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NRS Field Demonstration Work Plan

TVA Gallatin Fossil Plant
Summer County, Tennessee

Tennessee Valley Authority

Revision 0

May 27, 2021

Quality Information

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Revision 0	5/27/2021	Initial Version

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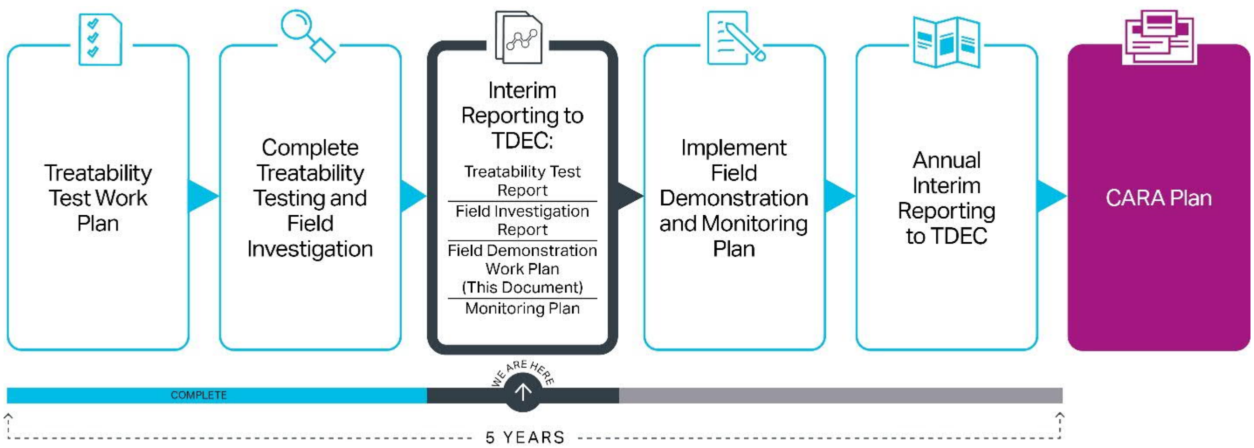
Executive Summary

This Field Demonstration Work Plan (work plan) describes the construction and performance monitoring of a permeable reactive barrier (PRB) at the Gallatin Fossil Plant (GAF). This work plan has been prepared in response to the Tennessee Department of Environment and Conservation (TDEC) Commissioner's Order Number OGC19-0004 (the Order). In accordance with the Order, the Tennessee Valley Authority (TVA) has completed laboratory testing to select an optimal amendment for the PRB and is now planning a field demonstration aimed at adjusting (increasing) the pH to sequester metals along the Non-Registered Site (NRS) boundary adjacent to the Cumberland River.

The NRS treatability test and field demonstration project are being completed over a five-year duration, which began on November 25, 2019 following TDEC approval of the NRS Treatability Testing Work Plan. The overall objective of the project is to perform field investigation and remedial testing and evaluation sufficient to develop a plan to meet groundwater protection standards (GWPS) at the NRS boundary compliance points.

Upon completion of a successful treatability test and field demonstration at the NRS, TVA will then develop a Corrective Action/Risk Assessment (CARA) Plan presenting recommendations for the closure method and groundwater remediation at the NRS. The following presents a general flow schematic for completion of the project, beginning with the treatability test and concluding with the CARA Plan.



The 2020 NRS Field Investigation Report and NRS Treatability Test Report have been developed and submitted to TDEC under separate cover (AECOM, 2021a, 2021b). As of the date of this report, TDEC has provided comments to these documents and TVA is preparing responses.

This Field Demonstration Work Plan describes implementation of the next step, a pilot-scale field demonstration for a PRB. As described in more detail in this work plan, the proposed PRB demonstration includes the following key elements:

1. **Dimensions:** The proposed PRB demonstration will be approximately 12 feet wide by 60 feet deep by 40 feet long. This width is adequate for installation of internal monitoring/recirculation wells and has a projected longevity of approximately eight years. The 60-foot depth is designed to assure that the PRB extends over the entire thickness of saturated soil with low pH (pH less than 5). The PRB depth will be confirmed and adjusted during construction by field verification of soil types and pH measurements. The 40-foot length was selected to intersect areas of low pH groundwater while minimizing the potential for groundwater to flow around the PRB to the downgradient monitoring wells used to monitor the field demonstration performance.
2. **Material of Construction:** The PRB will be constructed of concrete sand and dolomitic fines (DoloFines), which is a magnesium-rich form of quick lime. The bench-scale treatability testing

demonstrated that a 0.2% DoloFines to concrete sand blend would provide effective treatment, utilizing a chemistry similar to that of the local bedrock geochemistry. Minor adjustments to the DoloFines dose or source of sand are being evaluated to optimize performance. Results of the optimization testing and final decision of sand source and DoloFines dose will be included in the construction completion report.

3. **Location:** The proposed location is upgradient (northeast) of existing monitoring well 19R, at which groundwater has been observed to have low pH and concentrations of all four target metals (beryllium, cadmium, lithium, and nickel) exceeding GWPS.
4. **Performance Monitoring:** The performance monitoring network includes upgradient wells, wells inside the PRB and wells immediately down gradient of the PRB. Wells within the PRB include wells near the upgradient inside edge of the PRB, in the center of the PRB and on the downgradient inside edge of the PRB. Existing well 19R, which is located slightly further downgradient, will also be sampled. Groundwater monitoring is detailed in the NRS Field Demonstration Performance Monitoring Plan provided as **Appendix A**. This plan specifies quarterly monitoring for target metals and annual monitoring for additional constituents.
5. **Performance Criteria:** Objectives for a successful full-scale PRB have been previously established (Treatability Test Work Plan, AECOM, 2019). Two primary criteria are neutralizing acidic pH and meeting the GWPS for target metals, as well as maintaining compliance with GWPS for a broader list of analytes. Groundwater from within the central and downgradient section inside the PRB is expected to maintain compliance with the GWPS throughout the test period or achieve compliance with the GWPS by the conclusion of the test period. Monitoring wells located approximately four feet inside the upgradient edge are being installed to provide early indication of breakthrough as treatment media (the DoloFines) are consumed by acidic groundwater. Evidence of breakthrough (decreasing pH and/or presence of target metals at increasing concentrations) at the upgradient edge is anticipated during the test duration and not an indication of failure of the PRB. Data describing depletion of treatment capacity at various depths into the PRB can be used to develop the design for a full-scale remedy. Monitoring wells located downgradient of the PRB may not show response during the monitoring period due to the low average groundwater flow velocity. However, evidence of increasing pH or decreasing target metal concentrations in wells downgradient of the PRB would be an indication of a generally successful demonstration.
6. **Optional Components of the Demonstration Test:** Performance monitoring of the PRB will be conducted quarterly. Depending on results, contingency activities may be implemented to accelerate the flow of treated groundwater to downgradient areas, or to improve mixing within the PRB. These additional studies will be proposed if there is evidence of uneven groundwater quality within the PRB or if no change is observed in any of the downgradient wells.
7. **Evaluation of Construction Methods and Costs:** The field demonstration provides the opportunity to evaluate and refine PRB construction methods. The pilot scale PRB will be constructed by use of large diameter (4-foot) augers. Construction will be closely monitored, problem areas resolved, production rates documented, and costs tracked. This detailed information will later be used to develop a conceptual approach and cost for construction of a full-scale PRB (assuming the testing shows that PRB performance objectives are met).

A schedule for construction, monitoring and final reporting on the pilot test is provided in Section 7. Construction of the PRB is planned for the fall of 2021. Semi-annual reports will be prepared over a three-year monitoring period. The final report is scheduled to be submitted prior to November 25, 2024.

1. Introduction and Purpose

AECOM has prepared the following Field Demonstration Work Plan (work plan) on behalf of the Tennessee Valley Authority (TVA) to provide details of a planned pilot-scale field demonstration of a permeable reactive barrier (PRB) to be performed in response to the Tennessee Department of Environment and Conservation (TDEC) Commissioner's Order Number OGC19-0004 (the Order). The Order requires that TVA conduct a laboratory treatability test and field demonstration aimed at adjusting pH to sequester metals along the Non-Registered Site (NRS) boundary adjacent to the Cumberland River at TVA's Gallatin Fossil Plant (GAF) to evaluate whether such actions can achieve compliance with groundwater protection standards (GWPS). The Order also requires development of a Field Demonstration Work Plan, a Monitoring Plan, and ultimately a Corrective Action/Risk Assessment (CARA) Plan for closure of the NRS and remediation of groundwater to be completed following the field demonstration. The bench-scale treatability testing of potential remedial amendments was previously completed and documented in the NRS Treatability Test Report (AECOM, 2021b). Pursuant to the Order Section VII.B.1, this work plan describes implementation of the next step, a pilot-scale field demonstration for a PRB. For this demonstration, the PRB will be installed in an area known to contain low pH groundwater with target metal concentrations above the GWPS. The PRB will be oriented perpendicular to groundwater flow and will straddle the zone of low pH saturated alluvial materials. If the PRB demonstration is successful, groundwater passing through the PRB will have an increased pH and lower levels of target metals. To evaluate changes in pH and metals concentrations, monitoring wells will be installed upgradient, within and immediately downgradient of the PRB. In accordance with the Order, monitoring of the PRB must be completed within a 5-year timeline ending November 24, 2024. Based on the anticipated schedule for installation of the PRB in the Fall of 2021, the proposed monitoring period for the field demonstration is expected to be approximately three years.

1.1 Background

The NRS location is depicted in **Figure 1-1**, and a site layout is depicted as **Figure 1-2**. The NRS is an approximately 70-acre, closed surface impoundment historically used for the disposal of coal combustion residuals (CCR) prior to 1970. During groundwater monitoring activities for the NRS, concentrations of beryllium (Be), cadmium (Cd), nickel (Ni), and lithium (Li) (the target metals) were detected in groundwater samples collected from downgradient monitoring wells at concentrations greater than TDEC GWPS (TVA, 2017a).

The 2020 NRS Field Investigation Report (AECOM, 2021a) indicated that the source of the GWPS exceedances at the NRS did not appear to be associated with CCR, but rather with disposal of pyrite, which oxidizes to form acid in the presence of water and oxygen. The acidic conditions are believed to have resulted in Be, Cd, Li, and Ni concentrations above the GWPS in places along the downgradient boundary of the NRS (as well as in an area upgradient of the NRS). Previous studies documented in the Treatability Test Work Plan (AECOM 2019) concluded that the use of a pH adjustment strategy appears to be a feasible groundwater corrective action technology to mitigate GWPS exceedances in the alluvium at the NRS. The potential for pH adjustment to remove metals was further supported by a series of bench-scale treatability studies documented in the Treatability Test Report (AECOM, 2021b). The bench-scale treatability testing showed that the best performing amendment for a PRB would be a mixture of dolomitic fines (DoloFines), which is a magnesium-rich form of quick lime, and sand. The DoloFines/sand mixture was able to successfully remove target metals to below the GWPS from site groundwater while not mobilizing other metals in the laboratory. The next step in evaluating the feasibility of a full-scale PRB is the field demonstration described in this workplan.

A field investigation was performed to further assess the nature and extent of the acidic groundwater and associated target metals concentrations above GWPS. The Non-Registered Site Field Investigation Report (AECOM, 2021a) identified three areas of acidic groundwater, one upgradient area near well GAF-441U and two downgradient areas, near well 19R and GAF-444U. The two downgradient areas were evaluated as part of the development of this work plan for performance of the field demonstration, as discussed below.

1.2 Objectives

The objectives of the laboratory treatability test and the planned field demonstration are to determine whether pH and geochemical conditions can be adjusted in alluvial groundwater at the NRS and if such an adjustment can be an effective method to meet GWPS at the NRS boundary compliance points. The GWPS goals are:

Metal	GWPS (µg/L)
Beryllium (Be)	4
Cadmium (Cd)	5
Lithium (Li)	40
Nickel (Ni)	100

Notes:
µg/L – micrograms per liter
GWPS – groundwater protection standards

As described in the NRS Treatability Test Work Plan (AECOM, 2019) a successful reagent would also meet these criteria:

1. It is appropriate for safe handling and application at field scale at the NRS in the vicinity of the Cumberland River,
2. It reduces metals concentrations to below the GWPS in groundwater,
3. It sequesters metals such that they are not remobilized at concentrations above the GWPS,
4. It does not alter aquifer geochemistry in such a way as to mobilize non-target metals at concentrations approaching GWPS at a point-of-compliance, and
5. It has the potential to be utilized in a long-term, cost-effective remedial treatment in terms of capital cost and operations and maintenance.

The above goals were successfully met in the laboratory treatability testing. The objective of this work plan is to determine if the laboratory results can be duplicated in the field. The field demonstration is designed to provide the necessary data to evaluate the effectiveness, cost, and key design parameters of a full scale PRB.

1.3 Work Plan Organization

Section 2 provides the basis for site selection and dimensions of the PRB. Section 3 details the remedial amendment mixture and presents plans to optimize the mixture. Section 4 presents the construction method for the pilot-scale PRB. Section 5 describes the plan for monitoring PRB performance, and Sections 6 and 7 discuss permitting for the field demonstration and the anticipated schedule for implementation, respectively.

2. Pilot Scale PRB Location and Dimensions

The pilot PRB location is selected to be in an area where target metals concentrations in groundwater exceed the GWPS and pH is low (less than 5). Two locations, the areas near wells 19R and GAF-444U, meet these criteria. A comparison of the two locations is provided in **Table 2-1**. As shown in **Table 2-1**, the Li concentration at GAF-444U is typically less than the GWPS. While this does not preclude the GAF-444U area for the field demonstration, the concentrations of all four target metals at well 19R and nearby well S3 exceed GWPS, and therefore the well 19R area is preferred. This area includes both high-plasticity silty clay observed throughout most of the NRS and sandier deposits that are believed to be the primary transport pathway for low pH groundwater and associated dissolved metals concentrations above GWPS. The selected PRB pilot location is depicted in **Figure 2-1**. The proposed PRB is positioned to take advantage of existing well 19R as an additional downgradient monitoring location.

The NRS Field Investigation Report (AECOM, 2021a) documented the presence of acidic conditions in the area where the field demonstration is planned. A series of figures from the Field Investigation Report are provided in **Appendix B** to illustrate the conditions being targeted by the PRB in the field demonstration. These figures provide a detailed look at the geology and hydrogeology of the PRB demonstration area.

The length of the PRB will be approximately 40 feet. This length will promote groundwater flow into and through the PRB in the area upgradient of well 19R.

The proposed depth of the PRB is approximately 60 feet, with the reactive media placed in the approximately 3-foot to 60-foot depth interval. Details on soil types, pH, and target metals data for the 19R area are summarized in **Table 2-1**. This is based on the approximate groundwater elevation at 20 feet bgs and includes a margin of safety to prevent groundwater from overtopping the PRB during high water conditions. The PRB bottom depth of approximately 60 feet bgs is defined by the maximum depth of material with a low pH (less than 5). The PRB depth must extend beyond the depth of low pH material to ensure the whole depth interval of low pH and elevated target metals is treated. In addition, the PRB has been designed to be keyed into the underlying low permeability materials to reduce the potential for low pH water flowing underneath the PRB. Existing soil boring data and screened intervals for monitoring wells in the area provide a good indication of the ideal depth interval for the PRB. However, the soil types and depth to bedrock are variable, and thus the actual depth of the PRB may vary over its length and width. As discussed in detail in Section 4, soil types and pH will be assessed during construction of the PRB and exact depth will be based on observations during construction. Generally, the terminal depth of the PRB will be 60 feet bgs but the depth may be increased if field pH measurements are less than 5 Standard Units (S.U.), or if the geologist determines that the material has a high permeability relative to the surrounding alluvium.

The field demonstration will improve the understanding of reagent durability obtained from bench-scale studies to incorporate field data and develop a full-scale remedial design. The proposed approximate 12-foot width for the PRB was selected based on the calculated bed life, ability to monitor geochemical changes within the PRB, and PRB constructability. The expected bed life, or time to breakthrough, was calculated for various widths of the PRB using data from the laboratory treatability testing and estimates of groundwater flow. The Treatability Test Report (AECOM, 2021b) documented that a 0.2% DoloFines/sand mixture treated 0.45 liters of groundwater from well 19R per gram of DoloFines added. This work plan includes additional focused treatability testing to evaluate the performance of higher doses of DoloFines for use in the field demonstration. However, based on a 0.2% dose of DoloFines and an estimated groundwater flow through a 60-foot deep and 40-foot long section of saturated alluvium of 85,000 liters per year and, a 12-foot wide PRB would be expected to last approximately eight years. However, due to the presence of heterogeneous zones of high permeability materials, portions of the PRB may be exposed to more groundwater flow, and if so, those portions of the 12-foot barrier might be expected to last as little as five years at a 0.2% dose of DoloFines. As noted in Section 3, optimization of the PRB design by adjustment of reagent dose is being performed prior to implementation of the Field Demonstration. In addition, evaluation of in-wall mixing to extend PRB life is included as a potential contingency measure, as detailed in Section 5.6.

Anticipated PRB bed life was calculated for various PRB widths based on groundwater flow characteristics and the treatability test results for a 0.2% dose of DoloFines. The actual longevity of a barrier will be dependent upon the final dose selected and variability due to field conditions. The estimated bed life for a PRB in the well 19R area is provided in **Table 2-2a.** Similar calculations were performed for the well GAF-444U area for comparison and are presented in **Table 2-2b**. For the GAF-444U area the project longevity of the PRB is longer because the estimated rate of groundwater flow is lower and, based on the bench studies with the GAF-444U water, DoloFines treatment capacity is higher compared to the 19R water. Calculations of groundwater flow are provided in **Appendix C**.

Other considerations in selection of the PRB width include the ability to monitor the PRB and conservatism to account for potential imprecision in large-scale construction. A wider PRB mitigates the impacts of the sloughing of native soil during construction, which could decrease the effectiveness of the PRB by displacing treatment media in the PRB. A 12-foot wide PRB also provides space for installation of multiple monitoring wells along the axis of groundwater flow within the PRB (at 3, 6, and 10 feet into the PRB). The use of multiple wells within the PRB provides greater resolution of breakthrough times during the course of the monitoring period, and these data can be utilized to more accurately determine bed life under field conditions, such that this information incorporated into future remedy design. Because the high permeability sand may allow for additional mixing within the PRB, a gradual breakthrough of the PRB along the groundwater flow path may or may not occur. Nevertheless, installation of multiple wells along the flow path is worthwhile and not possible with a narrow PRB wall.

3. PRB Amendment Materials and Optimization

Based on a series of laboratory tests documented in the Treatability Test Report (AECOM, 2021b), a 0.2% DoloFines/sand amendment provided treatment of the target metals to below the GWPS while not causing any other metals to exceed the GWPS. For the 0.2% DoloFines/sand combination, 0.45 liters of 19R groundwater was treated prior to breakthrough per gram of DoloFines added. The laboratory tests were conducted with concrete sand supplied by Pine Bluffs Materials, Incorporated. While this DoloFines dose and sand type met all the performance criteria and is acceptable for use in the PRB, the Treatability Test Report identified opportunities to refine and optimize the amendment blend.

The sand used in the treatability testing contained low levels of target metals as determined by EPA method 6010B (Be 0.462 mg/kg, Cd 0.0539 mg/kg, Li 5.42 mg/kg and Ni 10.0 mg/kg). In the extreme case where testing was continued past breakthrough, concentrations of target metals in the effluent water from the sand columns exceeded the influent groundwater concentrations. This indicates that the low pH groundwater may have been leaching metals out of the sand after breakthrough. Use of an alternative sand may mitigate this potential problem. Up to four additional sand sources will be obtained and tested for metals by EPA Method 6010B and tested for leachability by EPA Method 1316 using groundwater from well 19R. The two alternative sands with the lowest target metals leachability will then be used in sand column studies (with and without DoloFines) as shown in **Table 3-1**. Sand column tests will employ the same methods and procedures used in the Treatability Test Report. Data will be compared to previous results with the original Pine Bluffs Materials sand. The best performing sand will be used for the demonstration test. Material safety data sheets for DoloFines and the specific sand currently planned for use in the field demonstration are provided in **Appendix D**.

The laboratory treatability studies included testing DoloFines doses of 0.0082%, 0.1% and 0.2%. Each increased dose provided some improved treatment. Testing of higher doses of DoloFines will be conducted to see if treatment of target metals can be extended without plugging the sand or mobilizing other metals. After the best sand/DoloFines combination is found, the test will be repeated, and effluent water tested for the full list of metals. The maximum dose to be tested has not been firmly established but is likely to be in the range of 1 to 2%. Doses above 2% may be the point where performance no longer improves, or the potential of the sand plugging becomes an issue. Plugging of the sand at higher doses appears unlikely for doses below 2% but will be evaluated for each trial by observing pressure changes during pumping water through the sand column and by visual examination of the column after the test is complete. A trial of 1% DoloFines and the previously tested Pine Bluff sand is included in Phase I optimization trials to provide an early indication of maximum percent of DoloFines.

Proposed optimization trials are summarized in **Table 3-1**. Flexibility in the testing, to change or add trials, is necessary to provide the best results. All trials and results along with final decisions on sand source and DoloFines dose will be reported to TDEC in the Construction Completion Report.

Table 3-1
Optimization Trials for Sand and DoloFines Dose

Stage	Amendment / Concentration	Sand	Groundwater	Pore Volumes/ Volume (L)	Samples	Analyses
I	Control/None	Sand #1	19R	12/6.5	12	pH and target metals
	Control/None	Sand #2	19R	12/6.5	12	pH and target metals
I	DoloFines 1%	Pine Bluff Sand	19R	12/6.5	12	pH and target metals
II	DoloFines/1%	Best Sand	19R	12/6.5	12	pH and target metals
	DoloFines/0.6%	Best Sand	19R	12/6.5	12	pH and target metals
III	To be determined based on Stage II maybe higher dose (up to 2% or intermediate in the 0.3 to 1% range)	TBD	19R	12/6.5	12	pH and target metals
	Repeat most successful sand / DoloFines mixture	TBD	19R	12/6.5	12	pH, target metals and full metals list

Notes:
L – liter
TBD – to be determined
target metals – Be, Cd, Li, Ni

4. PRB Construction

Construction of the PRB will be performed by the Contractor under supervision by TVA and AECOM. AECOM will provide Construction Quality Assurance (CQA) oversight of the construction, including a QA Manager that will review submittals, test data, and provide guidance and oversight to onsite CQA Representatives. The Contractor will be responsible for providing Construction Quality Control (CQC), including providing a full-time onsite QC Manager.

The following sections describe the selection of the PRB installation method and the general sequence of construction for the PRB, including instrumentation monitoring, construction contingency measures, QA/QC procedures, and the management of water, CCR, and auger cuttings generated during construction.

Engineering Drawings for the PRB installation are provided in **Appendix E**.

4.1 Selection of PRB Installation Method

The general methods that could be used for installation of the PRB are excavation with temporary shoring, one-pass trenching equipment, or large diameter augers. Of these general options, use of large diameter augers has been selected as being the most feasible. Key advantages of the large diameter augers are ability to accurately place the sand/DoloFines mixture, ability to periodically check and confirm soil types, ability to adjust depth based on field conditions, and cost relative to the other options. One-pass trenching is at or beyond the limits of feasibility at the design depth, and excavation with shoring would likely prove much more costly. Smearing of the sidewalls of the PRB and closing the more permeable sand seams is a potential concern with all the construction methods. However, because the PRB will be orders of magnitude more permeable than the surrounding alluvium and will intercept most of the vertical extent of the saturated alluvium, smearing is not expected to represent a significant impediment to groundwater flow through the PRB.

4.2 Surveillance and Instrumentation Monitoring Plan

Because the work will be performed adjacent to and within the perimeter dike system of the NRS, a dike stability evaluation has been performed to evaluate construction phase stability of the dike. Three new vibrating wire piezometers and one slope inclinometer are proposed to be installed for monitoring of the perimeter dike during construction. Two additional vibrating wire piezometers will be installed adjacent to either end of the PRB for water level monitoring only (not for stability purposes). The Preliminary Surveillance and Instrumentation Monitoring Plan (SIMP) provided in **Appendix F** will be implemented to monitor construction phase stability of the NRS perimeter dike system. This plan includes proposed threshold water level values for each piezometer to be monitored during construction in order to maintain adequate stability factors of safety.

4.3 Construction Contingency Planning

A Temporary Construction Emergency Action Plan (TCEAP) has been developed and is provided as **Appendix G**. The purpose of this TCEAP is to provide contingency planning and guidance to the Contractor in the event that execution of the work results in unplanned adverse impacts to the project area.

4.4 Site Preparation

Preparation of the site will include clearing of vegetation, stripping of topsoil (where present), and construction of temporary roadways, a working area for stockpiling of materials, and a turn-around for trucks. Drawing 3 in **Appendix E** provides a layout of the proposed laydown/construction staging areas and access roads for the project. To minimize the impacts of equipment loading on the perimeter dike system in accordance with the SIMP, heavy equipment used to install the pilot PRB should be located no closer than 11 feet to the crest of the NRS dike. In order to mobilize equipment for construction, road improvements will be made to allow equipment to access the construction area without traversing on the perimeter dike system.

4.5 Sand/DoloFines Blending

Based on processes developed on previous projects, the plan is to use ex-situ batch mixing of remedial amendment and sand piles using an excavator with a standard bucket or rake attachment. The Contractor will be allowed some flexibility in development of means and methods, and if the method of mixing is modified, TDEC will be notified. An onsite CQA Representative will oversee weighing of sand, calculating DoloFines amount, weighing of DoloFines, mixing and verification testing. Details of each blend will be recorded, and material placement in specific augers holes will be tracked. Blending will be conducted adjacent to the PRB as it is being constructed and blended material will be placed shortly after blending (the same day to the extent practical). The amount of material blended per day will be determined based on the daily rate of auguring. The procedures for safe handling, verifying quality of raw materials (sand and DoloFines), storage, blending and verification of blending are provided in **Appendix D**. Handling procedures include specifications for stockpile construction, covering and soil and erosion controls.

4.6 PRB Excavation and Amendment Placement

The PRB will be installed using a dual head, drilled shaft auger. The installation will involve augering and alluvium removal in conjunction with advancing steel casing to keep the hole open. The dual head equipment will be advanced to the target depth of 60 feet bgs, resulting in a fully cased open boring. If bedrock is encountered and confirmed, augering may be terminated above the target depth. A plan view of the augering layout for the PRB is provided on Drawing 4 in **Appendix E**. The Contractor will provide instrumentation to accurately determine the depth, plumbness, and volume of each hole to allow an accurate assessment of as-built conditions. The use of steel casing should provide a high degree of overall plumbness and uniformity of hole geometry. The following tolerances will be required for the augering:

- The maximum allowable horizontal deviation from the center of shaft shown on the drawings shall be one inch in any direction.
- The maximum allowable deviation of the finished drilled shaft from the vertical at any level is 1/4 in 100 (0.25%).

The Contractor shall demonstrate to the satisfaction of the QA Representative that construction is completed within these allowable tolerances. Should a deviation from these tolerances be identified, they will be reviewed by the Engineer and corrective measures implemented (e.g., repositioning of subsequent borings or completion of additional borings). The installation of the primary and secondary augered holes shall be sequenced and constructed within these allowable tolerances to provide the minimum required overlap between adjacent piles.

At the target depth, auger cuttings will be observed to evaluate the materials at the target depth to determine if the hole should be extended deeper based on observed sand content or pH of the soil cuttings. One auger boring every 8 feet along the length of the PRB will include testing of auger cuttings at the anticipated terminal depth (60 feet). The CQA Manager will review site data collected during construction to determine if auguring deeper is justified based on presence of soil with pH less than 5 S.U. (field test using site water from background location at 1 to 1 liquid to soil ratio), and a determination of the sand content of the soils relative to the screen intervals of wells 19R and S3. If sandy material extends below 60 feet, deeper auguring will be considered. Auguring will terminate if weathered bedrock is encountered. A professional geologist registered in the State of Tennessee will be on-site during augering as a CQA Representative to evaluate site conditions during drilling.

The holes will be constructed using augering equipment with corresponding steel casing to provide a 48-inch diameter opening. The holes will be installed in a “secant pile” pattern, with a 1.2-foot overlap to provide full coverage, as illustrated in the design drawings. Hole locations will be surveyed in place initially and re-established as needed during construction. Typically, each corner hole will be performed first to establish the limits of the proposed PRB. Thereafter, holes will be constructed using the secant pile pattern, with every other hole in each line overlapping 1.2 feet into the adjacent holes. Due to the nature of the installation process, some previously installed, blended sand will be removed and replaced during the construction process.

The blended sands/DoloFines will then be tremied into the open hole in such a way to allow corresponding removal of the casing in sections until ground surface is reached. The Contractor will use a Kelly bar, clam grabber, or similar digging tool to tamp each 2 feet of tremied blended sand to avoid the development of voids.

Although the PRB target interval is the lower 45 feet bgs of the 60-foot target depth, blended sand should be used to backfill from the bottom depth to the ground surface at the auguring location to prevent unblended material being mixed into blended material through the overlapping auger installation process. The top three feet of blended sand material will be replaced with native, low permeable material after completion of augering, as described in Section 4.8.

To evaluate the magnitude of clay smear to affect the PRB wall system, and, to minimize the overall potential impact, the top of the PRB will be visually evaluated prior to construction of the clay cap to assess the location, thickness, and distribution of smearing extending to the top of the PRB. At select locations, targeted supplementary augered locations may be performed to remove thickened smear zones that may impede free flow paths.

4.7 Dewatering and Water Treatment

Dewatering is not required to advance the augers but may be required for placement of the amended sand. Leaving very silty water in the auger holes could reduce the permeability of the PRB. Water in the augers could also cause DoloFines to separate out as the sand falls through the water column. If water is present at two or more feet above the bottom of the auger hole, it will be removed prior to sand placement.

Water in the auger holes will be pumped out and placed in one or more fractionation tanks. These tanks are typically 20,000-gallon capacity and will be placed upon containment. Water will be conveyed to the Plant, pre-treated as necessary to remove silt and adjust pH, and pumped through the Plant Flow Management System prior to discharge under the existing NPDES Permit.

4.8 Restoration and Surface Completion

Following installation of the PRB, the upper three feet of installed material will be over-excavated; a non-woven geotextile will be placed over the exposed sand subgrade extending at least five feet beyond the limits of the PRB; and the area will be backfilled to the ground surface. The backfill material will consist of clay (USCS classification CL or CH) and will be placed in maximum 8-inch thick loose (6-inch compacted) lifts. Each lift will be compacted to at least 95% of the Standard Proctor maximum dry density and within 2 percentage points of the Optimum Moisture Content. Two density tests will be performed per lift. The ground surface will be graded to encourage run-off away from the PRB. The surface will then be seeded and strawed as necessary and the limits of the geotextile and the PRB will be delineated and staked or permanently marked at the ground surface. TVA anticipates utilizing clay from onsite stockpiles located within the NRS for construction of the clay cover.

4.9 Ash Management

The PRB installation process will result in the accumulation of auger cuttings. Because the wall is located along the interior edge of the soil perimeter dike system, there is a small amount of CCR that will need to be removed in order to allow installation of the PRB. To minimize the potential for CCR to be entrained in auger cuttings, the area of the PRB will be pre-excavated to remove CCR, which is expected to be encountered only in the top three to five feet on the upgradient side of the PRB. Smaller quantities of CCR are expected to be generated during rotosonic drilling of the PUP-series wells. This material will be segregated from drill cuttings that do not contain CCR and will be managed with the pre-excavation material.

Any CCR that is encountered will be excavated, stockpiled separately, and transported onsite for disposal in the onsite North Rail Loop (NRL) CCR landfill (IDL # 83-0219). The NRL facility is permitted to accept all types of solid wastes (CCRs) generated as a result of power generation operations at GAF, and it is understood that a Special Waste Permit is not necessary for this activity.

Based on the proposed location of the PRB field demonstration, an estimated 100-200 cubic yards of CCR may be encountered during pre-excavation and monitoring well installation. TVA is requesting that TDEC's approval of this work plan serve as approval of this anticipated ash management activity pursuant to Tennessee Code Annotated Section 68-211-106(j).

4.10 Soil Cuttings Management

Following removal of the CCR from the work area, auger cuttings will consist of a mixture of dike raise material, alluvium, and blended sand. The total volume of auger cuttings, inclusive of blended sand removed during second-pass drilling, is estimated to be approximately 4,000 cubic yards of material. Soil auger cuttings will be stockpiled within the NRS in the soil stockpile noted as Construction/Laydown Area #1 on Drawing 3 in **Appendix E**. The cuttings will be seeded to prevent erosion.

4.11 Debris Management

Non-CCR debris/waste may be encountered during construction of the PRB field demonstration that may not be permitted for disposal within the NRL landfill. The NRS may contain 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 NRL landfill will be characterized and staged in a designated collection area within the boundaries of the NRS 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.

5. Performance Monitoring

Performance monitoring will occur over an approximately three-year period. As discussed in Section 5.5, specific performance criteria have been developed to determine the effectiveness of the PRB. Aspects of the monitoring and operation of the PRB may evolve as data is collected and reviewed. This section presents minimum monitoring requirements. Additional details are provided in the Performance Monitoring Plan included in **Appendix A**. During the field demonstration, quarterly assessment monitoring at the NRS will continue.

5.1 Performance Monitoring Network

The performance monitoring network is depicted in Drawing 5 in **Appendix E.** The monitoring network will consist of wells upgradient of the PRB (PUP-series wells), wells constructed within the PRB (PIN-series wells) and wells downgradient of the PRB (PDN-series wells), as well as existing wells 19R, S3, and GAF-526U. The new monitoring wells will be installed after installation of the PRB is completed. Methods used for well installation and development, sample collection, laboratory analysis, and data validation will be consistent with procedures described in the TVA's Technical Instructions.

5.1.1 Upgradient PRB Monitoring Network

The wells located upgradient of the PRB (PUP-series) will provide an indication of the water chemistry flowing into the PRB, and data from them will be compared to water chemistry inside and downgradient of the PRB in evaluating PRB effectiveness. The PUP-series wells will consist of three intermediate-depth wells, two shallow wells and one deep well. Intermediate wells will be completed to the approximate screened intervals of well 19R and S3 (see **Table 2-1**). Shallow wells will be screened above the screened interval of well 19R. Deep wells will be installed within the overburden below the depth of the bottom of the PRB. Precise screen intervals may be adjusted based on observations of soil types and field screening for pH using the soil pH procedure included in **Appendix B** of the Treatability Test Work Plan (the Sampling and Analysis Plan). This method will be modified to utilize non-acidic site groundwater. Wells will be installed utilizing rotosonic methods to allow collection of continuous soil cores. The shallow and intermediate wells will be 4-inch diameter PVC with ten-foot screen lengths. The deep well will be constructed of 2-inch diameter PVC with a two to five-foot long well screen and will be installed with at least three feet of vertical separation between the top of the well sand pack and the base of the PRB. If conditions are encountered such that bedrock is encountered and that separation cannot be maintained, a deep well may not be installed.

5.1.2 Internal PRB Monitoring Wells

Nine wells (the PIN-series wells) will be installed within the PRB to monitor geochemical changes within the PRB. The PIN-series will consist of three diagonal transects of three wells each installed in the PRB (see Drawing 5 in **Appendix E**). These wells will be constructed of a minimum of 4-inch diameter PVC and will have screen intervals from approximately two feet above the bottom of the PRB to five feet below the water table. Use of 4-inch diameter PVC is planned to facilitate possible use of groundwater recirculation pumps (see Section 5.5) to maximize the potential longevity of the PRB if permeable pathways preferentially load specific regions of the PRB. Screens slot size will be compatible with the final sand selection (likely poorly graded medium sand). The PIN-series of wells includes a row of three wells located approximately three feet from the upgradient PRB edge (Row "AA", three wells at the center of the PRB (Row "BB") and three wells approximately three feet from the downgradient edge of the PRB (Row "CC"). This arrangement will allow monitoring of groundwater chemistry at various points within the PRB to assess the rate of depletion of remedial amendment within the PRB, which is expected to first be consumed at the upgradient edge and progress toward the downgradient edge.

5.1.3 Downgradient PRB Monitoring Wells

A series of downgradient (PDN-series) wells will be installed to provide an indication of the water chemistry leaving the PRB, and data from them will be compared to water chemistry upgradient of the PRB to evaluate PRB effectiveness. The six downgradient (PDN-series) wells will be installed approximately five feet downgradient of the PRB. The PDN-series will consist of three intermediate wells, two shallow wells and one deep well. Installation and construction of the PDN-series wells (both couplets and the deep well) will be consistent with the upgradient wells, although the specific screened intervals may be adjusted based on observations of geology to intercept the most permeable materials in the subsurface. Use of 4-inch diameter PVC is proposed for the shallow and intermediate wells to allow the option of groundwater extraction from these wells, as needed, as discussed in Section 5.5.

5.2 PRB Soil Testing

Based on the sand size and observations during the bench-scale testing, no significant reduction in permeability of the PRB is anticipated. Conducting pumping tests or other activities that would stress the PRB are not proposed, except as discussed in Section 5.6 as a contingency. Permeability testing is part of the quality control process for the sand and will be conducted on sand prior to placement. Samples of blended sands and DoloFines will be collected from the PRB material during the final stages of construction when the PIN-series wells are installed. This material will be submitted to a geotechnical laboratory for permeability testing for potential comparison to PRB wall material after the field demonstration. While undisturbed samples of PRB wall material are not expected to be obtained, the sample collection will allow a qualitative visual comparison and quantitative estimates of PRB material permeability to be developed. In addition, at least one gallon of sand/DoloFines mixture obtained during installation of the PIN wells and at the end of the demonstration will be sent to AECOM's treatability lab for possible additional testing.

These samples will also allow for analytical testing of PRB material before and after the field demonstration to identify changes in analyte concentrations in the PRB matrix over time. Up to six samples will be collected before and after the field demonstration for analysis of the constituents identified in **Table 5-1**.

5.3 Groundwater Elevation Monitoring

Groundwater elevation monitoring will be conducted monthly for the first quarter after the PRB has been installed and then quarterly thereafter. For each groundwater monitoring event, all alluvial wells in the pilot test vicinity, including the existing wells 19R, S3, and GAF-526U will be measured for potentiometric surface elevation. The elevation monitoring will occur immediately before each groundwater monitoring event.

Groundwater elevation monitoring will be performed to assess whether the groundwater gradient suggest groundwater flow from the upgradient area into the PRB and out of the PRB toward the downgradient area. Only small head differences between monitoring wells are expected to exist over relatively short distances like the 12-foot width of the PRB, and therefore clear indications of the hydraulic gradient may not be apparent, given the potential for local variability among individual wells. However, groundwater elevation monitoring data will be used to note abnormal conditions, such as elevated groundwater levels within the PRB, that could be indicative of hydraulic issues with the PRB that would need to be addressed. Irregularities in groundwater elevation may be noted initially as water levels equilibrate after construction, but water levels around the PRB are expected to generally reflect the surrounding alluvium by the time the first monitoring event is performed. If irregular water levels persist, groundwater recirculation among the PUP-, PIN-, and PDN-series wells may be performed to improve the hydraulic connection across the PRB.

5.4 Groundwater Chemistry Monitoring

A Field Demonstration Performance Monitoring Plan is included in **Appendix A**, which provides detailed procedures for groundwater sample collection and analysis. A general description of the monitoring plan is provided below. Baseline monitoring, which will be used as a point-of-comparison to evaluate PRB performance, will consist of pre-construction monitoring at existing wells and a round of post-construction monitoring at the new wells described in Section 5.1. Initial pre-construction samples will be collected from existing monitoring wells 19R, S3, and GAF-526U immediately prior to PRB construction (i.e., during contractor mobilization).

The PUP-, PIN-, and PDN-series wells will be sampled for baseline conditions approximately one month after PRB construction and well installation, and then quarterly thereafter. Quarterly sampling constituents will include:

- pH by field test,
- Total and dissolved target metals,
- Cobalt, and
- Alkalinity.

A more comprehensive suite of metals (total and dissolved) and selected anions will be tested on the initial post-construction groundwater samples and annually thereafter. These constituents are identified and sampling methods are detailed in the Field Demonstration Performance Monitoring Plan provided as **Appendix A**.

The comprehensive sampling events include constituents which are not performance criteria for PRB. These additional constituents will be compared to results obtained during the bench studies, which may provide some insight on differences in chemistry (if any) between the bench studies and the in-situ PRB.

5.5 PRB Effectiveness Metrics

The most straightforward metric of PRB effectiveness is the groundwater chemistry observed downgradient of the PRB. However, due to the low groundwater velocity and heterogeneity of the alluvial aquifer, the effect of the PRB on groundwater chemistry at the PDN-series wells may not be apparent during the monitoring period. While it is difficult to anticipate all possible outcomes for the water chemistry sampling, it is useful to consider potential outcomes and how those outcomes will be viewed in evaluating the performance of the PRB. Potential scenarios and conclusions are discussed below and summarized in **Table 5-2** below.

Table 5-2
Potential Monitoring Results and Implications for Evaluation of PRB Effectiveness

Scenario	Upgradient Wells	Wells Inside the PRB	Downgradient wells	Interpretation / Recommendation
1	GWPS for one or more target metals is exceeded in one or more wells, pH is <5 in one or more wells.	GWPS is met for “B” and “C” rows of PIN-series wells.	Downward trend in target metals in one or more wells.	PRB is effective.
2	GWPS for one or more target metals is exceeded in one or more wells, pH is <5 in one or more wells.	GWPS is met for “B” and “C” row of PIN-series wells.	No trend in downgradient wells.	PRB likely effective but will require longer time period to change downgradient water chemistry. Consider accelerating groundwater flow (pumping water from downgradient wells and discharging to inside PRB).
3	GWPS for one or more target metals is exceeded in one or more wells, pH is <5 in one or more wells.	GWPS is exceeded in most wells completed inside the PRB, including “C” row of PIN-series wells.	No trend in downgradient wells.	PRB is not functioning as intended. Consider activating recirculation wells to improve contact between groundwater and amendment.
4	GWPS is not exceeded and pH is >5.	GWPS is met for “B” and “C” rows of PIN-series wells.	No trend in downgradient wells.	Inconclusive test. Consider accelerating groundwater flow.
5	GWPS is not exceeded and pH is >5.	GWPS is met for “B” and “C” rows of PIN-series wells.	Downward trend in target metals in one or more wells	PRB is effective, although durability estimate of PRB is uncertain. Would suggest longer durability due to weaker upgradient source.

Notes: PRB – permeable reactive barrier GWPS – groundwater protection standards

For the PUP-series of wells, the likely outcome is that the baseline pH will be less than 5 S.U. and concentrations of the target metals will exceed the GWPS in most of the wells screened at a similar depth to wells 19R and S3. However, given the vertical and horizontal variability of soil types, potential variability of low pH impacted groundwater, and localized influence from the PRB installation, it is possible that water chemistry may take a few quarters for consistent results to develop.

For the PIN-series of wells, it is anticipated that pH will be elevated relative to the surrounding alluvial aquifer and that target metals concentrations will be below the GWPS at the onset of the test, due to the presence of remedial amendment in the immediate vicinity of the well screens. However, it is possible that some PIN-series wells take some time to equilibrate to the surrounding PRB materials following installation, and GWPS may not immediately be met, but even then, the PIN-series wells are expected to show GWPS compliance or a clear downward trend relatively quickly. Over the course of the monitoring period, the “AA” row of PIN-series wells (i.e., those wells closest to the upgradient edge of the PRB) may begin to have downward trends in pH or increases in metals concentrations, as the remedial amendment in the leading edge of the PRB is depleted. The “AA” row of PIN-series wells are positioned at a location that, based on estimates of groundwater flow velocity and treatment capacity of the amendment, are likely to experience breakthrough of low pH groundwater with metals concentrations in excess of GWPS within the time span of the field demonstration. The “BB” row of PIN-series wells may likewise see breakthrough or trends suggesting decreased effectiveness. Thus, decreasing pH or increasing target metals concentrations in the ”AA” and “BB” rows of PIN-series would not be considered failure of the PRB. Exceeding GWPS in the “CC” row of PIN-series wells would be considered failure of the PRB. Monitoring would continue for one year to determine if the exceedances are a temporary condition resulting from PRB installation. If GWPS exceedances remain in the “BB” and “CC” series wells after one-year, contingency measures (see Section 5.6) will be taken.

Ideally, target metals concentrations will show a downward trend in the PDN-series of wells. This, together with maintaining GWPS compliance for the PIN-series wells, would be a clear indication of a successful PRB. With the PDN-series wells located approximately five feet from the PRB, changes in water chemistry are possible but not assured, given the slow rate of groundwater migration in native alluvium. It is possible, perhaps likely, that results in PDN-series wells will not be uniform, with wells screened in more permeable materials likely to more quickly show effects of the PRB. If no change in the PDN-series wells is observed after two years, measures to accelerate groundwater flow for the remainder of the pilot test will be considered (see Section 5.6).

It is possible that target metals levels in the PUP- and PDN-series of wells will temporarily increase as a result of agitation of alluvium during PRB installation. Any such increase should be short-lived, as geochemical conditions equilibrate following construction. Such observations would be assessed in the context of the CSM as subsequent changes in groundwater geochemistry are evaluated during the monitoring period.

Existing wells S3 and 19R are located approximately 15 feet downgradient of the PRB. A change in groundwater chemistry as a result of PRB installation is uncertain for these wells in the monitoring period of three years and depends both on the effectiveness of the PRB and the degree of interconnection of these wells to preferential migration pathways that intercept the PRB. If a trend towards higher pH or lower concentrations of metals is observed, that would be a positive indication for PRB effectiveness and an indication of groundwater flow controlled by migration through higher permeability seams with low pH.

