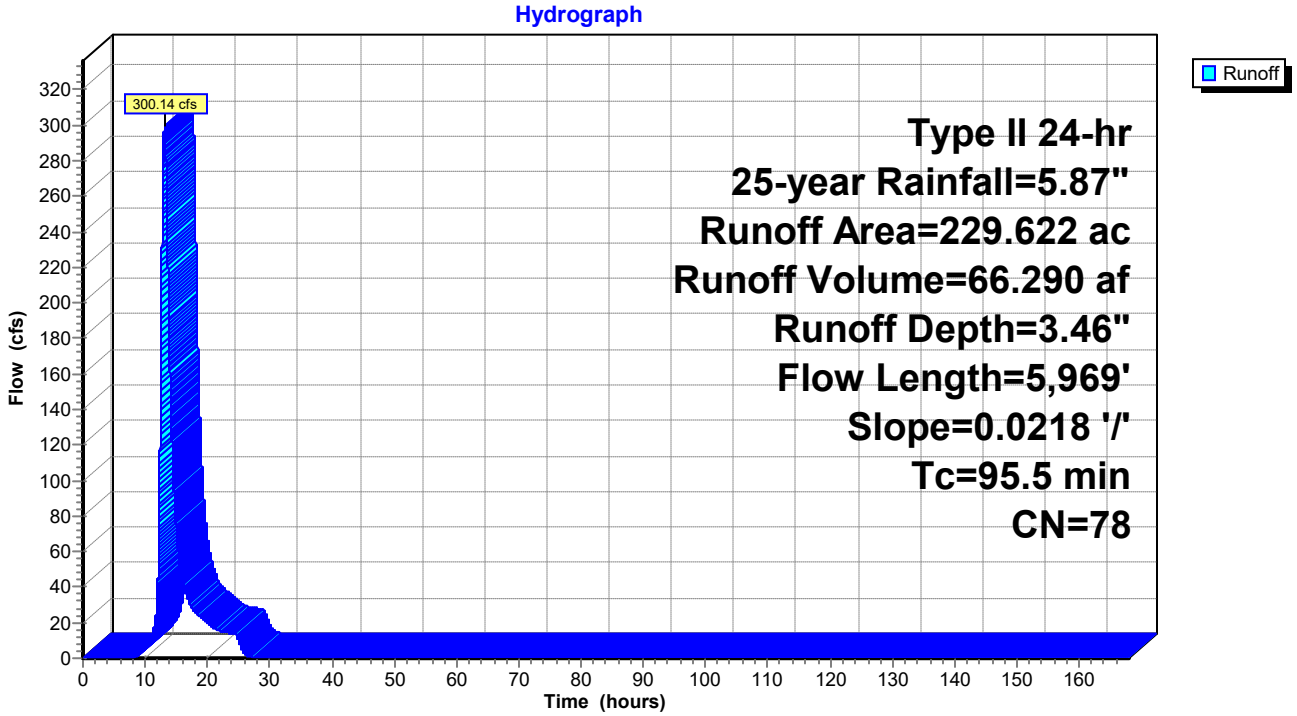
Runoff = 300.14 cfs @ 13.05 hrs, Volume= 66.290 af, Depth= 3.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=5.87"

Area (ac)	CN	Description
38.918	73	Woods, Fair, HSG C
190.704	79	Row crops, C&T + CR, Poor, HSG C
229.622	78	Weighted Average
229.622		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
95.5	5,969	0.0218	1.04		**Lag/CN Method,**

Subcatchment D2: Area north of Stilling Pond outlets



Summary for Subcatchment E1: Pond E Watershed

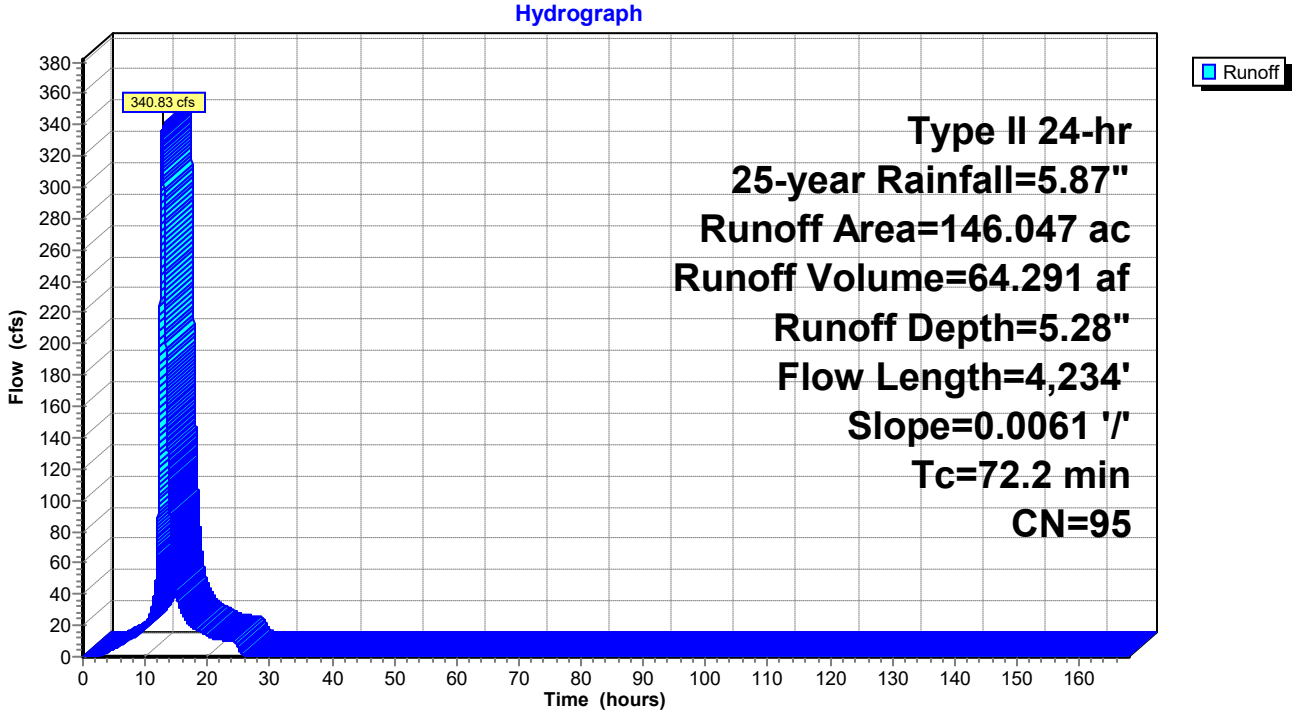
Runoff = 340.83 cfs @ 12.75 hrs, Volume= 64.291 af, Depth= 5.28"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=5.87"

	Area (ac)	CN	Description
*	145.547	95	Ash surface
	0.500	98	Water Surface, HSG A
	146.047	95	Weighted Average
	145.547		99.66% Pervious Area
	0.500		0.34% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
72.2	4,234	0.0061	0.98		**Lag/CN Method,**

Subcatchment E1: Pond E Watershed



Summary for Reach 1R: Primary Outlet Channel

[62] Hint: Exceeded Reach 2R OUTLET depth by 1.17' @ 13.30 hrs

Inflow Area = 229.622 ac, 0.00% Impervious, Inflow Depth = 3.04" for 25-year event
Inflow = 287.71 cfs @ 13.30 hrs, Volume= 58.188 af
Outflow = 287.71 cfs @ 13.30 hrs, Volume= 58.188 af, Atten= 0%, Lag= 0.1 min

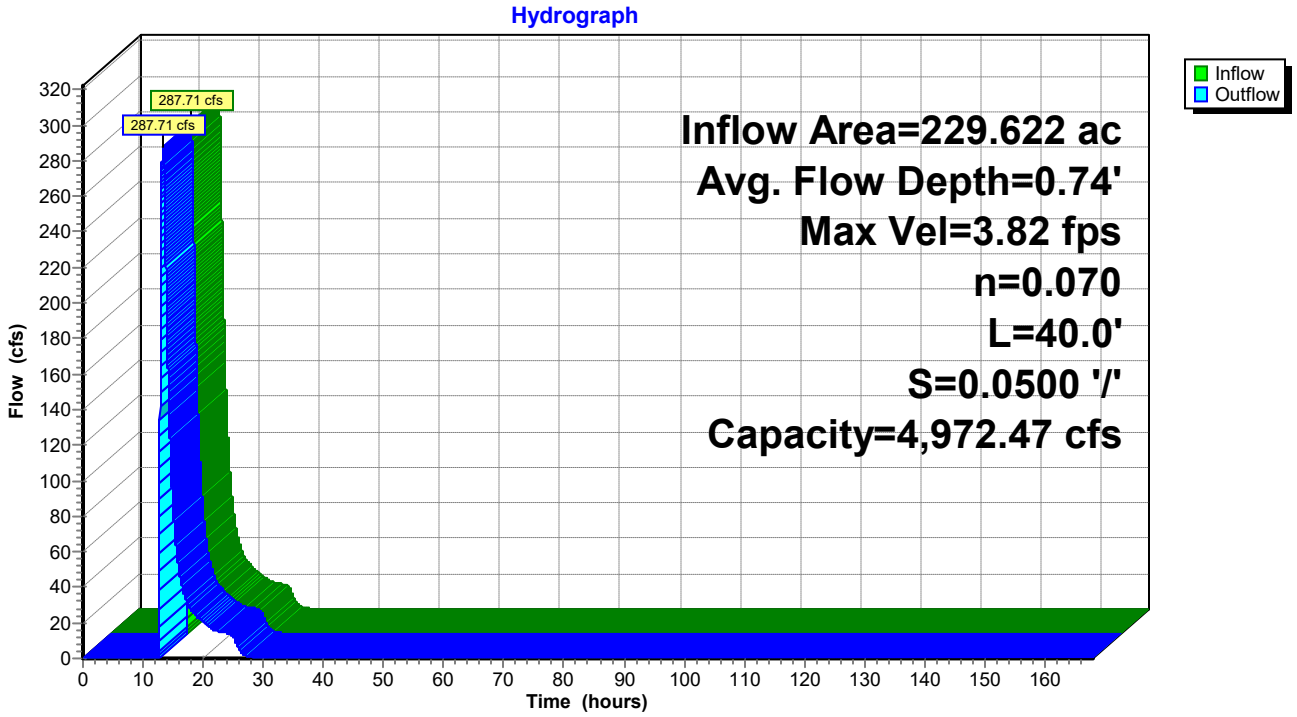
Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Max. Velocity= 3.82 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 0.87 fps, Avg. Travel Time= 0.8 min

Peak Storage= 3,016 cf @ 13.30 hrs
Average Depth at Peak Storage= 0.74'
Defined Flood Depth= 3.00' Flow Area= 327.0 sf, Capacity= 3,045.68 cfs
Bank-Full Depth= 4.00' Flow Area= 448.0 sf, Capacity= 4,972.47 cfs

