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INDIANA-KENTUCKY ELECTRIC CORPORATION**

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November 30, 2020

Submitted Electronically via Email

Mr. Andrew R. Wheeler, EPA Administrator
Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Mail Code 5304-P
Washington, DC 20460

**Re: Indiana-Kentucky Electric Corporation
Clifty Creek Power Station Alternative Closure Demonstration
Amendment 2**

Dear Administrator Wheeler:

The Indiana-Kentucky Electric Corporation (IKEC) hereby submits a second amended request to the U.S. Environmental Protection Agency (EPA) for approval for a site-specific alternative deadline to initiate closure pursuant to 40 C.F.R. § 257.103(f)(1) for the two CCR surface impoundments (West Boiler Slag Pond and the Landfill Runoff Collection Pond) located at the Clifty Creek Power Station near Madison, Indiana. IKEC is requesting an extension pursuant to 40 C.F.R. § 257.103(f)(1) to allow the impoundments to continue to receive CCR and non-CCR waste streams after April 11, 2021, in order to retrofit the facility operations sequentially and in a holistic manner to comply with both CCR regulatory requirements as well as new Steam Electric Effluent Limitation Guidelines (ELG) requirements at 40 CFR 423 (final rule published October 13, 2020), applicable to the ash transport water used to sluice boiler slag to the West Boiler Slag Pond.

Our original submittal was filed electronically on October 15, 2020, and the first amendment was filed on November 17, 2020. This second revision to our demonstration package includes additional descriptions, clarifications and details we shared with USEPA staff during an October 29, 2020, conference call reviewing our initial demonstration submittal, as well as additional data and details addressing feedback received from USEPA following submittal of our first amendment.

In addition to securing applicable environmental permits for construction and system modifications, the West Boiler Slag Pond (WBSP) and Landfill Runoff Collection Pond (LRCP) modifications include the following activities:

- WBSP activities:
 - Construction of a new concrete settling tank for boiler slag material within the WBSP footprint,

- Re-routing the boiler slag and mill reject sluice flows currently entering the unlined surface impoundment to the new concrete settling tank,
 - Installation of piping and water treatment for the establishment of a high recycle rate boiler slag ash transport water system compliant with new ELG requirements,
 - Repurposing of a portion of the unlined WBSP via construction of a new, lined low-volume wastewater treatment system (LVWTS) for treatment of non-CCR wastewater generated at the facility,
 - Rerouting of the non-CCR waste streams to the LVWTS once it is constructed, and
 - Initiation of closure activities for the balance of the unlined WBSP footprint.
- LRCP activities:
 - Construction of new stormwater controls to reroute stormwater from off-site sources away from plant property and around the west side of the LRCP to a new stormwater outfall,
 - Construction of a new landfill runoff/leachate management system, and
 - Initiation of closure of the balance of the LRCP.

Enclosed is a demonstration prepared by Burns & McDonnell that addresses all of the criteria in 40 C.F.R. § 257.103(f)(1)(i)-(iii) and contains the documentation required by 40 C.F.R. § 257.103(f)(1)(iv). As allowed by the agency, in lieu of hard copies of these documents, electronic files were submitted to Kirsten Hillyer, Frank Behan, and Richard Huggins via email.

If you have any questions regarding this submittal, please contact either myself at (740) 289-7299 or mbrown@ovec.com or Gabriel Coriell at either (740) 289-7267 or gcoriell@ovec.com.

Sincerely,



J. Michael Brown
Environmental, Safety & Health Director
Ohio Valley Electric Corporation/
Indiana-Kentucky Electric Corporation

JMB:klr

Attachments

cc: Kirsten Hillyer - USEPA
Frank Behan - USEPA
Richard Huggins - USEPA

**Clifty Creek Station
CCR Surface Impoundment
Demonstration for a Site-Specific
Alternative to Initiation of Closure
Deadline**



**Indiana-Kentucky Electric Corporation
Clifty Creek Station
Coal Combustion Residual Rule Compliance**

Revision 2
November 30, 2020

Clifty Creek Station CCR Surface Impoundment Demonstration for a Site- Specific Alternative to Initiation of Closure Deadline

Prepared for

**Indiana-Kentucky Electric Corporation
Clifty Creek Station
Coal Combustion Residual Rule Compliance
Madison, Indiana**

**Revision 2
November 30, 2020**

Prepared by

**Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri**

INDEX AND CERTIFICATION

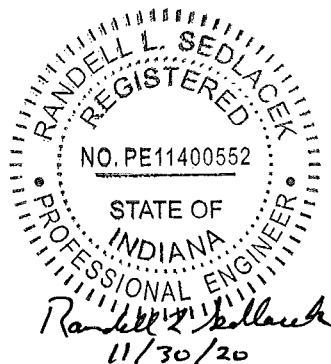
Indiana-Kentucky Electric Corporation Clifty Creek Station CCR Surface Impoundment Demonstration for a Site-Specific Alternative to Initiation of Closure Deadline

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Certification

I hereby certify, as a Professional Engineer in the State of Indiana, that the information in this document was assembled under my direct supervisory control. This report is not intended or represented to be suitable for reuse by the Indiana-Kentucky Electric Corporation or others without specific verification or adaptation by the Engineer.



Randell L. Sedlacek
Randell L Sedlacek, P.E. (IN PE11400552)

Date: November 30, 2020

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LIST OF ABBREVIATIONS

<u>Abbreviation</u>	<u>Term/Phrase/Name</u>
ACM	Assessment of Corrective Measures
ASD	Alternate Source Demonstration
BMcD	Burns & McDonnell
BSHS	Boiler slag handling system
CCR	Coal Combustion Residual
CFR	Code of Federal Regulations
ELGs	Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category
EPA	Environmental Protection Agency
EPC	Engineer-Procure-Construct
FEED	Front-end engineering design
FGD	Flue Gas Desulfurization
GPM	Gallons Per Minute
GWPS	Groundwater Protection Standards
IDEM	Indiana Department of Environmental Management
IKEC	Indiana-Kentucky Electric Corporation (Owner)
IDNR	Indiana Department of Natural Resources
LRCF	Landfill Runoff Collection Pond
LVWTS	Low Volume Wastewater Treatment System
MGD	Million gallons per day
MW	Megawatt
NPDES	National Pollutant Discharge Elimination System

<u>Abbreviation</u>	<u>Term/Phrase/Name</u>
OVEC	Ohio Valley Electric Corporation (Owner)
PDC	Power Distribution Center
PDR	Project Definition Report
PSD	Prevention of Significant Deterioration
POTW	Publicly Owned Treatment Works
RCRA	Resource Conservation and Recovery Act
RWS	Indiana Restricted Waste Site
TDS	Total Dissolved Solids
U.S.C.	United States Code
WBSP	West Boiler Slag Pond

EXECUTIVE SUMMARY

The Indiana-Kentucky Electric Corporation (IKEC) is submitting this Demonstration to the U.S. Environmental Protection Agency (EPA) in order to obtain approval of an alternative site-specific date to initiate closure of the West Boiler Slag Pond (WBSP) and the Landfill Runoff Collection Pond (LRCP), both of which are located at IKEC's Clifty Creek Station in Madison, Indiana. Specifically, IKEC requests EPA establish the alternative deadline of December 5, 2022, for the Clifty Creek Station to cease all waste flows to both the WBSP and initiate closure of this coal combustion residual (CCR) unit. In addition, IKEC requests approval of an alternative deadline of April 25, 2023, to cease all waste flows and initiate closure of the LRCP. The WBSP has an approximate surface area of 75 acres and receives boiler slag sluice flows from Units 1-6, as well as the majority of the non-CCR wastestreams generated from the operation of the plant. The LRCP has an approximate surface area of 40 acres and receives stormwater from the contributing watershed, much of which is not owned by IKEC, as well as from the facility's onsite CCR landfill.

IKEC began evaluating CCR compliance options in April 2015 with the assistance of Stantec Inc. (Stantec). In 2020, IKEC hired BMcD to prepare a project definition report (PDR), which covered the scope to install a concrete settling tank within the footprint of the existing WBSP to handle boiler slag material and eliminate the discharge of bottom ash transport water as required by the Steam Electric Effluent Limitation Guidelines (ELGs) at 40 CFR 423 (85 Fed. Reg. 64,650 (October 13, 2020)).

The following primary remaining activities have been identified that must be completed before IKEC can cease all CCR and non-CCR wastestreams to the CCR surface impoundments:

- WBSP activities:
 - Secure applicable environmental permits or permit modifications from the Indiana Department of Environmental Management (IDEM) and the Indiana Department of Natural Resources (IDNR)
 - Construct new concrete settling tank within the WBSP footprint to receive the boiler slag material
 - Reroute boiler slag and mill reject sluice flows to the new concrete settling tank and establish a high recycle rate system
 - Construct a new, lined low-volume wastewater treatment system (LVWTS) within the WBSP footprint for treatment of non-CCR wastewater generated at the facility
 - Reroute non-CCR wastestreams to the LVWTS

- LRCP activities:
 - Secure applicable environmental permits or permit modifications from IDEM and IDNR
 - Construct new stormwater controls to reroute stormwater around the west side of the LRCP to a new stormwater outfall
 - Construct new landfill runoff/leachate management system

IKEC will initiate closure of the WBSP and LRCP once the above tasks are complete. Alternative offsite disposal capacity is not available for wastestreams currently entering the WBSP or the LRCP. As acknowledged previously by EPA, it is not feasible to transport wet CCR to an offsite location and it is also not feasible to transport the large volume of non-CCR wastestreams offsite for disposal. Alternative onsite disposal capacity is not currently available and cannot be made available prior to April 11, 2021. In addition, as a result of the extensive existing power production infrastructure on the site, as well as numerous environmental and site-specific physical constraints such as public roadways, floodplains, streams and wetlands near the plant proper, the Clifty Creek Station lacks an alternative suitable location at the plant site for construction of the LVWTS needed to treat the non-CCR wastestreams. There are no other existing impoundments onsite large enough to treat all the non-CCR wastestreams without continued use of the CCR surface impoundments.

As a result, IKEC determined the best and most feasible location to construct the new, lined LVWTS to manage the non-CCR wastestreams currently routed to the WBSP is within a portion of the footprint of the existing WBSP. In addition, a new lined leachate pond and new stormwater collection pond will be constructed within the footprint of the LRCP to receive the non-CCR wastestreams from the landfill, which are currently routed to the LRCP. IKEC has determined that the best and most feasible location to construct the lined ponds are within the footprint of the existing LRCP.

Pre-construction activities, which include geotechnical investigation, survey, design, permitting, development of a commercial contract and procurement of equipment, are underway. Construction of the concrete settling tank, which will be sited within the footprint of the WBSP, is scheduled to commence in Summer 2021, pending receipt of state-approved permits, along with construction of the LVWTS and landfill runoff/leachate management system. Once construction of the new treatment systems is complete, closure of the CCR surface impoundments may begin. Based on the construction schedule set forth in this Demonstration, IKEC estimates all CCR and non-CCR wastestreams will cease flow to the existing WBSP by December 5, 2022 and to the LRCP by April 25, 2023.

As certified herein, the WBSP and LRCP are compliant with all the requirements of the CCR Rule. IKEC will continue to work to ensure that the facility remains in compliance with the applicable CCR Rule obligations until closure of the CCR surface impoundments and any necessary post-closure monitoring efforts are completed. Regular compliance activities, including required groundwater monitoring, are continuing. The WBSP is currently in detection monitoring and the LRCP is in assessment monitoring. All required documents have been placed into the facility's Operating Record and posted on the publicly available website, with notice provided to the Commissioner (i.e. Director) of IDEM as appropriate.

Consequently, because of the demonstrated lack of available alternative disposal capacity before April 11, 2021, as well as the compliance status of the CCR surface impoundments, including system interconnections, complexity, and need for sequencing of the pond closure and water redirect activities, combined with IKEC's diligent and good faith efforts to develop alternative disposal capacity in order to close the CCR surface impoundments, IKEC respectfully requests a site-specific alternative deadline of December 5, 2022, to initiate closure of the WBSP and April 25, 2023, to initiate closure of the LRCP at the Clifty Creek Station.

1.0 INTRODUCTION

On April 17, 2015, the Environmental Protection Agency (EPA) issued the final version of the federal Coal Combustion Residual (CCR) Rule, 40 CFR Part 257, Subpart D, to regulate the disposal of CCR materials generated at coal-fired units. The rule is being administered under Subtitle D of the Resource Conservation and Recovery Act (RCRA, 42 United States Code [U.S.C.] §6901 et seq.).

On August 28, 2020, the EPA Administrator issued revisions to the CCR Rule that require all unlined surface impoundments to cease receipt of CCR and non-CCR waste and initiate closure by April 11, 2021, unless an alternative closure deadline is requested and approved. 40 C.F.R. § 257.101(a)(1) (85 Fed. Reg. 53,516 (Aug. 28, 2020)). Specifically, owners and operators of a CCR surface impoundment may seek and obtain an alternative closure deadline by demonstrating that there is currently no alternative capacity available on or off-site and that it is not technically feasible to complete the development of alternative capacity prior to April 11, 2021. 40 C.F.R. § 257.103(f)(1). To make this demonstration, the facility is required to provide detailed information regarding the process the facility is undertaking to develop the alternative capacity. 40 C.F.R. § 257.103(f)(1). Any extensions granted cannot extend past October 15, 2023, except an extension can be granted until October 15, 2024, if the impoundment qualifies as an “eligible unlined CCR surface impoundment” as defined by the rule. 40 C.F.R. § 257.103(f)(1)(vi). Regardless of the maximum time allowed under the rule, EPA explains in the preamble to the Part A rule that each impoundment “must still cease receipt of waste as soon as feasible, and may only have the amount of time [the owner/operator] can demonstrate is genuinely necessary.” 85 Fed. Reg. 53,546.

IKEC’s Clifty Creek Station is subject to the CCR Rule and as such is required to ensure its CCR units maintain compliance with the requirements of the CCR Rule. Pursuant to the requirements set forth in the Rule, this document serves as IKEC’s Demonstration for a Site-Specific Alternative to Initiation of Closure Deadline for the existing CCR surface impoundments at the Clifty Creek Station, located near the town of Madison, Indiana in Jefferson County. This document seeks EPA approval under 40 CFR §257.103(f)(1) (for “Development of Alternative Capacity Infeasible”) for the Clifty Creek Station WBSP and LRCP to continue to receive CCR and/or non-CCR wastestreams by demonstrating that the CCR and/or non-CCR wastestreams must continue to be managed in the CCR surface impoundment because it is infeasible to complete the measures necessary to provide alternative disposal capacity by April 11, 2021.

To obtain an alternative closure deadline under 40 C.F.R. § 257.103(f)(1), a facility must meet the following three criteria:

1. § 257.103(f)(1)(i) - There is no alternative disposal capacity available on-site or off-site. An increase in costs or the inconvenience of existing capacity is not sufficient to support qualification;
2. § 257.103(f)(1)(ii) - Each CCR and/or non-CCR wastestream must continue to be managed in that CCR surface impoundment because it was technically infeasible to complete the measures necessary to obtain alternative disposal capacity either on or off-site of the facility by April 11, 2021; and
3. § 257.103(f)(1)(iii) - The facility is in compliance with all the requirements of the CCR rule.

To demonstrate that the first two criteria above have been met, 40 C.F.R. § 257.103(f)(1)(iv)(A) requires the owner or operator to submit a work plan that contains the following elements:

- A written narrative discussing the options considered both on and off-site to obtain alternative capacity for each CCR and/or non-CCR wastestream, the technical infeasibility of obtaining alternative capacity prior to April 11, 2021, and the option selected and justification for the alternative capacity selected. The narrative must also include all of the following:
 - An in-depth analysis of the site and any site-specific conditions that led to the decision to select the alternative capacity being developed;
 - An analysis of the adverse impact to plant operations if the CCR surface impoundment in question were to no longer be available for use; and
 - A detailed explanation and justification for the amount of time being requested and how it is the fastest technically feasible time to complete the development of the alternative capacity.
- A detailed schedule of the fastest technically feasible time to complete the measures necessary for alternative capacity to be available, including a visual timeline representation. The visual timeline must clearly show all of the following:
 - How each phase and the steps within that phase interact with or are dependent on each other and the other phases;
 - All of the steps and phases that can be completed concurrently;
 - The total time needed to obtain the alternative capacity and how long each phase and step within each phase will take; and
 - At a minimum, the following phases: engineering and design, contractor selection, equipment fabrication and delivery, construction, and start up and implementation.

- A narrative discussion of the schedule and visual timeline representation, which must discuss the following:
 - Why the length of time for each phase and step is needed and a discussion of the tasks that occur during the specific step;
 - Why each phase and step shown on the chart must happen in the order it is occurring;
 - The tasks that occur during each of the steps within the phase; and
 - Anticipated worker schedules.
- A narrative discussion of the progress the owner or operator has made to obtain alternative capacity for the CCR and/or non-CCR wastestreams. The narrative must discuss all the steps taken, starting from when the owner or operator initiated the design phase up to the steps occurring when the demonstration is being compiled. It must discuss where the facility currently is on the timeline and the efforts that are currently being undertaken to develop alternative capacity.

To demonstrate that the third criterion above has been met, 40 C.F.R. § 257.103(f)(1)(iv)(B) requires the owner or operator to submit the following information:

- A certification signed by the owner or operator that the facility is in compliance with all of the requirements of 40 C.F.R. Part 257, Subpart D;
- Visual representation of hydrogeologic information at and around the CCR unit(s) that supports the design, construction and installation of the groundwater monitoring system. This includes all of the following:
 - Map(s) of groundwater monitoring well locations in relation to the CCR unit(s);
 - Well construction diagrams and drilling logs for all groundwater monitoring wells; and
 - Maps that characterize the direction of groundwater flow accounting for seasonal variations.
- Constituent concentrations, summarized in table form, at each groundwater monitoring well monitored during each sampling event;
- A description of site hydrogeology including stratigraphic cross-sections;
- Any corrective measures assessment conducted as required at § 257.96;
- Any progress reports on corrective action remedy selection and design and the report of final remedy selection required at § 257.97(a);
- The most recent structural stability assessment required at § 257.73(d); and
- The most recent safety factor assessment required at § 257.73(e).

2.0 WORKPLAN

To demonstrate that the criteria in 40 C.F.R. § 257.103(f)(1)(i) and (ii) have been met, the following is a workplan, consisting of the elements required by § 257.103(f)(1)(iv)(A). IKEC has elected to install a system of multiple technologies to cease routing flow to the CCR surface impoundments, including a concrete settling tank for boiler slag and a new lined non-CCR low volume wastewater treatment system for the water balance flows. This workplan documents that there is no alternative capacity available on or off-site for each of the CCR and/or non-CCR wastestreams that IKEC plans to continue to manage in the surface impoundments and discusses the options considered for obtaining alternative disposal capacity. It also provides a detailed schedule for obtaining the selected alternative capacity, including a narrative description of the schedule and an update on the progress already made toward obtaining the alternative capacity.

2.1 Documentation of No Alternative Disposal Capacity and Approach to Obtain Capacity

The Clifty Creek Station is owned and operated by IKEC and is comprised of six operating coal-fired units with a combined 1,304 net MW of generation. The plant is located along the Ohio River in Jefferson County, just west of Madison, Indiana. Clifty Creek Station has one active CCR surface impoundment, the WBSP, and one inactive CCR surface impoundment, the LRCP, located as shown on the site plan in Appendix A.

The WBSP was constructed in 1955 during the development of the plant and is approximately 75 acres. The pond receives all the boiler slag sluice flows from Units 1-6 as well as the balance of non-CCR wastewater flows from the plant. Boiler slag sluice flows enter the WBSP (identified as the West Bottom Ash Pond on the water balance provided in Appendix B) on the northeast end and are conveyed through the pond to allow for settling of solids prior to discharge to the Ohio River via an NPDES permitted outfall (Outfall 002). The WBSP compliance info is summarized in Table 2-1.

Table 2-1: Clifty Creek Station WBSP Summary

CCR Surface Impoundment Name	Alternate Designation (see Appendix B)	Year Placed in Service	Impoundment Size (acres) / Storage Volume (acre-feet)	Lined?	Meets Location Restrictions?	Groundwater Status
West Boiler Slag Pond	West Bottom Ash Pond	1955	75 / 3,330	No	Yes	Detection Monitoring
Landfill Runoff Collection Pond	None	1957	40 / 1,549	No	Yes	Assessment Monitoring

The Clifty Creek Station operates under NPDES permit IN0001759, which was most recently issued by IDEM in 2017, and is set to expire April 30, 2022. The current permit incorporates the ELGs as issued in 2015 and requires compliance with the zero-discharge standard for boiler slag by April 1, 2022; however, IKEC will be working with IDEM's Office of Water Quality to modify this permit requirement to align it with the compliance strategy activities and schedule proposed herein, as well as the revisions to the ELG Rule (85 Fed. Reg. 64,650 (October 13, 2020)). IKEC has been making good faith effort to meet the original compliance schedule deadline of April 2022 contained in the facility's current NPDES permit, which will require the closure of the WBSP.

Due to the complexity of the WBSP closure, the CCR unit will be closed in phases. A closure application for Phase I closure of the WBSP was submitted to IDEM's Office of Land Quality in February 2020, after working with IDEM since April 2019 to develop that application. However, due to impacts realized due to COVID-19, as well as other impacts beyond the control of IKEC, an approval of the Phase I closure plan has yet to be secured, which directly impacts its ability to begin activities associated with modifying the facility to meet the compliance schedule assigned in the facility's NPDES permit by IDEM's Office of Water Quality. IKEC understands that IDEM intends to use the Indiana Restricted Waste Site (RWS) regulations to review the proposed closure design, as well as to manage its construction activities. Specifically, IDEM intends to permit the closure activities, which will include the construction activities associated with the boiler slag settling basins and new LVWTS, as a Type I RWS. A Type I RWS, which is normally required as a result of the characterization of the waste to be placed in the restricted waste site, requires the most stringent level of monitoring and containment. As a result of this proposed permitting scheme, IKEC will be unable to initiate construction activities until a final permit is received from IDEM for Phase I. Further, feedback from IDEM's initial review process of the Phase I closure

design is being incorporated into the design of the subsequent phases. As a result, closure applications associated with Phases II – IV have not yet been submitted to IDEM. IKEC intends to complete the design work associated with these phases expeditiously and seek approval from IDEM.

The LRCP was constructed between 1956 and 1957 during the development of the plant and is approximately 40 acres in size. The CCR surface impoundment is an inactive impoundment and has not received CCR materials since 1986; however, this impoundment still receives non-CCR wastestreams. The area serves predominantly as a stormwater pond managing the flow from the western portion of IKEC's CCR landfill as well as significant watershed acreage from offsite. The LRCP is also intended to receive leachate from the western portion of the facility's CCR landfill once additional landfill phases are developed in that area. The LRCP discharges through the Outfall 001 structure located in the southwest corner of the impoundment.

2.1.1 CCR Wastestreams

As outlined above, the WBSP receives boiler slag and mill rejects. Boiler slag is removed from the bottom of the boilers via the existing bottom ash water transport system. Mill rejects from the coal mills are removed in batch operation and sluiced to this impoundment. The WBSP also receives flow from the current FGD wastewater systems for Clifty Creek Station Units 1-6, which use an existing physical/chemical treatment system to remove FGD solids from the current discharge stream, as well as a variety of other low volume process wastewater and storm water runoff flows described in greater detail in Section 2.1.2. These additional flows are considered non-CCR wastestreams.

The WBSP must remain available for treatment of the CCR wastestreams until other projects that are currently underway to eliminate the discharge of ash transport water (and comply with the ELG rule) can be completed. These projects are described in detail within Section 2.1.6. Once these efforts are completed, Clifty Creek Station's CCR wastestreams will no longer be routed to the CCR surface impoundments. Table 2-2 summarizes the status of each of the CCR wastestreams throughout the period of the requested extension.

The LRCP currently does not receive any CCR wastestreams and is considered to be an inactive surface impoundment.

Table 2-2: Clifty Creek Station CCR Wastestreams

CCR Wastestream	Average Flow (MGD)	Description	IKEC Notes
Boiler Slag	2.90	Sluiced to existing West Boiler Slag Pond	The boiler slag ash transport water is sluicing CCR material, and this stream cannot be routed to any location onsite other than the existing CCR surface impoundment. IKEC has elected to install a boiler slag settling tank as part of a high recycle rate system to effectively eliminate this wastestream consistent with the updated CCR and ELG regulations by the requested site-specific deadline to initiate closure.

2.1.2 Non-CCR Wastestreams

Currently, Clifty Creek Station utilizes the WBSP to manage the majority of the non-CCR wastestreams on the plant site. The existing water balance is included in Appendix B of this demonstration. IKEC evaluated each non-CCR wastestream placed in the WBSP at Clifty Creek Station. For the reasons discussed below in Table 2-3, each of the following non-CCR wastestreams must continue to be placed in the WBSP due to lack of alternative capacity both on and off-site.

Table 2-3: Clifty Creek Station WBSP Non-CCR Wastestreams

Non-CCR Wastestream	Average Flow (MGD)	Description	IKEC Notes
Boiler room sump	7.98	Includes ash hopper overflow, generator sump flows, water treating plant, sump agitation water, and groundwater/general station use flows.	There is no existing alternative disposal capacity for these comingled wastestreams. This flow will be routed to the new lined LVWTS but must be treated within the remaining WBSP footprint while the LVWTS is being constructed. The volume of this flow is not feasible to segregate and route to temporary treatment measures.
Air heater wash flows	N/A (outage flow only)	Flows collected in the boiler room sumps before being pumped to the WBSP	This flow must be routed to the new LVWTS prior to discharge. There is no existing alternative disposal capacity for this wastestream, and this flow is comingled with the boiler room sump flows from the operating units before being routed to the WBSP. The volume of this combined flow (approximately 4 million gallons) is not feasible to segregate and route to temporary treatment measures.

Non-CCR Wastestream	Average Flow (MGD)	Description	IKEC Notes
FGD wastewater treatment system	0.37	Flows pumped to WBSP	There is no existing alternative disposal capacity for this wastestream. This flow could potentially be rerouted to an existing or new Outfall with additional, pumps, piping, wastewater sampling/characterization, and permit modifications; however, IKEC has chosen to devote its project resources, as well as those of IDEM, to the permanent solution (the necessary construction of the site LVWTS) rather than developing a separate project to reroute this <i>de minimis</i> wastestream away from the WBSP during the requested demonstration.
Coal yard sump flows	0.04 (estimated 5.60 for 10-year, 24-hour storm)	Flows pumped to WBSP (includes flow from East Area Runoff Collection Pond)	There is no existing alternative disposal capacity for this wastestream. Significant surge capacity must be provided for high flows during rain events and it is not feasible to segregate and route this flow to another existing non-CCR basin or to temporary treatment measures.
Drainage from fly ash silo and blower building	0.10	Flows pumped to WBSP	There is no existing alternative disposal capacity for this wastestream. This flow could potentially be rerouted to an existing or new Outfall with additional, pumps, piping, wastewater sampling/characterization, and permit modifications; however, IKEC has chosen to devote its project resources, as well as those of IDEM, to the permanent solution (the necessary construction of the site LVWTS) rather than developing a separate project to reroute this <i>de minimis</i> wastestream away from the WBSP during the requested demonstration.
FGD waste sump	0.03	Flows pumped to WBSP	There is no existing alternative disposal capacity for this wastestream. This flow could potentially be rerouted to an existing or new Outfall with additional, pumps, piping, wastewater sampling/characterization, and permit modifications; however, IKEC has chosen to devote its project resources, as well as those of IDEM, to the permanent solution (the necessary construction of the site LVWTS) rather than developing a separate project to reroute this wastestream away from the WBSP during the requested demonstration.

Non-CCR Wastestream	Average Flow (MGD)	Description	IKEC Notes
Stormwater Runoff and Leachate from East Portion of Landfill	0.14 (estimated 1.94 for 10-year, 24-hour storm)	Leachate and non-contact water from landfill and offsite drainage areas into WBSP	There is no existing alternative disposal capacity for this wastestream. IKEC could potentially reroute these flows north of the WBSP to Clifty Creek as part of the drainage modifications for the LRCP closure; however, the current plan is for the WBSP closure design to incorporate a flat-bottomed ditch which will redirect this flow to a new outfall to the Ohio River.
Landfill Leachate and Stormwater Runoff from West Portion of Landfill	0.796 (estimated 6.18 for 10-year, 24-hour storm)	Leachate, contact water from landfill runoff, and non-contact water from offsite drainage areas into LRCP	There is no existing alternative disposal capacity for this wastestream. IKEC plans to construct a new treatment system within the footprint of the LRCP to receive this flow.

The WBSP must remain available for treatment of non-CCR wastestreams until a new non-CCR basin, also referred to as the LVWTS, can be constructed and these flows can be routed to that new basin. Based on the lack of available space at the plant site as discussed in Section 2.1.3 (see also Figure 3 in Appendix A), the LVWTS will be built within a portion of the WBSP footprint.

The LRCP receives landfill stormwater runoff, as well as stormwater flow from more than 500 acres of watershed, most of which is not owned by IKEC and includes the runoff from Indiana Highway 56 and privately owned property. The LRCP was also planned to receive additional leachate and stormwater runoff from the west portion of the landfill once new landfill phases are developed in that area. The LRCP must remain available for stormwater flows until IKEC can construct new stormwater controls capable of managing storm water flowing into IKEC’s present controls, including the management and redirection of stormwater originating from off-site property. In addition, a new leachate treatment system will need to be constructed to manage the leachate from future phases of the facility’s CCR landfill. Based on the lack of available space as discussed in Section 2.1.3 (see also Figure 3 in Appendix A), the new landfill runoff/leachate management system will be constructed in the footprint of the existing LRCP. The new landfill runoff/leachate management system cannot be constructed until stormwater from the offsite watershed areas, which include stormwater flows from portions of Indiana Highway 56, are diverted around the LRCP. As part of this diversion, IKEC will need to secure multiple environmental permits from IDEM, and potentially IDNR.

2.1.3 Site-Specific Conditions Supporting Alternative Capacity Approach – § 257.103(f)(1)(iv)(A)(1)(i)

As shown on Figure 1 in Appendix A, Clifty Creek Station is bounded by the Ohio River to the south, Crooked Creek and a golf course to the east, Indiana Highway 56 to the north, and farmland and residential areas to the west. The site is also bisected by Clifty Creek and a limestone ridge known as the Devil's Backbone. Most of the Clifty Creek Station property which is outside of the existing floodplain is occupied with critical infrastructure including the CCR surface impoundment, the landfill and LRCP, the coal storage pile, the material handling equipment, the pollution control equipment (including electrostatic precipitators, selective catalytic reduction systems, JBR scrubber systems, and the FGD wastewater treatment system), the switchyard, and transmission lines. Figure 3 in Appendix A provides additional detail of the existing site conditions, including the property boundaries, floodplain limits, topography, as well as the proposed settling tank, LVWTS, and landfill pond footprints.

Based on the limited space available onsite at Clifty Creek Station, it is not possible to construct a new lined LVWTS with associated piping, chemical feed, and power supply that is large enough to receive non-CCR wastestreams and be outside the CCR surface impoundment footprint. By constructing the new lined LVWTS within the existing footprint of the WBSP, the Clifty Creek Station would also avoid the need to impact waters of the U.S. and other natural resources in the Clifty Creek watershed as part of this project.

In addition to the aforementioned facility boundaries, the LRCP is also significantly impacted by the immediate topography surrounding the CCR unit. The LRCP is confined to the north by steep, in some cases nearly vertical slopes, and to the south by the steep slopes of the Devil's Backbone. These slopes, as well as the farmland, the residential areas, and portions of Indiana Highway 56, all contribute to the stormwater currently managed in the LRCP. IKEC has determined that the topography and existing conditions of watershed area not owned or managed by the facility do not allow for the stormwater to be redirected or managed in an existing alternative location onsite, nor can IKEC prevent this off-site drainage area from flowing into the LRCP drainage area.

Based on the foregoing facts, IKEC cannot cease the flow of CCR and non-CCR wastestreams and initiate closure of the WBSP until the concrete settling tank construction is complete, the new lined LVWTS is constructed within the footprint of the WBSP, and the non-CCR wastestreams are rerouted to the new lined LVWTS. Additionally, IKEC cannot cease non-CCR wastestreams to the LRCP until the new stormwater management system and leachate system are constructed. Given the complexity of these projects, weather-driven impacts, and the need to sequence the activities as outlined above, those actions

cannot be completed prior to April 11, 2021. Thus, the conditions at Clifty Creek Station demonstrate that no alternative disposal capacity is available on-site or off-site, satisfying the requirement of 40 CFR 257.103(f)(1)(i)(A), and IKEC respectfully requests a site-specific extension of the deadline to initiate closure of the CCR surface impoundment until the date on which those actions are expected to be completed.

2.1.4 Impact to Plant Operations if Alternative Capacity Not Obtained – § 257.103(f)(1)(iv)(A)(1)(ii)

IKEC's entire generating capacity is sold to its parent (OVEC) at cost under the FERC approved OVEC-IKEC Power Agreement, and such capacity (along with capacity owned and operated directly by OVEC at its other power plant) is exclusively committed and available to OVEC's owners or their affiliates (who are public utilities or electric power cooperatives, collectively referred to herein as the "Sponsoring Companies")¹ under the terms of the FERC approved Inter-Company Power Agreement (ICPA). Under the ICPA, the Sponsoring Companies are responsible for their share of OVEC's costs and expenses, including for debt and other long-term obligations. The Sponsoring Companies and OVEC entered into an amended and restated ICPA, effective as of August 11, 2011, which extends its term to June 30, 2040. The OVEC-IKEC Power Agreement has the same extended term.

OVEC also supplies energy to the DOE's Portsmouth Uranium Enrichment facility located in Piketon, Ohio. The DOE is OVEC's only non-ICPA customer for power and energy. OVEC serves the DOE under a cost-based arranged power agreement approved by the Public Utilities Commission of Ohio (PUCO). Under this agreement, OVEC purchases energy from the wholesale energy market and resells such energy to DOE as needed in real time to meet all energy needs of the Portsmouth Uranium Enrichment Facility (which has been in the process of demolition and deconstruction since it permanently ceased operations).

¹ OVEC's current Sponsoring Companies (and their percentage of obligations under the ICPA) are as follows: Allegheny Energy Supply Company LLC (subsidiary of FirstEnergy Corp (FirstEnergy)), 3.01%; Appalachian Power Company (subsidiary of American Electric Power Company, Inc. (AEP)), 15.69%; Buckeye Power Generating, LLC (subsidiary of Buckeye Power, Inc.), 18.00%; The Dayton Power and Light Company (subsidiary of AES Corp), 4.90%; Duke Energy Ohio, Inc. (subsidiary of Duke Energy Corporation), 9.00%; Energy Harbor Corp, 4.85%; Indiana Michigan Power Company (subsidiary of AEP), 7.85%; Kentucky Utilities Company (subsidiary of PPL Corp (PPL)), 2.50%; Louisville Gas and Electric Company (subsidiary of PPL), 5.63%; Monongahela Power Company (subsidiary of FirstEnergy), 0.49%; Ohio Power Company (subsidiary of AEP), 19.93%; Peninsula Generation Cooperative (subsidiary of Wolverine Power Supply Cooperative, Inc.), 6.65%; and Southern Indiana Gas and Electric Company (subsidiary of CenterPoint Energy, Inc.), 1.50%.

OVEC's energy purchases to serve the DOE are made solely from the real-time market managed by the PJM Interconnection LLC (PJM) Regional Transmission Organization.

OVEC is a member of PJM; however, it does not sell electric capacity or energy to anyone other than at wholesale to the Sponsoring Companies under the ICPA, and at retail to the DOE under the PUCO approved agreement through resale of energy made available by PJM. Under the terms of the ICPA, the Sponsoring Companies either utilize their allocation of electric capacity and energy for their own retail customers (residential, commercial, and industrial), or sell such electric capacity and energy at wholesale, including in PJM-managed energy and capacity markets. In addition, OVEC maintains in excess of 700 miles of 345 KV transmission lines, all of which are subject to the management of PJM.

The CCR impoundments are the primary component of the existing wastewater treatment systems at the Clifty Creek Station. If the CCR Rule were to require closure of the CCR impoundments at the Clifty Creek Station prior to the requested site-specific deadlines, the Clifty Creek Station would be forced to cease operation, and the Sponsoring Companies would not receive their allocation of electric capacity and energy from the Clifty Creek Station to supply electricity to their retail public utility and electric power cooperative customers in Indiana and many neighboring states (or, as applicable, to allow such Sponsoring Companies to sell their allocation of such capacity or energy into power markets for the benefit of such ratepayers). A cessation of operations at the Clifty Creek Station also could cause increased and accelerated costs to OVEC and IKEC, including accelerated costs of demolition and decommissioning of the Clifty Creek Station and possible efforts by OVEC's creditors and other counterparties to try to accelerate their collection of existing debt or other long-term obligations, which (in turn) might trigger sizable and accelerated payment obligations for the Sponsoring Companies under the ICPA. In addition, an unplanned loss of such generating capacity might negatively impact grid stability and power markets in the PJM and surrounding region.

As described in Sections 2.1.1, 2.1.2, and 2.1.6 of this demonstration, in order to continue to operate, generate electricity, and ultimately comply with the CCR Rule, the ELGs, and the facility's NPDES permit conditions, the Clifty Creek Station must continue to use the WBSP for treatment of both CCR and non-CCR wastestreams and the LRCP for the treatment of non-CCR wastestreams until alternative disposal capacity can be developed. This development includes the following primary activities that must be completed in order to initiate closure of the CCR surface impoundment:

- WBSP:
 - Secure all applicable permits or permit modifications from IDEM and IDNR

- Construct new concrete settling tank within the WBSP footprint to receive the boiler slag material
- Reroute boiler slag and mill reject sluice flows to the new concrete settling tank and establish a high recycle rate system
- Construct a new lined LVWTS within the WBSP footprint
- Reroute non-CCR flows to the new lined LVWTS
- LRCP:
 - Secure all applicable permits or permit modifications from IDEM and IDNR
 - Construct new stormwater controls to reroute stormwater around the west side of the LRCP to new stormwater outfall
 - Construct new landfill runoff/leachate management system

2.1.5 Options Considered Both On and Off-Site to Obtain Alternative Capacity

As EPA explained in the preamble of the 2015 rule, it is typically not feasible for sites that sluice CCR material to an impoundment to eliminate the impoundment and dispose of the material offsite. See 80 Fed. Reg. 21,301, 21,423 (Apr. 17, 2015) (“[W]hile it is possible to transport dry ash off-site to [an] alternate disposal facility that is simply not feasible for wet-generated CCR. Nor can facilities immediately convert to dry handling systems.”). IKEC recognizes this fact and agrees with EPA that offsite disposal is not an option for Clifty Creek Station. IKEC also agrees it is not feasible to provide offsite treatment of the large volume of non-CCR wastewaters currently routed to the WBSP. Off-site disposal of these sluiced CCR and non-CCR wastestreams would require both on-site temporary storage and significant daily tanker truck traffic. The required daily tanker trucks (assuming 7,500-gallon capacity per truck) for each of the CCR and non-CCR sluiced wastestreams are summarized as follows:

- Boiler Slag sluice to WBSP (2.90 MGD): Approximately 380 daily trucks would be required, if a Publicly Owned Treatment Works (POTW) could be identified to receive it.
- Boiler room sump flows to WBSP (7.98 MGD): Approximately 1,060 daily trucks would be required.
- FGD wastewater treatment system flows to WBSP (0.37 MGD): Approximately 50 daily trucks would be required.
- Coal yard sump flows to WBSP (0.04-5.60 MGD): Approximately 5 daily trucks would be required, increasing up to over 740 daily trucks during rain events.
- Drainage from fly ash silo and blower building (0.10 MGD): Approximately 13 daily trucks would be required.

- Stormwater Runoff and Leachate from East Portion of Landfill to WBSP (0.14-1.94 MGD):
Approximately 18 daily trucks would be required, increasing up to over 250 daily trucks during rain events.
- Landfill Leachate and Stormwater Runoff from West Portion of Landfill to LRCP (0.796-6.18 MGD): Approximately 106 daily trucks would be required, increasing up to over 820 daily trucks during rain events.

The significant daily tanker truck volume for offsite disposal (over 1,600 trucks per day during normal operations and over 3,300 trucks per day during rain events) would result in increased potential for safety and noise impacts and further increases in fugitive dust, greenhouse gas emissions and carbon footprint which may require a Prevention of Significant Deterioration (PSD) permit and modification under the Clean Air Act Permit Program if the calculated increases in emissions are over the PSD limits. This increased traffic during rain events is also difficult to plan for and reliably perform in this location, regardless of whether suitable disposal locations can be identified. Setting up contractual arrangements for a local POTW to accept the wastewater would prove to be difficult since they also have to meet NPDES discharge limits. Therefore, most POTW's have their own permitting process to allow industry to discharge to their facilities, and they may be required to modify their NPDES discharge permit adding time to the overall compliance schedule. The potential for leaks/spills from the tank system or transportation of the wastewater offsite does also exist. Furthermore, the temporary wet storage needed to accommodate off-site disposal would require reconfiguration, design, installation, and associated environmental permitting that would extend the overall compliance schedule. Consequently, there are no feasible offsite-disposal options for the wet-generated wastestreams at Clifty.

The other pond onsite (the East Area Runoff Collection Pond, also referred to as the FGD Runoff Collection Pond) is not large enough to independently treat these flows without the continued use of the CCR surface impoundment. Further, the pond water is collected and pumped to the WBSP with the coal pile runoff, where it is discharged through the existing NPDES outfall structure. Any additional wastewater flows would result in an inundation of the coal yard with wastewater due to the limitation of the existing wastewater conveyance system. Eliminating flow to the WBSP would require a new permitted outfall and discharge structure at the East Area Runoff Collection Pond. Thus, IKEC must pursue onsite options for the handling of CCR and non-CCR wastestreams that are currently directed to the CCR surface impoundments.

The options considered for alternative disposal capacity of the wastestreams currently routed to the WBSP and LRCP are summarized in Table 2-4. For additional details on the CCR and non-CCR wastestreams, please refer to Table 2-2 and Table 2-3, respectively.

Table 2-4: Clifty Creek Station Alternatives for Disposal Capacity

Alternative Capacity Technology	Average Time (Months) ¹	Feasible at Clifty?	Selected?	IKEC Notes
Conversion to dry handling	33.8	Yes	Yes	Fly ash is currently dry handled at Clifty. A dry boiler slag handling solution was considered, but ultimately not selected due to business risk associated with mechanical equipment failures affecting six operating units. IKEC will install new concrete settling tank as part of a high recycle rate system to handle boiler slag. This solution was selected in May 2020 and is scheduled to be implemented by November of 2022. This is an aggressive schedule for compliance across all six units at the site, and significantly faster than the average time estimated by EPA.
Non-CCR wastewater basin	23.5	Yes	Yes	A new landfill runoff/leachate management pond and a new LVWTS are being constructed as one part of the solution to comply with the new requirements. The volume of non-CCR wastestreams cannot be contained within the existing non-CCR basin onsite with adequate residence time to meet discharge limits. There is not adequate real estate onsite (see Figure 3 in Appendix A), or within a reasonable distance, to construct additional non-CCR basins outside the footprint of the WBSP and LRCP, which extends the schedule required for construction of the new treatment systems since inflows into the ponds will need to be diverted around the work areas prior to initiating construction. EPA should note that while additional time is required for this construction based on the Clifty site conditions, IKEC will begin work grading/stabilizing/capping material in the WBSP and LRCP as required for final closure of the ponds during the requested extension.
Wastewater treatment facility	22.3	Yes	Yes	A chemical feed system is being constructed as part of the LVWTS.

Alternative Capacity Technology	Average Time (Months) ¹	Feasible at Clifty?	Selected?	IKEC Notes
New CCR surface impoundment	31	No	No	There is not adequate real estate onsite (see Figure 3 in Appendix A), or within a within a reasonable distance of the power plant, to construct a new CCR surface impoundment. Additionally, permitting required to construct a new surface impoundment would delay the cessation of waste streams and closure of the CCR impoundments past the deadline requested, and would not alone provide compliance with ELG.
Retrofit of a CCR surface impoundment	29.8	Yes	No	A retrofit alone would not have allowed for compliance with ELG. This would require complete removal of the CCR from the WBSP, which would extend the overall compliance schedule to allow for this removal while simultaneously continuing to use the WBSP to receive CCR and non-CCR wastestreams (that cannot be directed to an alternate location onsite).
Multiple technology system	39.1	Yes	Yes	This is being implemented as described above to include the concrete settling tank for boiler slag, new LVWTS (non-CCR basin and associated chemical feed system), and new non-CCR basins for landfill stormwater and leachate. This solution was selected in May 2020 and is scheduled to be implemented by April of 2023, which is an aggressive schedule for compliance across all six units at the site, and slightly faster than the average time estimated by EPA.
Temporary treatment system	Not defined	No	No	A new temporary treatment system for non-CCR wastestreams would need to handle/treat an average daily flow of 9.46 MGD, not including stormwater contributions. It is not technically feasible to build temporary tanks to provide this level of treatment during the construction of the LVWTS, and as shown in Figure 3 in Appendix A, there is not enough available space to install this temporary equipment. IKEC has chosen to focus on implementing the necessary measures for the selected technologies described above as soon as possible rather than try to develop temporary solutions for certain low volume wastestreams.

¹From Table 3. See 85 Fed. Reg. at 53,534.

IKEC began evaluating CCR handling technologies in 2017 with the assistance of BMcD. The evaluation for Clifty Creek Station had to consider not only the evolving requirements of the CCR Rule, but also the unknown revisions to the ELGs that would likely impact the approaches being considered for boiler slag management. BMcD completed an evaluation that investigated multiple technology options for boiler slag handling as described in Table 2-5, below.

Table 2-5: Boiler Slag Handling Technologies

Alternative Capacity Technology	Selected?	IKEC Notes
Underboiler Drag Chain Conveyor System	No	Not feasible due to space constraints under the boilers
Remote Drag Chain Conveyor System	No	Not selected due to concerns with equipment redundancy for six operating units and due to potential reliability risks associated with mechanical equipment in a highly abrasive environment
Dry Belt/Tray Conveying System	No	Not feasible due to boiler design
Proprietary B&W Submerged Grind Conveyor System	No	Not feasible due to space constraints under the boilers
Traditional Water Treatment Style Slag Handling System	No	Not practical; still in conceptual design phase
Pneumatic Conveying System	No	Not feasible due to boiler design
Rapid Remote Dewatering System	No	Not practical; still in conceptual design phase
Composite Liner Retrofit	No	Feasible; however, not compliant with ELG rule for limiting discharge of ash transport water
Concrete Settling Tank w/ Water Recirculation System	Yes	Selected

2.1.6 Approach to Obtain Alternative Disposal Capacity

Following the 2017 study, IKEC identified a preferred technology for further review, which included the concrete settling tank for boiler slag. This selection was based on comparison of each of the alternatives that were deemed to be technically feasible at Clifty Creek. IKEC worked with Stantec to develop WBSP closure phasing and grading design options which incorporate a concrete settling tank, also referred to as the Boiler Slag Handling System (BSHS), and new LVWTS for plant non-CCR wastestreams. The Phase

I permit-level drawings were prepared in January of 2020. Stantec continued to refine the design of the LVWTS and WBSP closure as part of the front-end engineering design (FEED) efforts.

In 2020 (following EPA release of the proposed ELG and CCR rule revisions), IKEC hired BMcD to prepare a PDR for installing the concrete settling tank within the footprint of the existing WBSP. The concrete settling tank will consist of three chambers, as shown on Figure 2 in Appendix A, which are sized to settle boiler slag material and mill rejects from the sluice water. Overflow from the chambers will collect in a recycle tank for recirculation back through the boiler slag sluicing system. For this system operation, sluice water will be directed to one of the chambers, with the second chamber being dewatered and cleaned of boiler slag material, and the third chamber in waiting to receive sluice flows or upset flows if needed. The tank will be constructed over existing CCR material. As discussed in more detail in Section 2.3, the footprint of the BSHS will be pre-loaded prior to installing the concrete structure to consolidate the material and reduce the potential for differential settlement and the resulting cracking. The tank is being designed to meet ACI 350-06 requirements for water retaining concrete structures with normal environmental exposure. Normal environmental exposure is defined as exposure to liquids with a pH greater than 5, or exposure to sulfate solutions 1000 ppm or less. The tank location is shown on Figure 2 in Appendix A. Typical plan and section sketches are also included in Appendix A.

As noted above, Stantec continues to develop the LVWTS design. The north basin (i.e. the primary basin) is currently sized to handle 4 million gallons of air heater wash with additional storage for a 50-year, 24-hour storm event and 2-feet of dead storage for solids accumulation. The south basin (i.e. secondary basin) is sized to provide a minimum of 24 hours of detention time at the average daily flow rate. The LVWTS will discharge to the Ohio River through a new NPDES outfall. The two basins will operate in series except during air heater wash events where wash water will be directed to the primary basin and all other flows will bypass the primary basin and be directed to the secondary basin. The preliminary sizing and location of the new lined LVWTS is shown in Figure 2 in Appendix A, and preliminary plan and section drawings prepared by Stantec are included in Appendix D.

The LVWTS will also be constructed over existing CCR material in order to minimize the overall compliance schedule by limiting the amount of offsite borrow material required to complete the project and to balance cut and fill within the existing basin. Furthermore, removing all of the CCR material from the WBSP and constructing a new lined LVWTS is not feasible while all of the CCR and non-CCR wastestreams continue to be routed to this unit. The construction must occur in the upper portions of the WBSP, while the lower portions continue to receive these flows. The LVWTS will receive a composite liner system. Preliminary cross sections of the LVWTS and details of the composite liner system are

provided in Appendix D. The footprint of the new LVWTS will be graded and stabilized prior to installing the new composite liner system. In addition to providing containment for the wastestreams discharged to the new LVWTS, the composite liner will also act as a cover system over underlying CCR materials which remain. Stantec is conducting a geotechnical investigation to better characterize properties of the existing CCR material and determine structural stability characteristics for the LVWTS.

IKEC also worked with Stantec to develop LRCP closure phasing and grading design options which incorporate the new stormwater management controls and landfill runoff and leachate ponds. These systems will either discharge via a stormwater outfall to Clifty Creek, an internal outfall to new stormwater ditches built into the WBSP closure design, or discharge to the Ohio River through NPDES Outfall 001. The proposed closure phasing was provided in March of 2020 and is included in Appendix D.

Based on the work completed to date, IKEC and BMcD identified the following primary scope items:

- New concrete settling tank, constructed within the footprint of the existing WBSP, to settle boiler slag and mill rejects and recycle water to the boiler slag sluicing system. This system is also referred to as the BSHS. See Appendix A for preliminary sketches showing the tank location and pond sections, as well as plan and section views of the structural components.
- Re-grading of boiler slag material to support construction of the new concrete settling tank and LVWTS.
- New lined LVWTS constructed south of the concrete settling tank, which will treat non-CCR wastestreams generated at the Clifty Creek Station. See Appendix D for preliminary plan and section drawings prepared by Stantec.
- Chemical treatment systems for the concrete settling tank and new lined LVWTS to promote settlement of fine particles and adjust pH if required.
- Diversion of offsite stormwater around the LRCP to a new stormwater outfall to support impending pond closure activities. See Appendix D for preliminary concept sketches.
- New landfill stormwater runoff and leachate management systems as part of the LRCP closure activities. See Appendix D for preliminary closure design concept sketches.

Each of the noted scope items is required to provide alternative treatment for the CCR and non-CCR wastestreams that currently flow to the WBSP and LRCP and initiate closure of the unlined CCR surface impoundments as required by the CCR Rule. The LVWTS, BSHS, and LRCP design features are designed to prevent migration of wastewaters into the underlying CCR material, and IKEC believes these

designs are environmentally responsible and will meet the intent of the Federal and State regulations associated with the closure of the CCR surface impoundments. The remainder of the work required to install the new ash handling technology, develop the new lined LVWTS, and develop the new water handling systems for the LRCP is described further in Section 2.3 of this demonstration.

2.1.7 Technical Infeasibility of Obtaining Alternative Capacity prior to April 11, 2021

Based on the foregoing facts, IKEC cannot cease all CCR and non-CCR wastestreams and initiate closure of the WBSP until the boiler slag handling conversion is complete and the new LVWTS is constructed, and the non-CCR wastewater flows are directed to the new lined treatment system. Additionally, IKEC cannot cease non-CCR wastestreams to the LRCP until the offsite stormwater flows are diverted and new landfill runoff/leachate management system is constructed. IKEC began its selected compliance project execution for Clifty Creek Station with scoping studies in 2015 and is in the process of negotiating either an EPC or design-bid-build contract to execute this project. This work is in progress but has not yet been completed. It is not technically feasible to procure the equipment, perform the necessary detailed design, and complete the pre-outage construction activities for each the boiler slag and low-volume wastewater projects and stormwater management systems over the course of the next six months. Consequently, it is not possible to implement the measures discussed above in a manner that would be successful by April 11, 2021.

Thus, the conditions at Clifty Creek Station demonstrate that no alternative disposal capacity is available on-site or off-site, satisfying the requirement of 40 CFR 257.103(f)(1)(i), and IKEC respectfully requests a site-specific extension of the deadline to initiate closure of the CCR surface impoundments until the date on which those actions are expected to be completed.

2.1.8 Justification for Time Needed to Complete Development of Alternative Capacity Approach – § 257.103(f)(1)(iv)(A)(1)(iii)

The schedule for developing alternative disposal capacity is described in more detail in Sections 2.2 and 2.3. The milestones for progress are summarized in Table 2-6, below. IKEC is requesting an alternative site-specific deadline of December 5, 2022 to cease receipt of wastestreams in the WBSP and initiate closure of that CCR unit and a deadline April 25, 2023, to cease receipt of wastestreams in the LRCP and initiate closure of that CCR unit. The primary factor affecting the compliance schedule at the Clifty Creek Station is the ability to manage CCR and non-CCR wastestreams throughout construction in a way that allows the plant to continue to meet the NPDES discharge limits. If IKEC were to consider alternative temporary solutions to allow for the WBSP to be removed from service, such a measure would require the

use of approximately 550 frac tanks to provide one day of storage capacity for these flows, not including stormwater contributions. These tanks would require significant site development for containment measures and significant interconnecting piping which would propose an unacceptable amount of potential for leaks. Furthermore, assuming a solids content of 1% in the comingled wastestreams, approximately five of these frac tanks would need to be removed and replaced each day. Instead, IKEC is choosing to bypass the flows around the construction work area so that the south portion of the pond can continue to handle these flows while construction is underway.

Additionally, as described earlier in this section IDEM has indicated to IKEC that they intend to approve the closure activities under their RWS landfill program as a Type I landfill. There is potential for extending the project schedule if IKEC has to work through multiple iterations of the design based on feedback from IDEM. IKEC will progress with activities as allowed by IDEM; however, IKEC must coordinate proposed pond closure work with IDEM and cannot proceed with major construction activities without IDEM approval. Proceeding without the required permitting approvals, as well as other various construction activities notifications required by the RWS program, could result in potential violations and enforcement action being brought against IKEC.

At the LRCP, IKEC must divert offsite stormwater around the pond limits in order for the landfill pond work to proceed. Due to the expansive drainage area (over 500 acres) and large variability of these stormwater flows, it is not feasible to capture the flows in frac tanks. Consequently, IKEC believes this requested schedule represents the fastest technically feasible timeframe for compliance at Clifty Creek Station, and these durations are faster than EPA’s assessment of the average time required to construct a dry ash handling conversion and a non-CCR basin. For Clifty Creek Station’s specific case, these options cannot be completed simultaneously due to site availability and operational constraints as the non-CCR LVWTS are being constructed within the existing footprint of the WBSP and LRCP. IKEC has overlapped these activities as much as feasible.

Table 2-6: Compliance Project Progress Milestones

Year or Progress Reporting Period	Status	Milestone Description	IKEC Notes
2020	Completed	Selection of ash handling solution and preparation of request for alternative site-specific deadline for initiation of closure of the CCR Surface Impoundments.	

Year or Progress Reporting Period	Status	Milestone Description	IKEC Notes
2020	On Schedule	FEED study and detailed scope development and award EPC or detailed design contracts	
April 30, 2021	Scheduled	BSHS site prep construction package awarded	
October 31, 2021	Scheduled	BSHS/LVWTS equipment procurement packages bid/awarded, BSHS/LVWTS and LRCP construction packages bid/awarded	
April 30, 2022	Scheduled	BSHS site prep construction complete, BSHS/LVWTS and LRCP construction underway with hillside (i.e. offsite stormwater) diversion channel complete	The hillside diversion channel will divert offsite stormwater flows around the west side of the LRCP to the new stormwater outfall.
October 31, 2022	Scheduled	BSHS/LVWTS foundations and equipment in place, BSHS operational	Tie-in outages and startup of LVWTS will be completed by the end of the calendar year. Normal flows of CCR and non-CCR wastewater to the WBSP will cease by December 5, 2022.
April 30, 2023	Scheduled	LVWTS operational, LRCP landfill runoff/leachate management system constructed	Normal flows of CCR and non-CCR wastewater to the LRCP will cease by April 25, 2023. WBSP and LRCP closures are underway as well (those activities are not part of this demonstration).

2.2 Detailed Schedule to Obtain Alternative Disposal Capacity

The required visual timeline representation of the schedule for the activities outlined in Sections 2.1.6 and 2.3 is included in Appendix C of this demonstration.

2.3 Narrative of Schedule and Visual Timeline

As shown in Appendix C and described in Sections 2.1.6 and 2.4, IKEC has already undertaken significant planning steps towards initiating closure of the WBSP and the LRCP. This section of the demonstration is focused on the remaining work necessary to obtain alternative disposal capacity for the CCR and non-CCR wastestreams and initiate CCR surface impoundment closures at the Clifty Creek Station. The durations shown in the schedule in Appendix C are based on a number of factors, including a

50-hour per week construction schedule, the estimated volume of concrete to be installed for the settling tank, piping quantities for the new concrete settling tank and LVWTS, and the estimated volume of earthwork required.

Contract Negotiation: IKEC is currently working with BMcD to jointly develop the front-end engineering deliverables for the project, develop specifications to procure the major equipment, perform the required geotechnical/survey/pilot trenching/laser scanning/water sampling activities necessary to support design, refine the project scope, and develop a target price to serve as the basis for either a multiple-subcontract Engineer-Procure-Construct (EPC) contract or a design-bid-build contract. These efforts involve completion of approximately 30% of the project design, as well as award of the contract and are expected to be completed in November of 2020. This contracting method has been selected to facilitate completing the project on a timeline that is as soon as technically feasible, consistent with the CCR Rule.

Boiler Slag Handling and WBSP Modifications: Detailed engineering for the boiler slag treatment equipment and LVWTS construction contracts will begin in November of 2020 after EPC or design-bid-build contract is awarded and this work is scheduled to be completed in December of 2021 following release of the electrical construction contract for bid. The design will be grouped into multiple work packages and construction subcontracts to facilitate the required construction sequence. These work packages include the site preparation efforts, pond closure, concrete settling tank (i.e. BSHS), and mechanical/electrical construction for the ash transport water recycle system and LVWTS (and associated chemical feed system). Permitting through the IDEM will include securing modifications to the NPDES permit and securing Permits-to-Install for the concrete settling tank and the LVWTS (and associated non-CCR wastestream piping reroutes, chemical feed systems, and WBSP closure). Six months of permitting time were included (note this covers both the boiler slag conversion and pond modification scope) and will coincide in part with the end of the detailed engineering for each required phase. These permit modifications must be completed before the associated construction of the BSHS concrete settling tank, WBSP Closure and the new LVWTS construction is initiated. While IKEC is currently reflecting an anticipated permitting timeframe of six months to secure permitting required to initiate closure, its experience has been that permitting associated with CCR units is not normally secured within the six-month timeframe indicated in Indiana regulations. Permitting timeframes have been closer to 12 months, and at times longer, to secure permits associated with CCR units in Indiana. IKEC is committed to working with IDEM to expedite project permitting in support of the timeline proposed herein but may experience project schedule impacts as a result in a delay in receiving required permits.

Preparation of equipment specifications for the pumps, chem feed system, overflow hoppers, and electrical equipment will occur concurrently with detailed engineering beginning in the November of 2020. The electrical equipment (PCM and associated transformers) is the only long-lead item provided in the schedule, and the remaining equipment procurement activities will be completed concurrent with this duration. The civil construction contract will include site preparation, dewatering the portion of the WBSP in the vicinity of the BSHS and LVWTS, installing piling and/or performing consolidation of subgrade soils (to be determined during ongoing geotechnical investigation), construction of the concrete settling tank, construction of the LVWTS, and closure of the CCR surface impoundments. This will likely be divided into two contract scopes to support construction of the concrete settling tank and redirection of the sluice flows concurrent with the required permitting efforts for the pond closure and LVWTS construction, with the goal of the EPC contractor (or the design-bid-build engineer) to accelerate this effort as much as possible. The mechanical/electrical scope will include installation of the major utility corridors (i.e. piping to/from the concrete settling tank and LVWTS), construction of the PCM at the concrete settling tank, installation of the new recycle pumps, installation of new raceway/cable to power the new equipment, and completion of balance of plant scope as required for the project.

The concrete settling tank construction will require close coordination between plant operations and the contractor. This work will proceed in the following order once construction is underway:

- The contractor will divert stormwater flows around the construction area.
- The contractor will reroute the WBSP influent flows around the BSHS and LVWTS construction area to the south. The contractor will dewater the north portion of the WBSP and place CCR material within the footprint of the concrete settling tank as required to support preparation of the subgrade. This area requires pre-loading (i.e. surcharge loading) to consolidate the CCR material and subgrade soils in the area. This activity must occur after the sluice flow is rerouted
 - The schedule duration is based on the contractor placing approximately 140,000 cubic yards (CY) of CCR material as part of the surcharge loading effort. After the surcharge material is placed, it will remain for 40-50 working days (approximately two months).
- The contractor will excavate approximately 75,000 CY of surcharge material as required to support the new concrete settling tank foundation construction.
- The contractor will construct the concrete settling tank and recycle tank floor and walls along with supporting system foundations. The construction duration shown in Appendix C is based on an estimated 75,000 labor hours for the 9,100 CY of concrete (and associated rebar) required for the project and is based on a crew working 50 hours per week. This work cannot start until the

Permit-to-Install is received for the BSHS. During this time the contractor will also install the PCM, transformer, and the chemical feed system foundations.

- The contractor will backfill the settling tank after the walls are complete. This activity is anticipated to take a month to complete. Following this effort, the contractor will install the stackout area slab. The phasing of this work is anticipated to take approximately six weeks of construction.
- After the foundations are completed and the mechanical construction contract is awarded, the contractor will install the PDC, transformers, and necessary mechanical equipment. This will include installation of the new pumps, chemical feed equipment, piping, and balance of plant items necessary to support recycling the boiler slag ash transport water system. The mechanical construction duration is based on an estimated 70,600 labor hours for the equipment installation and 28,800 feet of piping required for the project and is based on a crew working 50 hours per week. The piping installation will begin before the slag tank construction is completed, but the equipment erection and piping will not be able to complete until approximately two months after the tank walls are completed.
- The electrical construction will be performed concurrently, albeit slightly lagged to the mechanical construction. The electrical construction duration is based on an estimated 29,700 labor hours for the 6,600 feet of raceway and 238,600 feet of cable (and associated terminations) required for the project and is based on a crew working 50 hours per week. This work will be completed at least two months after the PCM and transformers are set in place to allow for terminations at those locations.
- The BSHS equipment startup and commissioning will take place over ten weeks following completion of the mechanical and electrical BSHS construction but prior to finishing LVWTS construction. This allows for sequential integration of Units 1-6 to transfer from wet to high recycle system handling. At this point, the sluicing of boiler slag to the WBSP will cease, and the high recycle rate system will be used for future handling of boiler slag at the Clifty Creek Station.
- During construction of the BSHS, the Contractor will proceed with construction of the LVWTS, including re-grading the area and installing a composite liner system, slope protection, and new pond outlet structure. CCR material removed from the LVWTS footprint will be used to regrade the pond closure area, including around the concrete settling tank area. These construction activities cannot proceed until IDEM approves the design and provides the permit to install these facilities:
 - The contractor will clear and grub the areas within the pond to be graded and install stormwater diversion channels to reroute flow around the work areas.