A specific statistical analysis of trends may not be appropriate for these data sets, as the timeframe for field demonstration monitoring period is short compared to the estimated groundwater velocities. Metals concentrations shifting from above the GWPS to below the GWPS, or vice versa, will be considered a significant event and apparent trends indicative of PRB effectiveness or depletion will be noted. Metals concentration trends will also be considered potentially significant if they are observed consistently over multiple events and the change is at least 25% compared to the starting point. Individual pH changes of less than 0.5 units will not be considered significant unless the change is part of such a trend.

5.6 Contingency Activities to Improve or Test PRB Performance

This section discusses contingencies that may be implemented to improve PRB performance or to provide a better test of PRB performance if initial monitoring results are inconclusive. For all of the contingencies discussed below, additional details would be developed and reported in a semi-annual report prior to implementation.

If several wells inside the PRB (PIN-series wells) exceed the GWPS and/or have pH <5, the cause may be inadequate mixing within the PRB. To correct this problem, recirculation pumps placed within the central “B-row” of PIN-series wells may be installed and operated. These wells would pump water from the bottom of the well and discharge it within the same well near the top of the saturated well screen, using a packer to promote circulation through the vertical profile around the well. The recirculation wells can be operated in a manner to minimize introduction of oxygen into the groundwater. The recirculation wells would be operated intermittently for a period of one or two weeks and then deactivated. The PIN-series wells would then be sampled to determine if water quality improves.

Double packer sampling of discrete depth intervals in the PRB may also be performed to determine if layers of varying water chemistry exist.

A possible outcome from the field demonstration would be that wells within the PRB remain below the GWPS but no change in water quality is observed in the downgradient wells. If this condition exists after two years of monitoring, it may be useful to both stress the PRB and possibly accelerate the flow of treated water towards the downgradient wells. To accomplish this, water could be extracted from the PDN-series wells and discharged into the wells inside the PRB or to the upgradient wells. This would stress the PRB by increasing the rate of impacted water coming into PRB. The pumping would simultaneously decrease the groundwater elevations in the downgradient wells and increase the groundwater elevation gradient across the PRB. This may accelerate the flow of treated groundwater towards the downgradient wells, especially in higher permeability seams. The flow rates and operational run times for such pumping will be determined based on observations during PRB construction and operation. Well yields are likely to be very low but may be adequate to allow observation of water quality changes. This type of operation would not be applicable to a full-scale PRB. The objective of extraction and injection is to obtain better data regarding PRB longevity during the field demonstration three-year monitoring period by accelerating flow through the PRB.

5.7 Overall PRB Effectiveness Evaluation

Objectives for a successful full-scale PRB are presented in Section 1.2. The Objectives are repeated here with a discussion of specific data to be obtained from the demonstration test.

1. **Is appropriate for safe handling and application at field scale at the NRS in the vicinity of the Cumberland River:** The low dose (0.2% to 2.0%) of DoloFines is safe to handle in the area of the river. While high pH values (over 11) are theoretically possible with DoloFines, the treatability testing indicates that the low dose of DoloFines will not cause elevated pH in downgradient areas. This concept will be further evaluated in the field demonstration by monitoring pH in existing and newly installed downgradient well.
2. **Reduces metals concentrations to below the GWPS in groundwater:** A network of monitoring wells will be tested quarterly for target metals. Reduction in target metals concentrations to below GWPS in the downgradient wells would be the clearest indication of PRB effectiveness, but **Table 5-2** provides additional guidelines describing how the data will be used to evaluate success or failure of the PRB.
3. **Sequesters metals such that they are not remobilized at concentrations above the GWPS:** This objective will be evaluated by monitoring groundwater quality within and downgradient of the PRB over a three-year period. Metals concentrations will be compared to baseline conditions (before PRB construction).
4. **Does not alter aquifer geochemistry in such a way as to mobilize non-target metals at concentrations approaching GWPS at a point-of-compliance:** This objective will be evaluated by testing the monitoring well network for a comprehensive list of metals every fourth quarterly monitoring event. Results will be compared to GWPS.
5. **Has the potential to be utilized in a long-term cost-effective remedial treatment in terms of capital cost and operations and maintenance:** The field demonstration will provide information on several aspects of PRB costs and effectiveness. The construction of the field demonstration will be documented and overseen by both TVA and AECOM. Technical challenges and costs will be clearly documented and used in evaluating the feasibility and cost of a full-scale PRB. The monitoring well network has been designed to evaluate breakthrough at various points in the pilot-scale PRB and thereby evaluate the longevity of the amendment. Potential plugging of the PRB will be evaluated by testing the permeability of the DoloFines/sand blend at the start of the pilot test and again at the end of the test (if evidence of plugging is observed). An order of magnitude decrease in permeability would be indicative of significant plugging. Groundwater elevation monitoring will be performed to verify that the hydraulic gradient indicates that water is flowing through the PRB. In terms of operation and maintenance, active operation of the PRB may or may not be required. The need for mixing wells within the PRB will be evaluated during the pilot test.

6. Anticipated Permitting Activities

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

- The project is anticipated to disturb less than one acre of land at any given time. Therefore, a General Construction Storm Water Permit for construction activities is not required. However, disturbed areas will be stabilized following construction.
- As part of the National Environmental Policy Act (NEPA) of 1970, a Categorical Exclusion Checklist (CEC) must be issued to document and mitigate any potential broader environmental impact of the work described herein.
- TVA anticipates that water that accumulates at the bottom of the PRB excavation during construction may be collected and placed in the GAF Flow Management System, following pre-treatment (if necessary), and discharged through Outfall 010 under the current NPDES Permit. A permit modification is not anticipated.
- As described in Section 4.9, TVA is requesting that TDEC's approval of this Work Plan serve as approval of this anticipated ash management activity pursuant to Tennessee Code Annotated Section 68-211-106(j).

TVA will make every effort to develop application materials and obtain the necessary permits such that the field demonstration may proceed as outlined in this work plan.

7. Reporting and Schedule

The following reports will be prepared to document the field demonstration:

- **Construction Completion and Baseline Sampling Report:** This report will provide details of the PRB including as built drawings, well completion diagrams and reporting, and QA/QC documentation. The report will also include results of baseline testing of the performance monitoring well network.
- **Semi-Annual Reports:** Brief technical memoranda presenting monitoring results will be prepared and submitted by TVA to TDEC. The semi-annual reports will propose, if applicable, changes in the monitoring program or changes in PRB operation (see possible operation changes in Section 5.6).
- **Final Field Demonstration Report:** The final report will document testing results and provide evaluation of PRB performance against the five objectives stated in Sections 1.2 and 5.7.

A proposed schedule is provided in **Table 7-1**. This schedule for construction and monitoring is dependent upon the schedule of TDEC's review and approval of this work plan. The Final Field Demonstration Report will be submitted by November 25, 2024, five years following TDEC approval of the Treatability Test Work Plan, consistent with the Consent Order.

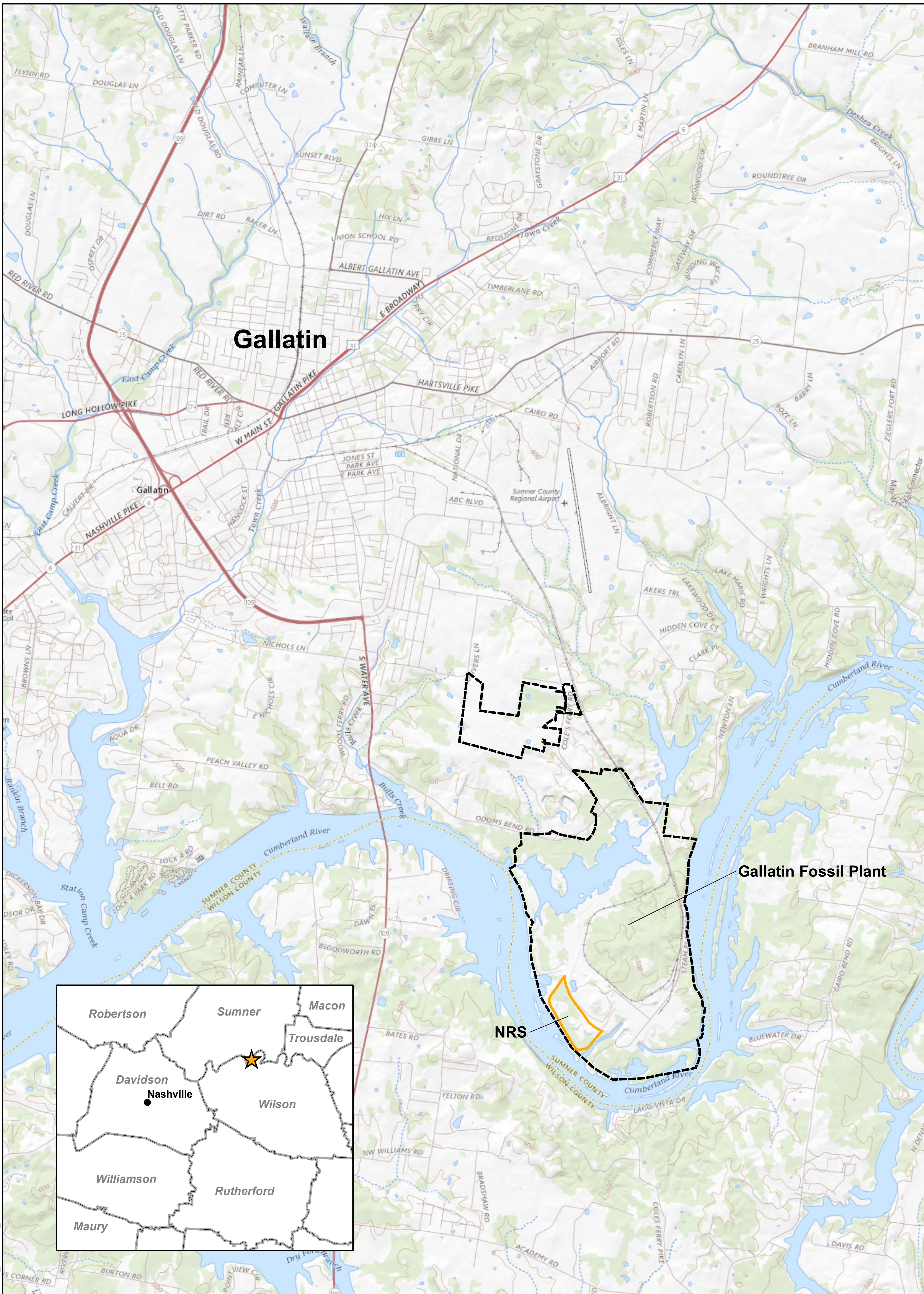
8. References

AECOM, 2019. NRS Treatability Test Work Plan, TVA Gallatin Fossil Plant, Revision 0. September 27, 2019.

AECOM, 2021a. 2020 Non-Registered Site Field Investigation Report, TVA Gallatin Fossil Plant, Revision 0. May 10, 2021.

AECOM, 2021b. Non-Registered Site Treatability Test Report, TVA Gallatin Fossil Plant, Revision 0. May 21, 2021.

Figures



LEGEND

Non-Registered Site (NRS) Boundary

TVA Gallatin Fossil Plant Property Boundary (Approximate)

N

0 4,000 8,000
Feet

NOTE: USGS 7.5' Topographic Quadrangle Map
Source - ESRI USGS Topo Layer

Document Path: M:\EnvData\viz\TVA_GAF\NRS920 - GIS\SITE_LOCATION_MAP.mxd

AECOM

Figure 1-1

GALLATIN FOSSIL PLANT (GAF)
LOCATION MAP

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
CARRIE.SMITH	M.STAUFFER	M.STAUFFER	REV. B

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
11/2/2020	FOSSIL AND HYDRO ENGINEERING

LEGEND:

- Well Screened in CCR
- Well Screened in Carters Limestone
- Well Screened in Lebanon Limestone
- Well Screened in Unconsonlidated Deposits
- CCR Management Units

CCR - Coal Combustion Residuals
ft bgs - feet below ground surface

N

0 200 400
Feet

AECOM

Figure 1-2

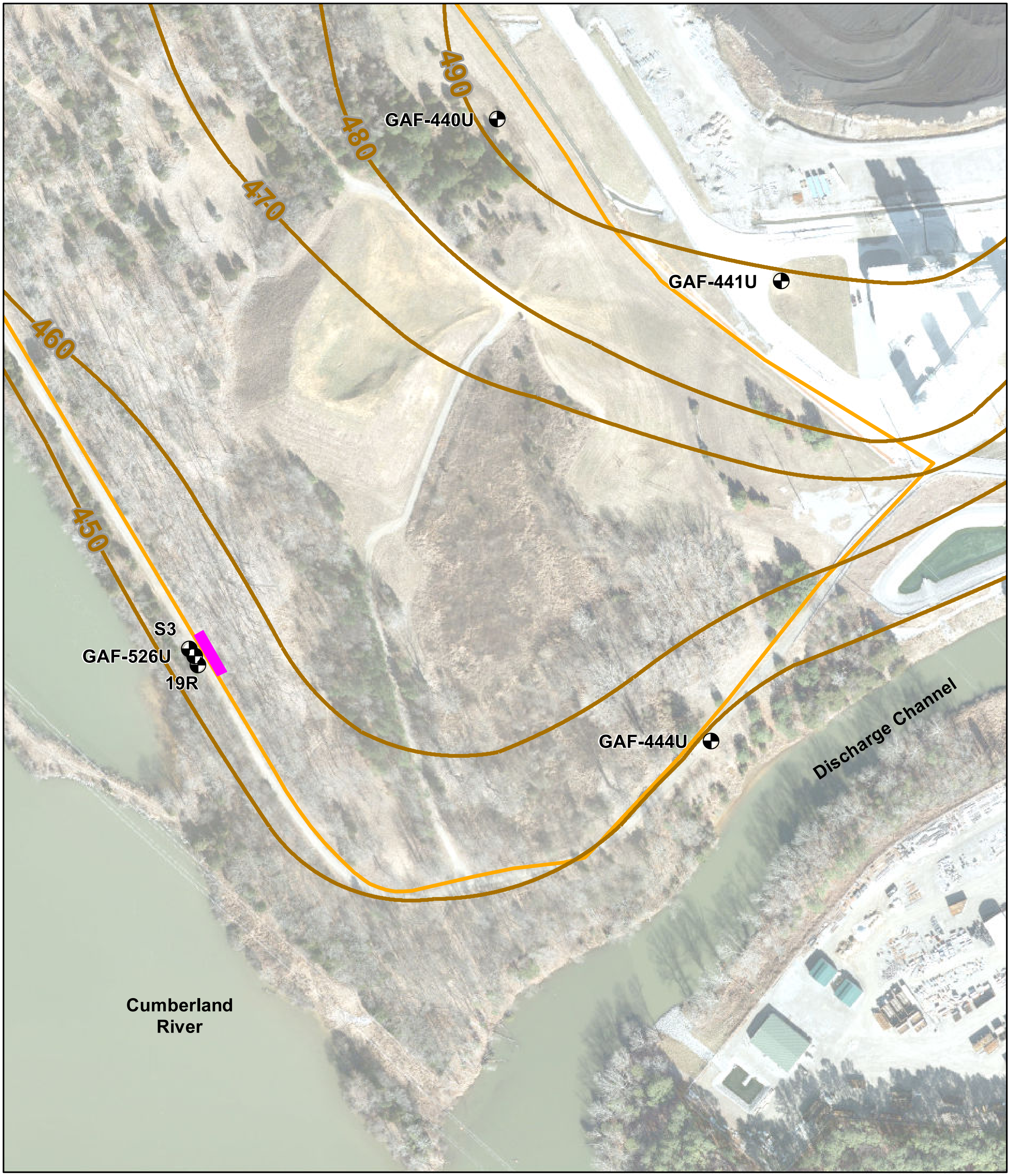
MONITORING WELL LOCATION MAP

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
T.ADHAM	M.FRIEDMAN	M.STAUFFER	REV. 0

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE: 3/5/2021
DEPT: FOSSIL AND HYDRO ENGINEERING

Document Path: K:\TVA_GAF\NRS\920 - GIS\Figure_1_2_Monitoring_Well_Location.mxd



LEGEND

CCR Management Units

Potentiometric Contour (ft msl) in Unconsolidated Material, June 15, 2020 (AECOM, 2021a)

Location of Permeable Reactive Barrier (PRB) Demonstration Test

Monitoring Well

Notes:
CCR - Coal Combustion Residuals
Aerial image dated February 2017

N

0 250 500
Feet

AECOM

Figure 2-1

LOCATION OF PROPOSED PERMEABLE REACTIVE BARRIER WALL DEMONSTRATION TEST

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
T.ADHAM	M.FRIEDMAN		

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
4/21/2021	FOSSIL AND HYDRO ENGINEERING

Tables

Table 2-2a
Permeable Reactive Barrier Wall Longevity Calculations - 19R Location
NRS Field Demonstraion Work Plan
TVA Gallatin Fossil Plant, Gallatin, Tennessee

Barrier Width (feet)	Length (feet)	Saturated Thickness (feet)[1]	Volume of Sand (CF)	Weight of Sand (kg) [2]	Weight of DoloFines @0.2% (g)	Treatment ratio (L GW/g DoloFines)[3]	Volume of Water Treated Before Breakthrough (L)	Maximum Anticipated Localized Groundwater Flow[4]		Average Groundwater Flow[4]	
								Annual Flow (L/yr) [5]	Barrier Wall Longevity (yr)	Annual Flow (L/yr) [5]	Barrier Wall Longevity (yr)
6	40	35	8,400	388,987	777,974	0.45	350,088	145,000	2.4	85,000	4.1
9	40	35	12,600	583,481	1,166,962	0.45	525,133	145,000	3.6	85,000	6.2
12	**40**	**35**	**16,800**	**777,974**	**1,555,949**	**0.45**	**700,177**	**145,000**	**4.8**	**85,000**	**8.2**
18	40	35	25,200	1,166,962	2,333,923	0.45	1,050,265	145,000	7.2	85,000	12.4
24	40	35	33,600	1,555,949	3,111,898	0.45	1,400,354	145,000	9.7	85,000	16.5
30	40	35	42,000	1,944,936	3,889,872	0.45	1,750,442	145,000	12.1	85,000	20.6
60	40	35	84,000	3,889,872	7,779,744	0.45	3,500,885	145,000	24.1	85,000	41.2
90	40	35	126,000	5,834,808	11,669,616	0.45	5,251,327	145,000	36.2	85,000	61.8

Notes:
Calculations assume a linear relationship between barrier wall width and longevity
CF = Cubic feet
DoloFines = Dolomitic fines, a magnesium-rich form of quick lime
kg = kilograms
g = grams
GW = groundwater
L = liter
yr = years
1. See Table 2-1 for details on saturated thickness
2. Weight of sand 102 pounds per cubic foot (lbs/cf)
3. In column study, 0.2% dose of dolofines (8.62 grams) treated 3.85 liters of water before breakthrough, treatment ratio is 3.85 liters/8.62 grams = 0.45 liters/gram
4. See Appendix B for details on flow calculations for maximum and realistically-anticipated groundwater flow. Average flow assumes 18.5 feet of material with higher hydraulic conductivity (K = 0.20 feet/day), which was observed at wells 19R and S3, and 16.5 feet of material with lower hydraulic conductivity (K = 0.023 feet/day), which is typical for the alluvium at the NRS. Maximum flow assumes full saturated thickness is high K material.
5. The volume of water expected to flow through the barrier wall in one year.

Table 2-2b
Permeable Reactive Barrier Wall Longevity Calculations - GAF-444U Location
NRS Field Demonstraion Work Plan
TVA Gallatin Fossil Plant, Gallatin, Tennessee

Barrier Width (feet)	Length (feet)	Saturated Thickness (feet)[1]	Volume of Sand (CF)	Weight of Sand (kg)[2]	Weight of DoloFines @0.2% (g)	Treatment ratio (L GW/g DoloFines)[3]	Volume of Water Treated Before Breakthrough (L)	Maximum-Anticipated Groundwater Flow[4] Annual Flow (L/yr)[5]	Maximum-Anticipated Groundwater Flow[4] Barrier Wall Longevity (yr)	Realistically-Anticipated Groundwater Flow[4] Annual Flow (L/yr)[5]	Realistically-Anticipated Groundwater Flow[4] Barrier Wall Longevity (yr)
6	40	35	8,400	388,987	777,974	0.6	466,785	194,000	2.4	37,000	12.6
9	40	35	12,600	583,481	1,166,962	0.6	700,177	194,000	3.6	37,000	18.9
12	40	35	16,800	777,974	1,555,949	0.6	933,569	194,000	4.8	37,000	25.2
18	40	35	25,200	1,166,962	2,333,923	0.6	1,400,354	194,000	7.2	37,000	37.8
24	40	35	33,600	1,555,949	3,111,898	0.6	1,867,139	194,000	9.6	37,000	50.5
30	40	35	42,000	1,944,936	3,889,872	0.6	2,333,923	194,000	12.0	37,000	63.1
60	40	35	84,000	3,889,872	7,779,744	0.6	4,667,846	194,000	24.1	37,000	126.2
90	40	35	126,000	5,834,808	11,669,616	0.6	7,001,770	194,000	36.1	37,000	189.2

Notes:
Calculations assume a linear relationship between barrier wall width and longevity
CF = Cubic feet
DoloFines = Dolomitic fines, a magnesium-rich form of quick lime
kg = kilograms
g = grams
GW = groundwater
L = liter
yr = years
1. See Table 2-1 for details on saturated thickness
2. Weight of sand 102 pounds per cubic foot (lbs/cf)
3. In microcosm studies treatment ratio for DoloFines and 444U water was 1.16 liter/gram, a 50% safety factor assumed for flow through conditions
4. See Appendix B for details on flow calculations for maximum and realistically-anticipated groundwater flow. Average flow assumes 3 feet of material with higher hydraulic conductivity (K = 0.20 feet/day), which was observed at wells 19R and S3, and 29 feet of material with lower hydraulic conductivity (K = 0.023 feet/day), which is typical for the alluvium at the NRS. Maximum flow assumes full saturated thickness is high K material.
5. The volume of water expected to flow through the barrier wall in one year.

Table 5-1 PRB Material Sample Analytes
NRS Field Demonstration Work Plan
TVA Gallatin Fossil Plant

Target Metals	Analytical Method
Beryllium	Analytical lab
Cadmium	Analytical lab
Lithium	Analytical lab
Nickel	Analytical lab
Other Metals and Metalloids	
Aluminum	Analytical lab
Antimony	Analytical lab
Arsenic	Analytical lab
Barium	Analytical lab
Boron	Analytical lab
Calcium	Analytical lab
Chromium	Analytical lab
Cobalt	Analytical lab
Copper	Analytical lab
Iron	Analytical lab
Lead	Analytical lab
Magnesium	Analytical lab
Manganese	Analytical lab
Mercury	Analytical lab
Molybdenum	Analytical lab
Phosphate	Analytical lab
Potassium	Analytical lab
Selenium	Analytical lab
Silver	Analytical lab
Sodium	Analytical lab
Thallium	Analytical lab
Vanadium	Analytical lab
Zinc	Analytical lab
Other Parameters	
Chloride	Analytical lab
Fluoride	Analytical lab
pH	Analytical lab and field test kit
Sulfate	Analytical lab

Table 7-1
Anticipated Schedule for PRB Construction, Monitoring, and Reporting
NRS Field Demonstration Work Plan
TVA Gallatin Fossil Plant, Gallatin, Tennessee

Activity	Start	Complete
Baseline Sampling of Three Existing Monitoring Wells		During Contractor Mobilization
Construction of PRB	July 2021	August 2021
Install Performance Monitoring Wells		August 2021
Baseline Sampling		September 2021
Q1 Sampling		December 2021
Construction Completion and Baseline Monitoring Report		January 2022
Q2 Sampling		March 2022
Q3 Sampling		June 2022
1st Semi-Annual Report		July 2022
Q4 Sampling		September 2022
Q5 Sampling		December 2022
2nd Semi-Annual Report		January 2023
Q6 Sampling		March 2023
Q7 Sampling		June 2023
3rd Semi-Annual Report		July 2023
Q8 Sampling		September2023
Q9 Sampling		December 2023
4th Semi-Annual Report		January 2024
Q10 Sampling		March 2024
Q11 Sampling		June 2024
5th Semi-Annual Report		July 2024
Final Report		November 2024

Notes:
Schedule is dependent upon timing of TDEC approval of this workplan.
The final report will be issued in November 2024, independent of the number of rounds of monitoring conducted before that time.

Appendix A
NRS Field Demonstration Performance Monitoring Plan

Field Demonstration Performance Monitoring Plan
Non-Registered Site

Tennessee Valley Authority
Gallatin Fossil Plant

Revision 0

May 25, 2021

Prepared for:

TENNESSEE VALLEY AUTHORITY

1101 Market Street
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Revision History

Revision	Revision Date	Description
0	5/25/2021	Initial Issue

Table of Contents

Tables

Figures

Attachments

1.0 Introduction

The Non-Registered Site #83-1324 (NRS) at the Tennessee Valley Authority (TVA) Gallatin Fossil Plant (GAF) is a closed surface impoundment formerly used to manage coal combustion residuals (CCR) from the coal-fired power plant (**Figure 1**). On June 13, 2019, TDEC issued a Commissioner's Order Number OGC19-0004 (Order) for the NRS. The Order requires TVA to conduct a laboratory-based treatability test and subsequent field demonstration to assess methods to meet Groundwater Protection Standards (GWPS) in groundwater at the NRS boundary adjacent to the Cumberland River. As part of the field demonstration, and consistent with Section VII.B.4 of the Order, TVA is required to prepare a plan for groundwater monitoring. As required by the Order, samples will be analyzed for CCR constituents listed in 40 CFR Part 257, Appendices III and IV along with additional constituents required by the state groundwater monitoring program (copper, nickel, silver, vanadium, and zinc). Samples will also be analyzed for pH and constituents that may help indicate PRB performance or might be mobilized by the treatment process.

In accordance with the Order, TVA is submitting to TDEC a Field Demonstration Work Plan for the NRS which includes this Field Demonstration Performance Monitoring Plan (PMP). This PMP specifies methods and procedures for the monitoring to be performed during the NRS field demonstration, as required under Section VII.B.4 of the Order.

Both during and after the field demonstration, on-going State Compliance Assessment Monitoring will continue.

1.1 Monitoring Objectives

The monitoring under this plan has been designed to meet the following objectives:

- Perform field demonstration performance monitoring at the NRS; and
- Comply with Section VII.B.4 of the Order.

1.2 Report Organization

This PMP has been organized into the following Sections:

Section 2 provides information about the locations to be monitored under this plan.

Section 3 describes the monitoring frequency, constituents, water level measurements, and data evaluation methods for the monitoring program.

Section 4 summarizes the field sampling and laboratory quality procedures to be used to generate representative data under this plan.

Section 5 presents a list of the references cited in this PMP.

Additional supporting documents are provided in **Attachments A** through **C**.

2.0 Field Demonstration Performance Monitoring Wells

The following section provides a discussion of the locations that are to be monitored under this plan. The groundwater system at the NRS and in the vicinity of the planned field demonstration is described in more detail in the NRS Field Investigation Report (AECOM, 2021).

The NRS field demonstration performance monitoring is intended to assess whether a pilot-scale field demonstration of a permeable reactive barrier (PRB) in the vicinity of well 19R can adjust pH and geochemical conditions in the groundwater in the overburden to achieve specific GWPS goals at the NRS boundary adjacent to the Cumberland River.

The performance monitoring network for the field demonstration will consist of a series of yet-to-be-constructed monitoring wells: PUP-series wells installed upgradient of the PRB, PIN-series wells constructed within the PRB, and PDN-series wells located downgradient of the PRB. All PRB wells will be installed after construction of the PRB has been completed. Three existing monitoring wells (19R, GAF-526U, and S-3) will also be monitored. The proposed field demonstration performance monitoring locations are shown on **Figure 2**; available well construction information is provided in **Table 1**. Additional details about the PRB and field demonstration, including more detailed descriptions of the proposed performance monitoring wells are provided in Section 5 of the Field Demonstration Work Plan, to which this PMP is attached.

This PMP will be resubmitted under separate cover with an updated well specification summary table (**Table 1**) and Boring/Construction logs for the PRB wells (**Attachment A**) once PRB construction and well installations have been completed.

3.0 Field Demonstration Performance Monitoring

The following section discusses the field demonstration performance monitoring for the NRS in accordance with the Order.

Because the purpose of the field demonstration monitoring is to assess performance of the PRB, substantive monitoring cannot begin until after the PRB and new monitoring wells are installed. However, once TDEC approves this monitoring plan, and prior to installation of the PRB, pre-construction monitoring will be performed. Specifically, immediately prior to PRB construction (i.e., during contractor mobilization), the three-existing field demonstration wells (19R, S3, and GAF-526U; see **Table 1**) will be sampled and analyzed for the constituents on **Table 2**.

Once the PRB and additional monitoring wells are installed, performance monitoring for the PRB will commence with an initial gauging and sampling event approximately one month after the PRB is constructed and the wells have been installed and developed, followed by quarterly sampling thereafter. Samples will be analyzed for different constituents at different frequencies, as detailed below and on **Table 2**:

- During the initial sampling event and on a quarterly basis thereafter, samples will be collected from most of the wells and analyzed for total and dissolved target metals (i.e., the constituents that exceed GWPS: beryllium, cadmium, lithium, and nickel), plus field pH, alkalinity, and cobalt; see **Table 2**). Well locations are shown on **Figure 2**, and sampling frequency at each well is provided on **Table 2**.
- During the initial sampling event and on an annual basis thereafter, samples will be collected from all wells shown on **Figure 2** and analyzed for a longer constituent list including additional metals, selected anions, etc. (see **Table 2** for specific constituents). This list includes constituents that may be created or mobilized by the treatment process (e.g., alkalinity, metals that may be mobilized under alkaline conditions).

Table 1 provides the sampling frequency for each well, and **Table 2** summarizes the analytical constituents, and frequency of analysis.

Based on observed geologic conditions in the vicinity, the two deeper wells (one each in the PUP- and PDN-series) may not recharge fast enough to provide meaningful water chemistry samples. Therefore, these wells will be sampled only if sufficient well recharge occurs. If the well is purged dry, a sample will be collected only if at least 10 feet of water has recharged the well within the 24-hour period following the well purge. If less than 10 ft of water has recharged in that period, no sample will be collected. In addition, there may be insufficient water to fill all sample bottles. Therefore, the measurement of field pH and filling bottles for filtered and unfiltered target metals (beryllium, cadmium, lithium, and nickel; see **Table 2**) will be completed first. Additional bottles will then be filled if there is sufficient water in the well.

Groundwater elevation monitoring will be conducted monthly for the first quarter after the PRB and monitoring wells have been installed and then quarterly thereafter. The quarterly elevation monitoring will occur immediately before each groundwater monitoring event. Water levels will be measured at all wells shown on **Figure 2**.

As described in the Field Demonstration Work Plan, the results of the initial sampling event for the PRB PUP- and PDN-series wells will be used to establish baseline conditions for evaluating effectiveness of the PRB. During the field demonstration, data from the PDN-series wells will be compared to both baseline (initial) conditions in the PDN-series wells and data from the PUP-series wells to evaluate the effectiveness of the PRB in adjusting pH and geochemical conditions in the groundwater in the overburden to achieve specific GWPS goals. In addition, data from well 19R, located directly downgradient from the PRB, will be compared to pre-construction sample results from the well. Details on evaluating the PRB performance and reporting results are provided in the Field Demonstration Work Plan.

The details of the field demonstration monitoring may change over time depending on the performance of the PRB. Changes to the monitoring will be reviewed and approved by TDEC.

The field demonstration monitoring will continue until the field demonstration is complete, as described in the Field Demonstration Work Plan. Following completion of the field demonstration, TVA will prepare and submit to TDEC a Corrective Action/Risk Assessment (CARA) Plan as required by the Order. The CARA Plan will present the proposed corrective action for groundwater as well as associated groundwater monitoring.

4.0 Field Sampling and Laboratory Procedures

The following section details the sample collection, quality control, and laboratory analytical procedures to be used for the NRS field demonstration groundwater monitoring.

TVA has developed a series of Technical Instructions (TIs) which provide standardized and consistent procedures for many tasks related to groundwater monitoring. The TIs are updated periodically, as deemed appropriate by TVA. Personnel conducting sampling activities will consult the most up-to-date TIs for additional details on sampling procedures. TVA will be responsible for providing the most up-to-date and applicable TIs to personnel involved in the sampling conducted under this plan.

4.1 Groundwater Level Gauging and Well Inspections

Prior to each sampling event, groundwater levels will be gauged in the wells to evaluate hydraulic gradients (locations provided on **Table 1** and **Figure 2**).

The depth to water surface from the top of the reference point (e.g., top of PVC well casing) will be measured in each well to the nearest 0.01 foot with an electronic water level indicator. Depth to water measurements are to be collected from the monitoring wells within an 8-hour period and will conclude prior to the collection of any groundwater samples.

Consistent with the current TVA TI, the well integrity will be assessed as part of the well preparation for sampling. If identified, the following issues are to be noted: damage to monitoring well pads, compromised above-ground casing integrity, issues with locking cap and/or well locks. If any of these conditions are noted, they are to be corrected.

4.2 Well Purging and Sampling

Additional details on procedures for well purging and sampling are provided in the applicable TIs, which shall be consulted by the personnel performing sampling activities.

Wells will be purged prior to sampling to obtain a representative groundwater sample from the well. Wells will typically be equipped with dedicated bladder pumps and tubing.

Generally, purging and sampling will be conducted using low-flow (low-stress) sampling methods. These methods are based on pumping at low rates with minimal drawdown in order obtain a representative groundwater sample with minimal stress to the groundwater system. Low-flow sampling methods will be performed in general accordance with USEPA published protocols (USEPA, 1996; USEPA, 2010). Due to the low permeability of unconsolidated clay materials and weathered bedrock, the NRS well generally have low yield. As a result, there may be wells which do not support low-flow sampling methods; the TIs provide appropriate alternate sampling methods.

During purging, field parameters will be monitored at periodic intervals using a calibrated, in-line, multi-parameter water quality monitor with a flow-through cell. Field parameters include temperature, pH, specific conductance, dissolved oxygen (DO), oxidation-reduction potential (ORP), and turbidity. The field instruments used to collect water quality data will be appropriately calibrated each day in accordance with the relevant TIs and the manufacturer's instructions. Water levels (to assess drawdown) will also be measured during purging, and the purge rates adjusted to minimize drawdown as specified in the appropriate TI.

Time, purge rate, depth to groundwater, and field parameters will be recorded throughout the purging operation on the groundwater sampling form, or equivalent (**Attachment B**). Well purge water will be handled in accordance with applicable investigation derived waste (IDW) protocols as described in the appropriate TI.

Purging will be considered complete when the measured values of selected field parameter readings have stabilized. Parameter stability criteria are specified in the TIs. Because samples are to be analyzed for metals, it is important for the turbidity to be low at the conclusion of purging to minimize bias due to the presence of particulates in the samples. The TIs provide additional details and instructions for instances where parameters do not stabilize, or turbidity is not sufficiently reduced.

Sample collection will begin after stabilization of the field parameters, or in accordance with the TIs if stability is not achieved.

The TIs also provide guidance in the case of low-yield wells, where drawdown cannot be minimized and/or stabilized. In the case of the two deeper wells (one each in the PUP- and PDN-series), these may not recharge fast enough to provide meaningful water chemistry samples. Therefore, these wells will be sampled only if sufficient well recharge occurs. If the well is purged dry, a sample will be collected only if at least 10 feet of water has recharged the well within the 24-hour period following the well purge. If less than 10 ft of water has recharged in that period, no sample will be collected.

4.3 Sample Collection and Preservation

Samples will be collected directly from the pump discharge line in new sample containers containing the appropriate preservatives (if applicable). When filling sample bottles, care will be taken to minimize sample aeration and overfilling. Samples will be placed on ice for preservation after collection in accordance with the appropriate TI.

Samples to be analyzed for dissolved metals will be filtered in the field using an in-line filter, in accordance with the appropriate TI.

All sample containers will be labeled with a permanent sample identification (ID). This sample ID will be unique for each sample collected and will be cross referenced on appropriate field documents and on the sample chain of custody (COC) form.

4.4 Field Test Kits

The NRS field demonstration requires collection of certain parameters (dissolved carbon dioxide, and ferrous iron [Fe(II)]) through use of colorimetric field-testing kits. The concentrations of these parameters in a sample can be affected by atmospheric interactions that may change the concentration of an analyte directly or may result in changes in an analyte concentration due to changing redox conditions. As a result, they can be subject to increasing error with increasing time that passes between sample collection and analysis. Where such considerations are the primary potential source of error, field test kits will be employed to manage that potential for error:

- Groundwater samples from monitoring wells will be field-analyzed for ferrous iron using the Hach® Ferrous Iron [Fe(II)] Color Disk Test Kit, model IR-18C, 0.2-7 mg/L.

- Groundwater carbon dioxide concentrations will be measured using the Hach® Carbon Dioxide Test Kit, Model CA-23 or equivalent. Water samples will not be filtered prior to using the carbon dioxide field test kit.

Detailed instructions for the Hach® kits are included in **Attachment C**.

4.5 Field Procedures Quality Control

Problems observed during sampling that might affect the quality of the samples will be identified and recorded on the sampling form (e.g., see **Attachment B)** in an appropriate location (i.e. the general comments/observations section). Problems that might affect sample quality include clogged sampling tubes, highly turbid samples, defective material and/or equipment, inability to comply with quality procedures, and atmospheric/ambient conditions.

4.6 Quality Control (QC) Samples

Generally, the following types of QC samples will be collected as part of the sampling process: field blanks, equipment (rinsate) blanks, field duplicate samples, and matrix spike/matrix spike duplicate samples (MS/MSD). Additional information on the various QC samples and the required sampling frequency is provided in the applicable TI.

4.7 Chain of Custody Procedures and Sample Shipment

All samples collected will be maintained under legal sample custody by using COC records. All sample coolers transported by shipment must be accompanied by a COC record placed inside the sealed cooler. Additional information on COC procedures are provided in the applicable TI.

4.8 Laboratory Analysis

Samples will be analyzed by a commercial laboratory accredited by the NELAC Institute (TNI) under contract to TVA or one of its consultants.

The field demonstration monitoring samples will be analyzed for the inorganic constituents in **Table 2** including: CCR Rule Appendix III and IV, along with the additional constituents required by the Order: copper, nickel, silver, vanadium, zinc, and potential PRB by-products.

In accordance with the TDEC solid waste policy manual guidance (TDEC, 2020) unless otherwise approved, analytical methods will be USEPA methods from USEPA Publication SW-846. The SW-846 method used will have laboratory reporting limits of the lowest practical quantitation limits (PQL) (i.e., laboratory reporting limits) that can be reliably achieved within specified limits of precision and accuracy.

4.9 Recordkeeping

Field records will be maintained in the project file by TVA or their representative. The field records to be maintained include records of equipment standardization and calibration (if applicable), field sampling forms, and daily record of events and/or field logbook notes. These records will be used to record pertinent data and observations for each sampling event in accordance with the applicable TVA TI. Data may be collected electronically and/or on paper forms/field logbooks. Blank copies of the current field forms are presented in **Attachment B**, these forms are subject to change in the future.

4.10 Data Evaluation and Reporting

The evaluation of monitoring data collected during the field demonstration and reporting are detailed in the Field Demonstration Work Plan, to which this PMP is attached.

5.0 References

AECOM, 2021. 2020 Non-Registered Site Field Investigation Report, Rev. 1. TVA Gallatin Fossil Plant, Sumner County, Tennessee. May 2021.

TDEC, 2020. Tennessee Department of Environment and Conservation, Division of Solid Waste Management, Solid Waste Program, Policy and Guidance Manual. May 2020.

USEPA, 1996. Office of Research and Development, Office of Solid Waste and Emergency Response. Ground Water Issue, Low-Flow (Minimal Drawdown Sampling Procedures), Document Number EPA/540/S-95/504. April 1996.

USEPA, 2010. Region I, Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells. January 2010.

TABLES

Table 1
Field Demonstration Performance Monitoring - Well Specification Summary
Field Demonstration Performance Monitoring Plan
Non-Registered Site

Well ID	Position Relative to Permeable Reactive Barrier	Geologic Strata Screened	Northing (GAF-PLG)	Easting (GAF-PLG)	Ground Surface Elevation (ft NGVD29)	Top of Casing Elevation (ft NGVD29)	Well Pipe Size and Type	Screen Interval (ft bgs)	Screen Elevation (ft NGVD29)	Sampling Frequency
19R	Downgradient	Unconsolidated	699761.39*	1879355.76*	476.28*	478.90*	2" PVC	39.5 - 49.5	426.78 - 436.78	Quarterly
GAF-526U	Downgradient	Unconsolidated	699778.34*	1879350.33*	476.03*	478.88*	2" PVC	63 - 68	408.03 - 413.03	Quarterly
S3	Downgradient	Unconsolidated	699791.33*	1879339.47*	476.03*	480.04*	2" PVC	48.7 - 58.7	417.33 - 427.33	Annually
PUP1S (a)	Upgradient	Unconsolidated	699792.21	1879381.05	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PUP1M (a)	Upgradient	Unconsolidated	699789.64	1879376.76	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PUP2M (a)	Upgradient	Unconsolidated	699778.05	1879383.70	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PUP2D (a)	Upgradient	Unconsolidated	699780.62	1879387.99	TBD	TBD	2" PVC	TBD - TBD	TBD	Annually
PUP3S (a)	Upgradient	Unconsolidated	699769.03	1879394.93	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PUP3M (a)	Upgradient	Unconsolidated	699766.46	1879390.64	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PIN1A (a)	Within	PRB	699788.93	1879366.47	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PIN1B (a)	Within	PRB	699784.31	1879364.57	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PIN1C (a)	Within	PRB	699779.69	1879362.67	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PIN2A (a)	Within	PRB	699775.90	1879374.26	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PIN2B (a)	Within	PRB	699771.26	1879372.38	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PIN2C (a)	Within	PRB	699766.64	1879370.48	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PIN3A (a)	Within	PRB	699757.69	1879385.13	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PIN3B (a)	Within	PRB	699758.22	1879380.17	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PIN3C (a)	Within	PRB	699758.75	1879375.21	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PDN1S (a)	Downgradient	Unconsolidated	699774.61	1879353.83	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PDN1M (a)	Downgradient	Unconsolidated	699776.15	1879356.40	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PDN2M (a)	Downgradient	Unconsolidated	699765.52	1879362.76	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PDN2D (a)	Downgradient	Unconsolidated	699757.46	1879364.09	TBD	TBD	2" PVC	TBD - TBD	TBD	Annually
PDN3S (a)	Downgradient	Unconsolidated	699752.39	1879367.13	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly
PDN3M (a)	Downgradient	Unconsolidated	699753.93	1879369.70	TBD	TBD	4" PVC	TBD - TBD	TBD	Quarterly

Notes:
* = As currently surveyed, data may have changed over time or over different surveys
(a) = Proposed Well, not yet installed. All construction information provided is approximate and subject to change.
bgs = Below ground surface
GAF-PLG = Gallatin Fossil Plant - Plant Local Grid
GWPS = Groundwater Protection Standard
NGVD29 = National Geodetic Vertical Datum of 1929
TBD = To be determined

Table 2
Field Demonstration Analytical Constituents and Sampling Frequency
Field Demonstration Performance Monitoring Plan
Non-Registered Site

Groundwater Constituent	CCR Rule Appendix III	CCR Rule Appendix IV	Tennessee Appendix I	Target Metals (Total & Dissolved)	Other Laboratory Analytes	Field Parameters	Sampling Frequency (b)
Acidity, Total					X		Annually
Alkalinity (a)					X		Quarterly
Aluminum					X		Annually
Antimony		X	X				Annually
Arsenic		X	X				Annually
Barium		X	X				Annually
Beryllium		X	X	X			Quarterly
Boron	X						Annually
Cadmium		X	X	X			Quarterly
Calcium	X						Annually
Carbon Dioxide (Dissolved) (c)						X	Annually
Chloride	X						Annually
Chromium (Total)		X	X				Annually
Cobalt		X	X				Quarterly
Copper			X				Annually
Dissolved Oxygen						X	Quarterly
Ferrous Iron [Fe(II)] (c)						X	Annually
Fluoride	X	X	X				Annually
Iron					X		Annually
Lead		X	X				Annually
Lithium		X		X			Quarterly
Magnesium					X		Annually
Manganese					X		Annually
Mercury		X	X				Annually
Molybdenum		X					Annually
Nickel			X	X			Quarterly
Oxidation Reduction Potential						X	Quarterly
pH (field)	X					X	Quarterly
Potassium							Annually
Radium 226 and 228		X					Annually
Selenium		X	X				Annually
Silver			X				Annually
Sodium					X		Annually
Specific Conductance						X	Quarterly
Strontium					X		Annually
Sulfate	X						Annually
Sulfide					X		Annually
Temperature						X	Quarterly
Thallium		X	X				Annually
Total Dissolved Solids	X						Annually
Total Organic Carbon					X		Annually
Total Suspended Solids					X		Annually
Turbidity						X	Quarterly
Vanadium			X				Annually
Zinc			X				Annually

Notes:

(a) - Alkalinity = Total as CaCO3, Hydroxide as CaCO3, Bicarbonate as CaCO3, and Carbonate as CaCO3.

(b) - All constituents will be sampled in the Initial (Pre & Post-Construction) Sampling events, and thereafter at the frequency specified.

(c) - Paramater will be analyzed using an appropriate field test kit.