100.00' x 4.00' deep channel, n= 0.070 Mountain streams w/large boulders
Side Slope Z-value= 3.0 '/' Top Width= 124.00'
Length= 40.0' Slope= 0.0500 '/'
Inlet Invert= 447.00', Outlet Invert= 445.00'

‡

Reach 1R: Primary Outlet Channel



Summary for Reach 2R: Outlet Channel North of RR

Inflow Area = 229.622 ac, 0.00% Impervious, Inflow Depth = 3.04" for 25-year event
Inflow = 287.81 cfs @ 13.28 hrs, Volume= 58.188 af
Outflow = 287.71 cfs @ 13.30 hrs, Volume= 58.188 af, Atten= 0%, Lag= 0.9 min

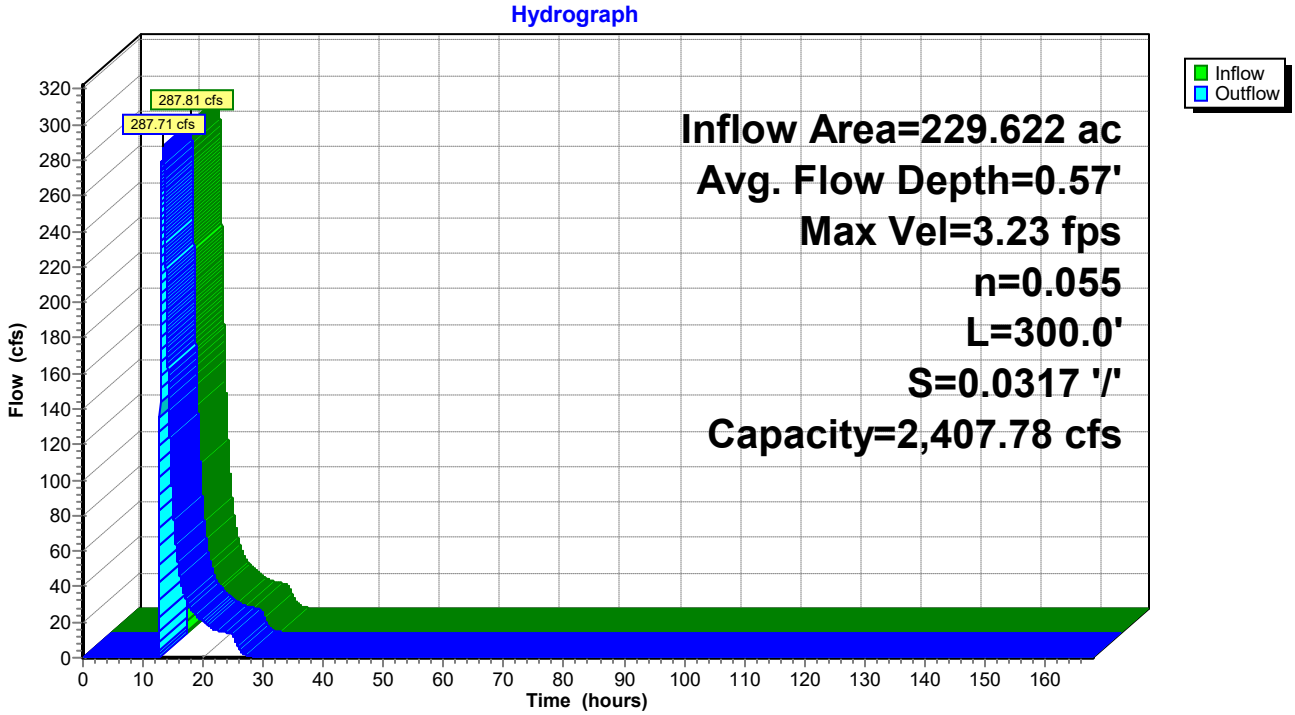
Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Max. Velocity= 3.23 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 0.65 fps, Avg. Travel Time= 7.7 min

Peak Storage= 26,702 cf @ 13.30 hrs
Average Depth at Peak Storage= 0.57'
Bank-Full Depth= 2.00' Flow Area= 340.0 sf, Capacity= 2,407.78 cfs

150.00' x 2.00' deep channel, n= 0.055
Side Slope Z-value= 10.0 '/' Top Width= 190.00'
Length= 300.0' Slope= 0.0317 '/'
Inlet Invert= 455.50', Outlet Invert= 446.00'

‡

Reach 2R: Outlet Channel North of RR



Summary for Pond PA2: West Rail Loop Pond 2 (2019 Topo)

Inflow Area = 57.402 ac, 0.00% Impervious, Inflow Depth = 2.98" for 25-year event
Inflow = 104.33 cfs @ 12.51 hrs, Volume= 14.260 af
Outflow = 21.08 cfs @ 13.68 hrs, Volume= 11.028 af, Atten= 80%, Lag= 70.4 min
Primary = 21.08 cfs @ 13.68 hrs, Volume= 11.028 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 474.47' @ 13.68 hrs Surf.Area= 194,765 sf Storage= 325,224 cf

Plug-Flow detention time= 403.7 min calculated for 11.028 af (77% of inflow)
Center-of-Mass det. time= 312.9 min (1,182.4 - 869.5)

Volume	Invert	Avail.Storage	Storage Description
#1	471.00'	1,404,909 cf	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
471.00	0	0	0
472.00	50,892	25,446	25,446
473.00	95,274	73,083	98,529
474.00	173,266	134,270	232,799
475.00	218,873	196,070	428,869
476.00	292,017	255,445	684,314
477.00	357,159	324,588	1,008,902
478.00	434,856	396,008	1,404,909

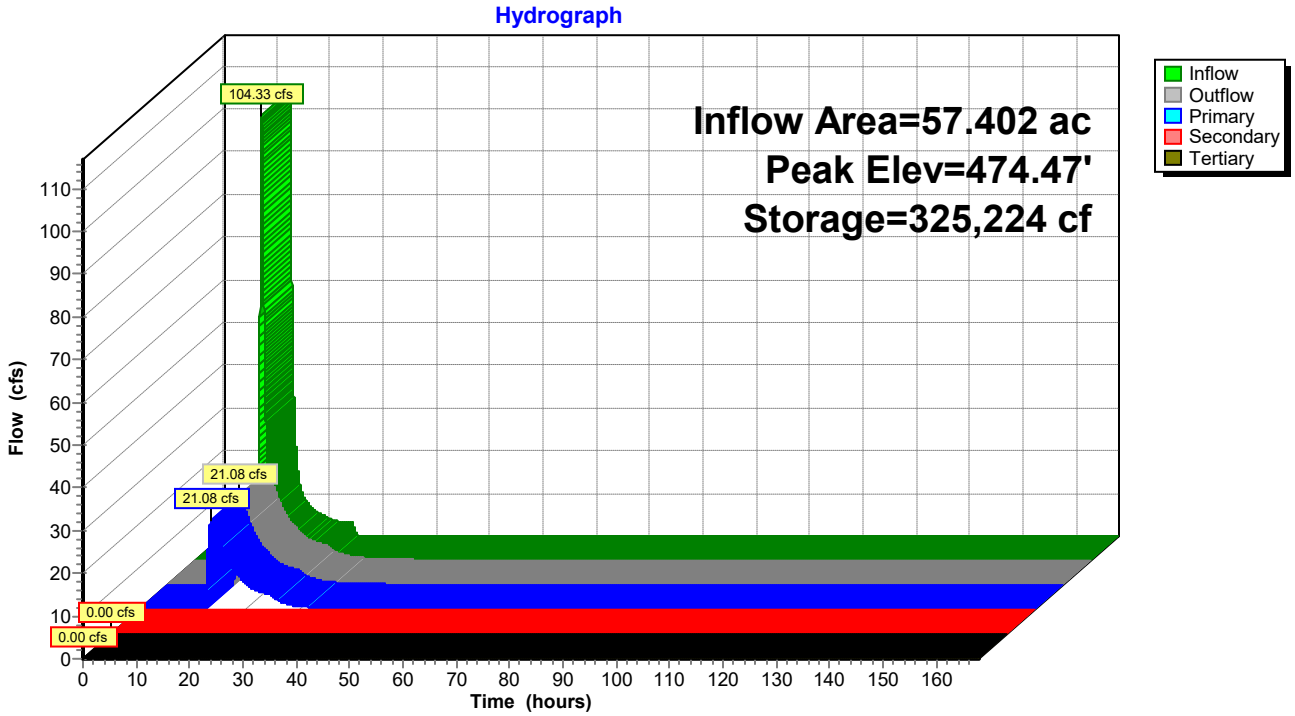
Device	Routing	Invert	Outlet Devices
#1	Primary	473.42'	**36.0" Round Culvert** L= 112.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 473.42' / 472.25' S= 0.0104 '/' Cc= 0.900 n= 0.012, Flow Area= 7.07 sf
#2	Primary	473.29'	**36.0" Round Culvert** L= 112.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 473.29' / 471.53' S= 0.0157 '/' Cc= 0.900 n= 0.012, Flow Area= 7.07 sf
#3	Primary	473.30'	**36.0" Round Culvert** L= 112.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 473.30' / 472.16' S= 0.0102 '/' Cc= 0.900 n= 0.012, Flow Area= 7.07 sf
#4	Secondary	476.00'	**Custom Weir/Orifice, Cv= 2.30 (C= 2.88)** Head (feet) 0.00 0.50 1.00 1.50 Width (feet) 0.00 11.50 232.41 412.66
#5	Tertiary	475.00'	**Custom Weir/Orifice, Cv= 2.40 (C= 3.00)** Head (feet) 0.00 1.00 2.00 3.00 Width (feet) 0.00 7.50 77.20 104.11

Primary OutFlow Max=21.08 cfs @ 13.68 hrs HW=474.47' TW=458.80' (Dynamic Tailwater)
- **1=Culvert** (Inlet Controls 6.09 cfs @ 2.76 fps)
- **2=Culvert** (Inlet Controls 7.55 cfs @ 2.92 fps)
- **3=Culvert** (Inlet Controls 7.44 cfs @ 2.91 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=471.00' TW=453.00' (Dynamic Tailwater)
- **4=Custom Weir/Orifice** (Controls 0.00 cfs)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=471.00' TW=469.70' (Dynamic Tailwater)
- **5=Custom Weir/Orifice** (Controls 0.00 cfs)

Pond PA2: West Rail Loop Pond 2 (2019 Topo)



Summary for Pond PA3: West Rail Loop Pond 1 (2019 Topo)