- The contractor will re-grade approximately 350,000 CY of material within the Phase 3 construction area (includes the LVWTS footprint). This schedule assumes that the CCR material will not need to be double handled prior to compacting in place.
- The composite liner system will likely consist of a geosynthetic clay liner, 60-mil high-density polyethylene geomembrane, geotextile, and 12-inches of suitable fill material. Preliminary liner details are provided in Appendix D. Additionally, 18-inches of riprap will be placed on the pond slopes and a minimum of 6-inches of concrete will be placed over the bottom of the primary basin to facilitate cleanout. Installation of the liner system components is planned to overlap as much as possible and finish two months after the grading operations.
- The contractor will install piping to reroute the non-CCR wastestreams to the LVWTS. This activity will happen concurrently with the BSHS construction, and the tie-points (tees and valves) will be installed as necessary during prior outages so that once the pond construction and NPDES permit modifications are completed, the flows to the new LVWTS can be initiated.
- Ditches will be graded within the WBSP closure area to convey flows from the LVWTS and portions of the closed pond to a new outfall structure. The ditches will be lined with a CCR Rule compliant cover system. This work will happen concurrently with the LVWTS and outfall construction as shown in the schedule.
- Startup and commissioning of new LVWTS is expected to take four weeks to optimize the chemical feed systems and cease use of the WBSP for non-CCR wastestreams. Startup cannot commence until the liner system is installed and accepted by IDEM. In addition, the mechanical and electrical construction scopes will also need to be completed.

LRCP Pond Modifications: Detailed engineering for the LRCP modifications will be performed concurrently with the BSHS/WBSP Modifications. The design will be grouped into work packages as needed to meet the compliance deadlines. The work packages include:

- Grading in a new stormwater ditch to divert offsite runoff around the LRCP to a new stormwater outfall south of the LRCP (approximately 140,000 CY of cut/fill).
- Dredging material from the proposed footprint of the new lined leachate and stormwater treatment systems (approximately 190,000 CY).
- Installing a new berm (approximately 69,000 CY of cut/fill) for the west leachate collection pond upstream of the leachate and stormwater treatments systems. The collection pond (5.8 acres) will accept landfill flows during construction of the treatment systems and will receive a composite liner system consisting of a geosynthetic drainage layer, GCL, flexible membrane liner,

geotextile, and 12-inch protective cover layer. The collection pond will eventually overflow to the treatment pond.

- Installing a new berm (approximately 60,000 CY of cut/fill) within the footprint of the dredged area for the sediment pond. The sediment pond (6.6 acres) will also receive a composite liner system as described for the leachate collection pond. The sediment pond will overflow to a ditch, which will tie into Outfall 001. The ditch will be constructed in the LRCP closure area and capped with the LRCP cover system.
- Installing a new berm (approximately 28,000 CY of cut/fill) within the footprint of the dredged area for the leachate treatment pond. The treatment pond (2.1 acres) will overflow to the sediment pond and will also receive a composite liner system.
- Installing a new leachate collection pond (2.0 acres) on the east side of the landfill. The new perimeter berm will require approximately 18,000 CY of cut/fill and will also receive a composite liner system. The east leachate collection pond will have the capability to overflow via an internal outfall to stormwater ditches which will be incorporated into the WBSP closure design.

Once the landfill ponds are in place the remaining LRCP area may be closed. IKEC will continue to work toward manners in which it can expedite the ultimate closure of the LRCP and provide regular updates per the requirement of the CCR Rule.

2.4 Progress Narrative Toward Obtaining Alternative Capacity

In the preamble to the final Part A rule, EPA explains that this “section [of the workplan] must discuss all of the steps taken, starting from when the owner or operator initiated the design phase all the way up to the current steps occurring while the workplan is being drafted.” 85 Fed. Reg. at 53,544. The discussion also must indicate where the facility currently is on the timeline and the processes that are currently being undertaken at the facility to develop alternative capacity. 85 Fed. Reg. at 53,545.

As described in Section 2.1.6 and as shown in Appendix C, IKEC has made considerable progress in developing a path forward for obtaining alternative disposal capacity for the CCR and non-CCR wastestreams at the Clifty Creek Station that are currently managed in the WBSP and LRCP. IKEC, Stantec, and BMcD have gone through multiple iterations of the project scoping and cost estimate development in order to find the best compliance solution for the plant. BMcD and IKEC have completed the project scoping and cost estimate development efforts, have selected the preferred compliance solution for the plant, and are finalizing the contracting approach. Water sampling efforts and preliminary design has been completed for the BSHS, laser scans have been completed in the boiler areas, and the BSHS geotechnical investigation has been completed. IKEC did not have a CCR closure trigger for the

WBSP, which is an eligible unlined CCR surface impoundment, prior to the release of the updated CCR Rule (*A Holistic Approach to Closure Part A: Deadline To Initiate Closure*), which was proposed (pre-published) on November 4, 2019, and finalized by EPA on August 28, 2020.

The LRCP has experienced a statistically significant level above a groundwater protection standard for Appendix IV parameters. As a result, an assessment of corrective measures was completed, which identified the most feasible corrective measures for the unit, but also identified additional field work that was needed to better understand site conditions prior to selecting and subsequently implementing the appropriate corrective measure. That field work continues, and includes:

1. Conducting additional characterization of the groundwater near the LRCP through a more expansive monitoring scheme. Additional groundwater monitoring wells were installed at the IKEC property line to determine if groundwater leaving the IKEC site exhibited similar concentrations of CCR groundwater parameters to the wells observed to be exceeding a groundwater protection standard (GWPS). To date, none of the wells at the IKEC property line have been found to exhibit similar concentrations of the CCR parameters.
2. Continuing to collect groundwater elevation information at various points across the site to help better understand the groundwater dynamics near the unit.
3. Assessing manners in which to effectively manage stormwater run-on from property not owned by IKEC to support redirecting stormwater away from the unit.
4. Collecting additional geotechnical data to further define the unit's subsurface characteristics. IKEC is reflecting that progress in semiannual Remedy Selection Progress Reports, which will be updated in December 2020.

Separately, IKEC determined it was appropriate to pause before executing its CCR/ELG compliance strategy prior to learning how the continued development of those rules could ultimately impact that strategy. For example, revisions being made to the bottom ash transport water requirements in the ELG rule were anticipated to impact the manner in which IKEC would manage its operation once the rule was issued final. It is imperative given the physical constraints of the facility that IKEC's CCR Rule compliance strategy, which will result in numerous plant modifications, would also enable the plant to meet the requirements of the revised ELG rule (85 Fed. Reg. 64,650 (October 13, 2020)).

3.0 DOCUMENTATION AND CERTIFICATION OF COMPLIANCE


To demonstrate that the criteria in 40 C.F.R. § 257.103(f)(1)(iii) has been met, the following information and submissions are submitted pursuant to 40 C.F.R. § 257.103(f)(1)(iv)(B) to demonstrate that the CCR surface impoundments are in compliance with the CCR Rule. The Clifty Creek Station includes the following CCR units:

- The West Boiler Slag Pond (one of the two units that are the subject of this demonstration)
- The Landfill Runoff Collection Pond (one of the two units that are the subject of this demonstration)
- The CCR Landfill

3.1 Owner's Certification of Compliance

In accordance with 40 CFR § 257.103(f)(1)(i)(C), I hereby certify that, based on my inquiry of those persons who are immediately responsible for compliance with environmental regulations for the Clifty Creek Station, the facility is in compliance with all of the requirements contained in 40 CFR §257 Subpart D – Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments. Clifty Creek's CCR compliance website is up-to-date and contains all the necessary documentation and notification postings.

INDIANA-KENTUCKY ELECTRIC CORPORATION



J. Michael Brown
Environmental, Safety & Health Director
November 30, 2020

3.2 Visual Representation of Hydrogeologic Information - § 257.103(f)(1)(iv)(B)(2)

Consistent with the requirements of § 257.103(f)(1)(iv)(B)(2)(i) – (iii), IKEC has attached the following items to this demonstration:

- Map(s) of groundwater monitoring well locations in relation to the CCR units are included in Appendix E1 (see Figures 8 and Figures 6/9/10 from the attached October 2016 report provided

by Applied Geology and Environmental Science, Inc. for the groundwater monitoring wells associated with the WBSP and the LRCP/CCR Landfill, respectively)

- Well construction diagrams and drilling logs for the groundwater monitoring wells are included in Appendix E1 (see Appendix B from the attached October 2016 report provided by Applied Geology and Environmental Science, Inc. for the requested information from all three CCR units.)
- Well construction diagrams and drilling logs for the four sentinel wells CF-19-08D, CF-19-14, CF-19-15, CF-19-15D, which were installed as part of IKEC's Assessment of Corrective Measures (ACM), are included in Appendix E5 (see Appendix D of the attached ACM report). Additionally, Figures F-1, F-3, and F-4 found in the ACM report depict the location of the sentinel wells, while cross sections associated with the area of the sentinel wells can be found in Figure F-2 of the ACM report.
- Maps that characterize the direction of groundwater flow accounting for seasonal variations (Appendix E2)

3.3 Groundwater Monitoring Results - § 257.103(f)(1)(iv)(B)(3)

The groundwater monitoring data through the second 2020 semi-annual sampling event is summarized in the table included as Appendix E3.

3.4 Description of Site Hydrogeology - § 257.103(f)(1)(iv)(B)(4)

Appendix E1 includes a description of the site hydrogeology (see Section 3.0 of the attached October 2016 report provided by Applied Geology and Environmental Science, Inc.) and stratigraphic cross-sections of the site are included as Appendix E4.

It is important to note that some groundwater flow direction can vary near the LRCP during periodic flooding events. As illustrated in the figures included in Appendix E2, groundwater flow can reverse directions during events of high flooding. These conditions are not frequent or long lasting. Wells were not installed on the north side of the LRCP since the area lies within a bedrock valley/channel that directs all groundwater flow to the end of the landfill where IKEC has located its groundwater monitoring wells. IKEC has conducted extensive geologic exploration and has determined that the Devils Backbone extends beyond the dam of the LRCP and directs groundwater toward the Ohio River. Groundwater is further confined by a separate geologic formation, which forms a steep rock wall running approximately parallel to the Devil's Backbone. Figure F-4 contained within IKEC's ACM for the LRCP provides a clear illustration of the site's unique geologic features.

3.5 Corrective Measures Assessment - § 257.103(f)(1)(iv)(B)(5)

Background sampling for the WBSP and LRCP occurred between January of 2016 and August of 2017 with nine independent samples collected. The first semiannual detection monitoring samples were collected in March of 2018. The WBSP remains in detection monitoring. Based on the results of the ongoing groundwater monitoring program, an assessment of corrective measures is not currently required for the WBSP.

The LRCP and CCR landfill share a multi-unit groundwater monitoring network. Upon completing background sampling efforts, the first round of detection monitoring took place in March of 2018. Based on the detection monitoring results from this first sampling event, statistically significant increases (SSIs) were confirmed for Boron in CF-15-08 and CF-15-09. At that time, IKEC took 90 days per the CCR Rule to conduct an Alternative Source Demonstration (ASD) for each of the CCR units. However, only the ASD for the CCR landfill was determined to be successful. The landfill remained in detection monitoring, but the LRCP was transitioned to assessment monitoring. A copy of the ASD is included in this demonstration in Appendix E3. Since a successful ASD was not found for the LRCP, the unit transitioned to assessment monitoring in September of 2018. The first assessment monitoring samples were collected in October of 2018. SSIs were detected for Molybdenum in CF-15-08 during that event. IKEC resampled in December 2018 and confirmed statistically significant levels of Molybdenum exceeding the GWPS in well CF-15-08. IKEC initiated a separate ASD for Molybdenum at this time, which was ultimately unsuccessful. While evaluating potential ASDs for the unit, IKEC concurrently began delineating the extent of the potential release. This work was initiated by installing the sentinel well system described above in Section 3.2, developing those wells, and subsequently sampling them to assist in evaluating the extent of the release. IKEC initiated its Assessment of Corrective Measures in May of 2019, which per the CCR Rule is anticipated to be completed within 90 days. However, due to delays encountered during ACM activities resulting from extended flood conditions, necessary site work could not be completed as originally scheduled. As a result, IKEC utilized the mechanism within the CCR Rule for an additional 60 days to support the ACM activities. After completing these activities, IKEC posted its original ACM report in September of 2019, and then held its public meeting in November of 2019. A copy of the ACM is included in this demonstration as Appendix E5.

3.6 Remedy Selection Progress Report - § 257.103(f)(1)(iv)(B)(6)

As noted above, an assessment of corrective measures and resulting remedy selection efforts are not currently required for the WBSP. The first remedy selection progress report for the LRCP (from May

2020) is included as Appendix E6. The second semi-annual progress report is currently being finalized and will be published on IKEC's CCR compliance website while EPA is reviewing this demonstration.

3.7 Structural Stability Assessment - § 257.103(f)(1)(iv)(B)(7)

Pursuant to § 257.73(d), the initial structural stability assessment reports for the CCR surface impoundments were prepared in October 2016 and are included as Appendix E7. As required for compliance, another stability assessment will be completed in October 2021. Periodic structural stability assessments are not required for landfills.

3.8 Safety Factor Assessment - § 257.103(f)(1)(iv)(B)(8)

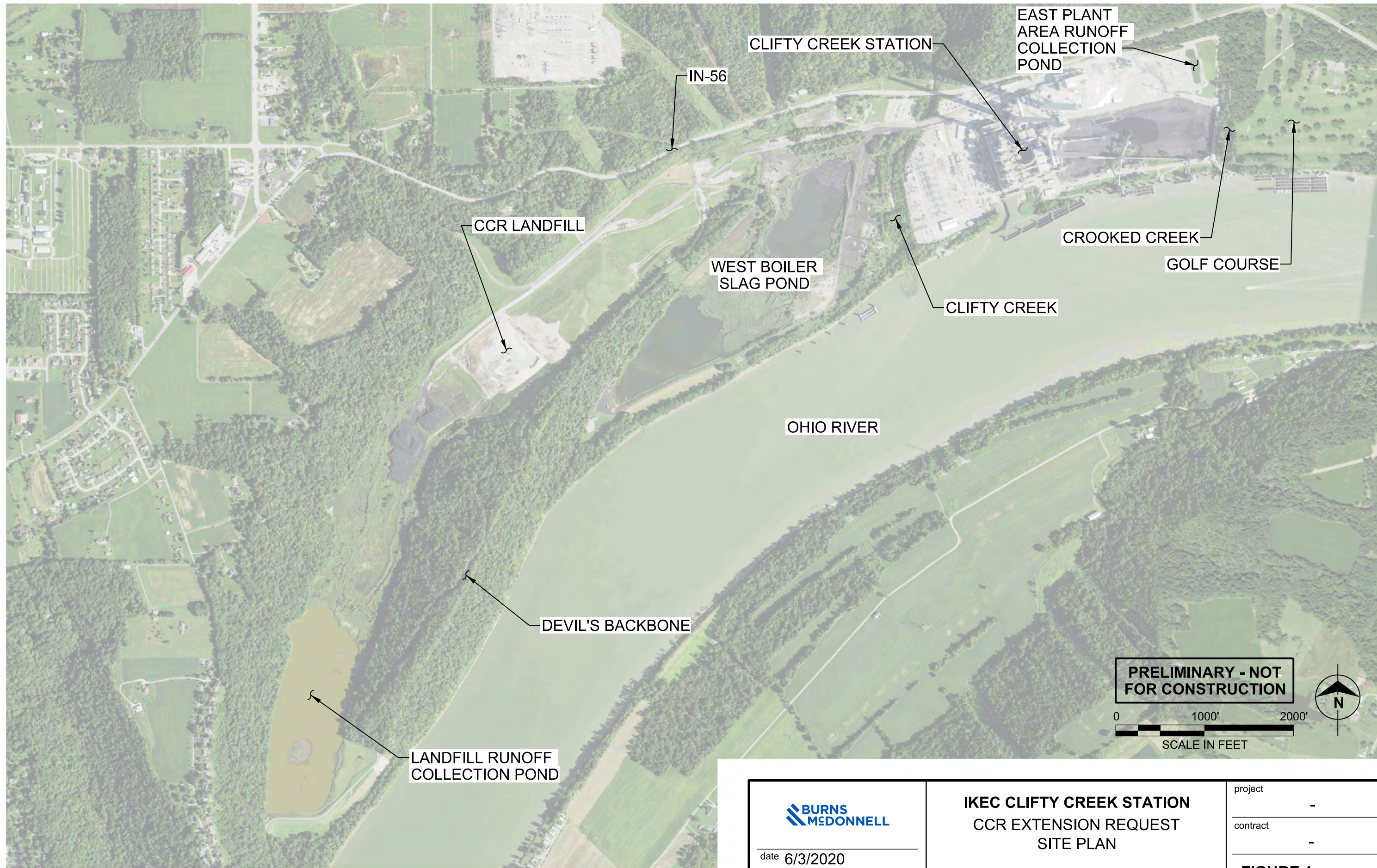
Pursuant to § 257.73(e), the initial safety factor assessment report for the CCR surface impoundments was prepared in October 2016 and is included as Appendix E8. As required for compliance, another stability assessment will be completed in October 2021. Periodic safety factor assessments are not required for landfills.

4.0 CONCLUSION

Based upon the information submitted in this demonstration, IKEC has demonstrated that the WBSP and LRCP at the Clifty Creek Station qualify for a site-specific alternative deadline for the initiation of closure as allowed by 40 CFR §257.103(f)(1).

Therefore, IKEC requests that EPA approve this demonstration, thereby granting the alternative deadline of December 5, 2022, to cease routing all CCR and non-CCR wastestreams to the WBSP and April 25, 2023, to cease routing all CCR and non-CCR wastestreams to the LRCP and initiate closure of these CCR surface impoundments. Following approval of this demonstration, IKEC will update the closure plan for the impoundments to further reflect the schedule and the methods identified herein. There are several variables that could impact the construction of the concrete settling tank, the new lined LVWTS, the new landfill runoff/leachate management system and the initiation of closure of the CCR surface impoundments, including delays in re-grading efforts associated with weather, contractor efficiency, the actual total volume of earthwork to be completed, and delays in securing any applicable state or federal permits. IKEC will update EPA on the project and any potential schedule impacts as part of the semi-annual progress reports required at 40 CFR § 257.103(f)(1)(x), and if a need for a later compliance deadline is determined, IKEC will seek additional time as described in 40 CFR § 257.103(f)(1)(vii).

APPENDIX A – SITE PLANS AND PRELIMINARY DESIGN FIGURES



PRELIMINARY - NOT FOR CONSTRUCTION

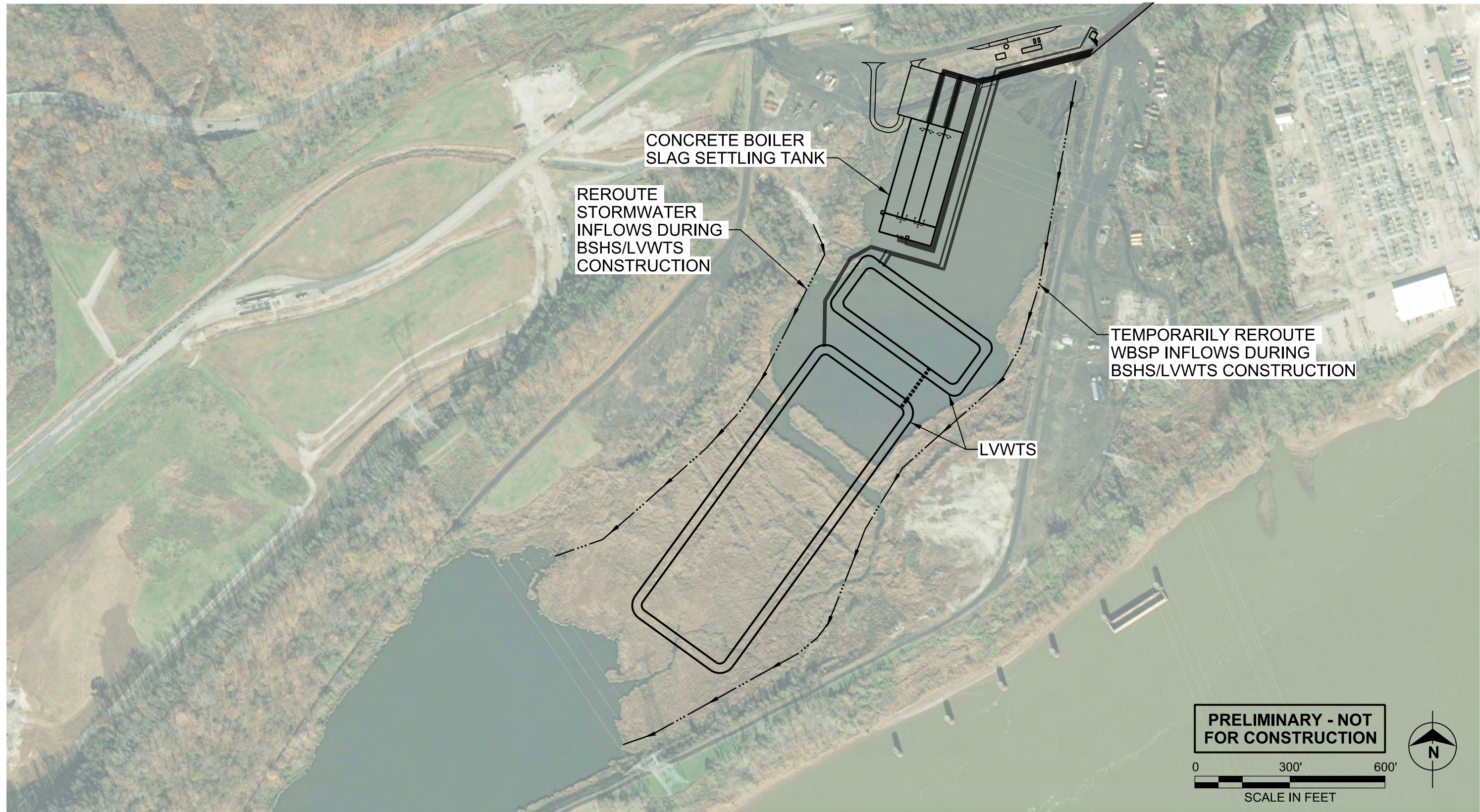


date 6/3/2020
designed A. MYERS

**IKEC CLIFTY CREEK STATION
CCR EXTENSION REQUEST
SITE PLAN**

project	-
contract	-

FIGURE 1



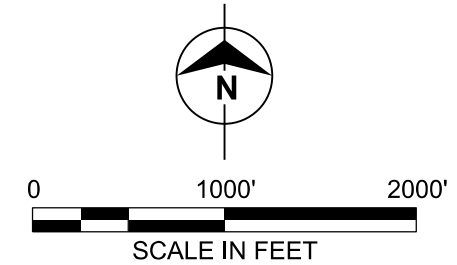
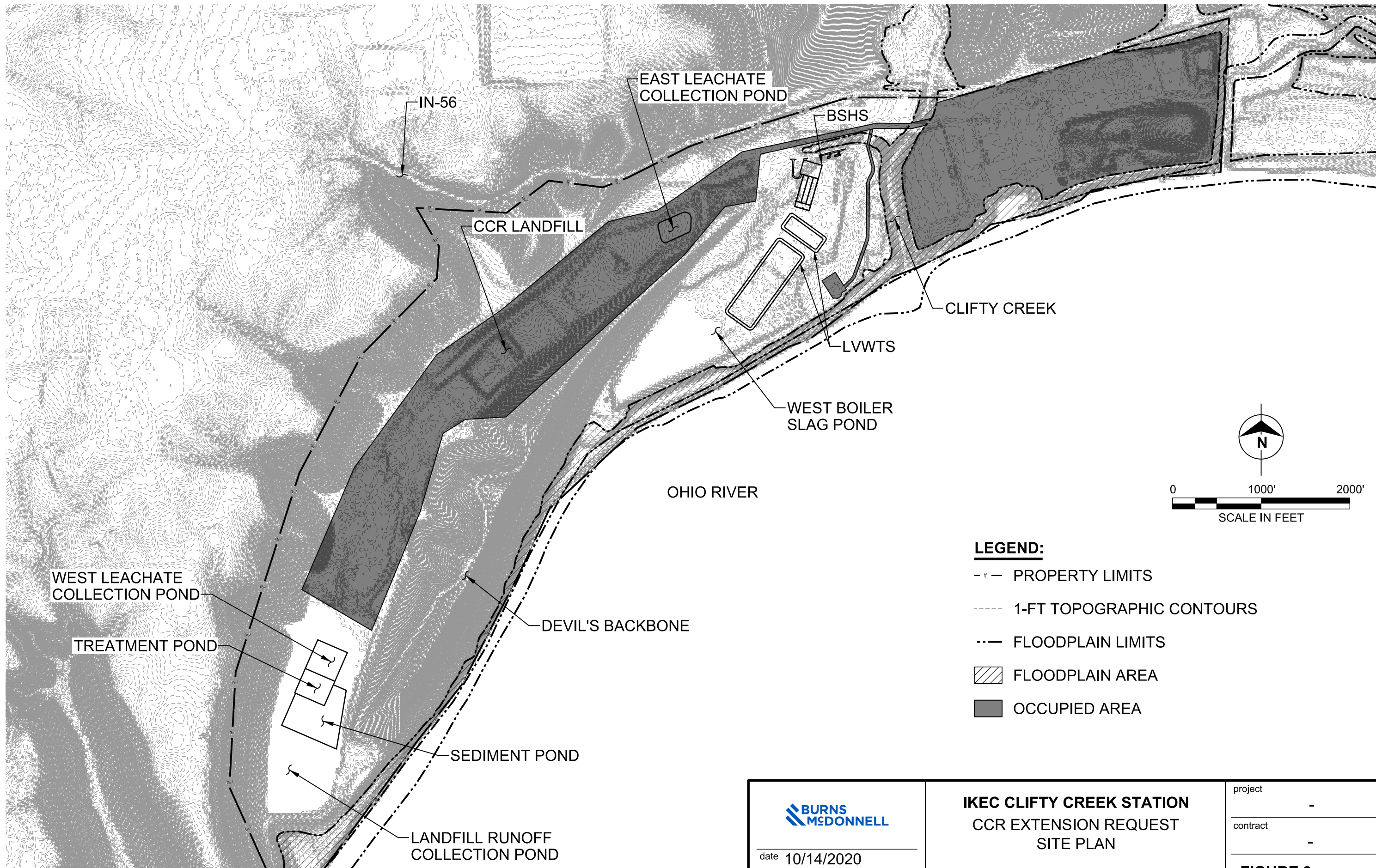
date 6/3/2020

designed A. MYERS

IKEC CLIFTY CREEK STATION
 CCR EXTENSION REQUEST
 BOILER SLAG CONVERSION
 PRELIMINARY LAYOUT

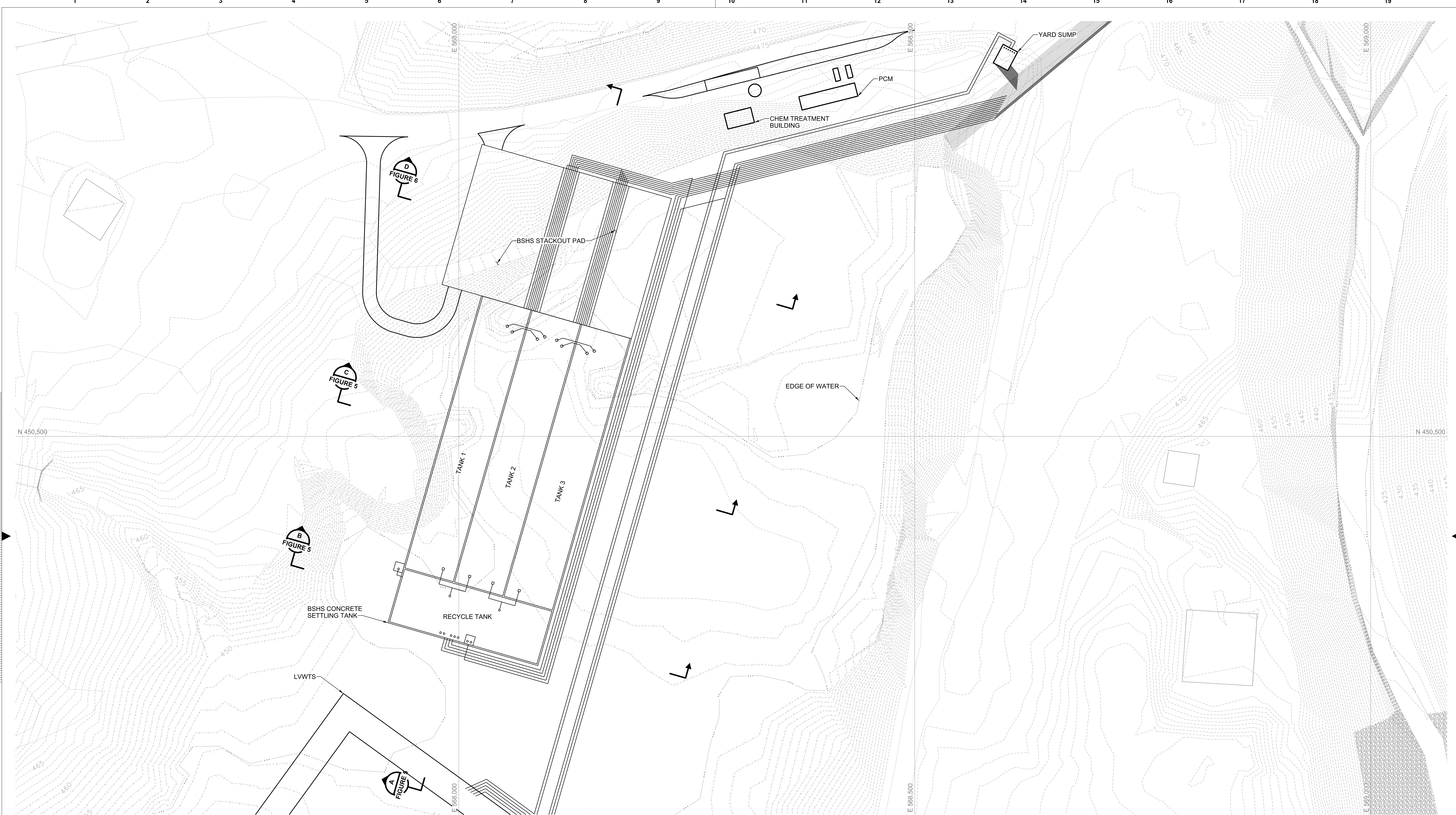
project	-
contract	-

FIGURE 2

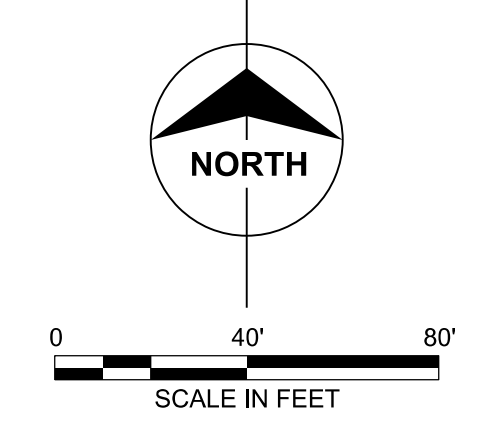


- LEGEND:**
- - - - PROPERTY LIMITS
 - 1-FT TOPOGRAPHIC CONTOURS
 - FLOODPLAIN LIMITS
 - ▨ FLOODPLAIN AREA
 - OCCUPIED AREA

 date 10/14/2020 designed A. MYERS	IKEC CLIFTY CREEK STATION CCR EXTENSION REQUEST SITE PLAN	project -
		contract -
		FIGURE 3



NOTES:
 1. AREA ADJACENT TO BSHS WITHIN THE WBSP LIMITS WILL BE BACKFILLED AND GRADED TO SUPPORT FINAL CLOSURE OF THE WBSP.
 2. DASHED CONTOURS REPRESENT EXISTING (I.E. CURRENT) GRADE BASED ON TOPOGRAPHIC/BATHYMETRIC SURVEY PROVIDED BY HREZO ENGINEERING ON OCTOBER 9, 2020.



PRELIMINARY - NOT FOR CONSTRUCTION

no.	date	by	ckd	description
A	11/06/20	AMM	--	FOR INFORMATION ONLY

BURNS MEDONNELL
 9400 WARD PARKWAY
 KANSAS CITY, MO 64114
 816-333-9400

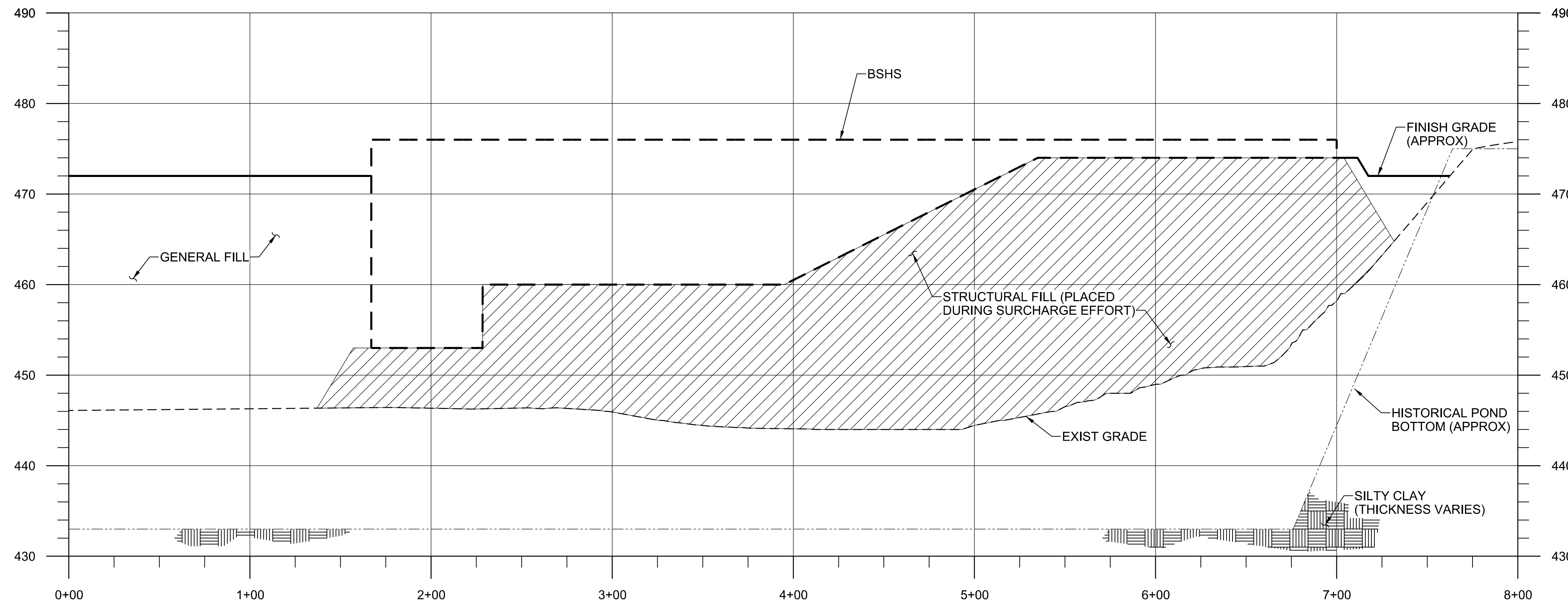
designed: A. MYERS
 detailed: A. MYERS

OVEC/IKEC
 Ohio Valley Electric Corporation / Indiana-Kentucky Electric Corporation

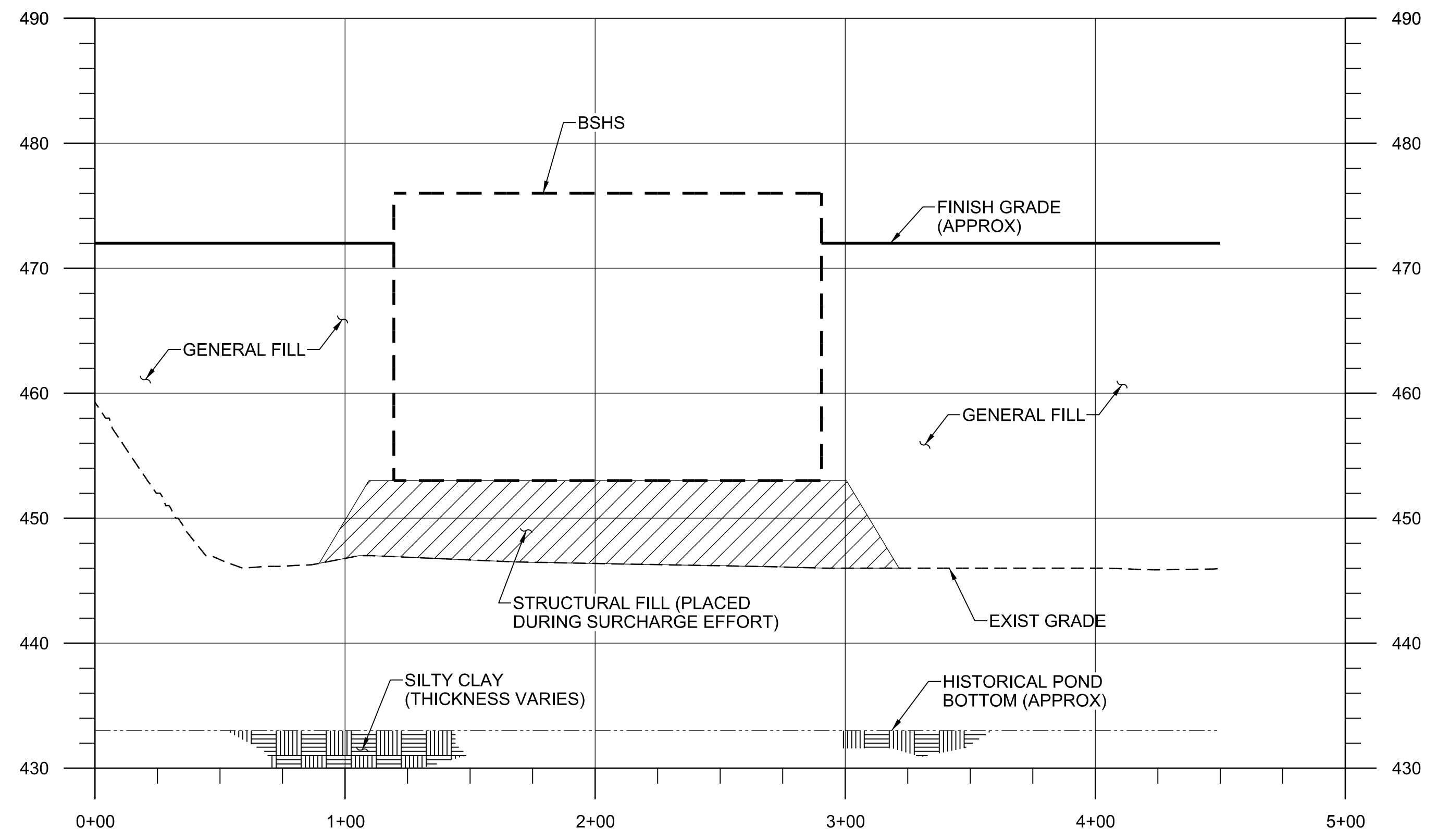
JEFFERSON COUNTY, INDIANA

IKEC CLIFTY CREEK STATION
 BSHS PLAN

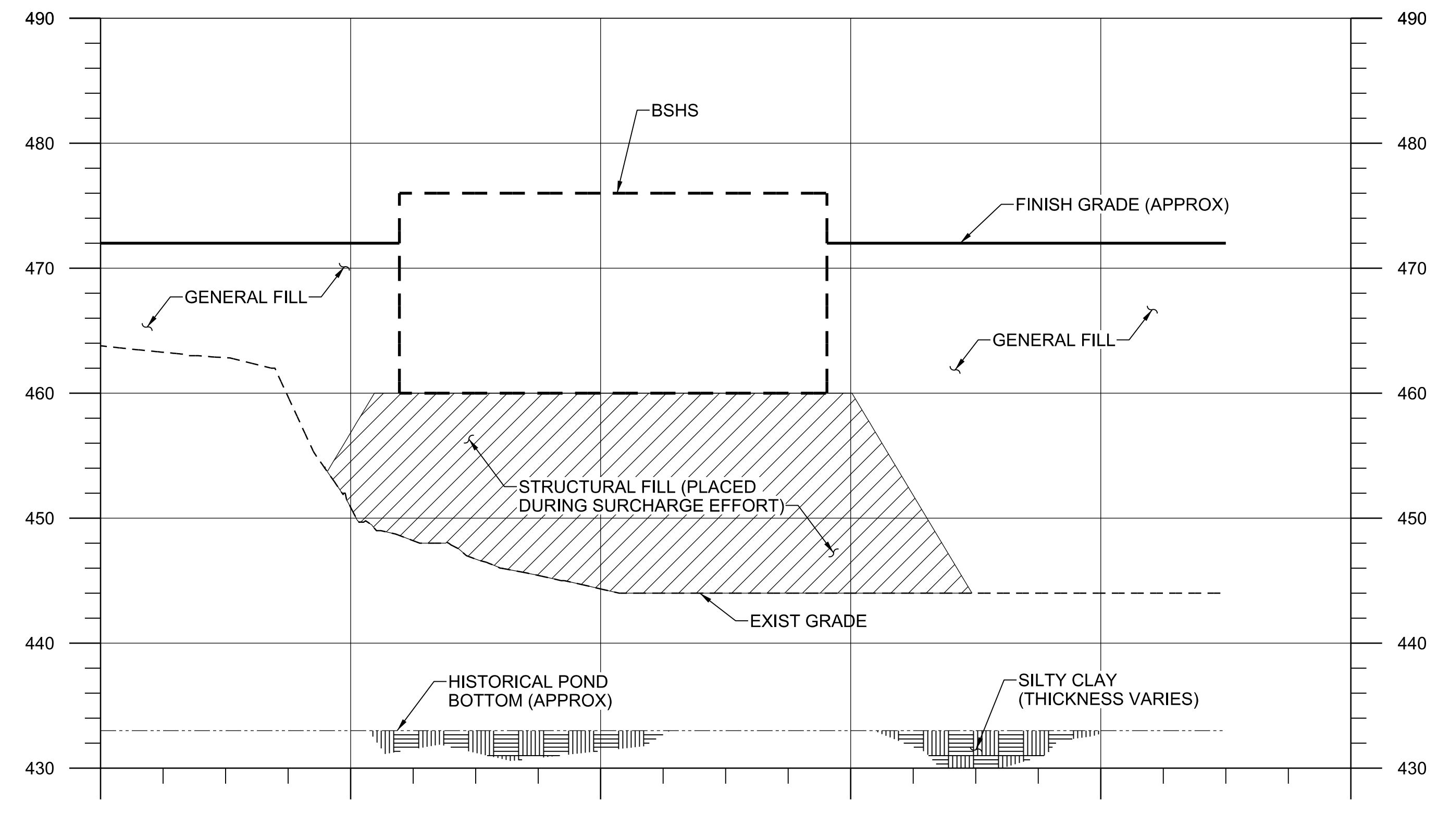
project 125241 | contract -
 drawing | rev. **A**
FIGURE 4
 sheet of sheets
 file FIGURE 4.dgn



SECTION **A**
TO **FIGURE 4**

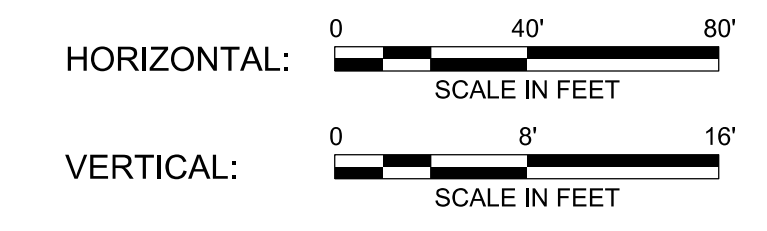


SECTION **B**
TO **FIGURE 4**



SECTION **C**
TO **FIGURE 4**

- NOTES:**
1. FINISH GRADE TO BE DETERMINED BY STANTEC. AREA ADJACENT TO BSHS WITHIN THE WBSP LIMITS WILL BE BACKFILLED AND GRADED TO SUPPORT FINAL CLOSURE OF THE WBSP.
 2. EXIST GRADE BASED ON TOPOGRAPHIC/BATHYMETRIC SURVEY PROVIDED BY HREZO ENGINEERING ON OCTOBER 9, 2020.
 3. POND BOTTOM APPROXIMATED BASED ON DESIGN GRADING DRAWINGS FROM THE CLIFTY CREEK WBSP HISTORY OF CONSTRUCTION.



PRELIMINARY - NOT FOR CONSTRUCTION

no.	date	by	ckd	description	no.	date	by	ckd	description
A	11/06/20	AMM	--	FOR INFORMATION ONLY					

BURNS MEDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400

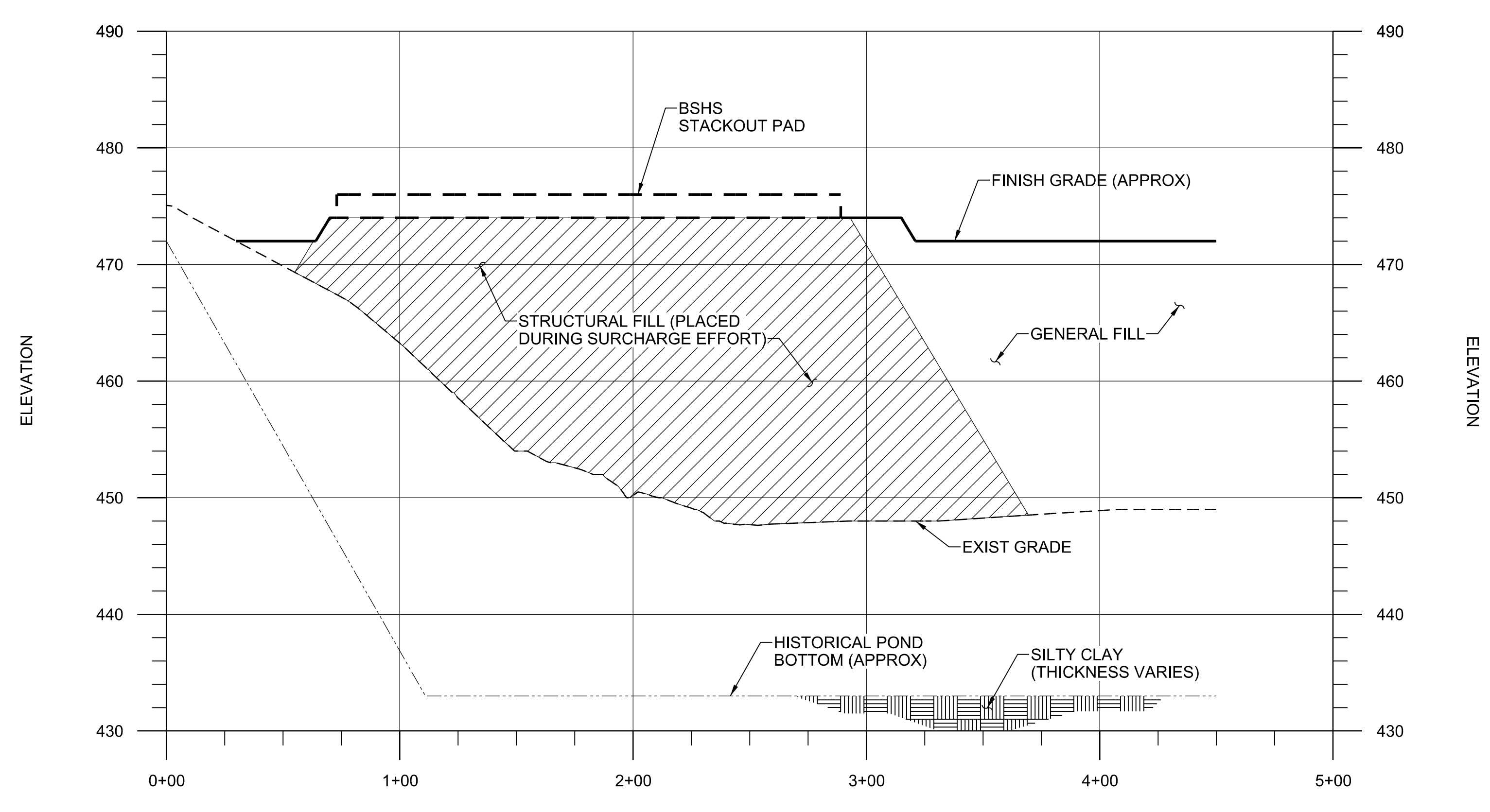


IKEC CLIFTY CREEK STATION
BSHS CROSS SECTIONS
SHEET 1

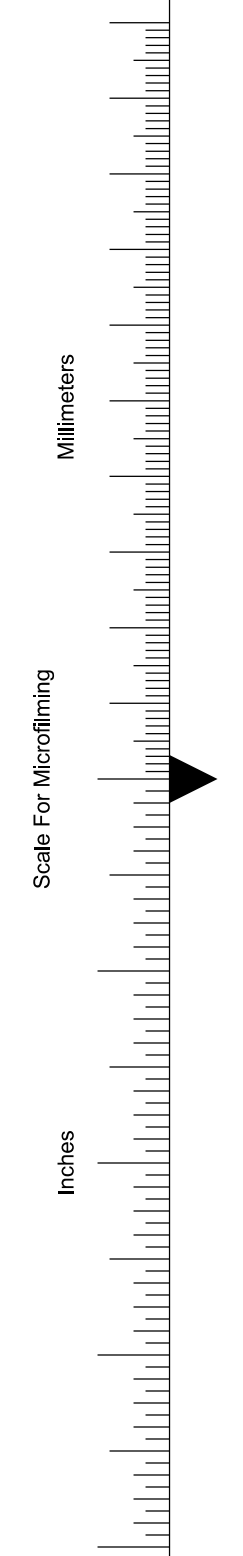
project	125241	contract	-
drawing		rev.	
FIGURE 5		A	
sheet	of	sheet	
file	FIGURE 5.dgn	sheet	

designed A. MYERS detailed A. MYERS

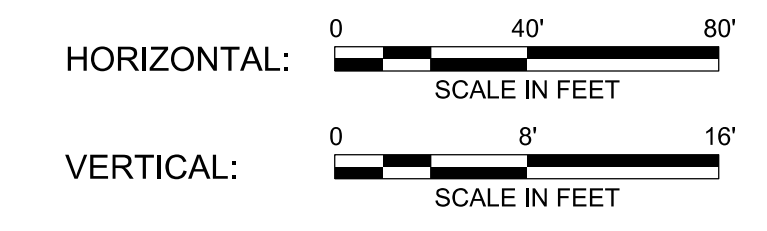
JEFFERSON COUNTY, INDIANA



SECTION D
FIGURE 4



- NOTES:**
1. FINISH GRADE TO BE DETERMINED BY STANTEC. AREA ADJACENT TO BSHS WITHIN THE WBSP LIMITS WILL BE BACKFILLED AND GRADED TO SUPPORT FINAL CLOSURE OF THE WBSP.
 2. EXIST GRADE BASED ON TOPOGRAPHIC/BATHYMETRIC SURVEY PROVIDED BY HREZO ENGINEERING ON OCTOBER 9, 2020.
 3. POND BOTTOM APPROXIMATED BASED ON DESIGN GRADING DRAWINGS FROM THE CLIFTY CREEK WBSP HISTORY OF CONSTRUCTION.



PRELIMINARY - NOT FOR CONSTRUCTION

no.	date	by	ckd	description	no.	date	by	ckd	description
A	11/06/20	AMM	--	FOR INFORMATION ONLY					

BURNS MEDONNELL
 9400 WARD PARKWAY
 KANSAS CITY, MO 64114
 816-333-9400

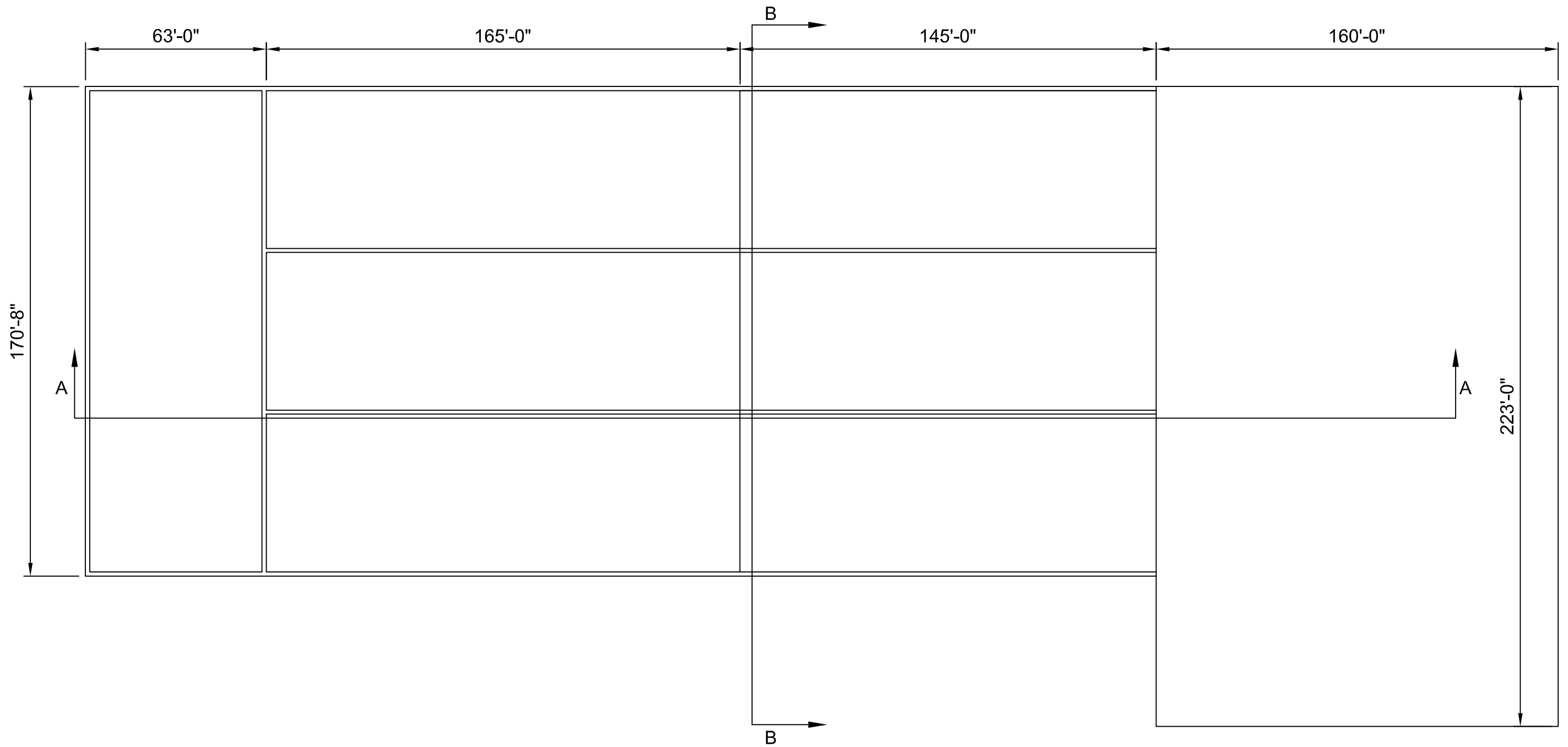
designed: A. MYERS
 detailed: A. MYERS

OVEC IKEC
Ohio Valley Electric Corporation Indiana-Kentucky Electric Corporation

JEFFERSON COUNTY, INDIANA

IKEC CLIFTY CREEK STATION
 BSHS CROSS SECTIONS
 SHEET 2

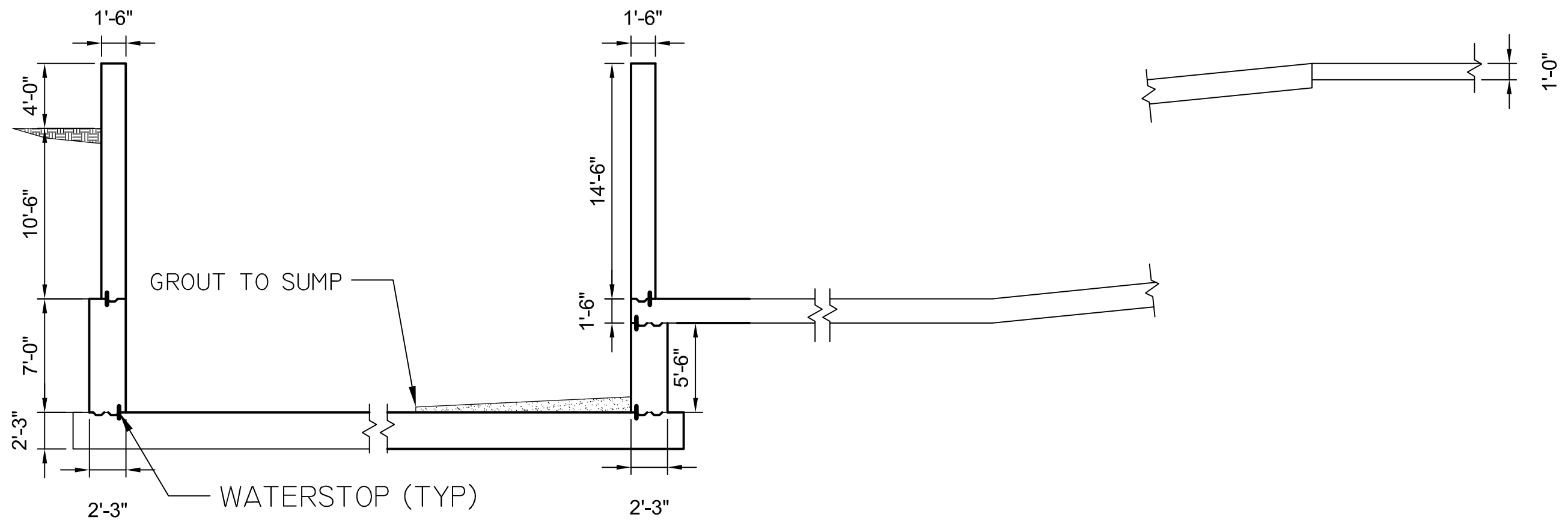
project: 125241 contract: -
 drawing: rev. **A**
FIGURE 6
 sheet of sheets
 file: FIGURE 6.dgn



date 10/30/2020
 designed R. MAESTRI

CLIFTY CREEK GENERATING STATION
 RECYCLE AND SETTLING TANKS
 PLAN VIEW

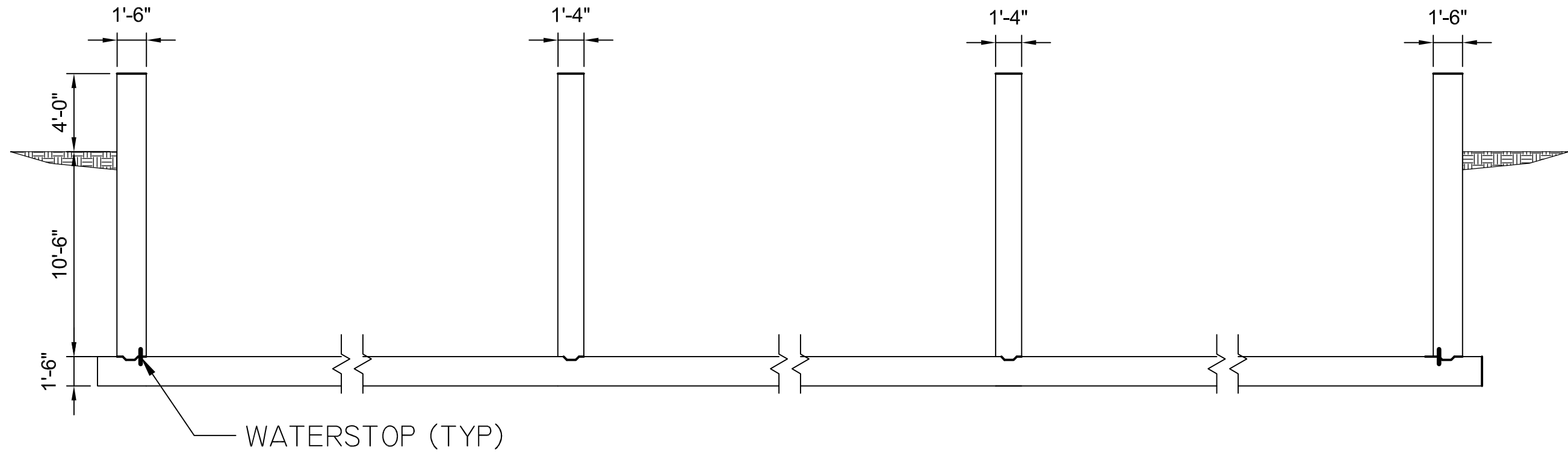
project 125241
 contract
 SK - S001



date 10/30/2020
 designed R. MAESTRI

CLIFTY CREEK GENERATING STATION
 RECYCLE AND SETTLING TANKS
 SECTION A

project	125241
contract	
SK -	S002

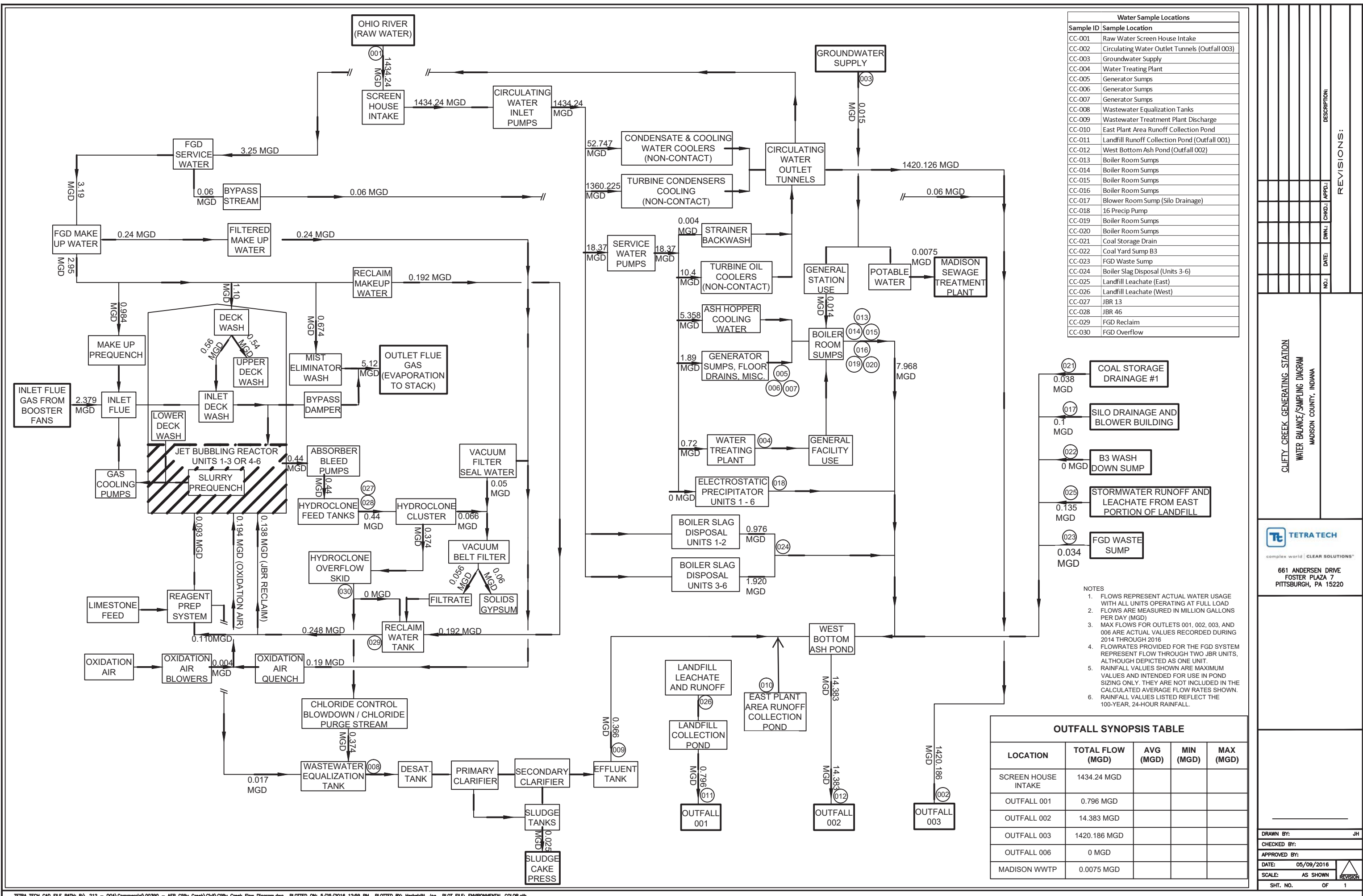


date 10/30/2020
 designed R. MAESTRI

CLIFTY CREEK GENERATING STATION
 RECYCLE AND SETTLING TANKS
 SECTION B

project 125241
 contract
 SK - S003

APPENDIX B – WATER BALANCE



Water Sample Locations	
Sample ID	Sample Location
CC-001	Raw Water Screen House Intake
CC-002	Circulating Water Outlet Tunnels (Outfall 003)
CC-003	Groundwater Supply
CC-004	Water Treating Plant
CC-005	Generator Sumps
CC-006	Generator Sumps
CC-007	Generator Sumps
CC-008	Wastewater Equalization Tanks
CC-009	Wastewater Treatment Plant Discharge
CC-010	East Plant Area Runoff Collection Pond
CC-011	Landfill Runoff Collection Pond (Outfall 001)
CC-012	West Bottom Ash Pond (Outfall 002)
CC-013	Boiler Room Sumps
CC-014	Boiler Room Sumps
CC-015	Boiler Room Sumps
CC-016	Boiler Room Sumps
CC-017	Blower Room Sump (Silo Drainage)
CC-018	16 Precip Pump
CC-019	Boiler Room Sumps
CC-020	Boiler Room Sumps
CC-021	Coal Storage Drain
CC-022	Coal Yard Sump B3
CC-023	FGD Waste Sump
CC-024	Boiler Slag Disposal (Units 3-6)
CC-025	Landfill Leachate (East)
CC-026	Landfill Leachate (West)
CC-027	JBR 13
CC-028	JBR 46
CC-029	FGD Reclaim
CC-030	FGD Overflow

021	COAL STORAGE DRAINAGE #1
017	SILO DRAINAGE AND BLOWER BUILDING
022	B3 WASH DOWN SUMP
025	STORMWATER RUNOFF AND LEACHATE FROM EAST PORTION OF LANDFILL
023	FGD WASTE SUMP

- NOTES
1. FLOWS REPRESENT ACTUAL WATER USAGE WITH ALL UNITS OPERATING AT FULL LOAD
 2. FLOWS ARE MEASURED IN MILLION GALLONS PER DAY (MGD)
 3. MAX FLOWS FOR OUTLETS 001, 002, 003, AND 006 ARE ACTUAL VALUES RECORDED DURING 2014 THROUGH 2016
 4. FLOWRATES PROVIDED FOR THE FGD SYSTEM REPRESENT FLOW THROUGH TWO JBR UNITS, ALTHOUGH DEPICTED AS ONE UNIT.
 5. RAINFALL VALUES SHOWN ARE MAXIMUM VALUES AND INTENDED FOR USE IN POND SIZING ONLY. THEY ARE NOT INCLUDED IN THE CALCULATED AVERAGE FLOW RATES SHOWN.
 6. RAINFALL VALUES LISTED REFLECT THE 100-YEAR, 24-HOUR RAINFALL.