FIGURES

LEGEND

Non-Registered Site (NRS)

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

Document Path: M:\EnvDataViz\TVA_GAF\11.0 GIS\928_GWMP\1_GAF_SiteMapv2.mxd

AECOM

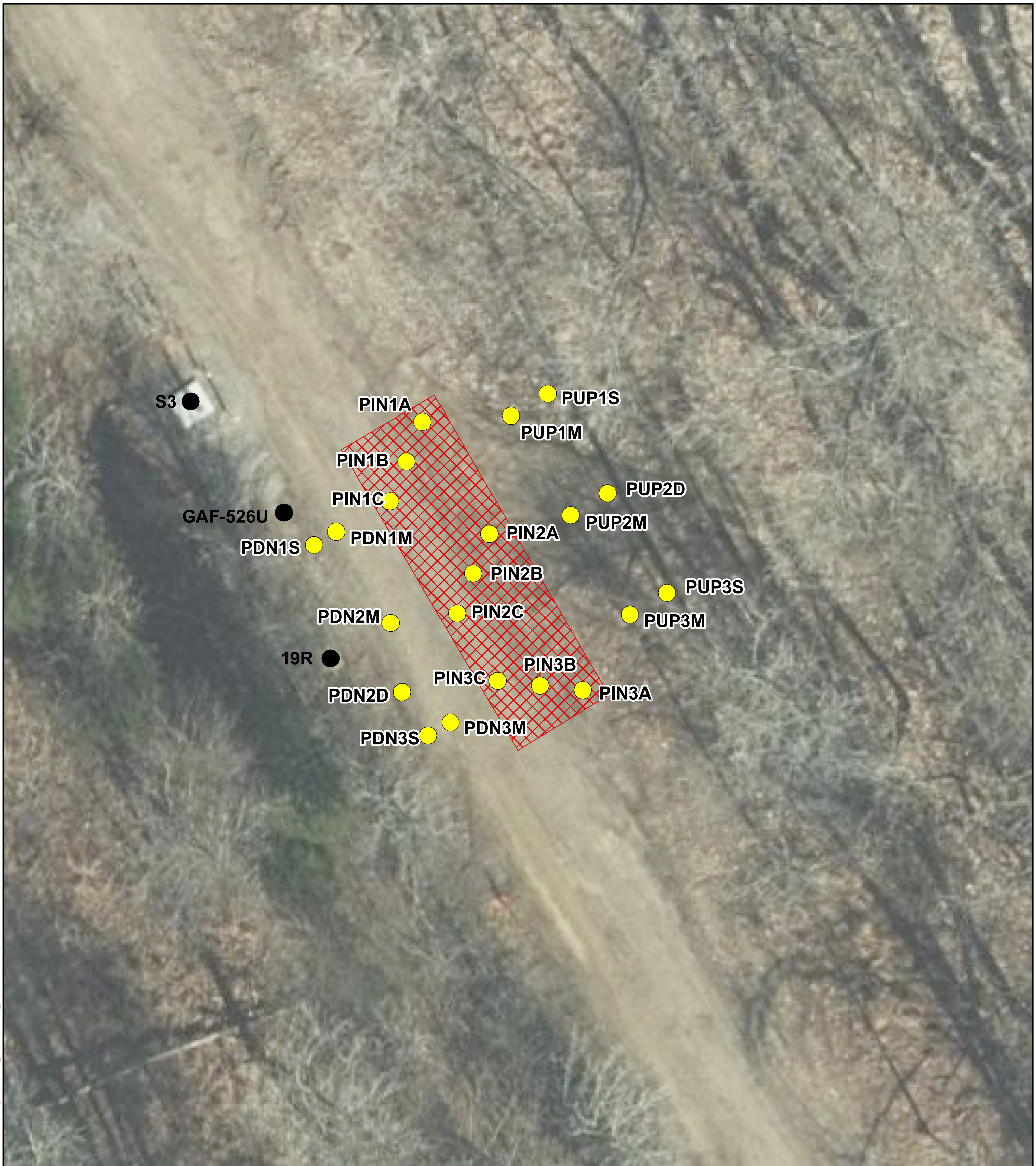
Figure 1

SITE MAP

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

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
APRIL 2021	FOSSIL AND HYDRO ENGINEERING



LEGEND
- Proposed PRB Monitoring Well
- Existing Monitoring Well
- Proposed PRB Wall

N

0 10 20
Feet

NOTE: Aerial image dated February 2017

AECOM

Figure 2

NRS FIELD DEMONSTRATION PERFORMANCE MONITORING LOCATIONS

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

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

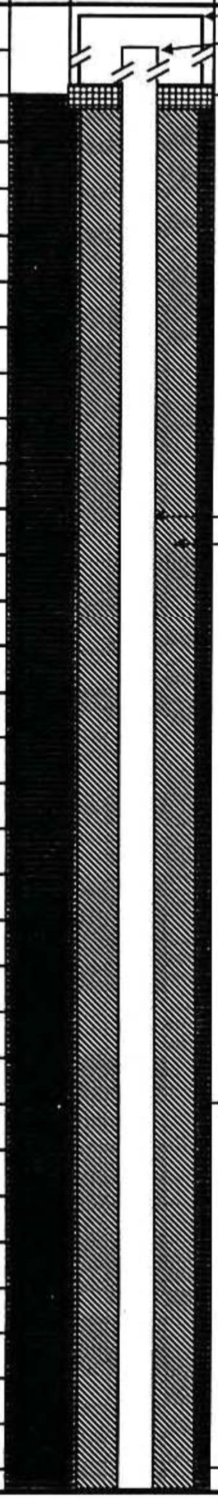
DATE: 5/12/2021
DEPT: FOSSIL AND HYDRO ENGINEERING

ATTACHMENTS

Attachment A – Well Boring and Construction Logs

New Replacement Well

Project:	TVA's Gallatin Fossil Plant Gallatin, Tennessee			BORING	MW-19R
Project No.:	1432-05-671	Elevation:	Unknown	Notes:	
ged by:	R.L. Russell, R.G. (TN Reg. Geo. Lic. #4979)	Depth:	50'	Descriptions based on visual observation of obtained samples.	
ws:	S&ME, Inc. (Tim Hall - TN Driller #813)	Start:	September 19, 2005		
quipment:	CME 55 with 6 5/8" augers	Complete:	September 20, 2005		



Depth (ft)	Elevation (ft)	Lithology	Boring	Run Length	Recovered	% Recovered	RQD	Lithologic Description
1								
0	Unknown							Ground Surface
1								**Clay** - silty, orange to orangish-brown, firm to stiff with cherty layers (0.0' - 22.0')
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								**Clay** - sandy-silty, red and tan (22.0' - 30.0')
23								
24								
25								
26								
27								
28								
29								
30								**Clay** - silty, dark brown (30.0' - 36.0')

S&ME

Project:	TVA's Gallatin Fossil Plant Gallatin, Tennessee			BORING	MW-19R
Project No.:	1432-05-671	Elevation:	Unknown	Notes:	
Logged by:	R.L. Russell, R.G. (TN Reg. Geo. Lic. #4979)	Depth:	50'	Descriptions based on visual observation of obtained samples.	
Crews:	S&ME, Inc. (Tim Hall - TN Driller #813)	Start:	September 19, 2005		
Equipment:	CME 55 with 6 5/8" augers	Complete:	September 20, 2005		

Depth (ft)	Elevation (ft)	Lithology	Boring	Run Length	Recovered	% Recovered	RQD	Lithologic Description
31								
32								Saturated Conditions at 32'
33								Hydrated bentonite seal
34								
35								
36								**Clay** - silty, tan to brown, soft, saturated (36.0' - 50.0')
37								
38								Sand filter
39								
40								
41								2" dia. PVC screen with pre-pack sand filter
42								
43								
44								
45								
46								
47								
48								
49								
50								**Boring Terminated** - bottom of boring at 50.0'
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								

S&ME

Project: GAF NRS Treatablility
Project Location: Gallatin, TN
Project Number: 60621225

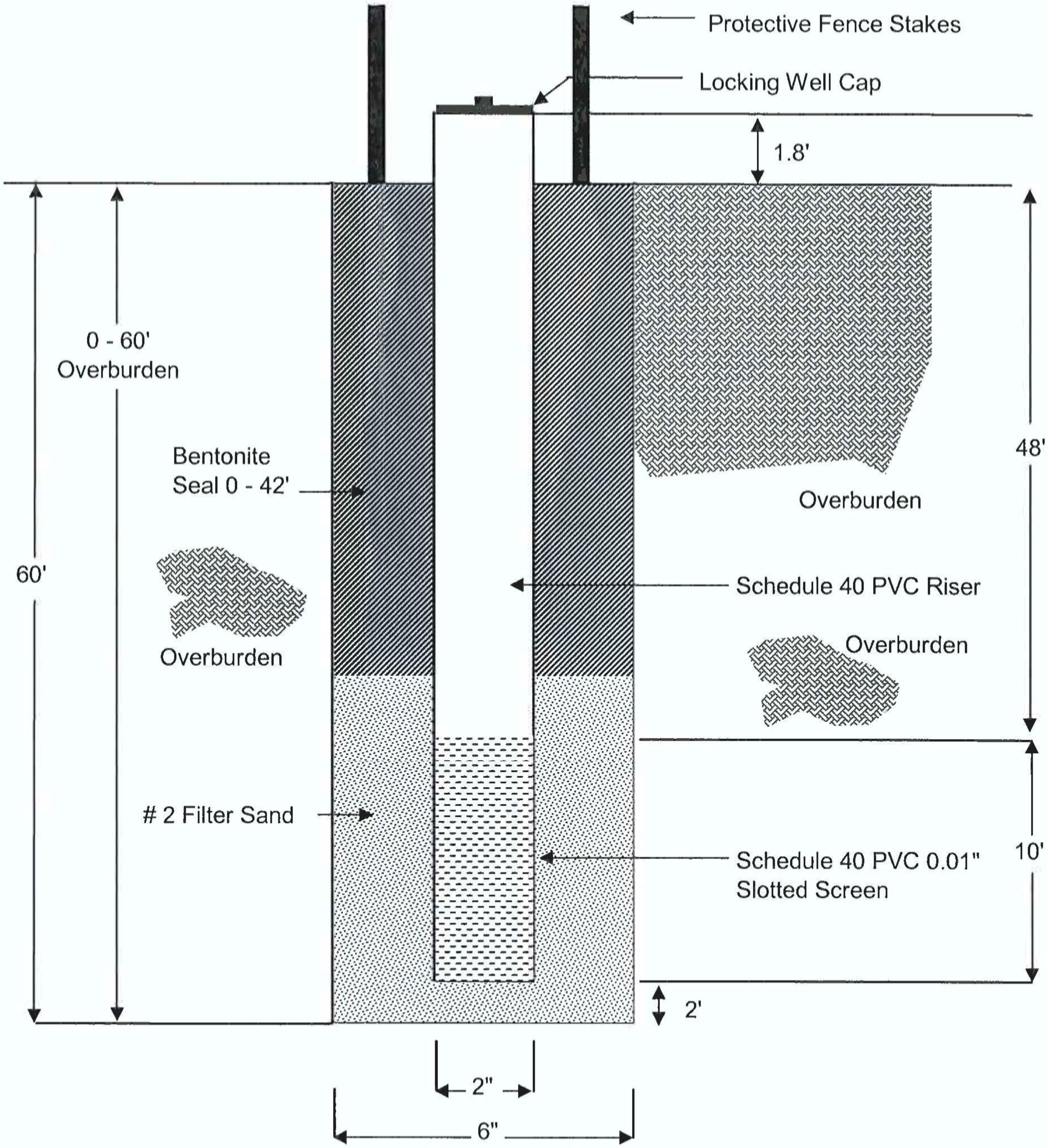
Log of Monitoring Well GAF-526U

Date(s) Drilled	3/11/20 to 3/12/20	Logged By	E. House	Checked By	N. Demers
Drilling Method	Rotosonic	Drill Bit Size/Type	Nominal 4", 6" (Sonic)	Total Depth of Borehole	95.0 feet
Drill Rig Type	Geoprobe 8420	Drilling Contractor	Cascade	Surface Elevation	476.03 ft above msl
Borehole Backfill	Monitoring Well - Installed 3/13/20 (Formerly NRS068)	Sampling Method(s)	6-inch sonic	Hammer Data	N/A
Coordinate Location	N 699,778.3 E 1,879,350.3	Groundwater Level(s)	N/A		

Elevation, feet	Depth, feet	SAMPLES: Type	Number	Sampling Resist. Blows/6" OR CORE% RQD	Recovery, %	Pocket Penetrometer (tsf)	MATERIAL DESCRIPTION	Water Content %	REMARKS AND OTHER DETAILS (Top of Casing 478.88 msl)
476.0	0.0						FILL: Brownish orange silty CLAY, Trace oragnics, Trace dark brown soils, Low to moderate plasticity, Stiff, Friable, Damp		
473.8	2.2						Orange silty CLAY, Trace fine grained silt, Moderate plasticity, Firm, Moist		Portland Grout (0'-5' bgs)
	5		SONIC 1		68	3.5			
	10						@ 10' bgs Increase in silt, Lower plasticity, Stiff, Dry		
	15		SONIC 2		74	4.0			2" Diameter PVC Riser (0'-63' bgs)
456.0	20.0						Dark orange CLAY SILT, Low plasticity, Soft, Friable, Dry		
	25		SONIC 3		94	1.0			
449.0	27.0						Orangish brown silty CLAY, Trace gravel/chert, Organic matter, Black mottling, Moderate plasticity, Firm, Dry		Bentonite Seal (5'-61' bgs)
443.0	33.0						Orange sandy CLAY, Fine grained sand, Low to moderate plasticity, Firm, Damp		
	35		SONIC 4		100	1.5			
	40						@ 40'-50' bgs Trace gravel, Firm		
	45		SONIC 5		100	2.5			
							@ 47'-50' bgs Decrease in sands		
	50						@ 50'-55.5' bgs Increase in cobble stones in various sizes and increase in sand, Wet		
	55		SONIC 6		100	2.0			
							@ 55.5'-59.7' bgs Mix of rounded GRAVEL and cobblestones and clayey sand, Medium to fine grained @ 57.3' bgs Brownish orange maroon and gray staining @ 58.1' bgs Low plasticity, Wet		
	60								

Elevation scale: 475, 470, 465, 460, 455, 450, 445, 440, 435, 430, 425, 420

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resist. Blows/6" OR CORE% RQD	Recovery, %	Pocket Penetrometer (tsf)	Graphic Log	MATERIAL DESCRIPTION	Water Content %	Well Details	REMARKS AND OTHER DETAILS
415	60–70	SONIC	7		100	3.5		@ 59.7'-60' bgs Medium brown clay lense, High plasticity, Firm, Damp @ 60' bgs Medium to dark in color, Moist to wet @ 68'-70' bgs Layering of medium brown limestone and silty CLAY, Firm, Damp pH: 4-4.5			**2" Diameter PVC Riser (0'-63' bgs)** **Sand Pack #2 (61'-69' bgs)** **0.010 Slot 2" Diameter PVC Screen (63'-68' bgs)** **Solid PVC End Cap**
405	70–80	SONIC	8		98	3.5		@ 77.5'-80' bgs Weathered rock			**Bentonite Backfill (69'-95' bgs)**
396.0	80.0										
395	80–90	SONIC	9		80	1.5		Medium brown weathered ROCK/silty CLAY, Low to medium plasticity, Damp pH: 5.5+			
386.0	90.0										
385	90–95	SONIC	10		88	N/A		LIMESTONE, Microcrystalline, Fresh, Medium hard, Dry			
381.0	95.0							End of Boring at 95´ bgs			



Date Constructed	9/15/2011	Ground Surface Elev.	Not Provided
Boring Depth	60'	Boring Termination Elev.	N/A
Bottom of Well	58'	Total Well Depth	58'
Length of Screen	10'	Length of Riser	49.8'
Top of Sand	42'	Vol./Wt. of Sand	N/A
Top of Bentonite	ground surface	Vol./Wt. of Bentonite	N/A
Top of Grout	N/A	Vol./Wt. of Grout	N/A

S&ME

Well Construction Figure

Monitoring Well I.D.: S-3

Project Name: TVA Gallatin Inactive Ash Pond | Project Number: 1431-11-240

Scale : NTS   Drawn By: TMD   Checked By: CTJ   Date: 10-6-11

PROJECT: TVA Gallatin Gallatin, Tennessee S&ME Project No. 1431-11-240	BORING LOG: S-3

DATE DRILLED: **9/15/11**	ELEVATION: FEET	NOTES: **Soil descriptions based on visual observation of obtained samples. Environmental samples collected from 36 to 38 ft and 58 to 60 ft.**
DRILLING METHOD: **CME 55, 3¼" H.S.A.**	BORING DEPTH: **60.0** FEET	
LOGGED BY: **TMD**	WATER LEVEL @ TOB: **50 feet**	
DRILLER: **D. Lowe**	WATER LEVEL @ 24 hrs: **Not Recorded**	

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO. SAMPLE TYPE	STANDARD PENETRATION TEST (SPT) DATA (blows/ft) 5 15 30	SPT INTERVALS (blows/6 inches) 1st	2nd	3rd	4th	N VALUE
5											
10											
15		Note - TVA decided to collect additional samples near location R-3 and construct an overburden monitoring well designated as S-3. Began sampling at 33.5 feet.									
20											
25											
30											

BORING LOG - TVA 11-240S.GPJ 11/10/11

NOTES:

1. *BORING, SAMPLING AND PENETRATION TEST DATA IN GENERAL ACCORDANCE WITH ASTM D-1586.*
2. *STRATIFICATION AND GROUNDWATER DEPTHS ARE NOT EXACT.*
3. *WATER LEVEL IS AT TIME OF EXPLORATION AND WILL VARY.*

S&ME

PROJECT: TVA Gallatin, Gallatin, Tennessee, S&ME Project No. 1431-11-240	BORING LOG: **S-3**

DATE DRILLED: **9/15/11**	ELEVATION: FEET	NOTES: **Soil descriptions based on visual observation of obtained samples. Environmental samples collected from 36 to 38 ft and 58 to 60 ft.**
DRILLING METHOD: **CME 55, 3¼" H.S.A.**	BORING DEPTH: **60.0** FEET	
LOGGED BY: **TMD**	WATER LEVEL @ TOB: **50 feet**	
DRILLER: **D. Lowe**	WATER LEVEL @ 24 hrs: **Not Recorded**	

DEPTH (feet)	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	1st	2nd	3rd	4th	N VALUE
35				1	3	6	6		12
40	**SANDY LEAN CLAY (CL)**- yellowish brown; moist; stiff - ALLUVIUM			UD-1 REC 88%					
50		⊽		2	6	7	10		17
55	**SILTY SAND (SM)**- red and orange brown; moist to wet; medium dense to loose - ALLUVIUM			3	2	4	5		9
60	Boring Terminated at a depth of 60 feet.								

STANDARD PENETRATION TEST (SPT) DATA (blows/ft): 5, 15, 30

BORING LOG - TVA 11-240S.GPJ 11/10/11

NOTES:

1. *BORING, SAMPLING AND PENETRATION TEST DATA IN GENERAL ACCORDANCE WITH ASTM D-1586.*
2. *STRATIFICATION AND GROUNDWATER DEPTHS ARE NOT EXACT.*
3. *WATER LEVEL IS AT TIME OF EXPLORATION AND WILL VARY.*

S&ME

Attachment B – Example Field Forms

Clear All Values

Print

Check and Submit

TVA- Groundwater Level Measurement Form

Program:		Facility Name:	
Date:		Project Number:	
Sampler(s) Name(s):			

Well ID	Well Type	Time	Depth to Groundwater (btoc,ft)	Depth to Bottom (btoc, ft)	Notes/Remarks

Notes:

Sampler (signature):

QA/QC'd by (Print):

QA/QC Date:

QA/QC'd by (signature):

Template Version: 03/11/2021

TVA

Program:
Facility:
Well ID:
Initial Depth to Water (feet):
Total Depth of Well (feet):
Method of Purging:
Measuring Point (toc, tor, etc.): Top of Casing

Project Number:
Well Type: Monitoring Well
Date:
Well Diameter (inches):
Total Water Column (feet): 0.00
Pump Start Time:
Pump Intake depth (feet)

* If water column is < Sample Set Volume contact TVA Project Manager

Clear All Values

Print

Check and Submit

Time	Water Level (feet)	Flow Rate	Temp. (°C)	pH (SU)	Specific Conductance	DO (mg/L)	DO (%)	ORP (mV)	Turbidity (NTU)	Comments/Observations During Purging (color, sediment, odor, etc.)
Stabilization Criteria			NA	± 0.1	± 3%	< 0.5 mg/L or ± 10%	NA	NA	± 10% or < 5 NTU	
										Controller Mode/Setting ID:
										Controller Pressure (PSI):
										Discharge Interval (seconds):
										Refill Interval (seconds):
Final Stabilization Values:		0								

	Time	Water Level (feet)	Flow Rate	Temp. (°C)	pH (SU)	Specific Conductance (mS/cm)	DO (mg/L)	DO (%)	ORP (mV)	Turbidity (NTU)
Post Sample Values:										

Sample ID:

QA/QC Sample Information Below:

Method of Sampling:
Sample Date:
Collection Time:
Total Volume Purged (gal.):
Sample Depth (feet):
Heavy Equipment in Area:
Post Metals Collection Turbidity (NTU):
Analysis:
Color:
Odor:
Ambient Air (°C)
Stability Reached (Y/N):
If No, Provide Explanation
Top of Screen (ft. btoc):

MS/MSD/LD Collected (Y/N?):
Field Blank ID:
Field Duplicate ID:
Equipment Blank ID:
Filter Blank ID:
Tubing Blank ID:
Lab Supplied DI Water Lot #:
Tubing Lot #:
Filter Lot #:
Filter Sample Metals (Y/N?):
Filter purged for a minimum of 500 mL, but no more than 750 mL prior to sample collection (Y/N?):
Sample on-Ice: Time:
Drawdown Stabilized ≤ 0.3 ft: N
Bottom of Screen (ft. btoc):

Depth to Water Meter Manufacturer: **Model:** **Serial No:**
Pump Controller Manufacturer: **Model:** **Serial No:**

Analytes:						
Method:						
Bottle Lot Number						
Bottle Type:						
Bottle Volume:						
Number of Bottles:						
Preservative:						

Lead Sampler Name: **Date:** **Signature:**
Sampler Name: **Date:** **Signature:**
Reviewed by: **Date:** **Signature:**

Template Version: 03/11/2021

Clear All Values | Print | Check and Submit

Template Version: 03/11/2021

EQUIPMENT CALIBRATION FORM

PROGRAM

Facility Name: **Date:**
Project Number: **Team Member:**

Morning (AM) Calibration					
Weather:					
Time (24hr) Start:			**Time (24hr) Finish:**		
Temperature (°C):			**Barometric Pressure (mbar):**		
NIST Thermometer:		Acceptance Criteria +/- 4°C	**Sonde or Local Meter:**		
Sonde:			BP Meter:		
Turbidity (NTUs):	NTU Standard	NTU Standard	NTU Standard	NTU Verification	Acceptance Criteria +/- 3 %
	Calibration Value	**Post Calibration**	Acceptance Criteria	**Notes:**	
Specific Conductance A			+/- 10 %	N/A	
Specific Conductance B			+/- 10 %	N/A	
pH 7 (SU)			+/- 0.05 (SU)	N/A	
pH 4 (SU)			+/- 0.05 (SU)	N/A	
pH 10 (SU)			+/- 0.05 (SU)	N/A	
D.O. (%)	N/A		95-105 %	N/A	
ORP (mV) A			+/- 10 mV	N/A	
ORP (mV) B			+/- 10 mV	N/A	

Afternoon (PM) Calibration Verification					
Weather:					
Time (24hr) Start:			**Time (24hr) Finish:**		
Temperature (°C):			**Barometric Pressure (mbar):**		
NIST Thermometer:		Acceptance Criteria +/- 4°C	Sonde or Local Meter:		
Sonde:			BP Meter		
Turbidity (NTUs)	NTU Standard	NTU Standard	NTU Standard	NTU Verification	Acceptance Criteria +/- 3 %
	Calibration Value	**Calibration Verification**	Acceptance Criteria	**Notes:**	
Specific Conductance A			+/- 10 %	N/A	
Specific Conductance B			+/- 10 %	N/A	
pH 7 (SU)			+/- 0.2 (SU)	N/A	
D.O. (%)	N/A		94-110 %	N/A	
ORP (mV) A			+/- 5 %	N/A	
ORP (mV) B			+/- 5 %	N/A	

Required Calibration Standards Information

Standard (@ 25°C)	Certified Value	Lot Number	Expiration Date	Date Opened	Cal. Temp. (°C)	Cal. Veri. Temp. (°C)
AM pH 4 (SU)						N/A
AM pH 7 (SU)						N/A
AM pH 10 (SU)						N/A
PM pH 7 (SU)					N/A	
Specific Conductance A						
Specific Conductance B						
ORP (mV) A						
ORP (mV) B						
Turbidity - 20 NTU					N/A	N/A
Turbidity - 100 NTU					N/A	N/A
Turbidity - 800 NTU					N/A	N/A
Turbidity - 10 NTU					N/A	N/A

ORP Calibration Solution type:	**Zobell's (Y or N)**	**Quinhydrone (Y or N)**

	Manufacturer	**Instruments Model**	**Serial Number**	**Calibrated Within AM Acceptance Criteria (Y/N):**
Water Quality Meter				
Turbidity Meter				
NIST Thermometer				
Field Printer	**Present (Y or N)**	**Power Source Present (Y or N)**	**Sufficient Paper Present (Y or N)**	**Ink present (Y or N)**
Explanations:				

Team Member Name print):	Date:	Signature:
Reviewed By (Print):	Date:	Signature:

Clear All Values | Print | Check and Submit

TVA

Daily Activity Log

If additional pages are needed, "Save As" this form and open a blank form

Page   of

Program:		**Facility Name:**	
Sampler(s) Name(s):		**Project Number:**	
Personnel Onsite:		**Date and Time Onsite:**	
Weather Conditions:		**Time Offsite:**	

Time	**Description of Daily Activities and Events:**

List Samples Collected:		**Sampler's Signature:**
Deviation from Plans:		
Visitors on Site:		**Sampler's Name** (print)**:**
Important Telephone Calls / Photos Taken:		

QA/QC'd by (Print)**:**	**QA/QC Date:**
QA/QC Signature:	
Project Manager:	

NOTE: Select "Site ID:" followed by "Program" before selecting other fields.

Tennessee Valley Authority

Clear All Values | Print | Check and Submit

COOLER No.:		of	
COC No:			
of	Pages		
Task Desc:			

Chain-of-Custody / Analytical Request Document

Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed and accurate

Program

Required Ship to Lab:	
Lab Name:	ALS Salt Lake
Lab Address:	
Lab Manager Contact Information	
Lab PM:	
Phone/Fax:	
Lab Email:	
Lab PO	

Required Project Information:			
Site ID #:			
Project #:			
Site Address			
City		State, Zip	
Site PM Name:			
Phone/Fax:			
Site PM Email:			

Required Sampler Information			
Sampler:			
Sampling Company:			
Address			
City/State		Phone No:	
Sampling Team Number:			
Send EDD/Hard Copy to:	tva_deliverables@envstd.com		

Analysis Turnaround Time

Calendar Days | Working Days

TAT if different from Below

- ☐ 24 Hours
- ☐ 3 Business Days
- ☐ 5 Business Days
- ☐ 10 Business Days (Standard)

Filtered | Preserve | Analysis

ITEMS #	SAMPLE ID Samples IDs MUST BE UNIQUE	SAMPLE LOCATION	Sample Depth: Depth Unit / Start Depth	Feet / End Depth	MATRIX CODE *Will update based on sample type	G= GRAB C=COMP	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	# OF CONTAINERS	Comments/Lab Sample I.D.
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											

Additional Comments/Special Instructions:

Additional volume collected should be used for MS/MSDs.

Dissolved samples field filtered.

RELINQISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME

Sample Receipt Conditions			
☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Temperature in °C	Sample on Ice?	Sample Intact?	Trip Blank?

SHIPPING METHOD: (Select Appropriate)	SAMPLER NAME AND SIGNATURE

Template Version: 03/11/2021

Attachment C – Hach® Field Test Kit Instructions

Iron, Ferrous, Test Kit

IR-18C (2667200)

DOC326.97.00063

Replacement items

Description	Unit	Item no.
Ferrous Iron Reagent Powder Pillows	100/pkg	103769
Color disc, iron, indoor light, 0–7 mg/L	each	9261000
Color disc, iron, outdoor light, 0–7 mg/L	each	9263700
Color comparator box	each	173200
Plastic viewing tubes, 18 mm, with caps	4/pkg	4660004
Vial with 2, 5, 10, 15, 20 and 25-mL marks	each	219300

Optional items

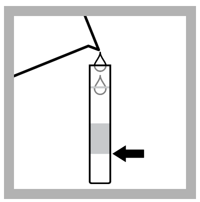
Description	Unit	Item no.
Caps for plastic viewing tubes (4660004)	4/pkg	4660014
Glass viewing tubes, glass, 18 mm	6/pkg	173006
Stoppers for 18-mm glass tubes and AccuVac Ampuls	6/pkg	173106
Water, deionized	500 mL	27249

Test preparation

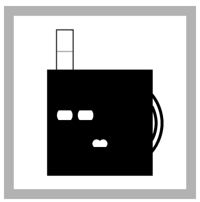
CAUTION: ⚠ ***Review the Safety Data Sheets (MSDS/SDS) for the chemicals that are used. Use the recommended personal protective equipment.***

- Analyze samples immediately after collection.
- Put the color disc on the center pin in the color comparator box (numbers to the front).
- Use the indoor light color disc when the light source is fluorescent light. Use the outdoor light color disc when the light source is sunlight.
- Rinse the tubes with sample before the test. Rinse the tubes with deionized water after the test.
- If the color match is between two segments, use the value that is in the middle of the two segments.
- If the color disc becomes wet internally, pull apart the flat plastic sides to open the color disc. Remove the thin inner disc. Dry all parts with a soft cloth. Assemble when fully dry.
- Undissolved reagent does not have an effect on test accuracy.
- To verify the test accuracy, use a standard solution as the sample.
- This test kit measures ferrous iron. To determine ferric iron (Fe^{3+}), subtract the ferrous iron result from a total iron test.

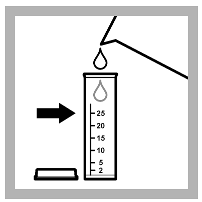
Test procedure—Iron, ferrous (0–7 mg/L Fe^{2+})



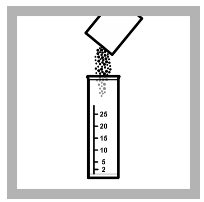
1. Fill a tube to the first line (5 mL) with sample.



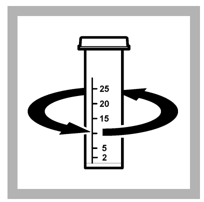
2. Put the tube into the left opening of the color comparator box.



3. Fill the vial to the 25-mL mark with sample.

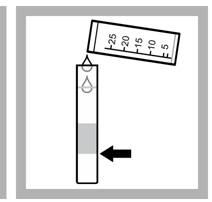


4. Add one Ferrous Iron Reagent Powder Pillow to the vial.

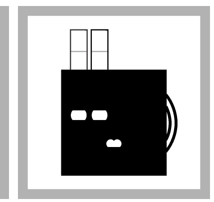


5. Swirl to mix. A orange color develops if ferrous iron is in the sample.

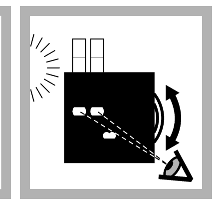
6. Wait 3 minutes.



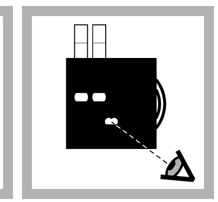
7. Fill a second tube to the first line (5 mL) with the prepared sample.



8. Put the second tube into the color comparator box.



9. Hold the color comparator box in front of a light source. Turn the color disc to find the color match.



10. Read the result in mg/L in the scale window.

12/2015, Edition 1

Carbon Dioxide Test Kit

1.25 to 25 mg/L, 2 to 40 mg/L, 5 to 100 mg/L CO_2

For test kit 143601 (CA-23) DOC326.98.00004

Additional copies available on www.hach.com

Test preparation

- Rinse labware with deionized water between tests.
- When titrating, count each drop of titrant. Hold the dropper vertically. Swirl after each drop is added.

CAUTION: Handle chemical standards and reagents carefully. Review Material Safety Data Sheets for safe handling, storage and disposal information.

Required items

Description	Unit	Catalog no.
Measuring Tube	each	43800
Mixing Bottle	6/pkg	232706
Phenolphthalein Indicator Solution	15 mL (½ oz) SCDB[1]	189736
Sodium Hydroxide Solution, 0.01 N	100 mL MDB[2]	67132

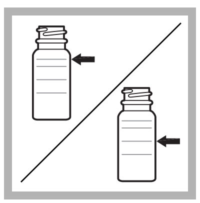
[1] Self-contained dropping bottle

[2] Marked dropping bottle

Optional items

Description	Unit	Catalog no.
Deionized Water	500 mL	27249

Low range (1.25 to 25 mg/L) and medium range (2 to 40 mg/L) test procedure



1. Low Range: Fill the bottle to the 23-mL mark with sample.

Medium Range: Fill the bottle to the 15-mL mark with sample.

2. Add one drop of Phenolphthalein Indicator Solution.

3. Add Sodium Hydroxide Solution by drops. Count the drops until the color changes to light pink and persists for 30 seconds. Swirl to mix after each drop.

4. Low Range: Calculate the result. Each drop of Sodium Hydroxide Solution used in step 3 equals 1.25 mg/L carbon dioxide (CO_2).

Medium Range: Calculate the result. Each drop of Sodium Hydroxide Solution used in step 3 equals 2 mg/L carbon dioxide (CO_2).

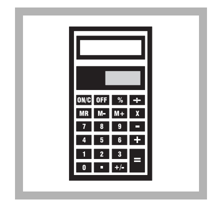
High range (5 to 100 mg/L) test procedure

1. Fill the plastic tube to the top with sample.

Pour the sample into the bottle.

2. Add one drop of Phenolphthalein Indicator Solution.

3. Add Sodium Hydroxide Solution by drops. Count the drops until the color changes to light pink and persists for 30 seconds. Swirl to mix after each drop.



4. Calculate the result. Each drop of Sodium Hydroxide Solution used in step 3 equals 5 mg/L carbon dioxide (CO_2).

For technical assistance or ordering information: visit www.hach.com, call 800-227-4224 or email techhelp@hach.com

Edition 1, August 2006

Appendix B
NRS Field Investigation Report Data Figures
(For Reference)

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Figure 3-1

GROUNDWATER ELEVATIONS IN OVERBURDEN AND ROCK WITH POTENTIOMETRIC ELEVATION CONTOURS IN UNCONSOLIDATED MATERIAL

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
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GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
1/14/2021	FOSSIL AND HYDRO ENGINEERING

LEGEND
- Coal Pile
- Unconsolidated Material- Disturbed Native Alluvium, Fill and Mixture of Alluvium/Fill
- Unconsolidated Material – Fine-Grained Alluvium, Typically Silty Clay with Varying Content of Sand and Gravel, Residuum
- CCR
- Upper Carters Limestone
- Lower Carters Limestone
- Lebanon Limestone
- Ridley Limestone

Coarser Material Encountered in Boring:
- Unconsolidated Sand and Less Frequently, Gravel; Typically Very Silty and/or Clayey

- Well Screen
- Ground Surface
- Formation Contact
- 1952 Surface Topography
- Estimated Potentiometric Surface in Unconsolidated Material June 15, 2020; Dashed Where Inferred Due to Limited Data
- Estimated Phreatic Surface in CCR June 15, 2020

- 489U 461.01 2E-06 cm/s — Monitoring Well ID and Potentiometric Surface (ft msl) in Well on June 15, 2020 Hydraulic conductivity from slug tests, low yield drawdown tests, or packer tests
- Groundwater Flow Direction
- 470' — Potentiometric Surface Contour (ft msl), June 15, 2020

- Approximate Location of Water Bearing Lebanon Ls. Fractures (L1)
- Approximate Location of Water Bearing Lebanon Ls. Fracture (L2)
- Electrical Conductivity (EC) Log in millisiemens/meter; scale varies at each location; response to right indicates increasing conductivity (e.g., clay).

Notes:
1. Lithology and top of rock interpretations at boring locations are based on boring logs and borehole geophysical data. Top of rock interpretations between borings are based on outcrops and topography.
2. Ground surface elevations derived from the 2017 LIDAR and 2016 River Bathymetry surveys.
3. Borings and wells are projected onto the cross section.

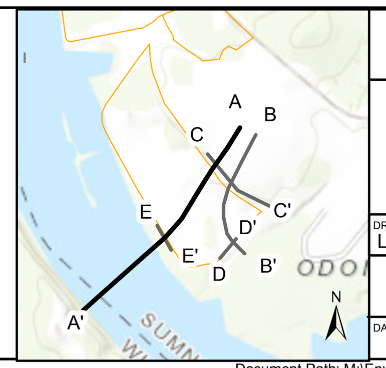

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Figure 3-3

HYDROGEOLOGIC CROSS SECTION A-A'
NRS

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
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GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE: 1/14/2021 DEPT: FOSSIL AND HYDRO ENGINEERING

Document Path: M:\EnvDataViz\TVA\11.0 GIS\geologic_cross_sections\MXD\NRS_202010\N3-3_RS_AA_202004.mxd

Well: GAF-447U	Screen Elevation: 439-444				
Date	pH	Be	Cd	Li	Ni
1/21/2020	6.5	0.182 U	0.217 U	3.39 U	8.1
4/23/2020	6.4	0.182 U	0.217 U	6.57 U*	7.26
6/17/2020	6.5	0.182 U	0.217 U	3.39 U	9.43
8/18/2020	6.7	0.182 U	0.217 U	3.39 U	11.9 J
10/19/2020	6.4	0.182 U	0.217 U	3.39 U	10.4

Well: 20	Screen Elevation: 421-431				
Date	pH	Be	Cd	Li	Ni
1/16/2020	6.2	0.182 U	0.217 U	3.43 J	17.2
4/22/2020	6.0	0.182 U	0.217 U	8.22	20
6/17/2020	6.2	0.182 U	0.217 U	8.7	16.7
7/15/2020*	6.9	0.182 U	0.217 U	6.78	16.9
8/17/2020	6.2	0.182 U	0.217 U	5.05	18.5
10/21/2020	6.2	0.182 U	0.217 U	6.40	15.1

Well: 27	Screen Elevation: 386-396				
Date	pH	Be	Cd	Li	Ni
1/14/2020*	6.8	0.182 U	0.217 U	6.11	0.916 J
4/22/2020	6.7	0.182 U	0.217 U	5.63	0.336 U
7/15/2020*	7.3	0.182 U	0.217 U	4.81 J	0.336 U
10/21/2020*	6.9	0.182 U	0.217 U	3.39 U	0.336 U

Well: GAF-440U	Screen Elevation: 450-460				
Date	pH	Be	Cd	Li	Ni
1/17/2020	6.7	0.215 J	0.217 U	4.79 J	9.98
4/23/2020	6.5	0.182 U	0.217 U	6.91 U*	5.96
6/18/2020	6.5	0.182 U	0.217 U	3.39 J	7.31
8/19/2020	6.8	0.182 U	0.217 U	3.39 U	6.64
10/20/2020	6.7	0.182 U	0.217 U	3.39 U	5.52

Well: GAF-441U	Screen Elevation: 451-461				
Date	pH	Be	Cd	Li	Ni
1/16/2020	3.5	18.6	11.8 J	16.4	705
4/24/2020	3.3	17.2	15	17 U	771
6/17/2020	3.3	14.8	19.9	17 U	887
8/18/2020	2.7	12.4	13.9	33.9 U	762
10/22/2020	3.7	13.1	8.23	13.4	612

Well: GAF-439U	Screen Elevation: 438-443				
Date	pH	Be	Cd	Li	Ni
1/21/2020	6.9	0.199 U*	0.217 U	3.6 J	1.74
4/22/2020	6.7	0.182 U	0.217 U	5	2.21
6/19/2020	6.6	0.182 U	0.217 U	3.9 J	2.29
8/20/2020	6.7	0.182 U	0.217 U	4.08 J	2.19
10/19/2020	6.7	0.182 U	0.217 U	3.39 U	2.64

Well: GAF-448U	Screen Elevation: 423-438				
Date	pH	Be	Cd	Li	Ni
1/20/2020	6.9	0.182 U	0.217 U	3.39 U	0.558 J
4/23/2020	6.5	0.182 U	0.217 U	6.22 U*	0.605 J
6/17/2020	6.8	0.182 U	0.217 U	3.39 U	1.33
8/18/2020	6.1	0.182 U	0.217 U	3.39 U	0.8 J
10/19/2020	6.6	0.182 U	0.217 U	3.39 U	0.779 J

Well: GAF-541U	Screen Elevation: 438-443				
Date	pH	Be	Cd	Li	Ni
4/24/2020	6.0	0.182 U	0.217 U	34.7	345
6/17/2020	6.1	0.182 U	0.217 U	30.2	241
8/18/2020	5.9	0.182 U	0.217 U	25.2	225
10/22/2020*	6.1	0.182 U	0.217 U	26.6	325

Well: GAF-442U	Screen Elevation: 439-449				
Date	pH	Be	Cd	Li	Ni
1/17/2020	6.5	0.182 U	0.217 U	3.39 U	1.42
4/22/2020	6.3	0.182 U	0.217 U	3.39 U	5.69 J
6/18/2020	6.3	0.182 U	0.217 U	3.39 U	1.39
8/19/2020	6.9	0.182 U	0.217 U	3.39 U	1.5
10/20/2020	6.3	0.182 U	0.217 U	3.39 U	1.49

Well: S3	Screen Elevation: 418-428				
Date	pH	Be	Cd	Li	Ni
1/20/2020	3.8	5.3	8.41	31.3	140
4/23/2020	3.8	4.61	8.45	33.6 U*	154
6/18/2020	3.7	4.9	8.46	32.6	150
8/19/2020	3.6	3.83	7.47	30	140
10/22/2020	4.1	4.37	7.90	29.0	140

Well: GAF-526U	Screen Elevation: 408-413				
Date	pH	Be	Cd	Li	Ni
4/23/2020	6.8	0.182 U	0.217 U	11 U*	3.03
6/18/2020	6.8	0.182 U	0.217 U	4.76 J	4.57
8/19/2020	6.8	0.182 U	0.217 U	4.42 J	3.58
10/19/2020	7.1	0.182 U	0.217 U	3.55	2.60

Well: 26	Screen Elevation: 373-383				
Date	pH	Be	Cd	Li	Ni
1/14/2020	7.2	0.427 J	0.217 U	4.97 J	5.08 J
4/22/2020	7.0	0.182 U	0.217 U	3.81 J	0.577 J
7/24/2020	7.1	0.182 U	0.217 U	3.39 U	0.682 J
10/21/2020	7.7	0.182 U	0.217 U	3.39 U	0.357 J

Well: GAF-444U	Screen Elevation: 423-433				
Date	pH	Be	Cd	Li	Ni
1/20/2020	4.1	11.7	7.22	35.9	643
4/24/2020	4.3	9.2	9.79	30.7	520
6/16/2020	4.5	7.58	9.17	31.5	552
8/19/2020	6.5	7.36	9.6	31.6	522
10/22/2020	4.2	8.44	9.26	31.2	536

Well: 19R	Screen Elevation: 427-437				
Date	pH	Be	Cd	Li	Ni
1/15/2020	3.5	13.3	4.65	146	191
4/22/2020	3.4	12.6	4.89	123	156
6/16/2020*	3.8	12.5	4.4	130	159
7/14/2020	4.1	13.5	5.79	126	176 J
8/17/2020	3.6	11.2	3.71	129	131
10/21/2020	3.6	12.4	4.54	131	140

Well: GAF-489U	Screen Elevation: 419-429				
Date	pH	Be	Cd	Li	Ni
1/21/2020	6.1	0.182 U	0.217 U	3.39 U	3.2 J
4/23/2020	5.8	0.182 U	0.217 U	6.23 U*	1.6
6/18/2020	5.6	0.182 U	0.217 U	3.39 U	2.26
8/20/2020	5.5	0.182 U	0.217 U	3.39 U	1.21
10/22/2020	5.8	0.182 U	0.217 U	3.39 U	1.92

Well: 22	Screen Elevation: 421-431				
Date	pH	Be	Cd	Li	Ni
1/16/2020	7.4	0.182 U	0.217 U	3.39 U	0.336 U
4/23/2020	7.1	0.182 U	0.217 U	6.55 U*	0.336 U
6/16/2020	7.4	0.182 U	0.217 U	3.39 U	0.336 U
7/15/2020*	7.7	0.182 U	0.217 U	3.39 U	0.336 U
8/18/2020	7.1	0.182 U	0.217 U	3.39 U	0.336 U
10/21/2020	7.0	0.182 U	0.217 U	3.39 U	0.336 U

NOTES:
-Target metals are beryllium (Be), cadmium (Cd), lithium (Li), and nickel (Ni)
* Only total metals analysis was available for the well on this sampling date.
-Results are in micrograms per liter (ug/l)
-CCR - Coal Combustion Residuals
-ft bgs - feet below ground surface

-The field PH reading for well GAF-444U in August 2020 is understood to be an instrument error, as the groundwater was retested on receipt by AECOM's treatability laboratory and was found to have a typical low pH for that well.
-Red - concentration exceeds its applicable groundwater protection standard or, if pH, is ≤ 5.5
Screen elevation in feet mean sea level (msl)

Groundwater Protection Standards

Be	4 ug/L	J =	Quantitation is approximate due to limitations identified during data validation.
Cd	5 ug/L	U =	Non detection at the concentration noted
Li	40 ug/L	U*=	This result should be considered “not detected” because it was detected in a rinsate blank or laboratory blank at a similar level.
Ni	100 ug/L		

445-449 Groundwater sample interval elevation (ft msl)

0 200 400
Feet

LEGEND:
- Direct Push Boring Location
- Well Screened in Unconsolidated Material
- Well Screened in Lebanon Limestone
- Well Screened in CCR
- Well Screened in Carters Limestone
- Approximate Eastern Extent of Saturated Overburden near the NRS
- CCR Management Units
- Primary Pyritic Sulfur Area - Area of NRS where pyritic sulfur exists at some of the highest mass fractions (up to 3.02%), in both the unsaturated and saturated zones, and to the greatest depth (25 ft bgs)

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Figure 4-1a

DISTRIBUTION OF PH AND DISSOLVED TARGET METALS IN MONITORING WELLS, 2020

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DATE:	DEPT:
1/14/2021	FOSSIL AND HYDRO ENGINEERING

LEGEND

- Unconsolidated Material - Disturbed Native Alluvium, Fill and Mixture of Alluvium/Fill
- Unconsolidated Material – Fine-Grained Alluvium, Typically Silty Clay with Varying Content of Sand and Gravel, Residuum
- CCR
- Lower Carters Limestone
- Lebanon Limestone
- Coal Pile
- Well Screen
- Ground Surface
- Formation Contact
- 1952 Surface Topography
- Estimated Potentiometric Surface in Unconsolidated Material June 15, 2020; Dashed Where Inferred Due to Limited Data

Soil Acid Base Accounting Net Neutralization Potential (NNP) Results

- Potentially acid generating NNP < -20
- Uncertain acid generating potential -20 ≤ NNP ≤ +20
- Potentially acid neutralizing NNP > 20
- Estimated Phreatic Surface in CCR June 15, 2020
- pH ≤ 5
- 5 < pH < 6
- pH ≥ 6
- S Pyritic sulfur detected from 0.37-3.72%
- S Pyritic sulfur detected from 0.03-0.29%
- S Pyritic sulfur <0.03%
- Groundwater Flow Direction
- 470' Potentiometric Surface Contour (ft msl), June 15, 2020

Dissolved Groundwater Concentrations (ug/L)

pH
Beryllium (Be)
Cadmium (Cd)
Lithium (Li)
Nickel (Ni)

Concentrations are shown in red if they are at or above the GWPS of 4 ug/L Be, 5 ug/L Cd, 40 ug/L Li, and 100 ug/L Ni. pH values are shown in red if value is at or below 5.5

Notes:
1. Lithology and top of rock interpretations art boring locations are based on boring logs and borehole geophysical data. Top of rock interpretations between borings are based on outcrops and topography.
2. Ground surface elevations derived from the 2017 LIDAR and 2016 River Bathymetry surveys.
3.Soil and in-situ groundwater analyses are from 2015 (NRS001 to NRS050) and 2020 (NRS051 to NRS070).
4. Well groundwater analyses from January 2020, except GAF-526U (April 2020), GAF-526L (January 2019) and GAF-440AR (January 2017).
5. Borings and wells are projected onto the cross section.
6. GWPS = groundwater protection standards
7. Filtered (dissolved) analytical results are presented on this figure for beryllium (Be), cadmium (Cd), lithium (Li) and nickel (Ni).
8. June 15, 2020 potentiometric contours and flow lines shown.
9. The primary pyritic sulfur area is the area of the NRS where pyritic sulfur exists at some of the highest mass fractions (up to 3.02%), in both the unsaturated and saturated zones, and to the greatest depth (25 ft bgs).