Inflow Area = 64.512 ac, 0.00% Impervious, Inflow Depth = 2.98" for 25-year event
Inflow = 143.47 cfs @ 12.35 hrs, Volume= 16.026 af
Outflow = 92.80 cfs @ 12.62 hrs, Volume= 16.026 af, Atten= 35%, Lag= 16.2 min
Primary = 92.80 cfs @ 12.62 hrs, Volume= 16.026 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 474.47' @ 12.62 hrs Surf.Area= 61,862 sf Storage= 80,262 cf

Plug-Flow detention time= 6.1 min calculated for 16.026 af (100% of inflow)
Center-of-Mass det. time= 5.8 min (863.8 - 857.9)

Volume	Invert	Avail.Storage	Storage Description
#1	469.70'	498,837 cf	**Custom Stage Data (Prismatic)** Listed below

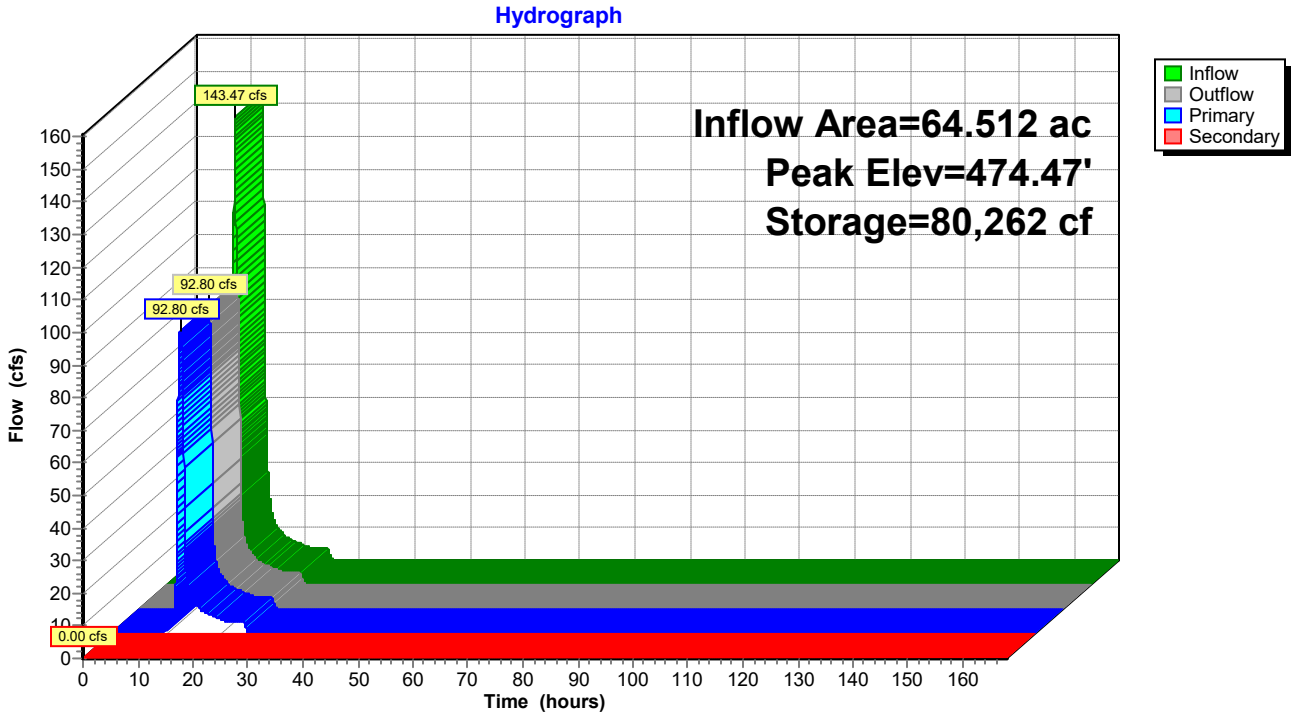
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
469.70	0	0	0
472.00	2,725	3,134	3,134
473.00	24,026	13,376	16,509
474.00	43,852	33,939	50,448
475.00	81,806	62,829	113,277
476.00	168,154	124,980	238,257
477.00	353,006	260,580	498,837

Device	Routing	Invert	Outlet Devices
#1	Primary	469.70'	**24.0" Round Culvert X 4.00** L= 150.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 469.70' / 468.57' S= 0.0075 '/' Cc= 0.900 n= 0.012, Flow Area= 3.14 sf
#2	Secondary	474.50'	**Custom Weir/Orifice, Cv= 2.30 (C= 2.88)** Head (feet) 0.00 0.50 1.50 2.50 Width (feet) 0.00 38.80 132.67 465.74

Primary OutFlow Max=92.80 cfs @ 12.62 hrs HW=474.47' TW=456.45' (Dynamic Tailwater)
└**1=Culvert** (Inlet Controls 92.80 cfs @ 7.39 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=469.70' TW=453.00' (Dynamic Tailwater)
└**2=Custom Weir/Orifice** (Controls 0.00 cfs)

Pond PA3: West Rail Loop Pond 1 (2019 Topo)



Summary for Pond PBC2: NRL Pond 1

Inflow Area = 65.266 ac, 0.00% Impervious, Inflow Depth = 3.08" for 25-year event
Inflow = 223.16 cfs @ 12.13 hrs, Volume= 16.729 af
Outflow = 1.78 cfs @ 24.28 hrs, Volume= 16.729 af, Atten= 99%, Lag= 729.3 min
Primary = 1.78 cfs @ 24.28 hrs, Volume= 16.729 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 477.00' Surf.Area= 31,384 sf Storage= 31,384 cf
Peak Elev= 485.89' @ 24.28 hrs Surf.Area= 95,147 sf Storage= 676,927 cf (645,543 cf above start)
Flood Elev= 489.00' Surf.Area= 105,696 sf Storage= 993,908 cf (962,525 cf above start)

Plug-Flow detention time= 3,426.0 min calculated for 16.007 af (96% of inflow)
Center-of-Mass det. time= 3,254.8 min (4,094.4 - 839.6)

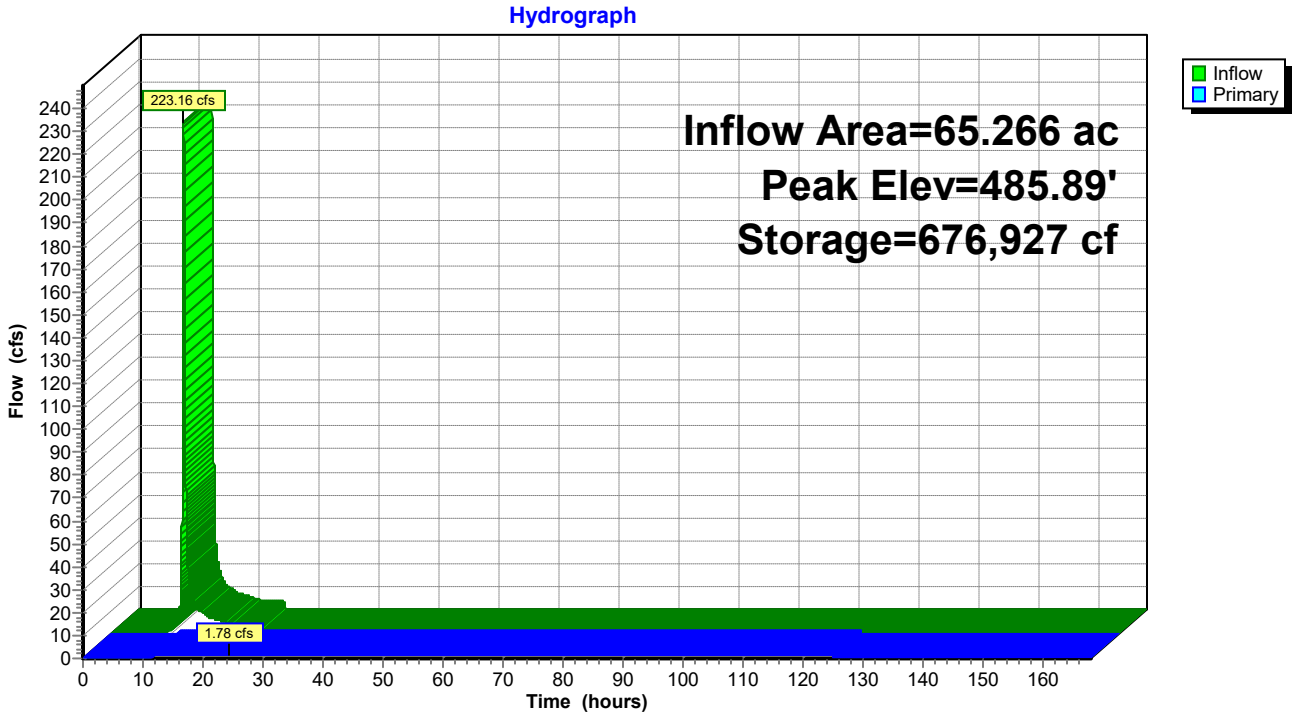
Volume	Invert	Avail.Storage	Storage Description
#1	476.00'	1,099,604 cf	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
476.00	2,192	0	0
478.00	60,575	62,767	62,767
480.00	69,438	130,013	192,780
482.00	77,913	147,351	340,131
484.00	86,595	164,508	504,639
486.00	95,641	182,236	686,875
488.00	105,696	201,337	888,212
490.00	105,696	211,392	1,099,604

Device	Routing	Invert	Outlet Devices
#1	Primary	478.00'	**Pump** Discharges@494.53' Turns Off@477.00' 8.0" Diam. x 5,770.0' Long Discharge, Hazen-Williams C= 130 Flow (gpm)= 800.0 800.1 Head (feet)= 100.00 0.00 -Loss (feet)= 69.74 69.76 =Lift (feet)= 30.26 -69.76

Primary OutFlow Max=1.78 cfs @ 24.28 hrs HW=485.89' TW=456.92' (Dynamic Tailwater)
└─**1=Pump** (Pump Controls 1.78 cfs)

Pond PBC2: NRL Pond 1



Summary for Pond PBC3: NRL Pond 2

Inflow Area = 24.994 ac, 0.00% Impervious, Inflow Depth = 3.08" for 25-year event
Inflow = 85.46 cfs @ 12.13 hrs, Volume= 6.407 af
Outflow = 1.78 cfs @ 19.65 hrs, Volume= 6.406 af, Atten= 98%, Lag= 451.4 min
Primary = 1.78 cfs @ 19.65 hrs, Volume= 6.407 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 477.00' Surf.Area= 33,234 sf Storage= 33,234 cf
Peak Elev= 480.37' @ 19.65 hrs Surf.Area= 76,704 sf Storage= 237,618 cf (204,384 cf above start)
Flood Elev= 489.00' Surf.Area= 127,092 sf Storage= 1,090,748 cf (1,057,514 cf above start)