OUTFALL SYNOPSIS TABLE				
LOCATION	TOTAL FLOW (MGD)	AVG (MGD)	MIN (MGD)	MAX (MGD)
SCREEN HOUSE INTAKE	1434.24 MGD			
OUTFALL 001	0.796 MGD			
OUTFALL 002	14.383 MGD			
OUTFALL 003	1420.186 MGD			
MADISON WWTP	0.0075 MGD			

CLIFTY CREEK GENERATING STATION
WATER BALANCE/SAMPLING DIAGRAM
MADISON COUNTY, INDIANA

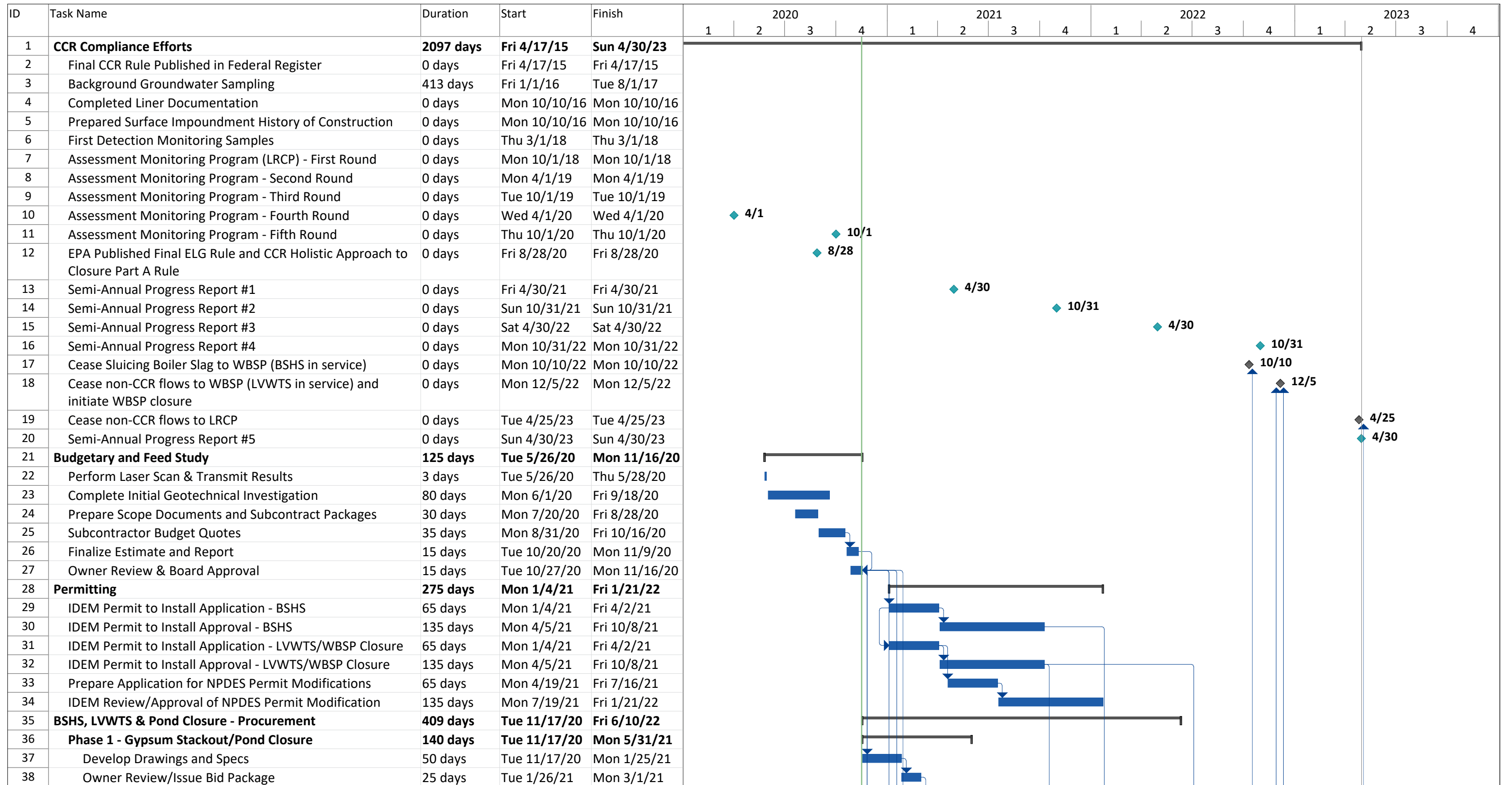
TETRA TECH
complex world | CLEAR SOLUTIONS™
661 ANDERSEN DRIVE
FOSTER PLAZA 7
PITTSBURGH, PA 15220

NO.	DATE	BY	CHKD.	APPD.	DESCRIPTION

REVISIONS:

DRAWN BY: JH
CHECKED BY:
APPROVED BY:
DATE: 05/09/2016
SCALE: AS SHOWN
SHT. NO. OF 1

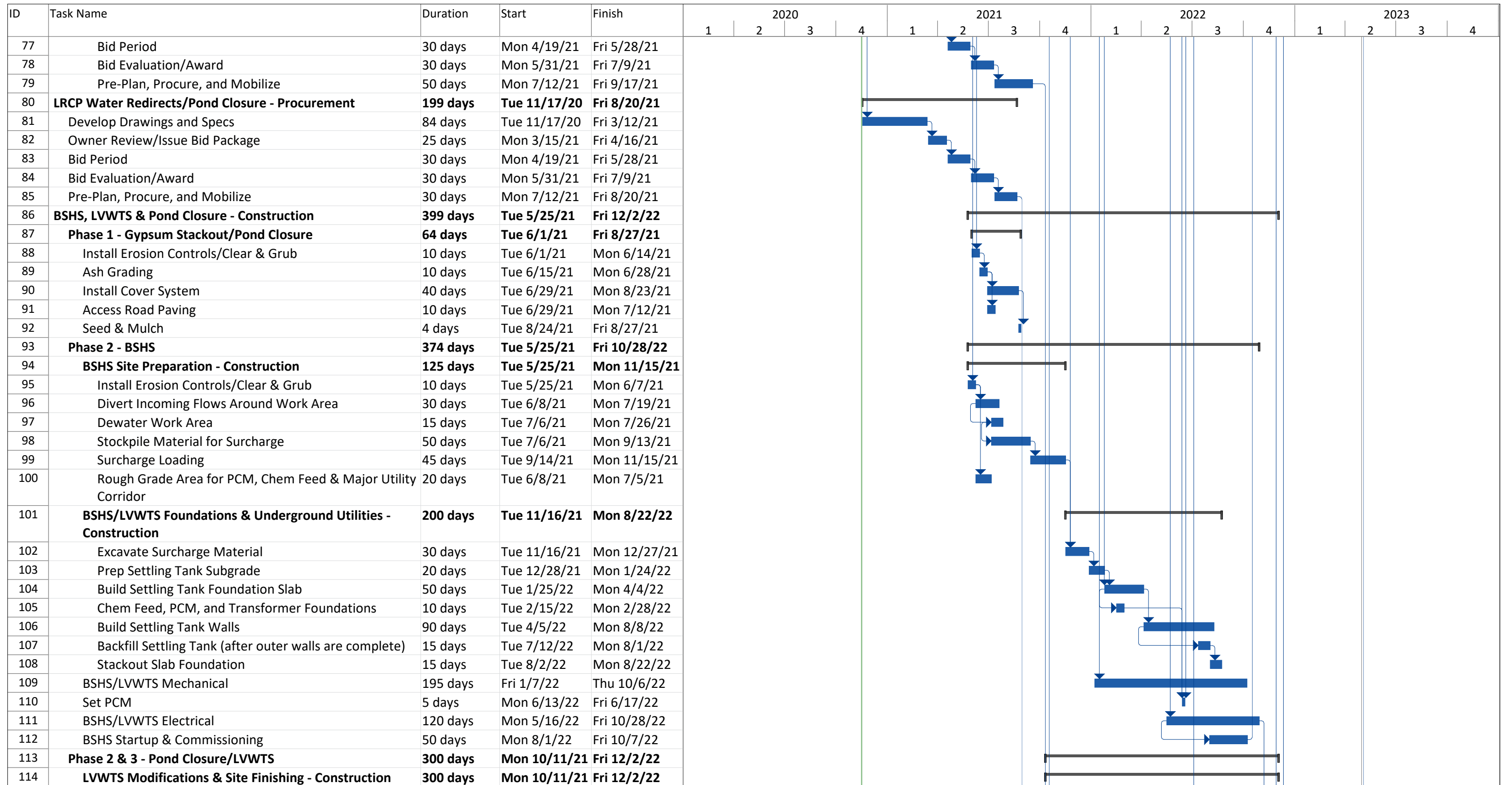
APPENDIX C – SCHEDULE



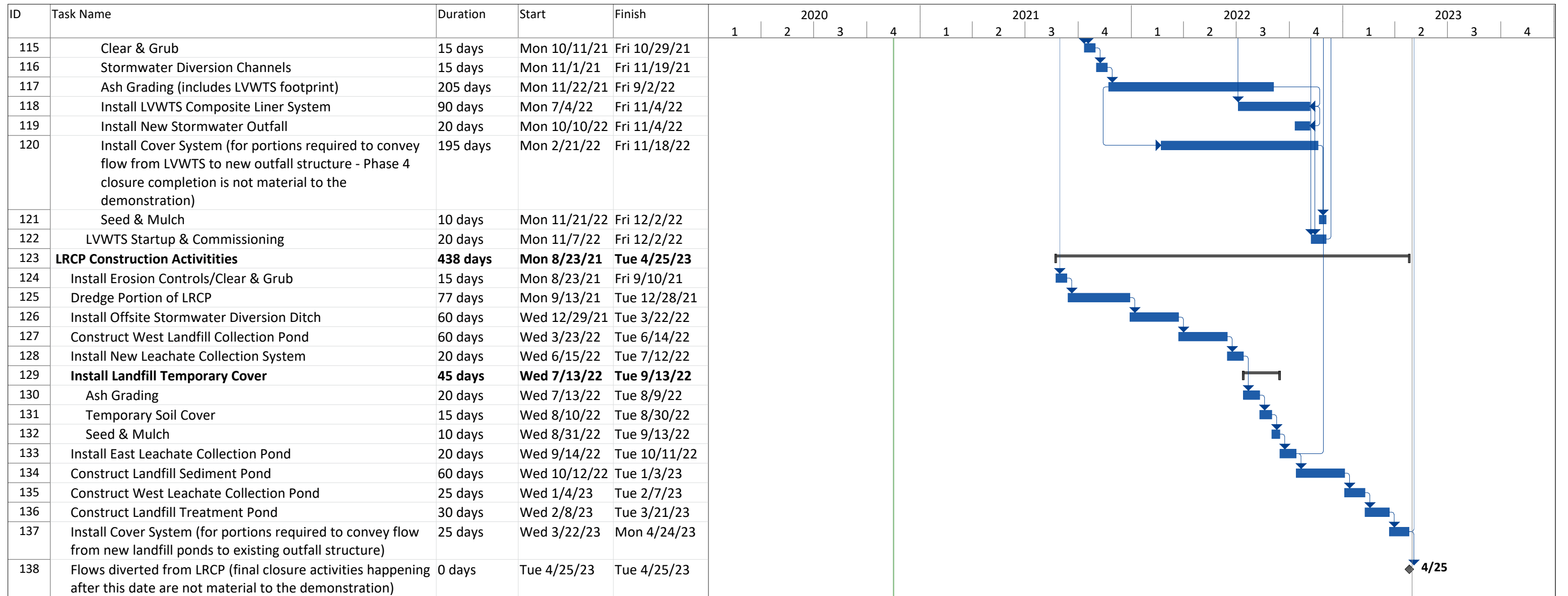
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	Split		External Milestone		Duration-only		Deadline	
	Milestone		Inactive Task		Manual Summary Rollup		Progress	
	Summary		Inactive Milestone		Manual Summary		Manual Progress	
	Project Summary		Inactive Summary		Start-only			

ID	Task Name	Duration	Start	Finish	2020				2021				2022				2023			
					1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
39	Bid Period	15 days	Tue 3/2/21	Mon 3/22/21																
40	Bid Evaluation/Award	20 days	Tue 3/23/21	Mon 4/19/21																
41	Pre-Plan, Procure, and Mobilize	30 days	Tue 4/20/21	Mon 5/31/21																
42	Phase 2 - BSHS	409 days	Tue 11/17/20	Fri 6/10/22																
43	BSHS Site Preparation - Procurement	135 days	Tue 11/17/20	Mon 5/24/21																
44	Develop Drawings and Specs	50 days	Tue 11/17/20	Mon 1/25/21																
45	Owner Review/Issue Bid Package	25 days	Tue 1/26/21	Mon 3/1/21																
46	Bid Period	15 days	Tue 3/2/21	Mon 3/22/21																
47	Bid Evaluation/Award	20 days	Tue 3/23/21	Mon 4/19/21																
48	Pre-Plan, Procure, and Mobilize	25 days	Tue 4/20/21	Mon 5/24/21																
49	BSHS Foundations & Underground Utilities Construction - Procurement	260 days	Tue 11/17/20	Mon 11/15/21																
50	Develop Drawings and Specs	170 days	Tue 11/17/20	Mon 7/12/21																
51	Owner Review/Issue Bid Package	20 days	Tue 7/13/21	Mon 8/9/21																
52	Bid Period	20 days	Tue 8/10/21	Mon 9/6/21																
53	Bid Evaluation/Award	20 days	Tue 9/7/21	Mon 10/4/21																
54	Pre-Plan, Procure, and Mobilize	30 days	Tue 10/5/21	Mon 11/15/21																
55	BSHS Major Electrical Equipment - Procurement	365 days	Mon 1/18/21	Fri 6/10/22																
56	Develop Bid Documents/Issue Bid Package	40 days	Mon 1/18/21	Fri 3/12/21																
57	Bid Period	30 days	Mon 3/15/21	Fri 4/23/21																
58	Review, Negotiate and Award	25 days	Mon 4/26/21	Fri 5/28/21																
59	Review and Approve Submittals	65 days	Mon 5/31/21	Fri 8/27/21																
60	Fabricate/Deliver to Site	270 days	Mon 5/31/21	Fri 6/10/22																
61	BSHS/LVWTS Mechanical Construction - Procurement	245 days	Fri 1/29/21	Thu 1/6/22																
62	Develop Drawings and Specs	80 days	Fri 1/29/21	Thu 5/20/21																
63	Owner Review/Issue Bid Package	45 days	Fri 5/21/21	Thu 7/22/21																
64	Bid Period	30 days	Fri 7/23/21	Thu 9/2/21																
65	Bid Evaluation/Award	25 days	Fri 9/3/21	Thu 10/7/21																
66	Pre-Plan, Procure, and Mobilize	65 days	Fri 10/8/21	Thu 1/6/22																
67	BSHS/LVWTS Electrical Construction - Procurement	195 days	Mon 8/16/21	Fri 5/13/22																
68	Develop Drawings and Specs	60 days	Mon 8/16/21	Fri 11/5/21																
69	Owner Review/Issue Bid Package	25 days	Mon 11/8/21	Fri 12/10/21																
70	Bid Period	30 days	Mon 12/13/21	Fri 1/21/22																
71	Bid Evaluation/Award	30 days	Mon 1/24/22	Fri 3/4/22																
72	Pre-Plan, Procure, and Mobilize	50 days	Mon 3/7/22	Fri 5/13/22																
73	Phase 2 & 3 - Pond Closure/LVWTS	185 days	Mon 1/4/21	Fri 9/17/21																
74	LVWTS Modifications & Site Finishing Construction - Procurement	185 days	Mon 1/4/21	Fri 9/17/21																
75	Develop Drawings and Specs	50 days	Mon 1/4/21	Fri 3/12/21																
76	Owner Review/Issue Bid Package	25 days	Mon 3/15/21	Fri 4/16/21																

Project: Clifty Creek CCR Surface Impoundments Extension Demonstration Date: Mon 11/16/20	Task		External Tasks		Manual Task		Finish-only	
	Split		External Milestone		Duration-only		Deadline	
	Milestone		Inactive Task		Manual Summary Rollup		Progress	
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	Project Summary		Inactive Summary		Start-only			



Project: Clifty Creek CCR Surface Impoundments Extension Demonstration Date: Mon 11/16/20	Task		External Tasks		Manual Task		Finish-only	
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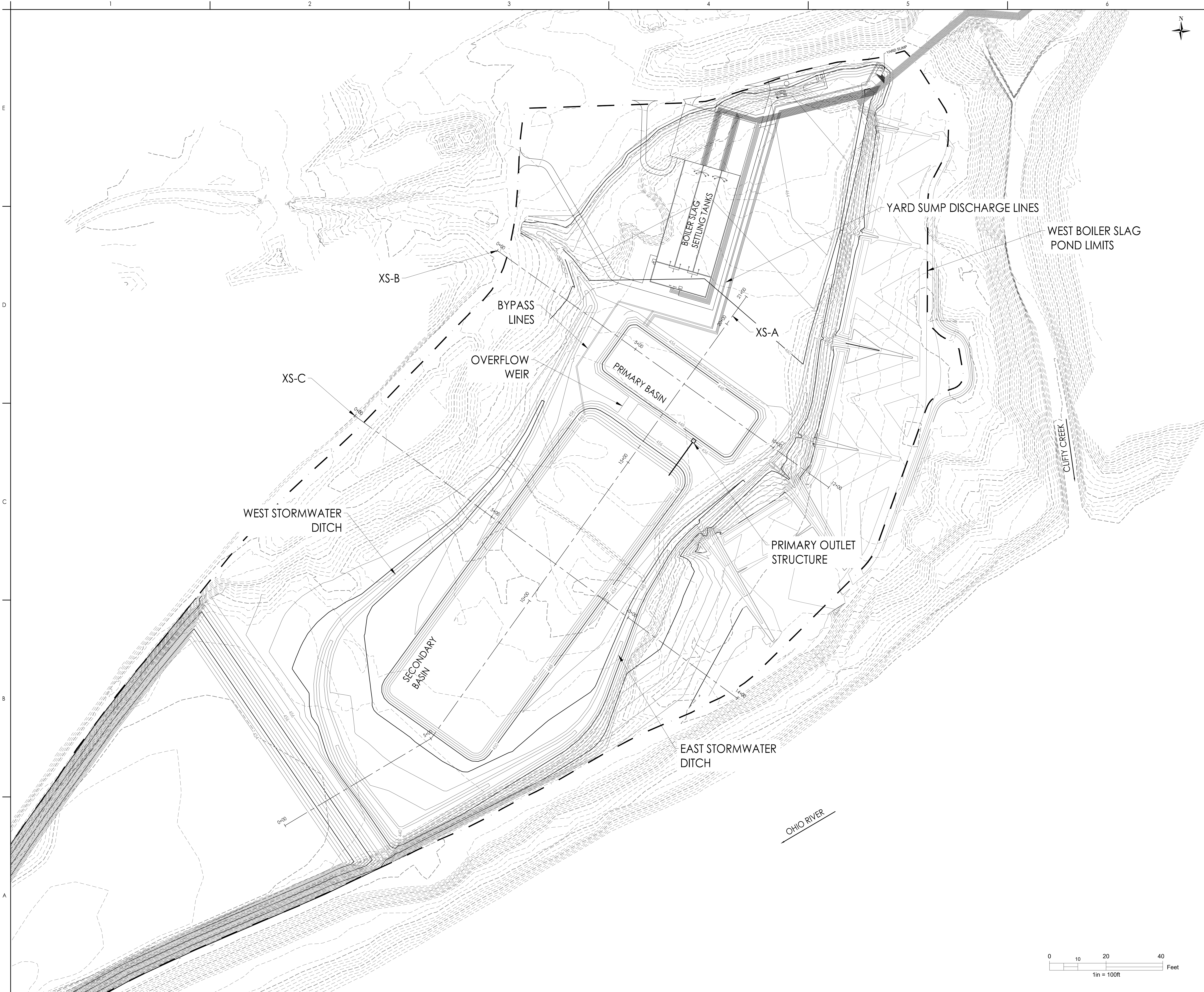


Project: Clifty Creek CCR Surface Impoundments Extension Demonstration Date: Mon 11/16/20	Task		External Tasks		Manual Task		Finish-only	
	Split		External Milestone		Duration-only		Deadline	
	Milestone		Inactive Task		Manual Summary Rollup		Progress	
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	Project Summary		Inactive Summary		Start-only			

APPENDIX D – STANTEC PRELIMINARY DESIGN FIGURES

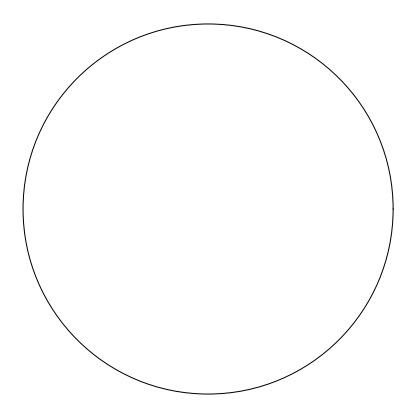
Notes

1. FINAL GRADE SURFACE ELEVATIONS ARE CONCEPTUAL ONLY AND ARE SUBJECT TO CHANGE DURING DETAILED DESIGN.
2. AN ALTERNATIVE CONFIGURATION WITH THE SECONDARY BASIN LOCATED IN THE FOOTPRINT OF THE SOUTHWEST CORNER OF THE WEST BOILER SLAG POND AND LOCATED OFF OF THE FINAL CAP HAS NOT BEEN SHOWN. THIS ALTERNATIVE WILL BE EVALUATED DURING DETAILED DESIGN.
3. PRIMARY AND SECONDARY BASIN GEOMETRY ANDS AND ELEVATIONS SHOWN ARE PRELIMINARY AND CONCEPTUAL IN NATURE AND SUBJECT TO CHANGE EXISTING GROUND SURFACE TAKEN FROM HREZO ENGINEERING SURVEY, DWG DATED 10/9/2020 PROVIDED BY B&MCD.
5. CLAY LAYER / HISTORIC CCR UNIT BOTTOM SURFACE ESTIMATED FROM HISTORIC CINDER STORAGE AREA DESIGN DRAWINGS, DATED 10/25/1954



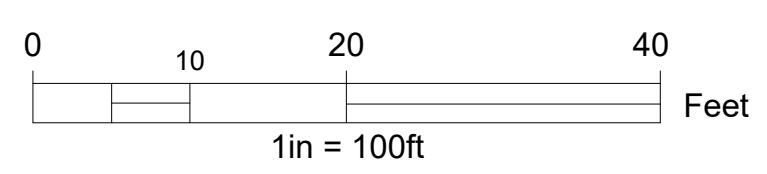
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					YYYY.MM.DD

Permit/Seal

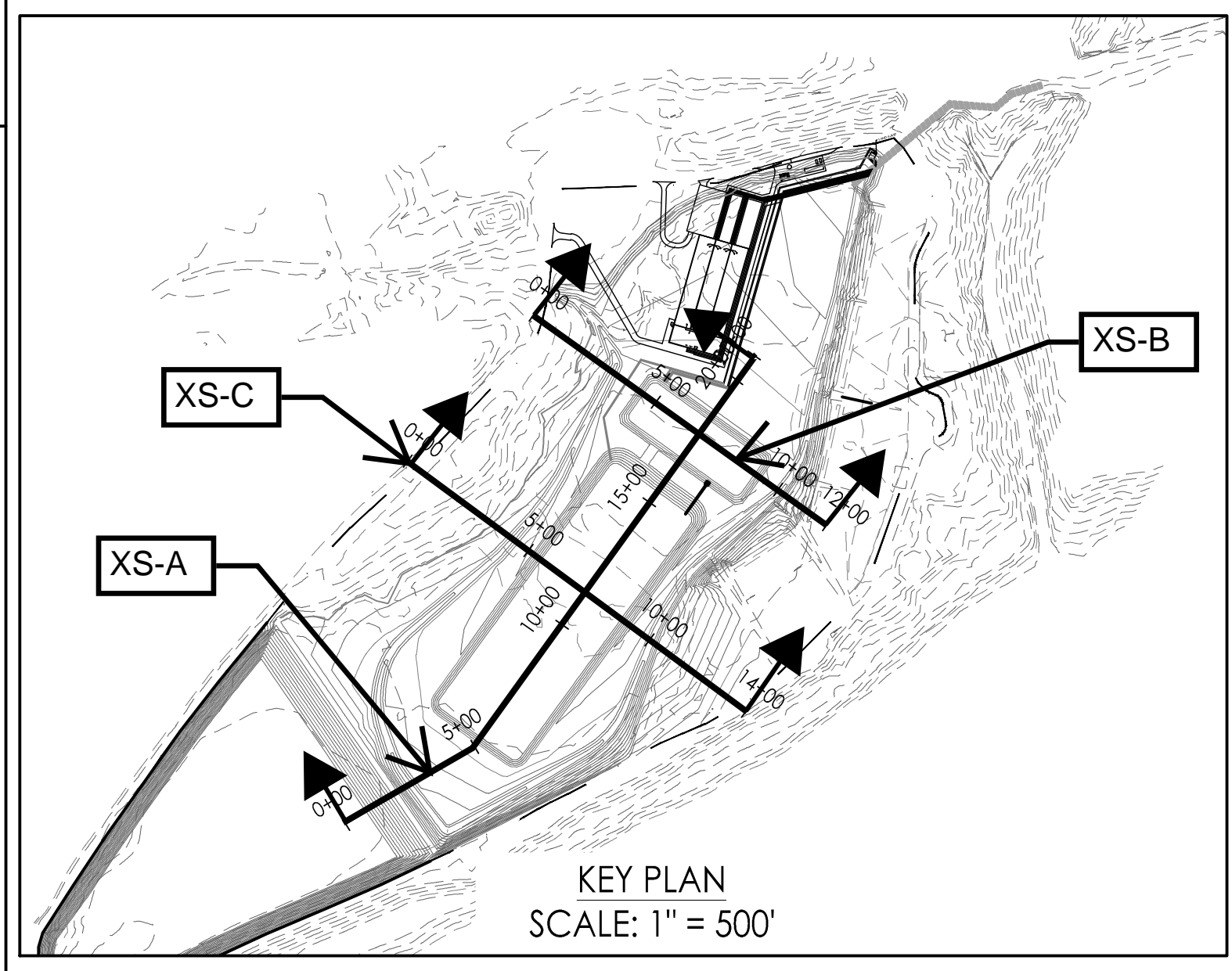
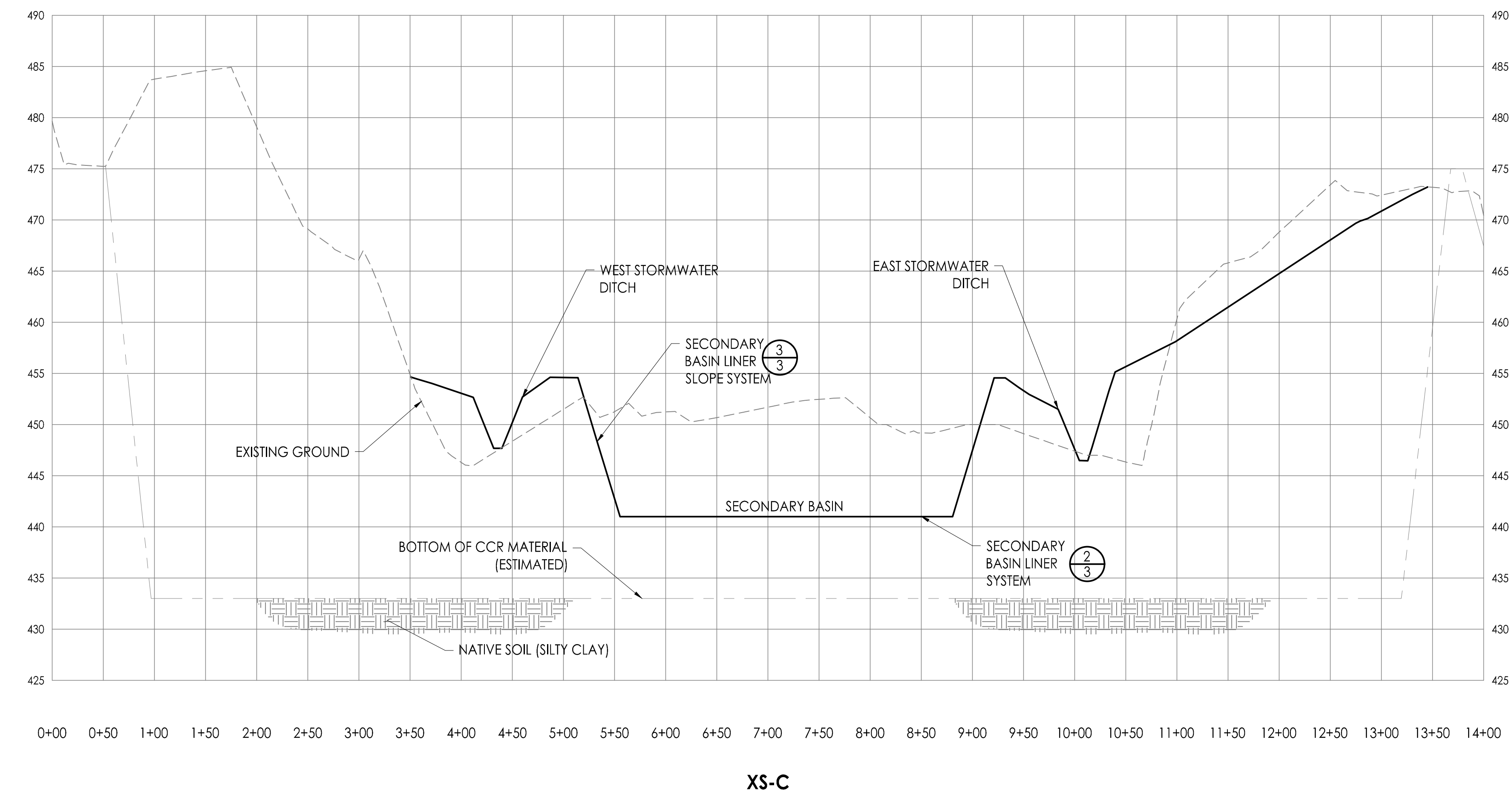
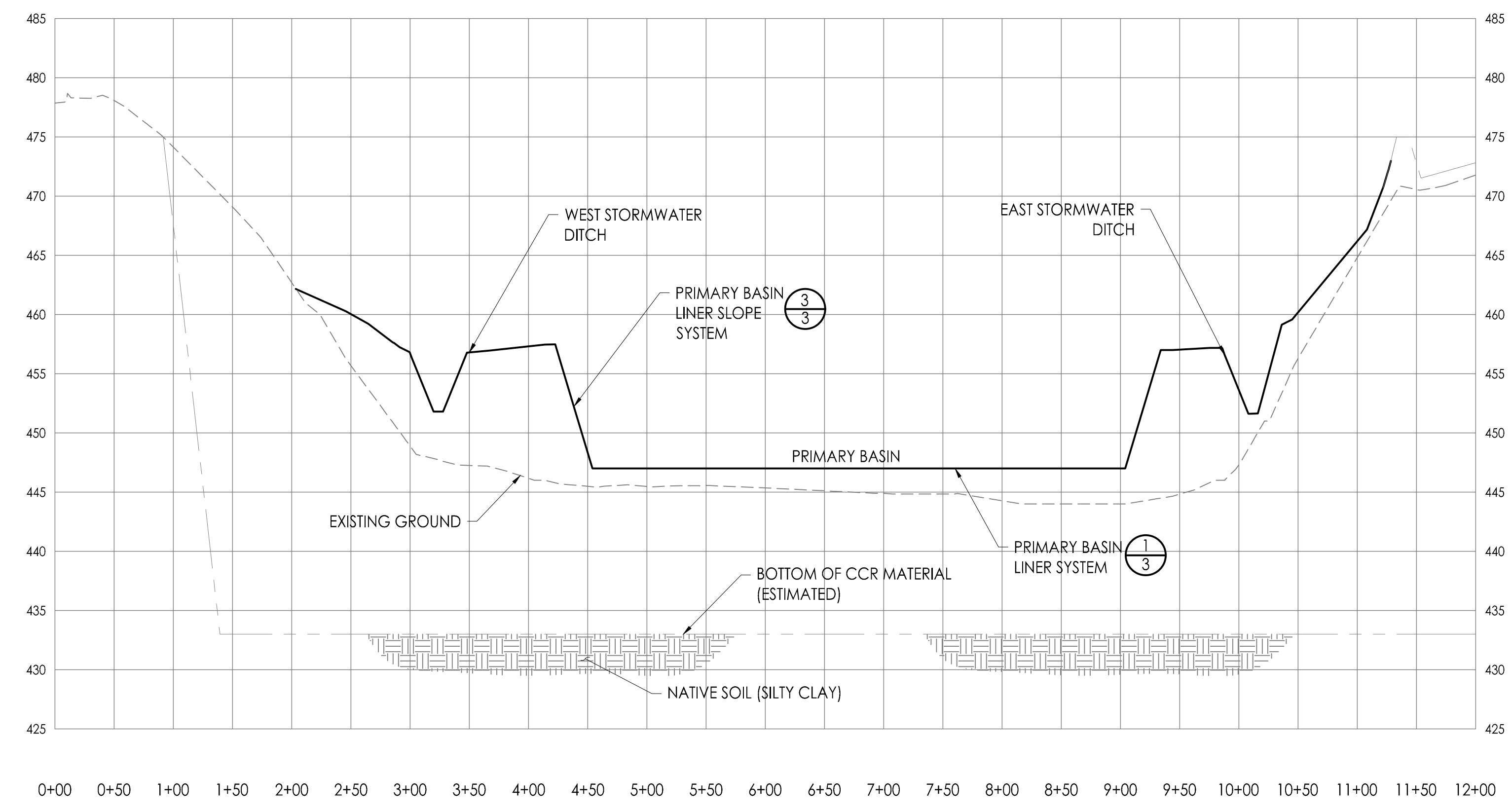
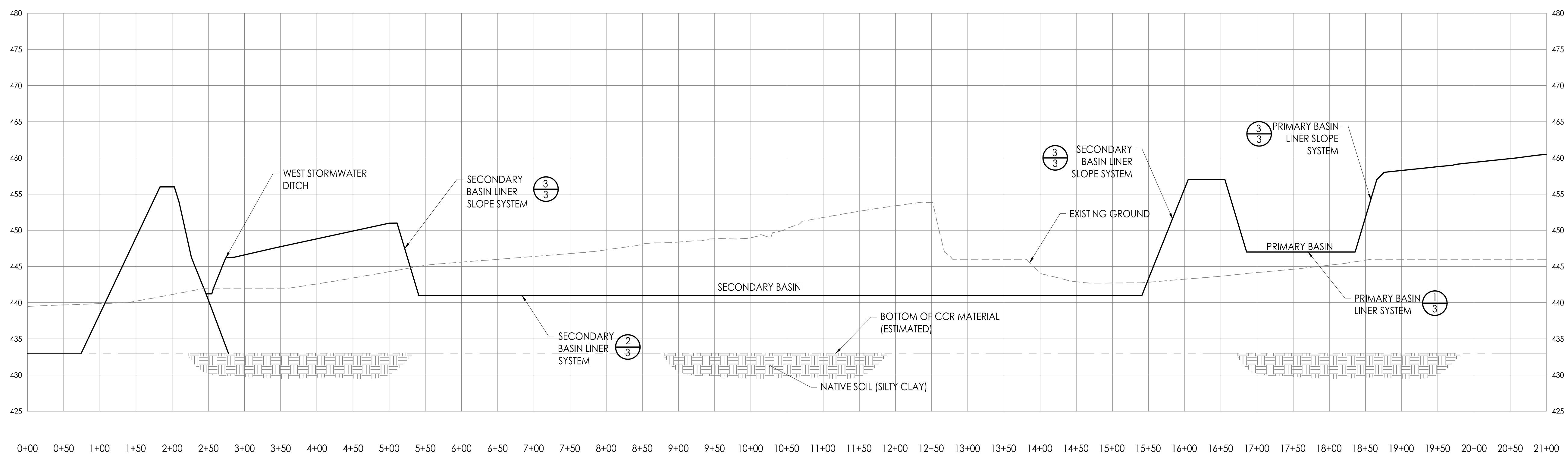



Client/Project

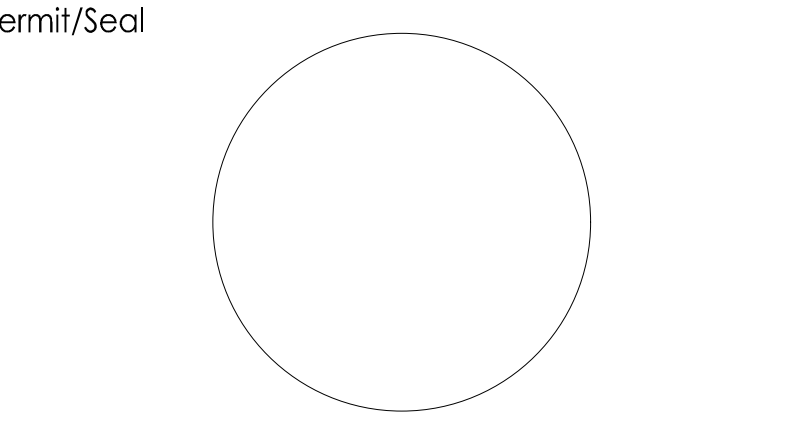
Title
LOW VOLUME WASTE TREATMENT SYSTEM
CONCEPTUAL LAYOUT



- Notes
1. FINAL GRADE SURFACE ELEVATIONS ARE CONCEPTUAL ONLY AND ARE SUBJECT TO CHANGE DURING DETAILED DESIGN.
 2. AN ALTERNATIVE CONFIGURATION WITH THE SECONDARY BASIN LOCATED IN THE FOOTPRINT OF THE SOUTHWEST CORNER OF THE FINAL CAP HAS NOT BEEN SHOWN. THIS ALTERNATIVE WILL BE EVALUATED DURING DETAILED DESIGN.
 3. PRIMARY AND SECONDARY BASIN GEOMETRY AND ELEVATIONS SHOWN ARE PRELIMINARY AND CONCEPTUAL IN NATURE AND SUBJECT TO CHANGE DURING DETAILED DESIGN.
 4. EXISTING GROUND SURFACE TAKEN FROM HREZO ENGINEERING SURVEY, DWG DATED 10/9/2020 PROVIDED BY B&M/C.
 5. CLAY LAYER / HISTORIC CCR UNIT BOTTOM SURFACE ESTIMATED FROM HISTORIC CINDER STORAGE AREA DESIGN DRAWINGS, DATED 10/25/1954

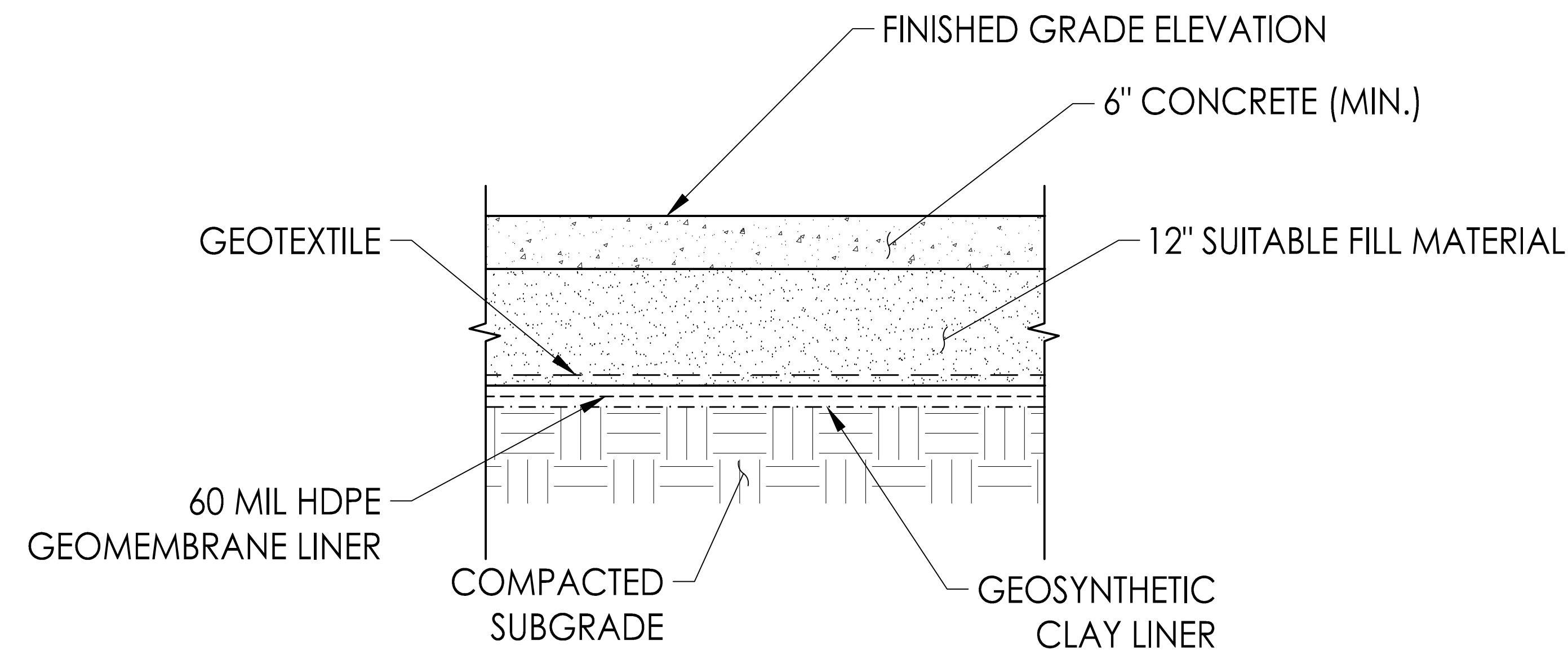


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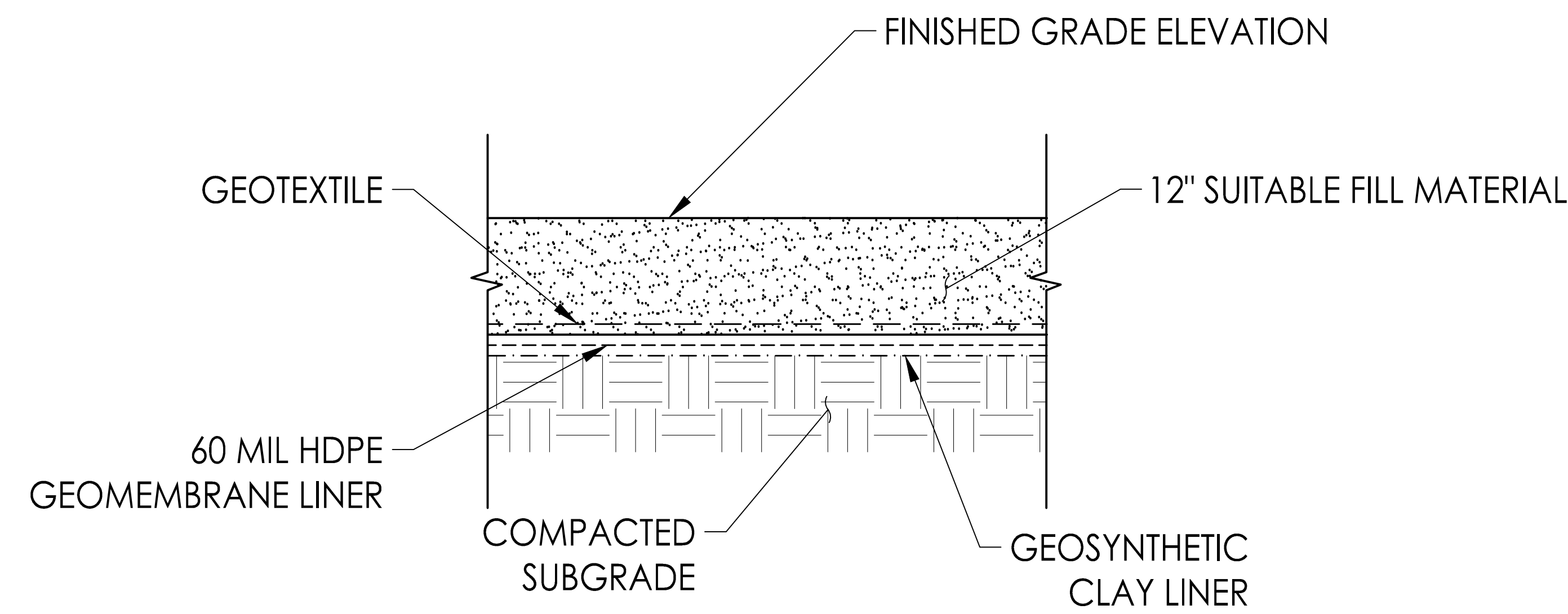


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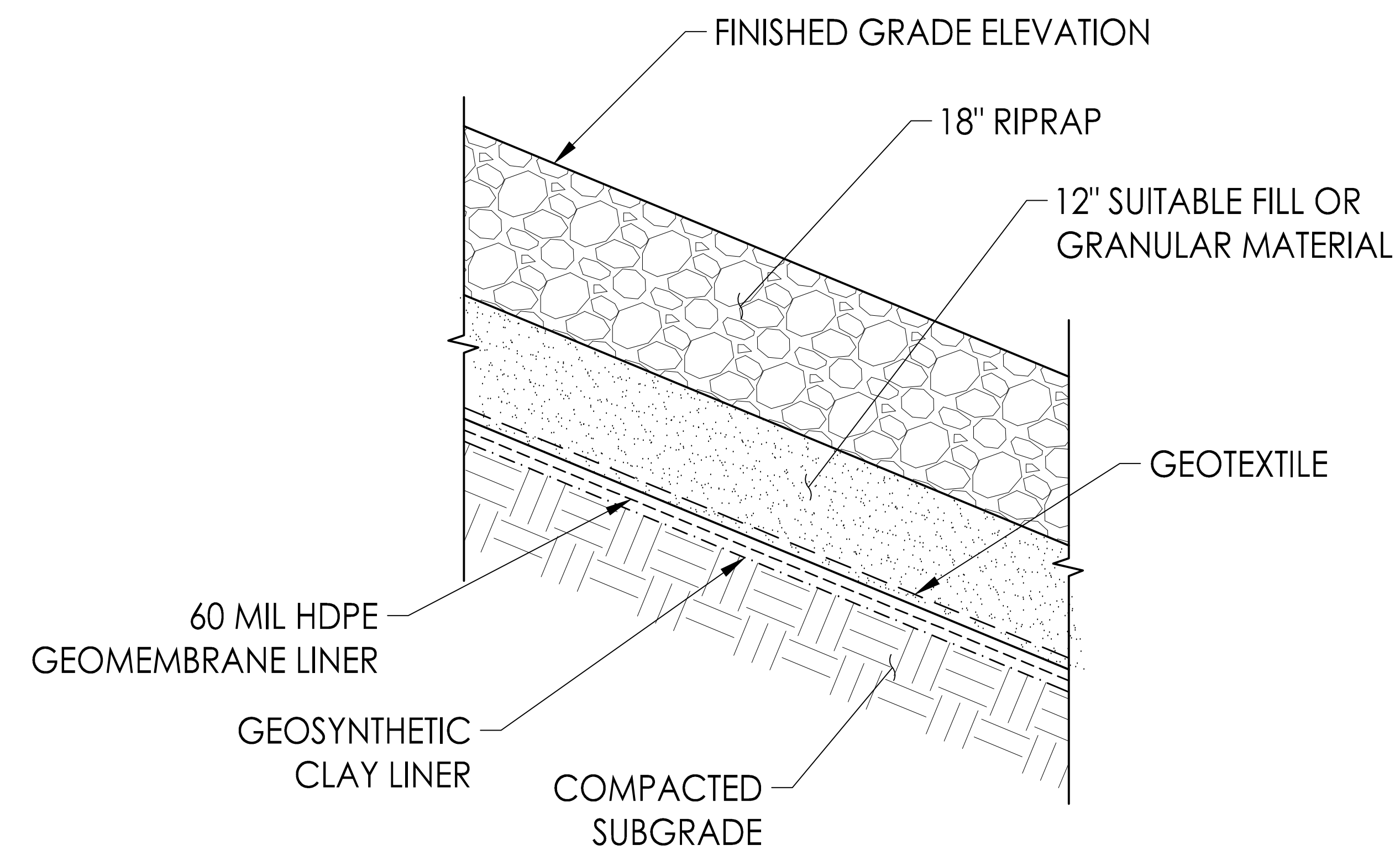
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3. PRIMARY AND SECONDARY BASIN GEOMETRY AND ELEVATIONS SHOWN ARE PRELIMINARY AND CONCEPTUAL IN NATURE AND SUBJECT TO CHANGE EXISTING GROUND SURFACE TAKEN FROM HREZO ENGINEERING SURVEY, DWG DATED 10/9/2020 PROVIDED BY B&MCO.
5. CLAY LAYER / HISTORIC CCR UNIT BOTTOM SURFACE ESTIMATED FROM HISTORIC CINDER STORAGE AREA DESIGN DRAWINGS, DATED 10/25/1954



1
 3 LVWTS PRIMARY BASIN TYPICAL BOTTOM SURFACE
 NOT_TO_SCALE

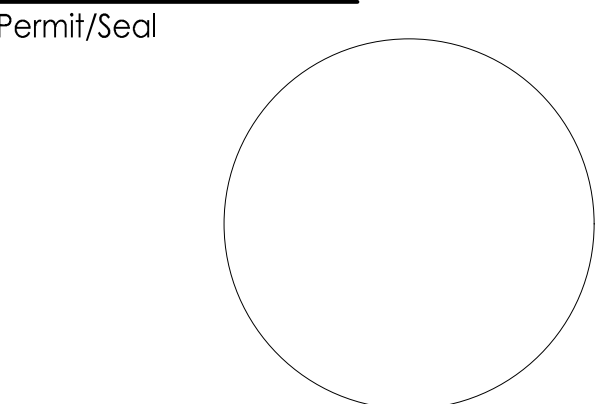


2
 3 LVWTS SECONDARY BASIN TYPICAL BOTTOM SURFACE
 NOT_TO_SCALE



3
 3 LVWTS PRIMARY AND SECONDARY BASIN TYPICAL SLOPE SURFACE
 NOT_TO_SCALE

ISSUED FOR INFORMATION	NM	JR	2020.11.16
Issued	By	Appd	YYYY.MM.DD
	Dwn	Dign	Chkd
			YYYY.MM.DD



Client/Project

Title
 LOW VOLUME WASTE TREATMENT SYSTEM
 LINER DETAILS

Project No. _____ Scale _____

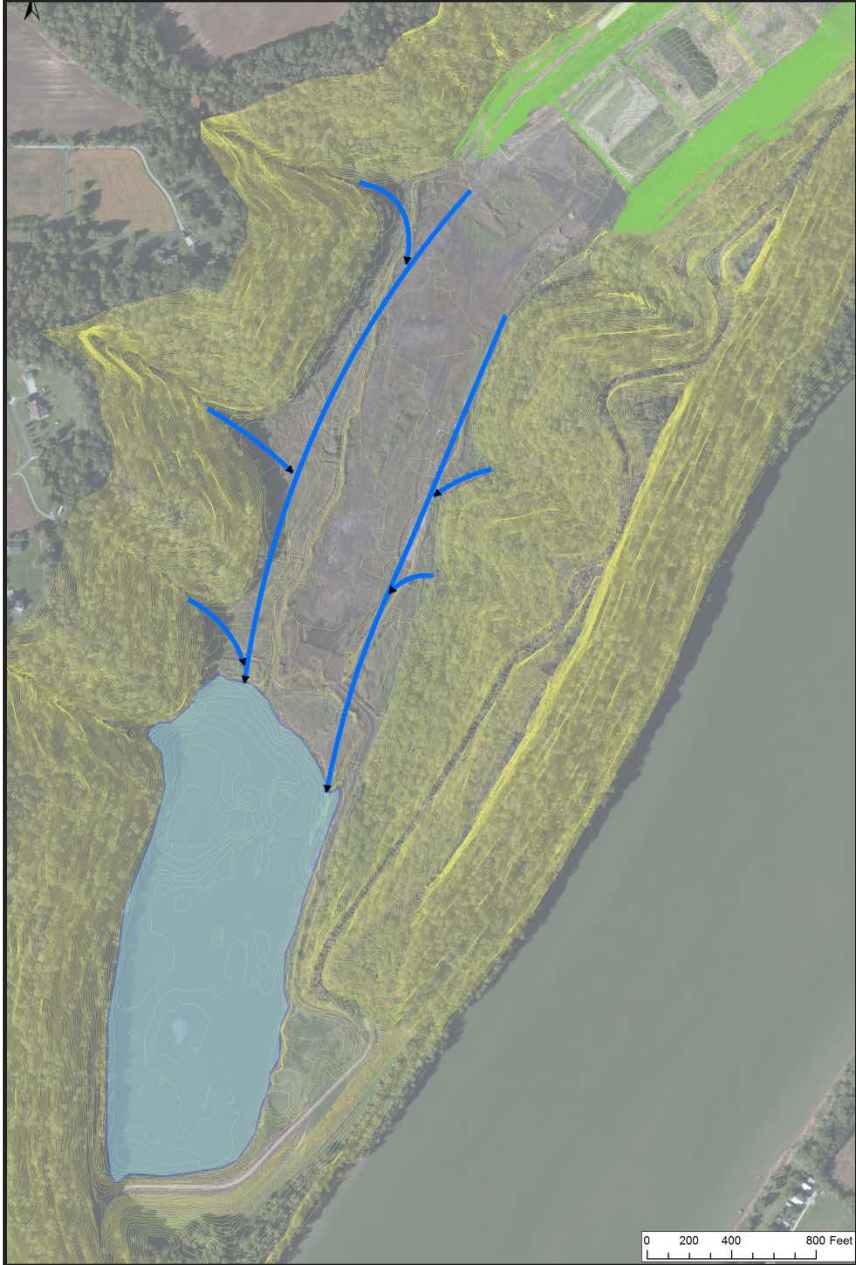
Revision Sheet 3 of 3 Drawing No. _____

Clifty Creek Station Landfill Runoff Collection Pond Closure - Conceptual Plan

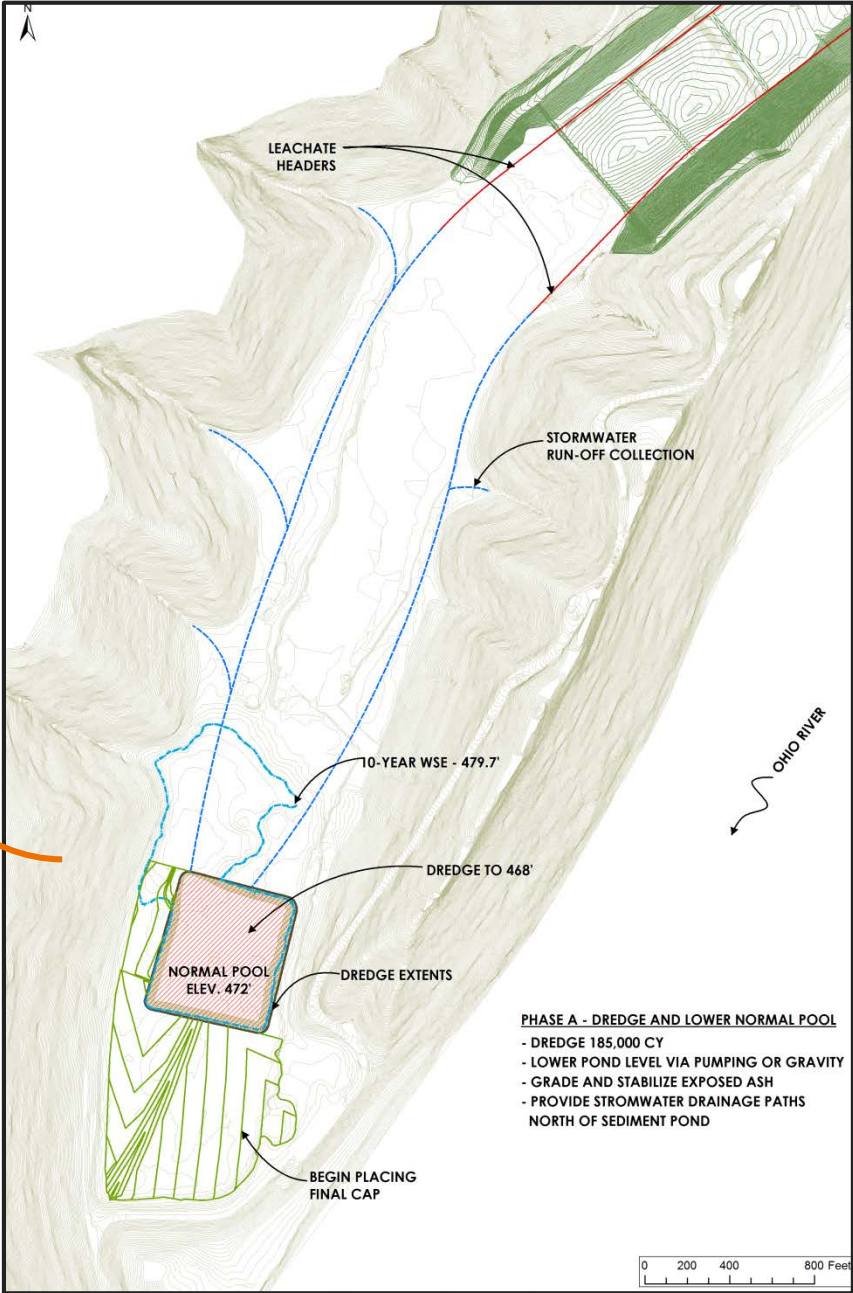
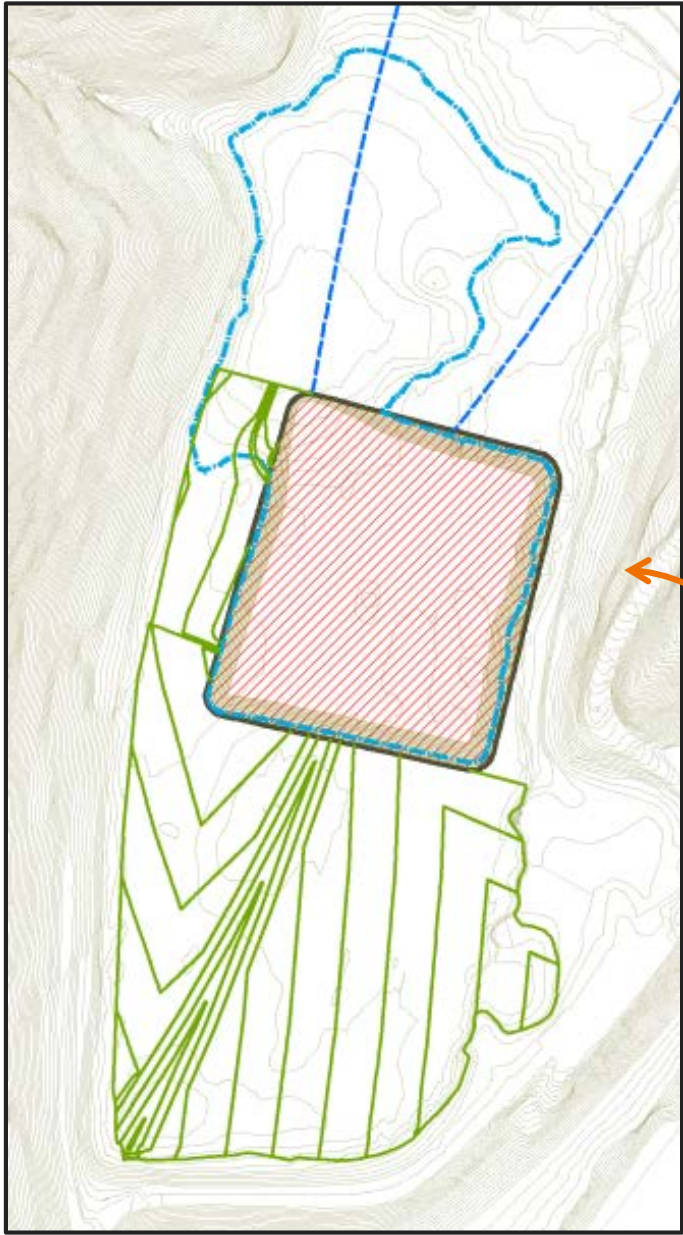
March 12, 2020 (rev 1)