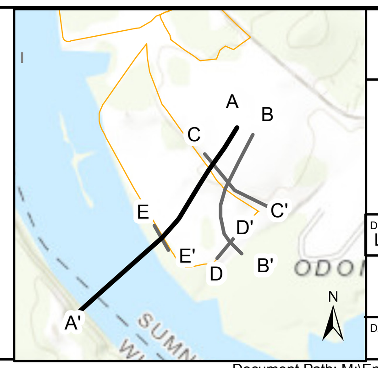

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Figure 4-8

GEOCHEMICAL CROSS SECTION A-A'
NRS

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
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GALLATIN FOSSIL PLANT
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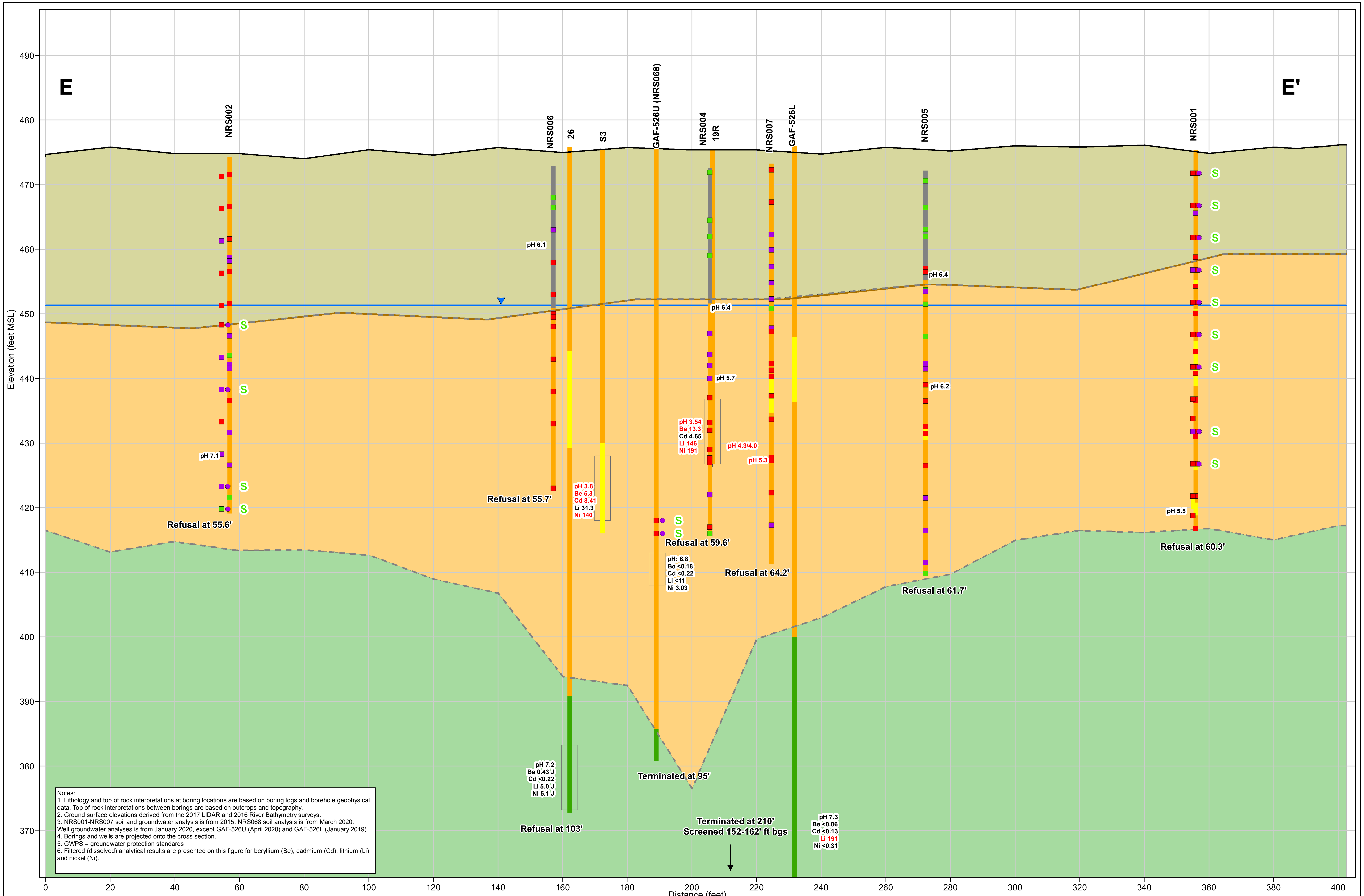
Document Path: M:\EnvDataViz\TVA\11.0 GIS\geologic_cross_sections\MXD\NRS_202010\geochem\NRS_AA_202004_geocher



LEGEND

- Unconsolidated Material - Disturbed Native Alluvium, Fill and Mixture of Alluvium/Fill
- Unconsolidated Material - Fine-Grained Alluvium Typically Silty Clay with Varying Content of Sand and Gravel, Residuum
- CCR
- Lower Carters Limestone
- Lebanon Limestone

Well Screen

Well or Soil Boring Lithology
- CCR
- Unconsolidated Sand and Less Frequently, Gravel; Typically Very Silty and/or Clayey
- Unconsolidated Fines, Predominantly Silt and/or Clay
- Lebanon Limestone

Soil Acid Base Accounting Net Neutralization Potential (NNP) Results
- Potentially acid generating NNP < -20
- Uncertain acid generating potential -20 ≤ NNP ≤ +20
- Potentially acid neutralizing NNP > 20
- Estimated Phreatic Surface in CCR June 15, 2020

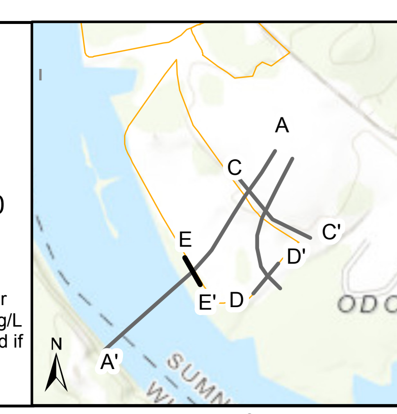
- pH ≤ 5
- 5 < pH < 6
- pH ≥ 6
- S Pyritic sulfur detected from 0.37-3.72%
- S Pyritic sulfur detected from 0.03-0.29%
- S Pyritic sulfur <0.03%

- Ground Surface
- Formation Contact
- 1952 Surface Topography
- Estimated Potentiometric Surface in Unconsolidated Material June 15, 2020

Dissolved Groundwater Concentrations (ug/L)

pH
Beryllium (Be)
Cadmium (Cd)
Lithium (Li)
Nickel (Ni)

Concentrations are shown in red if they are at or above the GWPS of 4 ug/L Be, 5 ug/L Cd, 40 ug/L Li, and 100 ug/L Ni. pH values are shown in red if value is at or below 5.5



AECOM

Figure 4-7

GEOCHEMICAL CROSS SECTION E-E'
NRS

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
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GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

DATE:	DEPT:
12/7/2020	FOSSIL AND HYDRO ENGINEERING

Document Path: M:\EnvDataViz\TVA\11.0 GIS\geologic_cross_sections\MXD\NRS_202010\geochem\NRS_eeV2geoChem.mxd

Appendix C
Groundwater Flow Calculations

Method for Calculating Darcy Velocity, Darcy Discharge, and Average Linear Velocity

Hydraulic parameters Darcy velocity, Darcy discharge, and average linear velocity were estimated to support the design basis for the field demonstration of a permeable reactive barrier (PRB). **Tables B1 and B2** provide the estimated values and the data sources and assumptions used in the estimates for the areas of wells 19R/S3 and well GAF-444U, respectively.

Darcy velocity, sometimes referred to as specific discharge, is the discharge of groundwater through a unit cross sectional area (e.g., 1 foot by 1 foot) of aquifer or saturated porous media. It is an apparent velocity, in units of length per time (L/T), representing the velocity at which groundwater would move through an aquifer if the aquifer were an open conduit (Fetter, 1980). This value is used to estimate the rate that groundwater discharges into a PRB oriented perpendicular to groundwater flow. Darcy velocity is multiplied by the PRB area (perpendicular to flow) to estimate the total discharge into the entire PRB, which is the Darcy discharge, in units of L^3/T.

A PRB in the area of wells 19R and S3 is assumed to extend to 60 feet (ft) below ground surface (bgs), which is the estimated depth of low pH groundwater, and is 40 ft long. The Darcy discharge is estimated to be 0.21 cubic feet per day (ft^3/d) or 0.0011 gallons per minute (gpm). For these estimates two Darcy velocity values were used, one to represent the 18.5 ft of saturated clayey sand with a higher hydraulic conductivity (K) of 0.20 feet per day (ft/d) and one to represent the 16.5 ft of the more typical predominantly fine-grained silty clay encountered with a bulk average K of 0.023 ft/d.

A PRB in the area of well GAF-444U is assumed to extend to 68 ft bgs, which is the estimated depth of low pH groundwater, and is 40 ft long. The Darcy discharge is estimated to be 0.09 ft^3/d or 4.7E-04 gpm. For these estimates two Darcy velocity values were used, one to represent the 3 ft of saturated clayey sand with a higher K of 0.20 ft/d and one to represent the 32 ft of the more typical predominantly fine-grained silty clay encountered with a bulk average K of 0.023 ft/d.

Average linear velocity, sometimes referred to as seepage velocity, is the actual rate a fluid particle moves through porous media. This parameter is used to estimate the time for a particle of water to travel between two points under a natural hydraulic gradient, such as between the PRB and a performance monitoring well. In the wells 19R and S3 area, the average linear velocity is estimated to range from 2.8 feet per year (ft/yr) in the more fine-grained porous media to 24 ft/yr in the more permeable clayey sand layers. In the well GAF-444U area, the average linear velocity is estimated to range from 3.7 ft/yr in the more fine-grained porous media to 33 ft/yr in the more permeable clayey sand layers.

Table C1. Parameters Used to Calculate Darcy Velocity, Darcy Discharge, and Average Linear Velocity for the Wells 19R and S3 Area

Parameter	Value		Data Sources and Assumptions
High hydraulic conductivity (K), clayey sand	7.1E-05 cm/s	0.20 ft/d	Average K at 19R and S3 (silty/clayey sand) from 39.5 to 58 ft bgs
Low hydraulic conductivity (K), bulk average	8.1E-06 cm/s	0.023 ft/d	Geomean of K in unconsolidated material across NRS
Effective porosity (n_e)		0.15	Assumed for silty fine sand and silty clay (unitless)
Depth to groundwater at 19R/S3		25 ft bgs	June 15, 2020
Depth to PRB bottom		60 ft bgs	Estimated extent of low pH groundwater
Saturated thickness at PRB - total		35 ft	Water table to depth of PRB
Saturated thickness at PRB - clayey sand		18.5 ft	Length of well screen 19R + S3
Saturated thickness at PRB - bulk average		16.5 ft	Water table to top of 19R screen (14.5 ft) + bottom S3 screen to barrier bottom (2 ft)
Hydraulic gradient (i) at well 19R/S3		0.050 ft/ft	Gradient directly upgradient and downgradient of 19R/S3 from 460 to 450 ft msl contour, June 15, 2020
High Darcy velocity (q) = Ki	3.7 ft/yr	0.010 ft/d	Using clayey sand K
Low Darcy velocity (q) = Ki	0.42 ft/yr	0.0011 ft/d	Using bulk average K
High Darcy discharge (Q) = qA	9.7E-04 gpm	0.19 ft^3/d	Per unit width of saturated unconsolidated material, sandy clay K
Low Darcy discharge (Q) = qA	9.8E-05 gpm	0.019 ft^3/d	Per unit width of saturated unconsolidated material, bulk average K
Total Darcy discharge (Q) in well 19R area (combined clayey sand and bulk average)	**1.1E-03 gpm**	**0.21 ft^3/d**	**Per unit width of saturated unconsolidated material to 60 ft bgs; 18.5 ft thickness of high K material and 16.5 ft of low K material**
Total Darcy discharge (Q) in well 19R area (bulk average)	2.1E-04 gpm	0.040 ft^3/d	Per unit width of saturated unconsolidated material to 60 ft bgs; 35 ft of bulk K material
Total Darcy discharge (Q) for 40 ft of PRB (combined clayey sand and bulk average)	4.3E-02 gpm	8 ft^3/d	Per 40 ft of PRB length to depth of 60 ft bgs; 18.5 ft thickness of higher K material and 16.5 ft of low K material
Total Darcy discharge (Q) for 40 ft of PRB (bulk average)	8.4E-03 gpm	1.6 ft^3/d	Per 40 ft of PRB length to depth of 60 ft bgs; 35 ft of bulk K material
High average linear velocity (*v*) = Ki/n_e	**24 ft/yr**	**0.067 ft/d**	**Using sandy clay K**
Low average linear velocity (*v*) = Ki/n_e	**2.8 ft/yr**	**0.0077 ft/d**	**Using bulk average K**

Table C2. Parameters Used to Calculate Darcy Velocity, Darcy Discharge, and Average Linear Velocity for the Well GAF-444U Area

Parameter	Value		Data Sources and Assumptions
High hydraulic conductivity (K), clayey sand	7.1E-05 cm/s	0.20 ft/d	Average K at 19R and S3 (silty/clayey sand) from 39.5 to 58 ft bgs
Low hydraulic conductivity (K), bulk average	8.1E-06 cm/s	0.023 ft/d	Geomean of K in unconsolidated material across NRS
Effective porosity (n_e)		0.15	Assumed for silty fine sand and silty clay (unitless)
Depth to groundwater at well GAF-444U		33 ft bgs	June 15, 2020
Depth to PRB bottom		68 ft bgs	Estimated extent of low pH groundwater
Saturated thickness at PRB - total		35 ft	Water table to depth of PRB
Saturated thickness at PRB - clayey sand		3 ft	Based on NRS052 (3 ft) and NRS070 (3 ft)
Saturated thickness at PRB - bulk average		32.0 ft	Total saturated thickness of PRB minus clayey sand layer thickness
Hydraulic gradient (i) at well GAF-444U		0.067 ft/ft	Gradient directly upgradient and downgradient of GAF-444U from 460 to 450 ft msl contour, June 15, 2020
High Darcy velocity (q) = Ki	4.9 ft/yr	0.013 ft/d	Using clayey sand K
Low Darcy velocity (q) = Ki	0.56 ft/yr	0.0015 ft/d	Using bulk average K
High Darcy discharge (Q) = qA	2.1E-04 gpm	0.04 ft^3/d	Per unit width of saturated unconsolidated material, sandy clay K
Low Darcy discharge (Q) = qA	2.6E-04 gpm	0.049 ft^3/d	Per unit width of saturated unconsolidated material, bulk average K
Total Darcy discharge (Q) in well GAF-444U area (combined clayey sand and bulk	**4.7E-04 gpm**	**0.09 ft^3/d**	**Per unit width of saturated unconsolidated material to 68 ft bgs; 3 ft thickness of high K material and 32 ft of low K material**
Total Darcy discharge (Q) in well GAF-444U area (bulk average)	2.8E-04 gpm	0.054 ft^3/d	Per unit width of saturated unconsolidated material to 68 ft bgs; 35 ft of bulk K material
Total Darcy discharge (Q) for 40 ft of PRB (combined clayey sand and bulk average)	1.9E-02 gpm	4 ft^3/d	Per 40 ft of PRB length to depth of 68 ft bgs; 3 ft thickness of higher K material and 32 ft of low K material
Total Darcy discharge (Q) for 40 ft of PRB (bulk average)	1.1E-02 gpm	2.2 ft^3/d	Per 40 ft of PRB length to depth of 60 ft bgs; 35 ft of bulk K material
High average linear velocity (v) = Ki/n_e	**33 ft/yr**	**0.090 ft/d**	**Using sandy clay K**
Low average linear velocity (v) = Ki/n_e	**3.7 ft/yr**	**0.0103 ft/d**	**Using bulk average K**

Reference:

Fetter, C.W. 1980. Applied Hydrogeology. Charles E, Merril Publishing Company, Columbus, Ohio.

Appendix D
Amendment Blending Procedure and Safety Data Sheets

Appendix D
Amendment Blending Procedure and Safety Data Sheets

DoloFines and Sand

This procedure describes the process of blending dolomitic fines (DoloFines) and sand for use in a permeable reactive barrier (PRB). Field modifications are allowable but must be approved prior to implementation by the Owner and CQA Manager.

1. Health and Safety

The Contractor shall develop a Safety Work Package including a Task Hazard Analysis (THA) prior to the start of work. The Work Package must be approved by the Owner. The Safety Data Sheets (SDS) for DoloFines and sand are provided as Attachment I. The SDSs will be available on-site at all times and review of the SDSs by all site workers is required. Both DoloFines and sand have the potential to generate dust. Proper handling and protective equipment to prevent issues related to dust must be specified in the Work Package.

2. Raw Materials Quality Assurance and Storage

The CQA Manager will coordinate sand and DoloFines purchases and review quality assurance data supplied by the vendors for each lot of material. Testing requirements for sand and DoloFines are provided in Attachment II.

An on-site CQA Representative will visually inspect each shipment. Dolofines will arrive in plastic sacks. Material in torn sacks will not be used. Upon receipt on-site, sacks of DoloFines will be further covered in plastic sheeting or stored under cover. Sand will arrive in bulk shipments. Sand deliveries will be inspected for excess organic matter, trash, frozen clumps, or stones obviously in excess of the particle size specifications. Sand saturated with water cannot be used for blending and will be rejected by the CQA Representative. Sand will be stored on plastic sheeting and kept covered except when actively in use.

3. Blending Procedure and Verification Testing

Each batch will be 20 to 30 cubic yards in size (approximately 40 tons). Equipment and materials are as follows:

- **Front end loader with scale.** The Contractor will provide calibration results prior to the start of work and will conduct a verification test on a weekly basis. The scale must have an accuracy of +/- 100 pounds.
- **Excavator with bucket and rake attachments.**
- **Blending Pad.** The blending pad will be approximately 50 feet by 50 feet in size. The blending pad will be a flat area cleared of vegetation and debris that could puncture the liner. The liner will consist of 40-mil LLDPE or two sheets of fiber reinforced 20-mil sheeting. The pad will have an approximately 6-inch perimeter berm. Plastic sheeting and tiedowns will be available at all times to cover the completed batches.
- **Scale for DoloFines.** A digital scale in the range of 50 to 200 pounds will be used. The scale must have an accuracy of +/- 3 pounds.
- **pH testing kit.** This will consist of 16-ounce jars, tap or bottled water, and two pH meters (a primary and a back-up unit).
- **Plastic scoops.**
- **Personnel protective equipment as described in the Work Package.**
- **Sand.** Sand used for blending maybe be damp but cannot be saturated with water. Sand is to be stored covered until ready for use.
- **DoloFines.** DoloFines must be dry and free flowing at the time or use. Large clumps (greater than 1 inch) or paste-like consistency is unacceptable.

The exact blending procedure may be modified as work proceeds. An example process is explained here as a starting point. Table 1 provides the format for documenting each batch of blended material produced. A measured weight of sand will first be placed on the mixing pad. The pile will have a hole dug in the middle. A measure quantity of DoloFines will then be added to the hole by placing the bags, cutting the bags open and then using a rope or chain attached to the excavator bucket to remove the bags (this process reduces potential exposure to dust). The pile is then blended for a period of approximately 15 minutes using the excavator bucket. A subsequent mixing for 5 minutes using a rake attachment is required for the first few batches but may be dropped if it provides no added benefit. The CQA Representative will perform a visual inspection of the pile before mixing is terminated. Mixing will continue until streaks or swirls of DoloFines are no longer visible. Based on observations from the laboratory, thoroughly blended sand will have a lighter appearance compared to unamended sand. It is acceptable to maintain a “working layer” of up to 12 inches of amended sand within the mixing area to facilitate removal of the blended material without tearing the liner.

After blending appears to be completed by visual observation, the CQA Representative will then collect three samples from various points within the blended pile for pH testing. pH testing will be conducted by placing sand to approximately ½ full in a wide mouth 16-ounce jar, adding water to near the top and shaking the mixture for 1 minute. The sand will be allowed to settle for 5 minutes. The pH probe will then be inserted to obtain a reading. The same procedure will be conducted with unamended sand to allow a comparison. All three samples of blended sand must have a pH reading of at least 1 unit higher than the unamended sand for the blend to be considered successful. If one or more samples fail, the batch will be re-blended and retested.

Completed batches will be placed into the PRB as soon as practical (same day). Blending will be conducted on an as needed basis, getting several days ahead is not allowed. Completed batches will be covered in plastic if not used that day or if rain is occurring or predicted.

The CQA Representative and Contractor are encouraged to refine the blending methods or propose and test different methods. If the mixing area or procedure is changed, a revised mixing work package shall be submitted for approval by the CQA Manager and Owner.

Table 1
CQA Tracking Sheet for DoloFines/Sand Blending

Batch #	Date	Weight of Sand (pounds)	Weight of DoloFines (pounds)	Percent DoloFines	Mixing Time (Minutes)	Verification Test Results (pH units)	Approx. Placement Within PRB
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

Attachment I

Safety Data Sheets

Safety Data Sheet

Dolomitic Quicklime

Revision date:
July 11, 2019

1. Identification

Product Name: Dolomitic Quicklime

Synonyms:
Dolime,
Dolo Fines,
Dolopel Fines,
Dolopel,
HD Dolopel
Hi Mag/Dolo Quicklime 12%MgO Blend,
Injectolime™,
Mini Pebble,
Pebble Lime,
Pebble Lime-Large,
Pebble Lime-Rescreened,
Pebble Lime-Small,
Pulverized Lime,
Dolo Quicklime Fines,
Dolomitic Injectolime™,
Dolomitic Quicklime,
Granular Dolime ,

Recommended Uses: Water treatment, steel flux, caustic agent, pH adjustment, acid gas absorption, construction

Manufacturer: Carmeuse Americas

US Office
11 Stanwix Street, 21st Floor
Pittsburgh, PA 15222
Phone: (412) 995-5500
Fax: (412) 995-5594

Canadian Office
PO Box 190
Ingersoll, ON N5C 3K5
Phone: (519) 423-6283
Fax: (519) 423-6545

Emergency Contact: Infotrac: (800) 535-5053 (24 hrs a day, 7 days a week)

2. Hazards Identification

GHS classification

Physical Hazards

None

Health Hazards

Skin Irritation	Category 2
Eye Damage	Category 1
Carcinogenicity	Category 1A
Specific Target Organ Toxicity – Single Exposure	Category 3
Specific Target Organ Toxicity – Repeated Exposure	Category 1

GHS Label Elements:

Signal Word: Danger

Hazard Statements:
Causes skin irritation.
Causes serious eye damage.
May cause respiratory irritation.
May cause cancer through inhalation
Causes damage to lungs through prolonged or repeated exposure by inhalation.

Precautionary Statements:
Obtain special instructions before use.
Do not handle until all safety precautions have been read and understood.
Keep container tightly closed
Do not breathe dust.
Wash thoroughly after handling.
Do not eat, drink or smoke when using this product.
Use only outdoors or in well-ventilated area
Wear protective gloves, clothing and eye protection
Do not use water on material spills.

Pictograms:

3. Composition

Chemical name	% by weight	CAS#
Calcium oxide	> 55	1305-78-8
Magnesium oxide	> 21	1309-48-4
Iron oxide	< 2	1309-37-1
Silica-crystalline quartz	0.1 - 2	14808-60-7

4. First Aid Measures

Eyes: Immediately flush eyes with generous amounts of water for at least 15 minutes. Pull back the eyelid to ensure that all lime dust has been washed out. Seek medical attention immediately. Do not rub eyes.

Skin: Wash exposed area with large amounts of water. Seek medical attention immediately.

Ingestion: Do not induce vomiting. Seek medical attention immediately. Never give anything by mouth unless instructed to do so by medical personnel.

Inhalation: Move victim to fresh air. Seek medical attention if necessary. If breathing has stopped, give artificial respiration

Most Important Symptoms: Irritation of skin, eyes, gastrointestinal tract or respiratory tract.

Immediate medical attention / special treatment? See first aid information above. Note to Physicians: Provide general supportive measures and treat symptomatically.

5. Fire Fighting Measures

Suitable (and unsuitable) fire extinguishing media: Use dry chemical fire extinguisher. Do not use water or halogenated compounds, except that large amounts of water may be used to deluge small quantities of this product.

Specific hazards arising from the product Inhalation, skin or eye contact, can result in serious injury. This product is not combustible or flammable. However, this product reacts with water, and can release heat sufficient to ignite combustible materials. This product is not considered to be an explosion hazard, although reaction with water or other incompatible materials may rupture containers. When this product is wet, it can be very slippery and can result in a slip hazard. Hazardous Combustion Products: None.

Special protective equipment and precautions for fire fighters Wear full fire-fighting turn-out gear (full Bunker gear), and respiratory protection (SCBA) to prevent inhalation, skin or eye contact.

6. Accidental Release Measures

Personal precautions, protective equipment, emergency procedures:

Avoid inhalation, eye and skin contact. Avoid generating airborne dust. Wear appropriate protective clothing as described in section 8.

Methods and materials for containment and clean up:

Utilize cleanup methods that minimize generating dust: vacuum. Avoid dry sweeping. Do not use water on large spills, as this product reacts with water and releases heat. Residue on surfaces may be removed with copious amount of water or vinegar.

7. Handling & Storage

Safe Handling: Avoid inhalation, skin and eye contact. Avoid generating airborne dust. An eye wash station should be readily available when this product is handled.

Safe Storage: Keep in tightly closed containers. Protect containers from physical damage. Store in a cool, dry, and well-ventilated location. Do not store near incompatible materials (see Section 10 below). Keep away from moisture. Long-term storage in aluminum containers is not recommended, as calcium oxide may corrode aluminum over long periods of time

8. Exposure Controls/Personal Protection

Occupational Exposure Limits

	OSHA PEL (mg/m^3)	ACGIH TLV (mg/m^3)	Ont. Reg. 833 TWAEV (mg/m^3)
Calcium oxide	5	2	2
Magnesium oxide	15	10	10
Iron oxide	5 (fume) 15 (total) 5 (respirable)	5	5 (respirable)
Silica, crystalline quartz, cristobalite and tridymite	0.05 (respirable)	0.025 (respirable)	0.1

Engineering Controls: Use with adequate general or local exhaust ventilation and to maintain exposure below occupational exposure limits.

Individual Protection Measures (Personal Protective Equipment):

Specific Eye / Face Protection: Safety glasses with side shields. In windy conditions, or if work activity generates elevated airborne dust levels, dust proof or chemical goggles are recommended. Contact lenses should not be worn.

Specific Skin Protection: When there is a risk of skin contact, wear appropriate clothing and gloves to prevent contact.

Specific Respiratory Protection: If exposure limits are exceeded, an approved particulate respirator, or supplied air respirator, appropriate for the airborne concentrations, should be used. Selection and use of the respiratory protective equipment must be in accordance with applicable regulations and good industrial hygiene practices.

Other: An emergency eye wash fountain and shower are recommended.

9. Physical & Chemical Properties

Appearance: White or grayish white material

Odor: Odorless

Odor threshold: Not Applicable

pH at 25 degrees C: 12.45

Melting Point: 4658 °F (2570 °C)

Boiling Point and range: 5162 °F (2850 °C)

Flash Point: Not Applicable

Evaporation Rate: Not Applicable

Flammability: Not Applicable

Upper/lower flammability or explosive limits	Not Applicable
Vapor pressure/density:	Non Volatile
Relative density:	2.0-2.8
Solubility:	Neglible in water but reacts with water to produce $Ca(OH)_2$ and heat Soluble in acids, glycerin, and sugar solutions
Partition coefficient: n-octanol/water	Not applicable
Auto-ignition temperature:	Not Available
Decomposition temperature:	Not available
Viscosity:	Not Applicable

10. Stability & Reactivity

Reactivity: Reacts with water to form calcium hydroxide, releasing heat. Reacts with acids to form calcium salts, releasing heat. Reacts with carbon dioxide in air to form calcium carbonate. See also Incompatibility below.

Chemical stability: Stable under normal storage and handling conditions.

Possibility of Hazardous Reactions: See "reactivity" above.

Conditions to avoid: Vicinity of incompatible materials.

Incompatibility: This product should not be mixed or stored with the following materials, due to the potential for violent reaction and release of heat:

- water (unless in a controlled process)
- acids
- reactive fluoridated compounds
- reactive brominated compounds
- reactive powdered metals
- reactive phosphorous compounds
- aluminum powder
- organic acid anhydrides
- nitro-organic compounds
- interhalogenated compounds

Hazardous decomposition products: None

11. Toxicological Information

Likely routes of exposure & symptoms:

Eyes: Contact can cause severe irritation or burning of eyes, including permanent damage.

Skin: Contact can cause severe irritation or burning of skin, especially in the presence of moisture.

Ingestion: This product can cause severe irritation or burning of gastrointestinal tract if swallowed.

Inhalation: This product can cause severe irritation of the respiratory system.

Chronic health effects: This product contains trace amounts of crystalline silica. Prolonged or repeated inhalation of respirable crystalline silica can cause silicosis, as serious lung disease.

Respiratory or skin sensitization: This material is not known to cause sensitization

Germ cell mutagenicity: No data available.

Carcinogenicity: This product is not listed as carcinogenic by OSHA, IARC, NTP, ACGIH, or the EU Directives. This product may contain trace amounts of crystalline silica quartz which is listed by IARC as “Carcinogenic to Humans” (Group 1) and “Known to be a Human Carcinogen" by NTP (National Toxicology Program).

Reproductive toxicity: No Data Available.

Numerical Measures of Toxicity: Crystalline Silica: Oral Rate LD_{50} > 22,500 mg/kg

12. Ecological Information

Because of the elevated pH of this product, it might be expected to produce some ecotoxicity upon exposure to certain aquatic organisms and aquatic systems in high concentrations
This material shows no bioaccumulation effect or food chain concentration toxicity.

13. Disposal Considerations

Dispose of contents in accordance with federal, state, provincial and local regulations.

14. Transport Information

UN Number	UN1910
UN Proper shipping name	Calcium Oxide
Transport Hazard class(es)	When transported by air only: Hazard Class 8-Corrosive
Packing group	When transported by air only: Packing Group III
Environmental hazards	This material is alkaline and if released into water or moist soil will cause an increase in pH

Transport in bulk (according to Annex II of MARPOL 73/79 and the IBC Code:

Special precautions which a user needs to be aware of	When being transported by air, quicklime is classified in the Department of Transportation (DOT) regulations as a hazardous material. (49 CFR 172.101). For aircraft transport only, Calcium Oxide is classified as Hazard Class 8-Corrosive, UN1910, Packing Group III. For passenger aircraft, the maximum net quantity allowed per container is 25 kg. For cargo aircraft, the maximum net quantity allowed per container is 100 kg. For quantities greater than 25 kg up to and including 100 kg, the container shall be labeled with CARGO AIRCRAFT ONLY. Because express carriers (i.e., Federal Express, Airborne Express, and United Parcel Service) ship by air, quicklime presented to these carriers for shipment must be packaged, marked, and labeled in accordance with IATA requirements, and must be accompanied by the appropriate shipping documentation. Only personnel trained and certified under applicable DOT Hazardous Materials Regulations (contained in Title 49 of the Code of Federal Regulations) may prepare any quicklime product for air transport. Quicklime is not classified as a hazardous material by DOT when transported by means other than by air.

15. Regulatory Information

CERCLA Hazardous Substances	Not listed
SARA Toxic Chemical (40 CFR 372.65)	Not listed
SARA Section 302 Extremely Hazardous Substances (40 CFR 355)	Not listed
SARA 311/312	Not listed
SARA Section 313 Toxic Chemicals reporting requirements	None
Threshold planning quantity (TPQ)	Not listed
RCRA Hazardous Waste Classification (40 CFR 261)	Not Classified
EPA Toxic Substances Control Act (TSCA) Status	The components of this product are each listed on the TSCA Inventory List in the “active” status.
California Proposition 65	Airborne crystalline silica particulates of respirable size are known to the State of California to cause cancer.
NFPA ratings	Health: 3 Fire: 0 Reactivity: 0 ~~W~~
HMIS Ratings	Health: 3 Fire: 0 Reactivity: 1 Personal protection: E
OSHA Specifically regulated substance (29 CFR 1910)	Not listed
OSHA Air contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)	Listed
MSHA	Not listed
Canada DSL	Listed
Canadian WHMIS Classification	D2A, Materials Causing other toxic effects. E, Corrosive Material

Canada CPR	This product has been classified in accordance with the hazard criteria of the Controlled Products Regulation of a Canada and this SDS contains all the required information.

16. Other Information

List of GHS Hazard Statements:	H315: Causes skin irritation H318: Causes serious eye damage H335: May cause respiratory irritation. H350: May cause cancer through inhalation H372: Causes damage to lungs through prolonged or repeated exposure by inhalation.
List of GHS Precautionary Statements:	P201: Obtain special instructions before use. P202: Do not handle until all safety precautions have been read and understood. P233: Keep container tightly closed P260: Do not breathe dust. P264: Wash thoroughly after handling. P270: Do not eat, drink or smoke when using this product. P271: Use only outdoors or in well-ventilated area P280: Wear protective gloves, clothing and eye protection

Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation and Liability Act	RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act	IARC	International Agency for Research on Cancer
NTP	National Toxicology Program		

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SAFETY DATA SHEET

Effective Date: 04/09/2019
Replaces: 11/01/2016

Natural Sand and Gravel

1. Identification

Product name:
Natural Sand and Gravel

Other means of identification/Synonyms/Common Names:
Construction Aggregate

Recommended use:
Natural sand and gravel is used as a construction material.
NATURAL SAND AND GRAVEL MUST NOT BE USED AS AN ABRASIVE BLASTING AGENT.

Recommended restrictions:
None Known

Manufacturer/Contact info:	**General Phone Number:**
Pine Bluff Materials Co. 1030 Visco Drive Nashville, TN 37210	1-615-254-1956
	Emergency Phone Number (24 hours/day, 7 days/week): US & Canada: 1-800-451-8346 / Contract #16839 Outside US & Canada: +1-760-602-8703
	Website: www.pbmat.com

2. Hazard(s) Identification

Physical hazard classifications:	**Health hazard classifications:**
Not Classified	Carcinogenicity-Category 1A Specific target organ toxicity, repeated exposure- Category 2

Signal word:

Danger

Hazard statement:
May Cause Cancer (Inhalation).
Causes damage to organs (lungs, respiratory system) through prolonged or repeated exposure (inhalation)

Precautionary statement:

Prevention

- Obtain special instructions before use.
- Do not handle until all safety precautions have been read and understood.
- Do not breathe dust.
- Use personal protective equipment as required. Wear protective gloves, protective clothing, eye protection, and face protection.
- Wash hands thoroughly after handling.
- Do not eat, drink or smoke when using this product.

Response

- If exposed or concerned get medical advice/attention.

Disposal

- Dispose of contents/container in accordance with all local, regional, national, and international regulations.

Hazards Not Otherwise Classified:
None Known
Supplemental information:
Respirable Crystalline Silica (RCS) may cause cancer. Natural sand and gravel is a naturally occurring mineral complex that contains varying quantities of quartz (crystalline silica). Natural sand and gravel may be subjected to various natural or mechanical forces that produce small particles (dust) which may contain respirable crystalline silica (particles less than 10 micrometers in aerodynamic diameter). Repeated inhalation of respirable crystalline silica (quartz) may cause lung cancer according to IARC, NTP; ACGIH states that it is a suspected cause of cancer. Other forms of RCS (e.g., tridymite and cristobalite) may also be present or formed under certain industrial processes.

3. Composition/information on ingredients

Chemical name	CAS number	%
Natural Sand and Gravel	None	100
Quartz (crystalline silica	14808-60-7	>1

4. First-aid measures

Inhalation:

Remove to fresh air. Dust in throat and nasal passages should clear spontaneously. Contact a physician if irritation persists or if breathing is difficult.

Eyes:

Immediately flush eye(s) with plenty of clean water for at least 15 minutes, while holding the eyelid(s) open. Occasionally lift the eyelid(s) to ensure thorough rinsing. Beyond flushing, do not attempt to remove material from eye(s). Contact a physician if irritation persists or later develops.

Skin:

Wash affected areas thoroughly with mild soap and fresh water. Contact a physician if irritation persists.

Ingestion:

If person is conscious do not induce vomiting. Give large quantity of water and get medical attention. Never attempt to make an unconscious person drink.

Most important symptoms/effects, acute and delayed:

Dust may irritate the eyes, skin, and respiratory tract. Breathing silica-containing dust for prolonged periods in the workplace can cause lung damage and a lung disease called silicosis. Symptoms of silicosis may include (but are not limited to) shortness of breath, difficulty breathing with or without exertion; coughing; diminished work capacity; diminished chest expansion; reduction of lung volume; right heart enlargement and/or failure.

Indication of immediate medical attention and special treatment needed:

Not all individuals with silicosis will exhibit symptoms of the disease. However, silicosis can be progressive, and symptoms can appear at any time, even years after exposures have ceased. Persons with silicosis have an increased risk of pulmonary tuberculosis infection.

For emergencies contact (24 hours/day, 7 days/week):

US & Canada: 1-800-451-8346 / Contract #16839
Outside US & Canada: +1-760-602-8703

5. Fire-fighting measures

Suitable extinguishing media:

This product is not flammable. Use fire-extinguishing media appropriate for surrounding materials.

Unsuitable extinguishing media:

None known

Specific hazards arising from the chemical:

Contact with powerful oxidizing agents may cause fire and/or explosions (see section 10 of SDS).

Special protective equipment and precautions for firefighters:

Use protective equipment appropriate for surrounding materials.

Fire-fighting equipment/instructions:

No unusual fire or explosion hazards noted. Not a combustible dust.

Specific methods:

The presence of this material in a fire does not hinder the use of any standard extinguishing medium. Use extinguishing medium for surrounding fire.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures:

Persons involved in cleanup processes should first observe precautions (as appropriate) identified in Section 8 of this SDS.

For emergencies contact (24 hours/day, 7 days/week):

US & Canada: 1-800-451-8346 / Contract #16839

Outside US & Canada: +1-760-602-8703

Environmental precautions:

Prevent from entering into sewers or drainage systems where it can harden and clog flow.

Methods and materials for containment and cleaning up:

Spilled material, where dust is generated, may overexpose cleanup personnel to respirable crystalline silica-containing dust. Do not dry sweep or use compressed air for clean-up. Wetting of spilled material and/or use of respiratory protective equipment may be necessary.

7. Handling and storage

Precautions for safe handling:

Respirable crystalline silica-containing dust may be generated during processing, handling, and storage. Use personal protection and controls identified in Section 8 of this MSDS as appropriate.

Conditions for safe storage, including any incompatibilities:

Do not store near food, beverages, or smoking materials.

8. Exposure controls/personal protection

Legend:

NE = Not Established; PEL = Permissible Exposure Limit; TLV = Threshold Limit Value; REL = Recommended Exposure Limit; STEL= Short Term Exposure Limit; OSHA = Occupational Safety and Health Administration; MSHA = Mine Safety and Health Administration; NIOSH = National Institute for Occupational Safety and Health; ACGIH = American Conference of Governmental Industrial Hygienists; AL=Action Level.

Component	OSHA/MSHA PEL	ACGIH TLV	NIOSH REL
Particulates not otherwise classified	15 mg/m^3 (total dust) 5 mg/m^3 (respirable fraction)	10 mg/m^3 (inhalable fraction) 3 mg/m^3 (respirable fraction)	NE
Respirable dust containing silica	OSHA: Use Respirable Crystalline Silica PEL MSHA: 10 mg/m^3 ÷ (% silica + 2)	Use Respirable Silica TLV	Use Respirable Silica REL
Total dust containing silica	OSHA: NE MSHA: 30 mg/m^3 ÷ (% silica + 3)	NE	NE
Respirable Crystalline Silica (quartz)	OSHA:0.05 mg/m^3 (0.025mg/m^3 AL) MSHA 10 mg/m^3 ÷ (% silica + 2)	0.025 mg/m^3	0.05 mg/m^3
Respirable Tridymite and Cristobalite (other forms of crystalline silica)	OSHA: Use PEL for Respirable Crystalline Silica MSHA: Use ½ of respirable dust containing silica PEL	0.025 mg/m^3	0.05 mg/m^3

Exposure Guidelines:

Respirable dust and quartz levels should be monitored regularly to determine worker exposure levels. Exposure levels in excess of allowable exposure limits should be reduced by all feasible engineering controls, including (but not limited to) wet suppression, ventilation, process enclosure, and enclosed employee workstations.

Engineering Controls:

Activities that generate dust require the use of general ventilation, local exhaust and/or wet suppression methods to maintain exposures below allowable exposure limits.

Eye Protection:

Safety glasses with side shields should be worn as minimum protection. Dust goggles should be worn when excessively (visible) dusty conditions are present or are anticipated.

Skin Protection (Protective Gloves/Clothing):

Use gloves to provide hand protection from abrasion. In dusty conditions, use long sleeve shirts. Wash work clothes after each use.

Respiratory Protection:

All respirators must be NIOSH-approved for the exposure levels present. (See NIOSH Respirator Selection Guide).
The need for respiratory protection should be evaluated by a qualified safety and health professional. Activities that generate dust require the use of an appropriate dust respirator where dust levels exceed or are likely to exceed allowable exposure limits. For respirable silica levels that exceed or are likely to exceed an 8 hr. Time Weighted Average (TWA) of 0.25 mg/m^3, a high efficiency particulate filter respirator must be worn at a minimum; however, if respirable silica levels exceed or are likely to exceed an 8 hr. TWA of 1.25 mg/m^3 a positive pressure, full face respirator or equivalent is required. Respirator use must comply with applicable MSHA (42 CFR 84) or OSHA (29 CFR 1910.134) standards, which include provisions for a user training program, respirator inspection, repair and cleaning, respirator fit testing, medical surveillance and other requirements.