Plug-Flow detention time= 1,395.8 min calculated for 5.643 af (88% of inflow)
Center-of-Mass det. time= 1,181.8 min (2,021.4 - 839.6)

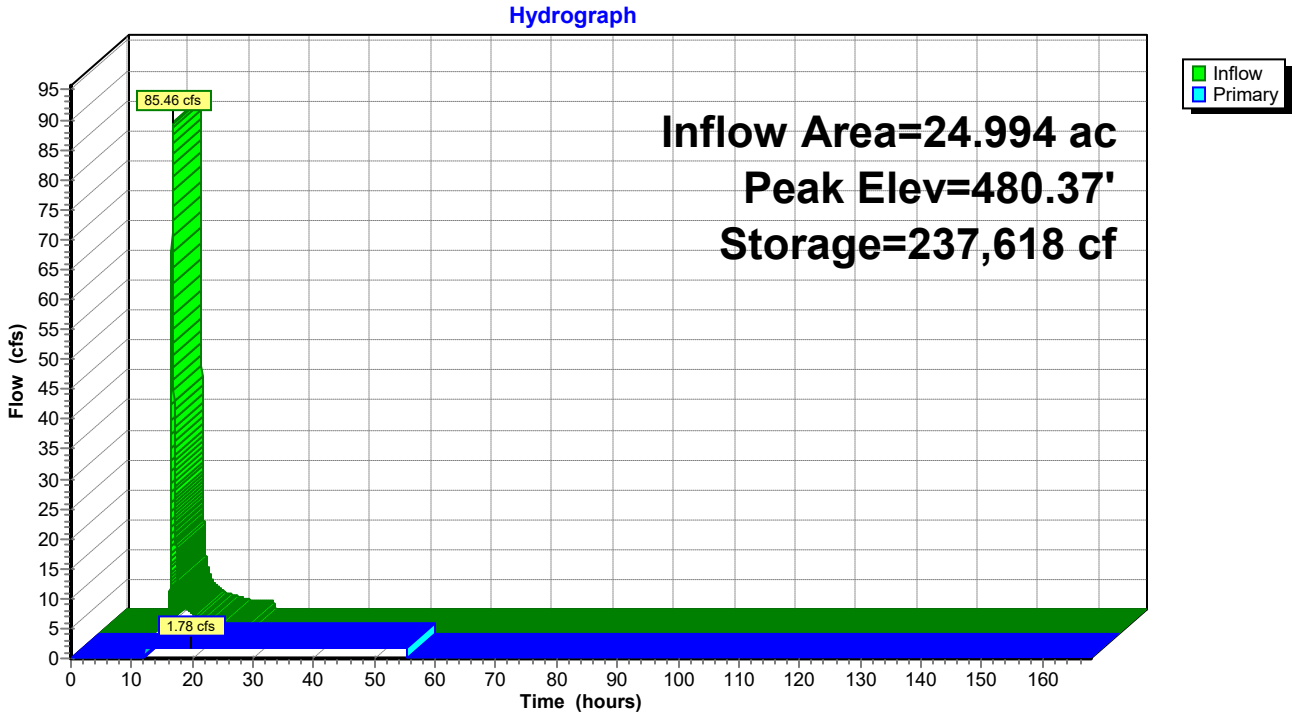
Volume	Invert	Avail.Storage	Storage Description
#1	476.00'	1,217,840 cf	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
476.00	0	0	0
478.00	66,468	66,468	66,468
480.00	75,171	141,639	208,107
482.00	83,409	158,580	366,687
484.00	92,039	175,448	542,135
486.00	101,195	193,234	735,369
488.00	127,092	228,287	963,656
490.00	127,092	254,184	1,217,840

Device	Routing	Invert	Outlet Devices
#1	Primary	478.00'	**Pump** Discharges@494.53' Turns Off@477.00' 8.0" Diam. x 5,770.0' Long Discharge, Hazen-Williams C= 130 Flow (gpm)= 800.0 800.1 Head (feet)= 100.00 0.00 -Loss (feet)= 69.74 69.76 =Lift (feet)= 30.26 -69.76

Primary OutFlow Max=1.78 cfs @ 19.65 hrs HW=480.37' TW=457.15' (Dynamic Tailwater)
└─**1=Pump** (Pump Controls 1.78 cfs)

Pond PBC3: NRL Pond 2



Summary for Pond PBC4: Pond Northeast of GAF Stilling Ponds

Inflow Area = 2,314.650 ac, 0.00% Impervious, Inflow Depth = 3.56" for 25-year event
Inflow = 2,692.59 cfs @ 13.36 hrs, Volume= 687.408 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 458.33' @ 30.58 hrs Surf.Area= 0.000 ac Storage= 687.408 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

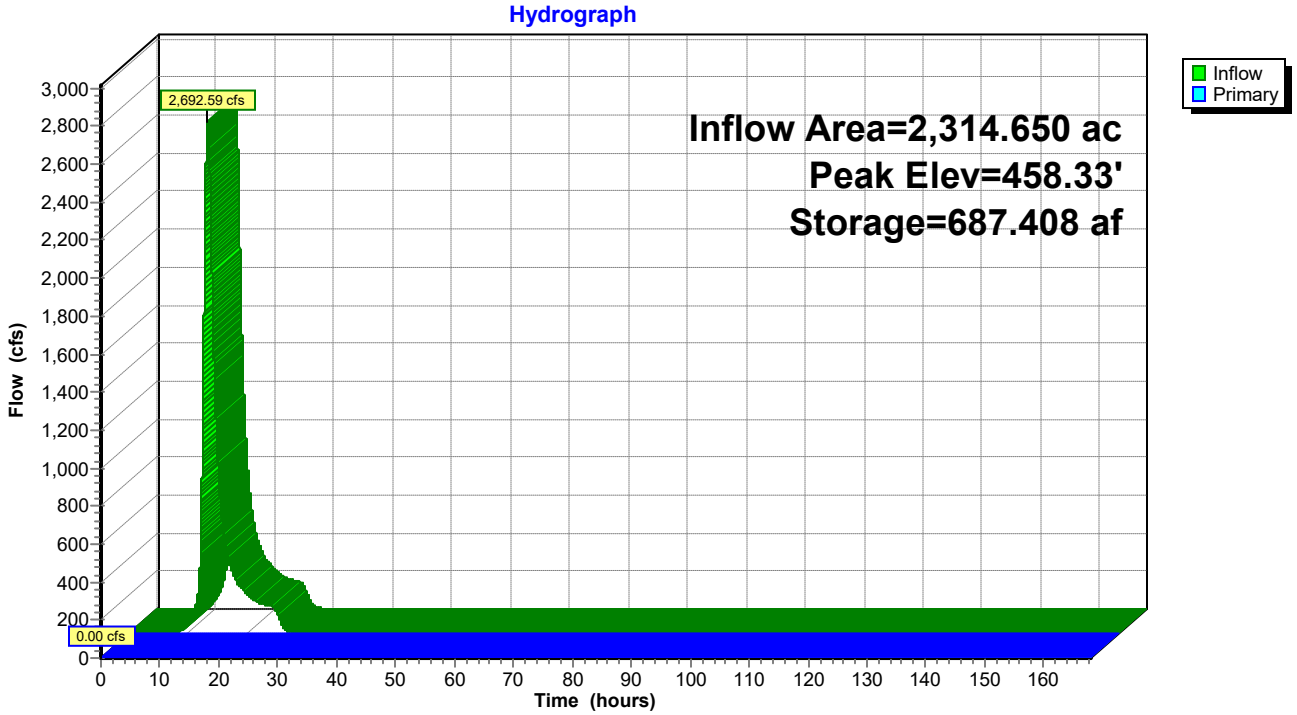
Volume	Invert	Avail.Storage	Storage Description
#1	451.00'	5,750.590 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
451.00	0.000
452.00	36.303
453.00	120.727
454.00	210.261
455.00	306.187
456.00	409.173
457.00	521.498
458.00	643.158
459.00	776.918
460.00	923.653
461.00	1,086.982
462.00	1,260.310
463.00	1,443.258
464.00	1,634.576
465.00	1,833.772
466.00	2,040.159
467.00	2,253.912
468.00	2,474.440
469.00	2,702.083
470.00	2,936.488
471.00	3,178.433
472.00	3,427.641
473.00	3,684.714
474.00	3,949.521
475.00	4,222.692
476.00	4,504.361
477.00	4,796.360
478.00	5,098.928
479.00	5,417.706
480.00	5,750.590

Device	Routing	Invert	Outlet Devices
#1	Primary	450.00'	**42.0" Round Culvert** L= 206.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 450.00' / 450.00' S= 0.0000 '/' Cc= 0.900 n= 0.012, Flow Area= 9.62 sf
#2	Device 1	458.73'	**72.0" x 72.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=451.00' TW=456.00' (Dynamic Tailwater)
└─**1=Culvert** (Controls 0.00 cfs)
└─**2=Orifice/Grate** (Controls 0.00 cfs)

Pond PBC4: Pond Northeast of GAF Stilling Ponds



Summary for Pond PBC5: Pond North of RR and Pond B

Inflow Area = 559.000 ac, 0.00% Impervious, Inflow Depth = 3.37" for 25-year event
Inflow = 376.94 cfs @ 14.51 hrs, Volume= 156.791 af
Outflow = 340.33 cfs @ 15.37 hrs, Volume= 138.448 af, Atten= 10%, Lag= 51.7 min
Primary = 87.64 cfs @ 15.37 hrs, Volume= 69.330 af
Secondary = 252.69 cfs @ 15.37 hrs, Volume= 69.118 af
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 459.40' @ 15.37 hrs Surf.Area= 558,077 sf Storage= 2,276,600 cf
Flood Elev= 465.90' Surf.Area= 691,518 sf Storage= 4,612,749 cf

Plug-Flow detention time= 367.6 min calculated for 138.448 af (88% of inflow)
Center-of-Mass det. time= 307.3 min (1,319.3 - 1,012.1)

Volume	Invert	Avail.Storage	Storage Description
#1	451.00'	4,612,749 cf	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
451.00	0	0	0
452.00	19,050	9,525	9,525
453.00	109,429	64,240	73,765
454.00	213,750	161,590	235,354
455.00	278,560	246,155	481,509
456.00	337,639	308,100	789,609
457.00	386,468	362,054	1,151,662
458.00	450,389	418,429	1,570,091
459.00	504,821	477,605	2,047,696
460.00	637,732	571,277	2,618,972
461.00	655,592	646,662	3,265,634
462.00	673,560	664,576	3,930,210
463.00	691,518	682,539	4,612,749