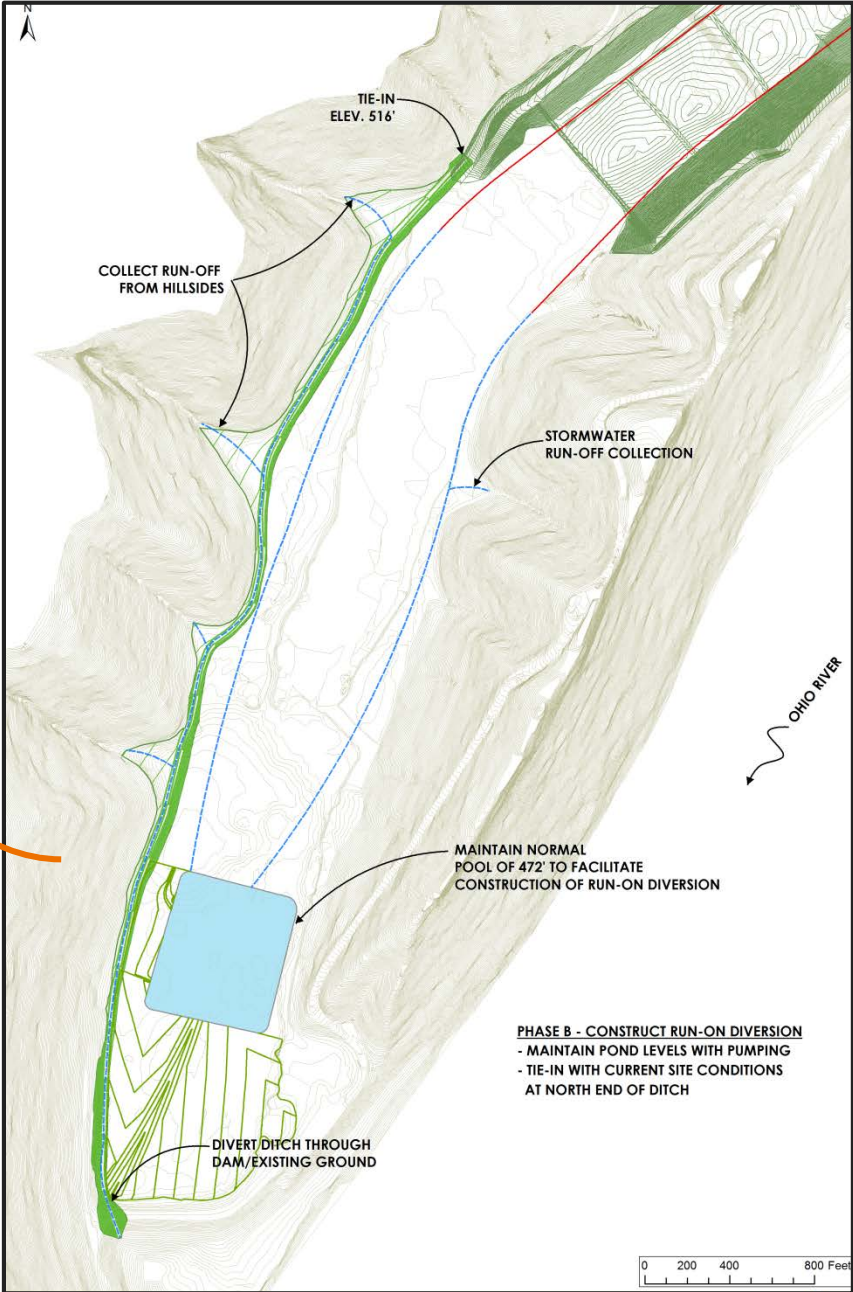
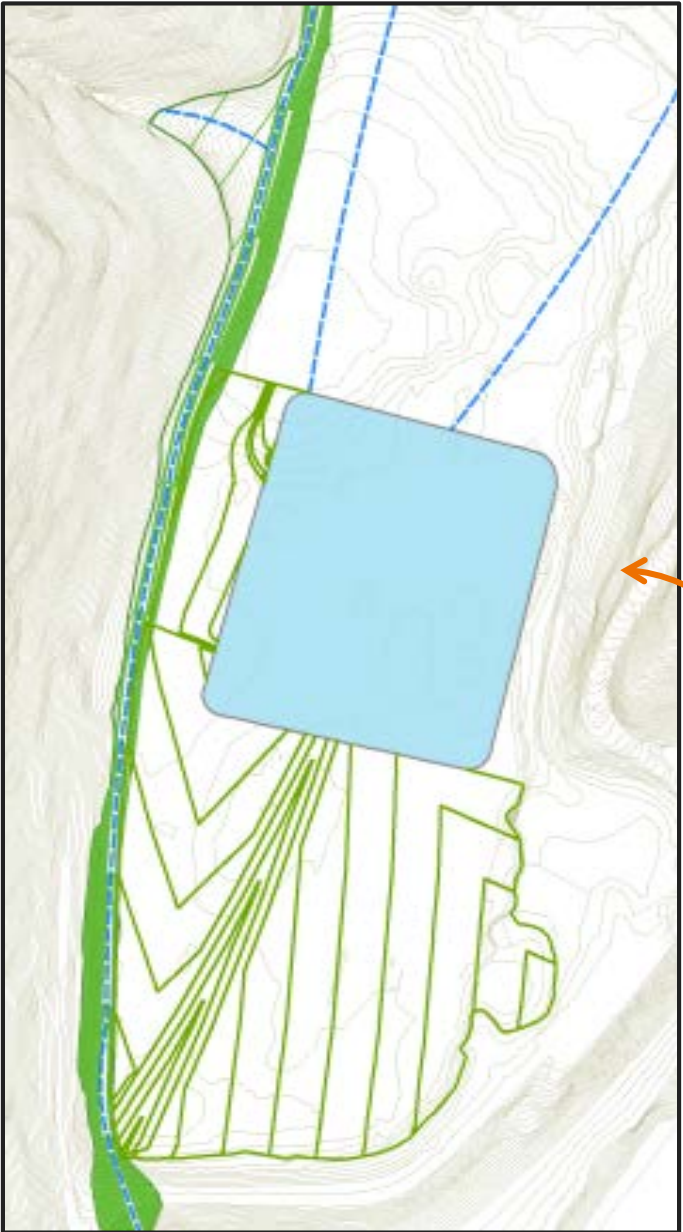
Existing Conditions



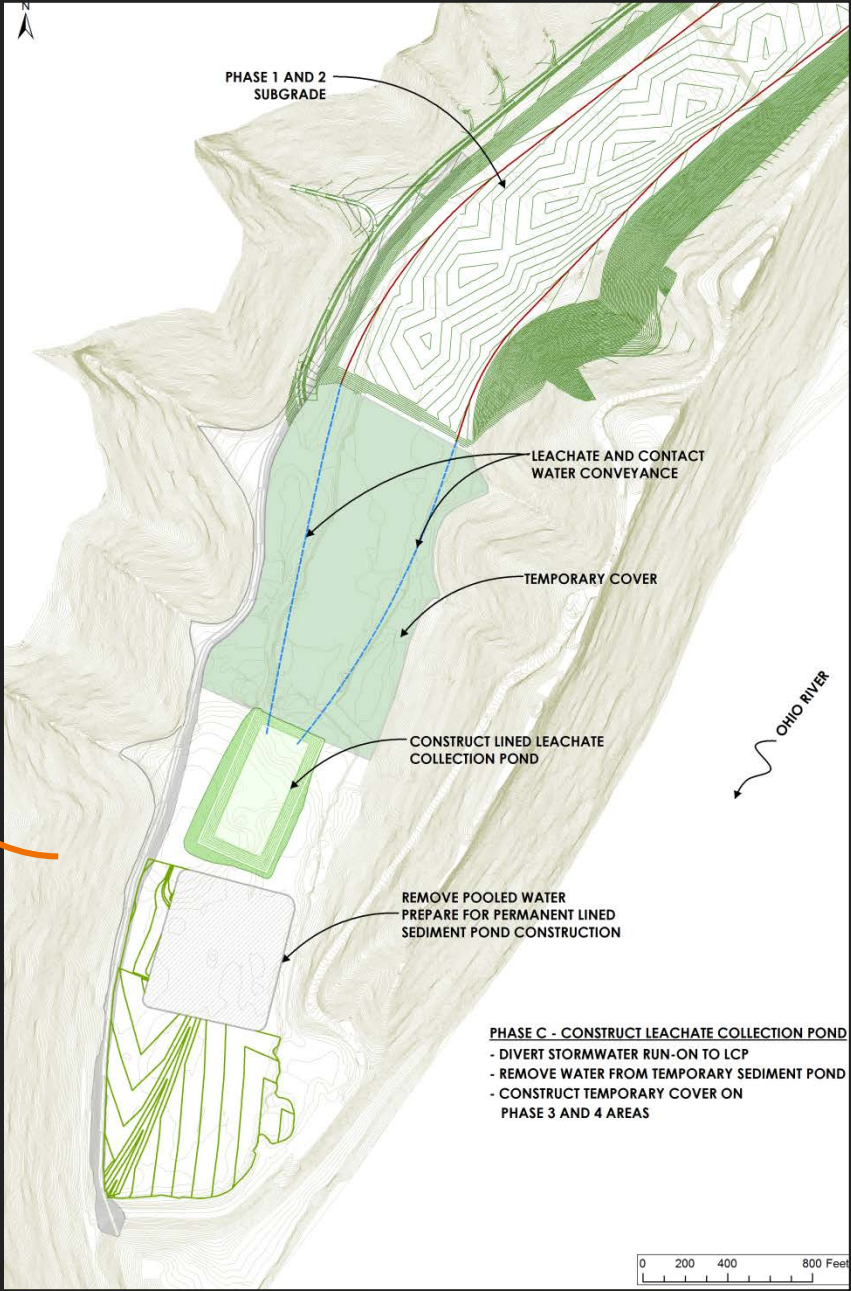
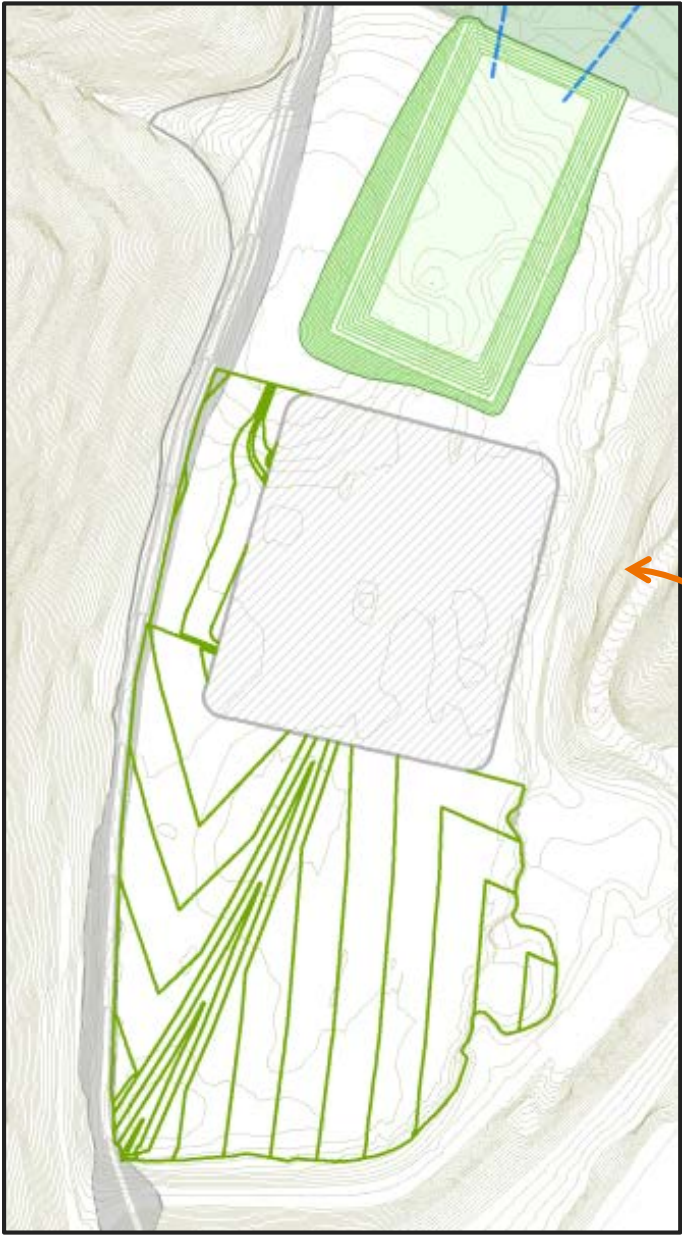
Phase A



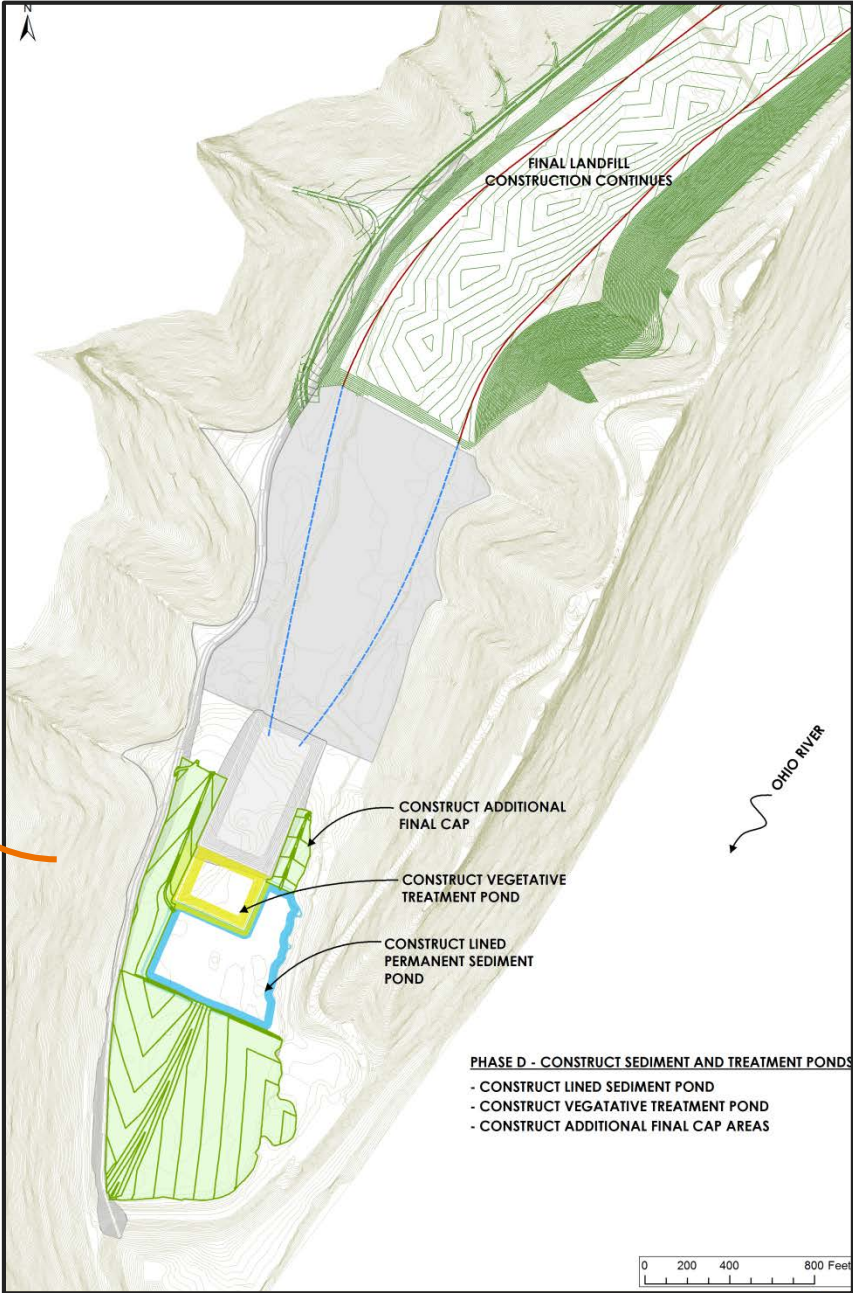
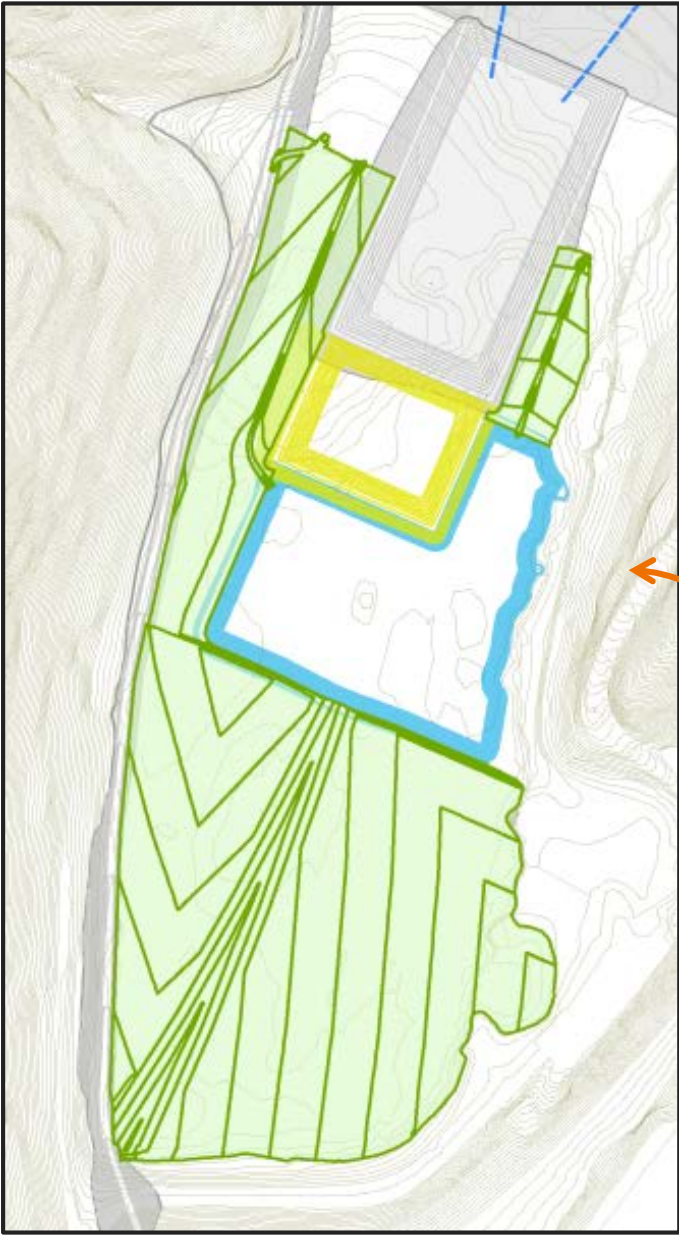
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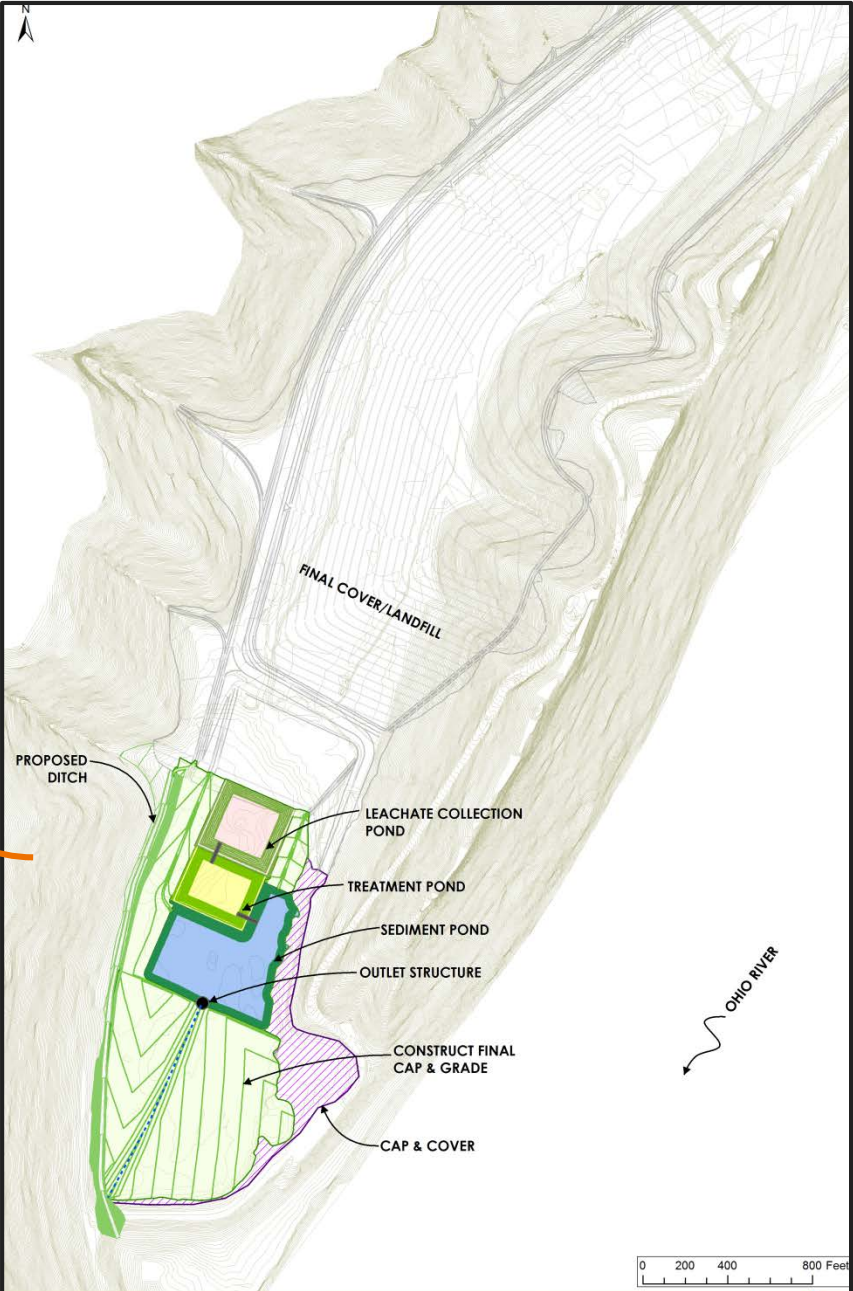
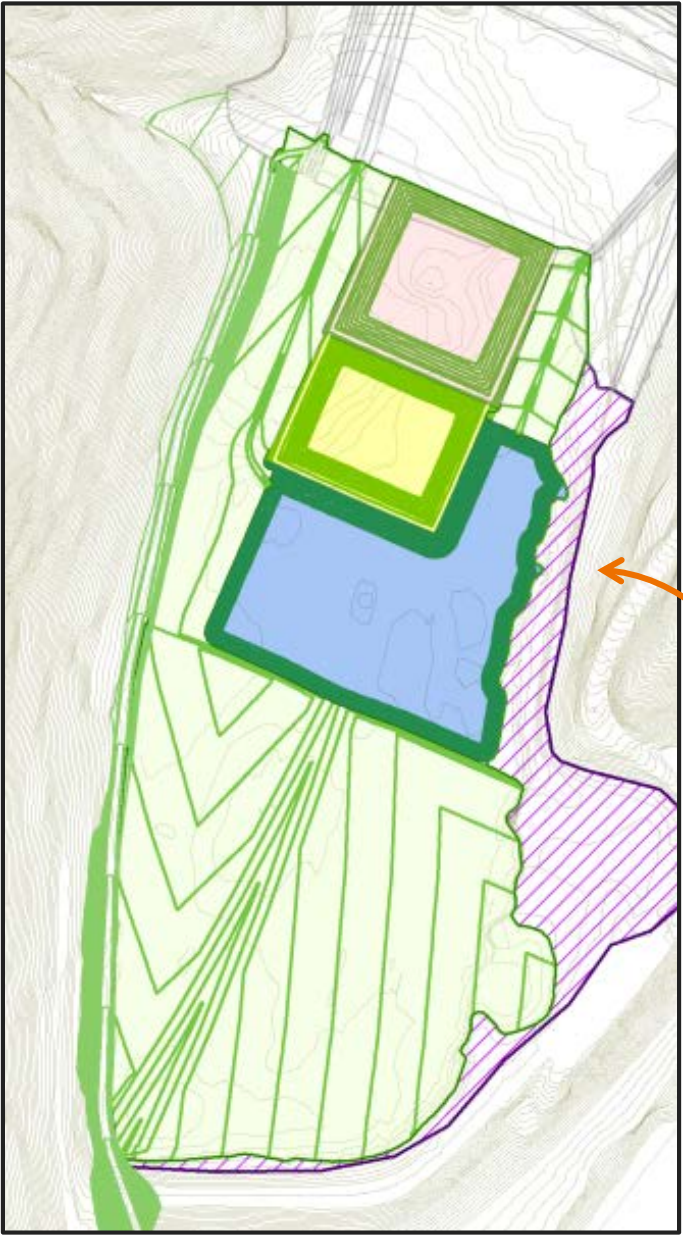
Phase C



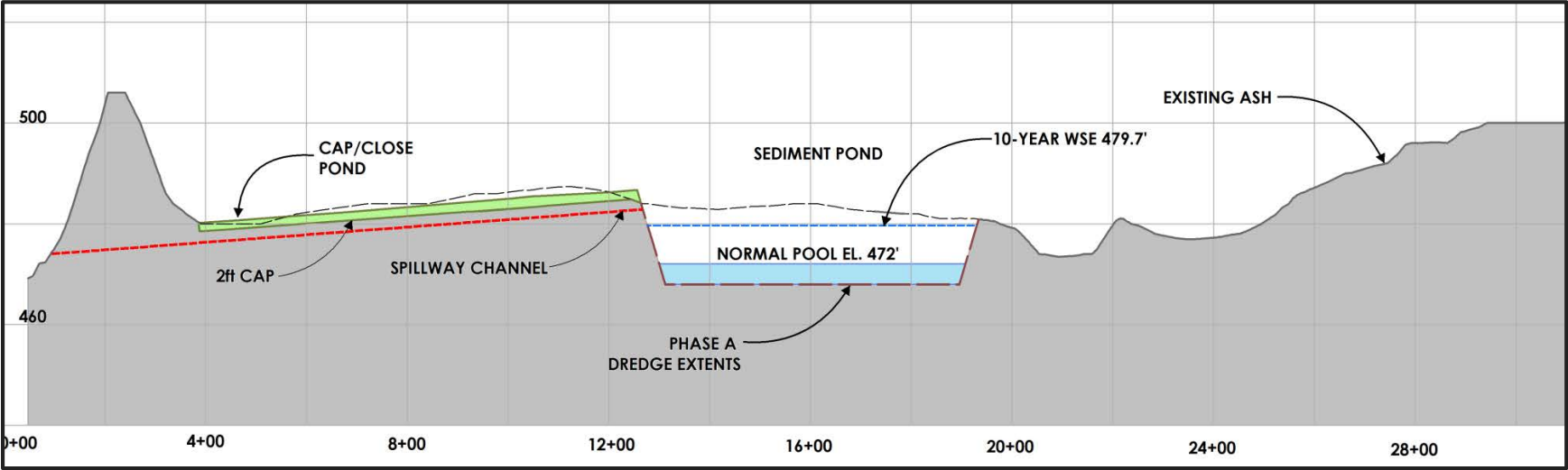
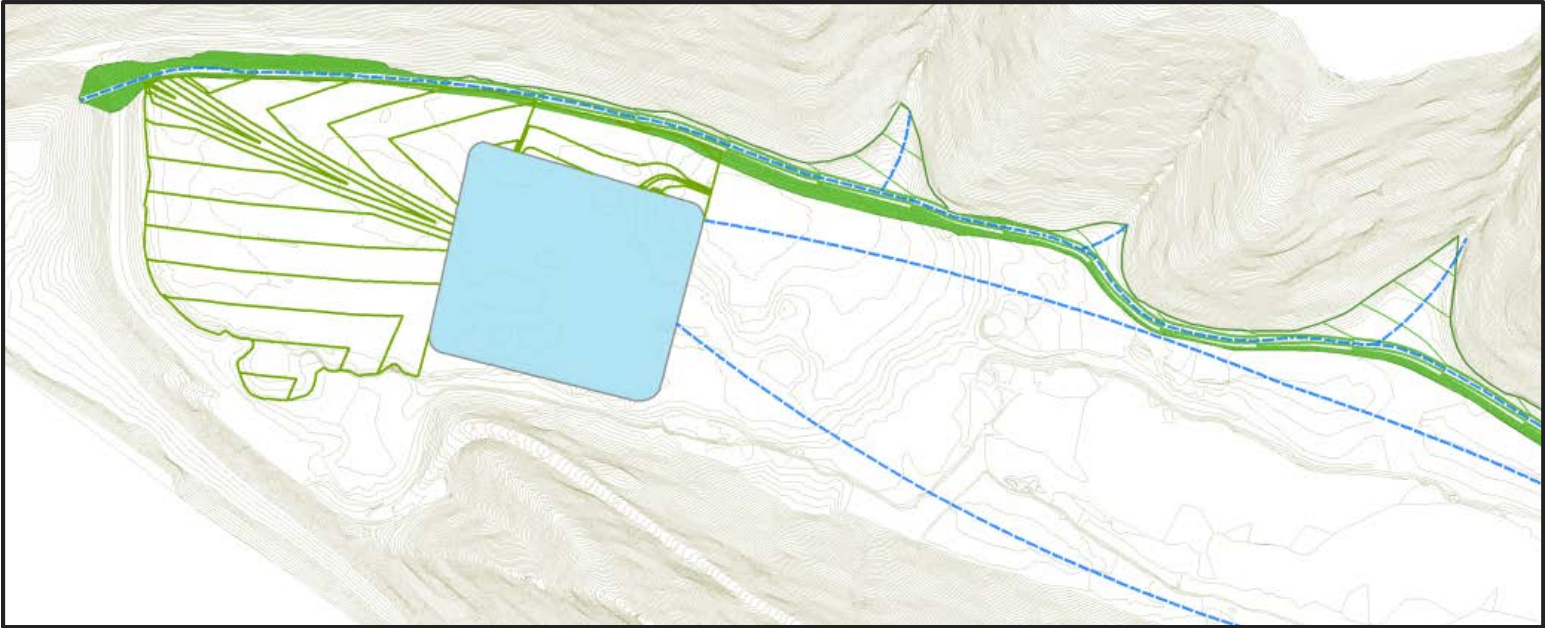
Phase D



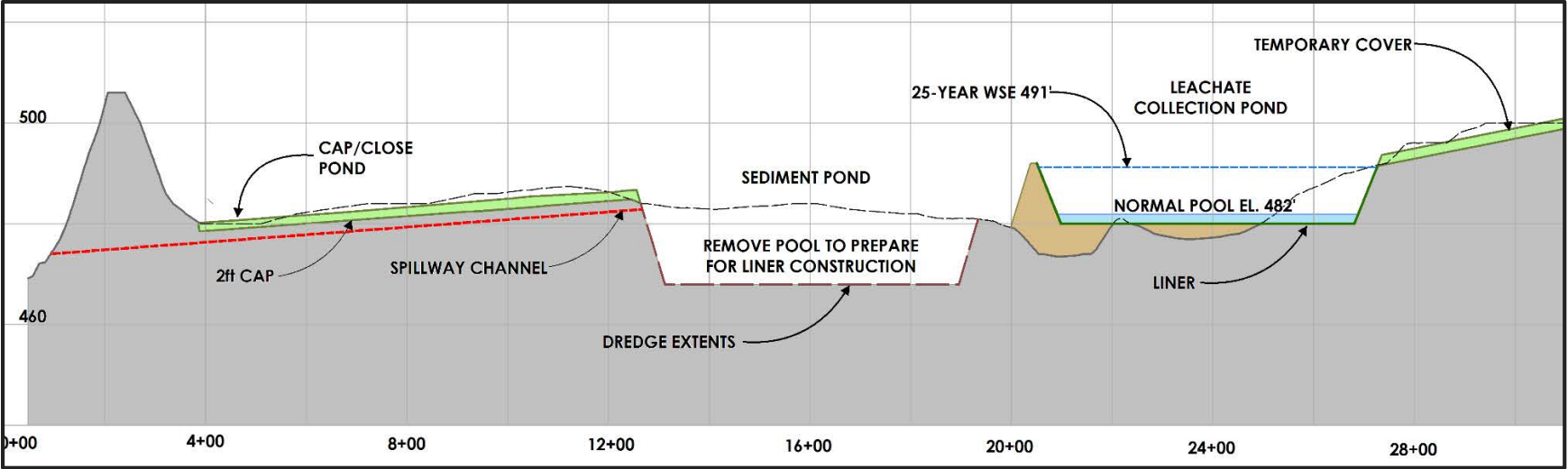
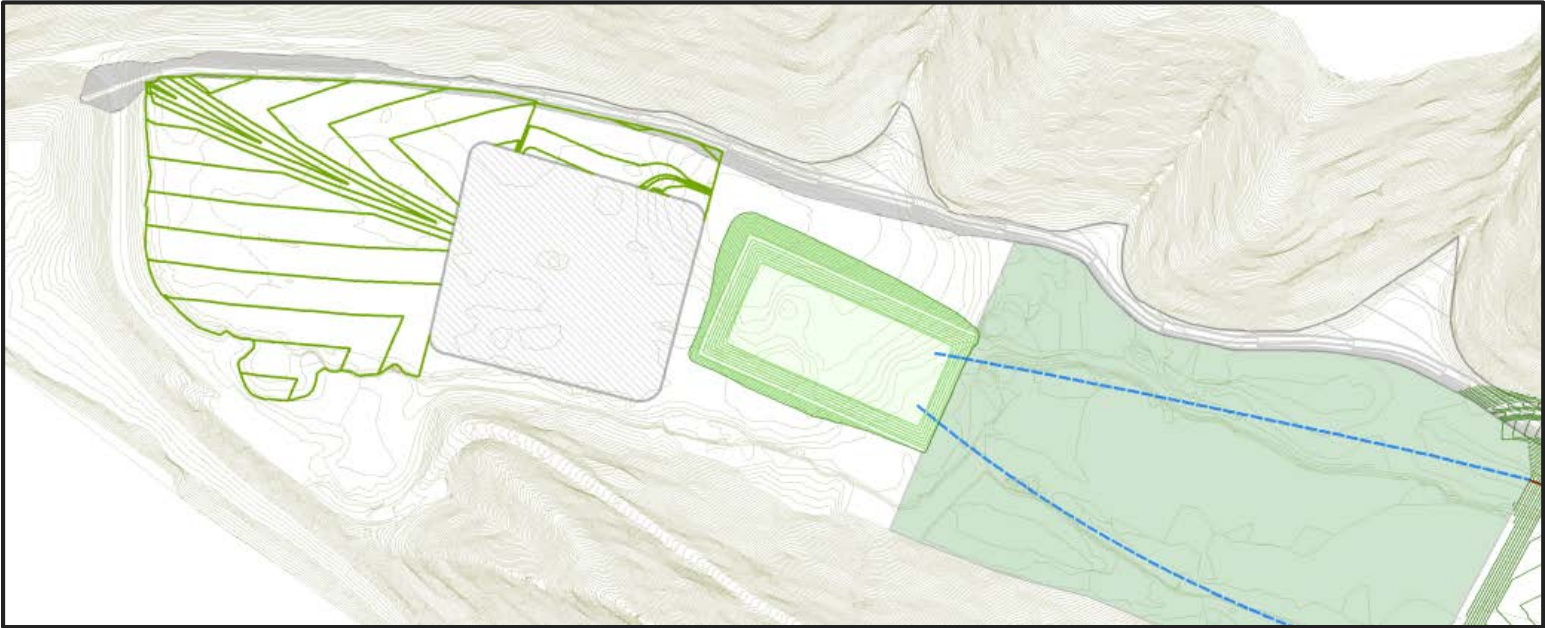
Final



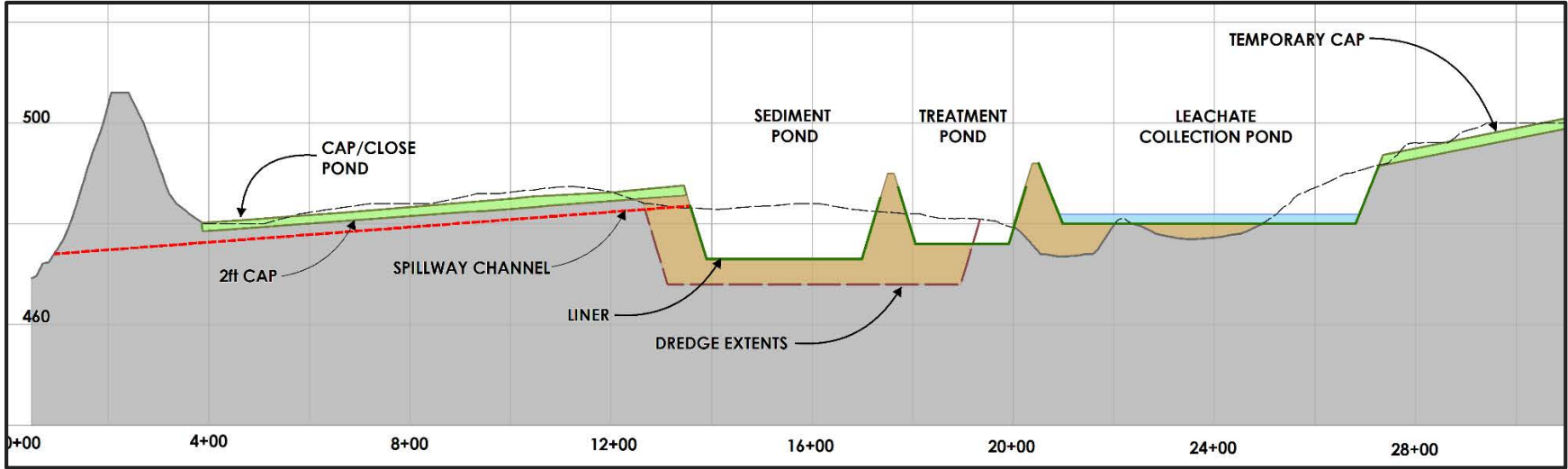
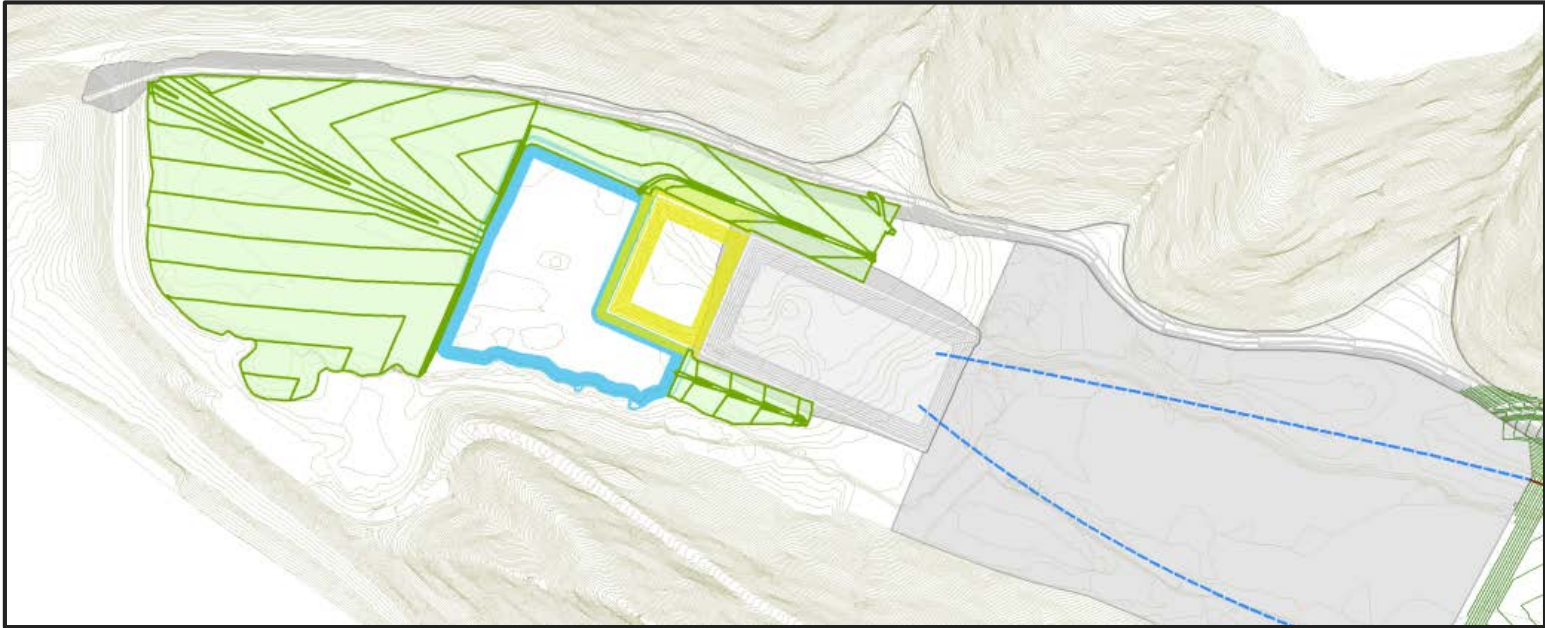
Phase A & B



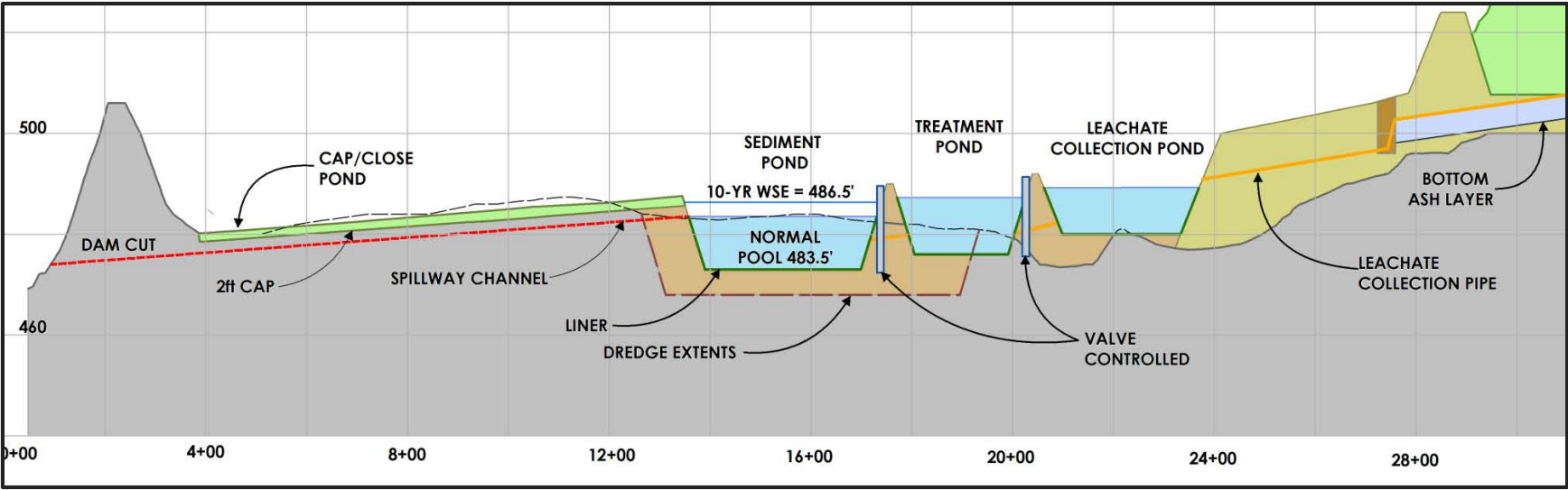
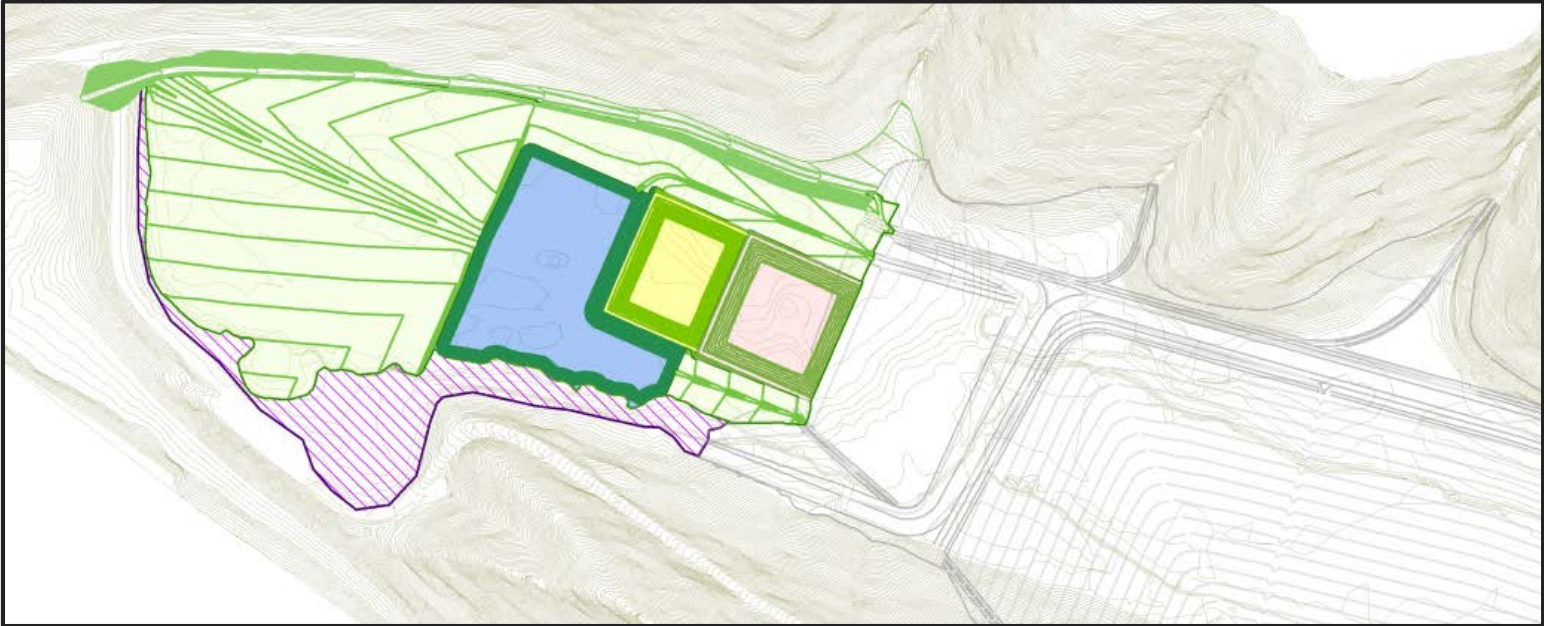
Phase C



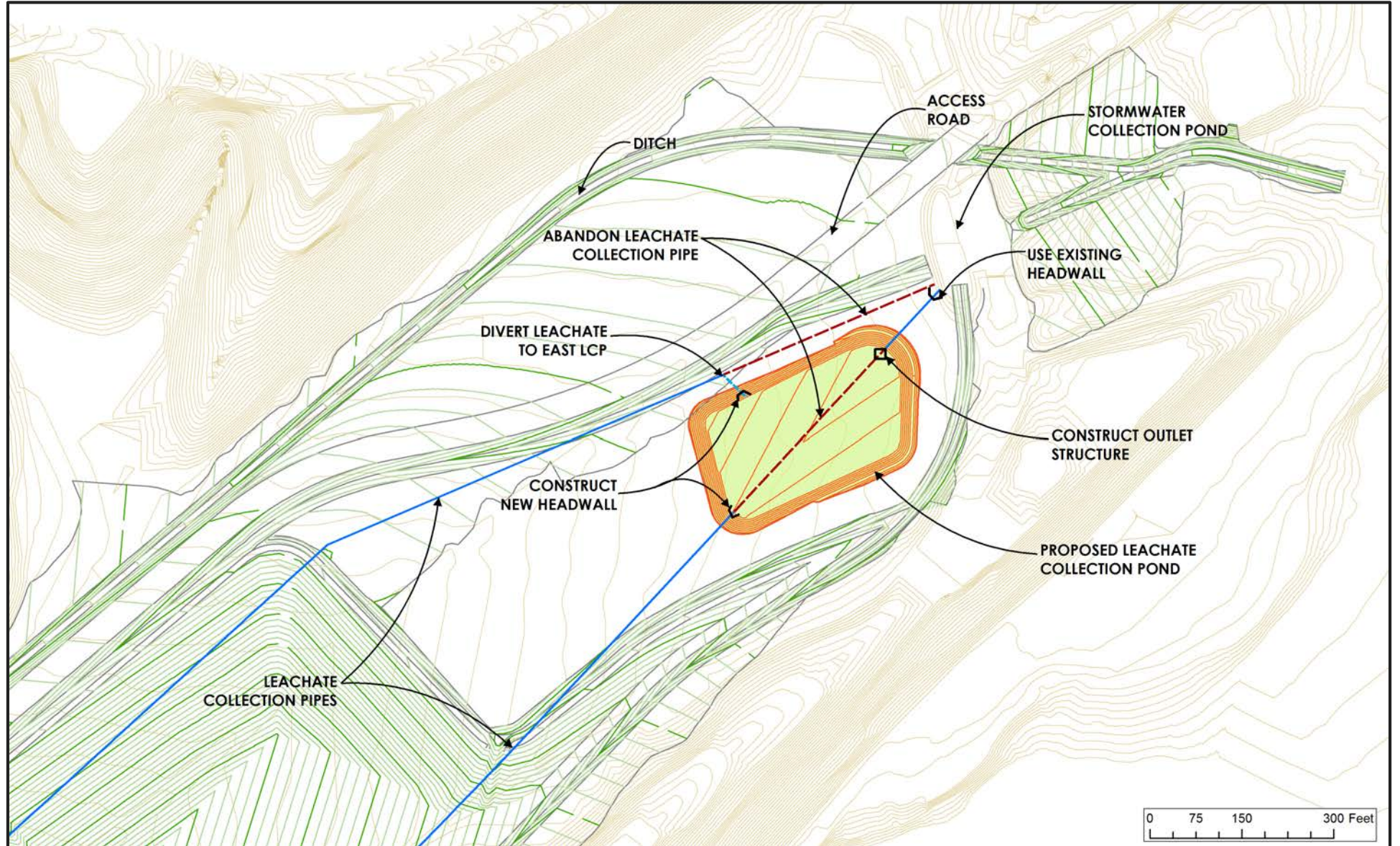
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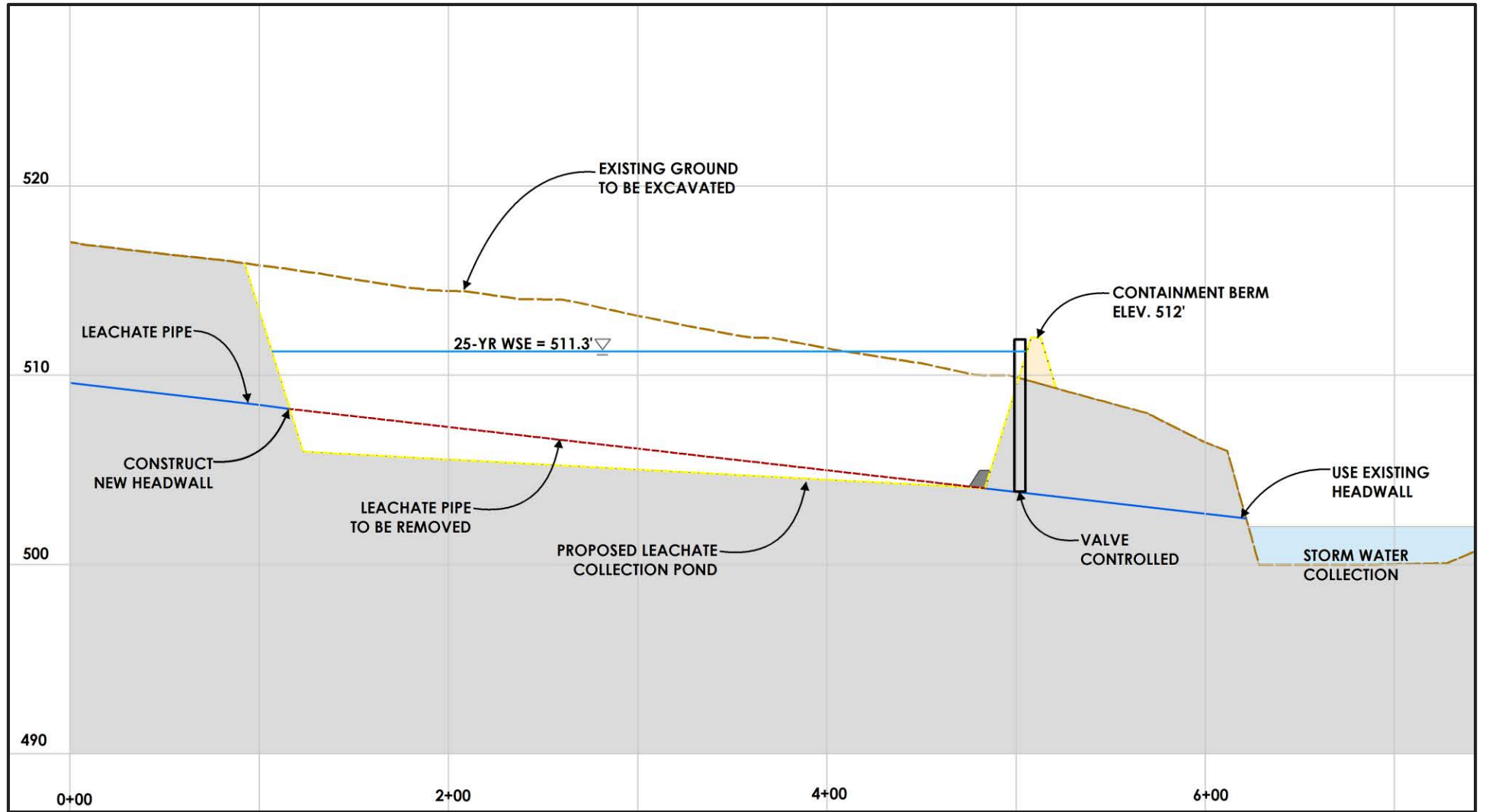
Final Configuration



East Leachate Collection Pond



East Leachate Collection Pond



APPENDIX E – COMPLIANCE DOCUMENTATION

APPENDIX E1 – GROUNDWATER MONITORING SYSTEM



Stantec Consulting Services Inc.
11687 Lebanon Road, Cincinnati OH 45241

November 13, 2018
File: 175534018
Revision 1

Indiana-Kentucky Electric Corporation
3932 U.S. Route 23
P.O. Box 468
Piketon, Ohio 45661

**RE: Groundwater Monitoring System
CCR Landfill, West Boiler Slag Pond, and Landfill Runoff Collection Pond
EPA Final Coal Combustion Residuals (CCR) Rule
Clifty Creek Station
Madison, Jefferson County, Indiana**

1.0 PURPOSE

This letter documents Stantec's certification of the groundwater monitoring system designed and constructed by Applied Geology and Environmental Science, Inc. (AGES) for the Indiana-Kentucky Electric Corporation (IKEC) Clifty Creek Station's CCR Landfill, West Boiler Slag Pond (WBSP), and Landfill Runoff Collection Pond (LRCP). The EPA Final CCR Rule requires owners or operators of CCR landfills and surface impoundments to install a groundwater monitoring system as per 40 CFR 257.91.

2.0 GROUNDWATER MONITORING SYSTEM - REQUIREMENTS

The performance standard listed in 40 CFR 257.91(a) requires that the groundwater monitoring system consist of sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that:

- (1) Accurately represents the quality of background groundwater that has not been affected by leakage from a CCR unit, and
- (2) Accurately represents the quality of groundwater passing the waste boundary of the CCR unit, by installing the downgradient monitoring system at the waste boundary ensuring detection of groundwater contamination in the uppermost aquifer. All potential contaminant pathways must be monitored.

In accordance with 40 CFR 257.91(b), the number, spacing, and depths of the monitoring system shall be determined based on site-specific technical information such as:

- (1) Aquifer thickness, groundwater flow rate, groundwater flow direction including seasonal and temporal fluctuations in groundwater flow, and
- (2) Saturated and unsaturated geologic units and fill materials overlying the uppermost aquifer, and materials comprising the confining unit defining the lower boundary of the

Design with community in mind



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uppermost aquifer, including, but not limited to, thicknesses, stratigraphy, lithology, hydraulic conductivities, porosities, and effective porosities.

40 CFR 257.91(c) states that the groundwater monitoring system must include the minimum number of monitoring wells necessary to meet the performance standards of 40 CFR 257.91(a), based on the site-specific information in 40 CFR 257.91(b). The groundwater monitoring system must consist of a minimum of one upgradient and three downgradient monitoring wells with additional monitoring wells as necessary to accurately represent the quality of background groundwater that has not been affected by leakage from the CCR unit and the quality of groundwater passing the waste boundary of the CCR unit.

The owner of multiple CCR units may install a single multiunit groundwater monitoring system to monitor multiple CCR units per Section 40 CFR 257.91(d). It must be equally as capable of detecting monitored constituents at the waste boundary of the CCR unit as the individual groundwater monitoring system defined in 40 CFR 257.91(a), (b), and (c) for each CCR unit based on number, spacing, and orientation of each CCR unit, hydrogeologic setting, site history, and engineering design of the CCR unit. If the owner or operator elects to install a multiunit groundwater monitoring system, and if the multiunit system includes at least one existing unlined CCR surface impoundment as determined by §275.71(a), and if at any time after October 19, 2015 the owner or operator determines in any sampling event that the concentrations of one or more constituents listed in appendix IV to this part are detected at statistically significant levels above the groundwater protection standard established under 40 CFR 257.95(h) for the multiunit system, then all unlined CCR surface impoundments comprising the multiunit groundwater monitoring system are subject to the closure requirements under §257.101(a) to retrofit or close.

40 CFR 257.91(e) states that the monitoring wells must be cased in a manner that maintains the integrity of the monitoring well borehole. The casing must be screened or perforated and packed with gravel or sand, where necessary, to enable collection of groundwater samples. The annular space above the sampling depth must be sealed to prevent contamination of samples and the groundwater.

3.0 SUMMARY OF FINDINGS

Stantec personnel reviewed the *Coal Combustion Residuals Regulation, Monitoring Well Installation Report (MWIR), Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Indiana* (AGES, October 2016, Revision 1.0 October 2018). Each of the four sections of 40 CFR 257.91, as shown above in Section 2.0 of this certification letter, is detailed below to evaluate



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compliance. The sections, tables, figures, and appendices detailed in the following paragraphs refer to the MWIR.

40 CFR 257.91(a)

Performance standard. *The groundwater monitoring system must consist of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that:*

- (1) Accurately represents the quality of background groundwater that has not been affected by leakage from a CCR unit, and*
- (2) Accurately represent the quality of groundwater passing the waste boundary of the CCR unit. The downgradient monitoring system must be installed at the waste boundary that ensures detection of groundwater contamination in the uppermost aquifer. All potential contaminant pathways must be monitored.*

This standard is met if §§257.91(b) through (e) are met. §§257.91(b), (c), (d), and (e) are discussed below.

40 CFR 257.91(b)

The number, spacing, and depths of the monitoring systems shall be determined based on site-specific technical information such as:

- (1) Aquifer thickness, groundwater flow rate, groundwater flow direction including seasonal and temporal fluctuations in groundwater flow, and*
- (2) Saturated and unsaturated geologic units and fill materials overlying the uppermost aquifer, and materials comprising the confining unit defining the lower boundary of the uppermost aquifer, including, but not limited to, thicknesses, stratigraphy, lithology, hydraulic conductivities, porosities, and effective porosities.*

The geology and hydrogeology for each CCR unit is discussed based on historical data in Section 3.0. The uppermost aquifer for each is identified using subsurface stratigraphy and the hydrogeologic study report (AGES, 2007) performed to support the landfill permit. Generalized geologic cross-sections are included as Figures 3, 5, and 7 (AGES, 2018). Tables 4 and 5 are the



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summaries of the slug tests performed for the CCR Landfill and LRCP and the WBSP, respectively. The aquifer testing results performed in May 2016 are included in Appendix F.

Section 4.2 outlines the evaluation of the existing well and piezometer data to estimate groundwater depth in the uppermost aquifer and likely groundwater flow direction. Six additional geotechnical borings were performed in the CCR units per Section 4.3. One boring was located downgradient of the southwest end of the CCR Landfill and LRCP with three borings performed in background areas for the units. Two soil borings were performed at the WBSP. The soil borings were intended to obtain more detailed subsurface geology and to identify location, thickness, and composition, of the uppermost aquifer. Soil samples from three borings were the basis of the grain-size analyses used to design the monitoring well screens and filter packs for two background monitoring wells at the CCR Landfill and LRCP multiunit system and one monitoring well at the WBSP (Section 4.4 and Appendix A).

40 CFR 257.91(c)

the groundwater monitoring system must include the minimum number of monitoring wells necessary to meet the performance standards of 40 CFR 257.91(a), based on the site-specific information in 40 CFR 257.91(b). The groundwater monitoring system must consist of a minimum of one upgradient and three downgradient monitoring wells with additional monitoring wells as necessary to accurately represent the quality of background groundwater that has not been affected by leakage from the CCR unit and the quality of groundwater passing the waste boundary of the CCR unit.

Section 4.6 outlines the monitoring well networks for each CCR unit to meet this requirement.

For the CCR Landfill and LRCP multiunit system, six monitoring wells were installed in 2015. Section 3.1 describes the underlying soil stratigraphy and hydrogeologic conditions of the combined unit. A groundwater divide is located in the valley where the CCR Landfill is located with groundwater flowing to the northeast or southwest within the confined bedrock valley. At the southwestern end of the combined unit, three downgradient monitoring wells were installed. Three monitoring wells were installed outside the hydrologic influence of the combined unit and the WBSP to serve as background monitoring wells. Section 4.6.1 and Table 2 lists the eight monitoring wells in the CCR network as three downgradient and six background (or background/intermediate). Figures 1, 5, 6, and 10 show the groundwater monitoring well locations for the CCR Landfill and LRCP multiunit system.



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The WBSP's groundwater monitoring network is described in Section 4.6.2 and Table 3. Ten monitoring wells were installed around the WBSP perimeter in late 2015 and early 2016. Three monitoring wells are noted as upgradient, while seven are listed as downgradient. Figures 7, 8, and 9 show the groundwater monitoring well locations of the WBSP.

As discussed in Section 5.0, slug testing was performed in one background well, one monitoring well at the CCR Landfill and LRCP multiunit system, and in three monitoring wells at the WBSP. The testing was performed to estimate saturated hydraulic conductivity of the uppermost aquifer. The test results are in Tables 4 and 5 with supporting data in Appendix F.

40 CFR 257.91(d)

The owner of multiple CCR units may install a single multiunit groundwater monitoring system to monitor multiple CCR units per Section 40 CFR 257.91(d). It must be equally as capable of detecting monitored constituents at the waste boundary of the CCR unit as the individual groundwater monitoring system defined in 40 CFR 257.91(a), (b), and (c) for each CCR unit based on number, spacing, and orientation of each CCR unit, hydrogeologic setting, site history, and engineering design of the CCR unit. If the owner or operator elects to install a multiunit groundwater monitoring system, and if the multiunit system includes at least one existing unlined CCR surface impoundment as determined by §275.71(a), and if at any time after October 19, 2015 the owner or operator determines in any sampling event that the concentrations of one or more constituents listed in appendix IV to this part are detected at statistically significant levels above the groundwater protection standard established under 40 CFR 257.95(h) for the multiunit system, then all unlined CCR surface impoundments comprising the multiunit groundwater monitoring system are subject to the closure requirements under §257.101(a) to retrofit or close.

Section 2.1 describes the site history and hydrogeologic setting of the CCR Landfill and LRCP. The two CCR units are located within an eroded bedrock channel confined as described in Section 3.1. The area initially served as a fly ash pond prior to development of a Type III CCR Landfill in 1988. Under the current Indiana Department of Environmental Management (IDEM) permit, the two CCR units are now approximately 208 acres with 109 acres designated for the CCR Landfill and 99 acres at the southwest end identified as the LRCP. The CCR Landfill and LRCP are served by a multiunit groundwater monitoring system that encompasses the historic fly ash pond footprint.



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40 CFR 257.91(e)

The monitoring wells must be cased in a manner that maintains the integrity of the monitoring well borehole. The casing must be screened or perforated and packed with gravel or sand, where necessary, to enable collection of groundwater samples. The annular space above the sampling depth must be sealed to prevent contamination of samples and the groundwater.

The monitoring well installation and development for the three CCR units is discussed in Section 4.5. Section 4.4 discusses the design of pre-packed well screens used for the construction of the monitoring wells. The two sections discuss the two-inch diameter slotted Schedule 40 PVC screen, 0.40-millimeter quartz sand filter pack, steel casing during well placement, and the four-foot-thick annular bentonite seal above the filter pack in each well. Monitoring well logs are detailed in Appendix B. Well construction for the monitoring networks of each CCR unit is detailed in terms of well ID, locations, elevations, and date of installation in Tables 2 and 3.