9. Physical and chemical properties

Appearance:

Gray or white solid in size from powder to boulders

Odor: No odor.	**PH:** Not applicable	**Decomposition temperature:** Not applicable
Melting point/freezing point: Not applicable	**Initial boiling point and boiling range:** Not applicable	**Flash point:** Non-combustible
Evaporation rate: Not applicable	**Flammability:** Not applicable	**Upper/lower flammability or explosive limits:** Not applicable
Vapor pressure: Not applicable	**Relative density:** Not applicable	**Solubility:** **0**
Partition coefficient: n-octanol/water. Not applicable	**Autoignition temperature:** Not applicable	

10. Stability and reactivity

Reactivity:

Not reactive under normal use.

Chemical stability:

Stable under normal temperatures and pressures.

Possibility of hazardous reactions:

None under normal use.

Conditions to avoid (e.g., static discharge, shock or vibration):

Contact with incompatible materials should be avoided (see below). See Sections 5 and 7 for additional information.

Incompatible materials:

Silica ignites on contact with fluorine and is incompatible with acids, aluminum, ammonium salts and magnesium.
Silica reacts violently with powerful oxidizing agents such as fluorine, boron trifluoride, chlorine trifluoride, manganese trifluoride, and oxygen difluoride yielding possible fire and/or explosions. Silica dissolves readily in hydrofluoric acid producing a corrosive gas – silicon tetrafluoride.

Hazardous decomposition products:

Silica-containing respirable dust particles may be generated. When heated, quartz is slowly transformed into tridymite (above 860°C/1580°F) and cristobalite (above 1470°C/2678°F). Both tridymite and cristobalite are other forms of crystalline silica.

11. Toxicological information

Primary Routes of Exposure:

Inhalation and contact with the eyes and skin.

Symptoms related to the physical, chemical, toxicological characteristics:

Inhalation:

Dusts may irritate the nose, throat and respiratory tract by mechanical abrasion. Coughing sneezing and shortness of breath may occur.

Symptoms of silicosis caused by chronic exposure to dust may include (but are not limited to) shortness of breath, difficulty breathing with or without exertion; coughing; diminished work capacity; diminished chest expansion; reduction of lung volume; right heart enlargement and/or failure. Persons with silicosis have an increased risk of pulmonary tuberculosis infection.

Eye Contact:

Dust particles can scratch the eye causing tearing, redness, a stinging or burning feeling, or swelling of the eyes with blurred vision.

Skin Contact:

Dust particles can scratch and irritate the skin with redness, an itching or burning feeling, swelling of the skin, and/or rash.

Ingestion:

Expected to be practically non-toxic. Ingestion of large amounts may cause gastrointestinal irritation including nausea, vomiting, diarrhea, and blockage.

Delayed and immediate effects and chronic effects from short- and long-term exposure:

Prolonged overexposure to respirable dusts in excess of allowable exposure limits can cause inflammation of the lungs leading to possible fibrotic changes, a medical condition known as pneumoconiosis. Smoking tobacco will impair the ability of the lungs to clear themselves of dust. Prolonged and repeated inhalation of respirable crystalline silica-containing dust in excess of allowable exposure limits may cause a chronic form of silicosis, an incurable lung disease that may result in permanent lung damage or death. Chronic silicosis generally occurs after 10 years or more of overexposure; a more accelerated type of silicosis may occur between 5 and 10 years of higher levels of exposure. In early stages of silicosis, not all individuals will exhibit symptoms (signs) of the disease. However, silicosis can be progressive, and symptoms can appear at any time, even years after exposure has ceased.

Repeated overexposures to very high levels of respirable crystalline silica for periods as short as six months may cause acute silicosis. Acute silicosis is a rapidly progressive, incurable lung disease that is typically fatal. Symptoms include (but are not limited to): shortness of breath, cough, fever, weight loss, and chest pain.

Respirable dust containing newly broken silica particles has been shown to be more hazardous to animals in laboratory tests than respirable dust containing older silica particles of similar size. Respirable silica particles which had aged for sixty days or more showed less lung injury in animals than equal exposures of respirable dust containing newly broken particles of silica.

There are reports in the literature suggesting that excessive crystalline silica exposure may be associated with autoimmune disorders and other adverse health effects involving the kidney. In particular, the incidence of scleroderma (thickening of the skin caused by swelling and thickening of fibrous tissue) appears to be higher in silicotic individuals. To date, the evidence does not conclusively determine a causal relationship between silica exposure and these adverse health effects.

Carcinogenicity:

Epidemiology studies on the association between crystalline silica exposure and lung cancer have had both positive and negative results. There is some speculation that the source and type of crystalline silica may play a role. Studies of persons with silicosis indicate an increased risk of developing lung cancer, a risk that increases with the level and duration of exposure. It is not clear whether lung cancer develops in non-silicotic patients. Several studies of silicotics do not account for lung cancer confounders, especially smoking, which have been shown to increase the risk of developing lung disorders, including emphysema and lung cancer.

In October 1996, an IARC Working Group designated respirable crystalline silica as carcinogenic (Group 1). In 2012, an IARC Working Group re-affirmed that inhalation of crystalline silica was a known human carcinogen. The NTP's Report on Carcinogens, 9th edition, lists respirable crystalline silica as a "known human carcinogen." In the year 2000, the American Conference of Governmental Industrial Hygienists (ACGIH) listed respirable crystalline silica (quartz) as a suspected human carcinogen (A-2). These classifications are based on sufficient evidence of carcinogenicity in certain experimental animals and on selected epidemiological studies of workers exposed to crystalline silica.

Additional toxicological information:

No specific data on product. Classification is based on components or similar materials.
Acute toxicity: Not classified
Skin corrosion/irritation: Not classified
Serious eye damage/eye irritation: Not classified
Respiratory sensitization: Not classified
Skin sensitization: Not classified
Germ cell Mutagenicity: Not classified
Carcinogenicity: May cause cancer (Inhalation).
Reproductive toxicity: Not classified
Specific target organ toxicity - single exposure: Not classified
Specific target organ- toxicity – repeated exposure: Causes damage to organs (lungs, respiratory system) through prolonged or repeated exposure (inhalation)
Aspiration toxicity: Not classified (not applicable- solid material)

12. Ecological information

Ecotoxicity (aquatic and terrestrial, where available):
Not applicable

Persistence and degradability:
Not applicable

Bioaccumulative potential.
Not applicable

Mobility in soil.
Not applicable

Other adverse effects.
Not applicable

13. Disposal considerations

Safe handling and disposal of waste:
Place contaminated materials in appropriate containers and dispose of in a manner consistent with applicable federal, state, and local regulations. Prevent from entering drainage, sewer systems, and unintended bodies of water. It is the responsibility of the user to determine, at the time of disposal, whether product meets criteria for hazardous waste. Product uses, transformations, mixture and processes, may render the resulting material hazardous.

14. Transport information

UN Number:
Not regulated

UN Proper shipping name:
Not regulated

Transport Hazard class:
Not applicable

Packing group, if applicable:
Not applicable

Marine pollutant (Yes/No):
Not applicable

15. Regulatory information

Toxic Substances Control Act (TSCA):
The components in this product are listed on the TSCA Inventory or are exempt.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA):
Releases of this material to air, land, or water are not reportable to the National Response Center under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or to state and local emergency planning committees under the Superfund Amendments and Reauthorization Act.

Superfund Amendments and Reauthorization Act of 1986 (SARA), Title III:
Section 302 extremely hazardous substances: None

Section 311/312 hazard categories: Delayed Health Section 313 reportable ingredients at or above de minimis concentrations: None
California Proposition 65: This product contains a chemical (crystalline silica) known to the State of California to cause cancer.
State Regulatory Lists: Each state may promulgate standards more stringent than the federal government. This section cannot encompass an inclusive list or all state regulations. Therefore, the user should review the components listed in Section 2 and consult state or local authorities for specific regulations that apply.

16. Other information

Disclaimer

NO WARRANTY IS MADE, EXPRESS OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR OTHERWISE.

Pine Bluff Materials Company and its subsidiaries and affiliates ("PBM") believe the information contained herein is accurate; however, PBM makes no guarantees with respect to such accuracy and assumes no liability whatsoever in connection with the use of any information contained herein by any party. The provision of the information contained herein is not intended to be, and should not be construed as, legal advice or as ensuring compliance with any federal, state, or local laws, rules or regulations. Any party using any information contained herein should review all applicable laws, rules and regulations prior to use.

Issue date: 01-November-2016
Revision date: 09-April-2019

Pine Bluff Materials Co.
1030 Visco Drive
Nashville, TN 37210

Attachment II

Sand Specifications

MECHANICAL ANALYSIS DATA

Sieve	2015 % average passing	Concrete Material Spec	ASTM C33 Fine Aggregate Spec	SD DOT FA Spec
3/8"	100	100	100	100
#4	98	95-100	95-100	95-100
#8	86	80-100	80-100	
#10			50-85	45-85
#16	67	50-85	50-85	45-85
#30	43	25-60	25-60	
#40	27		50-85	45-85
#50	15	10-30	5-30	10-30
#100	2.6	2-10	0-10	2-10
#200	1.1	0-2		
FM	2.99			
SHALE	0.1			

PHYSICAL PROPERTIES

	Result	ASTM C33 Fine Aggregate	SD DOT Specification Sec. 800.2
Bulk Specific Gravity (ASTM C127)	2.609	N/A	N/A
Absorption (%) (ASTM C127)	1.2	N/A	N/A
Sodium Soundness Loss (SD 220Q, ASTM C 88) + #4	1.6	10% max	10% max
Bulk Unit Weight (pcf)	100.0	N/A	N/A
LA Abrasion Loss (SD 221@Q, ASTM C131) Grading B		50% max	N/A
Lightweight Particles (coal & lignite) (Sp. Gr. Under 2.00, ASTM: C 123)	0.2%	1.0% max	1.0% max

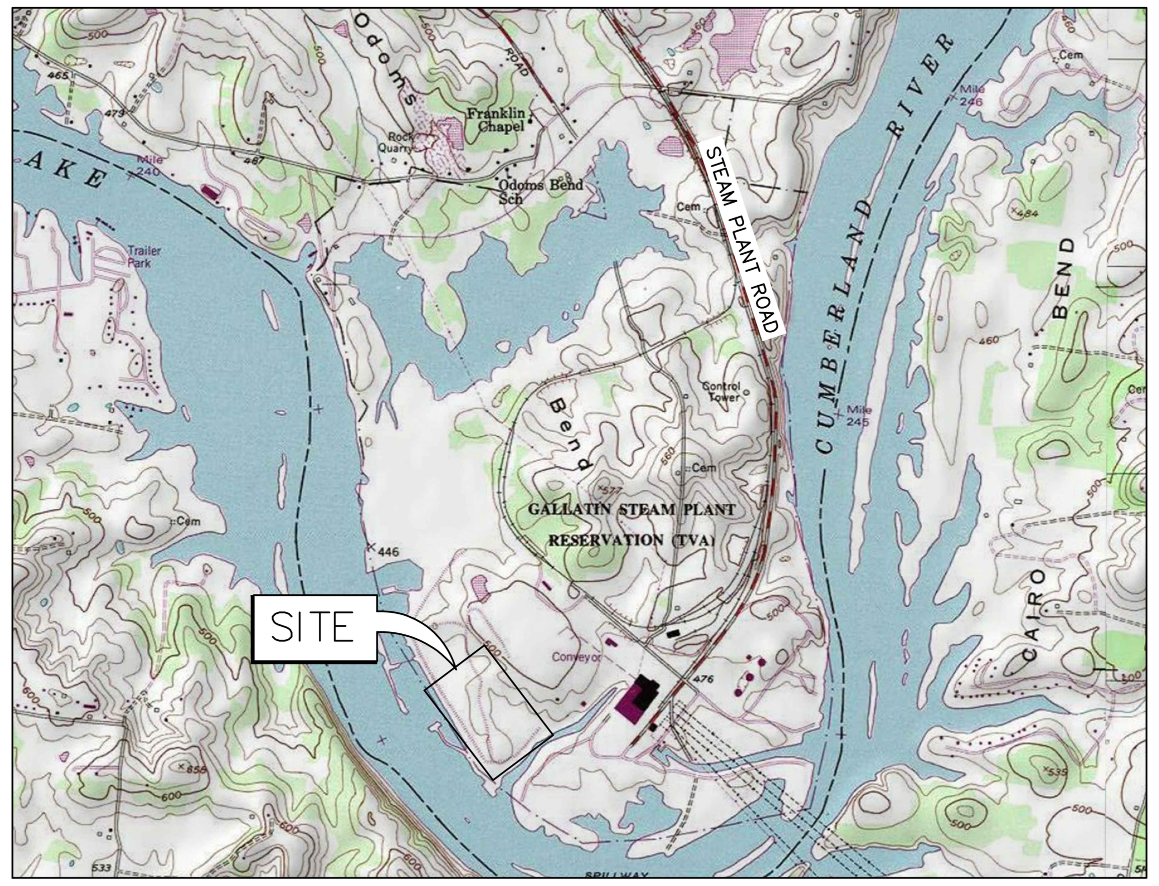
DoloFines Specifications

The DoloFines are to be purchased from Longview Quarry.

Appendix E
PRB Field Demonstration Engineering Drawings

TENNESSEE VALLEY AUTHORITY
GALLATIN FOSSIL PLANT
NRS REACTIVE BARRIER WALL
FIELD DEMONSTRATION

SUMNER COUNTY, TENNESSEE
MAY 25, 2021



SITE VICINITY MAP

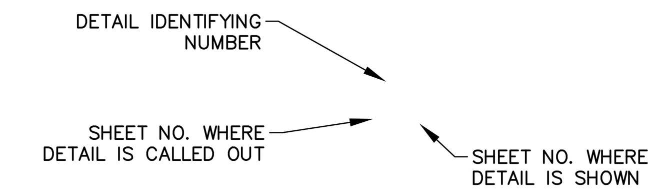
2000 0 2000 4000
SCALE FEET

N

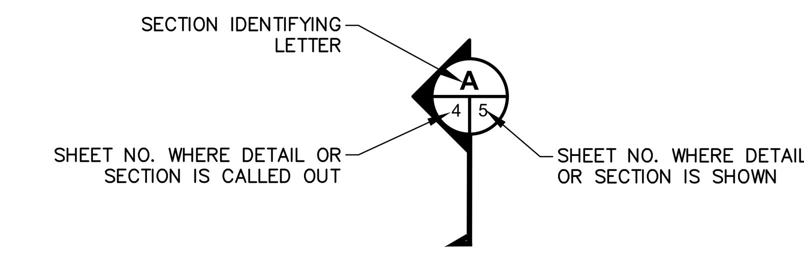
DRAWING INDEX

SHEET NUMBER	SHEET TITLE
10W361-01	TITLE SHEET
10W361-02	EXISTING SITE PLAN
10W361-03	SITE ACCESS, MIXING, & LAYDOWN AREAS
10W361-04	PERMEABLE REACTIVE BARRIER WALL LOCATION
10W361-05	PROPOSED PERFORMANCE MONITORING WELLS
10W361-06	CROSS-SECTION A-A'
10W361-07	CROSS-SECTION B-B'
10W361-08	MONITORING WELL DETAILS
10W361-09	DETAILS

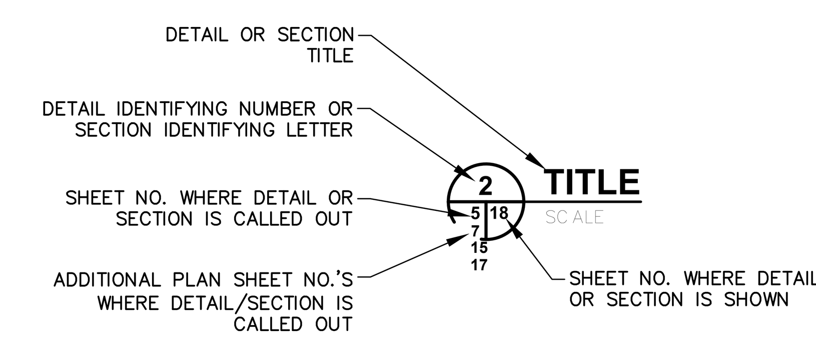
Tennessee811
Know what's below. Call before you dig.
PROVIDE 3 WORKING DAYS NOTICE



DETAIL REFERENCE ON SHEET WHERE DETAIL IS CALLED OUT



SECTION REFERENCE ON SHEET WHERE SECTION IS CALLED OUT



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

TVA

PREPARED FOR:

TENNESSEE VALLEY AUTHORITY
1101 MARKET STREET
CHATTANOOGA, TN 37402

PREPARED BY:

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

FOR PERMITTING PURPOSES ONLY

AECOM

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R											
R 0	5/25/21	MDW	MDW	DES	GWL	–	–	TVA	XXXXXX		E

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DISCIPLINE INTERFACE

SCALE: AS SHOWN EXCEPT AS NOTED

TITLE SHEET

GALLATIN FOSSIL PLANT
NRS REACTIVE BARRIER WALL
FIELD DEMONSTRATION

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
MDW	MDW	DES	GWL	–	–	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 5/25/21 | 39 | C | 10W361– 01 | R 0

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

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0 100 200 400
(IN FEET)

LEGEND

- 460 EXISTING MAJOR
- 462 EXISTING MINOR
- CUMBERLAND RIVER
- TVA PROPERTY LINE
- TREELINE
- GRAVEL ROAD

NOTES:

1. TOPOGRAPHIC SURVEY OF THE SITE IS BASED ON DATA OBTAINED BY TVA SURVEYING ON MAY 30, 2019. HORIZONTAL DATUM IS TVA NAD27 LOCAL GRID. VERTICAL DATUM IS NGVD29.

FOR PERMITTING PURPOSES ONLY

DAVID ERIC SKEGGS
REGISTERED ENGINEER
AGRICULTURE COMMERCE
No. 124294
STATE OF TENNESSEE
5-25-21

AECOM

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST
R 0	5/25/21	MDW	MDW	DES	GWL	–	–	TVA	XXXXXX	
FOR PERMITTING PURPOSES ONLY										

SCALE: AS SHOWN EXCEPT AS NOTED

EXISTING SITE PLAN

GALLATIN FOSSIL PLANT
NRS REACTIVE BARRIER WALL
FIELD DEMONSTRATION

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
MDW	MDW	DES	GWL	–	–	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 5/25/21 | 39 | C | 10W361-02 | R 0

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PLOT FACTOR:XX
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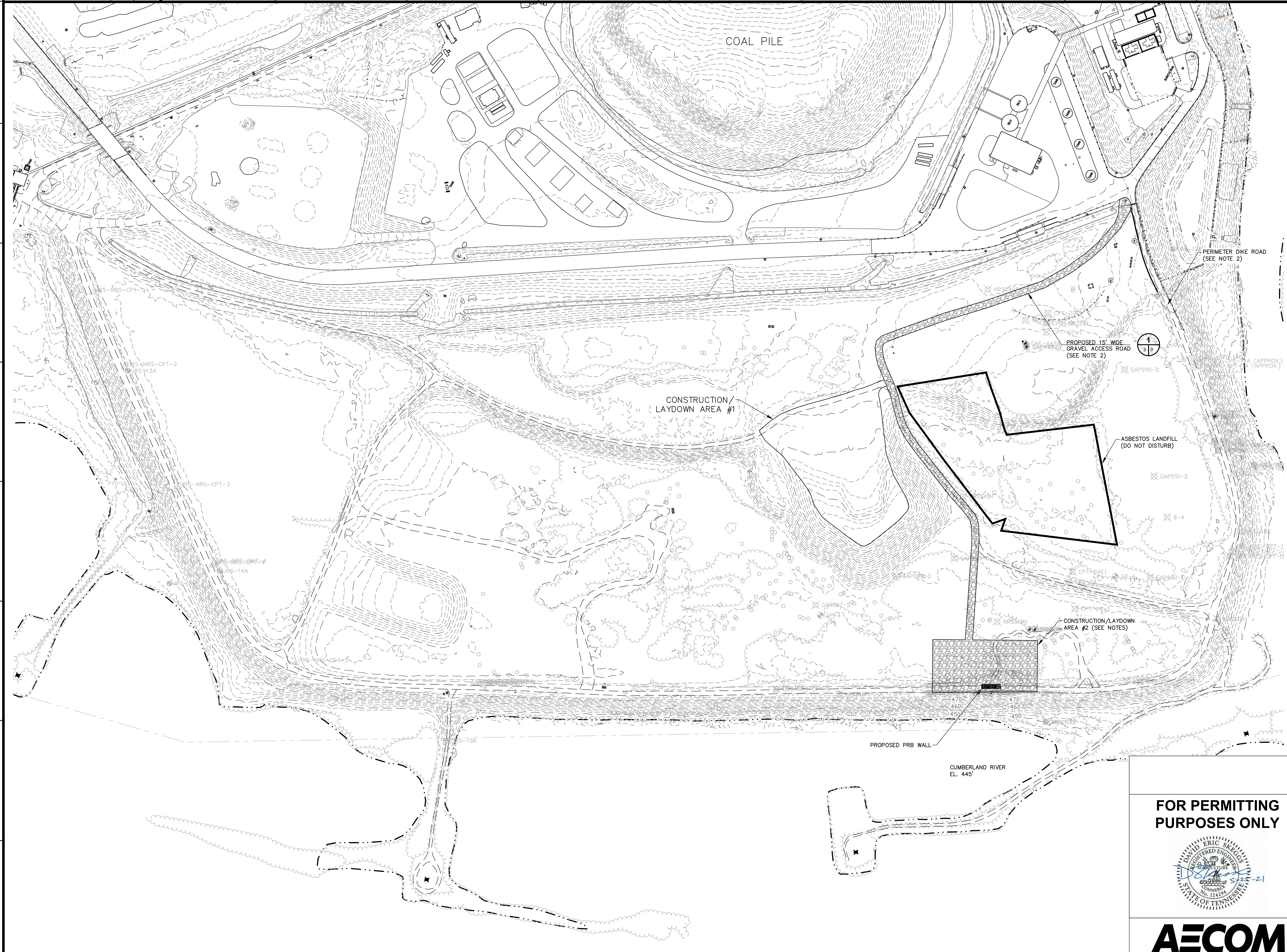

NOTES:

1. TOPOGRAPHIC SURVEY OF THE SITE IS BASED ON DATA OBTAINED BY TVA SURVEYING ON MAY 30, 2019. HORIZONTAL DATUM IS TVA NAD27 LOCAL GRID. VERTICAL DATUM IS NGVD29.
2. EQUIPMENT SHALL NOT TRAVERSE THE PERIMETER DIKE OF THE NRS. THEREFORE, THE GRAVEL ACCESS ROAD SHOWN IS PROPOSED TO PROVIDE EQUIPMENT ACCESS TO THE CONSTRUCTION AREA.
3. CONSTRUCTION/LAYDOWN AREA #1 IS A SOIL STOCKPILE. THIS AREA MAY BE USED FOR SAND MIXING AND/OR STAGING OF MATERIALS. SOIL FROM THIS AREA MAY BE USED DURING CONSTRUCTION. THE CONTRACTOR MUST MAINTAIN LESS THAN 1–ACRE OF SOIL DISTURBANCE DURING CONSTRUCTION AT ALL TIMES.
4. CONSTRUCTION/LAYDOWN AREA #2 CONTAINS A CCR SUBGRADE WITH 1–FOOT OF SOIL COVER. THE CONTRACTOR SHALL PROPOSE IMPROVEMENTS TO THIS AREA TO PROVIDE AN ADEQUATE SUBGRADE FOR EQUIPMENT AND MATERIALS AS NEEDED. TREE CLEARING HAS BEEN PERFORMED WITHIN THIS AREA PRIOR TO CONSTRUCTION OF THE PRB. MULCH REMAINING FROM TREE CLEARING MUST REMAIN WITHIN THE AREA.

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
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FOR PERMITTING PURPOSES ONLY											

DISCIPLINE INTERFACE 1 2 3 4

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DAVID ERIC SKEGGS REGISTERED ENGINEER AGRICULTURE COMMERCE No. 124294 STATE OF TENNESSEE

5-25-21

AECOM

SCALE: AS SHOWN EXCEPT AS NOTED

SITE ACCESS, MIXING, & LAYDOWN AREAS

GALLATIN FOSSIL PLANT NRS REACTIVE BARRIER WALL FIELD DEMONSTRATION

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
MDW	MDW	DES	GWL	–	–	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 5/25/21 | 39 | C | 10W361–03 | R 0

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PLOT FACTOR:XX
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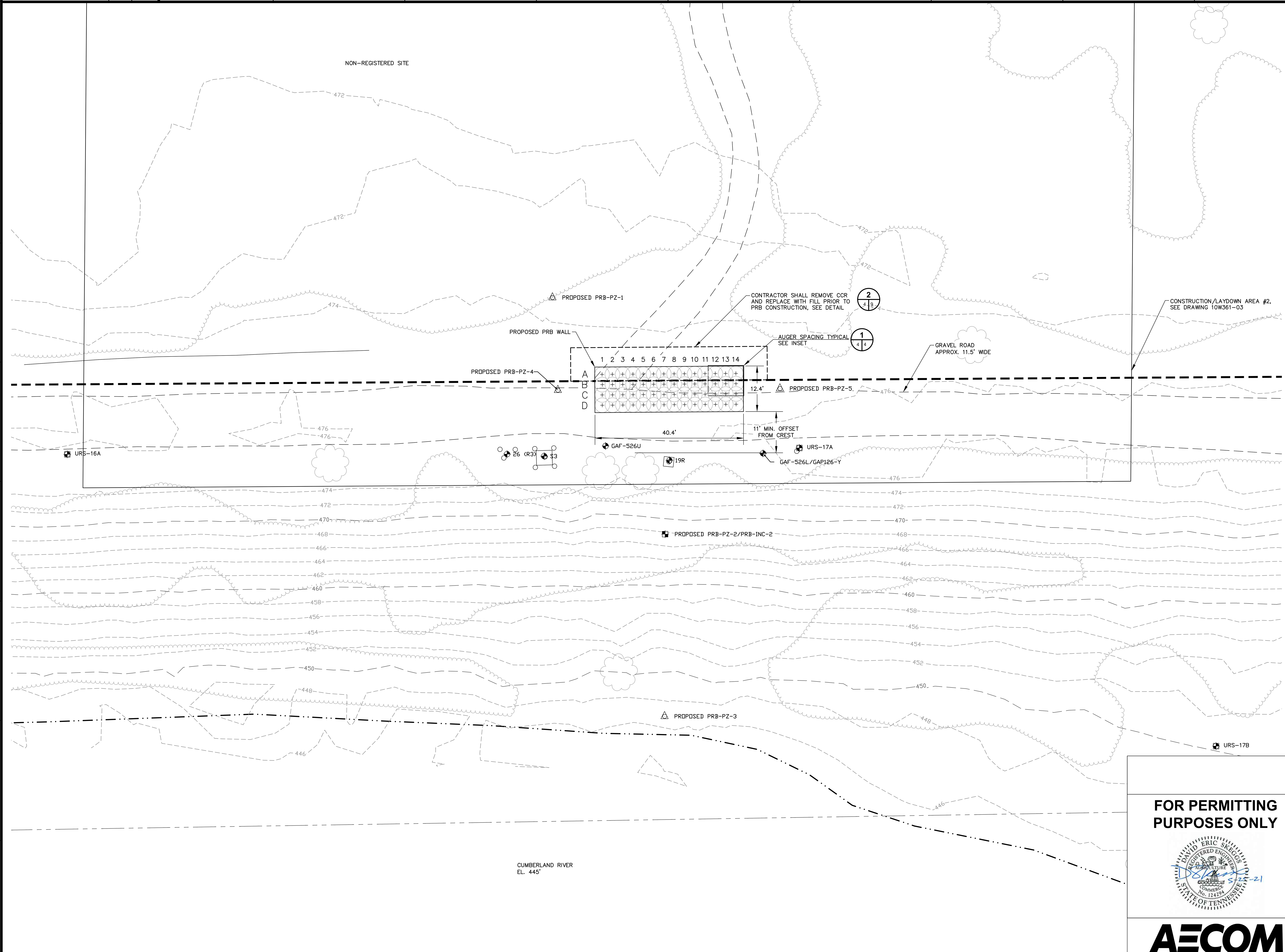


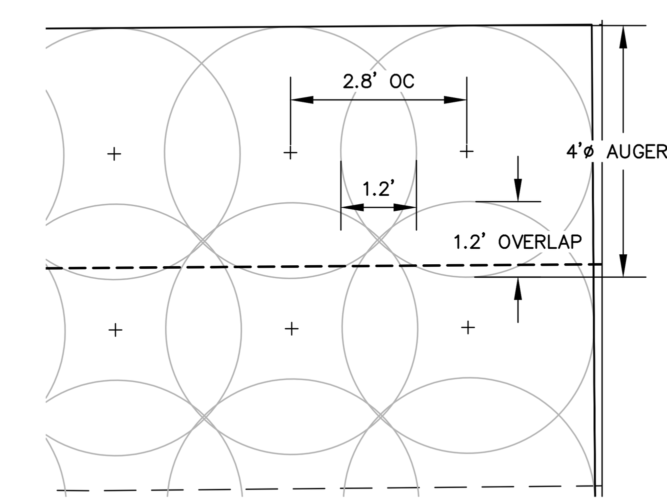
LEGEND

460	EXISTING MAJOR
462	EXISTING MINOR
	CUMBERLAND RIVER
	TVA PROPERTY LINE
	TREELINE
	GRAVEL ROAD
	NRS WASTE BOUNDARY
	4' DIA. AUGER LOCATION
	MONITORING WELL LOCATIONS
	EXISTING PIEZOMETER LOCATIONS
	PROPOSED PIEZOMETER LOCATIONS
	PROPOSED PIEZOMETER/INCLINOMETER LOCATIONS
	CCR REMOVAL AREA

0 5 10 20 (IN FEET)

AUGER LOCATIONS

POINT #	NORTHING	EASTING	POINT #	NORTHING	EASTING
A1	699789.042	1879366.630	C1	699786.166	1879361.825
A2	699786.640	1879368.068	C2	699783.763	1879363.263
A3	699784.237	1879369.506	C3	699781.361	1879364.701
A4	699781.835	1879370.944	C4	699778.958	1879366.139
A5	699779.432	1879372.382	C5	699776.556	1879367.578
A6	699777.030	1879373.821	C6	699774.154	1879369.016
A7	699774.628	1879375.259	C7	699771.751	1879370.454
A8	699772.225	1879376.697	C8	699769.349	1879371.892
A9	699767.420	1879379.573	C9	699766.946	1879373.330
A10	699765.018	1879381.012	C10	699764.544	1879374.769
A11	699769.823	1879378.135	C11	699762.142	1879376.207
A12	699762.616	1879382.450	C12	699759.739	1879377.645
A13	699760.213	1879383.888	C13	699757.337	1879379.083
A14	699757.811	1879385.326	C14	699754.934	1879380.522
B1	699787.560	1879364.253	D1	699784.727	1879359.422
B2	699785.201	1879365.665	D2	699782.325	1879360.861
B3	699782.799	1879367.104	D3	699779.923	1879362.299
B4	699780.397	1879368.542	D4	699777.520	1879363.737
B5	699777.994	1879369.980	D5	699775.118	1879365.175
B6	699775.592	1879371.418	D6	699772.715	1879366.613
B7	699773.189	1879372.856	D7	699770.313	1879368.052
B8	699770.787	1879374.295	D8	699767.911	1879369.490
B9	699768.385	1879375.733	D9	699765.508	1879370.928
B10	699765.982	1879377.171	D10	699763.106	1879372.366
B11	699763.580	1879378.609	D11	699760.703	1879373.804
B12	699761.177	1879380.048	D12	699758.301	1879375.243
B13	699758.775	1879381.486	D13	699755.899	1879376.681
B14	699756.373	1879382.924	D14	699753.496	1879378.119



AUGER SPACING (TYP)
SCALE: 1"=2'

NOTES:

1. TOPOGRAPHIC SURVEY OF THE SITE IS BASED ON DATA OBTAINED BY TVA SURVEYING ON MAY 30, 2019. HORIZONTAL DATUM IS TVA NAD27 LOCAL GRID. VERTICAL DATUM IS NGVD29.
2. THE PROPOSED PIEZOMETERS SHOWN ARE TO BE INSTALLED PRIOR TO CONSTRUCTION AND MONITORED IN ACCORDANCE WITH THE PROJECT SURVEILLANCE AND INSTRUMENTATION MONITORING PLAN (SIMP) DURING CONSTRUCTION.

FOR PERMITTING PURPOSES ONLY

DAVID ERIC SKEGGS, REGISTERED ENGINEER, AGRICULTURE COMMERCE, No. 124294, STATE OF TENNESSEE

5-25-21

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DISCIPLINE INTERFACE

SCALE: AS SHOWN EXCEPT AS NOTED

PERMEABLE REACTIVE BARRIER WALL LOCATION

GALLATIN FOSSIL PLANT NRS REACTIVE BARRIER WALL FIELD DEMONSTRATION

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
MDW	MDW	DES	GWL	–	–	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 DATE 5/25/21 39 C 10W361–04 R 0

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TASK COMPLETED BY:	REV NO.

PLOT FACTOR:XX
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39 C 10W361–04

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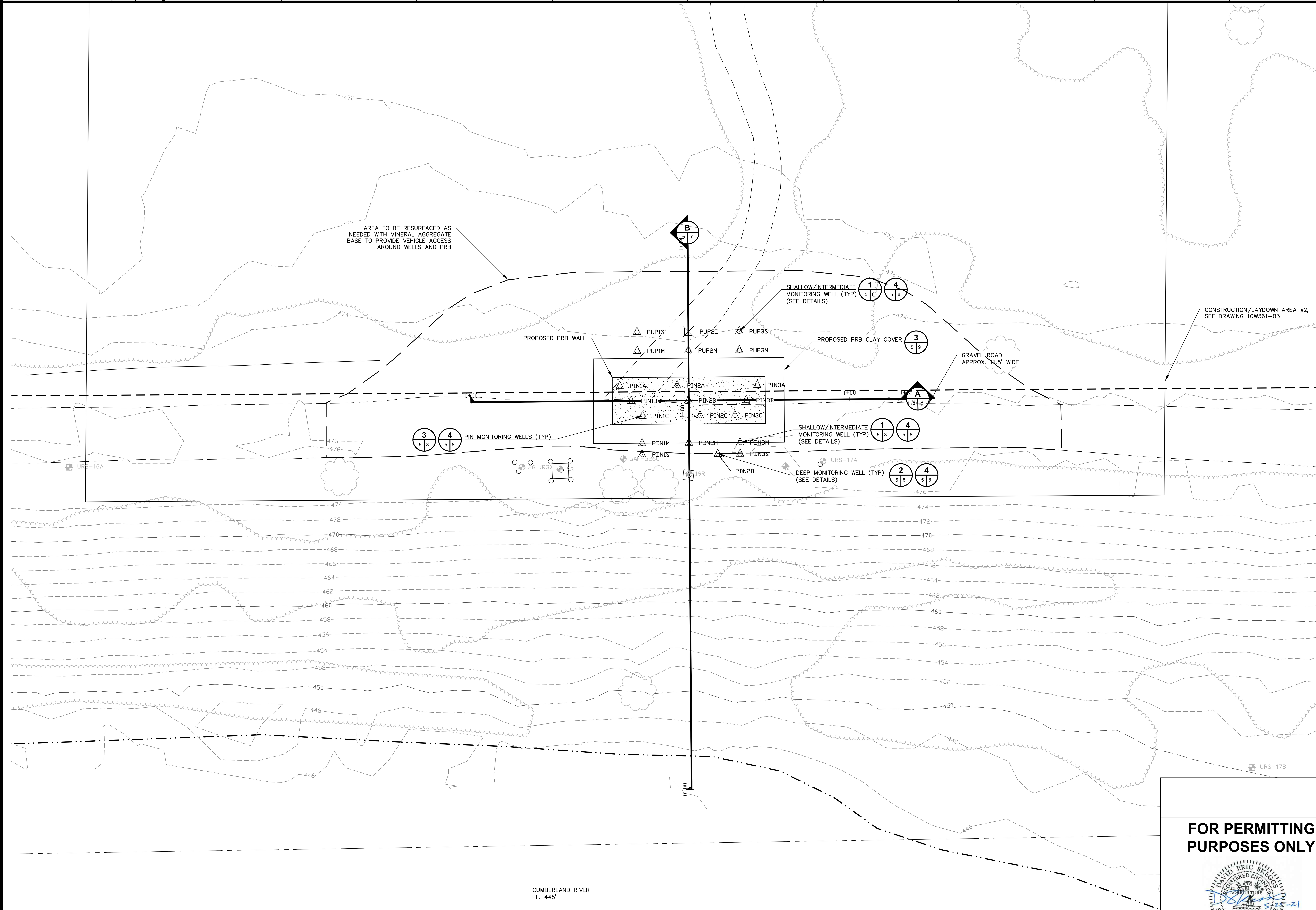

LEGEND

- 460 — EXISTING MAJOR
- 462 — EXISTING MINOR
- CUMBERLAND RIVER
- TVA PROPERTY LINE
- TREELINE
- GRAVEL ROAD
- NRS WASTE BOUNDARY
- EXISTING MONITORING WELL LOCATIONS
- EXISTING PIEZOMETER LOCATIONS
- PROPOSED MONITORING WELLS
- PROPOSED PIEZOMETERS

0 5 10 20 (IN FEET)

NOTES:

1. TOPOGRAPHIC SURVEY OF THE SITE IS BASED ON DATA OBTAINED BY TVA SURVEYING ON MAY 30, 2019. HORIZONTAL DATUM IS TVA NAD27 LOCAL GRID. VERTICAL DATUM IS NGVD29.

FOR PERMITTING PURPOSES ONLY

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST
R 0	5/25/21	MDW	MDW	DES	GWL	–	–	TVA	XXXXXX	
FOR PERMITTING PURPOSES ONLY										

SCALE: AS SHOWN — EXCEPT AS NOTED

PROPOSED PERFORMANCE MONITORING WELLS

GALLATIN FOSSIL PLANT
NRS REACTIVE BARRIER WALL
FIELD DEMONSTRATION

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
MDW	MDW	DES	GWL	–	–	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AECOM

AUTOCAD 2019 | DATE 5/25/21 | 39 | C | 10W361−05 | 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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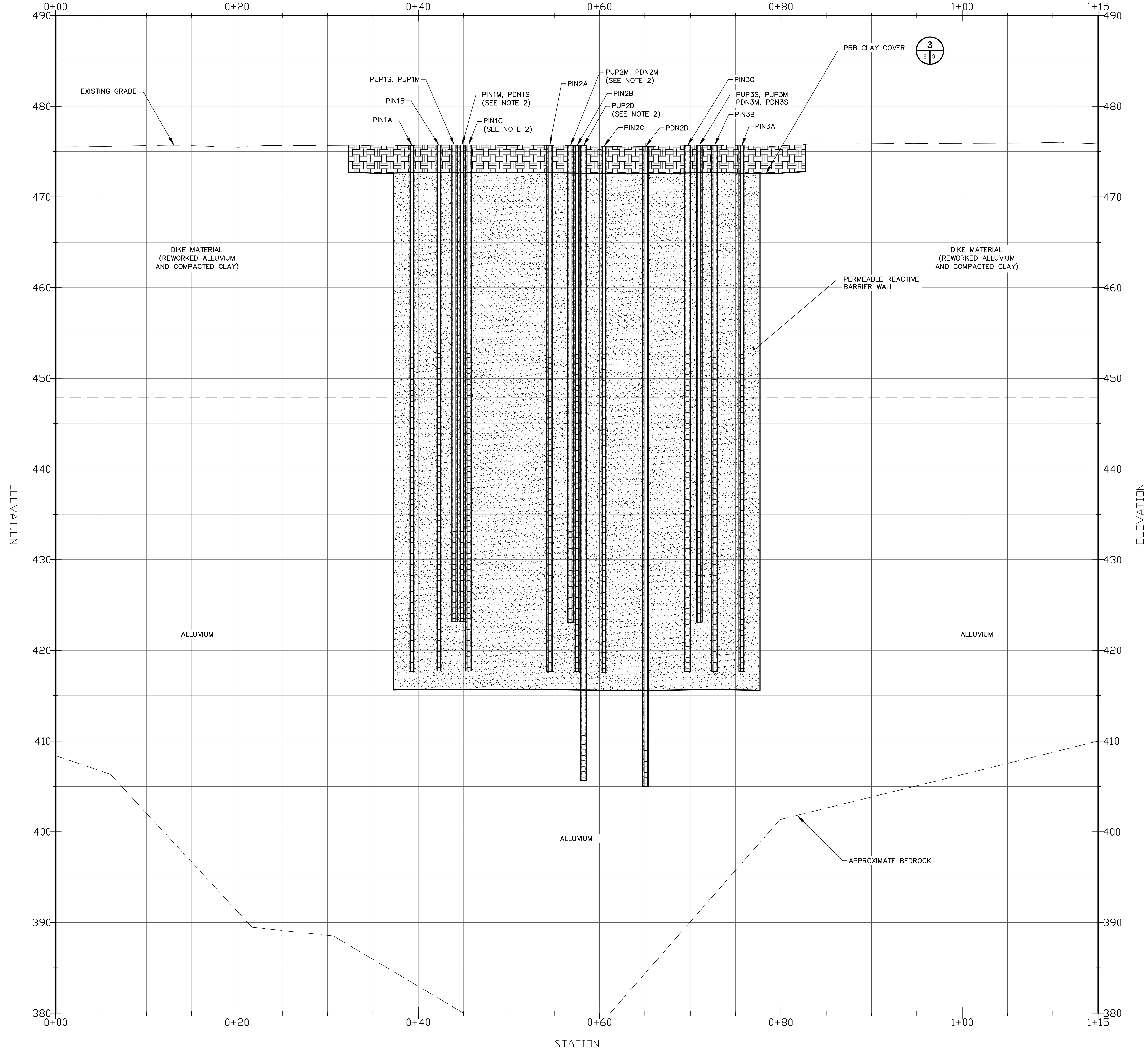

CROSS-SECTION A-A'

NOTES:

1. FOR MONIOTRING WELL CONSTRUCTION AND GROUND FINISH DETAILS, SEE DRAWING 10W361-08.
2. HORIZONTAL ALIGNMENT OF WELLS IS OFFSET FOR DISPLAY PURPOSES ONLY.

0 2.5 5 10
HORIZONTAL/VERTICAL SCALE (IN FEET)

FOR PERMITTING PURPOSES ONLY

DAVID ERIC SKEGGS — REGISTERED ENGINEER — AGRICULTURE COMMERCE — No. 124284 — STATE OF TENNESSEE — 5-25-21

AECOM

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST
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SCALE: AS SHOWN — EXCEPT AS NOTED

CROSS–SECTION A–A'

GALLATIN FOSSIL PLANT
NRS REACTIVE BARRIER WALL
FIELD DEMONSTRATION

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
MDW	MDW	DES	GWL	–	–	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

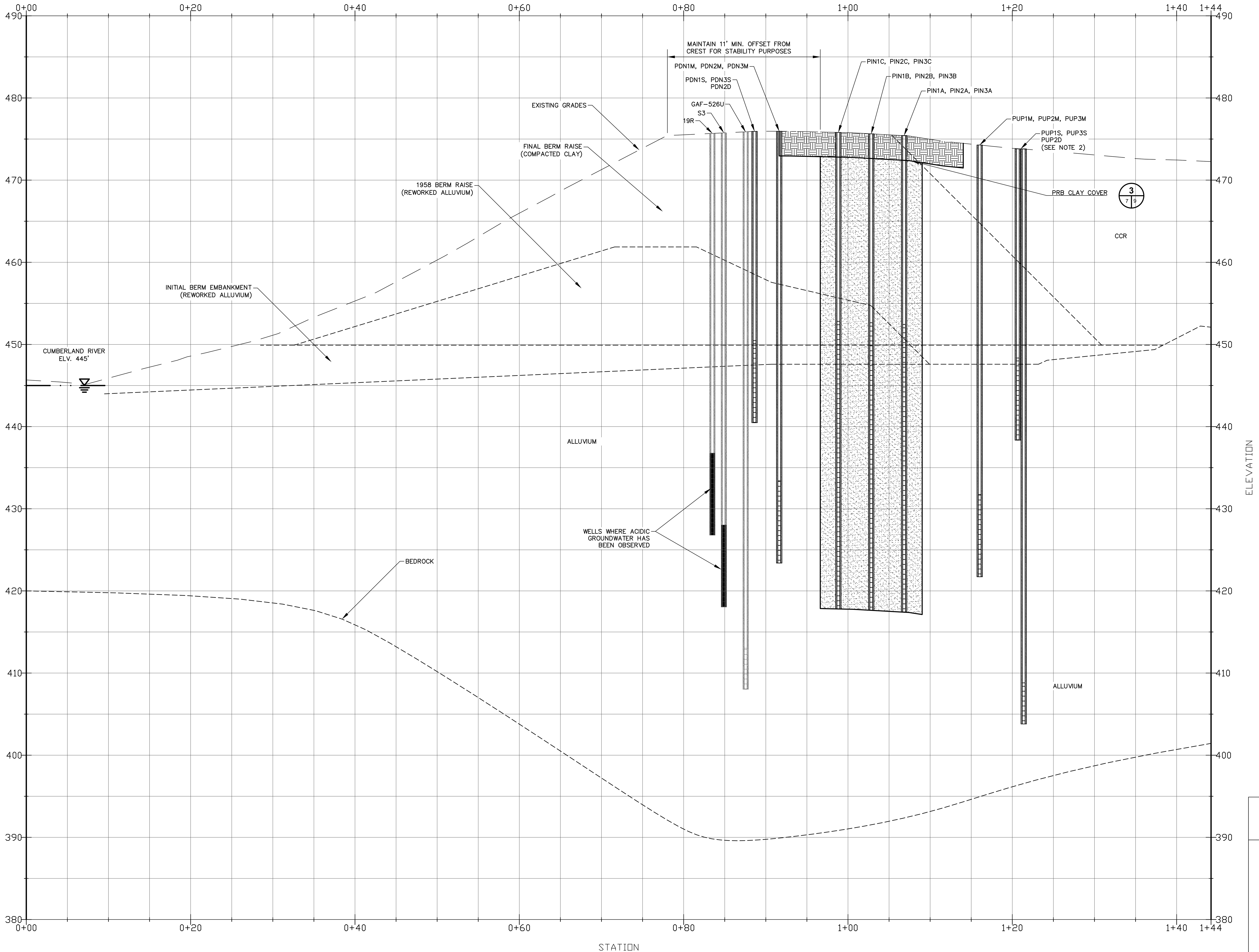
AUTOCAD 2019 | DATE 5/25/21 | 39 | C | 10W361–06 | R 0

AECOM	0
TASK COMPLETED BY:	REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

39 C 10W361-07



CROSS-SECTION B-B'

NOTES:

1. FOR MONIOTRING WELL CONSTRUCTION AND GROUND FINISH DETAILS, SEE DRAWING 10W361-08.
2. HORIZONTAL ALIGNMENT OF WELLS IS OFFSET FOR DISPLAY PURPOSES ONLY.