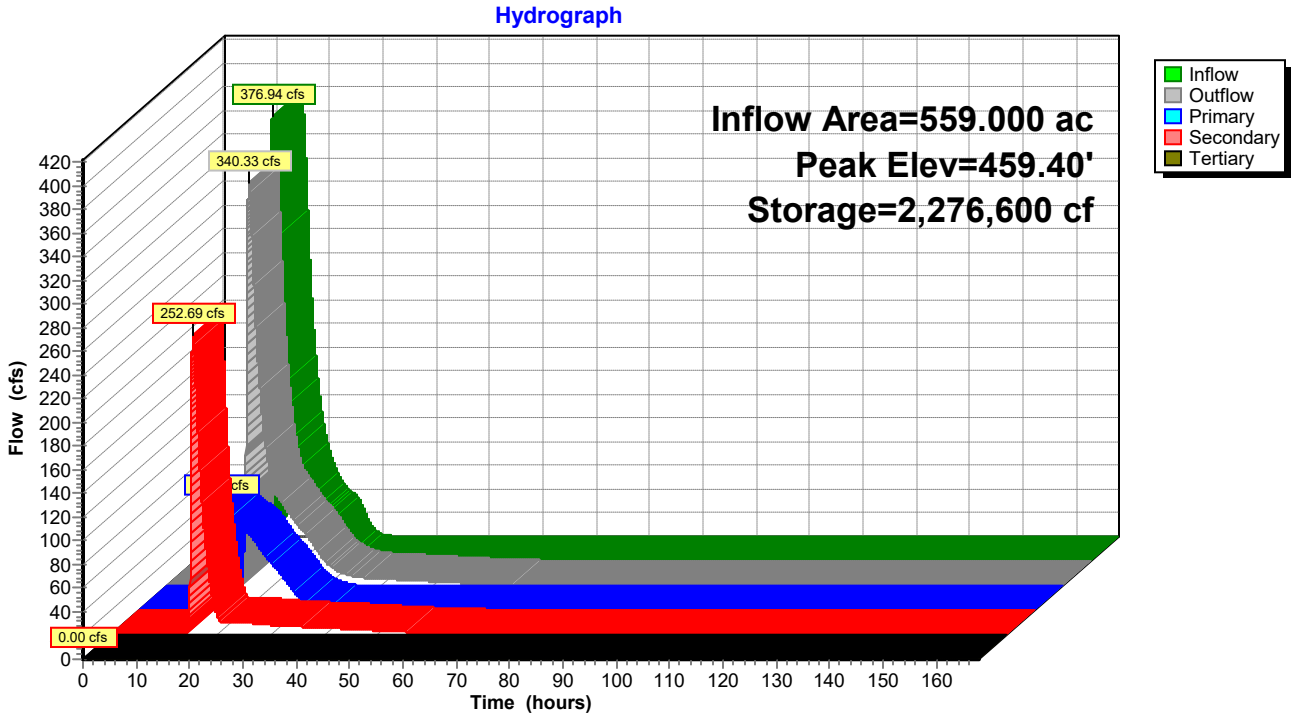
Device	Routing	Invert	Outlet Devices
#1	Primary	457.00'	**64.0" W x 43.0" H, R=32.5"/99.3" Pipe Arch CMP_Arch_1/2 64x43 X 2.00** L= 62.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 457.00' / 456.07' S= 0.0150 '/' Cc= 0.900 n= 0.024, Flow Area= 15.13 sf
#2	Secondary	459.00'	**350.0' long x 30.0' breadth Broad-Crested Weir to West** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#3	Secondary	452.00'	**24.0" Round Culvert to West X 0.67** L= 30.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 452.00' / 451.80' S= 0.0067 '/' Cc= 0.900 n= 0.024, Flow Area= 3.14 sf
#4	Tertiary	462.90'	**Railroad Berm to Stilling Pond B, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 1.10 2.10 Width (feet) 50.00 200.00 300.00

Primary OutFlow Max=87.64 cfs @ 15.37 hrs HW=459.40' TW=456.76' (Dynamic Tailwater)
└─**1=CMP_Arch_1/2 64x43** (Inlet Controls 87.64 cfs @ 3.84 fps)

Secondary OutFlow Max=252.68 cfs @ 15.37 hrs HW=459.40' TW=456.76' (Dynamic Tailwater)
├─**2=Broad-Crested Weir to West** (Weir Controls 239.68 cfs @ 1.71 fps)
└─**3=Culvert to West** (Inlet Controls 13.00 cfs @ 4.14 fps)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=451.00' TW=456.00' (Dynamic Tailwater)
└─**4=Railroad Berm to Stilling Pond B** (Controls 0.00 cfs)

Pond PBC5: Pond North of RR and Pond B



Summary for Pond PBC6: Lowlands north of Stilling Ponds

Inflow Area = 82.000 ac, 0.00% Impervious, Inflow Depth = 3.37" for 25-year event
Inflow = 127.68 cfs @ 12.77 hrs, Volume= 23.000 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 456.09' @ 28.12 hrs Surf.Area= 269,894 sf Storage= 1,001,867 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

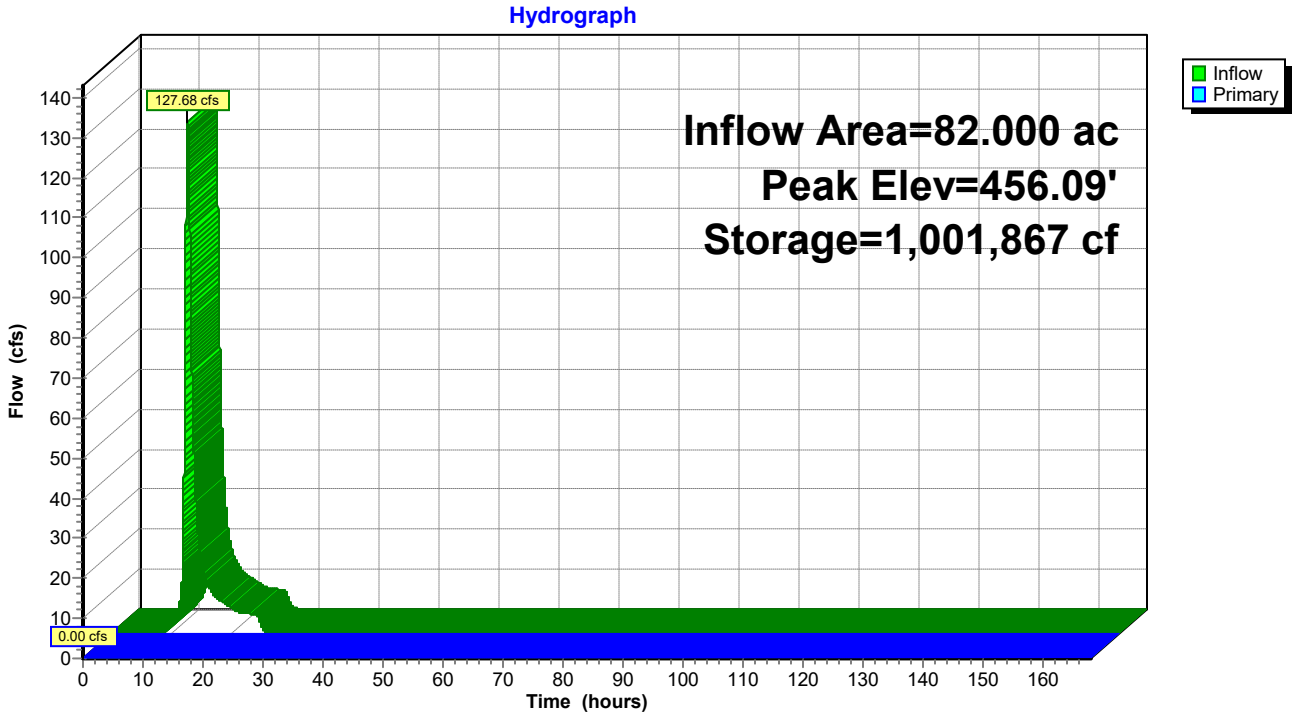
Volume	Invert	Avail.Storage	Storage Description
#1	449.00'	2,331,671 cf	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
449.00	0	0	0
450.00	46,779	23,390	23,390
451.00	72,994	59,887	83,276
452.00	125,956	99,475	182,751
453.00	161,593	143,775	326,526
454.00	203,435	182,514	509,040
455.00	232,808	218,122	727,161
456.00	267,132	249,970	977,131
457.00	298,725	282,929	1,260,060
458.00	336,676	317,701	1,577,760
459.00	378,524	357,600	1,935,360
460.00	414,097	396,311	2,331,671

Device	Routing	Invert	Outlet Devices
#1	Primary	459.00'	**300.0' long x 30.0' breadth Weir Flow to Pond B/C** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=449.00' TW=456.00' (Dynamic Tailwater)
└─**1=Weir Flow to Pond B/C** (Controls 0.00 cfs)

Pond PBC6: Lowlands north of Stilling Ponds



Summary for Pond PD2: Small Pond North of Pond "D" - Split Flow

Inflow Area = 229.622 ac, 0.00% Impervious, Inflow Depth = 3.46" for 25-year event
Inflow = 300.14 cfs @ 13.05 hrs, Volume= 66.290 af
Outflow = 287.81 cfs @ 13.28 hrs, Volume= 58.188 af, Atten= 4%, Lag= 13.6 min
Primary = 287.81 cfs @ 13.28 hrs, Volume= 58.188 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 457.09' @ 13.28 hrs Surf.Area= 142,534 sf Storage= 537,003 cf

Plug-Flow detention time= 100.8 min calculated for 58.188 af (88% of inflow)
Center-of-Mass det. time= 40.8 min (940.8 - 900.1)

Volume	Invert	Avail.Storage	Storage Description
#1	446.00'	875,783 cf	**Custom Stage Data - Small Area North of Pond D (Prismatic)** Listed below