The attached MWIR demonstrates that the groundwater monitoring system was designed and constructed to meet the requirements set forth in 40 CFR 257.91 (a), (b), (c), (d), and (e).



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4.0 QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION

I, Stan A. Harris, being a Professional Engineer in good standing in the State of Indiana, do hereby certify, to the best of my knowledge, information, and belief:

1. that the information contained in this certification is prepared in accordance with the accepted practice of engineering;
2. that the information contained herein is accurate as of the date of my signature below; and
3. that the groundwater monitoring systems for the IKEC Clifty Creek Station's CCR Landfill, West Boiler Slag Pond, and Landfill Runoff Collection Pond have been designed and constructed to meet the requirements specified in 40 CFR 257.91(a), (b), (c), (d), and (e).

SIGNATURE  DATE 11/13/18

ADDRESS: Stantec Consulting Services Inc.
11687 Lebanon Road
Cincinnati, Ohio 45241

TELEPHONE: (513) 842-8200

ATTACHMENTS: Applied Geology and Environmental Science, Inc. (AGES) (2018). Coal Combustion Residuals Regulation, Monitoring Well Installation Report, Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Indiana. October 2016. Revision 1.0. October.





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**COAL COMBUSTION RESIDUALS REGULATION
MONITORING WELL INSTALLATION REPORT**

**INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA**

OCTOBER 2016

Revision 1.0 November 2018

Prepared for:

INDIANA-KENTUCKY ELECTRIC CORPORATION (IKEC)

By:

APPLIED GEOLOGY AND ENVIRONMENTAL SCIENCE, INC.

**COAL COMBUSTION RESIDUALS REGULATION
MONITORING WELL INSTALLATION REPORT
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA**

OCTOBER 2016
Revision 1.0 November 2018

Prepared for:

INDIANA-KENTUCKY ELECTRIC CORPORATION (IKEC)

Prepared By:

Applied Geology and Environmental Science, Inc.

A handwritten signature in cursive script, reading "Diane E. Miller", written over a horizontal line.

Diane E. Miller, P.G.
Senior Geologist

A handwritten signature in cursive script, reading "Robert W. King", written over a horizontal line.

Robert W. King, P.G.
President/Chief Hydrogeologist

**COAL COMBUSTION RESIDUALS REGULATION
MONITORING WELL INSTALLATION REPORT
INDIANA-KENTUCKY ELECTRIC CORPORATION
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MONITORING WELL INSTALLATION REPORT
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA**

1.0 INTRODUCTION

On December 19, 2014, the United States Environmental Protection Agency (U.S. EPA) issued their final Coal Combustion Residuals (CCR) regulation which regulates CCR as a non-hazardous waste under Subtitle D of Resource Conservation and Recovery Act (RCRA) and became effective six (6) months from the date of its publication (April 17, 2015) in the Federal Register. The rule applies to new and existing landfills, and surface impoundments used to dispose of or otherwise manage CCR generated by electric utilities and independent power producers. Because the rule was promulgated under Subtitle D of RCRA, it does not require regulated facilities to obtain permits, does not require state adoption, and cannot be enforced by U.S. EPA. The only compliance mechanism is for a state or citizen group to bring a RCRA suit in federal district court against any facility that is alleged to be in non-compliance with the new requirements.

All CCR landfills and CCR surface impoundments (including inactive impoundments unless they close within three (3) years from the promulgation date of the rule) are subject to new, and typically more stringent than current, state requirements for groundwater monitoring and, if necessary, corrective action. Within 30 months after the date of publication (April 17, 2015) in the Federal Register, all existing CCR landfills and existing CCR surface impoundments must have installed groundwater monitoring systems, initiated a groundwater detection monitoring program, and begun assessing groundwater monitoring data to evaluate groundwater quality at each CCR unit.

In March 2015, the Indiana-Kentucky Electric Corporation (IKEC) contracted with Applied Geology and Environmental Science (AGES), Inc. to identify upgrades in the groundwater monitoring program for the Clifty Creek Station located in Madison, Indiana that would be necessary for compliance with the CCR regulation. Based on a review of available site data and the CCR regulation, AGES, IKEC and staff from Stantec worked together to develop a detailed scope of work and schedule for the groundwater monitoring system upgrades. Field work on the project (monitoring well installation and development) was conducted from November 2015 through January 2016.

Presented below are a discussion of the CCR units identified at the station, site geology and hydrogeology, and the well installation and development program.

2.0 BACKGROUND

The Clifty Creek Station, located in Madison, Indiana, is a 1,304-megawatt (MW) coal-fired generating plant operated by the IKEC, a subsidiary of the Ohio Valley Electric Company (OVEC). The Clifty Creek Station has six (6) 217.26-MW generating units and has been in operation since 1955. Beginning in 1955, ash products were sluiced to disposal ponds located in the plant site. During the course of plant operations, CCRs have been managed and disposed of in various units at the station. There are three (3) CCR units at the Clifty Creek Station (Figure 1):

- Type I Residual Waste Landfill (Type I Landfill);
- Landfill Runoff Collection Pond (LRCP); and,
- West Boiler Slag Pond (WBSP).

Information regarding the history and hydrogeology of each unit was obtained by reviewing several historic documents listed in Section 7.0 of this report.

2.1 Type I Residual Waste Landfill and Landfill Runoff Collection Pond

The active Type I Landfill occupies an approximately 200-acre area situated within an eroded bedrock channel. A total of 109 acres were approved as a Type I residual waste landfill by the Indiana Department of Environmental Management (IDEM) in 2007. The remaining 91 acres consist of the LRCP located at the southwest end of the Type I Landfill (Figures 1 and 2).

Beginning in 1955, ash products were sluiced to disposal ponds located in the bedrock channel at the plant site. To allow for more disposal capacity, an on-site fly ash pond was developed into a Type III residual landfill in 1988. All required permits for the Type III Residual Waste Landfill (Type III Landfill) were obtained from IDEM. The Type III Landfill was permitted to be constructed, and to serve as closure for the historic fly ash ponds. The Type III Landfill is located at the northeast end of the bedrock channel and went operational in 1991.

In 2013, IDEM approved IKEC's request to upgrade the Type III Landfill to a Type I residual waste landfill (Type I Landfill). As part of the process, the Type III Landfill was closed and the Type I Landfill was designed and constructed to serve as the cap for the closed Type III Landfill. The Type I Landfill is completely separated from the closed Type III Landfill by a geosynthetic liner and a compacted clay liner (Figure 3).

The LRCP is an unlined pond located at the southern edge of the station. It is bordered by the Type I Landfill to the north, natural grade to the east and west, and by a dam to the south that runs along the bank of the Ohio River. Approximately 508 acres of both landfill contact water and stormwater runoff drain to the LRCP (Stantec 2016). The base of the LRCP consists of historic hydraulically-placed fly ash. The LRCP does not receive CCR and any CCR within the

LRCP is not being actively managed. Therefore, the LRCP is identified as an inactive unit under the CCR Rule.

2.2 West Boiler Slag Pond

The WBSP currently serves as a settling facility for sluiced boiler slag produced at the plant. In addition to the process flows from the plant, approximately 510 acres drain to the WBSP. The pond is formed by natural grade to the north, east and west and a southern dike that runs along the bank of the Ohio River (Figures 1 and 2).

3.0 GEOLOGY & HYDROGEOLOGY

The site lies in the Central Lowland Physiographic Province along the western flanks of the Cincinnati Arch and within the Central Stable Region. The stratigraphic sequence in the regional area consists of widespread discontinuous layers of Quaternary deposits of alluvial and glacial origin overlying sedimentary rocks generally consisting of limestones, dolomites and interbedded shale. The exposed sedimentary rocks range in age from Mississippian to Ordovician. The Quaternary deposits are largely of glacial origin and consist of loess, till and outwash. Glacial outwash is present in nearly all of the stream valleys north of and including the Ohio River valley. The outwash is covered, in some cases, by a veneer of recent alluvial deposits from active streams.

Unconsolidated alluvial sediments deposited along the Ohio River valley, near or adjacent to the river constitute the major aquifer of the region. These deposits are normally found only within the Ohio River valley and the tributary streams north and northeast of the river. Wells installed in this aquifer typically yield 100 to 1,000 gallons per minute (gpm) depending upon their location and construction. The Ohio River valley is incised into Ordovician bedrock. The low permeability bedrock forms the lateral and underlying confinement to the aquifer.

3.1 Type I Residual Waste Landfill and Landfill Runoff Collection Pond

Based on information in the Hydrogeologic Study Report (AGES 2007), bedrock beneath the Type I Landfill & LRCP and the closed Type III Landfill consists of impermeable limestone and shale of the Ordovician Dillsboro formation, which is overlain by approximately 20 to 35 feet of gray clay. The gray clay is directly overlain by fly ash that had been historically hydraulically placed in the area. Generalized geologic cross-sections are presented in Figures 3 through 5. A limestone ridge known as the Devil's Backbone runs northeast to southwest along the length of the Type I Landfill & LRCP and the closed Type III Landfill. The Devil's Backbone acts as an impermeable barrier that forces groundwater passing beneath both of the landfills to flow either toward the northeast or toward the southwest. A detailed hydrogeologic study determined that a groundwater flow divide is present near the northeast end of the bedrock channel and that all groundwater beneath the active Type I Landfill flows toward the southwest (AGES 2007).

An aquifer does not exist beneath the Type I Landfill. Therefore, alluvial deposits located southwest of the LRCP are designated as the uppermost aquifer for the Type I Landfill & LRCP. These alluvial deposits consist of approximately 10 to 15 feet of silty clay, overlying various depths of fine to medium grained sand with gravel, silt and clay (Figure 5). The alluvial deposits overlay layers of clay and clayey gravel, which overlay limestone bedrock of the Dillsboro Formation at depths ranging from 15 to 90 feet below ground surface (bgs).

Based on historic aquifer testing conducted at the site, the upper silty clay deposits are relatively impermeable, do not yield adequate quantities of water to wells, and are considered to be an aquiclude. The lower fine to medium grained sand with gravel, silt and clay deposits are considered to be an unconfined or possibly semi-confined aquifer and are therefore designated as the uppermost aquifer at the Landfill and LRCP.

3.2 West Boiler Slag Pond

The WBSP is formed by natural grade to the north, east and west and a southern dike that runs along the bank of the Ohio River (Figures 1 and 2). A generalized geologic cross-section of this unit is presented in Figure 7. The Devil's Backbone borders the northern side of the WBSP.

Based on information from historical soil boring data, there appears to be a layer of fly ash, up to five (5) feet thick in the northeastern portion of the WBSP. Below the ash and extending to the south and west beneath the remainder of the pond, the WBSP is underlain by alluvial deposits consisting of layers of silty clay, sandy silt and silty sand ranging from approximately 16 feet bgs on the northwest side of the WBSP (closest to the Devil's Backbone) to approximately 90 feet bgs on the southeast side of the WBSP (closest to the Ohio River). These alluvial deposits sit directly on top the bedrock. Review of logs from historic soil borings indicated that a layer of silty clay extends from directly beneath the WBSP to an approximate elevation of 425 feet msl. Historic boring logs indicated that the clay is underlain by a layer of silt with fine sand that becomes more coarse-grained further to the north & northeast. This layer was determined to be the uppermost aquifer beneath the WBSP. Groundwater beneath the WBSP flows from the northwest to the southeast toward the Ohio River (Figure 8).

4.0 GROUNDWATER MONITORING SYSTEM DESIGN & INSTALLATION

4.1 Groundwater Monitoring System Design

Section §257.91 of the CCR regulation states that the groundwater monitoring system for each CCR unit must contain a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit and, accurately represent the quality of groundwater passing the waste boundary of the CCR unit.

Section §257.91(c) requires that the groundwater monitoring system for each CCR unit includes a minimum of one (1) upgradient/background monitoring well to accurately represent the quality of background groundwater that has not been affected by leakage from the CCR unit, and a minimum of three (3) downgradient monitoring wells located as close as practicable to the waste boundary to accurately represent the quality of groundwater passing the waste boundary of the CCR unit.

4.2 Data Review and Evaluation of Existing Wells and Piezometers

To begin the process, AGES reviewed available data for any existing monitoring wells and piezometers that had been installed around each CCR unit. The purpose of this data review was to identify the approximate depth to the uppermost aquifer for each CCR unit and to evaluate likely groundwater flow direction to ensure that the new CCR groundwater monitoring network contained the required number of upgradient/background and downgradient monitoring wells.

4.2.1 Type I Residual Waste Landfill and Landfill Runoff Collection Pond

In June 2015, water levels were collected from all of the existing monitoring wells and piezometers around the Type I Landfill and LRCP. These water levels confirmed that groundwater beneath the Type I Landfill and LRCP flows to the southwest toward the Ohio River.

Due to the geologic setting of the Type I Landfill and LRCP, there were no suitable upgradient groundwater monitoring locations and upgradient monitoring wells were not installed. To meet the monitoring requirements of the CCR regulation IKEC opted to install one (1) background monitoring well in an area outside the influence of the Landfill (Figure 9).

The Type I Landfill is the subject of an on-going monitoring program for the Indiana Department of Environmental Management (IDEM). Several downgradient monitoring wells are included in the IDEM monitoring program but upgradient monitoring wells were not installed. To ensure consistency in monitoring well construction for all of the wells in the CCR groundwater

monitoring network for the Type I Landfill and LRCP, IKEC opted to install all new monitoring wells for the groundwater monitoring network (Figure 10).

4.2.2 West Boiler Slag Pond

In June 2015, water levels were collected from all existing monitoring wells and piezometers around the WBSP. These water levels indicated that groundwater flow beneath the WBSP was from the northwest to the south/southeast toward the adjacent Ohio River.

No previous groundwater monitoring program had been conducted at the WBSP and the existing monitoring wells and piezometers had not been properly constructed to monitor groundwater quality in the uppermost aquifer beneath the WBSP. Therefore, IKEC opted to install new monitoring wells around the WBSP to meet the requirements of the CCR regulation (Figure).

4.3 **Soil Boring Installation**

At the WBSP, most of the existing monitoring wells and piezometers were not screened in the uppermost aquifer. In addition, no background/upgradient wells had previously been installed for the Type I Landfill and LRCP. To obtain geologic information specific to the target areas of the aquifers to be monitored at the Type I Landfill and LRCP and to locate suitable locations in which to install background/upgradient wells for the Type I Landfill and LRCP, IKEC conducted several borings in July 2015 (Figure 1). One (1) soil boring (Downgradient SW) was conducted downgradient of the southwest end of the Type I Landfill and LRCP and three (3) soil borings (BKG-1, BKG-2 and BKG-3) were conducted in background areas. Two (2) soil borings (WAP-1 and WAP-2) were also conducted at the WBSP (Figure 1).

The purpose of these borings was to obtain a more detailed description of the subsurface geology and to identify the location, size and composition of the uppermost aquifers at the Type I Landfill and LRCP and WBSP. Representative samples of the units identified as the uppermost aquifer in borings BKG-2 and BKG-3 at the Type I Landfill and LRCP and WAP-2 at the WBSP were collected and sent to a geotechnical soil laboratory for grain-size analysis to provide data to be used to design the groundwater monitoring system. Groundwater was not encountered in Type I Landfill and LRCP boring BKG-1 or in WBSP boring WAP-1. Therefore samples were not collected from these borings for analysis.

4.4 **Grain Size Analysis and Monitoring Well Design**

The CCR regulation requires that unfiltered groundwater samples be submitted for laboratory analysis of Appendix III and IV constituents. According to the preamble to the rule, the unfiltered sample requirement assumes that groundwater samples with a turbidity of less than 5 NTUs can be obtained from a properly designed monitoring well. The proper design of the sand

pack and well screen in each well is therefore critical to obtaining representative groundwater samples.

To support CCR well design, representative samples were collected of material from the uppermost aquifers at the Type I Landfill and LRCP, and the WBSP. These soil samples were submitted to a geotechnical laboratory for grain-size analysis per American Society for Testing and Materials (ASTM) Methods D421 and D422. The results of the grain size analyses were used to design the well screens and filter packs for the monitoring wells. The laboratory reports for the grain size analyses are included in Appendix A.

In accordance with U.S. EPA monitoring well design guidelines (U.S. EPA, 1991), the grain size of the filter pack was chosen by multiplying the 70% retention (or 30% passing) size of the formation, as determined by the grain size analysis, by a factor of 3 (for fine uniform formations) to 6 (for coarse, non-uniform formations). Table 1 summarizes the results of the grain-size analysis and the 70% retention size for each of the samples collected from each boring.

To reduce turbidity as much as possible, pre-packed well screens were selected for use in the monitoring wells. The 2-inch diameter 0.01" slotted Schedule 40 PVC pre-packed screens are designed specifically for sampling metals in groundwater. The pre-packed well screens were constructed using an inner filter pack consisting of 0.40 mm clean quartz filter sand between two layers of food-grade plastic mesh to reduce sample turbidity by filtering out smaller particles than is possible with standard filter packed wells and prepack screens. No metal components were used in the construction of the pre-packed well screens, thus eliminating potential interference with metals analysis.

4.5 Monitoring Well Installation and Development

Well installation and development at the Clifty Creek Station were conducted from November 2015 through January 2016 by Bowser Morner, Inc., under the supervision of AGES. During the field work, AGES oversaw all drilling activities, prepared lithologic descriptions of all soil, and took detailed field notes for all of the work.

To comply with the CCR regulation requiring the groundwater monitoring system for each CCR unit to contain a minimum of one (1) background/upgradient and three (3) downgradient monitoring wells, six (6) wells were installed at the Type I Landfill and LRCP and 10 monitoring wells were installed at the WBSP. Details regarding monitoring well installation are presented below.

4.5.1 Monitoring Well Installation

New monitoring wells at the Type I Landfill and LRCP were installed using either rotary vibratory or hollow stem auger drilling methods. With either method, the drill bit was

simultaneously pushed down and rotated. The drill head was advanced in 10-foot runs through an 8-inch metal casing to keep the borehole open. Continuous soil samples were obtained from the entire length of each 10-foot run and were logged by the AGES geologist (Appendix B). A steel casing was installed as each boring was advanced to keep the borehole open during well installation.

When using hollow stem augers, continuous split-spoon samples were collected and were logged by the AGES geologist (Appendix B). The augers were used to advance each boring to the desired depth and the augers were kept in place to keep the borehole open during well installation. The augers were removed as well installation progressed.

Once each borehole was advanced to the desired depth, a 5-foot or 10-foot pre-packed well screen was set into the borehole depending on the geologic conditions encountered in each borehole. An outer filter pack consisting of 0.40 mm clean quartz sand was installed directly around the pre-packed well screen. The sand was placed as the metal casing was pulled back in one (1)- to two (2)- foot increments to reduce caving effects and ensure proper placement of the filter pack. The filter pack extended two (2)-feet above the top of the screen.

A four (4)-foot thick annular bentonite seal was installed above the filter pack in each well. Once in place, the bentonite seal was allowed to hydrate before the remainder of the annular space around each monitoring well was backfilled using a grout consisting of portland cement and bentonite. Each monitoring well was completed with either an above-ground protective steel casing or a flush-mount steel well cover and a locking well cap. Following installation, each monitoring well was surveyed for elevation and location by IKEC personnel.

Well construction details for all of the wells installed at the Type I Landfill and LRCP, and WBSP are presented in Tables 2 & 3, respectively. All boring and well logs are included in Appendix B.

4.5.2 Monitoring Well Development

Well development was initiated at least 48 hours after installation of each of the monitoring wells. Development consisted of alternating surging and pumping with a submersible pump or bailing in low yielding wells. During development of the monitoring wells, field parameters including temperature, specific conductance, pH and turbidity were recorded at regular intervals. Development continued until each parameter stabilized and turbidity was less than 5 NTUs. Well development data is included in Appendix C.

4.6 **Groundwater Monitoring Networks**

To comply with the CCR regulation, each monitored CCR Unit must have a groundwater monitoring network consisting of a minimum of one (1) upgradient/background monitoring well

and a minimum of three (3) downgradient monitoring wells installed as close as practicable to the waste boundary. A discussion of the CCR monitoring network for each unit is presented below.

4.6.1 Type I Residual Waste Landfill and Landfill Runoff Collection Pond

In November and December 2015, six (6) monitoring wells were installed at the Type I Landfill and LRCP (Figures 9 and 10).

Three (3) monitoring wells (CF-15-07, CF-15-08 and CF-15-09) were installed downgradient of the Type I Landfill and LRCP (Figure 10). Based on exploratory soil borings and historical data, there were no suitable upgradient locations for the Type I Landfill and LRCP. Therefore, CF-15-04 was installed outside the hydrologic influence of the Type I Landfill to serve as the required background monitoring well. In addition, CF-15-06 was installed to serve as an additional background monitoring well and CF-15-05 was installed as a background/intermediate monitoring well to ensure groundwater from the WBSP is not impacting groundwater at CF-15-06. The locations of the background wells are shown on Figure 9.

The Devils Backbone is a limestone ridge that trends northeast-southwest along the southern side of the Type I Landfill and LRCP. This ridge acts as an impermeable barrier separating groundwater flowing beneath the Type I Landfill and LRCP from groundwater flowing beneath the WBSP. Therefore, the upgradient WBSP wells WBSP-15-01 and WBSP-15-02 were also included as background wells for the Type I Landfill and LRCP groundwater monitoring network.

Table 2, and Figures 9 and 10 present the construction information and locations of the monitoring wells in the Type I Landfill and LRCP groundwater monitoring network. The review of historic data and groundwater levels measured from each well in January, March and May 2016, indicated that groundwater beneath the Type I Landfill and LRCP flows toward the southwest toward the Ohio River. Groundwater levels for January, March and May 2016 are included in Appendix D. Groundwater flow maps for January, March and May 2016 are included in Appendix E.

4.6.2 West Boiler Slag Pond

Table 2 and Figure 8 present the construction information and locations of the monitoring wells in the WBSP groundwater monitoring network. In accordance with the minimum requirements of the CCR regulation, three (3) monitoring wells were installed upgradient of the WBSP (WBSP-15-01, WBSP-15-02 and WBSP-15-03) and seven (7) monitoring wells (WBSP-15-04 through WBSP-10) were installed downgradient of the WBSP.

Based on groundwater levels measured from each well in January, March and May 2016, groundwater beneath the WBSP flows from the northwest to the southeast toward the Ohio River. Groundwater levels for January, March and May 2106 are included in Appendix D. Groundwater flow maps for January, March and May 2016 are included in Appendix E.

5.0 AQUIFER TESTING

In May 2016, aquifer testing was conducted on one (1) background well (CF-15-04), one (1) Type I Landfill and LRCP well (CF-15-08), and three (3) WBSP wells (WBSP-15-02, WBSP-15-06 and WBSP-15-07) to obtain data to calculate the saturated hydraulic conductivity (K) for the uppermost aquifer beneath each unit. Both rising and falling head slug tests were performed on each well.

The falling head tests were performed by lowering a solid slug with a known volume, into the water column of the well and recording the drop in head over time. The rising head tests were performed by removing the solid slug and recording the rise in head over time. The change of head over time was recorded using a data logger and pressure transducer. Dedicated rope was used to lower the slug into each well and the slug was decontaminated between wells using the procedures specified in the Groundwater Monitoring Program Plan (GMPP) for the Clifty Creek Station. Slug testing was performed after well development and the completion of three (3) rounds of groundwater sampling.

The slug test data were evaluated using AQTESOLV, a commercially available software package. Data from each monitoring well were analyzed using both the Bouwer-Rice and Hvorslev slug test solutions which are straight-line analytical techniques commonly used to analyze rising and falling head slug test data. The AQTESOLV results for each well are presented in Appendix E.

Slug test results for the Type I Landfill and LRCP, and WBSP are summarized on Tables 4 and 5, respectively. The K for the background well CF-15-04 is 1.51×10^{-3} centimeters per second (cm/sec). The K for well CF-15-08 at the Type I Landfill and LRCP is 2.44×10^{-3} cm/sec. The mean K for the uppermost aquifer beneath the WBSP is 9.44×10^{-3} cm/sec.

6.0 CONCLUSIONS

To meet the requirements of the CCR regulation, new groundwater monitoring networks were installed at the Type I Landfill and LRCP and the WBSP. Based on available historic data and exploratory soil borings, the following units were identified as the uppermost aquifer at each CCR unit:

- **Type I Landfill and LRCP:** Historic data identified alluvial deposits located southwest of the Type I Landfill and LRCP as the uppermost aquifer. Based on historic data and soil borings conducted during this investigation, depths to these deposits range from 15 to 40 feet bgs.
- **West Boiler Slag Pond:** The WBSP is underlain by alluvial deposits consisting of layers of silty clay, sandy silt and silty sand ranging from approximately 16 feet bgs on the northwest side of the WBSP (closest to the Devil's Backbone) to approximately 90 feet bgs on the southeast side of the WBSP (closest to the Ohio River). Soil and well borings indicated that a layer of gray silt with fine sand, becoming more coarse-grained further to the north & northeast, located at an elevation of approximately 425 feet msl is the uppermost aquifer beneath the WBSP.

To meet the monitoring network requirements of the CCR regulation, six (6) monitoring wells were installed at the Type I Landfill and LRCP, and 10 monitoring wells were installed around the WBSP.

Following installation, development, and three (3) rounds of groundwater sampling, slug testing was conducted on two (2) monitoring wells at the Type I Landfill and LRCP, and three (3) monitoring wells at the WBSP. Data from the slug testing was used to calculate the mean K of the uppermost aquifer at the Landfill and LRCP, and beneath the WBSP. The K for the Type I Landfill and LRCP is 2.44×10^{-3} cm/sec and the mean K for the uppermost aquifer beneath the WBSP is 9.44×10^{-3} cm/sec.

To meet the monitoring requirements of the CCR regulation, the groundwater monitoring networks at each of the two (2) CCR units at the Clifty Creek station will be sampled in accordance with the GMPP.

7.0 REFERENCES

Applied Geology and Environmental Science, Inc. (AGES), 2006. Hydrogeologic Study Report, Clifty Creek Coal Ash Landfill Modification, Clifty Creek Station, Madison, Indiana. November 2006

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United States Environmental Protection Agency (U.S. EPA), 1991. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells. March 1991.

TABLES

TABLE 1
GRAIN SIZE ANALYSIS RESULTS
CLIFTY CREEK STATION
MADISON, INDIANA

CCR Unit	Boring No.	Sample Depth (feet)	70% Retention Size (mm)	Filter Pack Size (mm)	Screen Mesh (inches)	Unified Soil Classification Symbol & Description	
Type I Residual Waste Landfill and Landfill Runoff Collection Pond	Downgradient	24.0 - 34.0	0.05	0.40	0.01	SM	Silty Sand
Type I Residual Waste Landfill and Landfill Runoff Collection Pond - Background	BKG-2	29.0 - 35.0	0.0085	0.40	0.01	ML	Silt with Sand
Type I Residual Waste Landfill and Landfill Runoff Collection Pond - Background	BKG-3	33.0 - 43.0	0.015	0.40	0.01	ML	Silt
West Boiler Slag Pond	WAP-2	51.0 - 61.0	0.017	0.40	0.01	CL-ML	Sandy silty Clay

TABLE 2
GROUNDWATER MONITORING NETWORK
TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

Monitoring Well ID	Designation	Date of Installation	Coordinates		Ground Elevation (ft) ²	Top of Casing Elevation (ft) ²	Top of Screen Elevation (ft)	Base of Screen Elevation (ft)	Total Depth From Top of Casing (ft)
			Northing	Easting					
CF-15-04	Background	12/3/2015	451482.81	569307.19	465.55	468.03	439.55	429.55	38.48
CF-15-05	Background/Intermediate	12/1/2015	447491.91	565533.64	439.85	442.58	422.85	412.85	29.73
CF-15-06	Background	11/30/2015	447026.92	565190.31	437.49	440.40	431.49	421.49	18.91
CF-15-07	Downgradient	11/23/2015	443135.08	562259.25	438.61	441.11	432.61	422.61	18.50
CF-15-08	Downgradient	11/19/2015	443219.57	562537.29	460.33	462.79	430.33	420.33	42.46
CF-15-09	Downgradient	11/25/2015	443445.96	562871.69	456.73	459.45	447.73	442.73	16.72
WBSP-15-01	Background	11/30/2015	449072.27	566322.12	466.93	469.36	458.93	448.93	20.43
WBSP-15-02	Background	11/11/2015	449803.91	566987.30	473.83	476.76	457.83	452.83	23.93

Notes:

1. The Well locations are referenced to the North American Datum (NAD83), east zone coordinate system.
2. Elevations are referenced to the North American Vertical Datum (NAVD) 1988

**TABLE 3
GROUNDWATER MONITORING NETWORK
WEST BOILER SLAG POND
CLIFTY CREEK STATION
MADISON, INDIANA**

Monitoring Well ID	Designation	Date of Installation	Coordinates		Ground Elevation (ft) ²	Top of Casing Elevation (ft) ²	Top of Screen Elevation (ft)	Base of Screen Elevation (ft)	Total Depth From Top of Casing (ft)
			Northing	Easting					
WBSP-15-01	Upgradient	11/30/2015	449072.27	566322.12	466.93	469.36	458.93	448.93	20.43
WBSP-15-02	Upgradient	11/11/2015	449803.91	566987.30	473.83	476.76	457.83	452.83	23.93
WBSP-15-03	Upgradient	12/4/2015	451181.98	568093.60	484.91	488.03	476.91	471.91	16.12
WBSP-15-04	Downgradient	11/12/2015	450610.07	568637.65	471.17	473.71	416.17	406.17	67.54
WBSP-15-05	Downgradient	11/17/2015	450051.40	568495.72	471.90	474.42	410.90	400.90	73.52
WBSP-15-06	Downgradient	11/19/2015	449470.57	568402.50	471.28	473.51	395.78	385.78	87.73
WBSP-15-07	Downgradient	11/23/2015	448947.93	567946.39	468.82	471.31	426.82	416.82	54.49
WBSP-15-08	Downgradient	11/25/2015	448625.46	567343.24	468.56	471.06	415.76	405.76	65.30
WBSP-15-09	Downgradient	1/6/2016	448359.31	566711.13	471.21	470.69	421.21	410.21	59.48
WBSP-15-10	Downgradient	1/5/2016	448125.51	566225.21	471.21	470.69	425.21	435.21	55.48

Notes:

1. The Well locations are referenced to the North American Datum (NAD83), east zone coordinate system.
2. Elevations are referenced to the North American Vertical Datum (NAVD) 1988

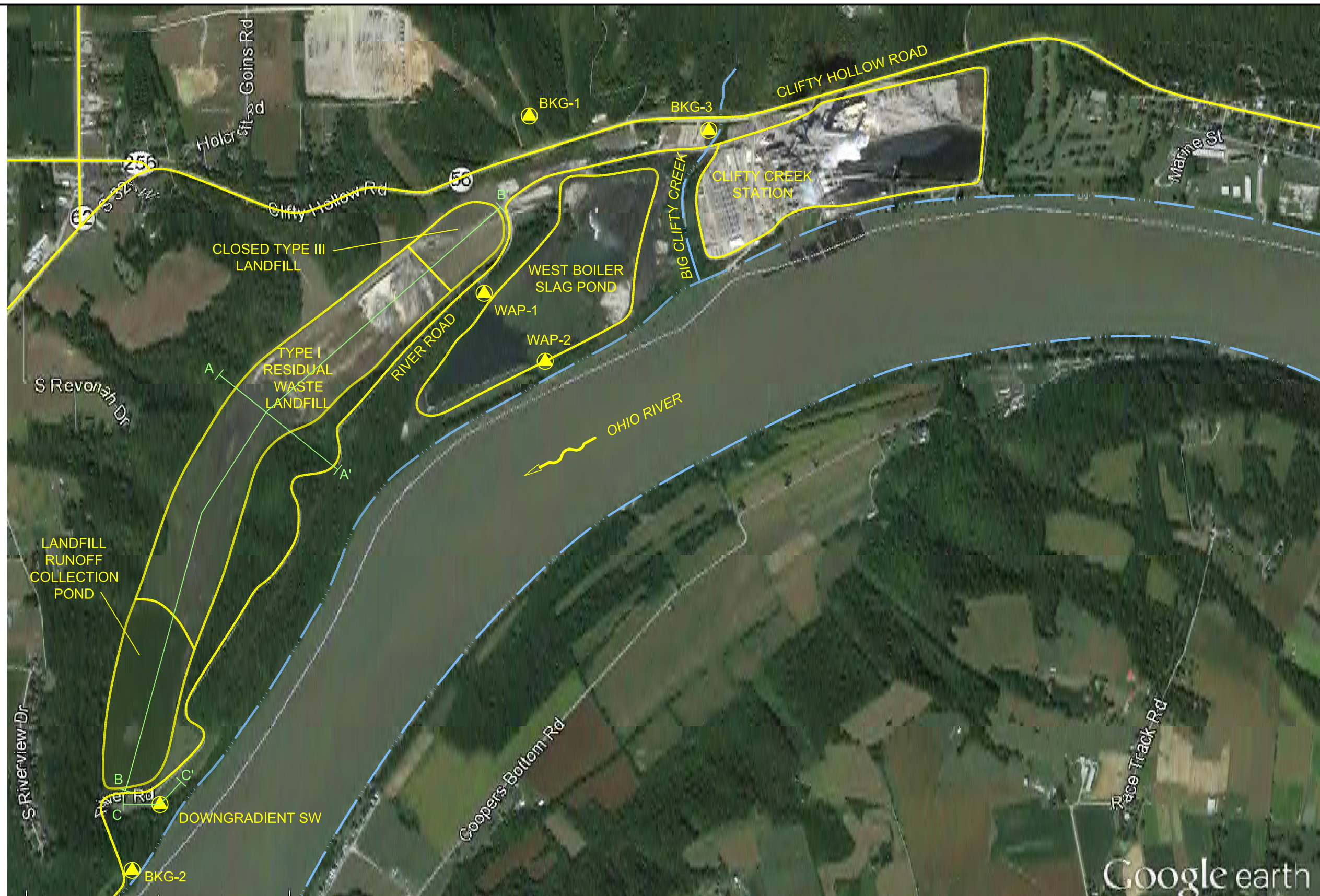
TABLE 4
SUMMARY OF AQUIFER TEST RESULTS
TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA
May 2016

Well	Test	Analytical Method	K (cm/sec)	Mean K (cm/sec)
CF-15-04 (Background)	Rising Head #1	Bouwer-Rice	1.82 E-2	1.51 E-2
		Hvorslev	2.21 E-2	
	Falling Head #1	Bouwer-Rice	9.26 E-3	
		Hvorslev	7.93 E-3	
	Rising Head #2	Bouwer-Rice	2.18 E-2	
		Hvorslev	2.65 E-2	
	Falling Head #2	Bouwer-Rice	5.95 E-3	
		Hvorslev	8.68 E-3	
CF-15-08 (Downgradient)	Rising Head #1	Bouwer-Rice	2.52 E-3	2.44 E-3
		Hvorslev	3.04 E-3	
	Falling Head #1	Bouwer-Rice	2.24 E-3	
		Hvorslev	2.70 E-3	
	Rising Head #2	Bouwer-Rice	1.90 E-3	
		Hvorslev	2.29 E-3	
	Falling Head #2	Bouwer-Rice	2.18 E-3	
		Hvorslev	2.62 E-3	

TABLE 5
SUMMARY OF AQUIFER TEST RESULTS
WEST BOILER SLAG POND
CLIFTY CREEK STATION
MADISON, INDIANA
May 2016

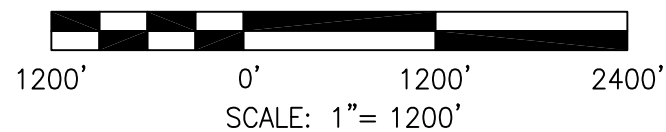
Well	Test	Analytical Method	K (cm/sec)	Mean K (cm/sec)
WBSP-15-02	Rising Head #1	Bouwer-Rice	5.65 E-6	1.04 E-5
		Hvorslev	7.41 E-6	
	Falling Head #1	Bouwer-Rice	1.23 E-5	
		Hvorslev	1.63 E-5	
WBSP-15-06	Rising Head #1	Bouwer-Rice	1.61 E-2	2.83 E-2
		Hvorslev	1.66 E-2	
	Falling Head #1	Bouwer-Rice	2.27 E-2	
		Hvorslev	2.27 E-2	
	Rising Head #2	Bouwer-Rice	3.63 E-2	
		Hvorslev	3.91 E-2	
	Falling Head #2	Bouwer-Rice	3.52 E-2	
		Hvorslev	3.78 E-2	
WBSP-15-07	Rising Head #1	Bouwer-Rice	9.24 E-6	1.02 E-5
		Hvorslev	1.06 E-5	
	Falling Head #1	Bouwer-Rice	9.66 E-6	
		Hvorslev	1.11 E-5	
			Mean K (cm/sec)	9.44 E-3

FIGURES



LEGEND:

SOIL BORING LOCATION



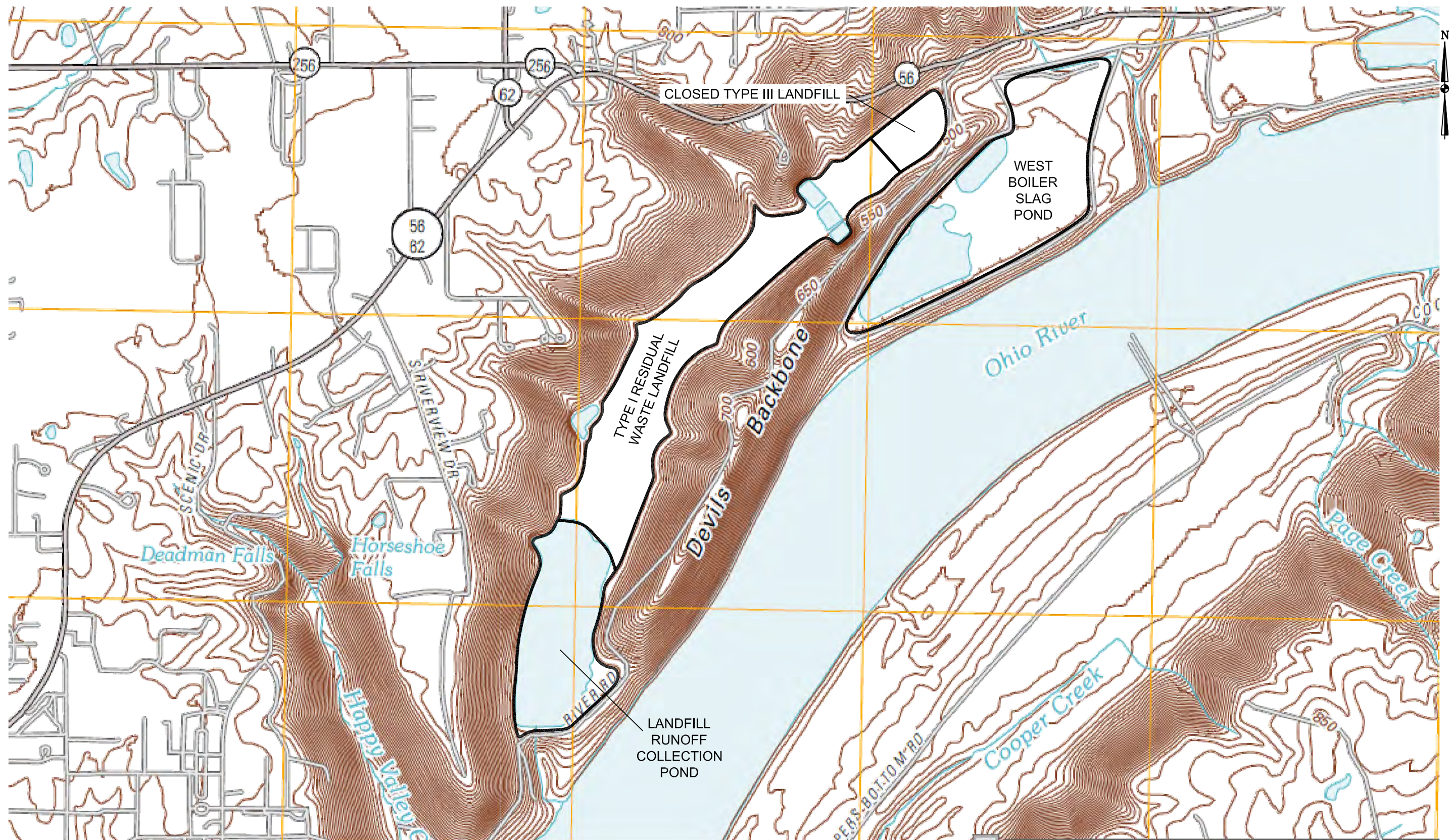
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2402 Hookstown Grade Road, Suite 200
Clinton, PA 15026
412.264.6453

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CLIFTY CREEK STATION
MADISON, INDIANA
SITE LOCATION MAP AND SOIL BORING LOCATIONS

DRAWING NAME	FIGURE 1	REV.	0
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SOURCE: USGS MADISON WEST 7.5 MINUTE TOPOGRAPHIC QUADRANGLE, 2010.

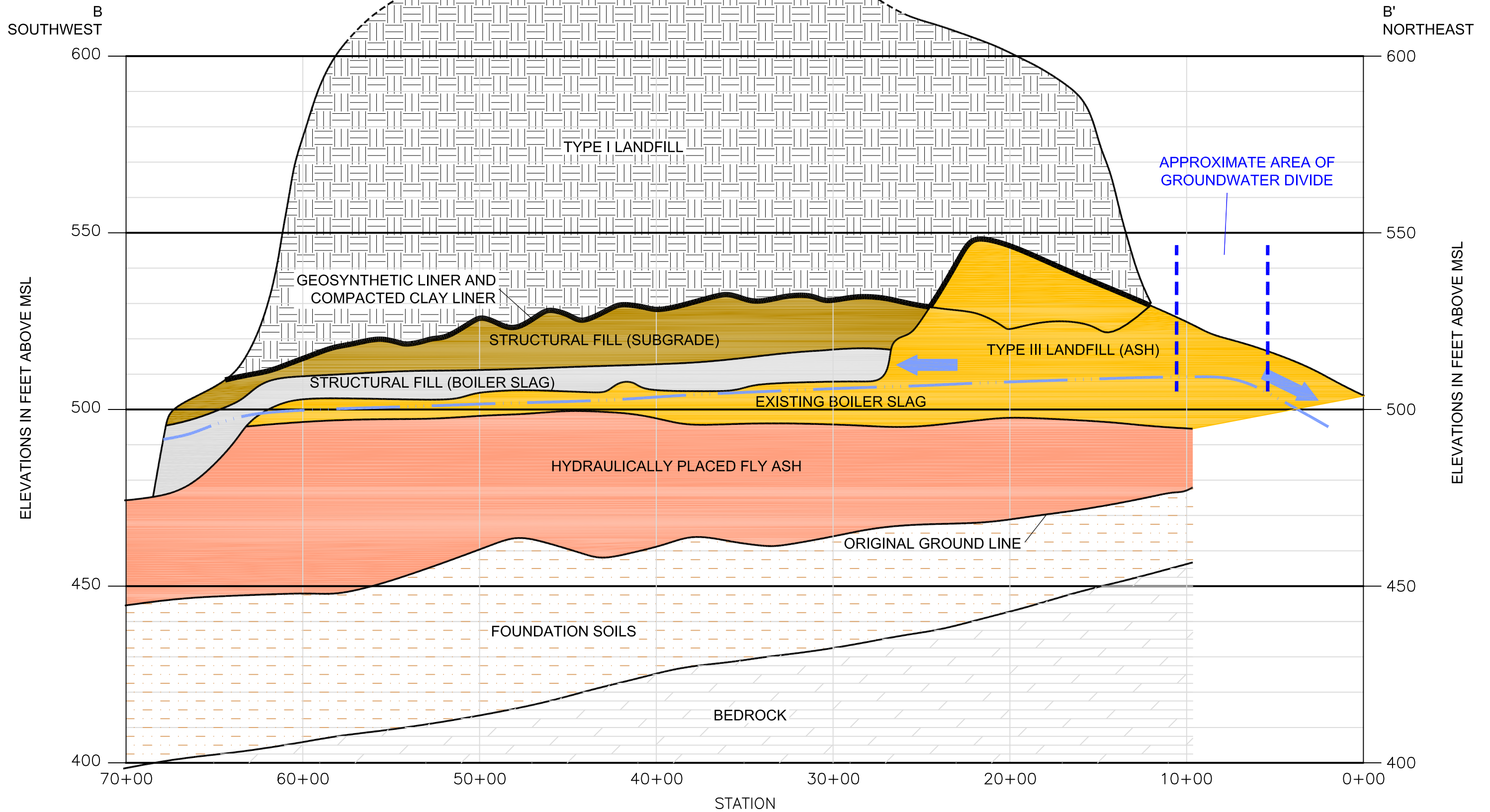
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CLIFTY CREEK STATION
MADISON, INDIANA
TOPOGRAPHIC MAP

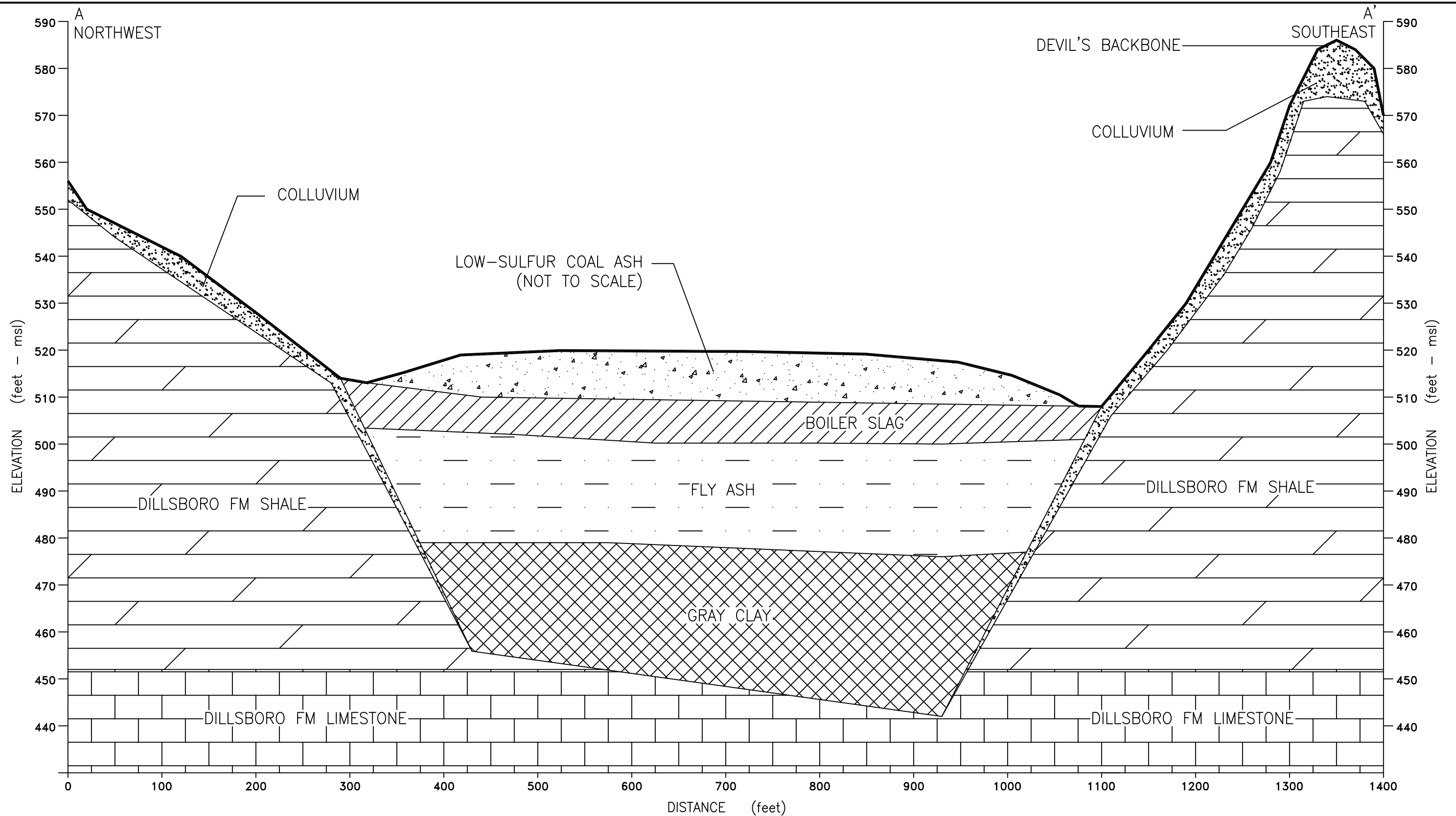
DRAWING NAME	FIGURE 2	REV.	0
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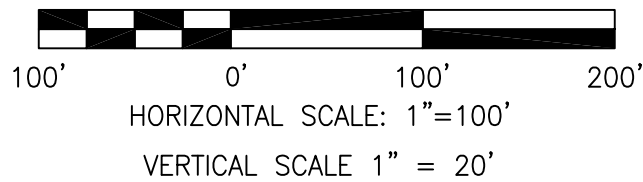
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CLIFTY CREEK STATION MADISON, INDIANA	
TYPE I RESIDUAL WASTE LANDFILL GENERALIZED GEOLOGIC CROSS-SECTION B-B' (SOUTHWEST-NORTHEAST)	
DRAWING NAME	FIGURE 3
REV.	0



NOTE:
CROSS-SECTION LOCATION SHOWN
ON FIGURE 1.

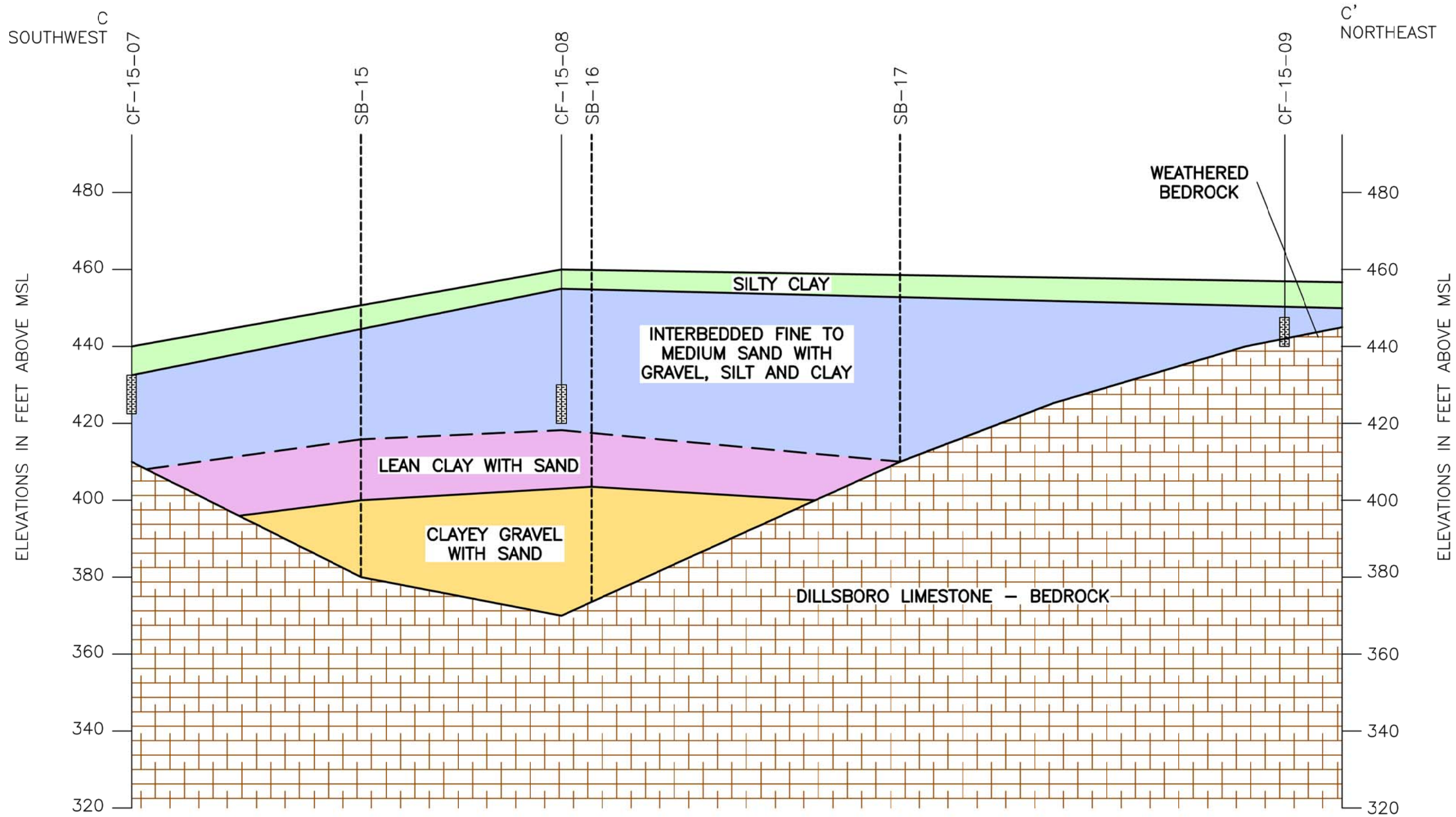
SOURCE: HYDROGEOLOGIC STUDY REPORT,
AGES, APRIL 2007.



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CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND GENERALIZED GEOLOGIC CROSS-SECTION A-A' (NORTHWEST-SOUTHEAST)	
DRAWING NAME	FIGURE 4
REV.	0



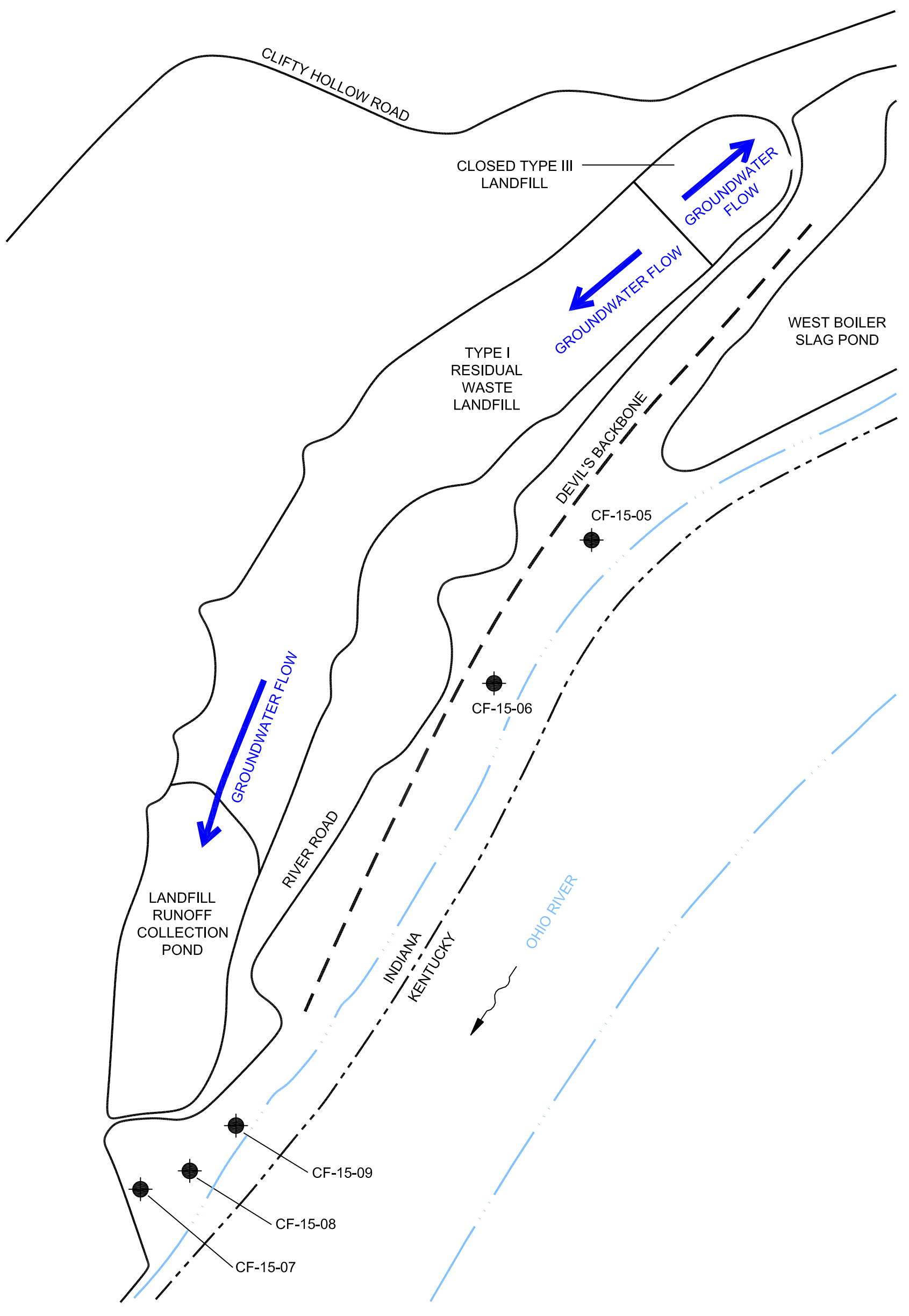
NOTES:

- 1) CROSS-SECTION LOCATION SHOWN ON FIGURE 1.
- 2) SOIL BORINGS SB-15, SB-16 AND SB-17 WERE DRILLED FOR THE 2006 LITIGATION REPORT TO DETERMINE DEPTH TO BEDROCK ONLY - DETAILED GEOLOGIC LOGS WERE NOT MAINTAINED (AGES 2006).
- 3) THE LEAN CLAY WITH SAND LAYER AND THE CLAYEY GRAVEL WITH SAND LAYER BASED ON DATA FROM THE STANTEC LRCP STABILITY ASSESSMENT REPORT (STANTEC 2016).

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CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND GENERALIZED GEOLOGIC CROSS-SECTION C-C'	
DRAWING NAME	FIGURE 5
REV.	0



LEGEND:

● MONITORING WELL LOCATION

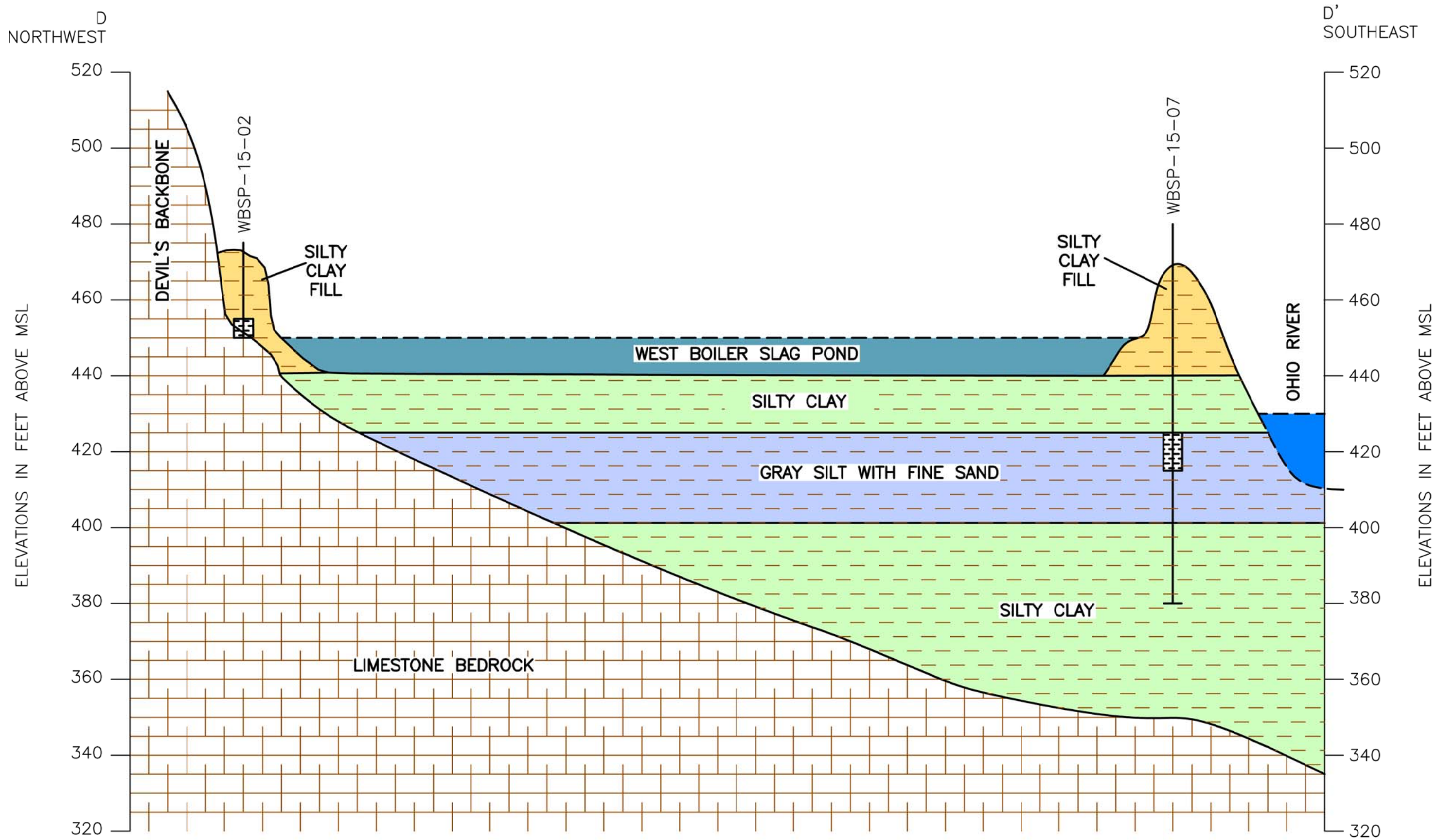
NOTE:

SEE FIGURE 7 FOR LOCATION OF BACKGROUND WELL CF-15-04.

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CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND MONITORING WELL LOCATIONS AND GENERALIZED GROUNDWATER FLOW	
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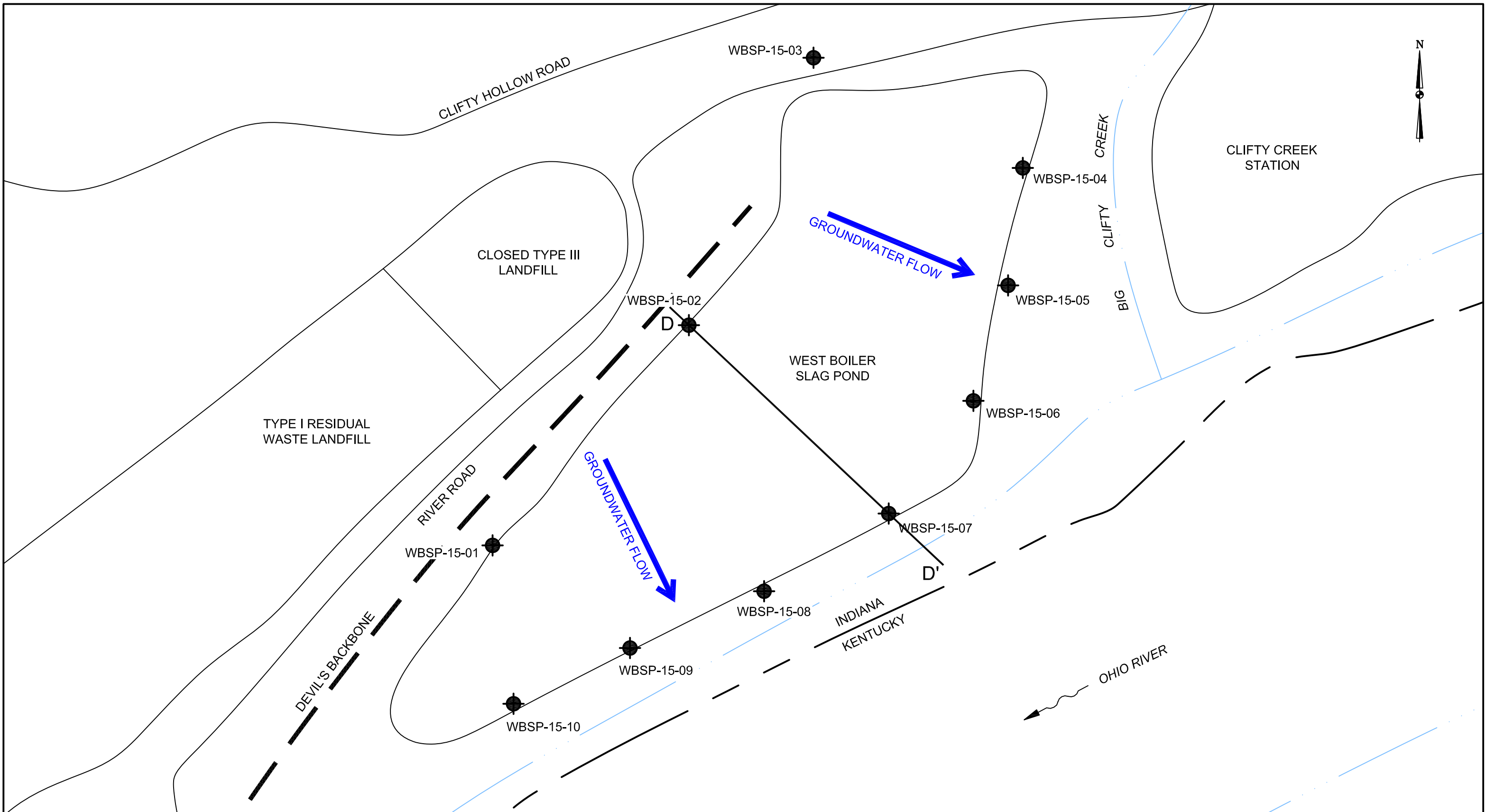


NOTE:
CROSS-SECTION LOCATION SHOWN ON FIGURE 1.