0 2.5 5 10
HORIZONTAL/VERTICAL SCALE (IN FEET)

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST
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FOR PERMITTING PURPOSES ONLY										

SCALE: AS SHOWN EXCEPT AS NOTED

FOR PERMITTING PURPOSES ONLY

CROSS-SECTION B-B'

GALLATIN FOSSIL PLANT
NRS REACTIVE BARRIER WALL
FIELD DEMONSTRATION

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
MDW	MDW	DES	GWL	–	–	TVA

AECOM

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 5/25/21 | 39 | C | 10W361-07 | R 0

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TASK COMPLETED BY:	REV NO.

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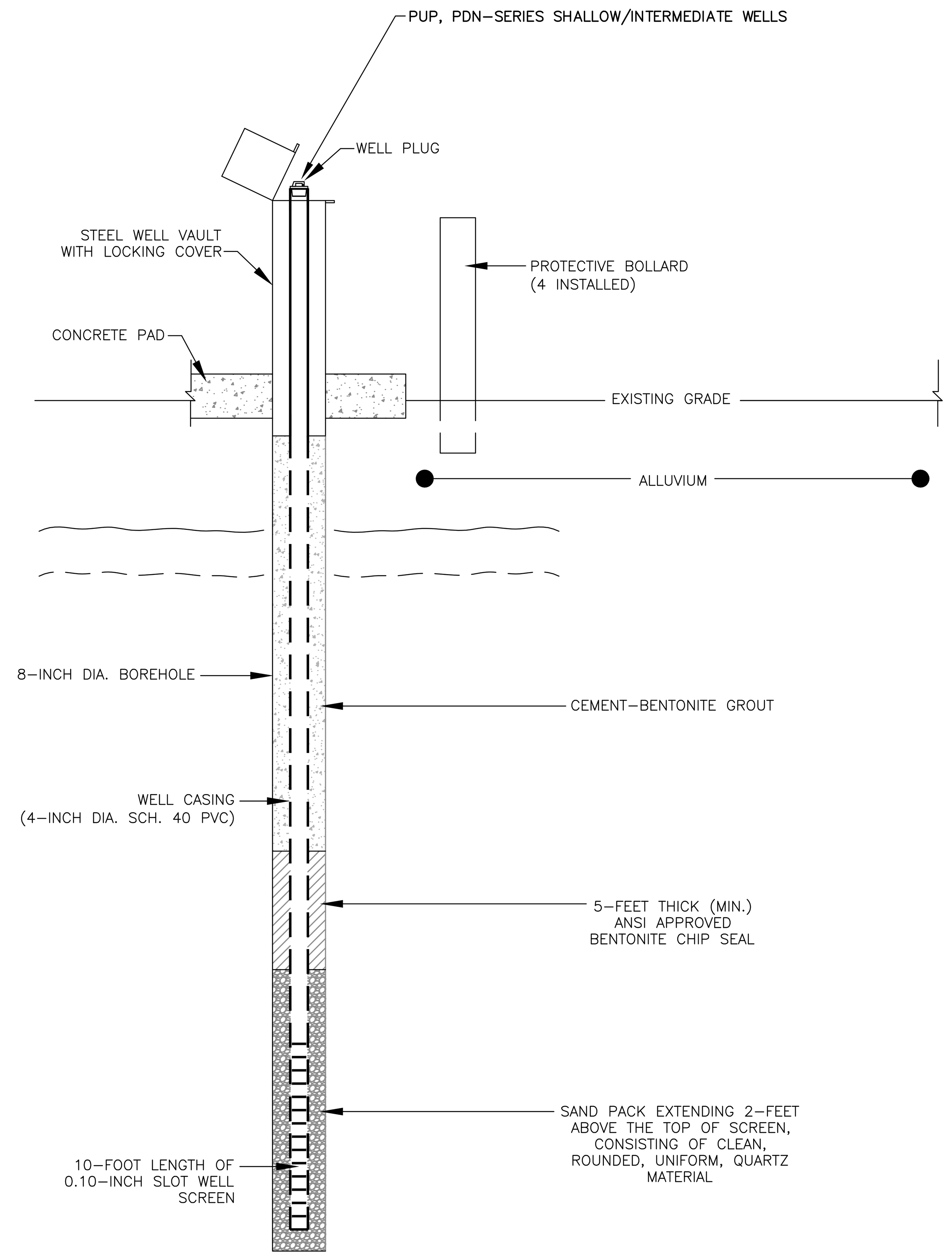
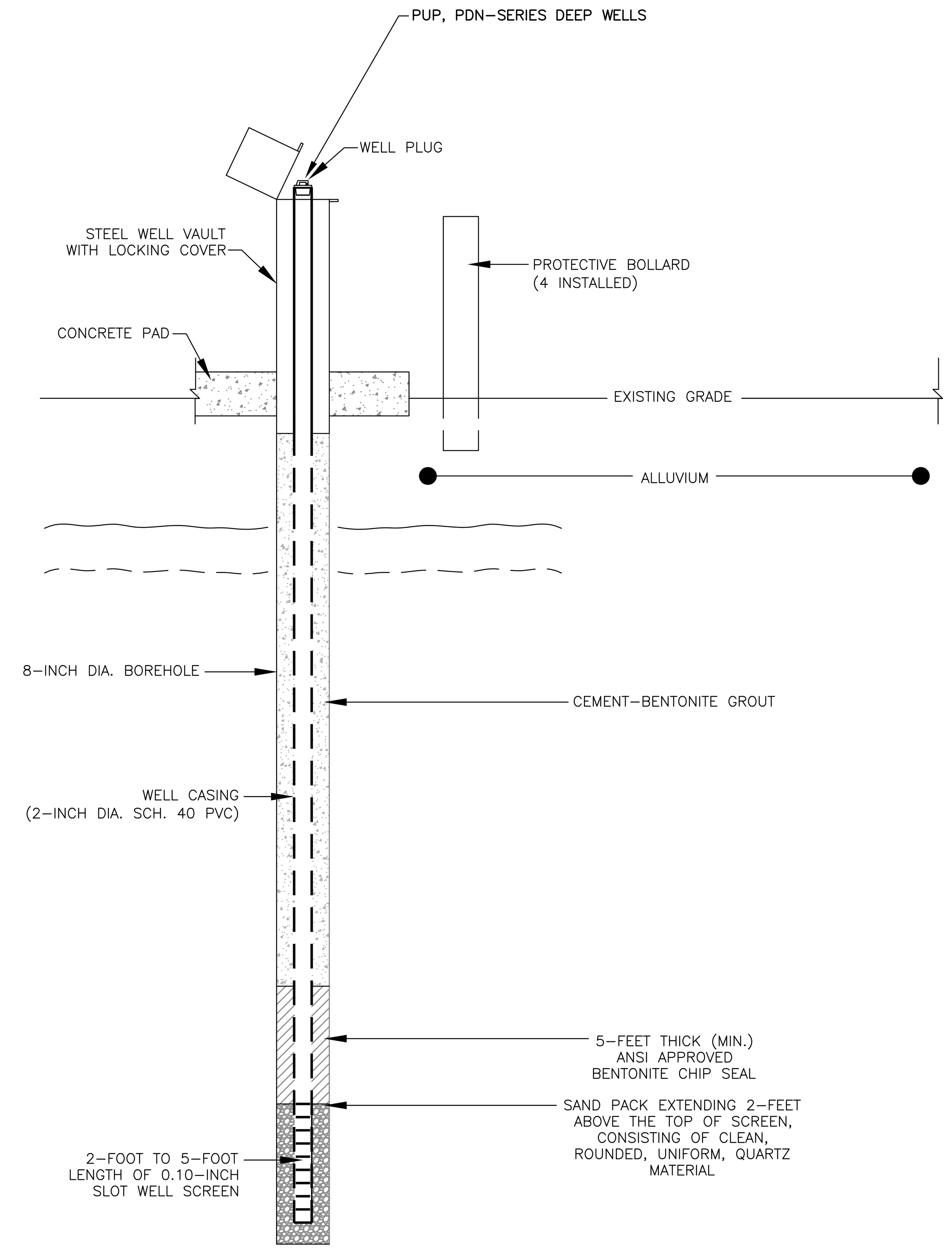


TYPICAL MONITORING WELL CONSTRUCTION DIAGRAM
(NOT TO SCALE)

1 (5/8) SHALLOW/INTERMEDIATE MONITORING WELL CONSTRUCTION DETAIL
SCALE: NOT TO SCALE



TYPICAL MONITORING WELL CONSTRUCTION DIAGRAM
(NOT TO SCALE)

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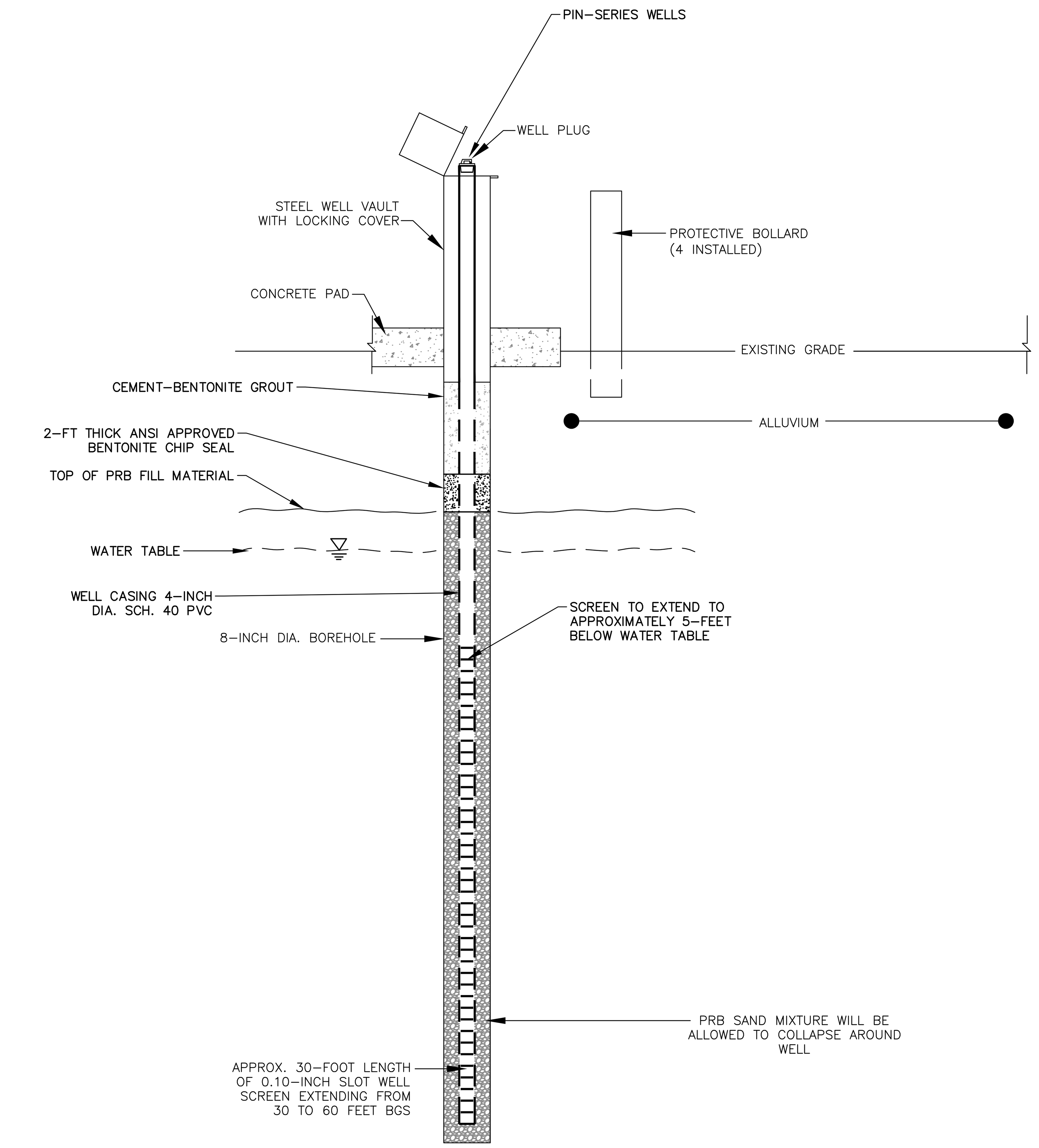
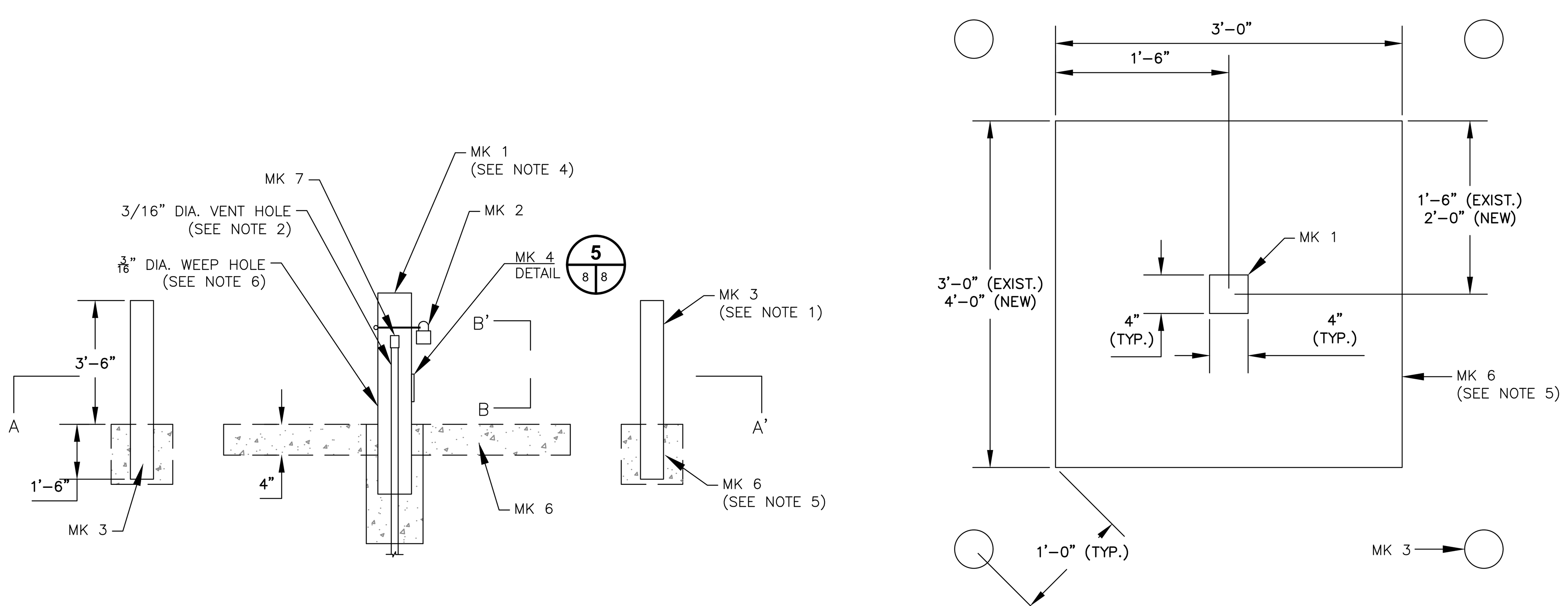


TYPICAL MONITORING WELL CONSTRUCTION DIAGRAM
(NOT TO SCALE)

3 (5/8) PIN MONITORING WELL CONSTRUCTION DETAIL
SCALE: NOT TO SCALE



SECTION – A-A'
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4 (5/8) SURFACE COMPLETION DETAIL
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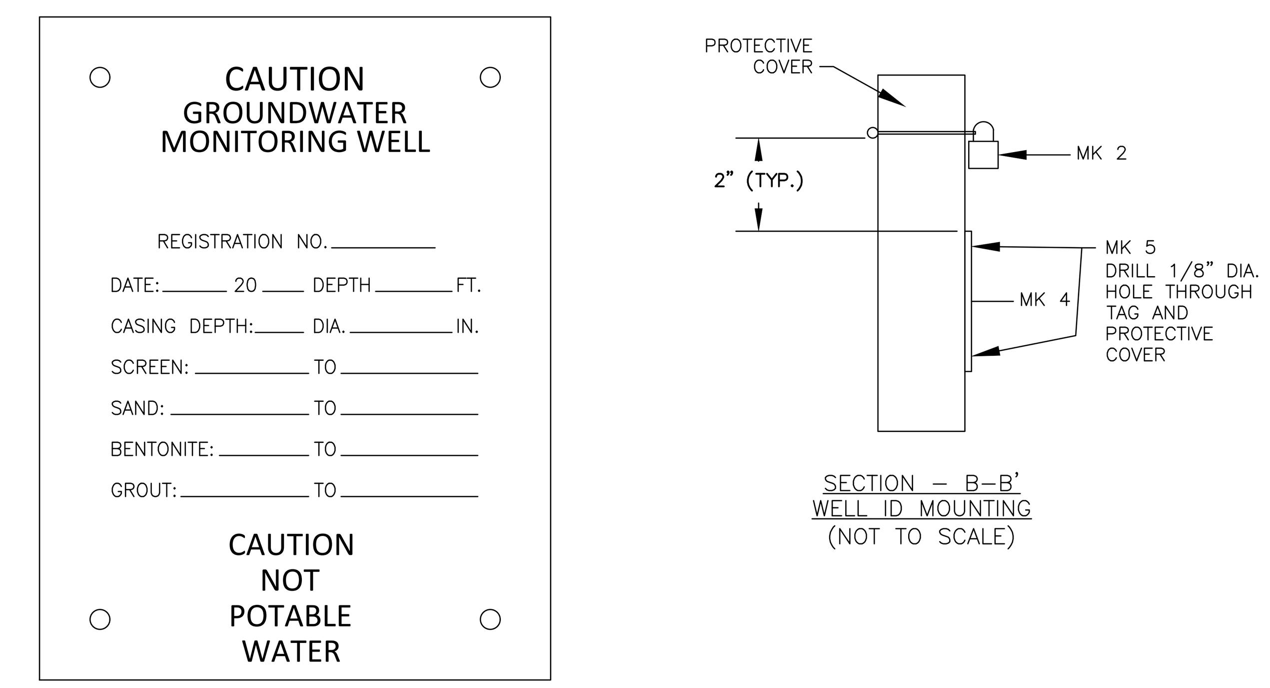
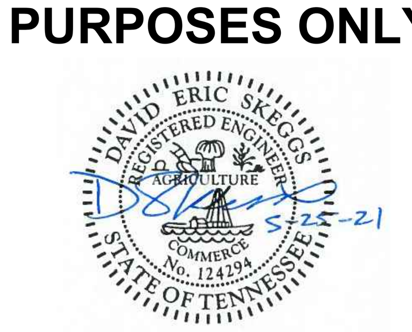


2 (02) DETAIL – WELL ID TAG (MK4)
(NOT TO SCALE)

SECTION – B-B'
WELL ID MOUNTING
(NOT TO SCALE)

5 (8/8) WELL ID TAG (MK4) DETAIL
SCALE: NOT TO SCALE

FOR PERMITTING PURPOSES ONLY



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R 0	5/25/21	MDW	MDW	DES	GWL	–	–	TVA	XXXXXX	
	FOR PERMITTING PURPOSES ONLY									

SCALE: AS SHOWN EXCEPT AS NOTED

MONITORING WELL DETAILS

GALLATIN FOSSIL PLANT
NRS REACTIVE BARRIER WALL
FIELD DEMONSTRATION

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
MDW	MDW	DES	GWL	–	–	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AECOM

AUTOCAD 2019 | DATE 5/25/21 | 39 | C | 10W361–08 | R 0

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DO NOT ALTER MANUALLY

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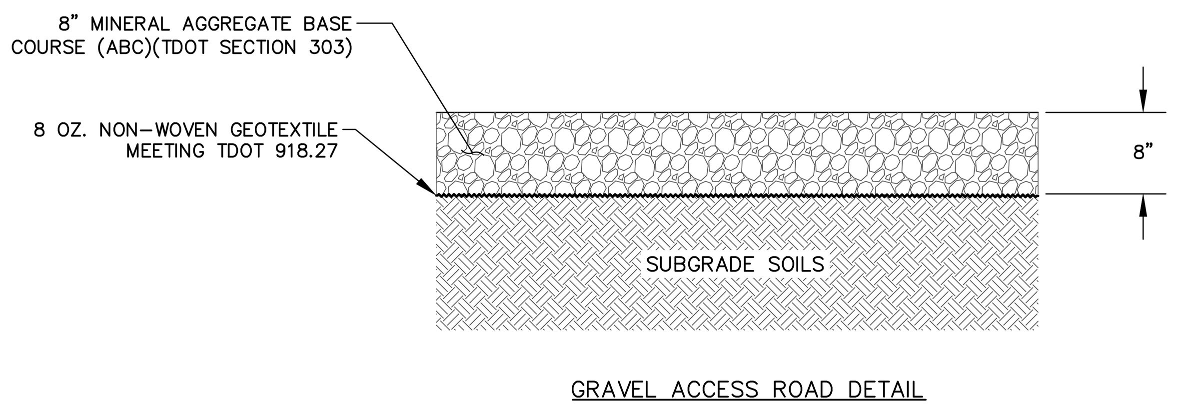

1 / 59 GRAVEL ACCESS ROAD DETAIL
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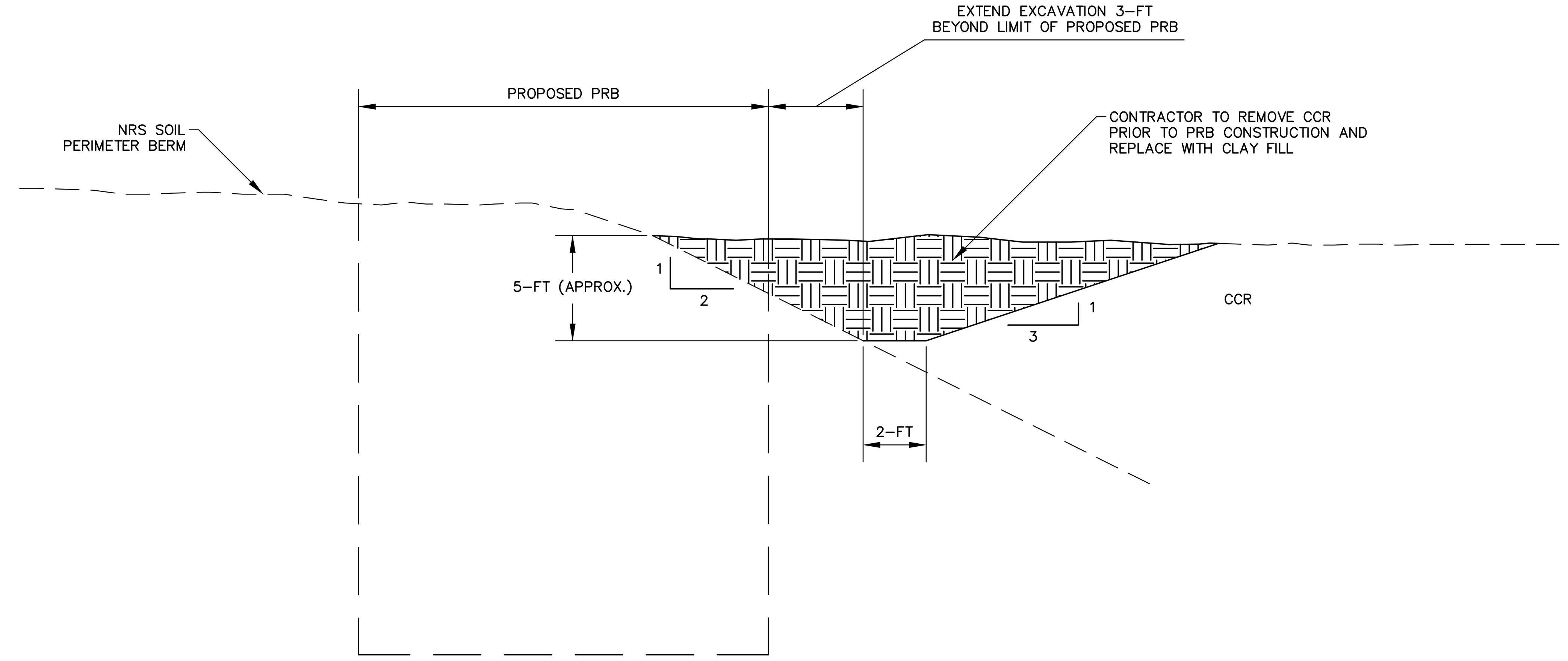

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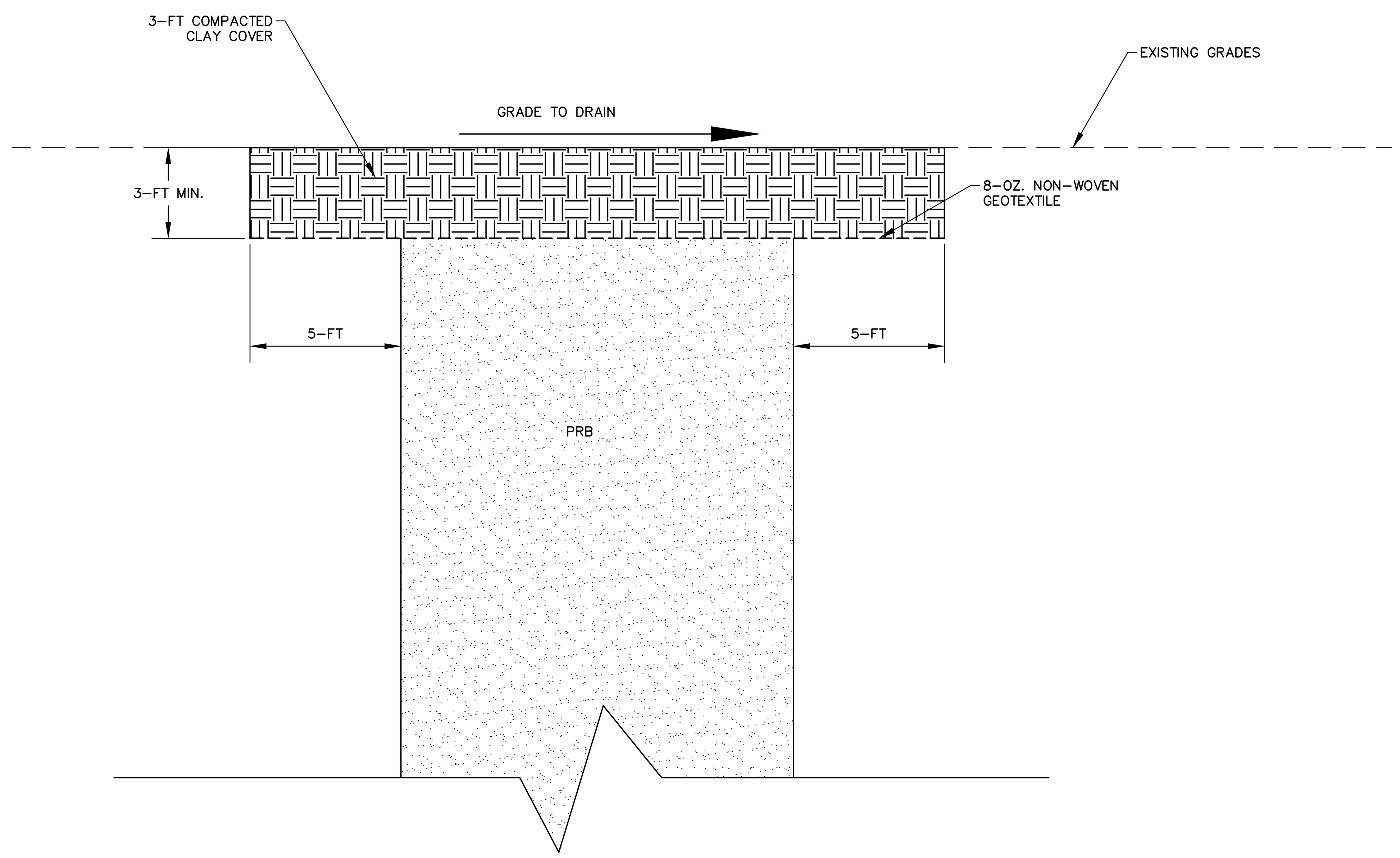

3 / 5 9 6 7 PRB CLAY COVER
SCALE: NOT TO SCALE

FOR PERMITTING PURPOSES ONLY

DAVID ERIC SKEGGS, REGISTERED ENGINEER, AGRICULTURE COMMERCE, No. 124284, STATE OF TENNESSEE — 5-25-21

AECOM

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
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FOR PERMITTING PURPOSES ONLY											

SCALE: AS SHOWN EXCEPT AS NOTED

DETAILS

GALLATIN FOSSIL PLANT
NRS REACTIVE BARRIER WALL
FIELD DEMONSTRATION

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
MDW	MDW	DES	GWL	–	–	TVA

GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD 2019 | DATE 5/25/21 | 39 | C | 10W361-09 | R 0

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TASK COMPLETED BY:	REV NO.

PLOT FACTOR:XX
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C.A.D. DRAWING DO NOT ALTER MANUALLY

Appendix F
Surveillance and Instrumentation Monitoring Plan (SIMP)

AECOM Imagine it. Delivered.

NRS Permeable Reactive Barrier Wall Field Demonstration Preliminary Surveillance, Instrumentation, and Monitoring Plan

Tennessee Valley Authority
Gallatin Fossil Plant

Revision 0
May 25, 2021

Quality information

Prepared by	Checked by	Verified by	Approved by
Josh Colley, P.E.	Michael Wall, P.E.	David Skeggs, P.E.	Gabe Lang, P.E.

Revision History

Revision	Date	Description
0	05/25/2021	Initial Issue

Prepared for:

Tennessee Valley Authority

Prepared by:

AECOM
1600 Perimeter Park
Morrisville, NC 27560
aecom.com

Table of Contents

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1. Purpose

1.1 Introduction

As part of ongoing closure activities at the Tennessee Valley Authority (TVA) Gallatin Fossil Plant (GAF), TVA is proposing to conduct a Field Demonstration at the Non-Registered Site (NRS). Specifically, the Study will evaluate the feasibility and performance of a proposed Permeable Reactive Barrier (PRB) Wall to be located along the NRS perimeter dike. The PRB Wall is proposed to be approximately 40 feet (ft) long, 12 ft wide, and 60 ft deep. It is planned to construct the wall using drilled piers in an overlapping pattern similar to a secant pile wall. Heavy construction equipment e.g. drill rigs, track hoes, loaders, and dump trucks etc. will be used to construct the wall.

Both existing and newly proposed instruments will be used to observe pore water pressure changes and slope movement both during and after construction. This Preliminary Surveillance, Instrumentation, and Monitoring Plan (SIMP) has been prepared by AECOM to define how these instruments should be used to monitor the NRS dike and detect potential instabilities that may occur during construction. This SIMP presents a summary of the existing and proposed instruments to be installed and monitored, required reading frequencies, appropriate Notification Levels (NL), Threshold Levels (TL), and Actions Levels (AL), and the roles and responsibilities pertaining to data processing, interpretation, and reporting.

AECOM understands that TVA is currently planning to begin construction of the PRB Wall in summer 2021. It should be noted that once a Contractor has been selected, NL, TL, and AL should be re-evaluated for the selected Contractor's proposed means and methods, and a Final SIMP prepared.

1.2 Scope of Preliminary Evaluation

The NRS dike is not currently being monitored using the existing instrumentation. This Preliminary SIMP has been prepared to establish appropriate NL, TL, and AL under the assumed, proposed loading conditions. It should be noted that the levels presented herein were established based on the preliminary slope stability analyses that were performed using data available at the time of calculation and assumed construction loads based on AECOM's prior experience.

The stability of the NRS slopes was initially evaluated as part of the NRS Structural Stability Assessment (Stability Assessment) performed by AECOM in 2018 (AECOM, 2018). As part of that work a field investigation and laboratory testing program were conducted to supplement the available historical data. An estimate of the subsurface stratigraphy was developed, material properties interpreted, and updated slope stability analyses performed. A detailed discussion of the investigation, laboratory testing and interpretation, material properties, and slope stability analyses can found in the Stability Assessment (AECOM, 2018). The analyses presented herein build upon these initial analyses.

The procedures described in this Preliminary SIMP are intended for use in monitoring the NRS dike in the general vicinity of the proposed PRB Wall during its construction. As part of the NRS Stability Assessment a number of cross sections were developed. The proposed PRB Wall is located approximately 45 ft north and 165 ft south of cross sections X-X' and W-W', respectively. Both sections were evaluated for use in the analyses presented herein. Ultimately, cross section X-X' was selected because: 1) the existing ground surface elevations at cross section X-X' and the PRB Wall centerline are very similar; and 2) cross section X-X' is closer to the PRB wall centerline, and therefore is likely to be more representative of the subsurface conditions at the PRB Wall.

The analyses presented herein evaluated slope failures that could result from an increase in pore water pressure during construction due to loading and/or changing phreatic conditions due to water levels within the NRS rising or changes in hydraulic conductivity due to wall construction. This SIMP does not address ground stability or bearing capacity within the NRS upstream of the dike. The selected PRB Wall Study Contractor shall prepare a plan to address concerns with ground stability or bearing capacity in consideration of specific construction activities to be performed over CCR. The selected Contractor's plan should address risks as necessary and define means and methods to manage their equipment and personnel in order to safely execute the work.

2. Surveillance and Instrumentation Summary

The surveillance, instrumentation, and monitoring procedures described herein are based on the results of the preliminary slope stability analyses and AECOM's experience with similar facilities under similar loading conditions. These procedures will need to be adjusted to reflect the selected Contractor's specific proposed means and methods. Additional adjustment may be necessary based on certain conditions and/or revised risk management strategies.

2.1 Surveillance

Surveillance will include visual observation of the NRS dike, including upstream and downstream areas. Whilst documented surveillance activities will be conducted by the Engineer, all parties will be responsible for observing conditions each day. The Engineer will outline specific conditions (or issues) that require routine attention to the relevant parties. Similar to worker safety initiatives, the observer should always err on the side of caution and report potential issues to the TVA Construction Manager (CM), TVA Engineering Manager (EM), and the Engineer regardless of whether the issue is judged to be critical or not.

Visual observation of the NRS dike may include, but is not limited to, the following:

- Dike Crest – Cracks and indications of settlement (particular attention should be paid to the orientation of cracking, if present, and whether differential settlement may be occurring);
- Dike Slope – Cracks, slides, and seepage (particular attention should be paid to the orientation of cracking, if present, and flow quantity and water clarity for seepage, if occurring); and
- Dike Toe – Seepage and boils (particular attention should be paid to flow quantity and water clarity for seepage, if occurring).

Visual observations of instrumentation will also be performed daily for signs of damage, missing parts (caps, etc.), and conditions around instrumentation (settlement, ponded water, etc.).

Surveillance activities will be documented in the Daily Surveillance and Instrumentation Summary Report prepared by the Engineer. Any observations judged critical by the Engineer will be discussed with the CM and EM at the time the observation and judgement are made.

2.2 Instrumentation

2.2.1 Slope Stability Monitoring

At the time of preparing this Preliminary SIMP, the NRS dike instrumentation is not routinely monitored. However, a limited amount of existing instrumentation is present within the NRS dike in the vicinity of the proposed PRB Wall. This includes nested sets of manually read vibrating wire piezometers, two at the crest (URS-16A and URS-17A) and one at the toe (URS-17B). These instruments will be monitored throughout construction. It is proposed to automate these piezometers, along with installing additional piezometers, as described below.

In addition to the exiting instrumentation, installation of new instrumentation is also proposed for the purpose of monitoring slope stability. This Preliminary SIMP has been developed to establish NL, TL, and AL for the new instruments. This Preliminary SIMP also includes monitoring of existing instruments as described later in this plan.

The proposed new instrumentation for slope stability monitoring includes three vibrating wire piezometers (with multiple transducers to be installed at each location at depths to be determined based on the specific subsurface conditions) and one slope inclinometer (installed in place with the crest piezometer). Note that the planned toe piezometer (PRB-PZ-3) is proposed to consist of shallow transducers pushed into place or installed via hand auger. Additional instruments may be installed, as needed, depending upon conditions encountered in the field. All instrumentation specific to monitoring of the slope (i.e. excluding instruments installed for the purposes of monitoring treatment performance of the PRB Wall) shall be installed prior to the start of construction. The new instruments will be installed by the Engineer. The PRB Wall Contractor may propose additional instruments specific to the construction activities to be performed. The piezometers installed by the Engineer shall be at least temporarily automated and incorporated into TVA's iSite Central system by TVA personnel, or as directed otherwise by TVA prior to construction. Automation includes monitoring level input into iSite Central in order to receive automated notifications of level exceedances. The proposed inclinometer(s) shall be manually read. A summary of the existing and proposed instruments is provided in **Table 1**.

The location of existing and proposed instrumentation is shown on **Figure 1** and on Drawing 10W361-04 of the PRB Wall Field Demonstration Drawings. Approximate instrumentation locations are also shown in the slope stability cross sections presented in **Appendix A**.

Table 1. Summary of Existing and Proposed Instrumentation

Instrument ID	Existing or Proposed	Instrument Type	Location Description
URS-17A-PZ-1 (23 ft bgs) URS-17A-PZ-2 (35 ft bgs) URS-17A-PZ-3 (50 ft bgs) URS-17A-PZ-4 (64 ft bgs)	Existing	Piezometer	Dike crest Approx. 45 ft south of PRB Wall centerline
URS-17B-PZ-1 (5 ft bgs) URS-17B-PZ-2 (9 ft bgs) URS-17B-PZ-3 (15 ft bgs) URS-17B-PZ-4 (30 ft bgs)	Existing	Piezometer	Dike toe Approx. 145 ft south of PRB Wall centerline
URS-16A-PZ-1 (18 ft bgs) URS-16A-PZ-2 (28 ft bgs) URS-16A-PZ-3 (38 ft bgs) URS-16A-PZ-4 (48 ft bgs)	Existing	Piezometer	Dike crest Approx. 165 ft north of PRB Wall centerline
PRB-PZ-1 (Three transducers, depths to be determined)	Proposed	Piezometer	NRS – screened in ash Approx. 20 ft upstream of PRB Wall
PRB-PZ-2 (Three transducers, depths to be determined)	Proposed	Piezometer	Dike crest Approx. 11 ft downstream of PRB Wall
PRB-PZ-3 (Three transducers, depths to be determined)	Proposed	Piezometer	Dike toe Approx. 65 ft downstream of PRB Wall
PRB-INC-2	Proposed	Inclinometer	Installed with PRB-PZ-2

Notes:

[1] bgs: below ground surface

[2] Piezometers URS-17A, -17B, and -16A, are outside the proposed construction area and are proposed to be monitored in order to serves as additional baseline/background data prior to construction as well as comparative data locations during construction. NL, TL, and AL are not set for these instruments.

2.2.2 Groundwater Flow Monitoring

In addition to the proposed slope stability monitoring instrumentation, two piezometers for groundwater flow monitoring are also planned. These piezometers (PRB-PZ-4 and PRB-PZ-5) will be installed along the crest of the NRS dike approximately 10 ft from each side of the PRB Wall. Theses instruments will be screened in the deeper foundation soils and their purpose is to monitor ground water flow conditions to ensure installation of the PRB Wall does not cause groundwater to flow around the wall rather than through it, therefore an NL, TL, and AL was not assigned for these instruments. However, consideration will still be given to the readings obtained from these instruments for comparative purposes when reviewing the overall data and evaluating slope stability.

3. Piezometer Monitoring Levels

3.1 Definition and Methodology

Monitoring levels are typically set in a tiered manner. A TL is established for conditions that require investigation but not necessarily remediation, and a higher AL is established for conditions that require intervention.

This Preliminary SIMP is applicable for conditions anticipated to exist during construction of the proposed PRB Wall. The monitoring levels for the piezometers associated with the PRB Wall construction are defined as follows:

- Notification Level – NL: AECOM recommends any single daily increase of 2 ft or more at any piezometer be established as a NL to alert the team. AECOM's experience indicates that rapid increases in pore water pressure, even if they remain below TL or AL, may be leading indicators of near future exceedances of those levels.
- Threshold Level – TL: Corresponds to an assumed phreatic surface in the slope stability analyses that indicates a calculated factor of safety (FS) of 1.25 against failure. Water elevations that exceed the TL should be taken as notice by the design team to investigate and assess more closely. Increased monitoring may be warranted.
- Action Level – AL: Corresponds to an assumed phreatic surface in the slope stability analyses that indicates a calculated FS of 1.15 against failure. Water elevations that exceed the AL require a work stoppage and/or site restrictions. Remedial action may be required.

For the purposes of this Preliminary SIMP, threshold and AL were determined by performing slope stability analyses using SLOPE/W, version 10.0.3.18569 (GeoStudio, 2019). Phreatic surfaces were estimated using SEEP/W, version 10.0.3.18569 (GeoStudio, 2019). At the time of performing the analyses, a contractor had not been selected, and as such, the exact equipment type, weight, dimensions etc. was unknown. Therefore, a conservative estimate based on engineering judgement and experience was made. The equipment used for the drilled piers was assumed to be placed on crane mats approximately 12 ft wide and apply a surcharge of 1,600 pounds per square foot (psf). In addition, support equipment, casings, spoils, etc. will be present during construction. This was assumed to be placed over a 14 ft wide area and exert a surcharge of approximately 800 psf. For the purposes of this analysis, the two loads were conservatively assumed to be placed side by side covering an area of approximately 35 ft (i.e. a 9 ft space between the loaded areas). This assumption is conservative since it is unlikely that both loads would be placed exactly side by side in the direction of a potential slip surface. The loads were offset from the downstream edge of the crest by approximately 11 ft, consistent with the proposed PRB Wall dimensions. The offset was checked to confirm that anticipated equipment loading will not negatively impact the calculated FS. The supporting calculations are presented in **Appendix A**. Consistent with other similar scopes of work performed at other TVA sites, the following procedure was utilized:

- A sensitivity analysis was performed where the boundary conditions in SEEP/W were adjusted to raise or lower the phreatic surface and the reading at each proposed instrument location could be estimated. The sensitivity analysis was performed until a calculated FS of 1.25 was obtained. The corresponding phreatic surface elevation at each instrument was then recorded and deemed the initial TL elevation. A similar sensitivity analysis was performed to obtain a calculated FS of 1.15, and the corresponding phreatic surface elevation at each instrument was taken as the initial AL elevation.
- The analyses included assessment in the downstream direction for global failures (failure surface passing beneath the bottom of the dike). Each analysis was performed using SLOPE/W, version 10.0.3.18569 (GeoStudio, 2019), utilizing the Spencer method, with optimized, circular failure surfaces. Further discussion can be found in **Appendix A**. Drained and undrained strengths were considered for the foundation soils. All other materials were assumed to be drained only. However, the undrained analyses were found to produce higher calculated FS. Therefore, the drained analyses were used to determine NL, TL, and AL.

3.2 Proposed Notification, Threshold, and Action Levels

The proposed NL, TL, and AL water level elevations are summarized in **Table 2** below. Supporting calculations are presented in **Appendix A**. It should be noted that the levels presented herein are preliminary only. As previously stated, once a Contractor has been selected for the PRB Wall Study construction, NL, TL, and AL should be re-evaluated for the selected Contractor's proposed means and methods, and a Final SIMP prepared.

Table 2. Summary of Notification, Threshold, and Action Levels

Section	Piezometer ID	Existing Ground Surface Elevation (ft NGVD29)	Current Water Level (ft NGVD29)	Notification Level (ft)	Threshold Level (ft NGVD29)	Action Level (ft NGVD29)
X-X' / PRB Wall	PRB-PZ-1	473.5	455	± 2 daily change	461	465
X-X' / PRB Wall	PRB-PZ-2	476	453	± 2 daily change	459	463
X-X' / PRB Wall	PRB-PZ-3	450	448.5	± 2 daily change	450[3]	450[3]

Notes:

[1] NGVD29: National Geodetic Vertical Datum of 1929.

[2] Per Section 3.1, the NL is not set at a specific elevation. Rather, a maximum daily change of 2 ft would trigger the NL

[3] A TL or AL at PRB-PZ-3 will only be considered to have been triggered if the corresponding TL or AL is also triggered at one or both of the other instruments.