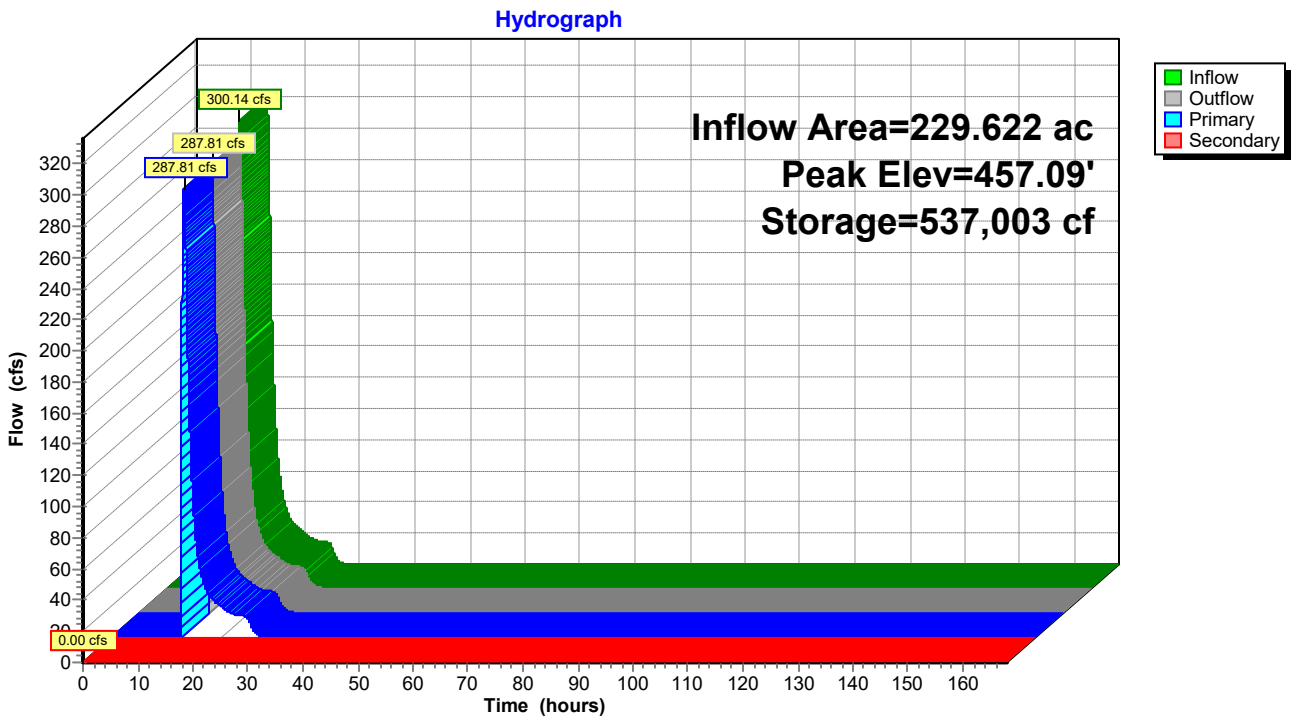
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
446.00	4,427	0	0
447.00	8,511	6,469	6,469
448.00	12,498	10,505	16,974
449.00	17,160	14,829	31,803
450.00	23,592	20,376	52,179
451.00	31,120	27,356	79,535
452.00	42,033	36,577	116,111
453.00	53,148	47,591	163,702
454.00	71,076	62,112	225,814
455.00	87,126	79,101	304,915
456.00	104,926	96,026	400,941
457.00	139,111	122,019	522,959
458.00	177,727	158,419	681,378
459.00	211,083	194,405	875,783

Device	Routing	Invert	Outlet Devices
#1	Primary	455.50'	**60.0' long x 20.0' breadth Broad-Crested Rectangular Weir - OffSite** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#2	Secondary	458.00'	**200.0' long x 25.0' breadth Broad-Crested Rectangular Weir - OnSite** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=287.81 cfs @ 13.28 hrs HW=457.09' TW=456.07' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir - OffSite** (Weir Controls 287.81 cfs @ 3.02 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=446.00' TW=456.00' (Dynamic Tailwater)
└─**2=Broad-Crested Rectangular Weir - OnSite** (Controls 0.00 cfs)

Pond PD2: Small Pond North of Pond "D" - Split Flow



Summary for Pond Pond A: Ash Pond A (2017 Bathymetry)

Starting WSE = 464.36 taken from measurements on 01.13.20.

Outlet data from Ash Pond Lowering and Flow Diversion plans (10W510-9)

Process Flows removed from system.

Siphons removed from model.

Inflow Area = 441.904 ac, 6.32% Impervious, Inflow Depth = 4.31" for 25-year event
Inflow = 439.13 cfs @ 13.68 hrs, Volume= 158.829 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 453.00' Surf.Area= 126,902 sf Storage= 206,187 cf
Peak Elev= 463.45' @ 168.00 hrs Surf.Area= 1,140,426 sf Storage= 7,124,764 cf (6,918,577 cf above start)
Flood Elev= 472.00' Surf.Area= 5,281,903 sf Storage= 27,526,862 cf (27,320,675 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	450.00'	27,998,693 cf	**Custom Stage Data (Prismatic)** Listed below

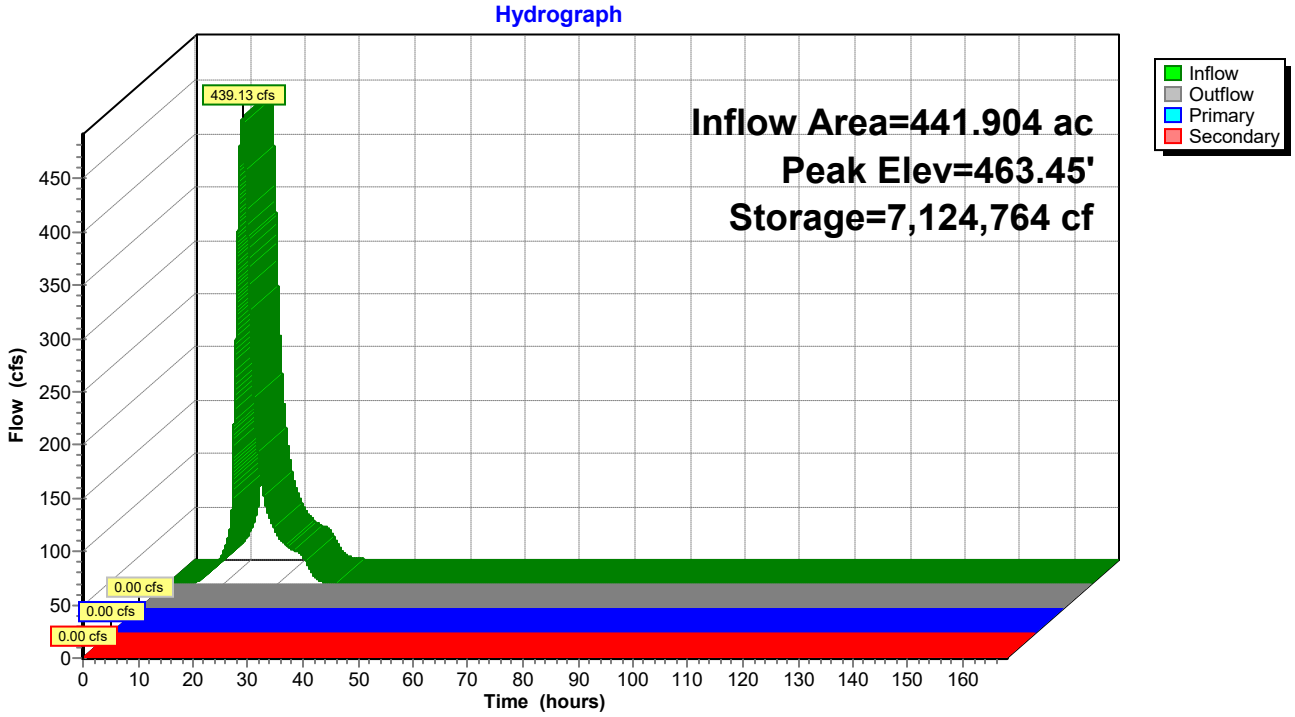
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
450.00	0	0	0
451.00	49,195	24,598	24,598
452.00	93,541	71,368	95,966
453.00	126,902	110,222	206,187
454.00	196,055	161,479	367,666
455.00	282,600	239,328	606,993
456.00	384,900	333,750	940,743
457.00	518,461	451,681	1,392,424
458.00	660,011	589,236	1,981,660
459.00	788,825	724,418	2,706,078
460.00	911,241	850,033	3,556,111
462.00	1,062,987	1,974,228	5,530,339
462.43	1,088,937	462,664	5,993,002
463.43	1,139,750	1,114,344	7,107,346
464.00	1,165,229	656,919	7,764,265
465.00	1,218,593	1,191,911	8,956,176
467.00	1,867,419	3,086,012	12,042,188
468.00	2,173,074	2,020,247	14,062,434
469.00	2,420,068	2,296,571	16,359,005
471.00	4,029,477	6,449,545	22,808,550
472.10	5,407,146	5,190,143	27,998,693

Device	Routing	Invert	Outlet Devices
#1	Primary	451.50'	**30.0" Round Culvert X 3.00** L= 150.0' Box, headwall w/3 square edges, Ke= 0.500 Inlet / Outlet Invert= 451.50' / 451.00' S= 0.0033 '/' Cc= 0.900 n= 0.012, Flow Area= 4.91 sf
#2	Device 1	463.62'	**192.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	463.76'	**192.0" Vert. Orifice/Grate** C= 0.600
#4	Device 1	463.80'	**192.0" Vert. Orifice/Grate** C= 0.600
#5	Secondary	472.00'	**5,000.0' long x 25.0' breadth Top of Dike - Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=453.00' TW=456.00' (Dynamic Tailwater)
└─**1=Culvert** (Controls 0.00 cfs)
  ├─**2=Orifice/Grate** (Controls 0.00 cfs)
  ├─**3=Orifice/Grate** (Controls 0.00 cfs)
  └─**4=Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=453.00' TW=456.00' (Dynamic Tailwater)
└─**5=Top of Dike - Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond Pond A: Ash Pond A (2017 Bathymetry)



Summary for Pond Pond BC: Stilling Ponds B&C Rock Check Dam Outlet

[80] Warning: Exceeded Pond PBC5 by 5.01' @ 8.06 hrs (13.88 cfs 15.479 af)

Inflow Area = 3,732.545 ac, 1.82% Impervious, Inflow Depth > 0.63" for 25-year event
Inflow = 502.42 cfs @ 12.08 hrs, Volume= 195.959 af
Outflow = 161.14 cfs @ 17.53 hrs, Volume= 194.792 af, Atten= 68%, Lag= 326.8 min
Primary = 161.14 cfs @ 17.53 hrs, Volume= 194.792 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 456.00' Surf.Area= 0.000 ac Storage= 206.702 af
Peak Elev= 457.23' @ 17.82 hrs Surf.Area= 0.000 ac Storage= 263.029 af (56.327 af above start)
Flood Elev= 460.50' Surf.Area= 0.000 ac Storage= 448.931 af (242.229 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 437.5 min (1,927.1 - 1,489.5)