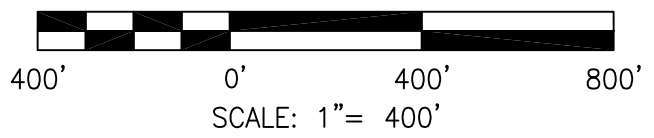
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DRAWING SCALE	NOT TO SCALE

AGES
Applied Geology And Environmental Science, Inc.
2402 Hookstown Grade Road, Suite 200
Clinton, PA 15026
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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GENERALIZED GEOLOGIC CROSS-SECTION D-D'	
DRAWING NAME	FIGURE 7
REV.	0



LEGEND:
 MONITORING WELL LOCATION

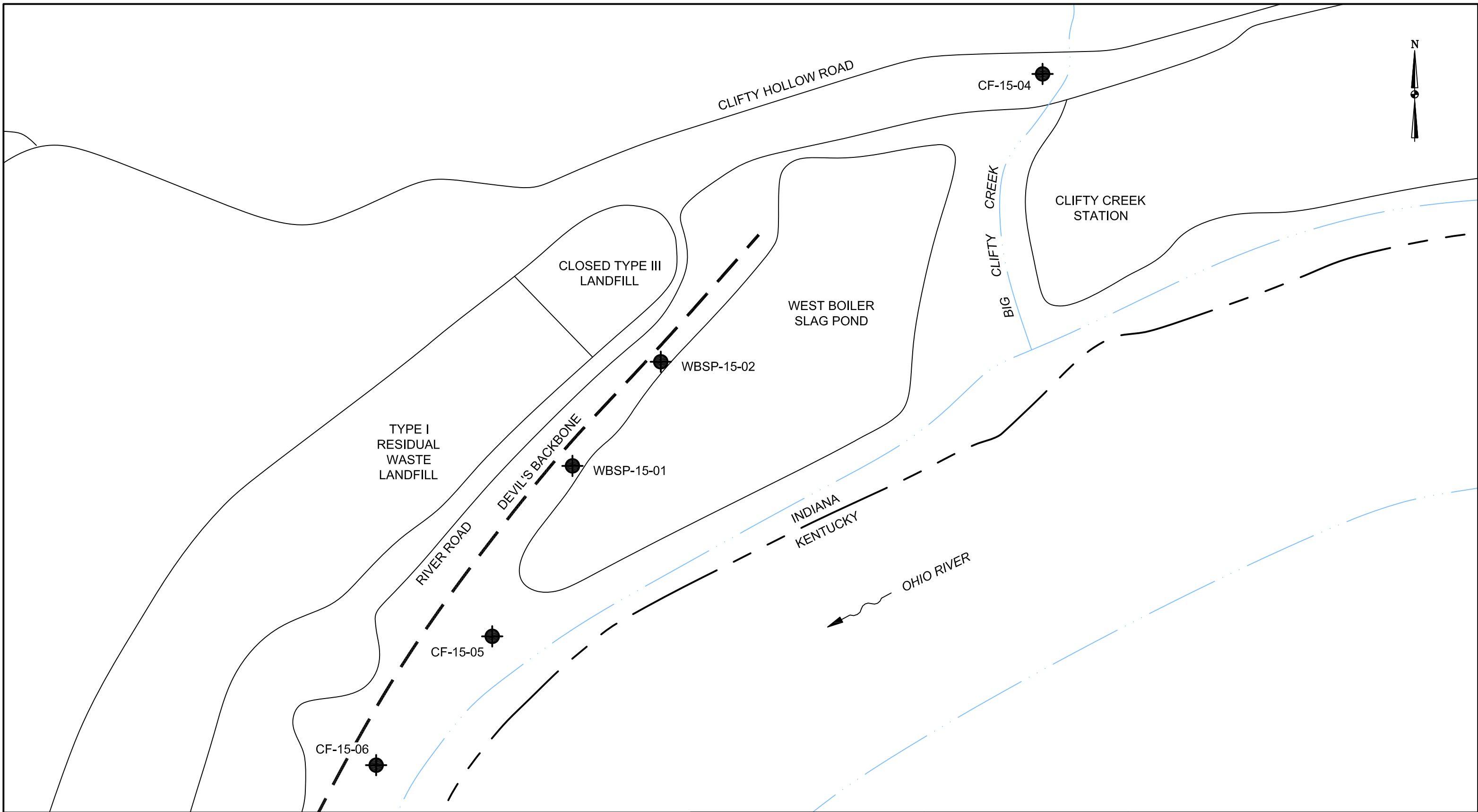


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DRAWING SCALE	AS SHOWN



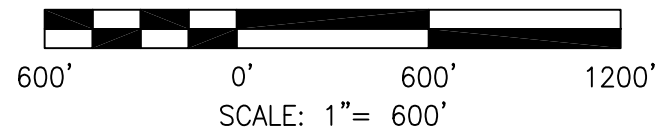
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 412.264.6453

INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND MONITORING WELL LOCATIONS AND GENERALIZED GROUNDWATER FLOW	
DRAWING NAME	FIGURE 8
REV.	0



LEGEND:

● MONITORING WELL LOCATION



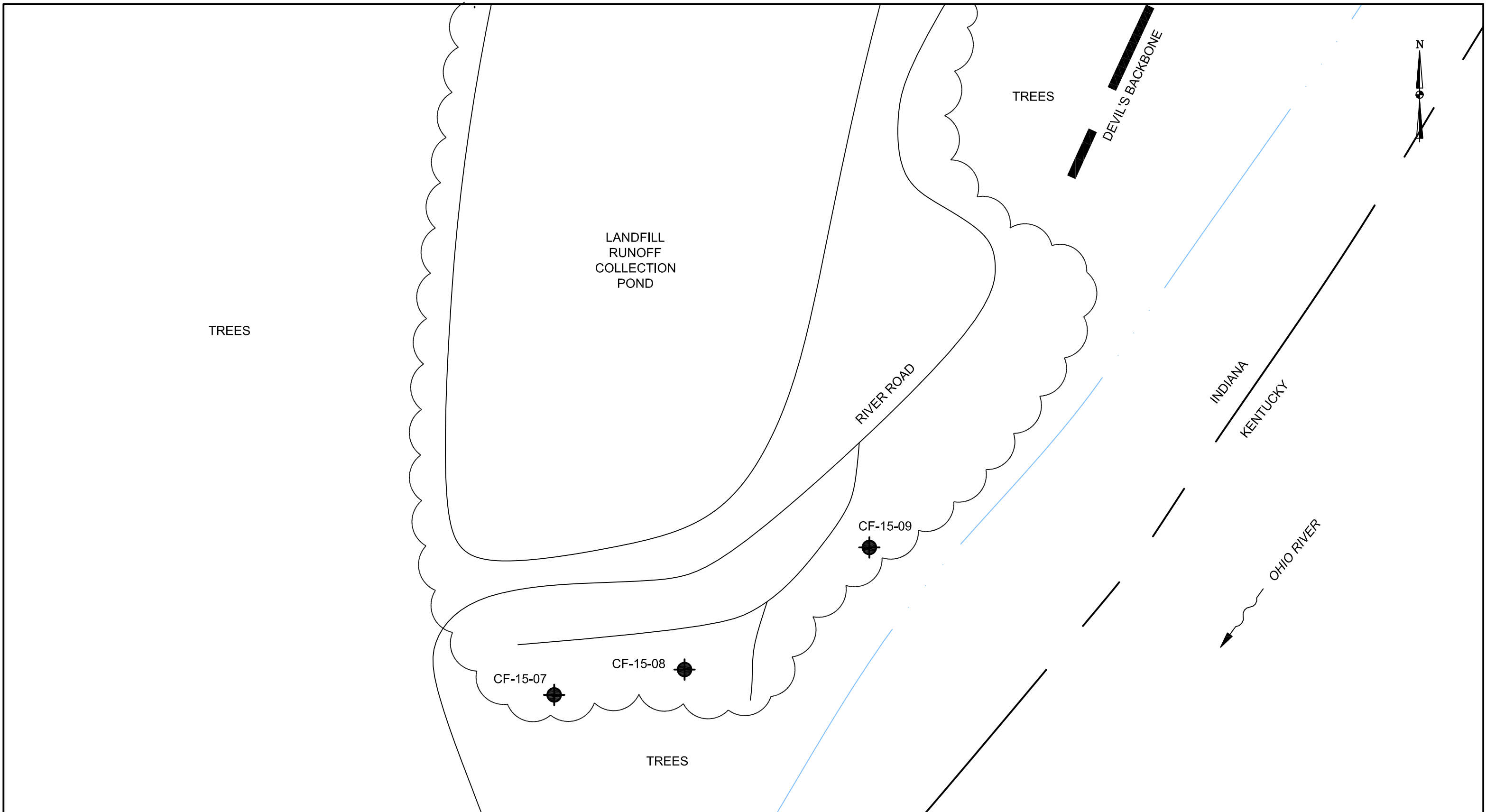
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DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION

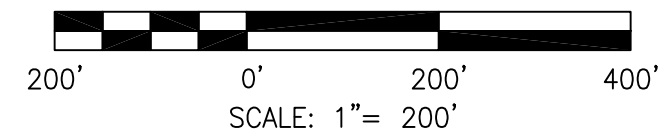
CLIFTY CREEK STATION
MADISON, INDIANA
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
BACKGROUND MONITORING WELL LOCATIONS

DRAWING NAME	FIGURE 9	REV.	0
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LEGEND:

 MONITORING WELL LOCATION



DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2015067-CLI
DWG. FILE	IKEC_Clifty MW Install_MWs_b02-b03-b04.dwg
DRAWING SCALE	AS SHOWN



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Clinton, PA 15026
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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND MONITORING WELL LOCATIONS	
DRAWING NAME	FIGURE 10
REV.	0

APPENDIX A

GRAIN SIZE ANALYSIS RESULTS



Summary of Soil Tests

Project Name Clifty Creek IKEC CCR Rule Eng Project Number 175534018
 Source WAP-2-51-61, 51.0'-61.0' Lab ID 2
 Sample Type SPT Date Received 7-21-15
 Date Reported 7-27-15

Test Results

Natural Moisture Content
 Test Not Performed
 Moisture Content (%): N/A

Atterberg Limits
 Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: 23
 Plastic Limit: 19
 Plasticity Index: 4
 Activity Index: 0.36

Particle Size Analysis
 Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	
	N/A	Passing
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
3/8"	9.5	100.0
No. 4	4.75	99.2
No. 10	2	98.0
No. 40	0.425	96.8
No. 200	0.075	69.6
	0.02	34.7
	0.005	17.0
	0.002	11.2
estimated	0.001	7.0

Moisture-Density Relationship
 Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.8	2.0
Coarse Sand	1.2	1.2
Medium Sand	1.2	---
Fine Sand	27.2	27.2
Silt	52.6	58.4
Clay	17.0	11.2

California Bearing Ratio
 Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity
 Estimated
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.65

Classification
 Unified Group Symbol: CL-ML
 Group Name: Sandy silty clay
 AASHTO Classification: A-4 (1)

Comments: _____

Reviewed By RJ



Particle-Size Analysis of Soils
ASTM D 422

Project Name Clifty Creek IKEC CCR Rule Eng
Source WAP-2-51-61, 51.0'-61.0'

Project Number 175534018
Lab ID 2

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method ASTM D 422
Prepared using ASTM D 421

Particle Shape Angular
Particle Hardness: Hard and Durable

Tested By TA
Test Date 07-22-2015
Date Received 07-21-2015

Sieve Size	% Passing
3/8"	100.0
No. 4	99.2
No. 10	98.0

Maximum Particle size: 3/8" Sieve

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

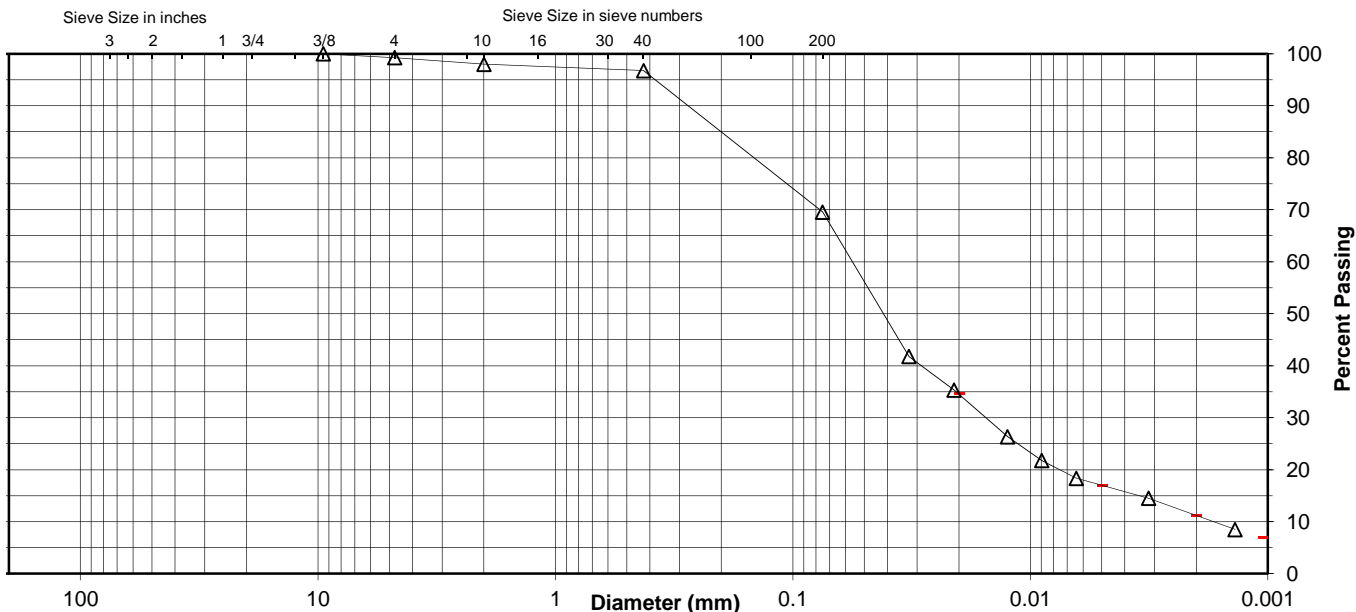
Specific Gravity 2.65

Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	96.8
No. 200	69.6
0.02 mm	34.7
0.005 mm	17.0
0.002 mm	11.2
0.001 mm	7.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay	
	0.0	0.8	1.2	1.2	27.2	52.6	17.0	
AASHTO	Gravel			Coarse Sand		Fine Sand	Silt	Clay
	2.0			1.2		27.2	58.4	11.2



Comments _____

Reviewed By RJ

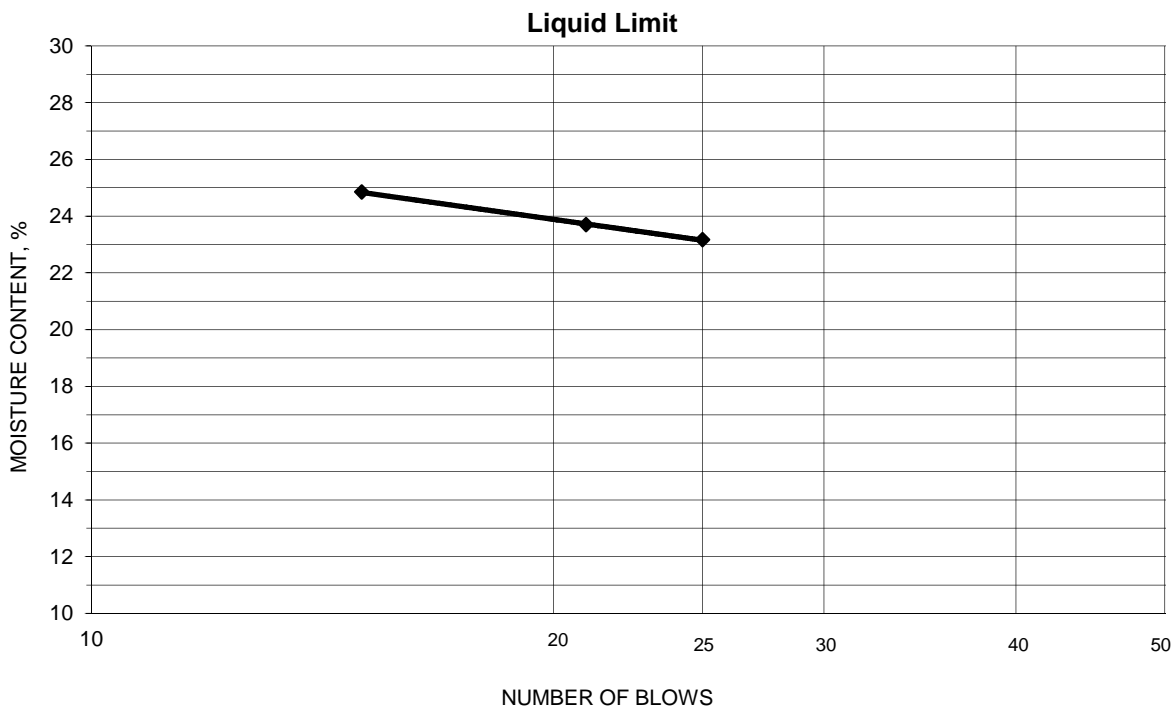


ATTERBERG LIMITS

Project Clifty Creek IKEC CCR Rule Eng
 Source WAP-2-51-61, 51.0'-61.0'
 Tested By KG Test Method ASTM D 4318 Method A
 Test Date 07-31-2015 Prepared Dry

Project No. 175534018
 Lab ID 2
 % + No. 40 3
 Date Received 07-21-2015

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
23.91	21.55	11.59	21	23.7	23
24.82	22.29	11.37	25	23.2	
27.00	23.79	10.87	15	24.8	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
22.36	20.83	12.71	18.8	19	4
20.94	19.66	12.73	18.5		

Remarks: _____

Reviewed By RJ



Summary of Soil Tests

Project Name Clifty Creek IKEC CCR Rule Eng Project Number 175534018
 Source SW-24-34, 24.0'-34.0' Lab ID 1
 Sample Type SPT Date Received 7-21-15
 Date Reported 7-27-15

Test Results

Natural Moisture Content
 Test Not Performed
 Moisture Content (%): N/A

Atterberg Limits
 Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: NP
 Plastic Limit: NP
 Plasticity Index: NP
 Activity Index: N/A

Particle Size Analysis
 Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		% Passing
Sieve Size	(mm)	
	N/A	
	N/A	
	N/A	
	N/A	
3/4"	19	100.0
3/8"	9.5	99.0
No. 4	4.75	96.5
No. 10	2	93.0
No. 40	0.425	90.7
No. 200	0.075	37.8
	0.02	13.6
	0.005	5.8
	0.002	3.5
estimated	0.001	2.0

Moisture-Density Relationship
 Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	3.5	7.0
Coarse Sand	3.5	2.3
Medium Sand	2.3	---
Fine Sand	52.9	52.9
Silt	32.0	34.3
Clay	5.8	3.5

California Bearing Ratio
 Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity
 Estimated
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.65

Classification
 Unified Group Symbol: SM
 Group Name: Silty sand
 AASHTO Classification: A-4 (0)

Comments: _____

Reviewed By RJ



Particle-Size Analysis of Soils
ASTM D 422

Project Name Clifty Creek IKEC CCR Rule Eng
Source SW-24-34, 24.0'-34.0'

Project Number 175534018
Lab ID 1

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method ASTM D 422
Prepared using ASTM D 421

Particle Shape Angular
Particle Hardness: Hard and Durable

Tested By JS
Test Date 07-22-2015
Date Received 07-21-2015

Maximum Particle size: 3/4" Sieve

Sieve Size	% Passing
3/4"	100.0
3/8"	99.0
No. 4	96.5
No. 10	93.0

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

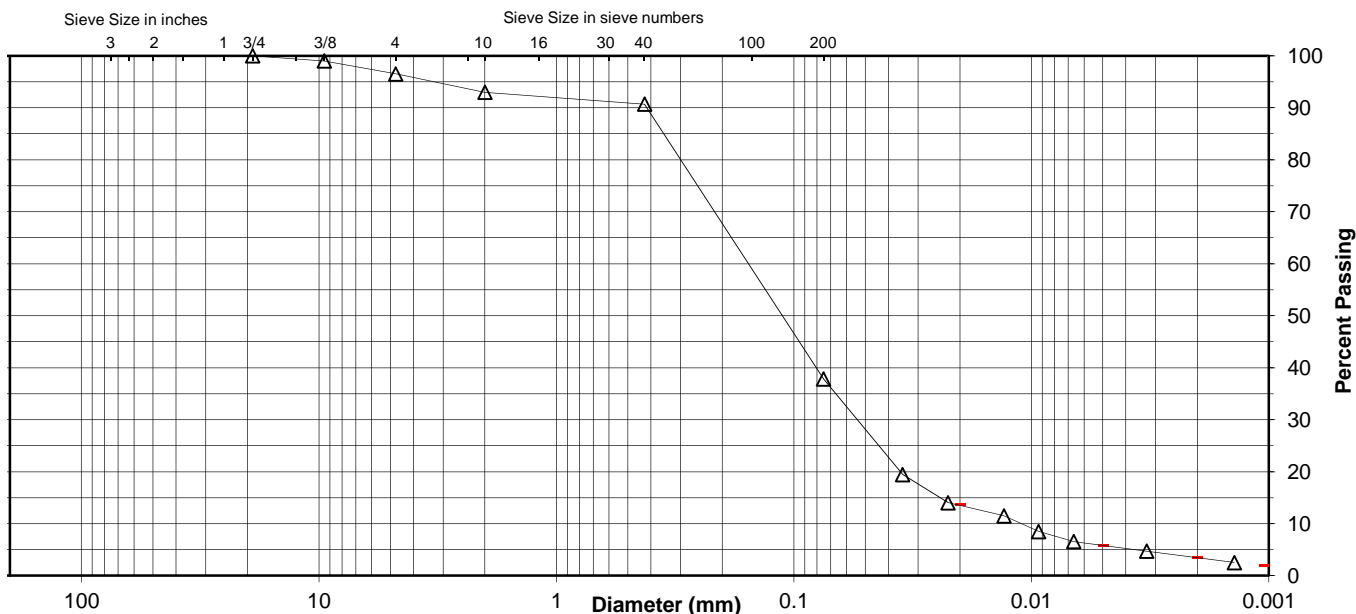
Specific Gravity 2.65

Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	90.7
No. 200	37.8
0.02 mm	13.6
0.005 mm	5.8
0.002 mm	3.5
0.001 mm	2.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	3.5	3.5	2.3	52.9	32.0	5.8
AASHTO	Gravel		Coarse Sand		Fine Sand	Silt	Clay
	7.0		2.3		52.9	34.3	3.5



Comments _____

Reviewed By RJ



Summary of Soil Tests

Project Name Clifty Creek IKEC CCR Rule Eng Project Number 175534018
 Source BKG-3-33-43, 33.0'-43.0' Lab ID 3
 Sample Type SPT Date Received 7-21-15
 Date Reported 7-27-15

Test Results

Natural Moisture Content
 Test Not Performed
 Moisture Content (%): N/A

Atterberg Limits
 Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: NP
 Plastic Limit: NP
 Plasticity Index: NP
 Activity Index: N/A

Particle Size Analysis
 Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	
	N/A	Passing
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
3/8"	9.5	100.0
No. 4	4.75	99.8
No. 10	2	99.7
No. 40	0.425	99.6
No. 200	0.075	98.4
	0.02	42.5
	0.005	10.7
	0.002	6.3
estimated	0.001	3.0

Moisture-Density Relationship
 Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

California Bearing Ratio
 Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity
 Estimated
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.65

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.2	0.3
Coarse Sand	0.1	0.1
Medium Sand	0.1	---
Fine Sand	1.2	1.2
Silt	87.7	92.1
Clay	10.7	6.3

Classification
 Unified Group Symbol: ML
 Group Name: Silt
 AASHTO Classification: A-4 (0)

Comments: _____

Reviewed By RJ



Summary of Soil Tests

Project Name Clifty Creek IKEC CCR Rule Eng Project Number 175534018
 Source BKG-2-29-35, 29.0'-35.0' Lab ID 4
 Sample Type SPT Date Received 7-23-15
 Date Reported 7-31-15

Test Results

Natural Moisture Content

Test Not Performed
 Moisture Content (%): N/A

Particle Size Analysis

Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		% Passing
Sieve Size	(mm)	
	N/A	
	N/A	
	N/A	
	N/A	
3/4"	19	100.0
3/8"	9.5	98.6
No. 4	4.75	98.1
No. 10	2	96.8
No. 40	0.425	94.3
No. 200	0.075	79.8
	0.02	46.9
	0.005	23.4
	0.002	16.0
estimated	0.001	12.0

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	1.9	3.2
Coarse Sand	1.3	2.5
Medium Sand	2.5	---
Fine Sand	14.5	14.5
Silt	56.4	63.8
Clay	23.4	16.0

Atterberg Limits

Test Method: ASTM D 4318 Method A
 Prepared: Dry

Liquid Limit: NP
 Plastic Limit: NP
 Plasticity Index: NP
 Activity Index: N/A

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity

Estimated

Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: ML
 Group Name: Silt with sand

AASHTO Classification: A-4 (0)

Comments: _____

Reviewed By RJ

APPENDIX B

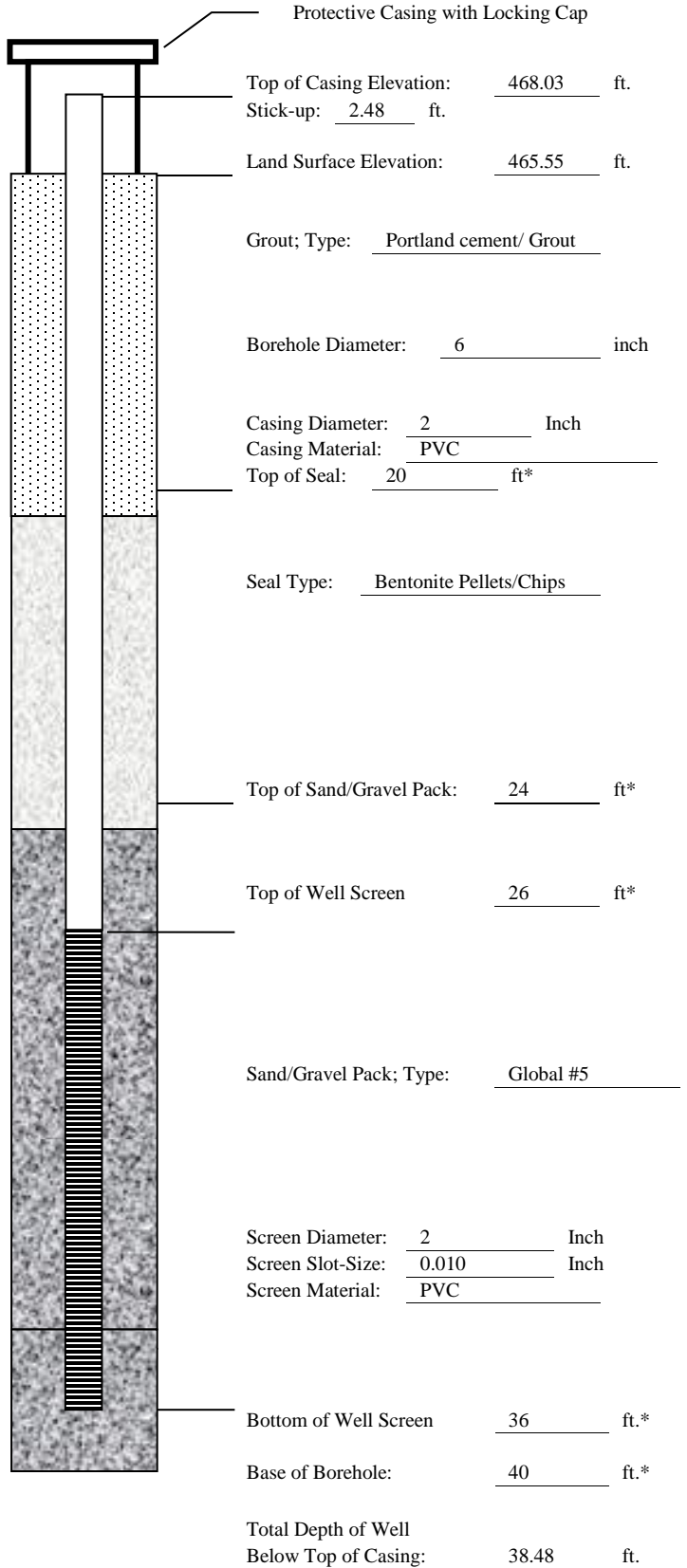
BORING & WELL LOGS

WELL CONSTRUCTION LOG

WELL NO. CF-15-04

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – Landfill Northeast End</u>
Installation Date(s):	<u>12/3/15</u>
Drilling Method:	<u>Roto-Sonic</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>12/9/15</u>
Development Method:	<u>Submersible Pump</u>
Field parameters stabilized:	<u>Turbidity = 0.91 NTUs</u>
Volume Purged:	<u>65 gallons</u>
Static Water-Level*:	<u>28.53'</u>
Top of Well Casing Elevation:	<u>468.03'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>451482.81</u>
Easting (X):	<u>569307.19</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Michael Gelles</u>

CONSTRUCTION MATERIALS USED:	
<u>6</u>	Bags of Sand
<u>2</u>	Bags/Buckets Bentonite Pellets
<u>6</u>	Bags Portland for Grout
<u> </u>	Bags Concrete/Sakrete



*Indicates Depth Below Land Surface

BORING NO. CF-15-05
SAMPLE/CORE LOG

Project Number: <u>2015067</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek Plant Landfill South End</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>11/29/15-11/30/15</u>	AGES Geologist: <u>Joe Webster</u>

Drilling Method: <u>HSA</u>	Coring Device Size: <u>NA</u>	Hammer Wt. <u>160lb</u>	and Drop <u>2ft</u>
Sampling Method: <u>NA</u>	Borehole Diameter: <u>4.25"</u>	Drilling Fluid Used: <u>Water</u>	
Sampling Interval: <u>NA</u>	Borehole Depth: <u>27'</u>	Surface Elevation: <u>439.85' MSL</u>	

NOTES/COMMENTS: _____

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-10		NA	Advance augers – no samples	N/A
10-12	2	2-2-2-2	Brown clay, little silt, very moist to wet	N/A
12-14	2	1-2-2-3	Brown clay, little silt, wet.	N/A
14-16	2	2-2-2-2	Brown clay, little silt, very moist to wet	N/A
16-18	2	2-3-2-2	Brown to olive gray clay, little silt, trace sand, very moist to wet	N/A
18-20	1.33	1-1-2-1	Olive gray clay, some silt, wet	N/A
20-22	2	2-2-3-2	Olive gray clay, some silt, wet	N/A
22-24	2	WH-WH-2-2	Gray clay, some silt, trace fine sand, moist to wet	N/A
24-26	2	1-1-2-2	Gray clay, some silt, trace fine sand, moist	N/A
26-27	0.1	10-50/1	Brown to gray weathered shale with limestone	N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A

WELL CONSTRUCTION LOG

WELL NO. CF-15-05

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – Landfill South End</u>
Installation Date(s):	<u>11/29/15-12/1/15</u>
Drilling Method:	<u>Hollow Stem Auger</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>12/16/15</u>
Development Method:	<u>Peristaltic Pump, Bailer</u>
Field parameters stabilized:	<u>Turbidity = 4.28 NTUs</u>
Volume Purged:	<u>46 gallons</u>
Static Water-Level*:	<u>11.23'</u>
Top of Well Casing Elevation:	<u>442.58'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>447491.91</u>
Easting (X):	<u>565533.64</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Joe Webster</u>

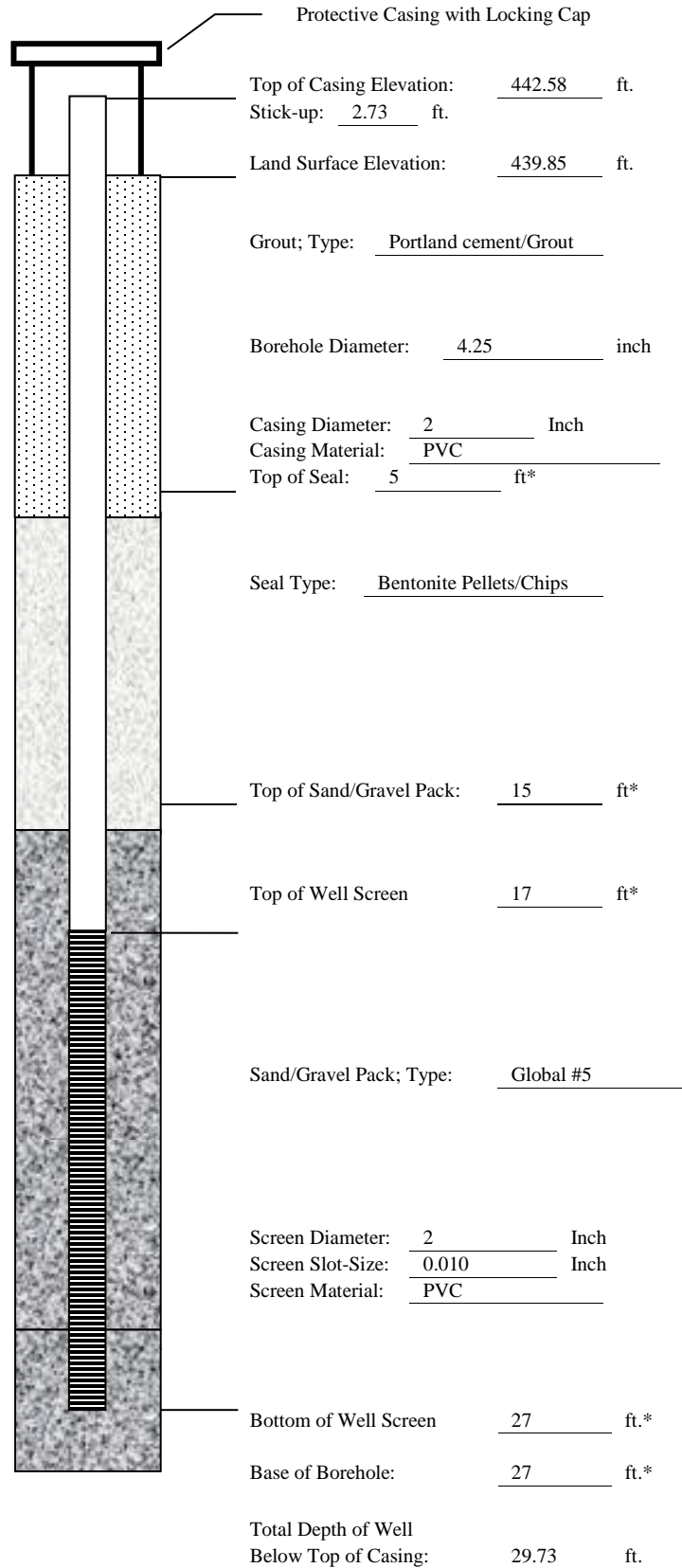
CONSTRUCTION MATERIALS USED:

_____ Bags of Sand

_____ Bags/Buckets Bentonite Pellets

_____ Bags Portland for Grout

_____ Bags Concrete/Sakrete



*Indicates Depth Below Land Surface

Project Number: <u>2015067</u> Project Location: <u>Clifty Creek Plant Landfill South End</u> Drilling Date(s): <u>11/29/15-11/30/15</u>	Log Page <u>1</u> of <u>1</u> Drilling Contractor: <u>Bowser Morner</u> AGES Geologist: <u>Joe Webster</u>
Drilling Method: <u>HSA</u> Coring Device Size: <u>NA</u> Hammer Wt. <u>160lb</u> and Drop <u>2ft</u> Sampling Method: <u>NA</u> Borehole Diameter: <u>4.25"</u> Drilling Fluid Used: <u>Water</u> Sampling Interval: <u>NA</u> Borehole Depth: <u>16'</u> Surface Elevation: <u>437.49' MSL</u>	
NOTES/COMMENTS: _____ _____ _____	

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-10		NA	Advance augers – no samples	N/A
10-12	1.5	3-3-3-5	Brown clay, some silt, soft, moist	N/A
12-14	1.7	3-3-4-3	Brown clay, little silt, soft, moist	N/A
14-16	0.8	4-7-46-50/4	Gray to brown, weathered shale with limestone, hard, dry	N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
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				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A

WELL CONSTRUCTION LOG

WELL NO. CF-15-06

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – Landfill South End</u>
Installation Date(s):	<u>11/29/15-11/30/15</u>
Drilling Method:	<u>Hollow Stem Auger</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>12/16/15</u>
Development Method:	<u>Peristaltic Pump, Bailer</u>
Field parameters stabilized:	<u>Turbidity = 5.59 NTUs</u>
Volume Purged:	<u>6.95 gallons</u>
Static Water-Level*:	<u>17.65'</u>
Top of Well Casing Elevation:	<u>440.40'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>447026.92</u>
Easting (X):	<u>565190.31</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Joe Webster</u>

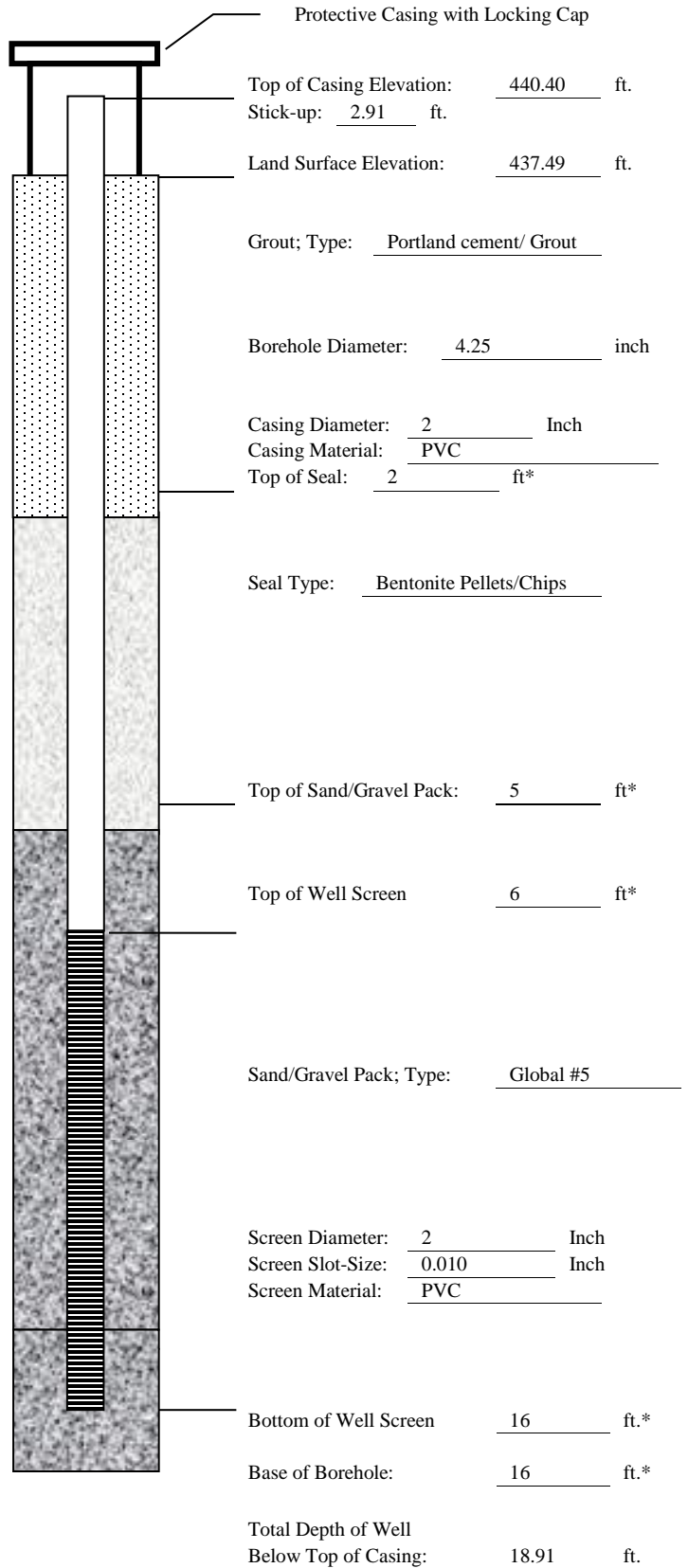
CONSTRUCTION MATERIALS USED:

_____ Bags of Sand

_____ Bags/Buckets Bentonite Pellets

_____ Bags Portland for Grout

_____ Bags Concrete/Sakrete



*Indicates Depth Below Land Surface

BORING NO. CF-15-07
SAMPLE/CORE LOG

Project Number: <u>2015067</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek Plant</u> <u>Landfill South End</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>11/19/15-11/23/15</u>	AGES Geologist: <u>Joe Webster</u>

Drilling Method: <u>HSA</u>	Coring Device Size: <u>NA</u>	Hammer Wt. <u>160lb.</u> and Drop <u>2ft</u>
Sampling Method: <u>NA</u>	Borehole Diameter: <u>4.25"</u>	Drilling Fluid Used: <u>Water</u>
Sampling Interval: <u>NA</u>	Borehole Depth: <u>16'</u>	Surface Elevation: <u>438.61' MSL</u>

NOTES/COMMENTS: _____

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-10		NA	Advance augers – no samples	N/A
10-12	1	1-1-3-5	Brown silty clay, stiff, plastic, wet	N/A
12-14	0	NA	No recovery	N/A
14-16	1.35	3-2-2-2	Brown gray silty clay with mottling, trace gravel, stiff, moist	N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A

WELL CONSTRUCTION LOG

WELL NO. CF-15-07

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – Landfill South End</u>
Installation Date(s):	<u>11/23/15</u>
Drilling Method:	<u>Hollow Stem Auger</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>12/15/15</u>
Development Method:	<u>Peristaltic Pump, Bailer</u>
Field parameters stabilized:	<u>Turbidity = 4.42 NTUs</u>
Volume Purged:	<u>12.5 gallons</u>
Static Water-Level*:	<u>5.92'</u>
Top of Well Casing Elevation:	<u>441.11'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>443135.08</u>
Easting (X):	<u>562259.25</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Joe Webster</u>

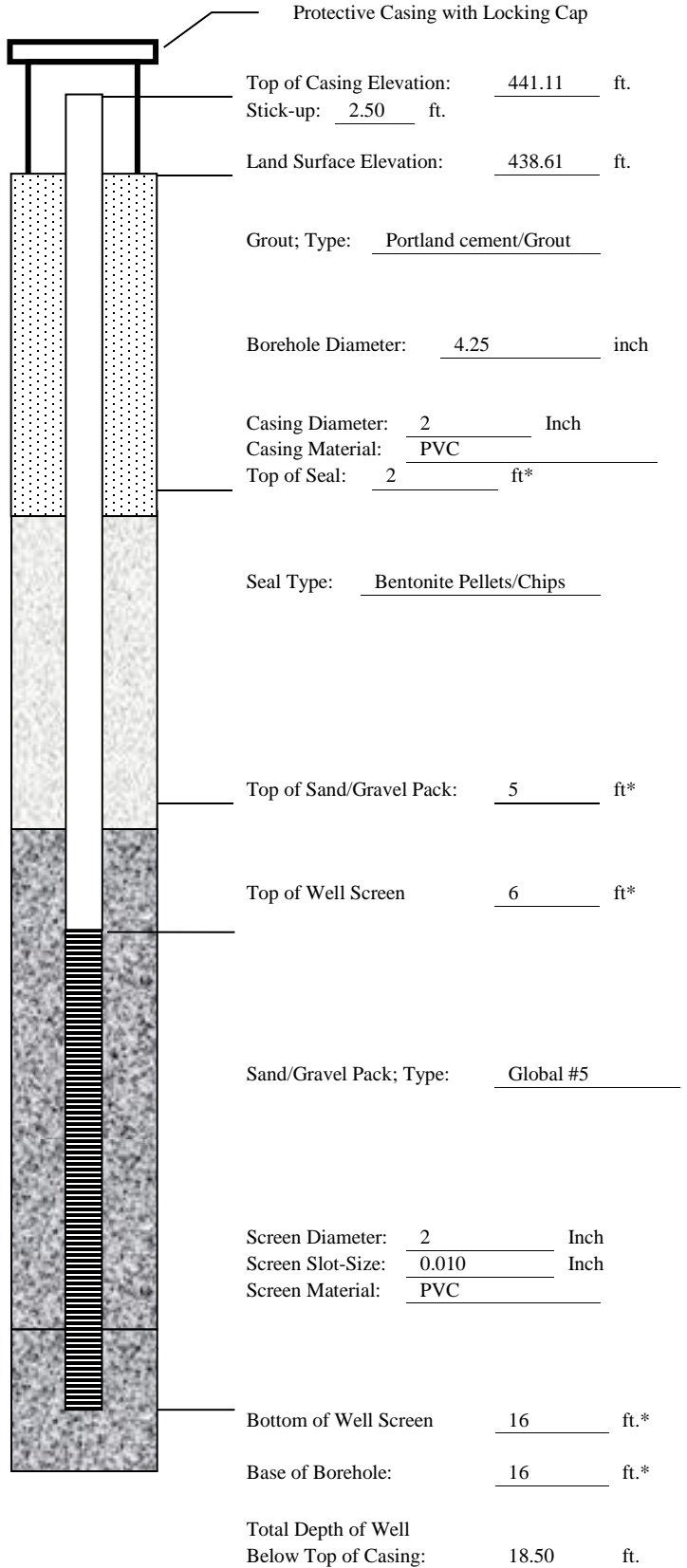
CONSTRUCTION MATERIALS USED:

_____ Bags of Sand

_____ Bags/Buckets Bentonite Pellets

_____ Bags Portland for Grout

_____ Bags Concrete/Sakrete



*Indicates Depth Below Land Surface

BORING NO. CF-15-08
SAMPLE/CORE LOG

Project Number: <u>2015067</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek Plant Landfill South End</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>11/17/15-11/19/15</u>	AGES Geologist: <u>Mike Gelles</u>
Drilling Method: <u>HSA</u>	Coring Device Size: <u>NA</u> Hammer Wt. <u>160lb</u> and Drop <u>2ft</u>
Sampling Method: <u>NA</u>	Borehole Diameter: <u>4.25"</u> Drilling Fluid Used: <u>Water</u>
Sampling Interval: <u>NA</u>	Borehole Depth: <u>40'</u> Surface Elevation: <u>460.33' MSL</u>
NOTES/COMMENTS: _____ _____	

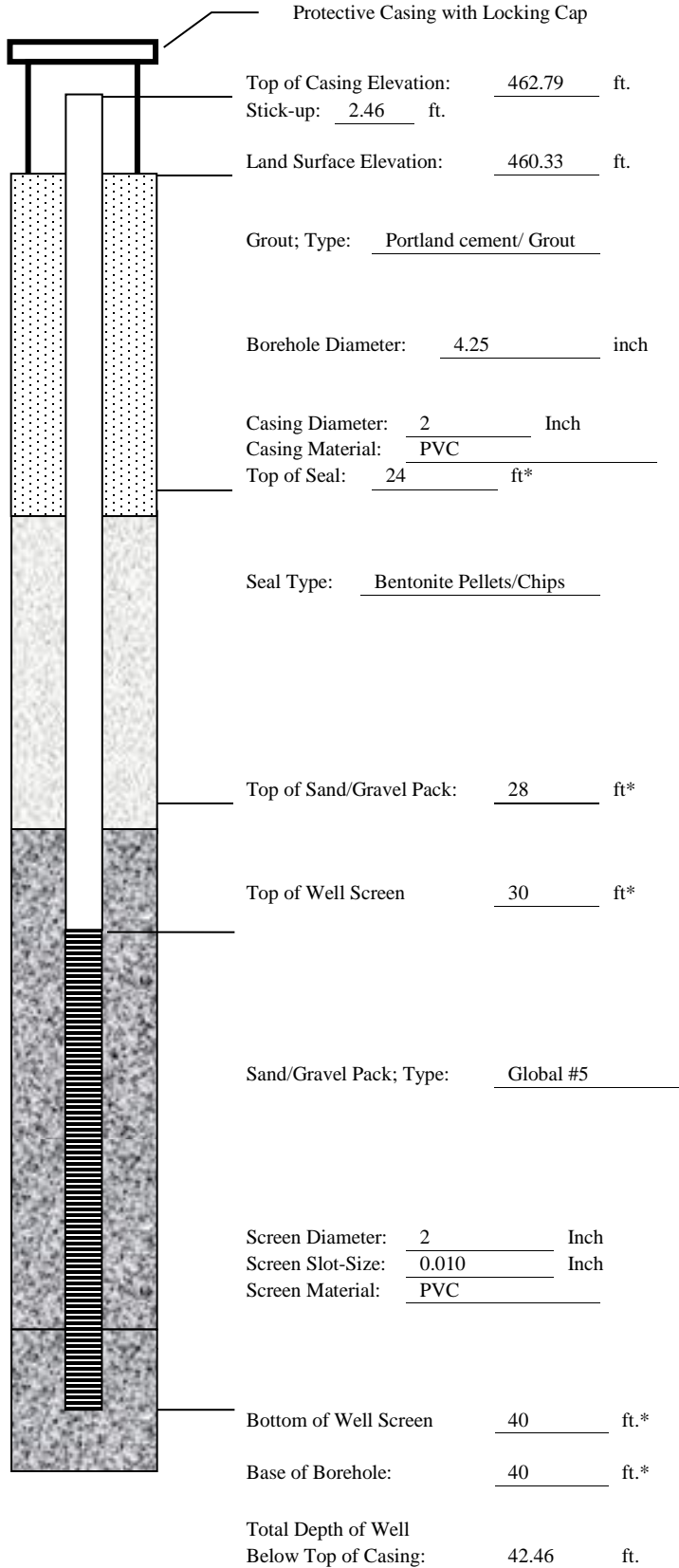
Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-10		NA	Advance augers – no samples	N/A
10-12	2	3-6-6-7	Orange brown silty clay, fine sand, slightly plastic, moist	N/A
12-14	1.4	5-7-10-10	Light brown silt, loose, moist	N/A
14-16	1.6	4-8-12-10	Light brown silt, loose, moist	N/A
16-18	1.6	7-6-9-7	Light brown silt, loose, moist	N/A
18-20	1.6	3-6-4-4	18'-19' Light brown silt, loose, moist; 19'20' Light brown silt, loose, wet	N/A
20-22	1.2	2-3-6-6	Light brown silt, trace clay, wet	N/A
22-24	0.1	2-3-3-3	Brown silt, clay, wet	N/A
24-26	2	2-4-6-7	Brown silt, clay, wet	N/A
26-28	2	3-5-5-5	Brown fine and medium sand, trace silt, trace clay, wet	N/A
28-30	2	3-5-9-12	Brown fine and medium sand, trace silt, trace clay, wet	N/A
30-32	1.2	1-2-2-2	Brown fine and medium sand, medium gravel, trace silt, trace clay, wet	N/A
32-34	2	4-5-5-9	Brown fine and medium sand, fine and medium gravel, trace silt, trace clay, wet	N/A
34-36	2	WH-3-6-8	Brown fine and medium sand, fine and medium gravel, trace silt, trace clay, wet	N/A
36-38	2	4-5-7-8	Brown fine and medium sand, fine and medium gravel, trace silt, trace clay, wet	N/A
38-40	2	3-5-5-11	38'-39.75' Brown fine and medium sand, fine and medium gravel, trace silt, trace clay, wet; 39.75'-40' gray fine and medium sand, silt, trace clay, wet	N/A

WELL CONSTRUCTION LOG

WELL NO. CF-15-08

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – Landfill South End</u>
Installation Date(s):	<u>11/17/15-11/19/15</u>
Drilling Method:	<u>Hollow stem Auger</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>12/8/15</u>
Development Method:	<u>Submersible Pump</u>
Field parameters stabilized:	<u>Turbidity = 2.16 NTUs</u>
Volume Purged:	<u>100 gallons</u>
Static Water-Level*:	<u>24.31'</u>
Top of Well Casing Elevation:	<u>462.79'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>443219.57</u>
Easting (X):	<u>562537.29</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Michael Gelles</u>

CONSTRUCTION MATERIALS USED:	
<u>4.5</u>	<u>Bags of Sand</u>
<u>0.5</u>	<u>Bags/Buckets Bentonite Pellets</u>
<u>3</u>	<u>Bags Portland for Grout</u>
<u> </u>	<u>Bags Concrete/Sakrete</u>



Top of Casing Elevation: 462.79 ft.

Stick-up: 2.46 ft.

Land Surface Elevation: 460.33 ft.

Grout; Type: Portland cement/ Grout

Borehole Diameter: 4.25 inch

Casing Diameter: 2 Inch

Casing Material: PVC

Top of Seal: 24 ft*

Seal Type: Bentonite Pellets/Chips

Top of Sand/Gravel Pack: 28 ft*

Top of Well Screen 30 ft*

Sand/Gravel Pack; Type: Global #5

Screen Diameter: 2 Inch

Screen Slot-Size: 0.010 Inch

Screen Material: PVC

Bottom of Well Screen 40 ft.*

Base of Borehole: 40 ft.*

Total Depth of Well
Below Top of Casing: 42.46 ft.

*Indicates Depth Below Land Surface

BORING NO. CF-15-09
SAMPLE/CORE LOG

Project Number: <u>2015067</u> Project Location: <u>Clifty Creek Plant Landfill South End</u> Drilling Date(s): <u>11/24/15-11/25/15</u>	Log Page <u>1</u> of <u>1</u> Drilling Contractor: <u>Bowser Morner</u> AGES Geologist: <u>Joe Webster</u>
Drilling Method: <u>HSA</u> Coring Device Size: <u>NA</u> Hammer Wt. <u>NA</u> and Drop <u>NA</u> Sampling Method: <u>NA</u> Borehole Diameter: <u>4.25"</u> Drilling Fluid Used: <u>Water</u> Sampling Interval: <u>NA</u> Borehole Depth: <u>14'</u> Surface Elevation: <u>456.73' MSL</u>	
NOTES/COMMENTS: _____ _____	

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-10		NA	Advance augers – no samples	N/A
10-12	1.8	5-9-6-9	Brown weathered shale wilt limestone, hard, dry	N/A
12-14	0.2	50/4	Brown weathered shale wilt limestone, hard, dry	N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A

WELL CONSTRUCTION LOG
WELL NO. CF-15-09

Project Number:	2015067
Project Location:	Clifty Creek Plant – Landfill South End
Installation Date(s):	11/24/15-11/25/15
Drilling Method:	Hollow Stem Auger
Drilling Contractor:	Bowser Morner
Development Date(s):	12/16/15
Development Method:	Peristaltic Pump, Bailer
Field parameters stabilized.	
Turbidity = 3.21 NTUs	
Volume Purged:	6 gallons
Static Water-Level*	12.18'
Top of Well Casing Elevation:	459.45'
Well Purpose:	Groundwater Monitoring
Northing (Y):	443445.96
Easting (X):	562871.69
Comments/Notes:	2 inch PVC riser and screen 5 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.
Inspector:	Joe Webster

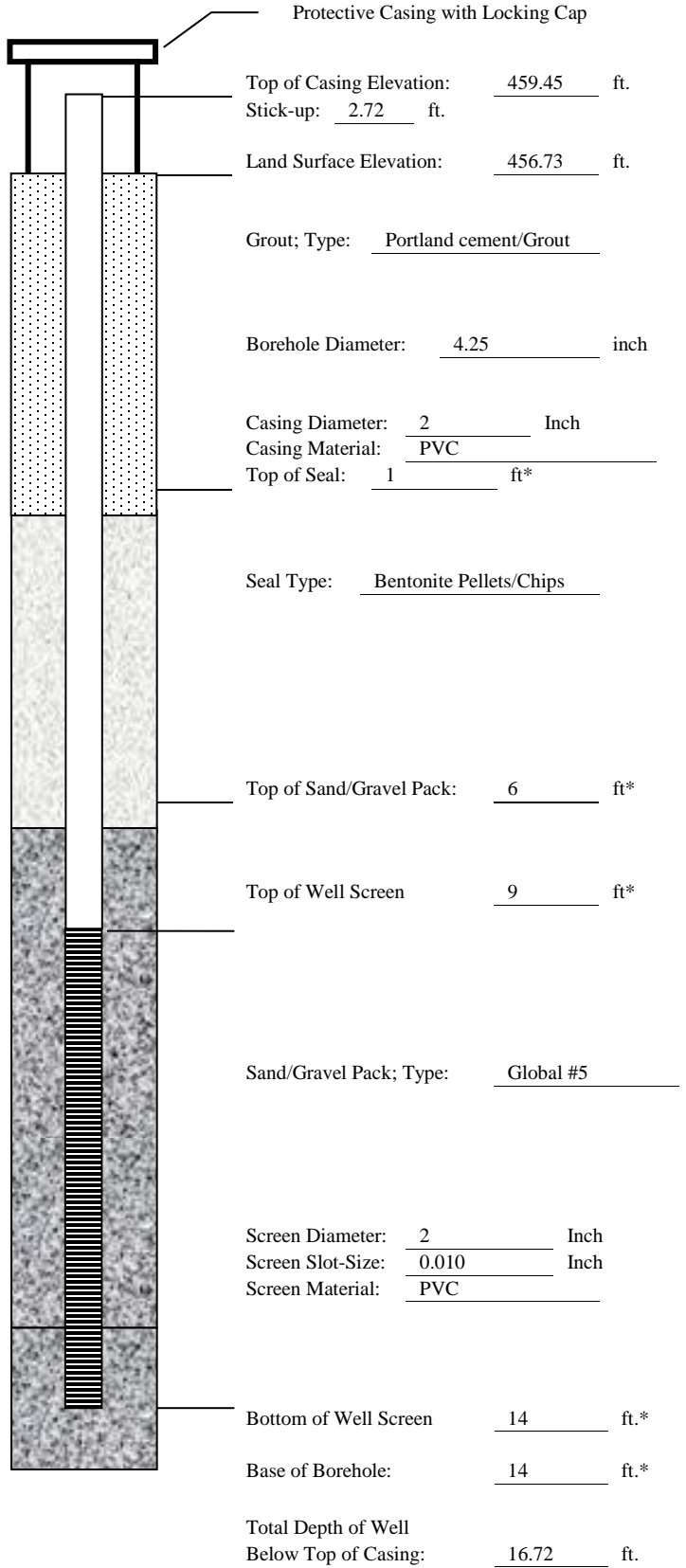
CONSTRUCTION MATERIALS USED:

_____ Bags of Sand

_____ Bags/Buckets Bentonite Pellets

_____ Bags Portland for Grout

_____ Bags Concrete/Sakrete



*Indicates Depth Below Land Surface

BORING NO. WAP-1
SAMPLE/CORE LOG

Project Number: <u>P200852</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek- West Boiler Slag Pond</u>	Drilling Contractor: <u>Stan Tec</u>
Drilling Date(s): <u>7-8-15</u>	AGES Geologist: <u>Mike Gelles</u>
Drilling Method: <u>HSA</u>	Coring Device Size: <u>NA</u> Hammer Wt. <u>NA</u> and Drop <u>NA</u>
Sampling Method: <u>NA</u>	Borehole Diameter: _____ Drilling Fluid Used: <u>None</u>
Sampling Interval: <u>NA</u>	Borehole Depth: _____ Surface Elevation: _____
NOTES/COMMENTS: _____ _____	

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-2	1.5	4-9-16-32	Brown/black silt and fine sand, bottom ash, coal dust, moist	N/A
2-4	1.7	9-21-42-46	Brown/black silt and fine sand, coal dust, moist	N/A
4-6	1.8	12-27-28-25	Brown/black silt, sand, boiler slag, moist	N/A
6-8	1.8	2-7-3-4	Top 1.1' Brown/black boiler slag, silt, fine sand, moist, stiff Bottom 0.7' Brown gray clay, moist, stiff	N/A
8-10	1.6	2-3-6-8	Brown grey silty clay, moist	N/A
10-12	2.0	2-3-6-9	Brown grey to brown, silty clay, moist, stiff	N/A
12-14	2.0	3-4-8-11	Brown silty clay, moist, stiff	N/A
14-16	2.0	3-3-7-9	Brown silty clay moist, stiff	N/A
16-18	2.0	1-2-4-15	Top 1.7' Brown silty clay ,very moist, stiff Bottom 0.3' Rock (limestone), fragments of bedrock	N/A
18-20	1.7	20-6-13-17	Brown Silty clay, moist, stiff, layers of limestone, 20' refusal 50 blows on limestone bedrock.	N/A
20	0	50/0	Refusal – limestone bedrock	N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A

**CONTINUED SAMPLE/CORE LOG
BORING NO. B-1**

Project No: 2015078 HMI Inspector: Mike Gelles Page 2 of 2

BORING NO. BKG-2
SAMPLE/CORE LOG

Project Number: <u> P200852 </u>	Log Page <u> 1 </u> of <u> 1 </u>
Project Location: <u> Clifty Creek- Background-2 </u>	Drilling Contractor: <u> Stan Tec </u>
Drilling Date(s): <u> 7-8-15 </u>	AGES Geologist: <u> Mike Gelles </u>
Drilling Method: <u> HSA </u>	Coring Device Size: <u> NA </u>
	Hammer Wt. <u> NA </u> and Drop <u> NA </u>
Sampling Method: <u> NA </u>	Borehole Diameter: <u> </u>
	Drilling Fluid Used: <u> None </u>
Sampling Interval: <u> NA </u>	Borehole Depth: <u> </u>
	Surface Elevation: <u> </u>
NOTES/COMMENTS: <u> Sample collected for grain size analysis @ 29.0 – 35.0’ </u>	

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-15	N/A	N/A	Brown silty clay, moist	N/A
15-17	100%	2-3-3-4	Brown, silty clay, moist, slightly plastic	N/A
17-19	100%	3-1-2-2	Brown, silty clay, moist, slightly plastic	N/A
19-21	100%	3-3-3-5	Brown, silty clay, moist, plastic	N/A
21-23	100%	1-2-2-5	Brown, silty clay, moist, plastic	N/A
23-25	100%	2-5-4-5	Brown, silty clay, moist, plastic	N/A
25-27	100%	3-5-8-15	Brown, silty clay, moist, plastic	N/A
27-29	100%	10-8-5-6	Brown, silty clay, moist, plastic	N/A
29-31	100%	4-6-11-9	Top 1.0’ Brown fine & medium sand, silt wet Bottom 1.0’ Gray clay trace silt, stiff, moist	N/A
31-33	100%	6-6-6-6	Gray silt, trace clay, wet	N/A
33-35	100%	3-5-4-6	Gray silt, trace clay, wet	N/A