4. Slope Inclinometer Monitoring Levels

The planned slope inclinometer(s) will be manually read. During construction, it is recommended that the proposed slope inclinometer be monitored for total, cumulative displacement from the baseline reading and from previous readings. For the proposed inclinometers, AECOM recommends any individual daily lateral increase of 0.2 inches and a cumulative lateral movement of 0.4 inches from the baseline be considered a TL event. Any individual daily lateral increase of 0.5 inches and cumulative lateral movement of 1 inch from the baseline shall be considered an AL event.

Any exceedance of a TL will require review by the Engineer or designated qualified personnel. The Engineer will also review previous week's construction activity, trends of nearby piezometer readings, and slope inclinometer plots to determine recommended actions. The recommendations may consist of increased reading frequency, site inspections, stopping work, etc. Recommendations involving stopping work will be reported to the CM and EM immediately with written follow-up recommendations within 8 hours. Other recommendations not involving work stoppage will be reported within 24 hours of the exceedance. The identification of shear planes in the slope inclinometer data will also be considered a TL/AL.

5. Instrumentation Reading Process

Following piezometer automation by TVA personnel, the monitoring levels defined herein will be applied by TVA to the database's (iSite) automatic notification system. Piezometer readings will be recorded at least hourly. An increase in the frequency of recordings will be determined by the CM, EM, and the Engineer as warranted for various construction activities or observed trends in data. Both the Engineer and the Contractor will have access to the recorded instrumentation data in iSite for daily retrieval and assessments during construction. Automated notifications of monitoring level exceedances will be received by the Engineer and the Contractor. If the Engineer or Contractor is not permitted to receive the automated exceedance notifications, then TVA Instrumentation Engineering Services (IES) will forward notifications immediately for review and assessment. The slope inclinometer(s) will be manually read twice daily.

The Engineer will be responsible for checking that the appropriate monitoring levels are set for each piezometer and slope inclinometer prior to the start of construction. TVA will provide the Engineer with a contact to update monitoring levels as needed. Note that the monitoring levels may be modified depending on actual site conditions and as approved by the CM, EM, and the Engineer. A master summary table of instrument readings and monitoring levels for both new and existing instrumentation will be developed and maintained by the Engineer.

6. Notifications and Reporting

6.1 Notifications

The automated piezometers report water level (hydraulic head) data to TVA's iSite Central system. The monitoring levels presented herein will be applied to iSite's automatic notification system. Notification e-mails will be sent to the Engineer and Contractor if a piezometer exceeds an NL, TL, or AL. If the Engineer or Contractor cannot be permitted to receive notification e-mails directly, then IES will receive the notifications and forward them immediately.

The slope inclinometer(s) will be manually read. The Engineer will review slope inclinometer data on a daily basis to determine if exceedances have occurred. The data will also be provided to the Contractor.

6.2 Reporting

Automated readings for all piezometers will be obtained by the Engineer and the Contractor each day of construction. The slope inclinometer(s) will be manually read twice daily. Readings will be reported in the Daily Surveillance and Instrumentation Summary Report prepared by the Engineer. The Engineer is responsible for reviewing the data for possible trends and conditions that may indicate developing instabilities. The Engineer will submit a completed Daily Surveillance and Instrumentation Summary Report to the CM, EM, and Contractor within 24 hours of reading collections. This frequency of reporting may be reduced as determined by the CM and EM. Separately, the Contractor shall maintain a plot of the daily readings to look for possible trends in the data and report adverse trends or conditions to the CM, EM, and Engineer.

If the NL is exceeded for any of the instruments, the Engineer will provide written notification on the Daily Surveillance and Instrumentation Summary Report for that day.

If the TL is exceeded for any of the instruments, the Engineer will review the data and report significant instrumentation findings to the CM and EM immediately with written documentation to follow within 24 hours after the time of discovery. Significant instrument findings include, but are not limited to, observations exceeding TL, detection of newly developing adverse trends, and/or any observations that indicate a potential failure mode has been or will be initiated in the near future.

If an AL is exceeded for any of the instruments, construction activities should be stopped, and access should be immediately restricted in the vicinity of individual instruments with readings at or above the AL. The Engineer will review the data and report significant instrumentation findings (including AL exceedances) to the CM and EM immediately with written documentation to follow within 24 hours after the time of discovery. Additional instruments, more frequent readings, modified construction procedures, and/or other activities may be warranted when AL are exceeded.

6.3 Corrective Actions

If instrument readings exceed defined monitoring levels, the Contractor will determine the cause(s) for the exceedance and propose corrective action(s) to stabilize the condition. If the Contractor believes that work can safely continue (with or without corrective action), they will prepare a request that defines the exceedance along with any determined cause(s) and will provide a basis for accepting risk under this condition. Proposed corrective action(s), requests to continue work, etc. will be approved by the CM, EM, and Engineer prior to implementation.

If the NL is exceeded for any of the instruments, the Owner may require the Engineer to take additional actions including more frequent readings or additional surveillance. If the TL or AL is exceeded for any of the instruments, installation of additional instruments, more frequent readings, modified construction procedures, and/or other activities may be warranted. Other corrective actions may include ceasing PRB wall construction and/or temporary work stoppages, implementing waiting periods for settlement or slope stabilization, area restrictions, or other appropriate actions.

7. Roles and Responsibilities

For this Preliminary SIMP, the following personnel shall be responsible for reporting and taking appropriate actions.

- AECOM will install the proposed instrumentation included in this Preliminary SIMP prior to construction. The Contractor is responsible for instrumentation protection during construction and will notify the CM, EM, and Engineer prior to modifying any instrumentation.
- All existing and proposed vibrating wire piezometers will be automated by TVA personnel. Automation includes setting up notification e-mails for monitoring level exceedances in TVA's iSite Central system. The Engineer will be responsible for verifying the monitoring levels in iSite. Notification e-mails of monitoring level exceedances will be received by the Engineer. If the Engineer cannot be permitted to receive notification e-mails directly, then IES will receive the notifications and forward them to the Engineer immediately. These notifications will also be made available to the Contractor.
- The Engineer shall be responsible for downloading the automated vibrating wire piezometer data from iSite and manually reading the slope inclinometer(s), processing the data, and reviewing exceedances of established NL, TL, and AL, and reporting the data in the Daily Surveillance and Instrumentation Summary Report. As part of this evaluation, the Engineer shall consider readings and other available information, in addition to the established monitoring levels. If NL exceedances are observed, the Engineer will report the exceedances on the Daily Surveillance and Instrumentation Summary Report. If a TL or AL is exceeded for any of the instruments, the Engineer will review the data and report significant instrumentation findings to the CM and EM immediately with written documentation to follow within 24 hours after the time of discovery. The report should include a running summary of instrument readings throughout construction including existing instruments.
- The Contractor shall be responsible for ensuring compliance with the Preliminary SIMP in addition to the construction documents (i.e. QMP, Plans for Construction, Technical Specifications, Contingency Plan, Temporary Construction Emergency Action Plan (TCEAP), etc.). The Contractor is responsible for the safety of personnel and equipment. If instrument readings exceed defined monitoring levels, the Contractor will determine the cause(s) for the exceedance and proposed corrective action(s) to stabilize the condition. If the Contractor believes that work can safely continue (with or without corrective action), they will prepare a request that defines the exceedance along with any determined cause(s) and will provide a basis for accepting risk under this condition. Proposed corrective action(s), requests to continue work, etc. will be approved by the CM, EM, and Engineer prior to implementation.
- The Engineer will document their surveillance activities in the Daily Surveillance and Instrumentation Summary Report. Any observations judged critical by the Engineer will be discussed with the CM and EM at the time of the observation and judgement are made. While documented surveillance activities will be conducted by the Engineer, all parties will be responsible for observing conditions each day. The Engineer will outline specific conditions (or issues) that require routine attention to the relevant parties. Similar to worker safety initiatives, the observer should always err on the side of caution and report potential issues to the TVA Construction Manager (CM), TVA Engineering Manager (EM), and the Engineer regardless of whether the issue is judged to be critical or not.
- The Contractor is responsible for providing safe access to all instrumentation and surveillance areas for all parties performing daily inspections, including the Engineer.
- The Engineer will maintain piezometer and slope inclinometer reading plots relative to defined monitoring levels and include them in the Daily Surveillance and Instrumentation Summary Report. The Engineer will review instrument readings (values, frequencies, etc.) during the daily reporting effort to verify that defined Preliminary SIMP requirements are being met. Deficiencies will be reported to the CM and EM at the time the issue is identified. The Engineer will also determine whether any negative trends are present in the data and if so, report these to the CM and EM at the time the trend is identified.
- The EM shall represent the Owner (TVA) and be the point of contact for the CQA Team/Manager. The EM will coordinate with the CM if corrective actions are warranted. The EM shall also make any required notifications to its Dam Safety Officer.
- The CM shall represent the Owner (TVA) and be the point of contact for the Contractor. The CM will coordinate with the EM and may require corrective actions for the Contractor.

8. References

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.

GeoStudio (2019), SLOPE/W and SEEP/W version 10.0.3.18569, GEOSLOPE International Ltd., Calgary, Canada.

Figures

LEGEND

- Existing Piezometers
- Proposed Instruments - Slope Stability
- Proposed Instruments - Groundwater
- PRB Wall (Approximate)
- Property Boundary (Approximate)
- NRS Boundary

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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:
MAY 2021	FOSSIL AND HYDRO ENGINEERING

Appendices

Appendix A – Slope Stability Calculation Package

1 PURPOSE

As part of ongoing closure activities at the Tennessee Valley Authority (TVA) Gallatin Fossil Plant (GAF), TVA is proposing to conduct a Treatability Pilot Study (Study) at the Non-Registered Site (NRS). Specifically, the Study will evaluate the feasibility and performance of a proposed Permeable Reactive Barrier (PRB) Wall. The PRB Wall is proposed to be approximately 40.4 feet (ft) long, 12.4 ft wide, and 60 ft deep. It is planned to construct the wall using drilled piers in an overlapping pattern similar to a secant pile wall. Heavy construction equipment e.g. drill rigs, track hoes, etc. will be used to construct the wall. The propose PRB Wall location is shown on **Figure 1**.

The purpose of this Calculation Package (package) is to present preliminary slope stability analyses to evaluate the stability of selected, NRS cross sections under anticipated loads to establish preliminary setbacks for proposed equipment configurations. In addition, short term, proposed loading specific, Threshold Levels (TL) and Action Levels (AL) for the proposed piezometers were developed to support the Preliminary Surveillance and Instrumentation Monitoring Plan (SIMP). It should be noted that once a contractor has been selected, stability of the NRS slopes and TL and AL should be re-evaluated for the selected contractor's proposed means and methods, and a Final SIMP prepared.

The stability of the NRS slopes was initially evaluated as part of the NRS Structural Stability Assessment (Stability Assessment) performed by AECOM in 2018 (AECOM, 2018). As part of that work a field investigation and laboratory testing program were conducted to supplement the available historical data. An estimate of the subsurface stratigraphy was developed, material properties interpreted, and updated slope stability analyses performed. A detailed discussion of the investigation, laboratory testing and interpretation, material properties, and slope stability analyses can found in the Stability Assessment (AECOM, 2018). The analyses presented herein build upon these analyses.

2 METHODOLOGY

2.1 Slope Stability

The slope stability analyses presented herein was performed using Spencer's method (Spencer, 1967) as implemented in the two dimensional limit-equilibrium slope stability software SLOPE/W, version 10.0.3.18569 (GeoStudio, 2019). Spencer's method, which satisfies vertical and horizontal force equilibrium and moment equilibrium, was selected because it is considered to be more rigorous that other methods such as simplified Janbu method or

Bishop's method. SLOPE/W is used to generate potential slip surfaces, calculate the Factor of Safety (FS) for each surface, and identify the critical surface with the lowest calculated FS.

Circular slip surfaces were evaluated using the entry-exit search method. Entry ranges were assigned starting at the crest of the NRS perimeter dike and extending approximately 100 ft into the NRS. Exit ranges were assigned starting at the toe of the NRS dike and extending approximately 100 ft beyond the toe. These ranges were selected to only evaluate large-scale global slip surfaces that encompass the entire NRS dike. Entry/exit points were located approximately every 5 ft along the entry and exit ranges and 35 radius increments were used for each case. The minimum slip surface depth for these analyses is 20 ft, and was selected to prevent the analysis of local stability slip surfaces. The critical circular slip surface was optimized into a non-circular shape, with up to 1,000 iterations performed before the final, critical slip surface was selected.

Phreatic conditions for all analyses were modeled using a piezometric line within SLOPE/W. Because the subsurface geometry (and therefore hydraulic conductivities) in the NRS dike will change with the construction of the wall, SEEP/W version 10.0.3.18569 (GeoStudio, 2019) was used to generate phreatic surfaces which were then imported into SLOPE/W. The SEEP/W model was first calibrated against the available 2017 water level measurements (AECOM, 2018). Then, SEEP/W was used to estimate the phreatic surfaces for post-PRB Wall construction cases and in the sensitivity analyses performed to obtain TL and AL. Materials that are anticipated to remain below the water table at all times were modelled as saturated materials. Per the GeoStudio Engineering Methodology handbook (GeoStudio, 2012), materials that exist above and below the water table were modelled as saturated/unsaturated materials. Following this approach provides more accurate estimates of the phreatic surface and flow quantities. The volumetric water content and hydraulic conductivity functions were estimated using the in-built functions in SEEP/W, as described in Section 3.4.

2.2 Action and Threshold Levels

Consistent with other similar scopes of work performed at other TVA sites, the following procedure was utilized:

- A sensitivity analysis was performed where the boundary conditions in SEEP/W were adjusted to raise or lower the phreatic surface and the reading at each proposed instrument location could be estimated. The sensitivity analysis was performed until a calculated FS of 1.25 was obtained. The corresponding phreatic surface elevation at each instrument was then recorded and deemed the initial threshold level elevation. A similar sensitivity analysis was performed to obtain a calculated FS of 1.15, and the corresponding phreatic surface elevation at each instrument was taken as the initial action level elevation.

3 INPUT PARAMETERS

3.1 Cross Section

As discussed previously, the stability of the NRS slopes was initially evaluated as part of the NRS Stability Assessment (AECOM, 2018). As part of that assessment a number of cross sections were developed. The proposed PRB Wall is located approximately 45 ft north and 165 ft south of cross sections W-W' and X-X', respectively. Both sections were evaluated for use in the analyses presented herein. Ultimately, cross section X-X' was selected because: 1) the existing ground surface elevations at cross section X-X' and the PRB Wall centerline are very similar; and 2) cross section X-X' is closer to the PRB wall centerline, and therefore is likely to be more representative of the subsurface conditions at the PRB Wall.

3.2 Subsurface Stratigraphy

A detailed discussion of the subsurface stratigraphy can be found in the NRS Stability Assessment (AECOM, 2018). A brief summary is provided below. The stratigraphy at cross section X-X' consists of, from top to bottom, the following:

- **CCR**: Present within the NRS (i.e. not encountered within the NRS dike). Based on the results of AECOM's physical characterization of the CCR, the CCR at the NRS predominantly consists of non-plastic silt.
- **Final Raise**: The Final Raise is a compacted clay upstream dike raise that was constructed on top of the 1958 Raise sometime in the 1960s. It is likely that the Final Raise was also constructed out of native alluvial borrow soils. Based on AECOM's field investigation, the Final Raise predominately consists of slightly overconsolidated lean clay.
- **1958 Raise**: The 1958 Raise is a compacted clay upstream dike raise that was constructed on top of the Initial Embankment in 1958. It is likely that the 1958 Raise was also constructed out of native alluvial borrow soils. Based on AECOM's field investigation, the 1958 Raise predominately consists of normally consolidated lean clay.
- **Initial Embankment**: The Initial Embankment is a compacted clay fill constructed in the early 1950s as part of the original site grading for GAF. It is likely that the Initial Embankment was constructed out of native alluvial borrow soils. Based on AECOM's field exploration, the Initial Embankment predominately consists of slightly overconsolidated lean clay.
- **Lower Alluvium**: The Lower Alluvium is an alluvial native clay deposited by the adjacent Cumberland River. Based on AECOM's site exploration, the Lower Alluvium predominantly consists of moderately to highly overconsolidated lean clay.

- **<u>Clayey Sand Alluvium</u>**: The Clayey Sand Alluvium is a zone of clayey sand, sandy clay, and clayey gravel deposited by the adjacent Cumberland River. Based on AECOM's site explorations, the Clayey Sand Alluvium predominantly consists of moderately to significantly overconsolidated clayey sand, sandy clay, and clayey gravel.
- **<u>Residuum – North</u>**: The residual soils are clayey in nature and were formed by the in-place weathering of the parent limestone bedrock. Based on AECOM's site exploration, the Residuum – North predominantly consists of lightly to moderately overconsolidated fat clay, although some zones of lean clay, clayey sand, and clayey gravel are also present.
- **<u>Bedrock</u>**: Limestone bedrock.

3.3 Phreatic Surface and Boundary Conditions

As discussed in Section 2.1, SEEP/W was used to estimate the phreatic surfaces for use in the slope stability analyses presented herein. Boundary conditions are applied to the seepage model to define conditions at discrete points within the SEEP/W model. The following boundary conditions were applied:

- **<u>Upstream Model Edge</u>**: varies. This represents the phreatic surface within the NRS. Under normal conditions this at approximately 463.5 ft National Geodetic Vertical Datum of 1929 (NGVD29). In the TL and AL cases, this was raised until the desired target FS was obtained.
- **<u>Downstream Dike Face</u>**: Potential Seepage Face (total flux = 0 with "Potential Seepage Face Review". This allows SEEP/W to iterate the position of the phreatic surface by allowing flow to leave the model where this boundary condition is assigned. This boundary condition remains the same in all cases.
- **<u>Downstream Area</u>**: Total head = 445 ft NGVD29. This represents the Cumberland River, which is generally consistent in elevation at approximately 445 ft NGVD29. This boundary condition remains the same in all cases.

3.4 Material Properties

3.4.1 Strength

Drained and undrained strengths were considered for the foundation soils. All other materials were assumed to be drained only. However, the undrained analyses were found to produce higher calculated FS. Therefore, the drained analyses were used to determine NL, TL and AL. A detailed discussion of the investigation, laboratory testing and interpretation, material properties, and slope stability analyses can found in the Stability Assessment (AECOM, 2018).

This includes a discussion on the selection of anisotropic strength functions. A summary of the material strengths is provided in **Table 1**.

3.4.2 Hydraulic Conductivity

As discussed previously, materials below the phreatic surface were modelled with saturated hydraulic conductivities. Materials partially above the phreatic surface were modelled with as saturated/unsaturated materials, which require a volumetric water content function and a hydraulic conductivity function.

The volumetric water content function can be estimated within SEEP/W using the soil type e.g. clay, silt, sand, etc. and saturated water content. The saturated water content can be calculated as shown in **Equation 1**.

$$w = \frac{S * e}{G_s} \qquad \textbf{Equation 1}$$

where:

w = water content, %;

S = degree of saturation. S = 1 for saturated soil;

e = void ratio; and

G_s = specific gravity.

The hydraulic conductivity function was estimated within SEEP/W based on the volumetric water content, saturated hydraulic conductivity, and an in-built estimation method. In this the Fredlund-Xing-Huang (1994) method, since it is simpler than other methods built in to SEEP/W that require more advance laboratory testing.

Because extensive hydraulic conductivity testing of each material is not available, the materials were grouped according to type e.g. CCR, dike fill, foundation soil, etc. This is considered acceptable since the analyses performed herein are based on a sensitivity analysis approach and the goal is to obtain water elevations corresponding to TL and AL, rather than analyzing one specific case to obtain a calculated FS under those specific circumstances. As noted in Section 3.3, the initial SEEP/W was calibrated to provide a good approximation to available 2017 measured water levels. A summary of the calibrated hydraulic conductivity properties, and any supporting assumed properties, is presented in **Table 2**.

3.5 Equipment Loading

At the time of performing the analyses, a contractor had not been selected, and as such, the exact equipment type, weight, dimensions etc. was unknown. Therefore, a conservative estimate based on engineering judgement and experience was made. The equipment used for the drilled piers was assumed to be placed on crane mats approximately 12 ft wide and apply a surcharge of 1,600 pounds per square foot (psf). In addition, support equipment, casings, spoils, etc. will be present during construction. This was assumed to be placed over a 14 ft wide area and exert a surcharge of approximately 800 psf. For the purposes of this analysis, the two loads were conservatively assumed to be placed side by side covering an area of approximately 35 ft (i.e. a 9 ft space between the loaded areas). This assumption is conservative since it is unlikely that both loads would be placed exactly side by side in the direction of a potential slip surface.

3.6 Target Factor of Safety

TVA's CCR Structural Stability Program's Construction and Major Modifications of CCR Storage Facilities Document (TVA, 2020) and CCR and CCR Landfill Life Cycle Management Document (TVA, 2021) and the United States Army Corps of Engineers (USACE) provide 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. AECOM understands that as part of the Stability Assessment (AECOM, 2018), sections of the NRS perimeter dikes were found to not meet the target FS of 1.5 for long term conditions. Therefore, a target FS of 1.3 was selected for the short term and long term conditions presented herein. As discussed in Section 2.2, the target FS for the AL and TL is 1.25 and 1.15, respectively.

3.7 Cases Analyzed

Slope stability analyses were performed for cross section X-X', assuming both drained and undrained foundation soil conditions. Note that the TL and AL were established using drained foundation soils, then those cases were checked using undrained foundation soils to confirm that a higher calculated FS was obtained under those conditions. The cases considered are as follows:

<u>Existing Conditions</u>: Existing conditions, consistent with previous Structural Assessment (AECOM, 2017). Run a baseline case for comparison purposes.

<u>Existing Conditions + Equipment Loading</u>: Same as previous case with anticipated equipment loads added. Loads were offset from the downstream edge of the crest by approximately 11 ft, consistent with the proposed PRB Wall dimensions. Offset was checked to confirm that anticipated equipment loading will not negatively impact the calculated FS.

PRB Wall: Similar to the existing conditions cases with proposed PRB Wall added. Water elevation within the NRS assumed consistent with existing conditions. Analyzed with and without anticipated equipment loads.

Threshold Level: Similar to the PRB Wall cases. Water elevation within the NRS increased to obtain TL target FS of 1.25. Analyzed with and without anticipated equipment loads.

Action Level: Similar to the PRB Wall cases. Water elevation within the NRS increased to obtain AL target FS of 1.15. Analyzed with and without anticipated equipment loads.

4 RESULTS AND CONCLUSIONS

4.1 Slope Stability – Drained Foundation Soils

The results of slope stability analyses for the existing conditions, existing conditions + equipment loading, PRB Wall, and PRB Wall + equipment loading with drained foundation soils are presented in **Attachment 1A**, **1B**, **2A**, and **2B**, respectively. The equipment loading was offset consistent with the proposed PRB Wall design and was found to not negatively impact the calculate FS i.e. the calculated FS with and without equipment loading was calculated to be the same. The calculated FS for the existing conditions and PRB wall case was found to be 1.43 and 1.42, respectively. Note that smaller equipment offsets were evaluated and were found to not negatively impacted the calculated FS. However, 11 ft was used as the offset to correspond with the current PRB Wall design.

4.2 Action and Threshold Levels

As discussed in Section 1, piezometers are proposed to be installed as part of the Preliminary SIMP to support monitoring of the NRS perimeter dike during and after PRB Wall construction. The results of the slope stability analyses for the TL and AL, with and without equipment loading, are presented in **Attachment 3A**, **3B**, **4A**, and **4B**. A summary of the water level elevations at each of the proposed piezometer locations for the TL and AL is summarized in **Table 3**. It should be noted that once a contractor has been selected, stability of the NRS slopes and TL and AL should be re-evaluated for the selected contractor's proposed means and methods, and a Final SIMP prepared.

4.3 Slope Stability – Undrained Foundation Soils

The results of slope stability analyses for the existing conditions, existing conditions + equipment loading, PRB Wall, and PRB Wall + equipment loading with undrained foundation soils are presented in **Attachment 5A**, **5B**, **6A**, and **6B**, respectively. The calculated FS for these cases were 1.79, 1.66, 1.79, and, 1.66, respectively. Note that these are higher that the FS calculated assuming drained foundation soils.

The results of the slope stability analyses for undrained foundation soils with phreatic surfaces corresponding to the TL, TL + equipment loading, AL, and AL + equipment loading are presented in **Attachment 7A**, **7B**, **8A**, and **8B**. The calculated FS for these cases were 1.52, 1.46, 1.79, and 1.31, respectively. Note that these are higher that the FS calculated assuming drained foundation soils.

5 REFERENCES

AECOM (2016), “Environmental Investigation Plan”, Revision 1, 20 June 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.

EPRI (2012), “State-of-the-Practice Liners and Caps for Coal Combustion Product Management Facilities”, Electric Power Research Institute, October 2012.

Fredlund D.G., Xing A., and Huang S. (1994), “Predicting the permeability function for unsaturated soils using the soil-water characteristic curve”, Canadian Geotechnical Journal, 31(4): 533–546.

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Holtz, R.D., and Kovacs, W.D. (1981), “An Introduction to Geotechnical Engineering”, Prentice-Hall, Inc., Upper Saddle River, NJ, 1981.

Spencer, E. (1967), “A Method of Analysis of the Stability of Embankments Assuming Parallel Inter-Slice Forces”, Geotechnique, Vol. 17, No. 1, 1967, pp. 11-26.

TVA (2020), "Construction and Major Modifications of CCR Storage Facilities", Revision 0, June 11, 2020

TVA (2021), "CCR Landfill Life Cycle Management", Revision 0, March 31, 2021.

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

TABLES

Table 1. Summary of Selected Design Strengths (after AECOM, 2018)

Material	Unit Weight, γ_t (pcf[1])	Cohesion, c' (psf[[1])	Friction Angle, ϕ' (degrees)	Triaxial Undrained Strength at Crest (psf)	Triaxial Undrained Strength at Toe (psf)	Direct Simple Shear Undrained Strength at Crest (psf)	Direct Simple Shear Undrained Strength at Toe (psf)
CCR	90	0	42	-	-	-	-
Final Raise	132	0	35	-	-	-	-
1958 Raise	132	0	35	-	-	-	-
Initial Embankment	132	0	35	-	-	-	-
Lower Alluvium	131	0	35	2500	-	1250	-
Clayey Sand Alluvium	120	0	35	1500	2700	750	1300
Residuum - North	122	0	34	1750	1500	1600	1400
Bedrock	Infinite Strength			-	-	-	-
PRB Wall[2]	120	0	32	-	-	-	-
PRB Clay Cap[3]	130	150	35	-	-	-	-

Notes:

[1] pcf: pounds per cubic foot; psf: pounds per square foot.
[2] The PRB Wall will be constructed primarily of sand type materials. The strengths used herein are estimates based on properties typical of sands.
[3] The PRB Wall clay cap will be constructed primarily of clay type materials. The strengths used herein are estimates based on properties typical of clays.
[4] Details discussing the anisotropic shear strength functions may be found in the Structural Assessment (AECOM, 2018).

Table 2. Summary of Calibrated Hydraulic Conductivities

Material	Assumed Void Ratio, e	Assumed Specific Gravity, G_s	Calculated Saturated Water Content, W (%)	Assumed Saturated Hydraulic Conductivity, K (cm/s[1]) (ft/s[1])	Comments
CCR	0.67	2.3	29	1×10^{-6} cm/s 3.28×10^{-8} ft/s	e calculated based on porosity, n, equal to 0.4, typical of CCR (EPRI, 2012), G_s selected typical of CCR (EPRI, 2012). K falls within the upper limits of date reported in the Environmental Investigation Plan, EIP (AECOM, 2016).
Dike Materials - Final Raise - 1958 Raise - Initial Embankment	0.7	2.7	26	1×10^{-6} cm/s 3.28×10^{-8} ft/s	e typical of clayey soils. G_s selected consistent with the Structural Assessment (AECOM, 2018). K adjusted as part of SEEP/W calibration.
Foundation Materials - Lower Alluvium - Clayey Sand Alluvium - Residuum - North	N/A – saturated	N/A – saturated	N/A – saturated	1×10^{-5} cm/s 3.28×10^{-7} ft/s	--
Bedrock	N/A – saturated	N/A – saturated	N/A – saturated	1×10^{-9} cm/s 3.28×10^{-11} ft/s	--
PRB Wall	0.8	2.65	30	1 cm/s 3.28×10^{-2} ft/s	
PRB Clay Cap	0.7	2.7	26	1×10^{-8} cm/s 3.28×10^{-10} ft/s	e and G_s assumed similar to dike fill. Saturated K typical of clayey soils

Notes:

[1] cm/s: centimeters per second; ft/s: foot per second.

Table 3. Summary of Threshold and Action Levels

Piezometer ID	Existing Ground Surface Elevation (ft NGVD29)	Current Water Level (ft NGVD29)	Threshold Level (ft NGVD29)	Action Level (ft NGVD29)
PRB-PZ-1	473.5	455	461	465
PRB-PZ-2	476	453	459	463
PRB-PZ-3	450	448.5	450	450

FIGURES

LEGEND

- Existing Piezometers
- Proposed Instruments - Slope Stability
- Proposed Instruments - Groundwater
- PRB Wall (Approximate)
- Property Boundary (Approximate)
- NRS Boundary

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:
MAY 2021	FOSSIL AND HYDRO ENGINEERING

ATTACHMENTS

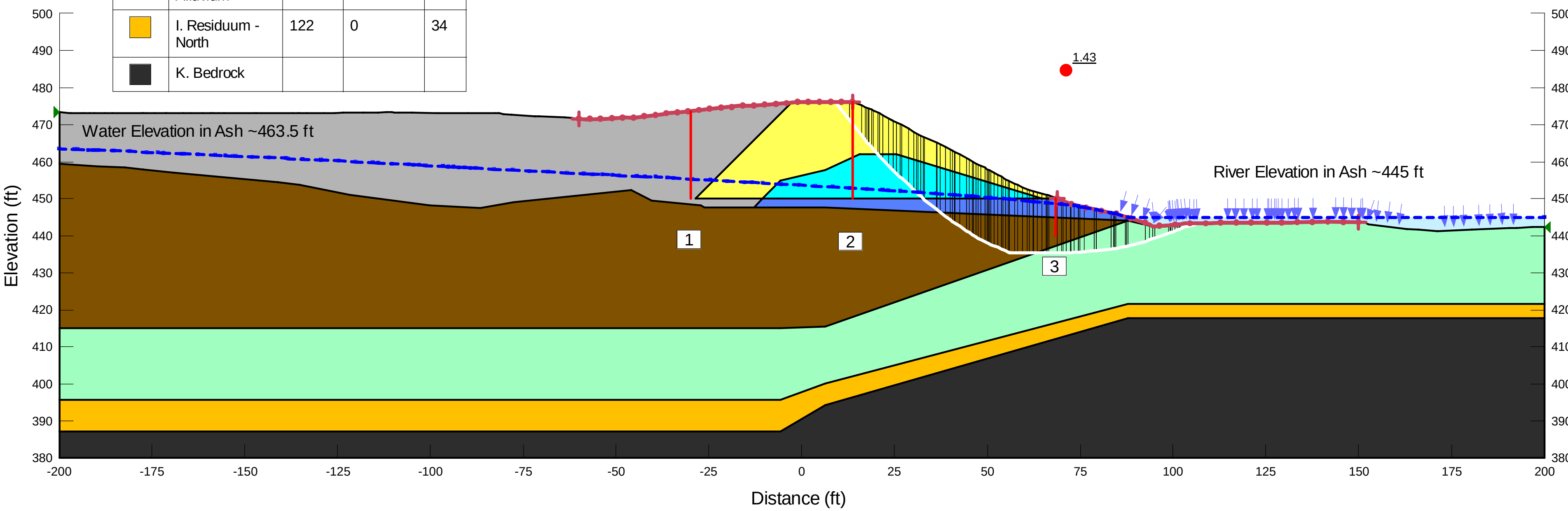
TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

1A - No Wall, No Load, Ash Water Level - 463.5ft [Drained Alluvium]

All piezometers shown at approximate location for illustrative purposes only.

1. PRB-PZ-1
2. PRB-PZ-2/INC-2
3. PRB-PZ-3

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	A. CCR	90	0	42
	B. Final Raise	132	0	35
	C. 1958 Raise	132	0	35
	D. Initial Embankment	132	0	35
	F. Lower Alluvium	131	0	35
	G. Clayey Sand Alluvium	120	0	35
	I. Residuum - North	122	0	34
	K. Bedrock			



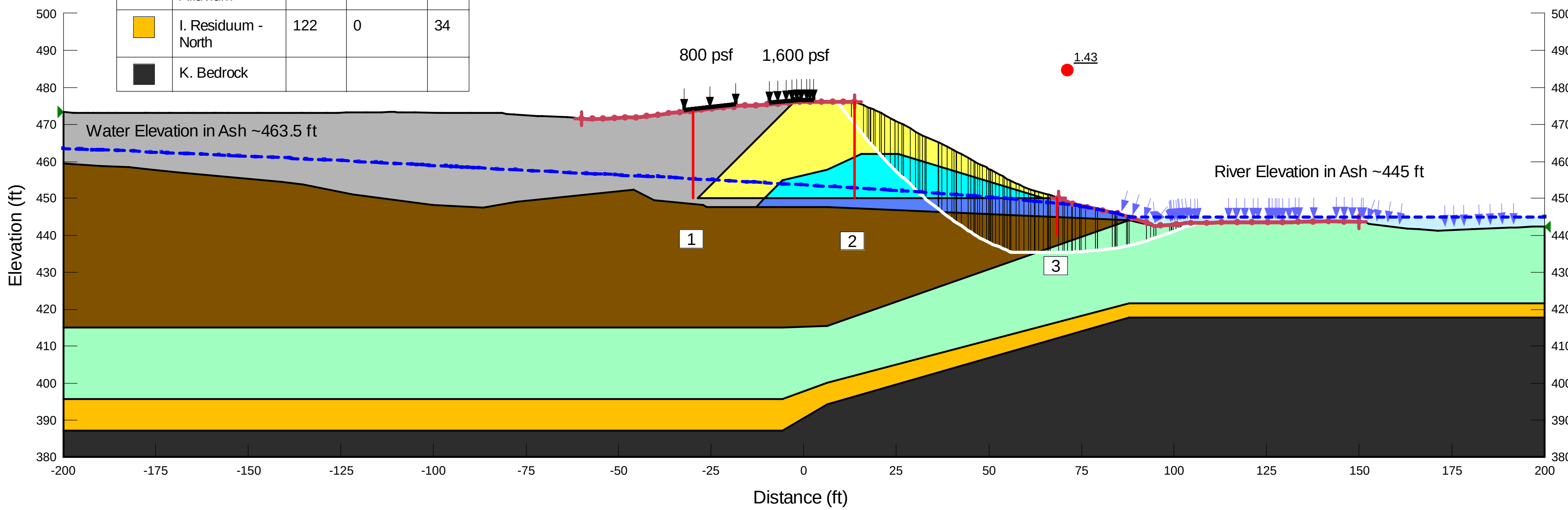
TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

1B - No Wall, Offset Load, Ash Water Level - 463.5ft [Drained Alluvium]

All piezometers shown at approximate location for illustrative purposes only.

1. PRB-PZ-1
2. PRB-PZ-2/INC-2
3. PRB-PZ-3

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	A. CCR	90	0	42
	B. Final Raise	132	0	35
	C. 1958 Raise	132	0	35
	D. Initial Embankment	132	0	35
	F. Lower Alluvium	131	0	35
	G. Clayey Sand Alluvium	120	0	35
	I. Residuum - North	122	0	34
	K. Bedrock			



TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

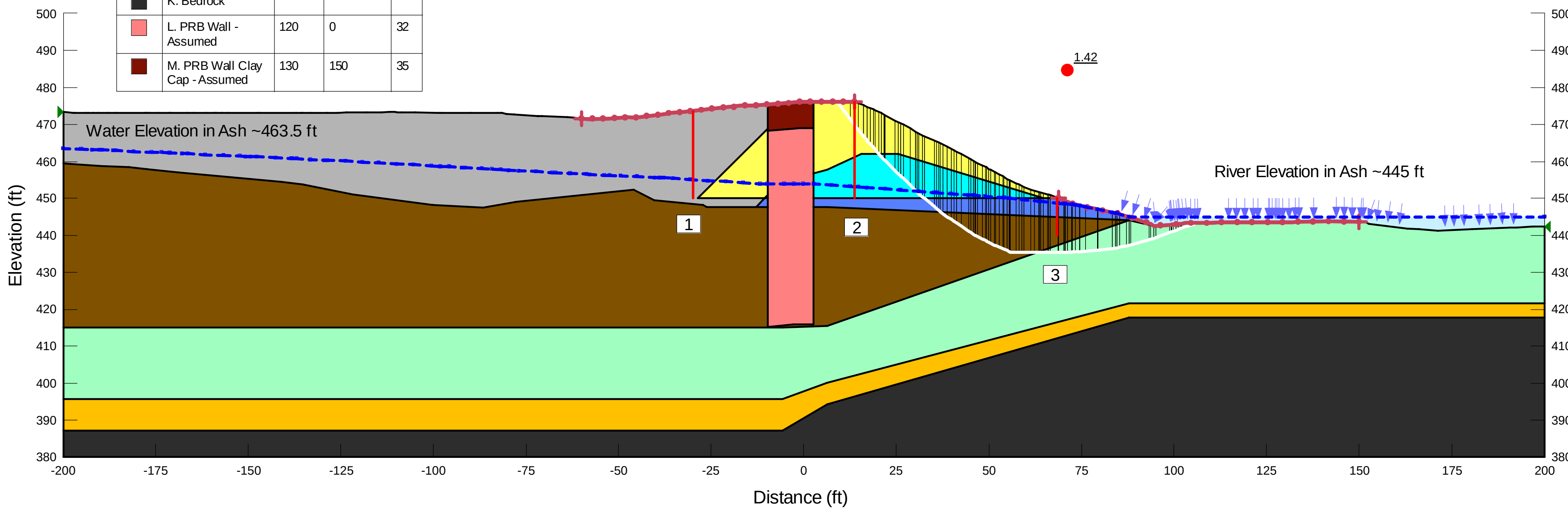
AECOM

2A - PRB Wall, No Load, Ash Water Level - 463.5ft [Drained Alluvium]

All piezometers shown at approximate location for illustrative purposes only.

1. PRB-PZ-1
2. PRB-PZ-2/INC-2
3. PRB-PZ-3

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	A. CCR	90	0	42
	B. Final Raise	132	0	35
	C. 1958 Raise	132	0	35
	D. Initial Embankment	132	0	35
	F. Lower Alluvium	131	0	35
	G. Clayey Sand Alluvium	120	0	35
	I. Residuum - North	122	0	34
	K. Bedrock			
	L. PRB Wall - Assumed	120	0	32
	M. PRB Wall Clay Cap - Assumed	130	150	35



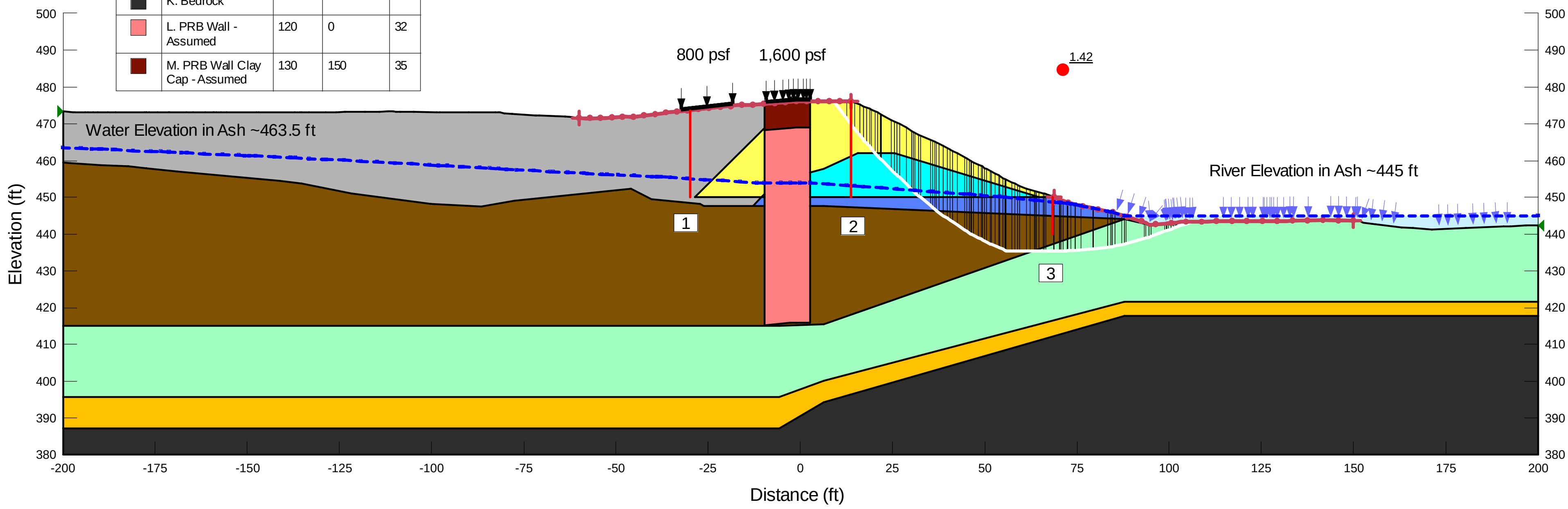
TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

2B - PRB Wall, Offset Load, Ash Water Level - 463.5ft [Drained Alluvium]

All piezometers shown at approximate location for illustrative purposes only.

1. PRB-PZ-1
2. PRB-PZ-2/INC-2
3. PRB-PZ-3

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	A. CCR	90	0	42
	B. Final Raise	132	0	35
	C. 1958 Raise	132	0	35
	D. Initial Embankment	132	0	35
	F. Lower Alluvium	131	0	35
	G. Clayey Sand Alluvium	120	0	35
	I. Residuum - North	122	0	34
	K. Bedrock			
	L. PRB Wall - Assumed	120	0	32
	M. PRB Wall Clay Cap - Assumed	130	150	35



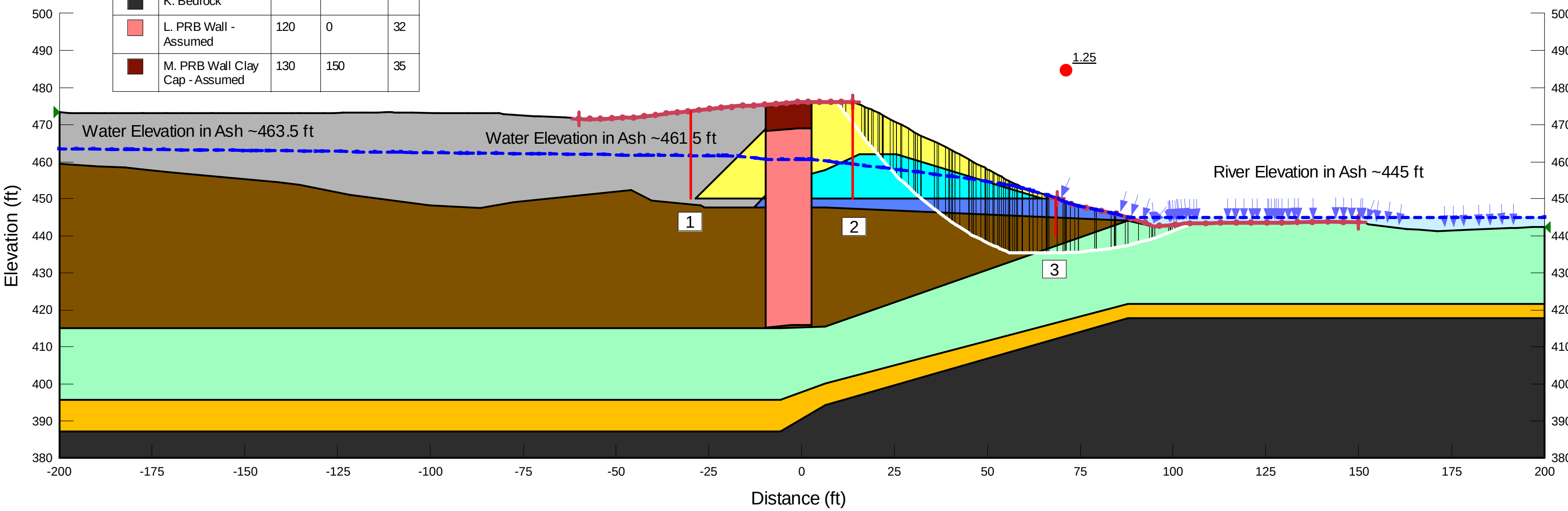
TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

3A - PRB Wall, No Load, Ash Water Level - Threshold Level [Drained Alluvium]

All piezometers shown at approximate location for illustrative purposes only.