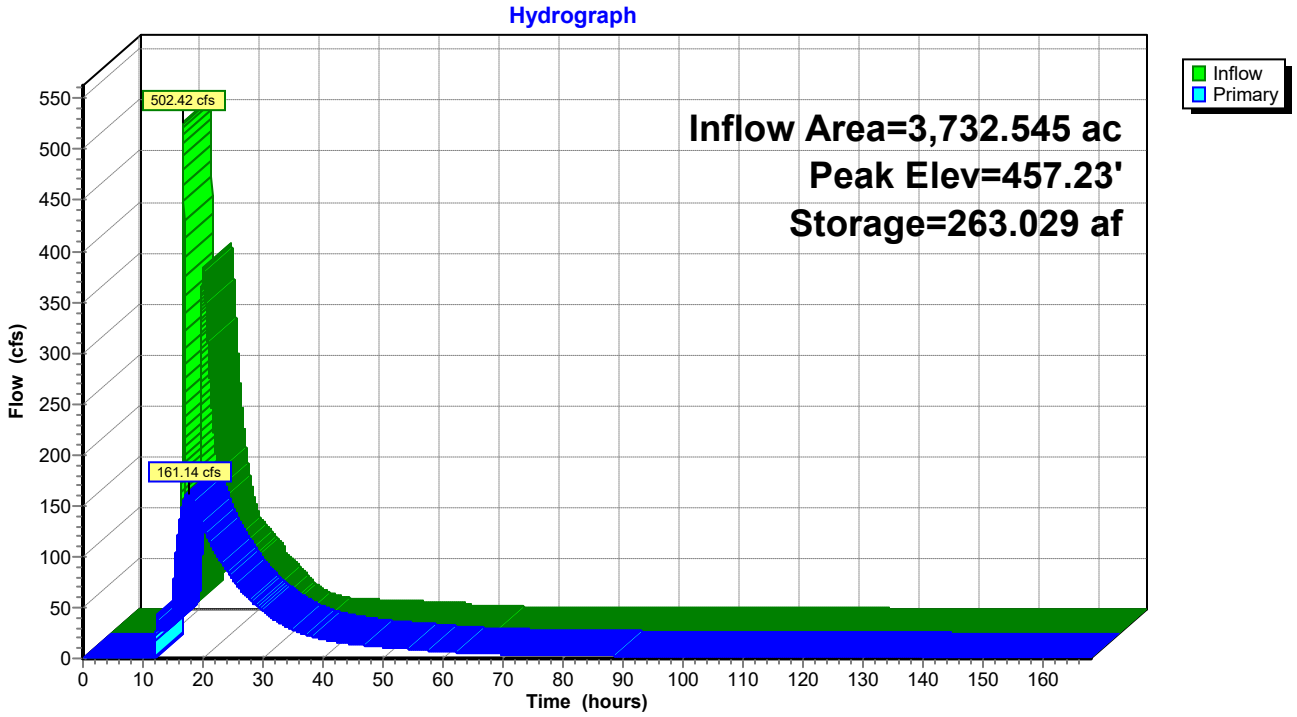
Volume	Invert	Avail.Storage	Storage Description
#1	449.00'	795.000 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
449.00	0.000
450.00	23.789
451.00	39.479
452.00	61.914
453.00	90.729
454.00	125.233
455.00	164.384
456.00	206.702
457.00	251.661
458.00	301.281
459.00	356.350
460.00	416.418
461.00	481.445
462.00	578.770
465.00	795.000

Device	Routing	Invert	Outlet Devices
#1	Primary	456.00'	**121.0' long x 29.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=161.14 cfs @ 17.53 hrs HW=457.23' TW=457.16' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 161.14 cfs @ 1.09 fps)

Pond Pond BC: Stilling Ponds B&C Rock Check Dam Outlet



Summary for Pond Pond D: Stilling Pond D Outlet

[80] Warning: Exceeded Pond Pond BC by 0.12' @ 11.97 hrs (41.65 cfs 1.163 af)

Inflow Area =	3,745.094 ac,	2.00% Impervious,	Inflow Depth >	0.64"	for 25-year event	
Inflow =	162.51 cfs @	17.52 hrs,	Volume=	199.612 af		
Outflow =	161.23 cfs @	17.89 hrs,	Volume=	199.421 af,	Atten= 1%,	Lag= 22.5 min
Primary =	116.93 cfs @	17.89 hrs,	Volume=	178.780 af		
Secondary =	44.30 cfs @	17.89 hrs,	Volume=	20.641 af		
Tertiary =	0.00 cfs @	0.00 hrs,	Volume=	0.000 af		

Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 456.00' Surf.Area= 0.000 ac Storage= 39.437 af
Peak Elev= 457.17' @ 17.89 hrs Surf.Area= 0.000 ac Storage= 48.334 af (8.897 af above start)
Flood Elev= 460.50' Surf.Area= 0.000 ac Storage= 79.070 af (39.633 af above start)

Plug-Flow detention time= 874.1 min calculated for 159.974 af (80% of inflow)
Center-of-Mass det. time= 69.8 min (1,969.2 - 1,899.4)

Volume	Invert	Avail.Storage	Storage Description
#1	447.00'	129.994 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
447.00	0.000
448.00	0.153
449.00	1.944
450.00	5.134
451.00	9.222
452.00	14.102
453.00	19.687
454.00	25.820
455.00	32.429
456.00	39.437
457.00	46.952
458.00	55.216
459.00	64.156
460.00	73.831
461.00	84.309
462.00	95.451
465.00	129.994

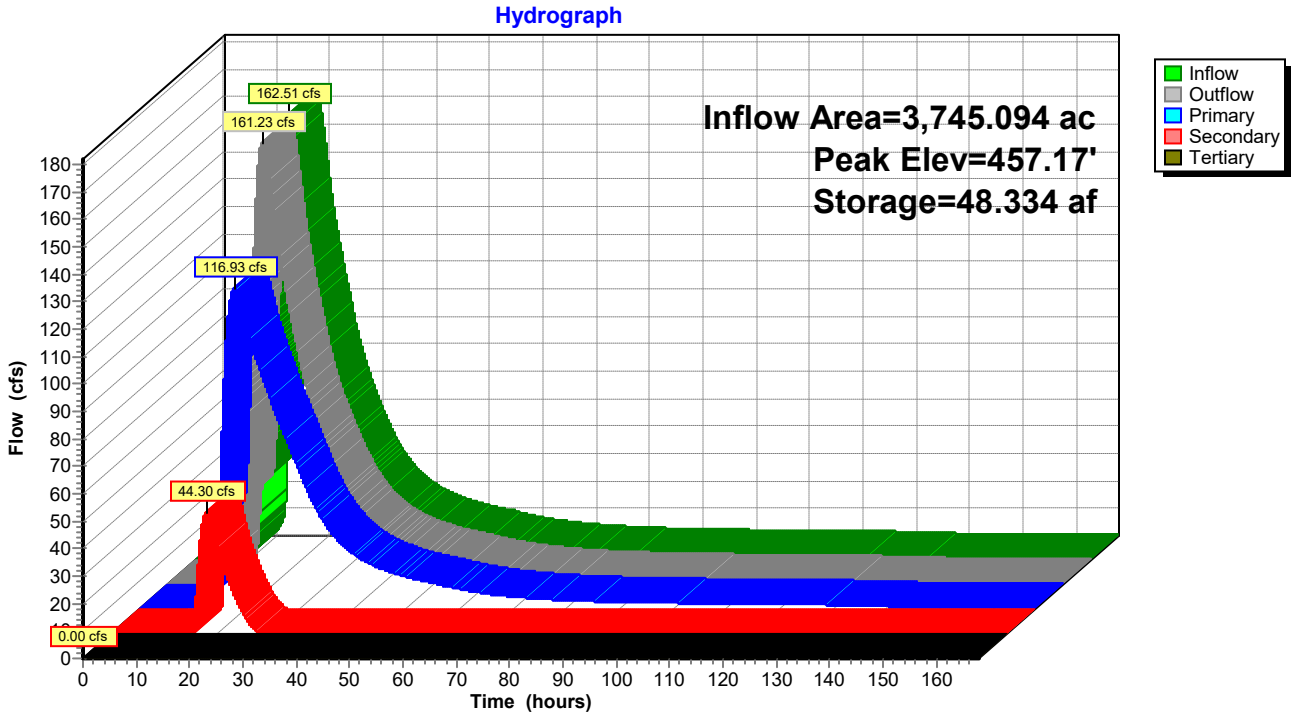
Device	Routing	Invert	Outlet Devices
#1	Secondary	448.48'	**36.0" Round Discharge Culvert for Raised Morning Glories X 4.00** L= 146.5' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 448.48' / 447.00' S= 0.0101 '/' Cc= 0.900 n= 0.012, Flow Area= 7.07 sf
#2	Device 1	449.60'	**36.0" Round Inlet Culvert for Raised Morning Glories X 4.00** L= 108.8' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 449.60' / 448.55' S= 0.0097 '/' Cc= 0.900 n= 0.012, Flow Area= 7.07 sf
#3	Device 2	456.75'	**48.0" Horiz. Morning Glory Orifice X 4.00** C= 0.600 Limited to weir flow at low heads
#4	Primary	447.53'	**36.0" Round Newer Outlet Culverts X 4.00** L= 107.4' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 447.53' / 447.00' S= 0.0049 '/' Cc= 0.900 n= 0.012, Flow Area= 7.07 sf
#5	Device 4	450.91'	**36.0" Round Newer Central Culverts X 4.00** L= 45.0' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 450.91' / 447.53' S= 0.0751 '/' Cc= 0.900 n= 0.012, Flow Area= 7.07 sf
#6	Device 5	452.90'	**36.0" Round Newer Inlet Culverts X 4.00** L= 26.8' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 452.90' / 450.91' S= 0.0743 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 7.07 sf
#7	Device 6	456.00'	**7.0' long Newer Spillway Sharp-Crested Rectangular Weir X 4.00** 2 End Contraction(s) 3.0' Crest Height
#8	Tertiary	459.10'	**Uncontrolled Weir to North, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 0.40 0.90 1.40 Width (feet) 41.00 160.55 269.23 390.72
#9	Tertiary	461.50'	**331.1' long x 10.6' breadth Broad-Crested Rectangular Weir West Saddle Dike** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.51 2.58 2.70 2.68 2.67 2.68 2.67 2.64

Primary OutFlow Max=116.93 cfs @ 17.89 hrs HW=457.17' TW=445.03' (Dynamic Tailwater)
└─**4=Newer Outlet Culverts** (Passes 116.93 cfs of 457.32 cfs potential flow)
  └─**5=Newer Central Culverts** (Passes 116.93 cfs of 404.91 cfs potential flow)
    └─**6=Newer Inlet Culverts** (Passes 116.93 cfs of 226.47 cfs potential flow)
      └─**7=Newer Spillway Sharp-Crested Rectangular Weir** (Weir Controls 116.93 cfs @ 3.70 fps)

Secondary OutFlow Max=44.30 cfs @ 17.89 hrs HW=457.17' TW=445.03' (Dynamic Tailwater)
└─**1=Discharge Culvert for Raised Morning Glories** (Passes 44.30 cfs of 428.87 cfs potential flow)
  └─**2=Inlet Culvert for Raised Morning Glories** (Passes 44.30 cfs of 335.34 cfs potential flow)
    └─**3=Morning Glory Orifice** (Weir Controls 44.30 cfs @ 2.11 fps)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=456.00' TW=445.00' (Dynamic Tailwater)
├─**8=Uncontrolled Weir to North** (Controls 0.00 cfs)
└─**9=Broad-Crested Rectangular Weir West Saddle Dike** (Controls 0.00 cfs)

Pond Pond D: Stilling Pond D Outlet



Summary for Pond Pond E: Ash Pond E (2019 Topo)

Sharp Crested Weir Added by modifying stop logs.