BORING NO. WAP-2
SAMPLE/CORE LOG

Project Number: <u>P200852</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek- West Boiler Slag Pond</u>	Drilling Contractor: <u>Stan Tec</u>
Drilling Date(s): <u>7-9-15</u>	AGES Geologist: <u>Mike Gelles</u>
Drilling Method: <u>HSA</u>	Coring Device Size: <u>NA</u> Hammer Wt. <u>NA</u> and Drop <u>NA</u>
Sampling Method: <u>NA</u>	Borehole Diameter: _____ Drilling Fluid Used: <u>None</u>
Sampling Interval: <u>NA</u>	Borehole Depth: _____ Surface Elevation: _____
NOTES/COMMENTS: <u>Sample collected for grain size analysis @ 51.0 – 61.0'</u>	

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-10	N/A	N/A	Red brown silty clay, gravel, moist	N/A
10-35	N/A	N/A	Red brown silty clay, some gravel, moist	N/A
35-37	No recovery	3-6-8-11	No description	N/A
37-39	1.9	3-6-9-10	Brown silty clay, moist, trace gravel	N/A
39-41	1.9	WOH-3-7-9	Brown gray silt clay, moist, trace sand	N/A
41-43	2.0	2-3-3-5	Brown gray silt, clay, moist	N/A
43-45	1.8	1-1-2-4	Brown gray silt, clay, moist	N/A
45-47	2.0	WOH-2-1-3	Brown gray silt, clay, moist	N/A
47-49	1.9	WOH-1-3-3	Brown gray silt, clay, moist	N/A
49-51	1.9	WOH-2-1-3	Brown gray silt, clay, moist	N/A
51-53	1.9	WOH-2-1-4	Brown gray silt, clay, wet	N/A
53-55	2.0	WOH-1-3-3	Brown gray silt, clay, wet	N/A
55-57	2.0	1-2-4-7	Brown gray silt, clay, wet	N/A
57-59	2.0	1-1-2-3	Brown gray silt, clay, wet	N/A
59-61	2.0	1-1-4-8	Brown gray silt, clay, wet	N/A
				N/A

BORING NO. BKG -1
SAMPLE/CORE LOG

Project Number: <u> P200852 </u>	Log Page <u> 1 </u> of <u> 1 </u>
Project Location: <u> Clifty Creek- Background-1 </u>	Drilling Contractor: <u> Stan Tec </u>
Drilling Date(s): <u> 7-9-15, 7-10-15 </u>	AGES Geologist: <u> Mike Gelles </u>
Drilling Method: <u> HSA </u>	Coring Device Size: <u> NA </u>
	Hammer Wt. <u> NA </u> and Drop <u> NA </u>
Sampling Method: <u> NA </u>	Borehole Diameter: <u> </u>
	Drilling Fluid Used: <u> None </u>
Sampling Interval: <u> NA </u>	Borehole Depth: <u> </u>
	Surface Elevation: <u> </u>
NOTES/COMMENTS: _____ _____	

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-2	1.6	3-6-15-15	Gravel, brown sandy clay, moist (Fill)	N/A
2-4	0.5	6-5-4-3	Gravel, brown sandy clay, moist (Fill)	N/A
4-6	1.9	3-2-2-4	Gravel, brown sandy clay and silty clay, moist (Fill)	N/A
6-8	1.2	4-2-3-8	Gravel, brown sandy clay, moist	N/A
8-10	1.6	4-5-4-5	Brown silty clay, moist and sandy clay, rock fragments.	N/A
10-12	1.6	8-5-5-8	Brown sandy clay, rock fragments, moist	N/A
12-14	1.4	8-2-6-9	Brown sandy clay gravel (fill) wet	N/A
14-16	1.0	2-2-1-3	Brown sandy clay, rock fragments, moist	N/A
16-18	0.5	1-2-5-50	Brown sand clay, rock fragments, wet, bedrock 17.5 to 17.8 Refusal on limestone.	N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A

BORING NO. **BKG-3**
SAMPLE/CORE LOG

Project Number: <u> P200852 </u>	Log Page <u> 1 </u> of <u> 1 </u>
Project Location: <u> Clifty Creek- Background-3 </u>	Drilling Contractor: <u> Stan Tec </u>
Drilling Date(s): <u> 7-15-15 </u>	AGES Geologist: <u> Mike Gelles </u>

Drilling Method: <u> HSA </u>	Coring Device Size: <u> NA </u>	Hammer Wt. <u> NA </u>	and Drop <u> NA </u>
Sampling Method: <u> NA </u>	Borehole Diameter: <u> </u>	Drilling Fluid Used: <u> None </u>	
Sampling Interval: <u> NA </u>	Borehole Depth: <u> </u>	Surface Elevation: <u> </u>	

NOTES/COMMENTS: Sample collected for grain size analysis @ 33.0 – 43.0’

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-5	N/A	N/A	Gravel, ash, silty clay brown, black, moist	N/A
5-13	N/A	N/A	Brown gray silty clay, moist	N/A
13-15	N/A	N/A	Brown gray silty clay, moist, fine sand ,wet	N/A
15-20	N/A	N/A	Brown gray silty clay, fine sand, moist	N/A
20-25	N/A	N/A	Brown gray silty clay, fine sand, moist	N/A
25-27	1.0	11-5-15-24	Brown orange silty clay, rock fragments, wet	N/A
27-29	1.0	10-20-18-13	Brown orange sand fine & medium, gravel round, moist, rock fragments	N/A
29-31	1.0	8-20-19-28	Brown tan sand fine & medium, silt, moist to wet	N/A
31-33	2.0	7-50/2	Brown tan sand fine & medium, silt, wet, weathered limestone (from above, not true interval)	N/A
33-35	0.8	10-5-5-6	Top 0.5’ Brown orange silt moist Bottom 0.3’ Gray brown silt, saturated	N/A
35-37	1.5	4-2-2-3	Brown gray silt, wet	N/A
37-39	1.5	2-1-3-3	Brown gray silt, clay, wet	N/A
39-41	1.8	1-3-4-4	Brown gray silt, clay, wet	N/A
41-43	1.8	1-2-3-5	Brown gray silt, clay ,wet	N/A
				N/A
				N/A
				N/A

**CONTINUED SAMPLE/CORE LOG
BORING NO. B-1**

Project No: 2015078 HMI Inspector: Mike Gelles Page 2 of 2

BORING NO. Downgradient SW
SAMPLE/CORE LOG

Project Number: <u>P200852</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek Landfill– Downgradient SW</u>	Drilling Contractor: <u>Stan Tec</u>
Drilling Date(s): <u>7-8-15</u>	AGES Geologist: <u>Mike Gelles</u>
Drilling Method: <u>HSA</u>	Coring Device Size: <u>NA</u> Hammer Wt. <u>NA</u> and Drop <u>NA</u>
Sampling Method: <u>NA</u>	Borehole Diameter: _____ Drilling Fluid Used: <u>None</u>
Sampling Interval: <u>NA</u>	Borehole Depth: _____ Surface Elevation: _____
NOTES/COMMENTS: <u>Samples collected for grain size analysis @ 24.0 – 34.0'</u>	

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-5	N/A	N/A	Very moist clay, brown with some silt	N/A
5-10	N/A	N/A	Moist-damp, brown, stiff clay, no gravel, some silt	N/A
10-15	N/A	N/A	Very moist, brown with some grey clay, trace silt, no sand or gravel	N/A
15-20	N/A	N/A	Very moist- wet, brown with some gray, clay and silt with some very fine sand no gravel	N/A
20-22	2.0	1-1-2-2	Upper 0.8' Very moist brown silty clay with sand; Lower 1.2' wet/saturated brown silt & very fine sand	N/A
22-24	1.6	WOH/12-1/12	Saturated, brown, very fine sandy silt, free water in spoon	N/A
24-26	2.0	1/12-1-1	Upper 1.8' Saturated, brown, very fine sandy silt, free water in spoon; Lower 0.2' Saturated, brown sand with silt and some fine gravel	N/A
26-28	1.0	WOH – 1/18	Saturated, brown loose silty sand with trace clay, no gravel	N/A
28-30	1.7	WHO-1-2-4	Saturated, brown fine sand with silt and few 3/8" pieces of gravel, few small clay areas	N/A
30-32	1.2	1-4-9-10	Upper 0.5' Brown silt, clay and sand, firm; Lower 0.7' Saturated, brown, fine sand, silt, with some clay and gravel, compacted	N/A
32-34	0.5	6-10-11-15	Poor recovery, large gravel in shoe, brown wet silty fine sand	N/A
34-36	1.5	4-4-5-10	Saturated brown sand all sizes and some small gravel, with 1-2" silt lense and few small clay areas; 15% silt throughout	N/A
36-38	1.6	1-4-10-12	Saturated, brown sand all sizes, mostly fine with silt and gravel; Lower 0.6' dense	N/A
38-40	1.5	3-6-7-10	Wet, brown, sand with silt and gravel and some clay, compacted	N/A
				N/A

**CONTINUED SAMPLE/CORE LOG
BORING NO. B-1**

Project No: 2015078 HMI Inspector: Mike Gelles Page 2 of 2

				N/A
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BORING NO. WBSP-15-01
SAMPLE/CORE LOG

Project Number: <u>2015067</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek Plant West Boiler Slag Pond</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>11/30/15</u>	AGES Geologist: <u>Mike Gelles</u>

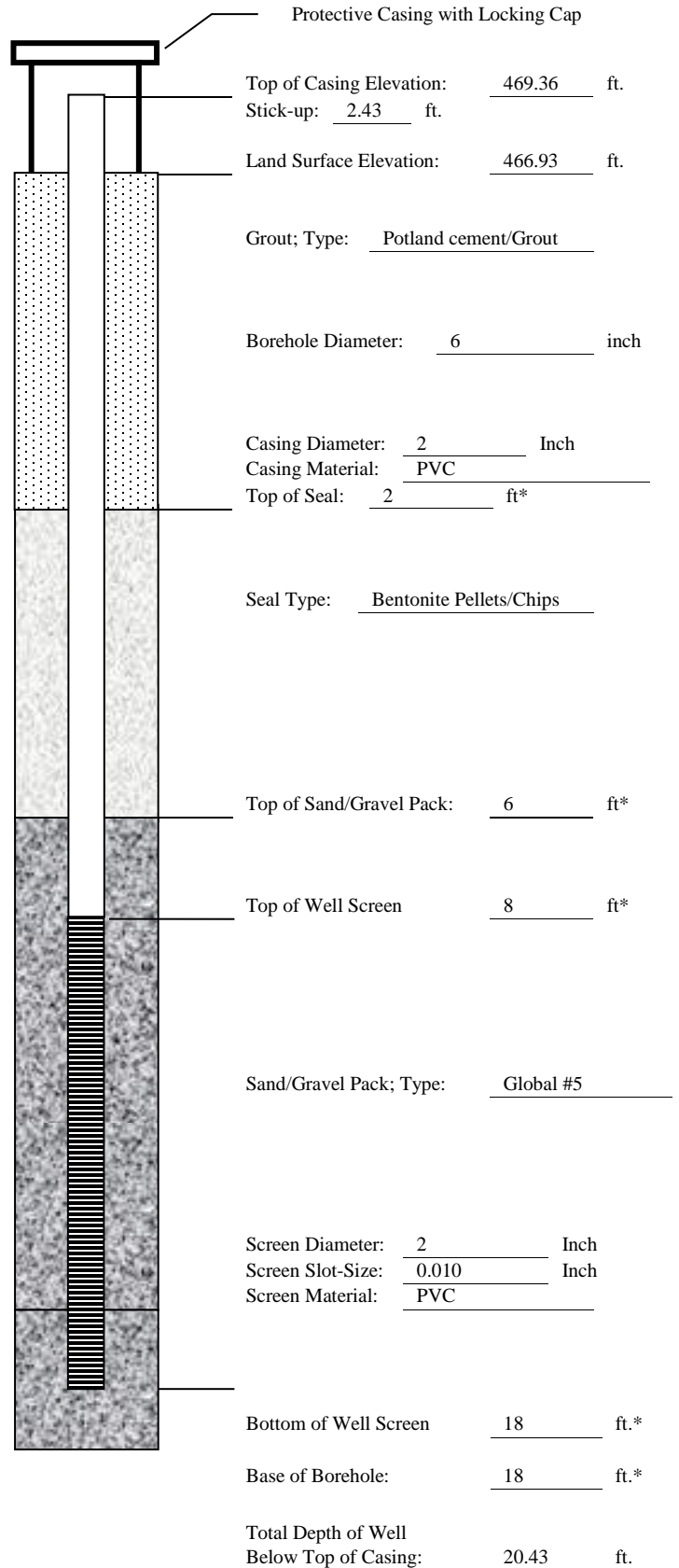
Drilling Method: <u>Roto-Sonic</u>	Coring Device Size: <u>NA</u>	Hammer Wt. <u>NA</u>	and Drop <u>NA</u>
Sampling Method: <u>NA</u>	Borehole Diameter: <u>6"</u>	Drilling Fluid Used: <u>Water</u>	
Sampling Interval: <u>NA</u>	Borehole Depth: <u>18'</u>	Surface Elevation: <u>466.93' MSL</u>	

NOTES/COMMENTS: _____

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-10	8	NA	Yellow brown silty clay, stiff, plastic, moist	N/A
10-18	8	NA	10'-15' Yellow brown silty clay, stiff, plastic, moist; 12'-14' wet; 15'-18' Light gray limestone	N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A

WELL CONSTRUCTION LOG
WELL NO. WBSP-15-01

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – West Boiler Slag Pond</u>
Installation Date(s):	<u>11/30/15</u>
Drilling Method:	<u>Roto-Sonic</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>12/16/15</u>
Development Method:	<u>Submersible Pump, Peristaltic Pump, Bailer</u>
<u>Field parameters stabilized. Turbidity = 3.12 NTUs</u>	
Volume Purged:	<u>33 gallons</u>
Static Water-Level*:	<u>16.76'</u>
Top of Well Casing Elevation:	<u>469.36'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>449072.27</u>
Easting (X):	<u>566322.12</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Michael Gelles</u>



- CONSTRUCTION MATERIALS USED:**
- 4 Bags of Sand
 - 2 Bags/Buckets Bentonite Pellets
 - Bags Portland for Grout
 - Bags Concrete/Sakrete

*Indicates Depth Below Land Surface

BORING NO. W BSP-15-02
SAMPLE/CORE LOG

Project Number: <u>2015067</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek Plant West Boiler Slag Pond</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>11/11/15</u>	AGES Geologist: <u>Mike Gelles</u>

Drilling Method: <u>Roto-Sonic</u>	Coring Device Size: <u>NA</u>	Hammer Wt. <u>NA</u>	and Drop <u>NA</u>
Sampling Method: <u>NA</u>	Borehole Diameter: <u>6"</u>	Drilling Fluid Used: <u>Water</u>	
Sampling Interval: <u>NA</u>	Borehole Depth: <u>21'</u>	Surface Elevation: <u>473.83' MSL</u>	

NOTES/COMMENTS: _____

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-10	5	NA	Red brown silt, fine sand, black boiler slag, loose, moist	N/A
10-20	8	NA	10'-11' Red brown silt, fine sand, black boiler slag, loose, moist; 11'-19' light brown silty clay, stiff, moist; 19'-20' light brown silty clay, stiff, rock fragments, moist	N/A
20-21	1	NA	Gray limestone	N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A

WELL CONSTRUCTION LOG

WELL NO. WBSP-15-02

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – West Boiler Slag Pond</u>
Installation Date(s):	<u>11/11/15</u>
Drilling Method:	<u>Roto-Sonic</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>12/7/15</u>
Development Method:	<u>Submersible Pump, Peristaltic Pump, Bailer</u>
<u>Field parameters stabilized. Turbidity = 3.69 NTUs</u>	
Volume Purged:	<u>114.5 gallons</u>
Static Water-Level*:	<u>15.40'</u>
Top of Well Casing Elevation:	<u>476.76'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>449803.91</u>
Easting (X):	<u>566987.30</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>5 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Michael Gelles</u>

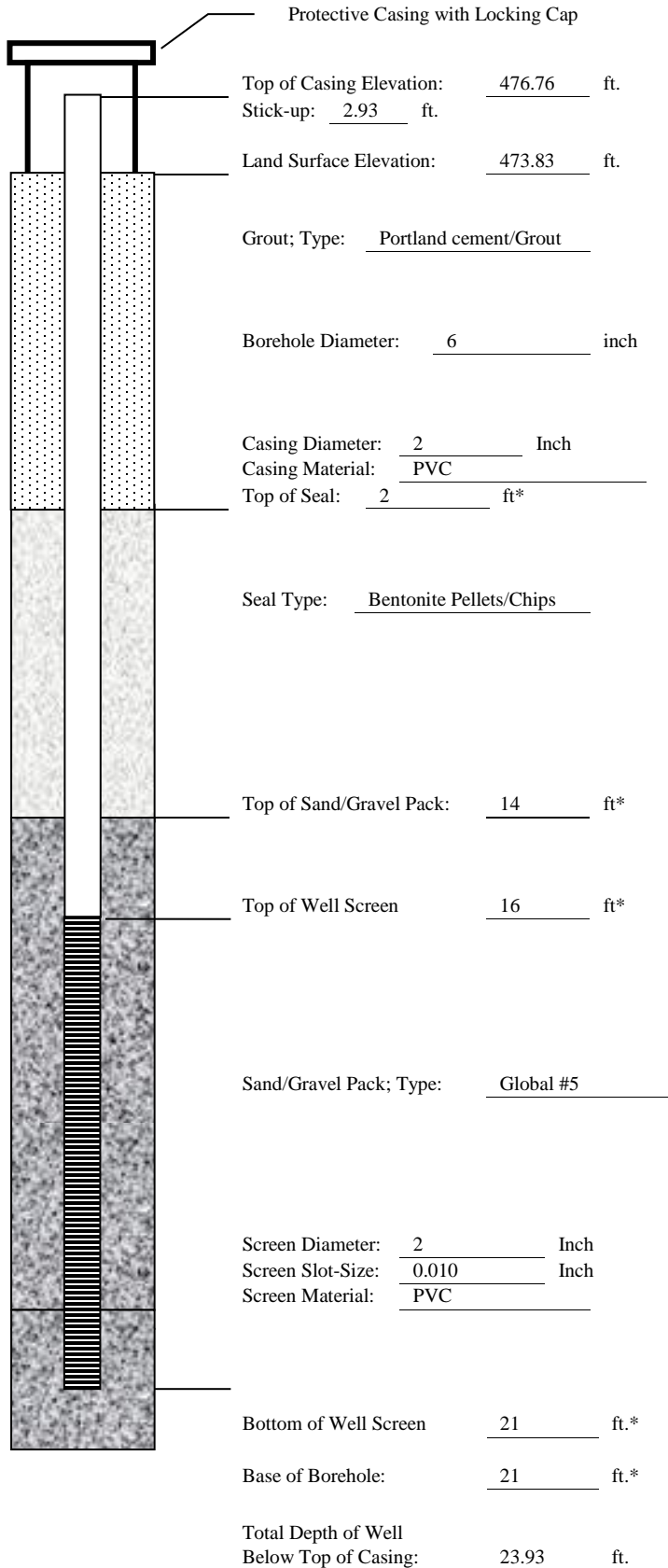
CONSTRUCTION MATERIALS USED:

3 Bags of Sand

4 Bags/Buckets Bentonite Pellets

_____ Bags Portland for Grout

_____ Bags Concrete/Sakrete



*Indicates Depth Below Land Surface

BORING NO. **WBSP-15-03**
SAMPLE/CORE LOG

Project Number: <u>2015067</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek Plant</u> <u>West Boiler Slag Pond</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>12/4/15</u>	AGES Geologist: <u>Mike Gelles</u>
Drilling Method: <u>Roto-Sonic</u> Coring Device Size: <u>NA</u> Hammer Wt. <u>NA</u> and Drop <u>NA</u>	
Sampling Method: <u>NA</u> Borehole Diameter: <u>6"</u> Drilling Fluid Used: <u>Water</u>	
Sampling Interval: <u>NA</u> Borehole Depth: <u>18'</u> Surface Elevation: <u>484.91' MSL</u>	
NOTES/COMMENTS: _____ _____	

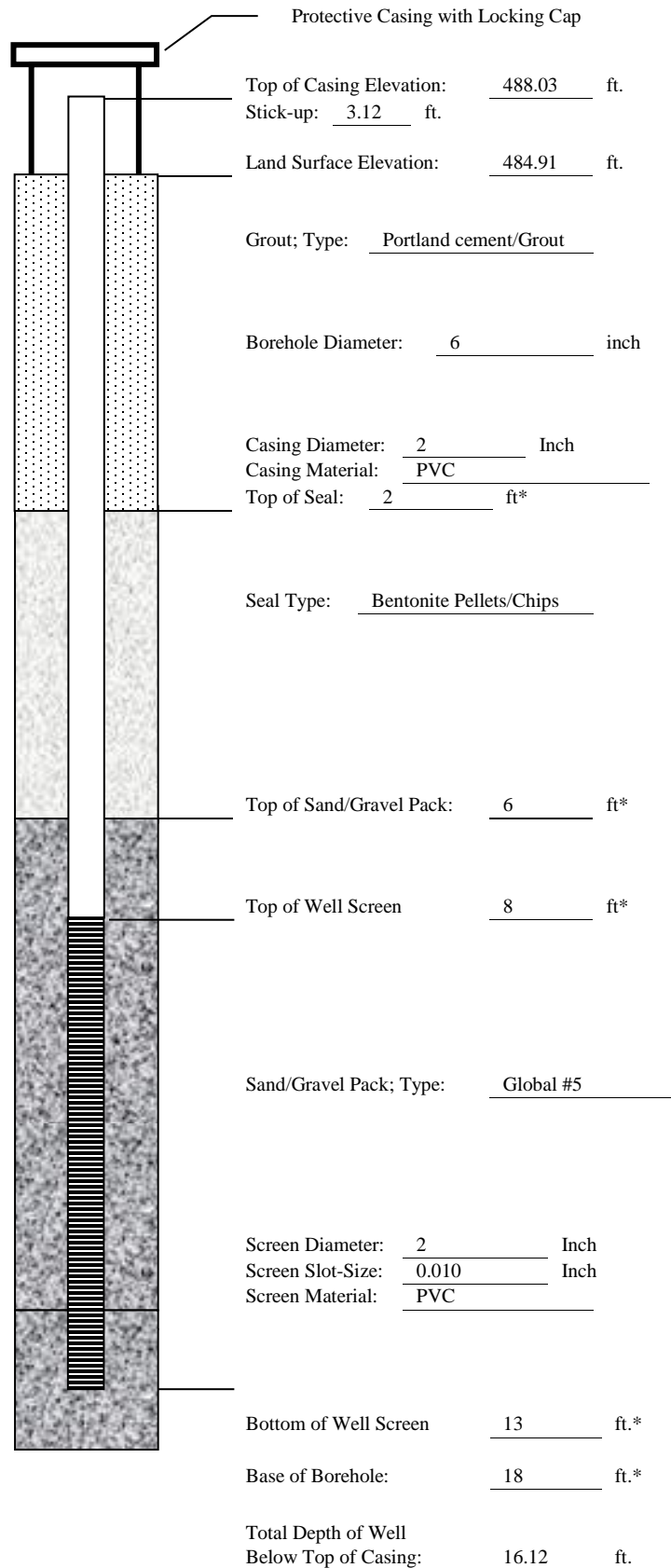
Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-10	2	NA	Brown silty clay, black boiler slag, limestone fragments, stiff, plastic, moist	N/A
10-18	8	NA	10'-13' Brown silty clay, black boiler slag, limestone fragments, stiff, plastic, moist; 13'-18' Gray, limestone, weathered, dry	N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A

WELL CONSTRUCTION LOG

WELL NO. WBSP-15-03

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – West Boiler Slag Pond</u>
Installation Date(s):	<u>12/4/15</u>
Drilling Method:	<u>Roto-Sonic</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>12/15/15</u>
Development Method:	<u>Submersible Pump, Peristaltic Pump, Bailer</u>
<u>Field parameters stabilized. Turbidity = 2.42 NTUs</u>	
Volume Purged:	<u>14.5 gallons</u>
Static Water-Level*:	<u>11.08'</u>
Top of Well Casing Elevation:	<u>488.03'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>451181.98</u>
Easting (X):	<u>568093.60</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>5 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Michael Gelles</u>

CONSTRUCTION MATERIALS USED:	
<u>3</u>	<u>Bags of Sand</u>
<u>4</u>	<u>Bags/Buckets Bentonite Pellets</u>
<u> </u>	<u>Bags Portland for Grout</u>
<u> </u>	<u>Bags Concrete/Sakrete</u>



*Indicates Depth Below Land Surface

BORING NO. WBSP-15-04
SAMPLE/CORE LOG

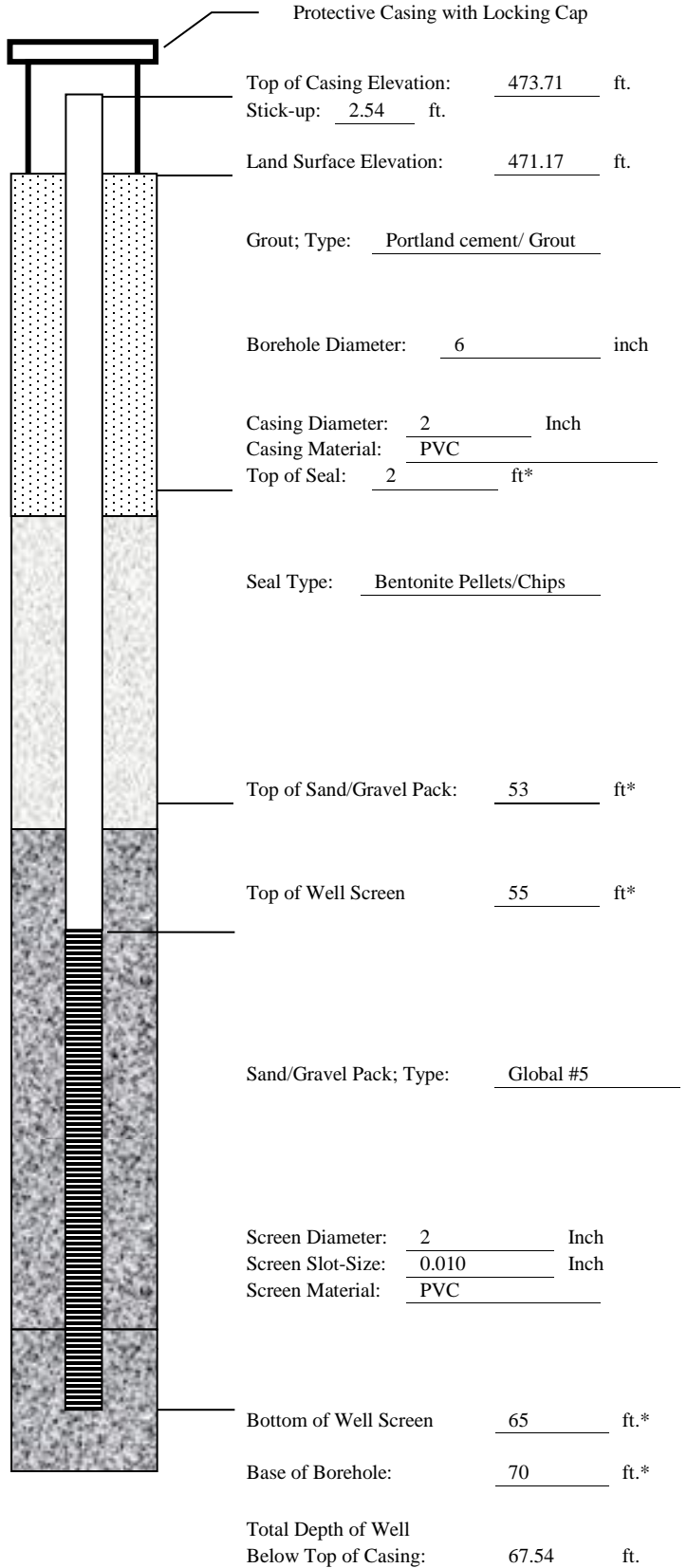
Project Number: <u>2015067</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek Plant West Boiler Slag Pond</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>11/11/15-11/12/15</u>	AGES Geologist: <u>Mike Gelles</u>
Drilling Method: <u>Roto-Sonic</u> Coring Device Size: <u>NA</u> Hammer Wt. <u>NA</u> and Drop <u>NA</u>	
Sampling Method: <u>NA</u> Borehole Diameter: <u>6"</u> Drilling Fluid Used: <u>Water</u>	
Sampling Interval: <u>NA</u> Borehole Depth: <u>70'</u> Surface Elevation: <u>471.17' MSL</u>	
NOTES/COMMENTS: _____ _____	

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-10	8	NA	Red brown silt, fine sand, boiler slag, loose, moist	N/A
10-20	8	NA	Red brown silt, fine sand, boiler slag, loose, moist	N/A
20-30	8	NA	20'-28' Red brown silt, fine sand, boiler slag, loose, moist; 28'-30' wet	N/A
30-40	7	NA	Red brown silt, fine sand, boiler slag, loose, wet	N/A
40-50	10	NA	40'-45' Red brown silt, fine sand, boiler slag, loose, wet; 45'-47' Yellow brown clay, stiff, plastic, moist; 47'-49' Yellow brown gravel angular, fine and medium sand, wet; 49'-50' Orange brown sandy clay, fine, stiff, moist	N/A
50-60	9	NA	50'-53' Orange brown sandy clay, fine, stiff, moist; 53' - 60' Light brown sand, fine, medium, coarse, gravel angular fine, medium, coarse, large, wet	N/A
60-70	7	NA	60'-68.5' Light brown sand, fine, medium, coarse, gravel angular fine, medium, coarse, wet; 68.5' -70' light brown sand, fine, medium, coarse, black coal and peat, wet	N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A

WELL CONSTRUCTION LOG
WELL NO. WBSP-15-04

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – West Boiler Slag Pond</u>
Installation Date(s):	<u>11/11/15-11/12/15</u>
Drilling Method:	<u>Roto-Sonic</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>12/9/15</u>
Development Method:	<u>Submersible Pump</u>
Field parameters stabilized.	
Turbidity = 0.91 NTUs	
Volume Purged:	<u>65 gallons</u>
Static Water-Level*	<u>50.68'</u>
Top of Well Casing Elevation:	<u>473.71'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>450610.07</u>
Easting (X):	<u>568637.65</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Michael Gelles</u>

CONSTRUCTION MATERIALS USED:	
<u>5</u>	Bags of Sand
<u>2</u>	Bags/Buckets Bentonite Pellets
<u>12</u>	Bags Portland for Grout
<u> </u>	Bags Concrete/Sakrete



*Indicates Depth Below Land Surface

BORING NO. WBSP-15-05
SAMPLE/CORE LOG

Project Number: <u>2015067</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek Plant West Boiler Slag Pond</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>11/13/15-11/17/15</u>	AGES Geologist: <u>John Campbell</u>
Drilling Method: <u>Roto-Sonic</u>	Coring Device Size: <u>NA</u> Hammer Wt. <u>NA</u> and Drop <u>NA</u>
Sampling Method: <u>NA</u>	Borehole Diameter: <u>6"</u> Drilling Fluid Used: <u>Water</u>
Sampling Interval: <u>NA</u>	Borehole Depth: <u>71'</u> Surface Elevation: <u>471.90' MSL</u>
NOTES/COMMENTS: _____ _____	

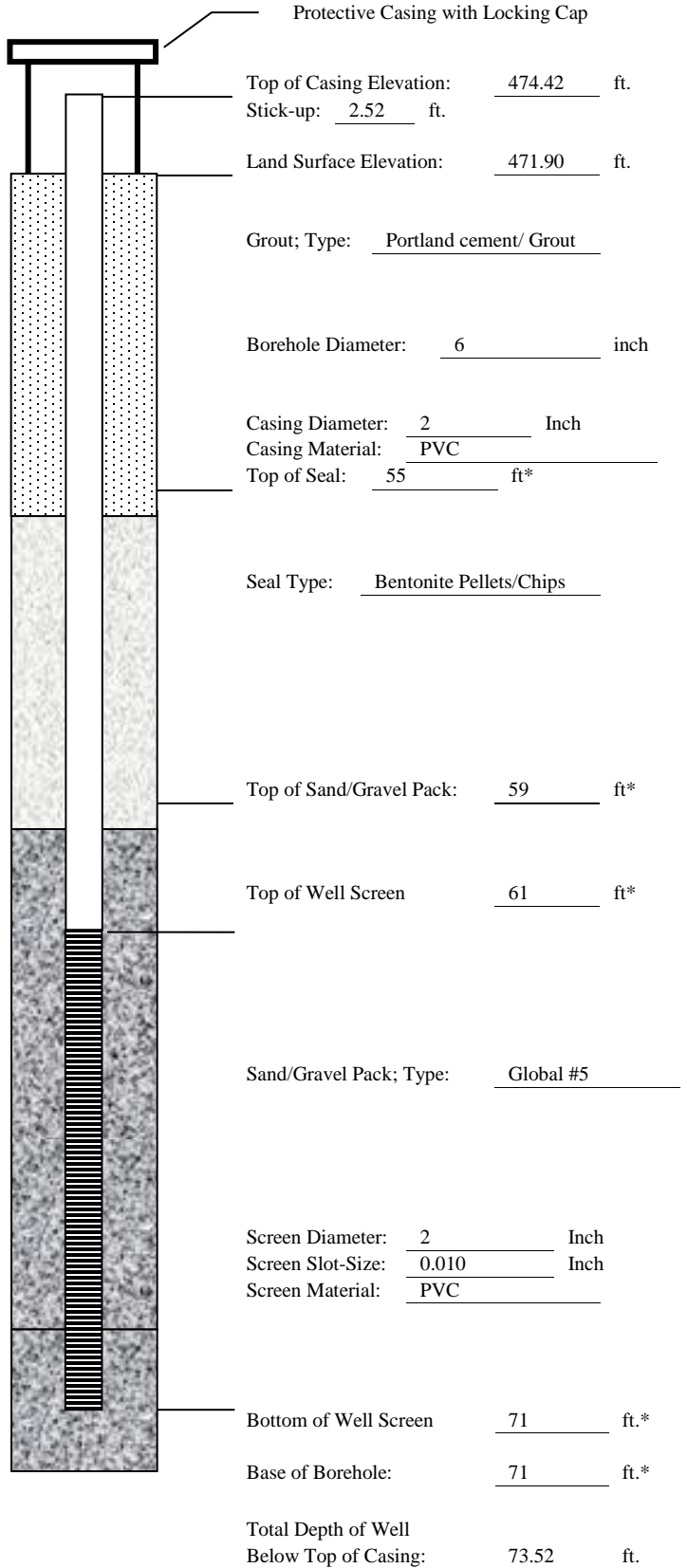
Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-10	8	NA	Red brown silt, fine sand, black boiler slag, loose, moist	N/A
10-20	8	NA	Red brown silt, fine sand, black boiler slag, loose, moist	N/A
20-30	6	NA	Red brown silt, fine sand, black boiler slag, loose, moist	N/A
30-40	5	NA	30'-33' Red brown silt, fine sand, black boiler slag, loose, moist; 33'-35' brown clay, wet, loose	N/A
40-50	8	NA	40'-45' Brown clay(till), plastic, moist; 45'-50' gray clay(till), plastic, moist	N/A
50-60	9	NA	50'-59' Gray silty clay(till); sand fine, medium, coarse, and gravel subrounded fine, medium, coarse, large, little silt, very moist	N/A
60-70	5	NA	Gray to brown sand fine, medium, coarse, and gravel subrounded fine, medium, coarse, large, little silt, wet	N/A
70-71	1	NA	Gray to brown sand fine, medium, coarse, and gravel subrounded fine, medium, coarse, large, little silt, wet	N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A

WELL CONSTRUCTION LOG

WELL NO. WBSP-15-05

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – West Boiler Slag Pond</u>
Installation Date(s):	<u>11/13/15-11/17/15</u>
Drilling Method:	<u>Roto-Sonic</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>12/16/15</u>
Development Method:	<u>Submersible Pump</u>
Field parameters stabilized.	
Turbidity = 4.28 NTUs	
Volume Purged:	<u>46 gallons</u>
Static Water-Level*:	<u>52.42'</u>
Top of Well Casing Elevation:	<u>474.42'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>450051.40</u>
Easting (X):	<u>568495.72</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>John Campbell</u>

CONSTRUCTION MATERIALS USED:	
<u>6</u>	Bags of Sand
<u>2</u>	Bags/Buckets Bentonite Pellets
<u>18</u>	Bags Portland for Grout
<u> </u>	Bags Concrete/Sakrete



*Indicates Depth Below Land Surface

BORING NO. WBSP-15-06
SAMPLE/CORE LOG

Project Number: <u>2015067</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek Plant West Boiler Slag Pond</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>11/18/15-11/19/15</u>	AGES Geologist: <u>John Campbell</u>
Drilling Method: <u>Roto-Sonic</u> Coring Device Size: <u>NA</u> Hammer Wt. <u>NA</u> and Drop <u>NA</u>	
Sampling Method: <u>NA</u> Borehole Diameter: <u>6"</u> Drilling Fluid Used: <u>Water</u>	
Sampling Interval: <u>NA</u> Borehole Depth: <u>90'</u> Surface Elevation: <u>471.28' MSL</u>	
NOTES/COMMENTS: _____ _____	

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-10	7	NA	Black boiler slag and ash, loose, fill	N/A
10-20	7	NA	Black boiler slag and ash, loose, fill	N/A
20-30	6	NA	Black boiler slag and ash, loose, fill; 27'-30' wet	N/A
30-40	6	NA	Black boiler slag and ash, loose, fill, 30'-34' wet; 34'-36' brown clay, some silt, hard, damp	N/A
40-50	10	NA	40'-48' Gray silty clay, soft, very moist, moist 7'-8'; brown silty clay, firm, damp	N/A
50-60	10	NA	Gray silty clay, firm to soft, moist to very moist	N/A
60-70	10	NA	60'-65' Gray silty clay, firm, moist to very moist; 65' - 70' Gray silt, clay, firm, wet	N/A
70-80	4	NA	70' - 72' Gray silty clay, firm, moist to very moist; 72' - 74' Gray silt, clay, firm, wet; 74'-76' Gray to brown sand fine, medium, coarse, large and gravel subrounded fine, medium, coarse, large, wet	N/A
80-90	9	NA	80'-88' Gray to brown sand fine, medium, coarse, large and gravel subrounded fine, medium, coarse, large, wet; 88' - 89' Gray to brown sand fine, medium, coarse, large to sand fine, medium, wet	N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A

WELL CONSTRUCTION LOG

WELL NO. WBSP-15-06

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – West Boiler Slag Pond</u>
Installation Date(s):	<u>11/18/15-11/19/15</u>
Drilling Method:	<u>Roto-Sonic</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>12/9/15</u>
Development Method:	<u>Submersible Pump</u>
Field parameters stabilized:	<u>Turbidity = 3.44 NTUs</u>
Volume Purged:	<u>100 gallons</u>
Static Water-Level*:	<u>51.55'</u>
Top of Well Casing Elevation:	<u>473.51'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>449470.57</u>
Easting (X):	<u>568402.50</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>John Campbell</u>

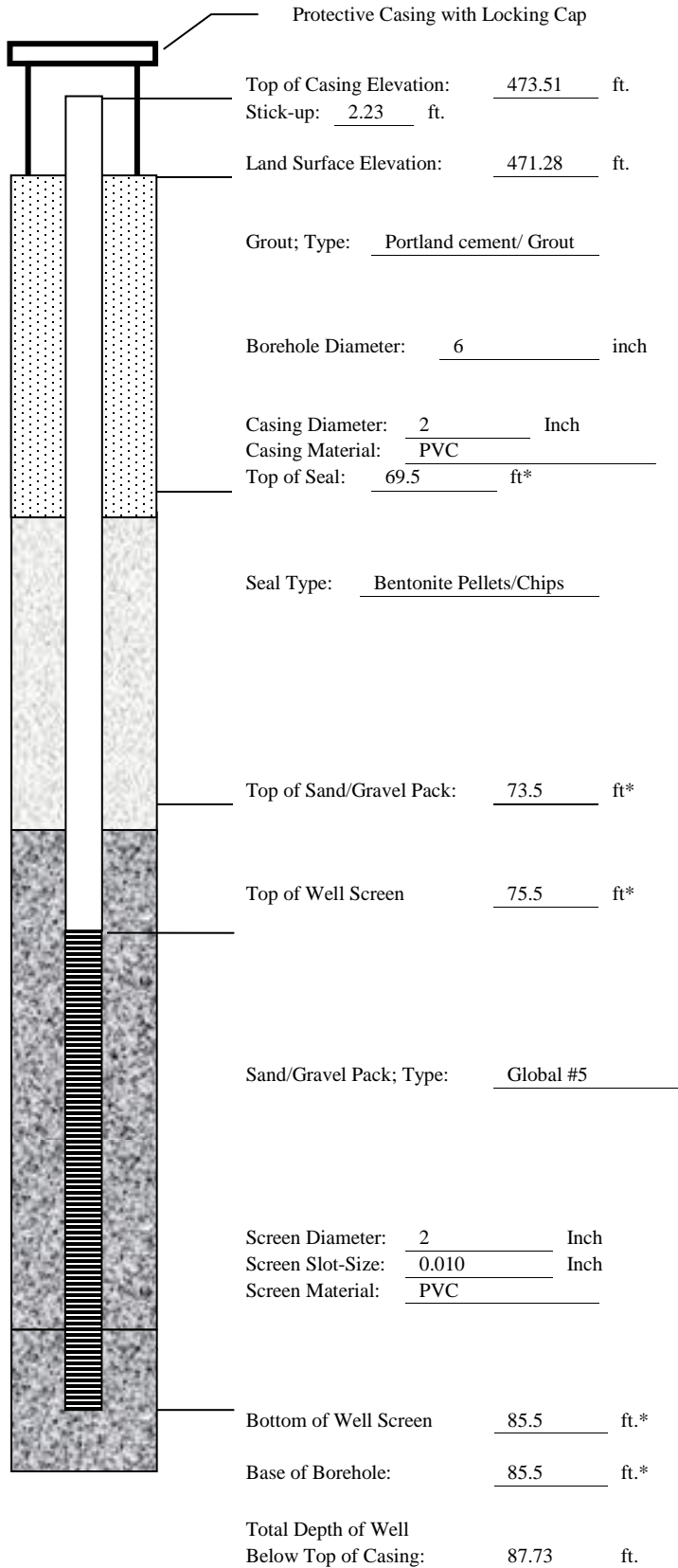
CONSTRUCTION MATERIALS USED:

6 Bags of Sand

2 Bags/Buckets Bentonite Pellets

12 Bags Portland for Grout

 Bags Concrete/Sakrete



Top of Casing Elevation: 473.51 ft.

Stick-up: 2.23 ft.

Land Surface Elevation: 471.28 ft.

Grout; Type: Portland cement/ Grout

Borehole Diameter: 6 inch

Casing Diameter: 2 Inch

Casing Material: PVC

Top of Seal: 69.5 ft*

Seal Type: Bentonite Pellets/Chips

Top of Sand/Gravel Pack: 73.5 ft*

Top of Well Screen 75.5 ft*

Sand/Gravel Pack; Type: Global #5

Screen Diameter: 2 Inch

Screen Slot-Size: 0.010 Inch

Screen Material: PVC

Bottom of Well Screen 85.5 ft.*

Base of Borehole: 85.5 ft.*

Total Depth of Well
Below Top of Casing: 87.73 ft.

*Indicates Depth Below Land Surface

BORING NO. WBSP-15-07
SAMPLE/CORE LOG

Project Number: <u>2015067</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek Plant West Boiler Slag Pond</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>11/20/15-11/23/15</u>	AGES Geologist: <u>John Campbell</u>
Drilling Method: <u>Roto-Sonic</u> Coring Device Size: <u>NA</u> Hammer Wt. <u>NA</u> and Drop <u>NA</u>	
Sampling Method: <u>NA</u> Borehole Diameter: <u>6"</u> Drilling Fluid Used: <u>Water</u>	
Sampling Interval: <u>NA</u> Borehole Depth: <u>90'</u> Surface Elevation: <u>468.82' MSL</u>	
NOTES/COMMENTS: _____ _____	

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-10	10	NA	Silty clay, some sand, some fine gravel, dense, hard, slightly moist. fill	N/A
10-20	8.5	NA	Brown silty clay, sand and gravel, gray 13'-14.5', moist to very moist	N/A
20-30	10	NA	20'-28' Brown with gray silty clay, moist; 28'-30' brown silty clay, some gravel, trace sand, very moist to wet	N/A
30-40	10	NA	30'-34' Gray silt, well compacted, damp; 34'-40' brown silty clay, very hard, damp	N/A
40-50	10	NA	40'-48' Gray silt, some very fine sand lenses, some clay; 48'-50' gray silt, clay, moist	N/A
50-60	10	NA	50'-58' Gray silt, clay, moist; 58'-60' yellow brown silty clay, moist	N/A
60-70	10	NA	60'-64' Gray silt, some sand lenses, some clay; 64'-70' gray silty clay, some roots and organic matter, firm	N/A
70-80	9	NA	70'-78' Gray silty clay, some roots and organic matter, firm; 78'-80' Gray silt, some sand lenses, some clay, wet	N/A
80-90	9	NA	80'-83' Gray sandy silty, clay, wet; 83'-86' gray silty clay, hard, moist; 86'-90' gray sand, silt, wood, wet	N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A

WELL CONSTRUCTION LOG

WELL NO. WBSP-15-07

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – West Boiler Slag Pond</u>
Installation Date(s):	<u>11/20/15-11/23/15</u>
Drilling Method:	<u>Roto-Sonic</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>12/16/15</u>
Development Method:	<u>Submersible Pump</u>
Field parameters stabilized.	
Turbidity = 2.86 NTUs	
Volume Purged:	<u>35.5 gallons</u>
Static Water-Level*:	<u>41.01'</u>
Top of Well Casing Elevation:	<u>471.31'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>448947.93</u>
Easting (X):	<u>567946.39</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>John Campbell</u>

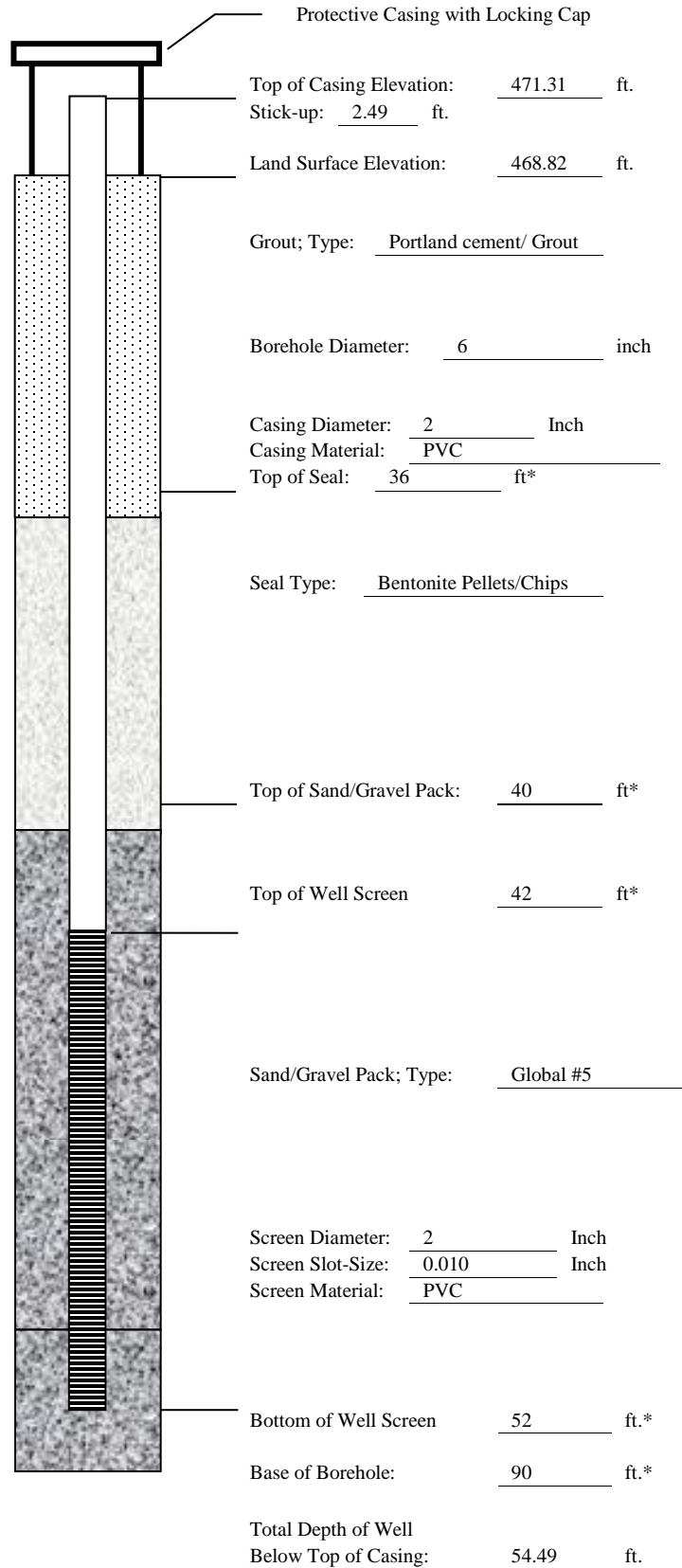
CONSTRUCTION MATERIALS USED:

6 Bags of Sand

14 Bags/Buckets Bentonite Pellets

12 Bags Portland for Grout

 Bags Concrete/Sakrete



*Indicates Depth Below Land Surface

BORING NO. WBSP-15-08
SAMPLE/CORE LOG

Project Number: <u>2015067</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek Plant West Boiler Slag Pond</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>11/24/15-11/25/15</u>	AGES Geologist: <u>John Campbell</u>
Drilling Method: <u>Roto-Sonic</u> Coring Device Size: <u>NA</u> Hammer Wt. <u>NA</u> and Drop <u>NA</u>	
Sampling Method: <u>NA</u> Borehole Diameter: <u>6"</u> Drilling Fluid Used: <u>Water</u>	
Sampling Interval: <u>NA</u> Borehole Depth: <u>80'</u> Surface Elevation: <u>468.56' MSL</u>	
NOTES/COMMENTS: _____ _____	

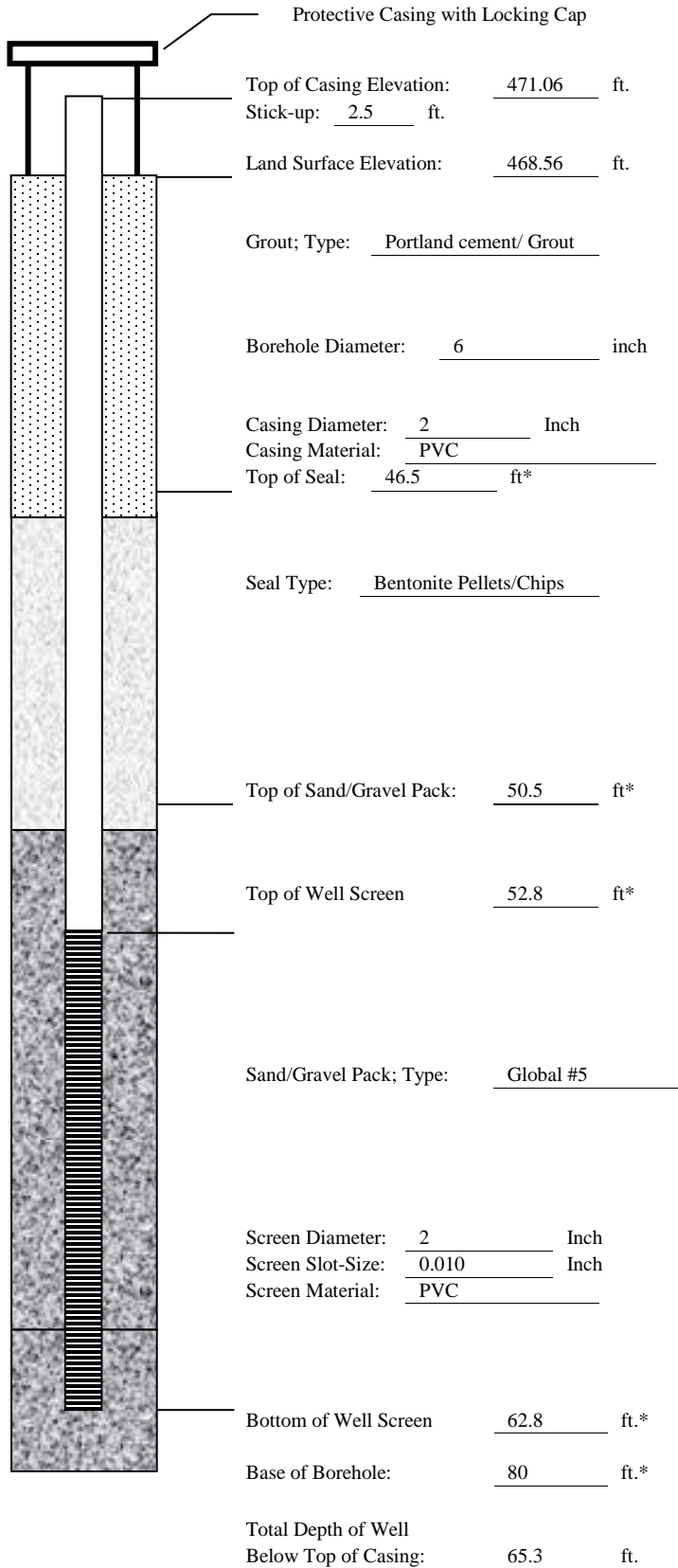
Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-10	8	NA	Brown silty clay, some sand and gravel, damp, fill	N/A
10-20	9	NA	Brown silty clay, firm, damp to moist	N/A
20-30	7	NA	Brown silty clay, firm, moist	N/A
30-40	10	NA	30'-37' Brown silty clay, firm, moist; 37'-40' gray clay, stiff, slightly plastic, very moist	N/A
40-50	9	NA	40'-44.5' Gray clay, stiff, slightly plastic, very moist; 44.5'-50' Gray silt, clay, some very fine sand, wet	N/A
50-60	10	NA	50'-59' Gray silt, clay, some very fine sand, wet; 59'-60' gray silty clay, moist	N/A
60-70	8.5	NA	Gray silty and silty clay lenses intermittent, wet	N/A
70-80	9	NA	70'-76' Gray silty and silty clay lenses intermittent, wet; 76'-79' gray silty clay, firm, moist	N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A
				N/A

WELL CONSTRUCTION LOG

WELL NO. WBSP-15-08

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – West Boiler Slag Pond</u>
Installation Date(s):	<u>11/24/15-11/25/15</u>
Drilling Method:	<u>Roto-Sonic</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>12/16/15</u>
Development Method:	<u>Submersible Pump</u>
Field parameters stabilized.	
Turbidity = 4.96 NTUs	
Volume Purged:	<u>89.5 gallons</u>
Static Water-Level*:	<u>37.02'</u>
Top of Well Casing Elevation:	<u>471.06'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>448625.46</u>
Easting (X):	<u>567343.24</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>John Campbell</u>

CONSTRUCTION MATERIALS USED:	
<u>8</u>	Bags of Sand
<u>4</u>	Bags/Buckets Bentonite Pellets
<u>12</u>	Bags Portland for Grout
<u> </u>	Bags Concrete/Sakrete



*Indicates Depth Below Land Surface

BORING NO. WBSP-15-09
SAMPLE/CORE LOG

Project Number: <u>2015067</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek Plant West Boiler Slag Pond</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>1/5/16-1/6/16</u>	AGES Geologist: <u>Mike Gelles</u>
Drilling Method: <u>HSA</u>	Coring Device Size: <u>NA</u> Hammer Wt. <u>160lb.</u> and Drop <u>2ft</u>
Sampling Method: <u>NA</u>	Borehole Diameter: <u>4.25"</u> Drilling Fluid Used: <u>Water</u>
Sampling Interval: <u>NA</u>	Borehole Depth: <u>60'</u> Surface Elevation: <u>471.21' MSL</u>
NOTES/COMMENTS: _____ _____	

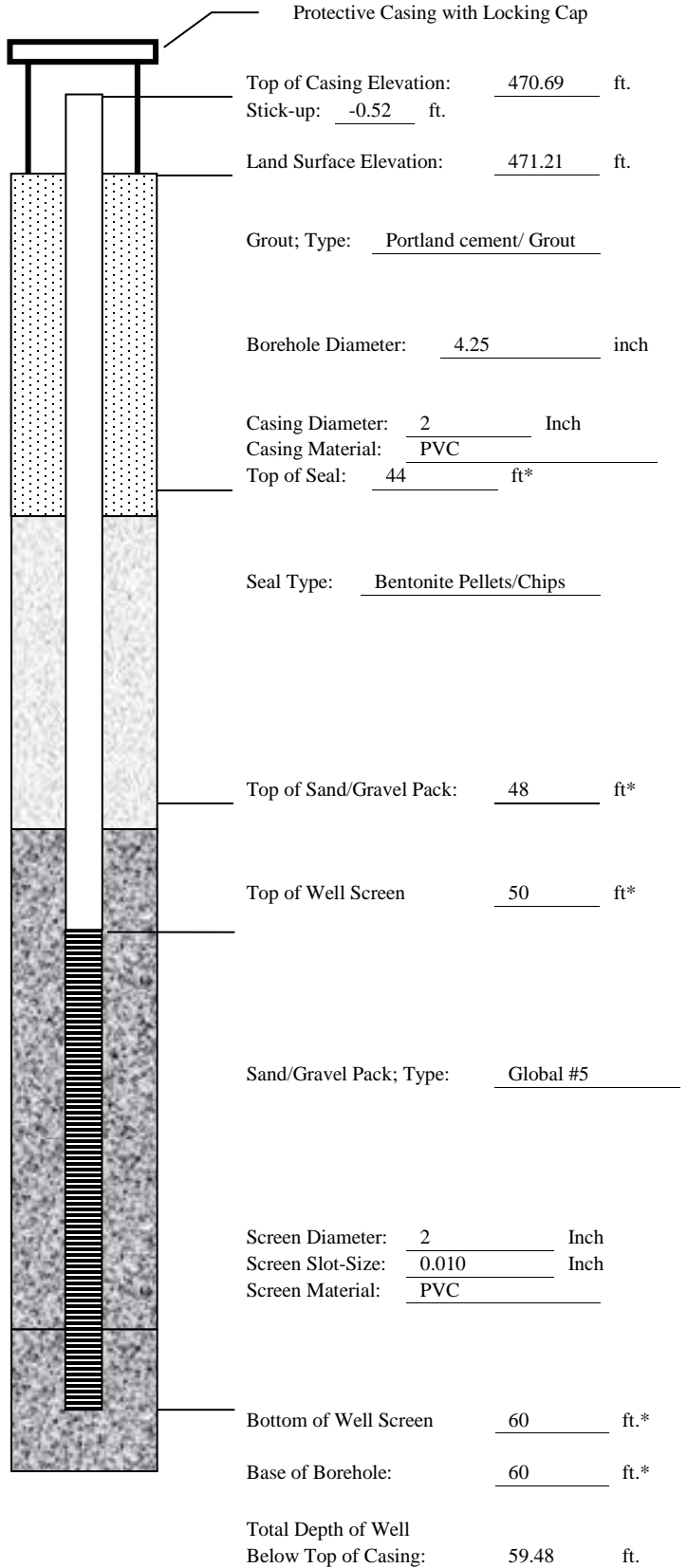
Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-30			Advance augers – no samples	N/A
30-32	1	4-5-7-8	Orange brown silty clay, trace fine sand, stiff, moist	N/A
32-34	1.2	3-6-8-9	Orange brown silty clay, trace fine sand, stiff, moist	N/A
34-36	1.8	3-5-8-7	Orange brown silty clay, trace fine sand, stiff, moist	N/A
36-38	1	2-3-5-7	Orange brown silty clay, trace fine sand, stiff, moist	N/A
38-40	1.6	2-3-4-6	Orange brown silty clay, trace fine sand, stiff, moist	N/A
40-42	1.5	3-3-5-6	Orange brown silty clay, trace fine sand, stiff, moist; to gray last 8"	N/A
42-44	2	3-5-7-8	42'-43' Orange brown silty clay, trace fine sand, stiff, moist; 43'-44' Gray silty clay, stiff, moist	N/A
44-46	2	3-4-4-4	44'-44.5' Gray silty clay, stiff, moist; 44.5'-46' gray silty fine sand, moist	N/A
46-48	2	1-2-2-3	46'-46.5' Gray silty fine sand, moist; 46.5'-48' gray silty clay, fine sand, stiff, plastic, moist	N/A
48-50	2	3-4-4-4	48'-49' Gray silty clay, fine sand, stiff, plastic, moist; 49'-50' Orange brown sandy clay fine, stiff, wet	N/A
50-52	2	2-4-4-4	Gray brown sandy silt, fine sand seams, wet	N/A
52-54	2	2-2-3-5	Orange brown sandy silt, fine sand seams, wet	N/A
54-56	2	3-4-5-6	Gray brown sandy silt, fine sand seams, wet	N/A
56-58	2	2-2-2-2	Gray brown sandy silt, fine sand seams, wet	N/A
58-60	2	2-2-3-3	Gray brown sandy silt, fine sand seams, wet	N/A
				N/A

WELL CONSTRUCTION LOG
WELL NO. WBSP-15-09

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – West Boiler Slag Pond</u>
Installation Date(s):	<u>1/5/16-1/6/16</u>
Drilling Method:	<u>Hollow Stem Auger</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>1/19/16</u>
Development Method:	<u>Submersible Pump</u>
Field parameters stabilized.	
Turbidity = 3.57 NTUs	
Volume Purged:	<u>74.5 gallons</u>
Static Water-Level*	<u>38.52'</u>
Top of Well Casing Elevation:	<u>470.69'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>448359.31</u>
Easting (X):	<u>566711.13</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Michael Gelles</u>

CONSTRUCTION MATERIALS USED:

<u>7</u>	Bags of Sand
<u>2</u>	Bags/Buckets Bentonite Pellets
<u>10</u>	Bags Portland for Grout
<u> </u>	Bags Concrete/Sakrete



*Indicates Depth Below Land Surface

BORING NO. WBSP-15-10
SAMPLE/CORE LOG

Project Number: <u>2015067</u>	Log Page <u>1</u> of <u>1</u>
Project Location: <u>Clifty Creek Plant West Boiler Slag Pond</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>1/4/16-1/5/16</u>	AGES Geologist: <u>Mike Gelles</u>
Drilling Method: <u>HSA</u>	Coring Device Size: <u>NA</u> Hammer Wt. <u>160lb.</u> and Drop <u>2ft</u>
Sampling Method: <u>NA</u>	Borehole Diameter: <u>4.25"</u> Drilling Fluid Used: <u>Water</u>
Sampling Interval: <u>NA</u>	Borehole Depth: <u>56'</u> Surface Elevation: <u>471.21' MSL</u>
NOTES/COMMENTS: _____ _____	