1. PRB-PZ-1
2. PRB-PZ-2/INC-2
3. PRB-PZ-3

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	A. CCR	90	0	42
	B. Final Raise	132	0	35
	C. 1958 Raise	132	0	35
	D. Initial Embankment	132	0	35
	F. Lower Alluvium	131	0	35
	G. Clayey Sand Alluvium	120	0	35
	I. Residuum - North	122	0	34
	K. Bedrock			
	L. PRB Wall - Assumed	120	0	32
	M. PRB Wall Clay Cap - Assumed	130	150	35



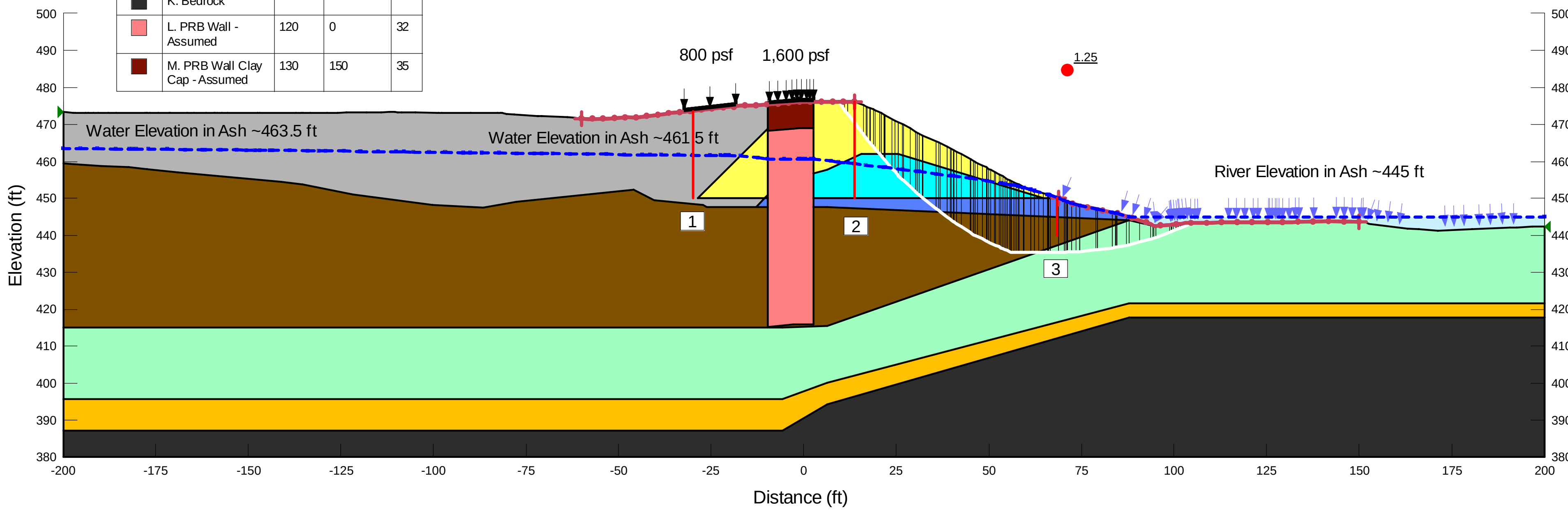
TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

3B - PRB Wall, Offset Load, Ash Water Level - Threshold Level [Drained Alluvium]

All piezometers shown at approximate location for illustrative purposes only.

1. PRB-PZ-1
2. PRB-PZ-2/INC-2
3. PRB-PZ-3

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	A. CCR	90	0	42
	B. Final Raise	132	0	35
	C. 1958 Raise	132	0	35
	D. Initial Embankment	132	0	35
	F. Lower Alluvium	131	0	35
	G. Clayey Sand Alluvium	120	0	35
	I. Residuum - North	122	0	34
	K. Bedrock			
	L. PRB Wall - Assumed	120	0	32
	M. PRB Wall Clay Cap - Assumed	130	150	35



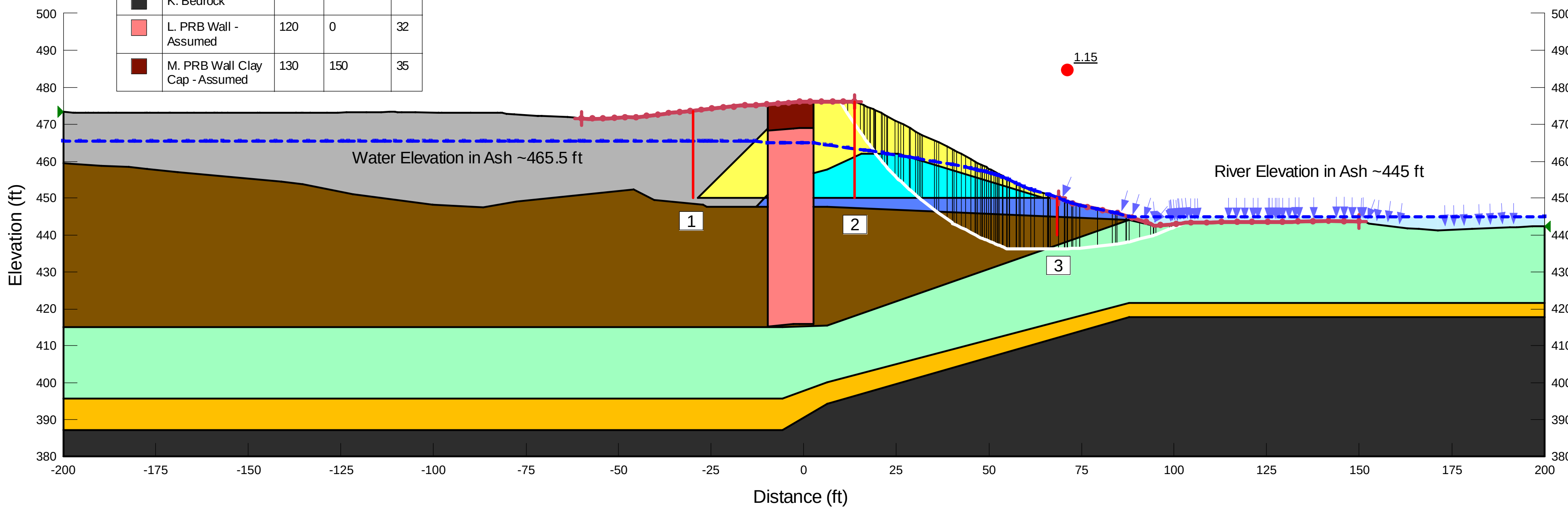
TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

4A - PRB Wall, No Load, Ash Water Level - Action Level [Drained Alluvium]

All piezometers shown at approximate location for illustrative purposes only.

1. PRB-PZ-1
2. PRB-PZ-2/INC-2
3. PRB-PZ-3

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	A. CCR	90	0	42
	B. Final Raise	132	0	35
	C. 1958 Raise	132	0	35
	D. Initial Embankment	132	0	35
	F. Lower Alluvium	131	0	35
	G. Clayey Sand Alluvium	120	0	35
	I. Residuum - North	122	0	34
	K. Bedrock			
	L. PRB Wall - Assumed	120	0	32
	M. PRB Wall Clay Cap - Assumed	130	150	35



TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

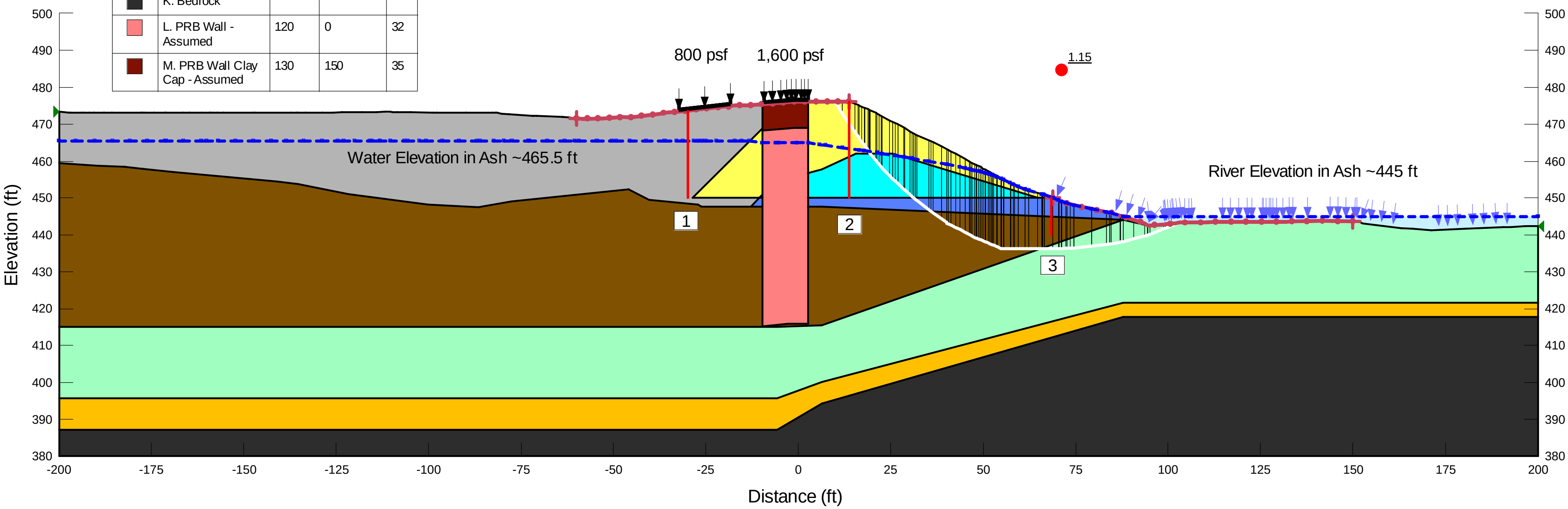
AECOM

4B - PRB Wall, Offset Load, Ash Water Level - Action Level [Drained Alluvium]

All piezometers shown at approximate location for illustrative purposes only.

1. PRB-PZ-1
2. PRB-PZ-2/INC-2
3. PRB-PZ-3

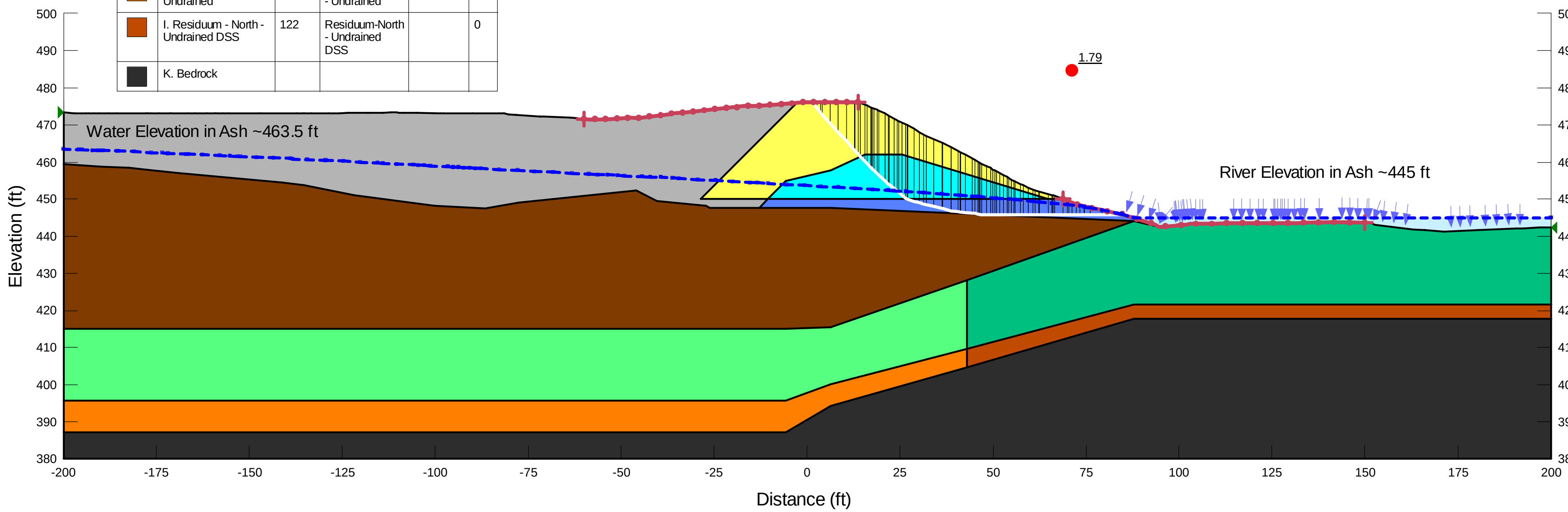
Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	A. CCR	90	0	42
	B. Final Raise	132	0	35
	C. 1958 Raise	132	0	35
	D. Initial Embankment	132	0	35
	F. Lower Alluvium	131	0	35
	G. Clayey Sand Alluvium	120	0	35
	I. Residuum - North	122	0	34
	K. Bedrock			
	L. PRB Wall - Assumed	120	0	32
	M. PRB Wall Clay Cap - Assumed	130	150	35



TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

5A - No Wall, No Load, Ash Water Level - 463.5ft [Undrained Alluvium]

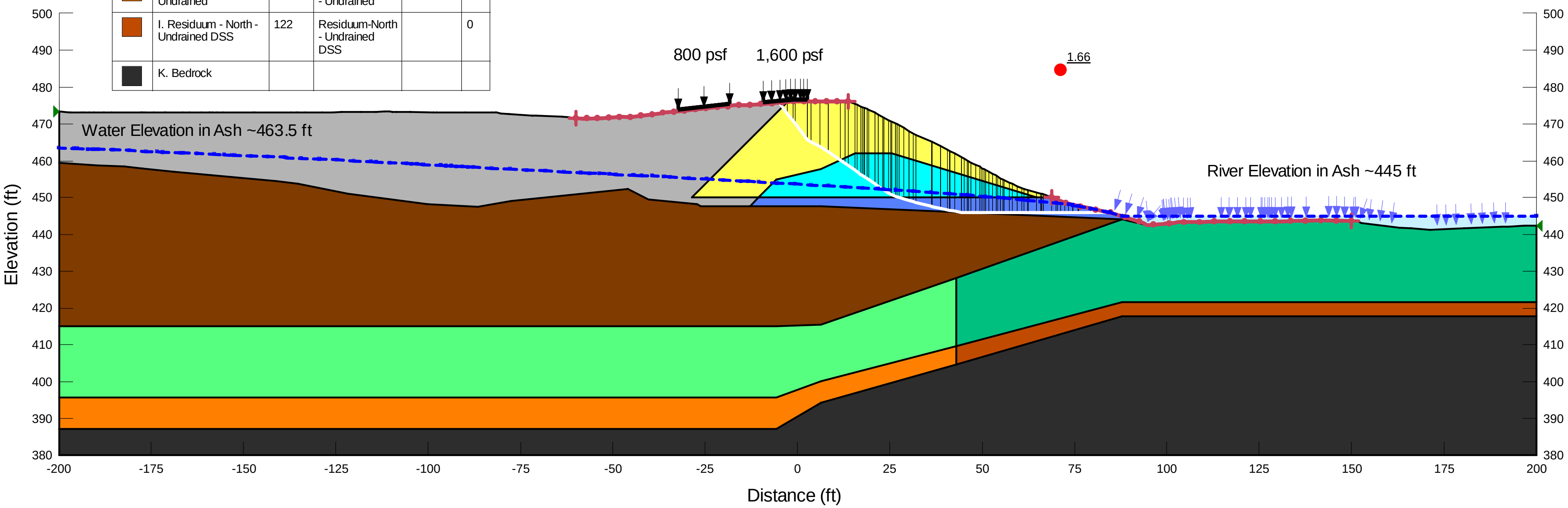
Color	Name	Unit Weight (pcf)	Cohesion Fn	Cohesion' (psf)	Phi' (°)
	A. CCR	90		0	42
	B. Final Raise	132		0	35
	C. 1958 Raise	132		0	35
	D. Initial Embankment	132		0	35
	F2. Lower Alluvium - Undrained	131		2,500	0
	G1. Clayey Sand Alluvium - Undrained	120	Clayey Sand Alluvium - Undrained		0
	G2. Clayey Sand Alluvium - Undrained DSS	120	Clayey Sand Alluvium - Undrained DSS		0
	I. Residuum - North - Undrained	122	Residuum-North - Undrained		0
	I. Residuum - North - Undrained DSS	122	Residuum-North - Undrained DSS		0
	K. Bedrock				



TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

5B - No Wall, Offset Load, Ash Water Level - 463.5ft [Undrained Alluvium]

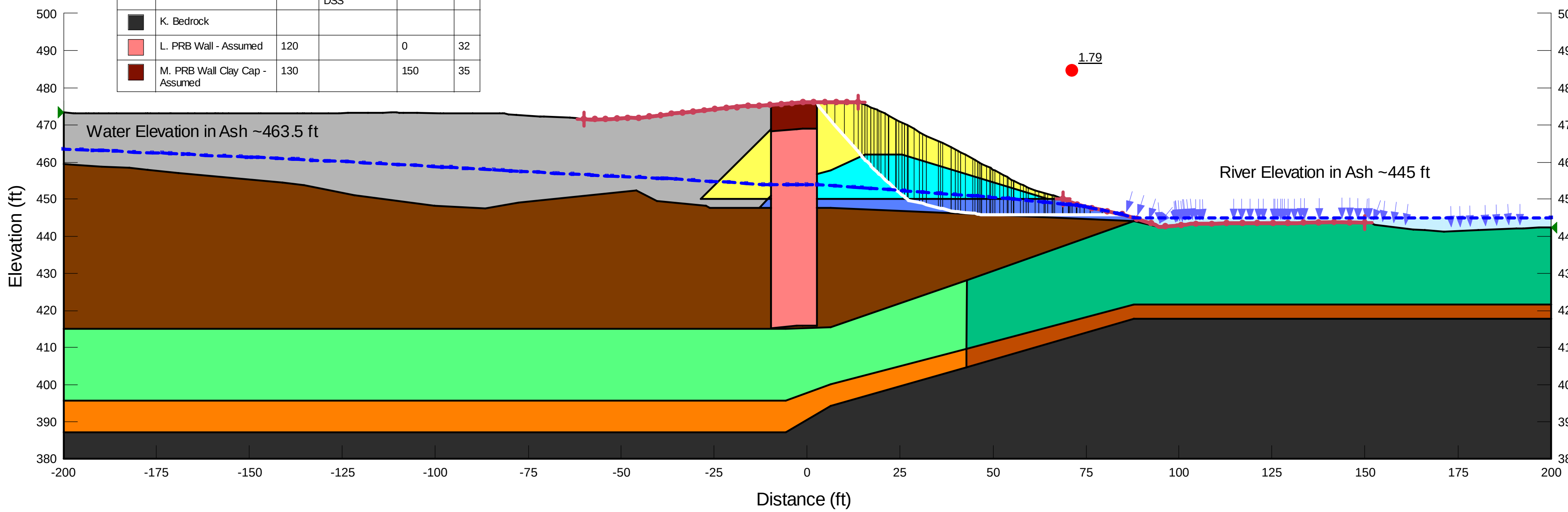
Color	Name	Unit Weight (pcf)	Cohesion Fn	Cohesion' (psf)	Phi' (°)
	A. CCR	90		0	42
	B. Final Raise	132		0	35
	C. 1958 Raise	132		0	35
	D. Initial Embankment	132		0	35
	F2. Lower Alluvium - Undrained	131		2,500	0
	G1. Clayey Sand Alluvium - Undrained	120	Clayey Sand Alluvium - Undrained		0
	G2. Clayey Sand Alluvium - Undrained DSS	120	Clayey Sand Alluvium - Undrained DSS		0
	I. Residuum - North - Undrained	122	Residuum-North - Undrained		0
	I. Residuum - North - Undrained DSS	122	Residuum-North - Undrained DSS		0
	K. Bedrock				



TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

6A - PRB Wall, No Load, Ash Water Level - 463.5ft [Undrained Alluvium]

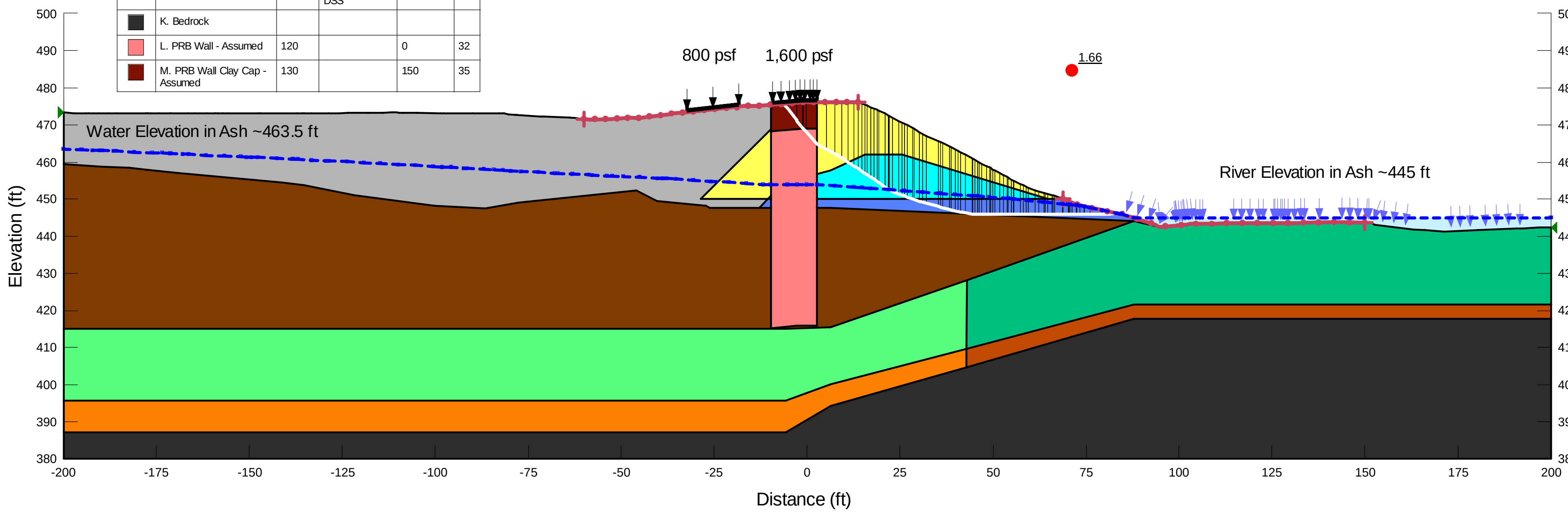
Color	Name	Unit Weight (pcf)	Cohesion Fn	Cohesion' (psf)	Phi' (°)
	A. CCR	90		0	42
	B. Final Raise	132		0	35
	C. 1958 Raise	132		0	35
	D. Initial Embankment	132		0	35
	F2. Lower Alluvium - Undrained	131		2,500	0
	G1. Clayey Sand Alluvium - Undrained	120	Clayey Sand Alluvium - Undrained		0
	G2. Clayey Sand Alluvium - Undrained DSS	120	Clayey Sand Alluvium - Undrained DSS		0
	I. Residuum - North - Undrained	122	Residuum-North - Undrained		0
	I. Residuum - North - Undrained DSS	122	Residuum-North - Undrained DSS		0
	K. Bedrock				
	L. PRB Wall - Assumed	120		0	32
	M. PRB Wall Clay Cap - Assumed	130		150	35



TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

6B - PRB Wall, Offset Load, Ash Water Level - 463.5ft [Undrained Alluvium]

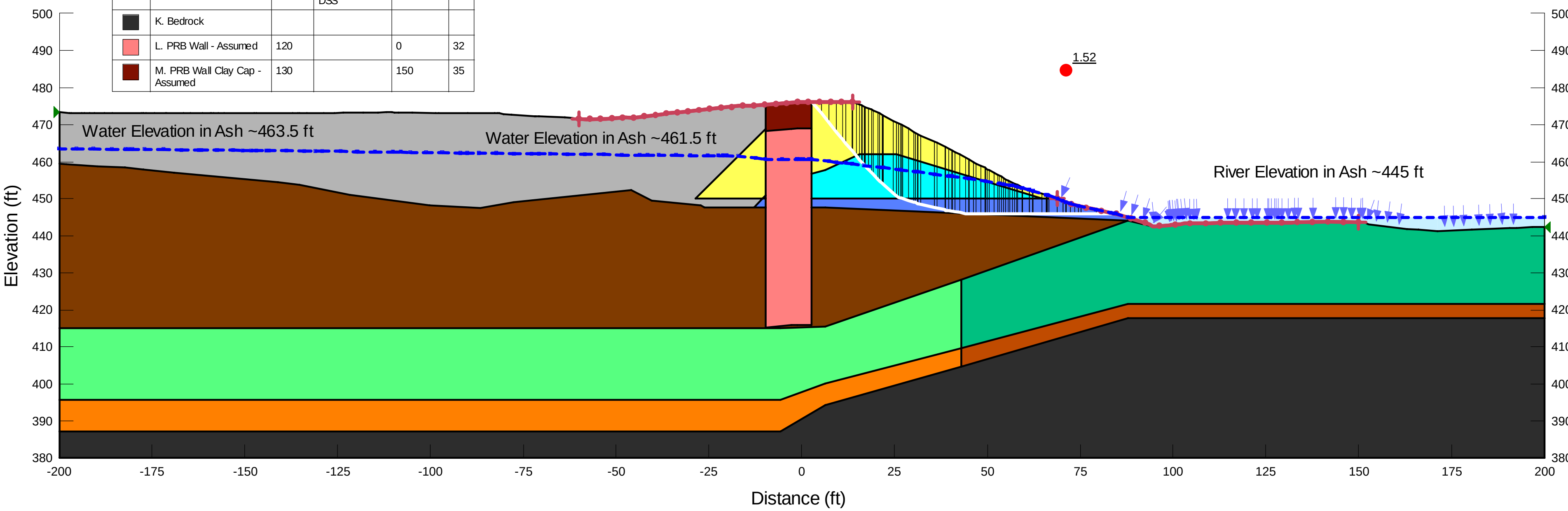
Color	Name	Unit Weight (pcf)	Cohesion Fn	Cohesion' (psf)	Phi' (°)
	A. CCR	90		0	42
	B. Final Raise	132		0	35
	C. 1958 Raise	132		0	35
	D. Initial Embankment	132		0	35
	F2. Lower Alluvium - Undrained	131		2,500	0
	G1. Clayey Sand Alluvium - Undrained	120	Clayey Sand Alluvium - Undrained		0
	G2. Clayey Sand Alluvium - Undrained DSS	120	Clayey Sand Alluvium - Undrained DSS		0
	I. Residuum - North - Undrained	122	Residuum-North - Undrained		0
	I. Residuum - North - Undrained DSS	122	Residuum-North - Undrained DSS		0
	K. Bedrock				
	L. PRB Wall - Assumed	120		0	32
	M. PRB Wall Clay Cap - Assumed	130		150	35



TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

7A - PRB Wall, No Load, Ash Water Level - Threshold Level [Undrained Alluvium]

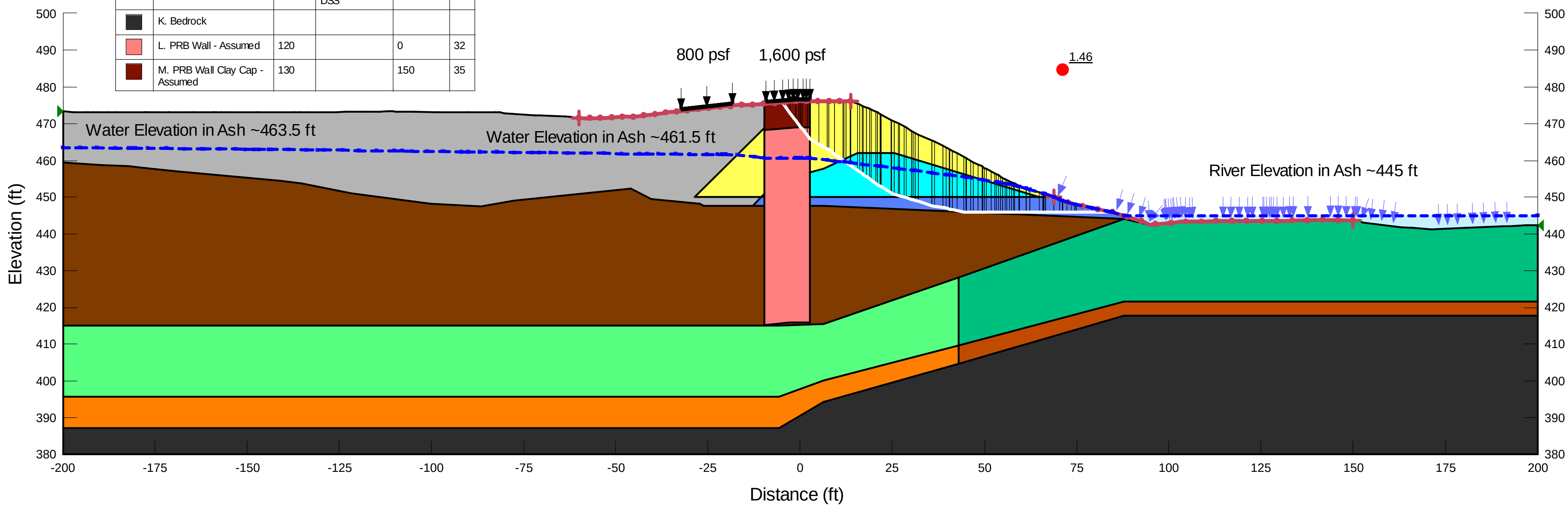
Color	Name	Unit Weight (pcf)	Cohesion Fn	Cohesion' (psf)	Phi' (°)
	A. CCR	90		0	42
	B. Final Raise	132		0	35
	C. 1958 Raise	132		0	35
	D. Initial Embankment	132		0	35
	F2. Lower Alluvium - Undrained	131		2,500	0
	G1. Clayey Sand Alluvium - Undrained	120	Clayey Sand Alluvium - Undrained		0
	G2. Clayey Sand Alluvium - Undrained DSS	120	Clayey Sand Alluvium - Undrained DSS		0
	I. Residuum - North - Undrained	122	Residuum-North - Undrained		0
	I. Residuum - North - Undrained DSS	122	Residuum-North - Undrained DSS		0
	K. Bedrock				
	L. PRB Wall - Assumed	120		0	32
	M. PRB Wall Clay Cap - Assumed	130		150	35



TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

7B - PRB Wall, Offset Load, Ash Water Level - Threshold Level [Undrained Alluvium]

Color	Name	Unit Weight (pcf)	Cohesion Fn	Cohesion' (psf)	Phi' (°)
	A. CCR	90		0	42
	B. Final Raise	132		0	35
	C. 1958 Raise	132		0	35
	D. Initial Embankment	132		0	35
	F2. Lower Alluvium - Undrained	131		2,500	0
	G1. Clayey Sand Alluvium - Undrained	120	Clayey Sand Alluvium - Undrained		0
	G2. Clayey Sand Alluvium - Undrained DSS	120	Clayey Sand Alluvium - Undrained DSS		0
	I. Residuum - North - Undrained	122	Residuum-North - Undrained		0
	I. Residuum - North - Undrained DSS	122	Residuum-North - Undrained DSS		0
	K. Bedrock				
	L. PRB Wall - Assumed	120		0	32
	M. PRB Wall Clay Cap - Assumed	130		150	35

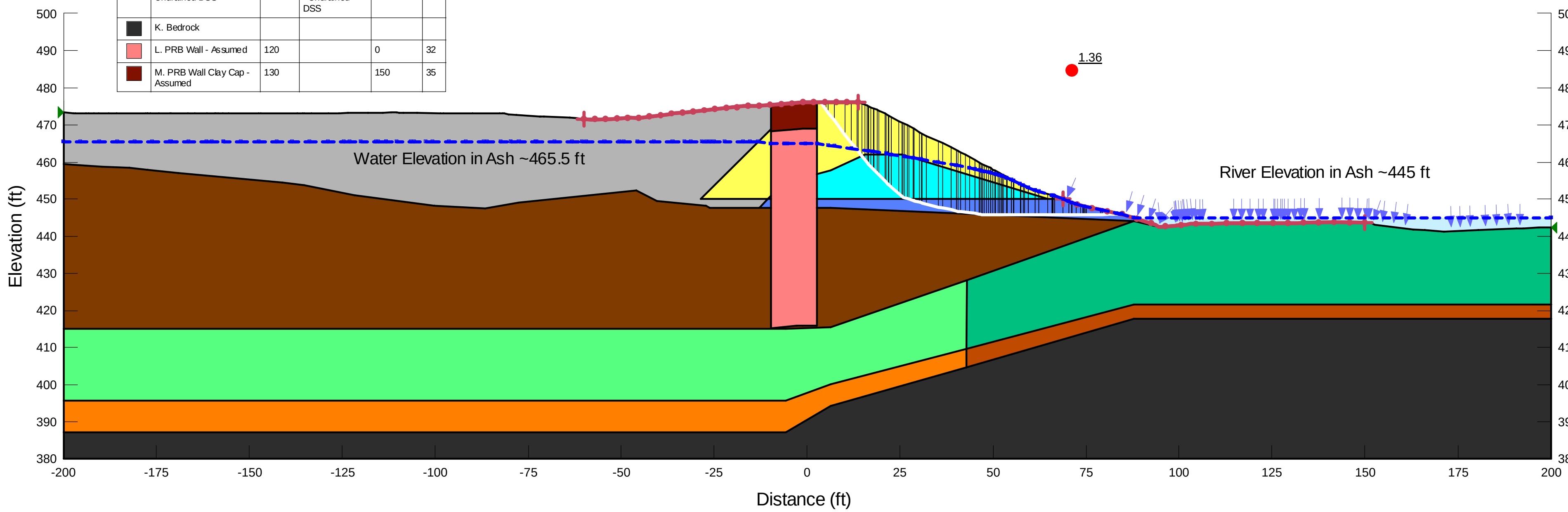


TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

AECOM

8A - PRB Wall, No Load, Ash Water Level - Action Level [Undrained Alluvium]

Color	Name	Unit Weight (pcf)	Cohesion Fn	Cohesion' (psf)	Phi' (°)
	A. CCR	90		0	42
	B. Final Raise	132		0	35
	C. 1958 Raise	132		0	35
	D. Initial Embankment	132		0	35
	F2. Lower Alluvium - Undrained	131		2,500	0
	G1. Clayey Sand Alluvium - Undrained	120	Clayey Sand Alluvium - Undrained		0
	G2. Clayey Sand Alluvium - Undrained DSS	120	Clayey Sand Alluvium - Undrained DSS		0
	I. Residuum - North - Undrained	122	Residuum-North - Undrained		0
	I. Residuum - North - Undrained DSS	122	Residuum-North - Undrained DSS		0
	K. Bedrock				
	L. PRB Wall - Assumed	120		0	32
	M. PRB Wall Clay Cap - Assumed	130		150	35

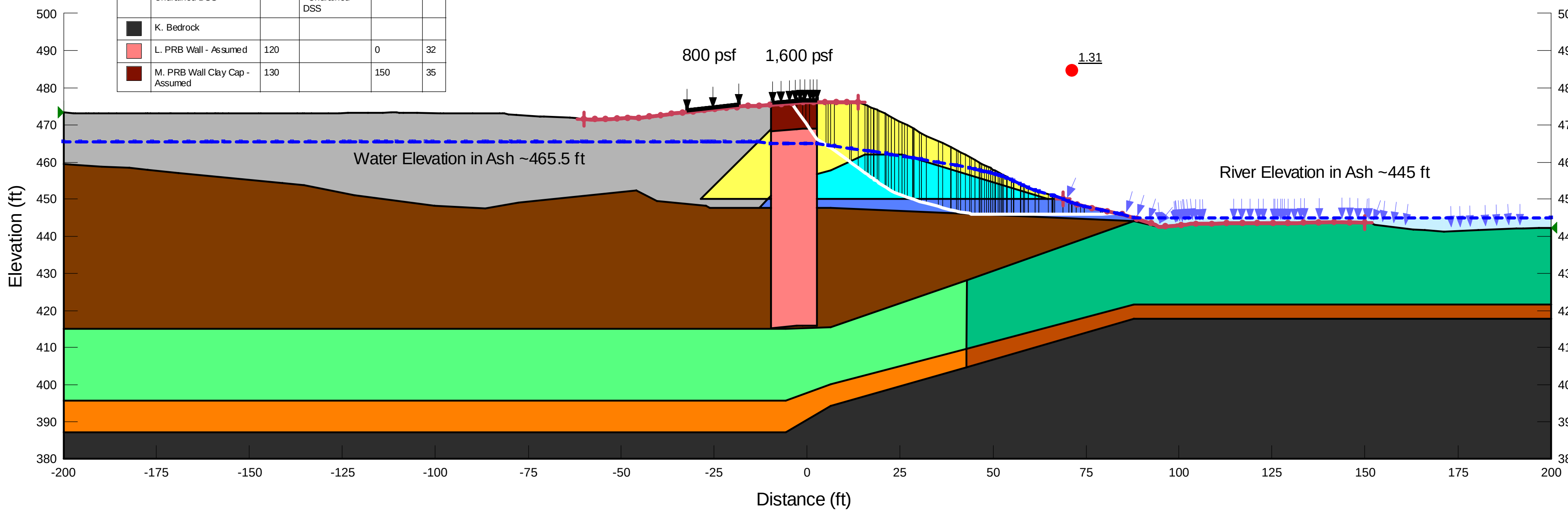


TVA GAF - NRS Permeable Reactive Barrier Wall
Section X-X'

AECOM

8B - PRB Wall, Offset Load, Ash Water Level - Action Level [Undrained Alluvium]

Color	Name	Unit Weight (pcf)	Cohesion Fn	Cohesion' (psf)	Phi' (°)
	A. CCR	90		0	42
	B. Final Raise	132		0	35
	C. 1958 Raise	132		0	35
	D. Initial Embankment	132		0	35
	F2. Lower Alluvium - Undrained	131		2,500	0
	G1. Clayey Sand Alluvium - Undrained	120	Clayey Sand Alluvium - Undrained		0
	G2. Clayey Sand Alluvium - Undrained DSS	120	Clayey Sand Alluvium - Undrained DSS		0
	I. Residuum - North - Undrained	122	Residuum-North - Undrained		0
	I. Residuum - North - Undrained DSS	122	Residuum-North - Undrained DSS		0
	K. Bedrock				
	L. PRB Wall - Assumed	120		0	32
	M. PRB Wall Clay Cap - Assumed	130		150	35



Appendix G
Temporary Construction Emergency Action Plan (TCEAP)

NRS Permeable Reactive Barrier Wall Field Demonstration Temporary Construction Emergency Action Plan

Tennessee Valley Authority
Gallatin Fossil Plant

Revision 0
May 25, 2021

Quality information

Prepared by	Checked by	Verified by	Approved by
David Skeggs, P.E.	Josh Colley, P.E.	Michael Wall, P.E.	Gabe Lang, P.E.

Revision History

Revision	Date	Description
0	05/25/2021	Initial Issue

Prepared for:

Tennessee Valley Authority

Prepared by:

AECOM
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Morrisville, NC 27560
aecom.com

Table of Contents

1. Purpose

As part of ongoing closure activities at the Tennessee Valley Authority (TVA) Gallatin Fossil Plant (GAF), TVA is proposing to conduct a Field Demonstration at the Non-Registered Site (NRS). Specifically, the Study will evaluate the feasibility and performance of a proposed Permeable Reactive Barrier (PRB) Wall to be located along the NRS perimeter dike. The PRB Wall is proposed to be approximately 40 feet (ft) long, 12 ft wide, and 60 ft deep. It is planned to construct the wall using drilled piers in an overlapping pattern similar to a secant pile wall. Heavy construction equipment e.g. drill rigs, track hoes, loaders, and dump trucks etc. will be used to construct the wall.

This document is a Temporary Construction Emergency Action Plan (TCEAP) that addresses construction of the PRB Field Demonstration. The purpose of this TCEAP is to provide contingency planning and guidance to the Contractor in the event that execution of the work results in unplanned adverse impacts to the project area.

This plan represents minimum contingency requirements. The Contractor shall provide input on the contingency items discussed in this plan prior to beginning construction.

2. Contingency Materials and Equipment

Prior to beginning construction, the Contractor shall provide the following quantities of materials for use or confirm with TVA that the following materials are available for use on-site:

- Concrete Sand: 50 tons
- TDOT No. 57 Stone: 50 tons
- TDOT No 2 Stone: 90 tons
- TDOT Class A-1 Rip Rap: 90 tons

During construction, it will be required that the Contractor and/or TVA maintain equipment onsite capable of implementing emergency actions should the need arise. The equipment required to be on site must be of adequate size and capacity to move and place material in a safe and timely manner and must be in good working order and accessible for use by the Contractor at any time. The following list represents the minimum equipment required:

- One (1) excavator
- Two (2) dump trucks
- One (1) bulldozer

3. Potential Construction Impacts

Potential adverse impacts that could take place during construction are discussed in the following sections. For each event listed, emergency contingency actions are suggested that should be implemented immediately upon observation of an adverse condition. The Construction Manager shall be contacted immediately upon initiation of any contingency actions.

3.1 Shallow Sloughing, Slope Instability, or Seepage

The project will be constructed adjacent to the Cumberland River along the perimeter dike of the NRS, a 70-acre Coal Combustion Residual (CCR) unit. Construction equipment is anticipated to operate adjacent to the perimeter dike, which will subject the construction area to new loading conditions. During these operations, slope sloughing, seepage, or instability could occur.

To observe and monitor pore water pressures within the perimeter dike system as a result of the construction loading, inspections, and monitoring of the downstream slope of the NRS shall be performed in accordance with the

Surveillance and Instrumentation Monitoring Plan (SIMP). Excess pore water or movement indicated by the instrumentation may result in the stoppage of work.

In addition to the SIMP procedures, the following contingency actions should be taken if shallow sloughing or seepage is observed along the perimeter dike system during construction:

- If the slope face slips or appears to be moving, immediately backfill the instability with Class A-1 rip rap. Smaller sloughs may be packed with No. 57 stone.
- If flowing seepage water is noticed within the slope face, backfill the seepage portion of the slope with concrete sand. After sand has been placed over the area, place a 1-ft layer of No. 57 stone over the sand to provide extra weight.

3.2 Heavy Equipment

In accordance with the project SIMP, heavy equipment and material stockpiles are required to maintain an 11-ft minimum offset from the downstream crest of the perimeter dike system. This will require equipment to access the site without traversing the perimeter dike access road of the NRS. Only personal vehicles may traverse the perimeter access road during construction. The Contractor shall develop a traffic plan to maintain adequate traffic patterns, appropriate use of signs or flaggers, and visual clearance for all equipment.

3.3 Working over CCR Subgrades

Construction activities will require construction equipment to traverse over areas of the NRS containing a CCR subgrade. The Contractor shall be aware that there are inherent risks associated with working on CCR, including but not limited to, soft bearing conditions or saturated subgrades and unstable excavation slopes. Failures and instabilities may occur on apparently firm surfaces when loaded. It is the Contractor's responsibility to actively manager their equipment and personnel to safely execute the work.

Prior to construction, the Contractor shall submit a plan to the Owner and Engineer for stabilizing the proposed construction areas to be utilized. When conditions change or if planned stabilization practices do not prove adequate, the Contractor shall stop work, re-evaluate the construction methods, and modify the plans and procedures accordingly. If working conditions become unstable, work shall be stopped, and all personnel and equipment shall exit the area. A revised stabilization plan shall be submitted to document the modified procedures based on site conditions.

If soft ground conditions are identified, areas that require stabilization may be completed using the following techniques or a combination of these techniques:

- Soil stabilization methods (lime/cement).
- Bridging over the subgrade using geogrid and No 2 or No 57 stone.
- Utilizing crane mats to distribute loading over the unstable areas.

Other stabilization methods may be utilized by the Contractor but must be proposed and approved by the Owner and Engineer. Note that any stabilization effort that requires the excavation of CCR will require regulatory approvals and may cause a delay in the work.

3.4 Work Near Water

The construction will occur adjacent to the Cumberland River. The Contractor should be aware of potential dangers associated with work near water. The following corrective measures should be considered during construction:

- Employees working within 6 feet of water must wear a personal flotation device (PFD).
- Provide equipment operators with appropriate means to break equipment/cab windows in the event that equipment becomes submerged.
- Require that at least one employee trained in CPR and first aid is onsite during work activities.

- Provide adequate Best Management Practices for equipment working adjacent to the River to prevent against environmental release. Spill kits should be available onsite in the event of an environmental release.
- The Construction Manager shall be notified immediately if a release occurs. A release will trigger implementation of the site Emergency Action Plan.

3.5 Extensive Rainfall/Flooding

During a large storm event, uncontrolled discharge of stormwater runoff could cause erosion, saturation of the construction site, and interruption of construction activities. The Contractor should maintain an awareness of weather conditions predicted at the site and plan accordingly by protecting stockpiles, soil borrow areas and excavations in advance of large storm events. Every effort should be made to prevent rainfall or runoff to enter the PRB, auger borings or casings. While the project is not anticipated to disturb more than an acre of land and does not require a Storm Water Pollution Prevention Plan (SWPPP), erosion and sediment control best management practices may be necessary in the event of large storm events to prevent uncontrolled storm water runoff or sediment discharge from the work area.

3.6 Construction Dewatering

Dewatering is not required to advance the augers but may be required for placement of the amended sand during PRB construction. Water in the auger holes will be pumped out and placed in one or more fractionation tanks. These tanks are typically 20,000-gallon capacity and will be placed upon containment. Water will be conveyed to the Plant, pre-treated as necessary to remove silt and adjust pH, and pumped through the Plant Flow Management System prior to discharge under the existing NPDES Permit.

Additional construction dewatering may be required if subsurface water prevents the proper installation of the PRB, or if SIMP monitoring of water levels within the CCR or perimeter dike indicates a need for additional construction dewatering to maintain adequate factors of safety.

3.7 Damage to Instrumentation or Monitoring Wells

The work is to be performed in the vicinity of several existing groundwater monitoring wells and instrumentation utilized for geotechnical monitoring. During construction, new instrumentation and monitoring wells are proposed. These instruments and wells are to be maintained throughout the construction. To minimize the potential for damage to instrumentation posts with orange construction safety fencing or other protective measures approved by the Owner shall be installed around existing instrumentation. Flagging of the instruments may be necessary as an additional visual control for equipment operators.

4. Emergency Response Notification Procedures

It is important that all personnel are familiar with emergency response and incident management procedures. Following selection of the Contractor but prior to construction, an emergency response contact list shall be developed to provide clear instruction for notification procedures for all parties in the event of an emergency or contingency action.