Horizontal Ofrice Modified by adding flat top and 24" Grate to top of 48" Riser

Inflow Area = 146.047 ac, 0.34% Impervious, Inflow Depth = 5.28" for 25-year event
Inflow = 340.83 cfs @ 12.75 hrs, Volume= 64.291 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 449.00' Surf.Area= 162,770 sf Storage= 199,294 cf
Peak Elev= 455.49' @ 28.09 hrs Surf.Area= 817,349 sf Storage= 2,999,789 cf (2,800,496 cf above start)
Flood Elev= 475.00' Surf.Area= 4,497,441 sf Storage= 53,503,754 cf (53,304,461 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	445.00'	53,951,067 cf	**Custom Stage Data (Prismatic)** Listed below

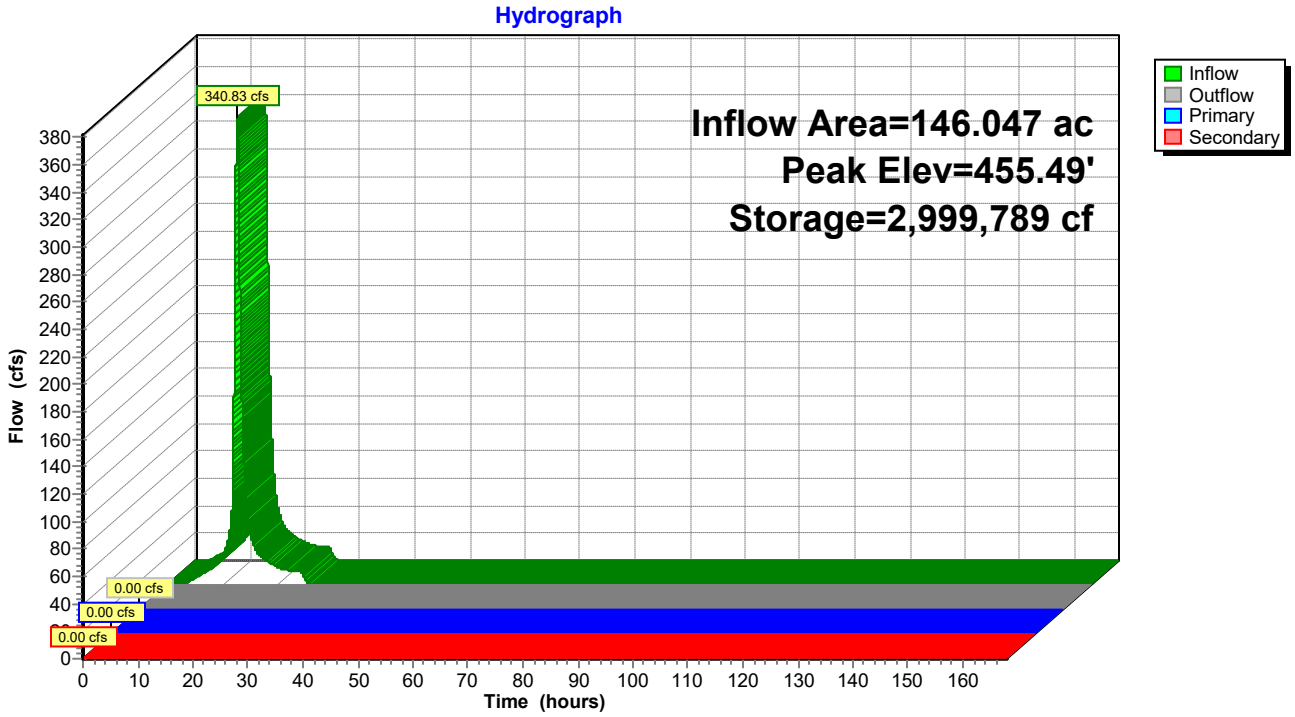
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
445.00	411	0	0
446.00	13,391	6,901	6,901
447.00	30,548	21,970	28,871
448.00	73,764	52,156	81,027
449.00	162,770	118,267	199,294
450.00	247,240	205,005	404,299
451.00	326,565	286,903	691,201
452.00	407,315	366,940	1,058,141
453.00	466,510	436,913	1,495,054
454.00	535,811	501,161	1,996,214
455.00	661,201	598,506	2,594,720
456.00	976,939	819,070	3,413,790
461.00	1,423,990	6,002,323	9,416,113
463.00	1,728,758	3,152,748	12,568,861
464.00	2,300,770	2,014,764	14,583,625
465.00	2,511,376	2,406,073	16,989,698
466.00	2,697,989	2,604,683	19,594,380
468.00	3,086,281	5,784,270	25,378,650
471.00	4,035,979	10,683,390	36,062,040
472.00	4,254,324	4,145,152	40,207,192
473.00	4,446,267	4,350,296	44,557,487
475.10	4,500,000	9,393,580	53,951,067

Device	Routing	Invert	Outlet Devices
#1	Primary	455.00'	**30.0" Round Culvert X 2.00** L= 250.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 455.00' / 454.00' S= 0.0040 '/' Cc= 0.900 n= 0.012, Flow Area= 4.91 sf
#2	Device 1	459.42'	**7.8' long Sharp-Crested Rectangular Weir (skimmer plate) X 2.00** 2 End Contraction(s)
#3	Secondary	475.00'	**5,000.0' long x 30.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=449.00' TW=456.00' (Dynamic Tailwater)
└─**1=Culvert** (Controls 0.00 cfs)
  └─**2=Sharp-Crested Rectangular Weir (skimmer plate)** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=449.00' TW=456.00' (Dynamic Tailwater)
└─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond Pond E: Ash Pond E (2019 Topo)



Summary for Pond River: Cumberland River - 445 Normal WSE

Below is a list of tailwater elevations that must be implented into the downstream River node, under starting water surface elevation, for the corresponding storm event.

Normal Operating - 50 year: 447.0 ft.
100 - 1000 year: 452.0 ft.
1/2 and Full PMP: 454.0 ft.

Adjust Outlet Elevation to Coorespond to Tailwater Condition

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[62] Hint: Exceeded Reach 1R OUTLET depth by 0.24' @ 167.99 hrs

Inflow Area = 3,974.716 ac, 1.89% Impervious, Inflow Depth > 82.73" for 25-year event
Inflow = 2,272.50 cfs @ 13.30 hrs, Volume= 27,403.026 af, Incl. 1,955.00 cfs Base Flow
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

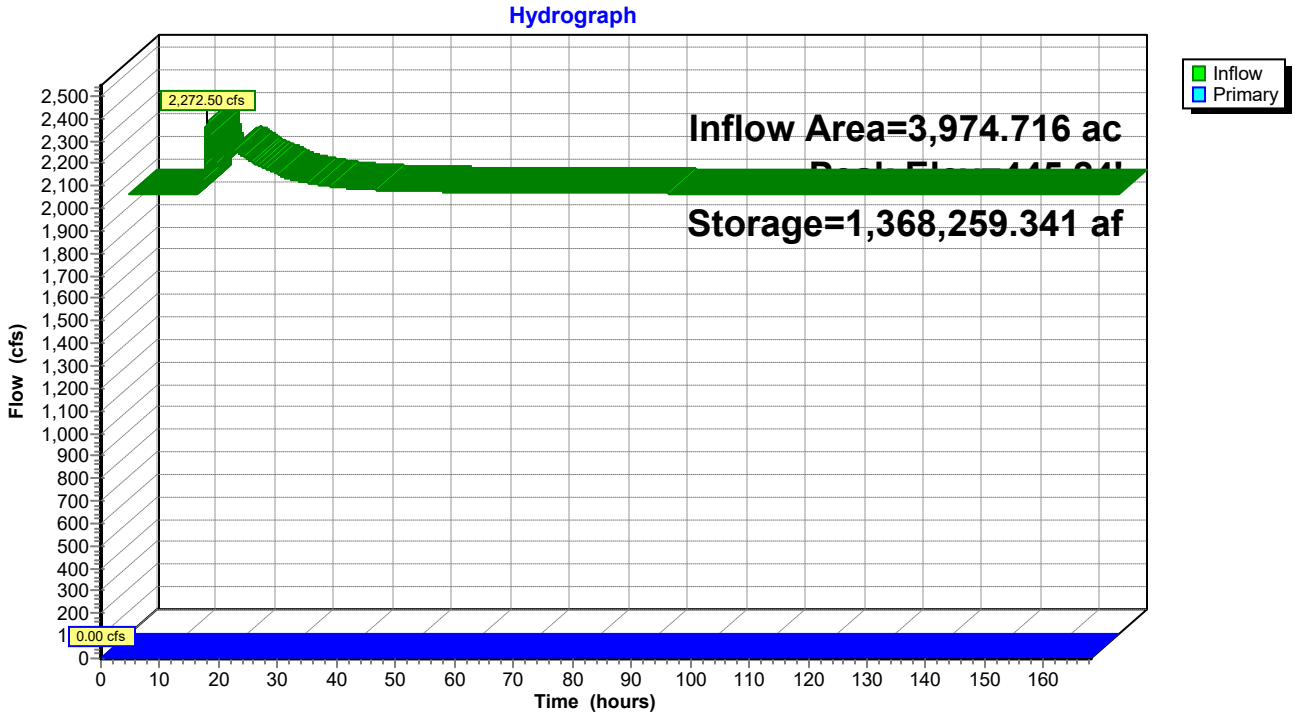
Routing by Dyn-Stor-Ind method, Time Span= 0.00-168.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 445.00' Surf.Area= 114,285.714 ac Storage= 1,340,857.143 af
Peak Elev= 445.24' @ 168.00 hrs Surf.Area= 114,696.011 ac Storage= 1,368,259.341 af (27,402.198 af above sta
Flood Elev= 452.00' Surf.Area= 126,285.714 ac Storage= 2,182,857.143 af (842,000.000 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	432.00'	162,400.000 af	**Custom Stage Data (Prismatic)** Listed below (Recalc) x 200
		162,400.000 af	x 20.00 = 3,248,000.000 af Total Available Storage

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
432.00	23.000	0.000	0.000
460.00	35.000	812.000	812.000

Device	Routing	Invert	Outlet Devices
#1	Primary	454.00'	**200.0' long x 200.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=445.00' (Free Discharge)
└**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond River: Cumberland River - 445 Normal WSE