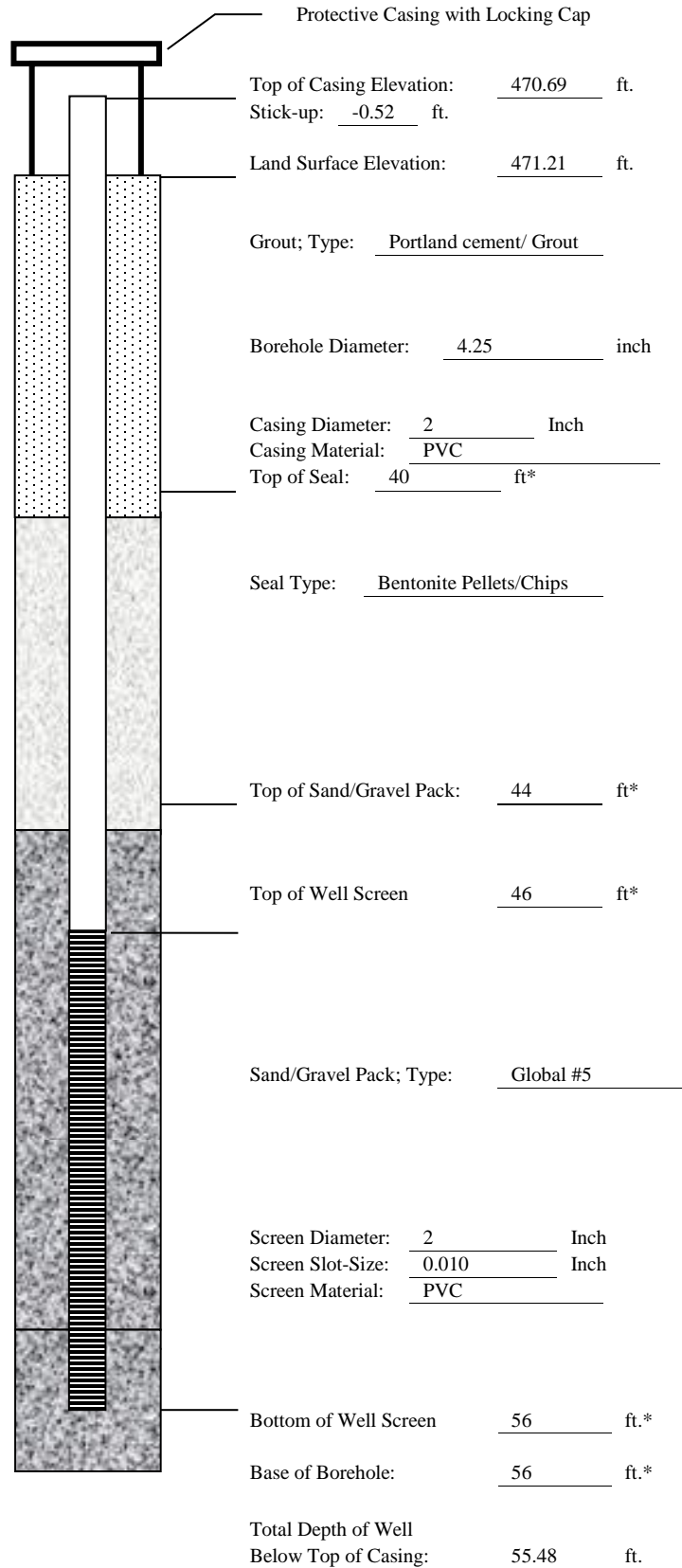
Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-30			Advance augers – no samples	N/A
30-32	1.5	4-8-10-11	Orange brown silty clay, trace fine sand, stiff, moist	N/A
32-34	2	4-7-9-12	Orange brown silty clay, trace fine sand, stiff, moist	N/A
34-36	1.5	4-8-10-10	Orange brown silty clay, trace fine sand, stiff, moist	N/A
36-38	1.6	4-4-5-7	36'-37' Orange brown silty clay, trace fine sand, stiff, moist; 37'-38' brown gray sandy silt, moist	N/A
38-40	2	3-3-4-4	Brown gray silty clay, stiff, moist	N/A
40-42	2	2-2-3-3	Brown gray silty clay, stiff, moist	N/A
42-44	2	2-2-3-3	Orange brown sandy clay, stiff, plastic, moist	N/A
44-46	2	1-1-2-1	Orange brown sandy clay, stiff, plastic, moist; with 3"-4" fine and medium sand seams, wet	N/A
46-48	2	1-1-1-2	Brown gray sandy clay, stiff, plastic, moist; fine and medium sand seams, wet	N/A
48-50	1	1-2-2-3	Brown gray silty clay, fine sand, wet	N/A
50-52	1.6	2-2-3-4	Brown gray silty clay, fine sand, wet	N/A
52-54	1	1-2-2-3	Brown gray silty clay, fine sand, wet	N/A
54-56	2	1-2-2-2	Brown gray silty clay, fine sand, wet	N/A
				N/A
				N/A
				N/A

WELL CONSTRUCTION LOG

WELL NO. WBSP-15-10

Project Number:	<u>2015067</u>
Project Location:	<u>Clifty Creek Plant – West Boiler Slag Pond</u>
Installation Date(s):	<u>1/4/16-1/5/16</u>
Drilling Method:	<u>Hollow Stem Auger</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>1/20/16</u>
Development Method:	<u>Submersible Pump</u>
Field parameters stabilized:	<u>Turbidity = 3.59 NTUs</u>
Volume Purged:	<u>58.5 gallons</u>
Static Water-Level*:	<u>39.28'</u>
Top of Well Casing Elevation:	<u>470.69'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>448125.51</u>
Easting (X):	<u>566225.21</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u> <u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Michael Gelles</u>

CONSTRUCTION MATERIALS USED:	
<u>8.5</u>	<u>Bags of Sand</u>
<u>2</u>	<u>Bags/Buckets Bentonite Pellets</u>
<u>10</u>	<u>Bags Portland for Grout</u>
<u> </u>	<u>Bags Concrete/Sakrete</u>



*Indicates Depth Below Land Surface

APPENDIX C

WELL DEVELOPMENT DATA

TABLE C-1
SUMMARY OF WELL DEVELOPMENT DATA
KYGER CREEK PLANT
GALLIA COUNTY, OHIO

Well/ Piezometer	Dates	Method	Volume (gal)	Final Turbidity (NTU)
Type I Residual Waste Landfill and Landfill Runoff Collection Pond				
CF-15-04	12/9/2015	Pump	65	0.91
CF-15-05	12/09/2015 - 12/16/2015	Pump	46	4.28
CF-15-06	12/09/2015 - 12/18/2016	Pump/Bail	21	9.59
CF-15-07	12/08/2015 - 12/15/2015	Pump/Bail	13	4.42
CF-15-08	12/8/2015	Pump	100	2.16
CF-15-09	12/08/2015 - 12/16/2015	Pump/Bail	6	3.21
West Boiler Slag Pond				
WBSP-15-01	12/03/2015 - 12/17/2015	Pump/Bail	23	70.8
WBSP-15-02	12/03/2015 - 12/15/2015	Pump	31.5	3.48
WBSP-15-03	12/09/2015 - 12/15/2015	Pump/Bail	15	2.42
WBSP-15-04	12/02/2015 - 12/08/2015	Pump	110	1.37
WBSP-15-05	12/02/2015 - 12/03/2015	Pump	130	1.87
WBSP-15-06	12/03/2015 - 12/09/2015	Pump	100	3.44
WBSP-15-07	12/02/2015 - 12/16/2015	Pump/Bail	36	2.86
WBSP-15-08	12/02/2015 - 12/16/2015	Pump	90	4.96
WBSP-15-09	1/08/2016 - 1/19/2016	Pump	59	3.57
WBSP-15-10	1/07/2016 - 1/20/2016	Pump	33	3.59

APPENDIX D

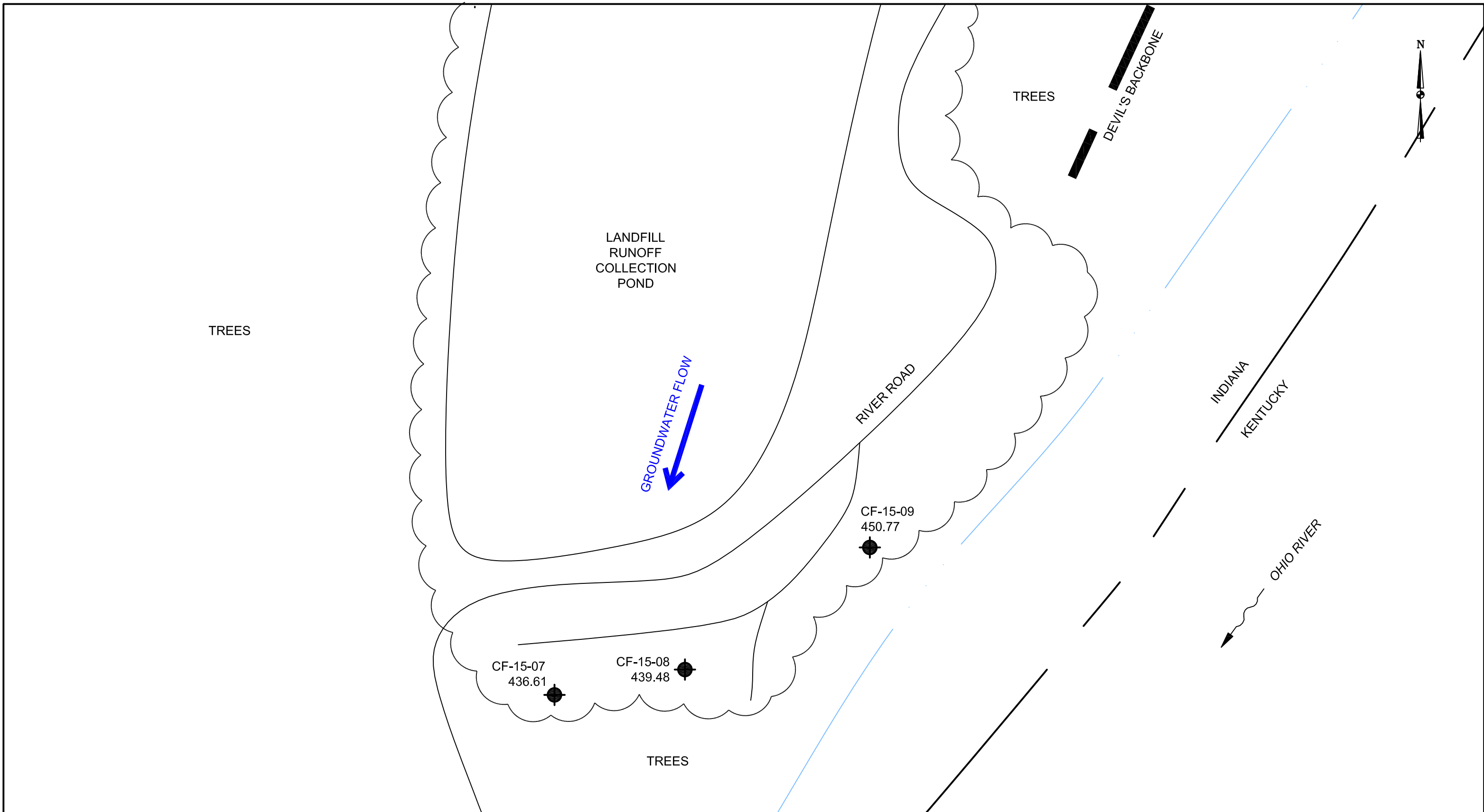
**GROUNDWATER LEVELS
January 2016 through May 2016**



TABLE D-1
CLIFTY CREEK CREEK PLANT
SUMMARY OF GROUNDWATER ELEVATION DATA
JANUARY 2016 - MAY 2016

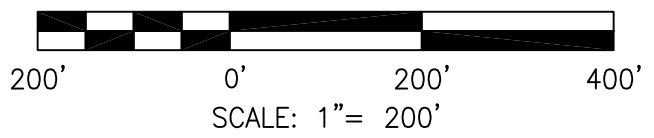
Monitoring Well Designation	Jan-16 Groundwater Elevation (ft)	Mar-16 Groundwater Elevation (ft)	May-16 Groundwater Elevation (ft)
LANDFILL AND LANDFILL RUNOFF COLLECTION POND			
CF-15-04	439.83	441.19	441.27
CF-15-05	438.68	439.86	436.25
CF-15-06	432.27	437.12	429.22
CF-15-07	436.61	438.08	437.48
CF-15-08	439.48	440.54	440.88
CF-15-09	450.77	451.58	450.69
WEST BOILER SLAG POND			
WBSP-15-01	451.72	453.01	453.27
WBSP-15-02	468.31	472.52	471.52
WBSP-15-03	477.03	477.11	477.62
WBSP-15-04	429.22	436.25	424.96
WBSP-15-05	428.95	436.12	424.84
WBSP-15-06	428.82	436.06	424.77
WBSP-15-07	429.72	430.41	430.88
WBSP-15-08	434.03	434.62	434.81
WBSP-15-09	432.17	430.39	432.21
WBSP-15-10	431.41	433.28	432.58

APPENDIX E


GROUNDWATER CONTOUR MAPS
January 2016 through May 2016



LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION

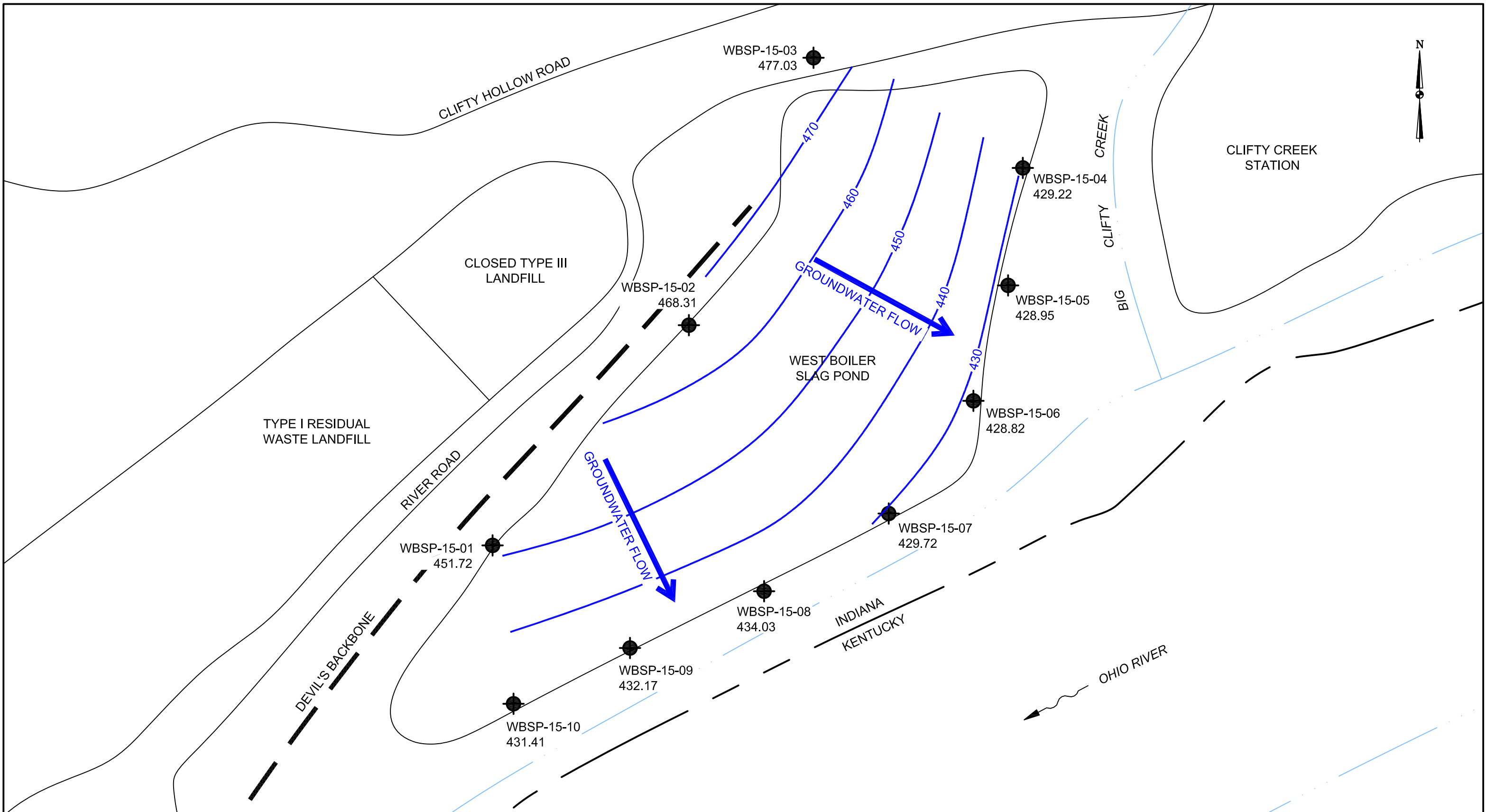


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CHECKED BY	
JOB NO.	2015067-CLI
DWG. FILE	IKEC_Clifty MW Install_Appx E_Jan16 b08.dwg
DRAWING SCALE	AS SHOWN

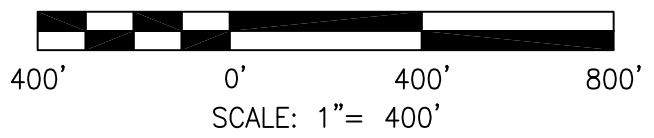


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 412.264.6453

INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND GROUNDWATER LEVELS & FLOW DIRECTION-JANUARY 2016	
DRAWING NAME	FIGURE E-1
REV.	0



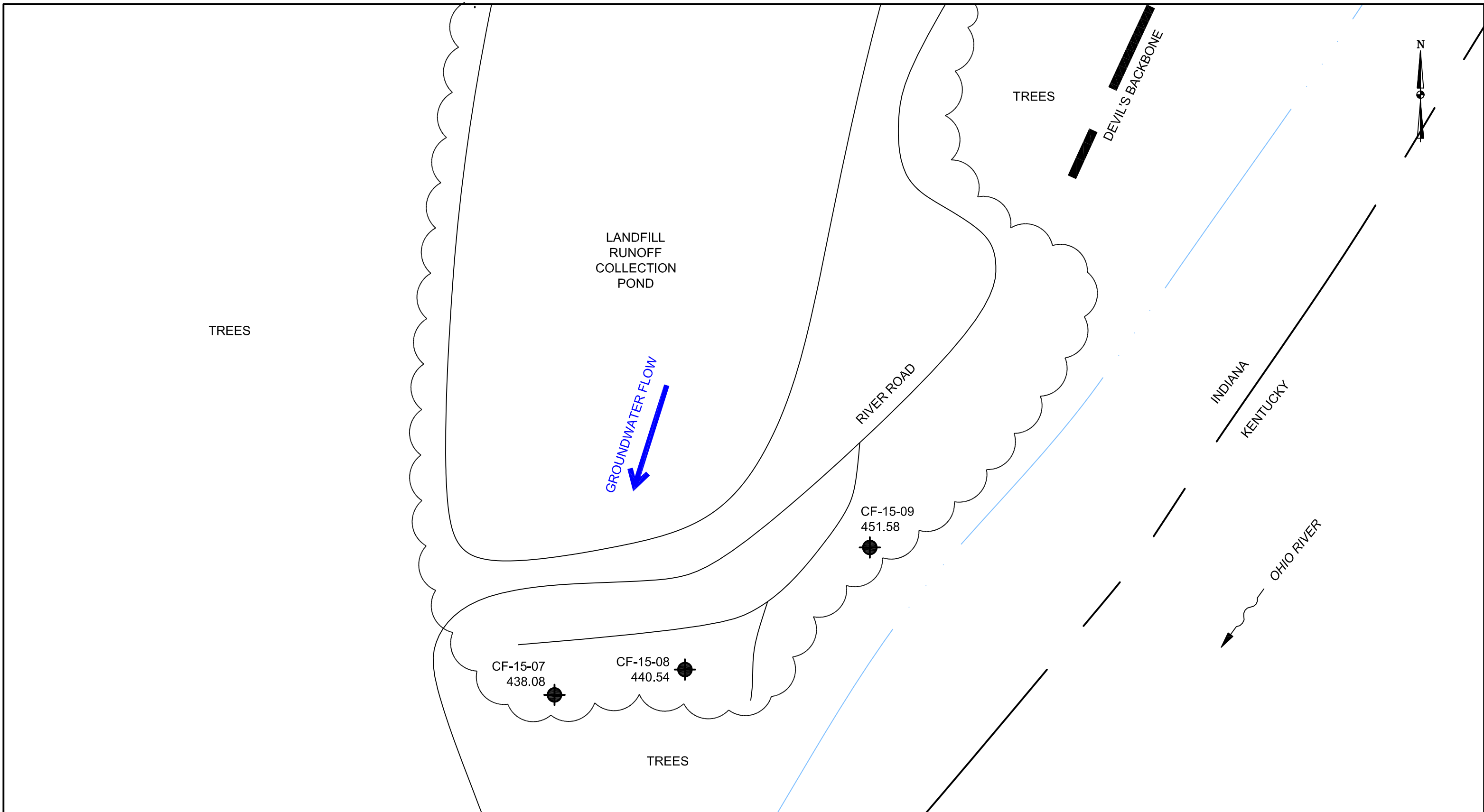
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION





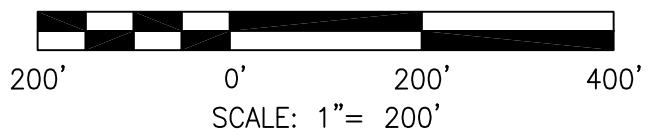
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DATE	
CHECKED BY	
JOB NO.	2015067-CLI
DWG. FILE	IKEC_Clifty MW Install_Appx E_Jan16 b08.dwg
DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS & FLOW DIRECTION-JANUARY 2016	
DRAWING NAME	FIGURE E-2
REV.	0



LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION

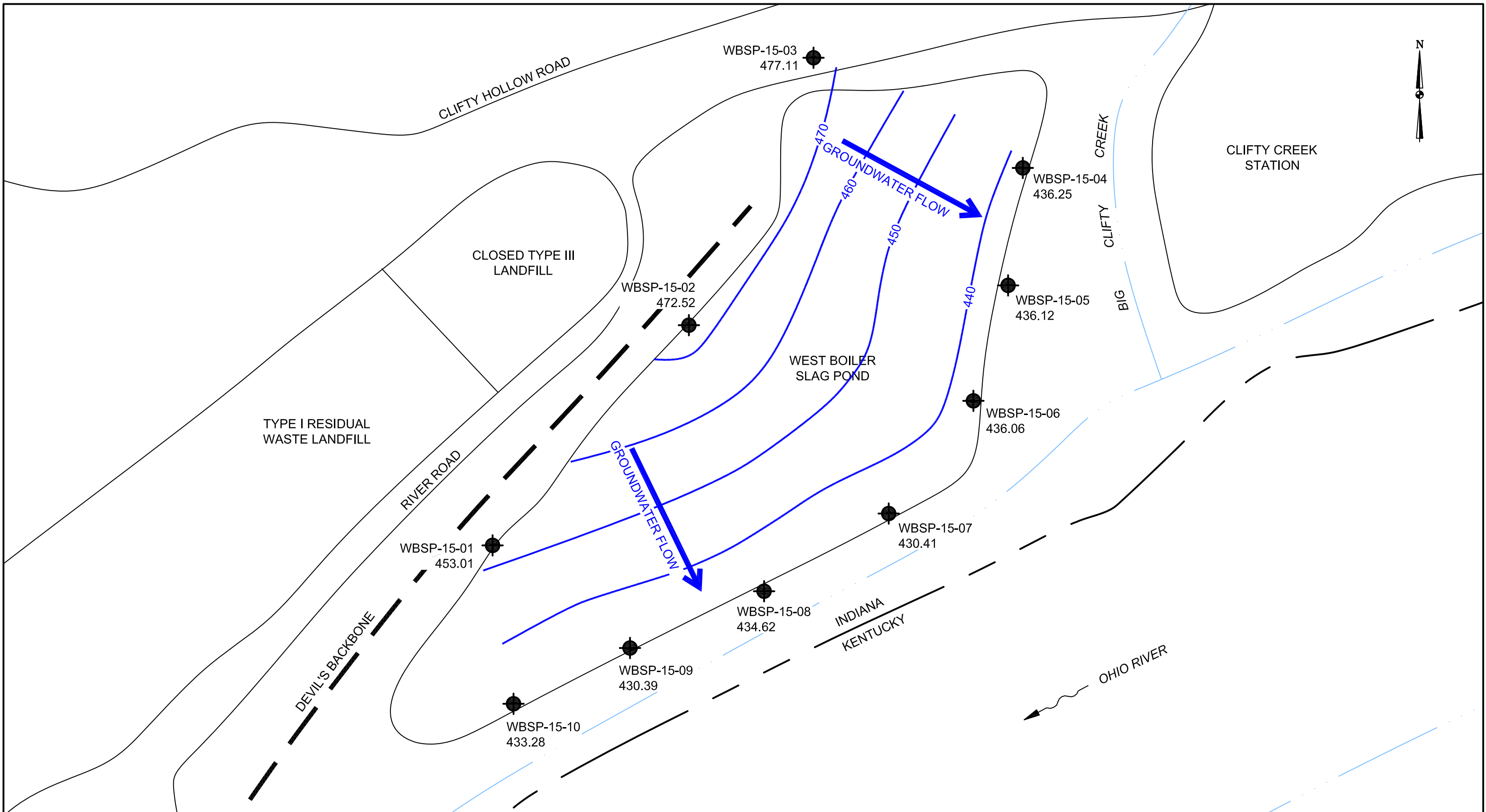


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DATE	
CHECKED BY	
JOB NO.	2015067-CLI
DWG. FILE	IKEC_Clifty MW Install_Appx E_Mar16 b09.dwg
DRAWING SCALE	AS SHOWN

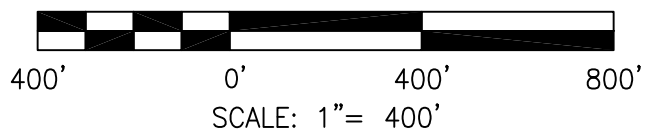


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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND GROUNDWATER LEVELS & FLOW DIRECTION-MARCH 2016	
DRAWING NAME	FIGURE E-3
REV.	0



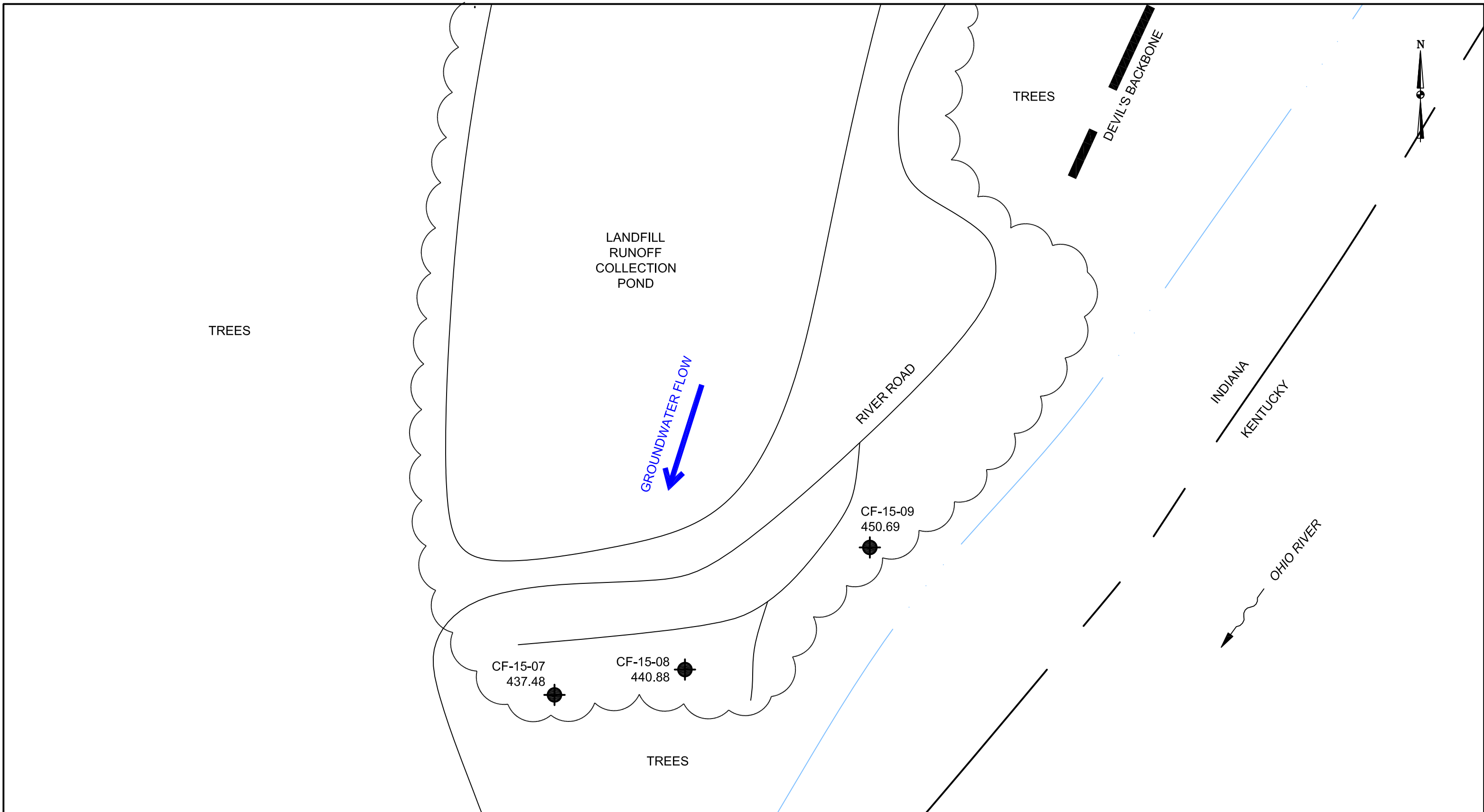
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION





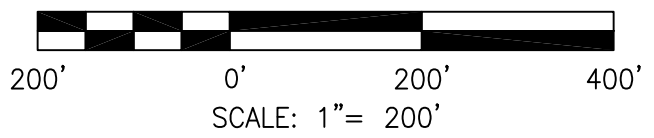
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JOB NO.	2015067-CLI
DWG. FILE	IKEC_Clifty MW Install_Appx E_Mar16 b09.dwg
DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS & FLOW DIRECTION-MARCH 2016	
DRAWING NAME	FIGURE E-4
REV.	0



LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION

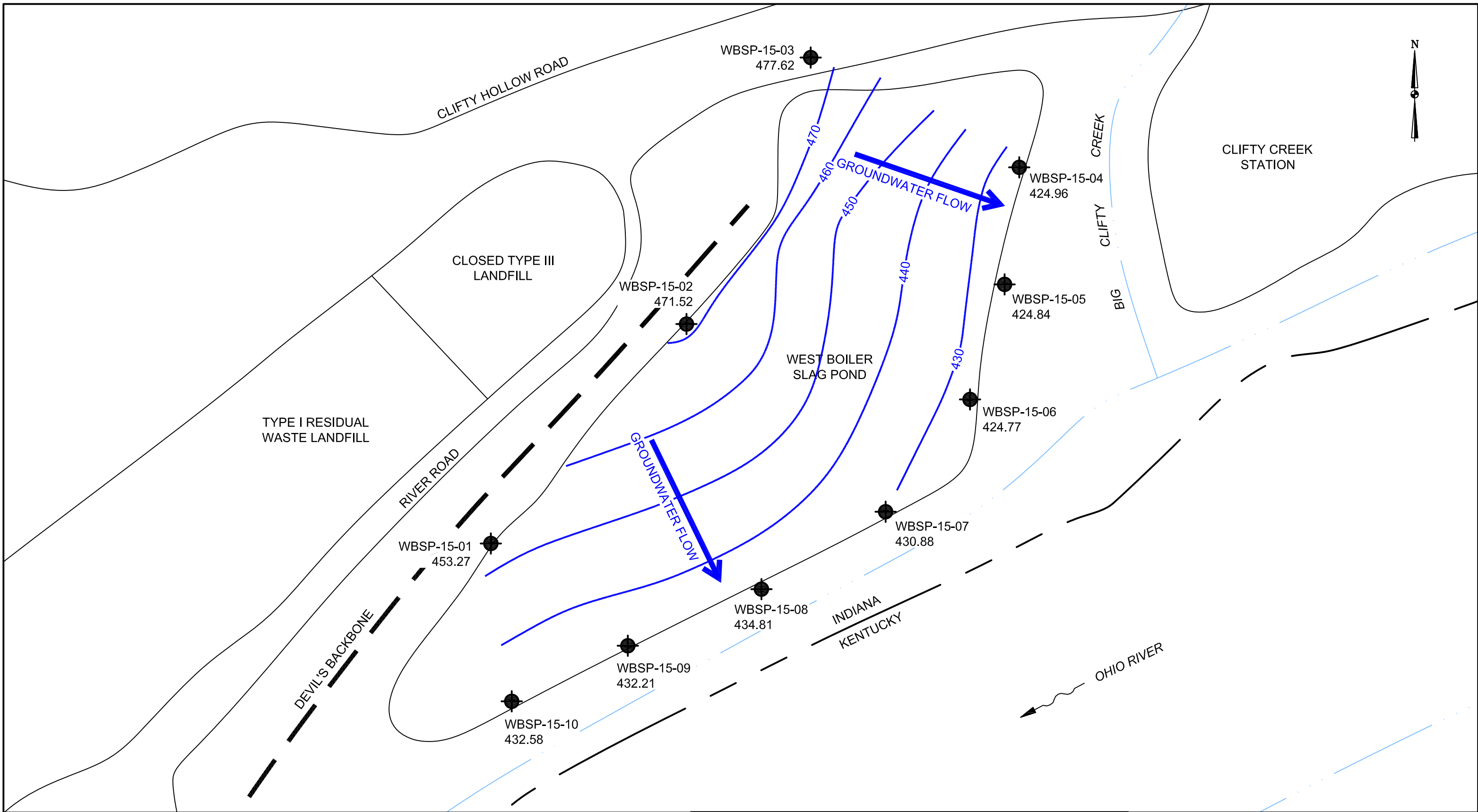


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CHECKED BY	
JOB NO.	2015067-CLI
DWG. FILE	IKEC_Clifty MW Install_Appx E_May16 b10.dwg
DRAWING SCALE	AS SHOWN

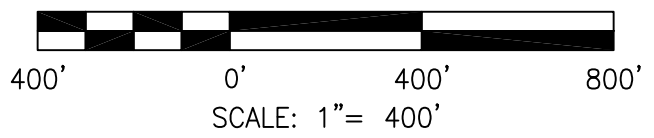


AGES
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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND GROUNDWATER LEVELS & FLOW DIRECTION-MAY 2016	
DRAWING NAME	FIGURE E-5
REV.	0



LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION



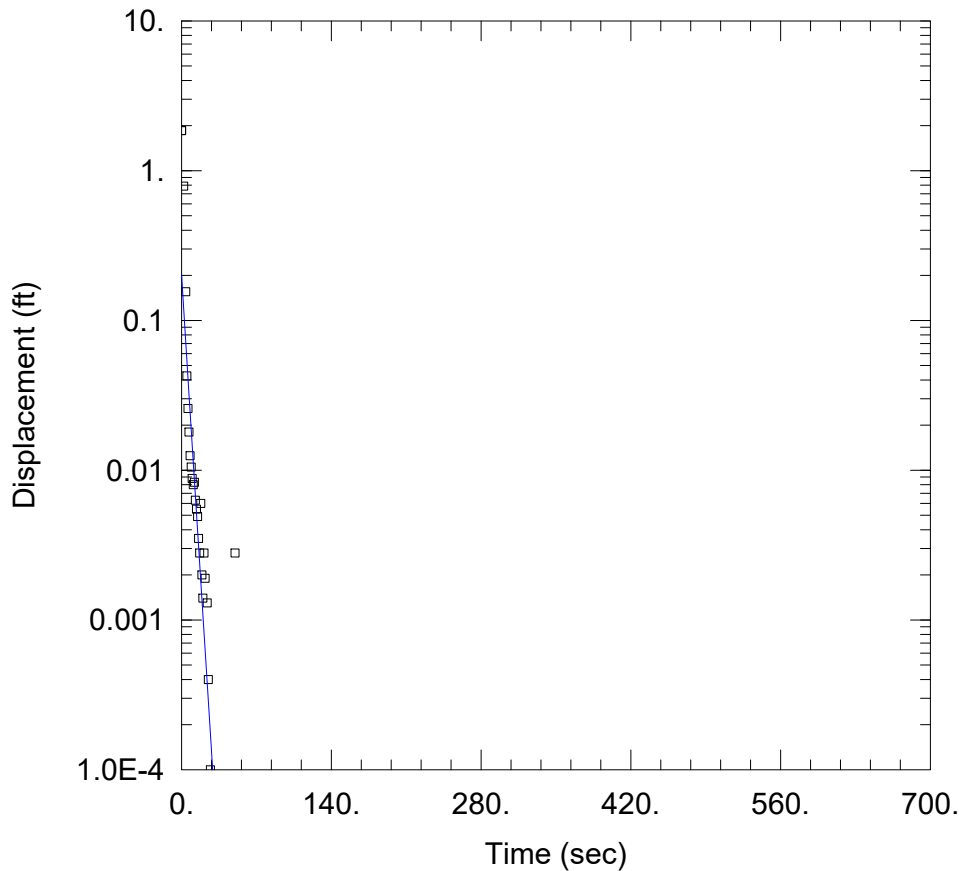
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DATE	
CHECKED BY	
JOB NO.	2015067-CLI
DWG. FILE	IKEC_Clifty MW Install_Appx E_May16 b10.dwg
DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS & FLOW DIRECTION-MAY 2016	
DRAWING NAME	FIGURE E-6
REV.	0

APPENDIX F

AQUIFER TESTING RESULTS
May 2016



IN-A

Data Set: Y:\...\CF-15-04_IN-A-BR.aqt

Date: 08/19/16

Time: 14:14:21

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-04

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 10.16 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-04)

Initial Displacement: 1.851 ft

Static Water Column Height: 12.29 ft

Total Well Penetration Depth: 39. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

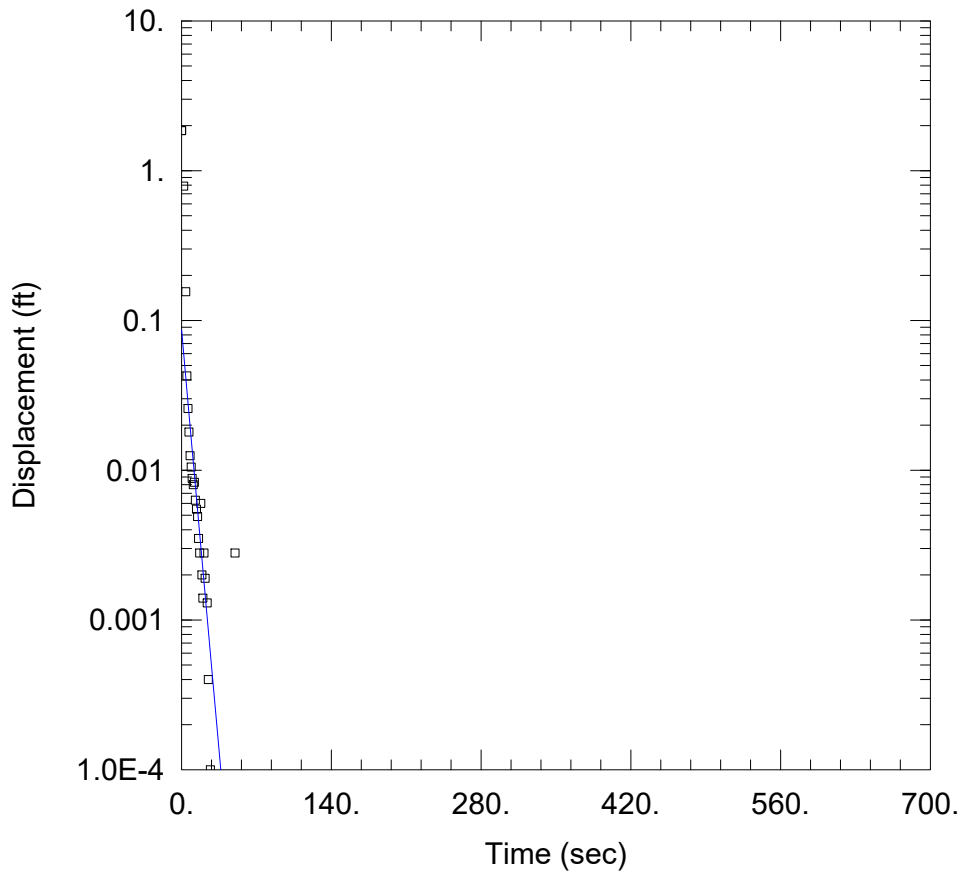
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

$K = 0.009257$ cm/sec

$y_0 = 0.2015$ ft



IN-A

Data Set: Y:\...\CF-15-04_IN-A-H.aqt

Date: 08/19/16

Time: 14:15:09

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-04

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 10.16 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-04)

Initial Displacement: 1.851 ft

Static Water Column Height: 12.29 ft

Total Well Penetration Depth: 39. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

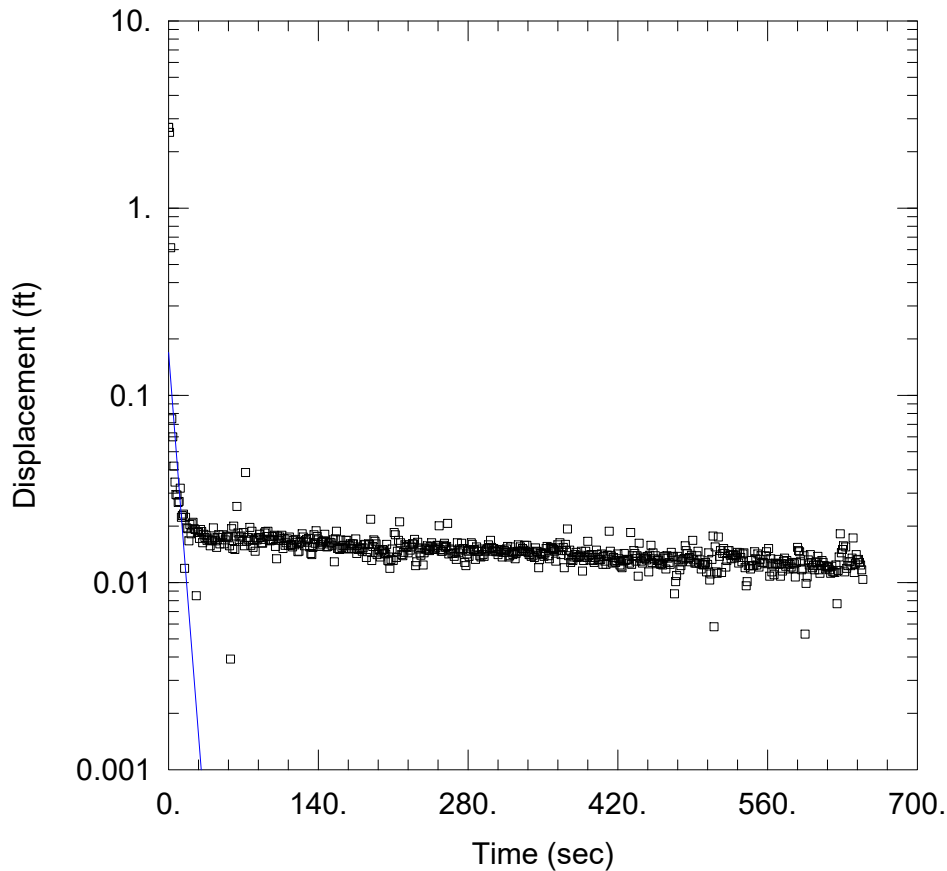
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 0.007934$ cm/sec

$y_0 = 0.08653$ ft



IN-B

Data Set: Y:\...\CF-15-04_IN-B-BR.aqt

Date: 08/19/16

Time: 14:16:29

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-04

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 10.16 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-04)

Initial Displacement: 2.697 ft

Static Water Column Height: 12.24 ft

Total Well Penetration Depth: 39. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

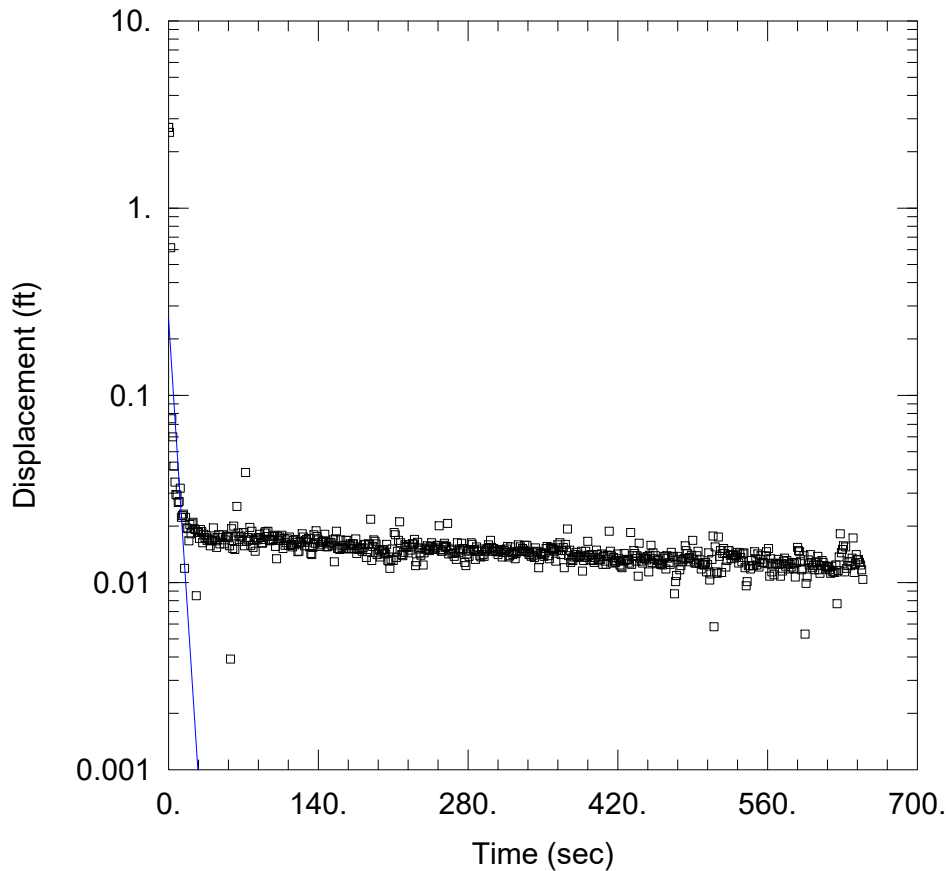
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

$K = 0.005947$ cm/sec

$y_0 = 0.1693$ ft



IN-B

Data Set: Y:\...\CF-15-04_IN-B-H.aqt

Date: 08/19/16

Time: 14:17:22

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-04

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 10.16 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-04)

Initial Displacement: 2.697 ft

Static Water Column Height: 12.24 ft

Total Well Penetration Depth: 39. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

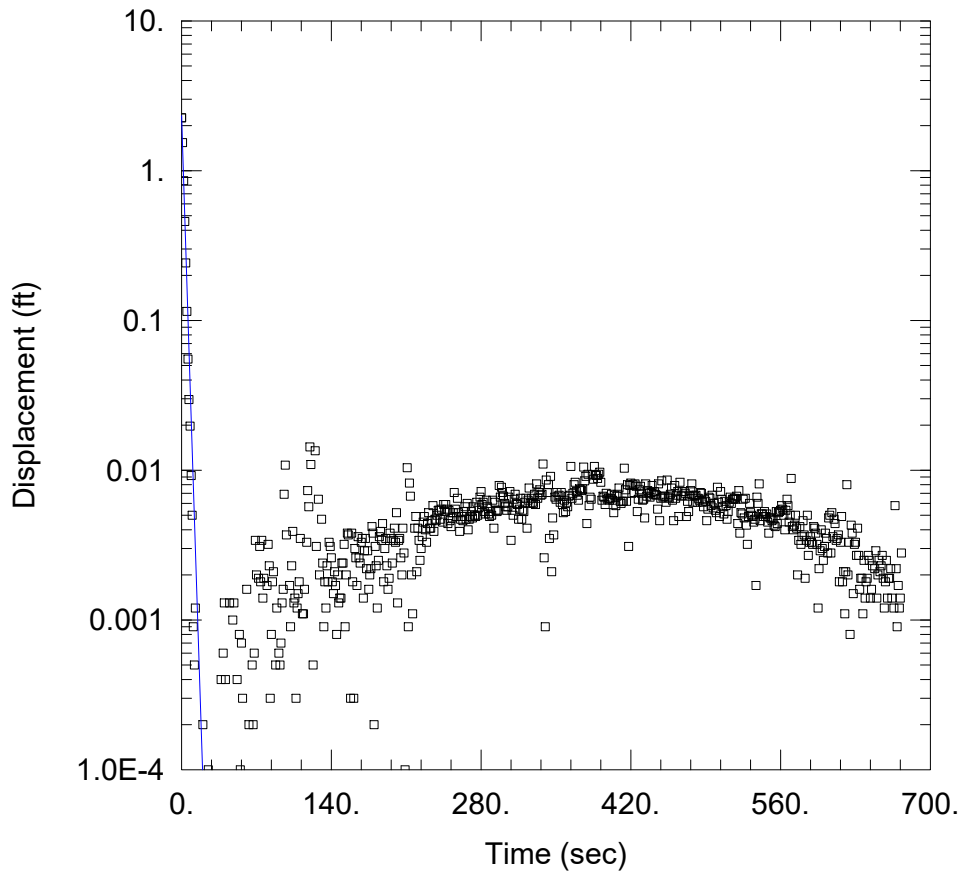
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 0.008677$ cm/sec

$y_0 = 0.2563$ ft



OUT-A

Data Set: Y:\...\CF-15-04_OUT-A-BR.aqt

Date: 08/19/16

Time: 14:18:16

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-04

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 10.16 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-04)

Initial Displacement: 2.254 ft

Static Water Column Height: 12.25 ft

Total Well Penetration Depth: 39. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

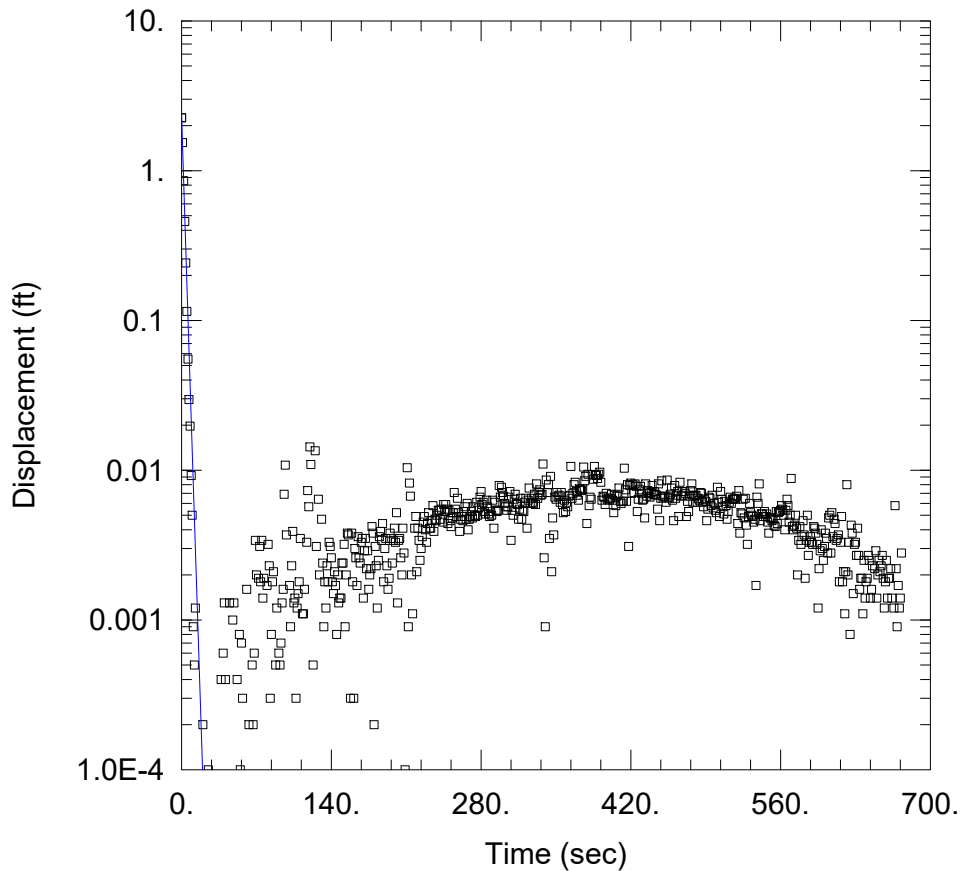
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

$K = 0.01815$ cm/sec

$y_0 = 2.326$ ft



OUT-A

Data Set: Y:\...\CF-15-04_OUT-A-H.aqt

Date: 08/19/16

Time: 14:19:10

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-04

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 10.16 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-04)

Initial Displacement: 2.254 ft

Static Water Column Height: 12.25 ft

Total Well Penetration Depth: 39. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

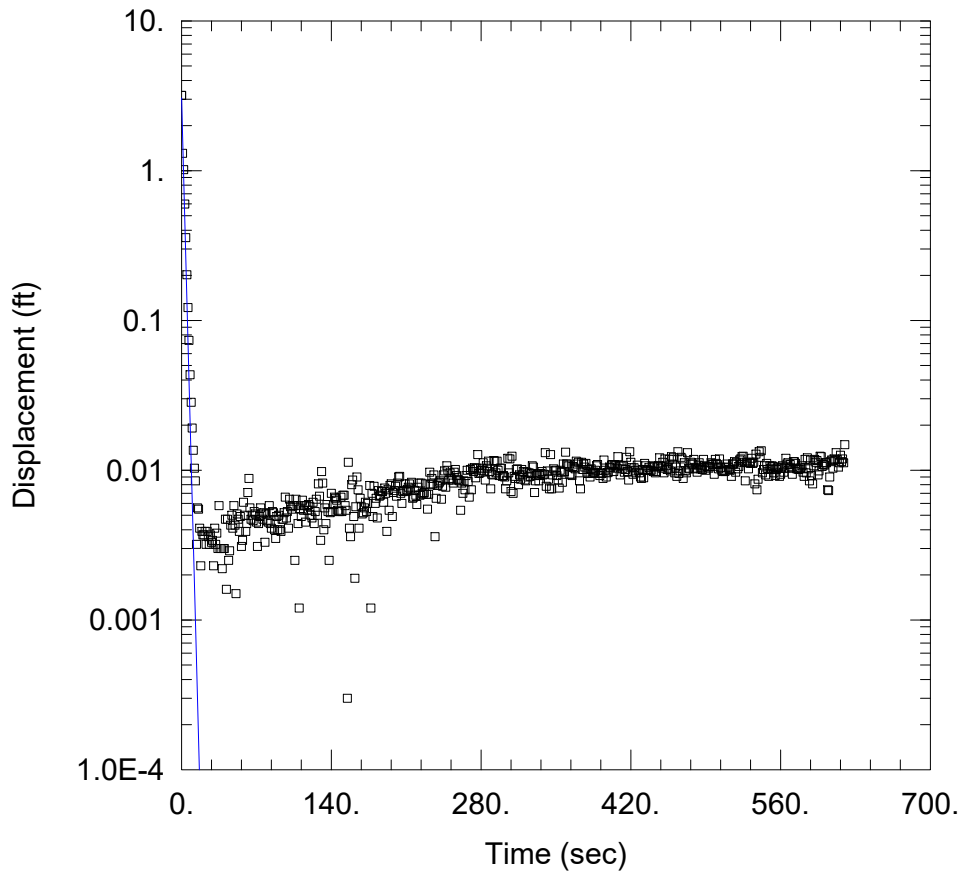
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 0.02206$ cm/sec

$y_0 = 2.326$ ft



OUT-B

Data Set: Y:\...\CF-15-04_OUT-B-BR.aqt

Date: 08/19/16

Time: 14:20:16

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-04

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 10.16 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-04)

Initial Displacement: 3.18 ft

Static Water Column Height: 12.25 ft

Total Well Penetration Depth: 39. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

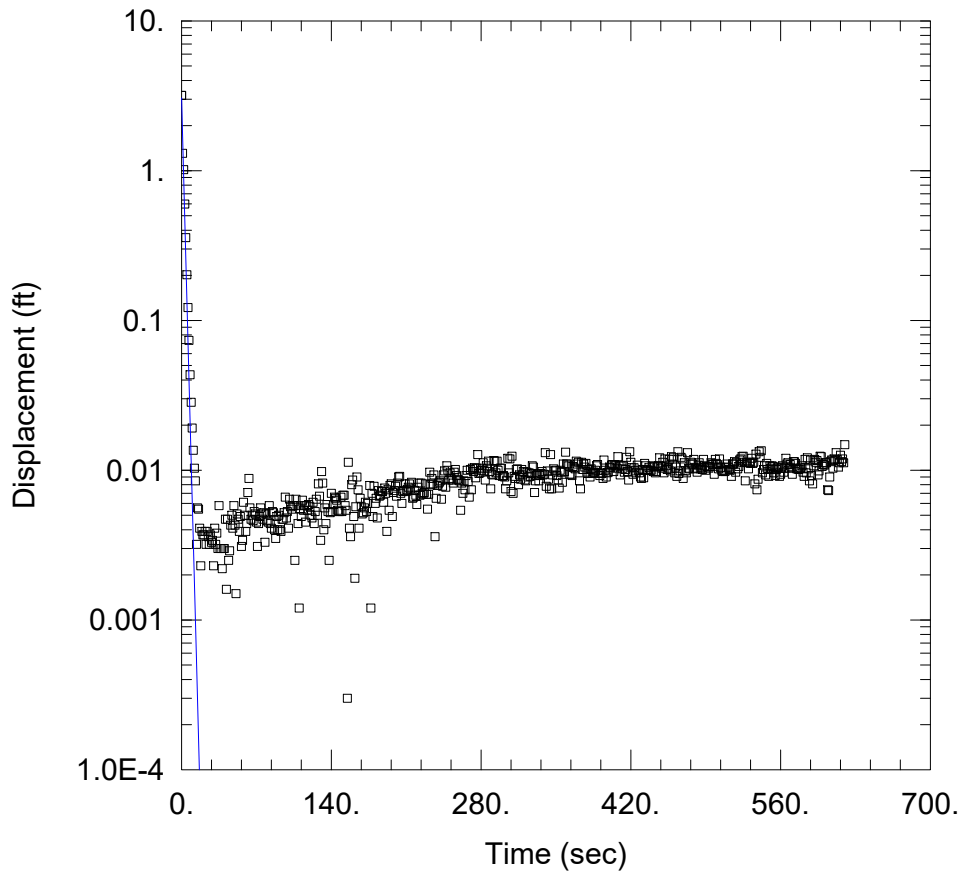
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

$K = 0.02184$ cm/sec

$y_0 = 3.061$ ft



OUT-B

Data Set: Y:\...\CF-15-04_OUT-B-H.aqt

Date: 08/19/16

Time: 14:21:26

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-04

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 10.16 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-04)

Initial Displacement: 3.18 ft

Static Water Column Height: 12.25 ft

Total Well Penetration Depth: 39. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

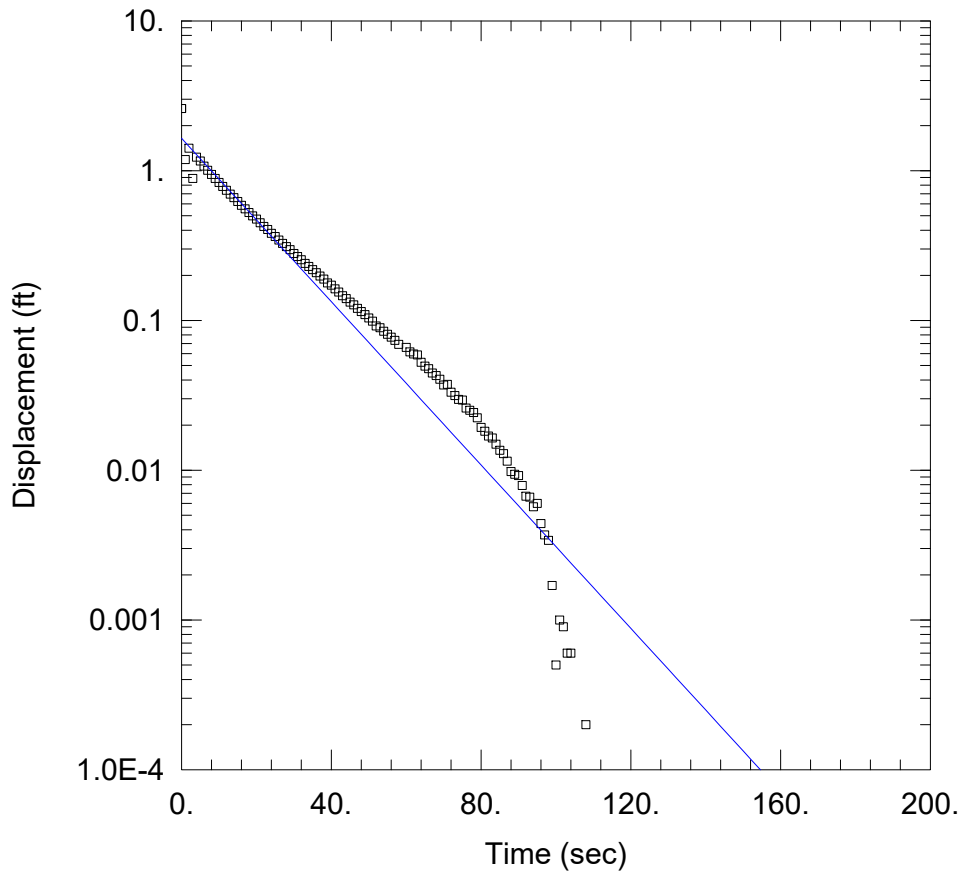
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 0.02651$ cm/sec

$y_0 = 3.061$ ft



IN-A

Data Set: Y:\...\CF-15-08_IN-A-BR.aqt

Date: 08/19/16

Time: 14:22:21

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-08

Test Date: 05/16/2016

AQUIFER DATA

Saturated Thickness: 20.05 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-08)

Initial Displacement: 2.599 ft

Static Water Column Height: 22.6 ft

Total Well Penetration Depth: 41. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

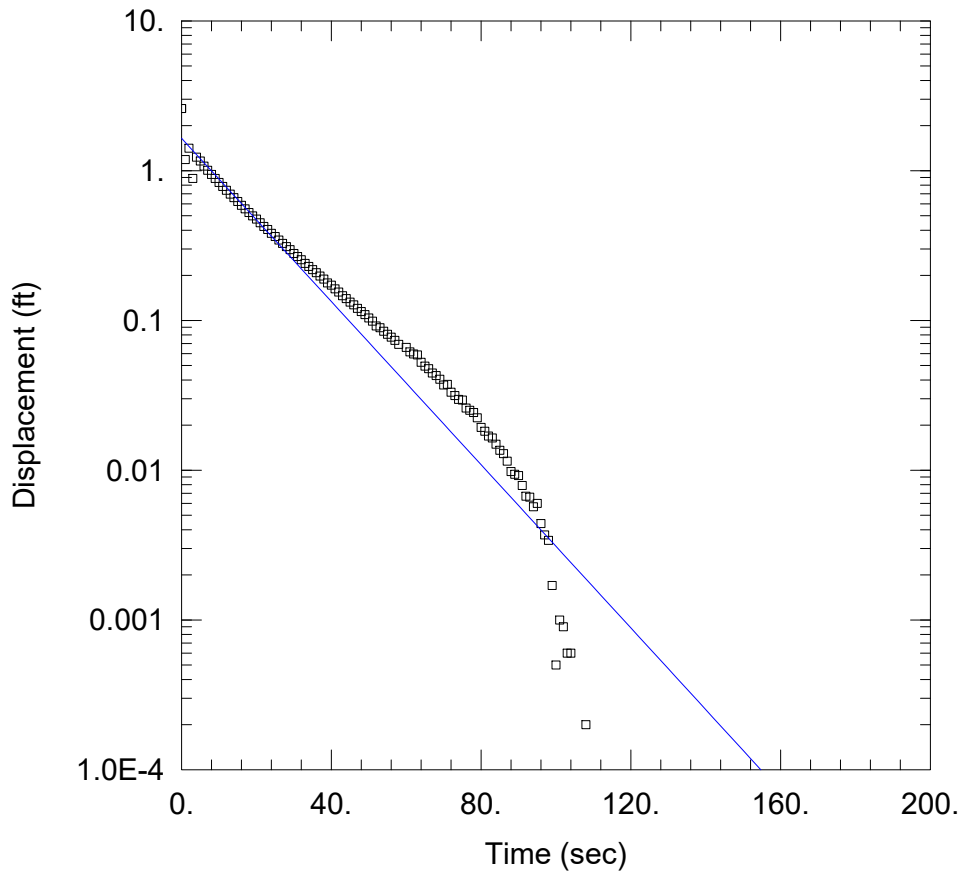
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

$K = 0.002241$ cm/sec

$y_0 = 1.646$ ft



IN-A

Data Set: Y:\...\CF-15-08_IN-A-H.aqt

Date: 08/19/16

Time: 14:23:18

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-08

Test Date: 05/16/2016

AQUIFER DATA

Saturated Thickness: 20.05 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-08)

Initial Displacement: 2.599 ft

Static Water Column Height: 22.6 ft

Total Well Penetration Depth: 41. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

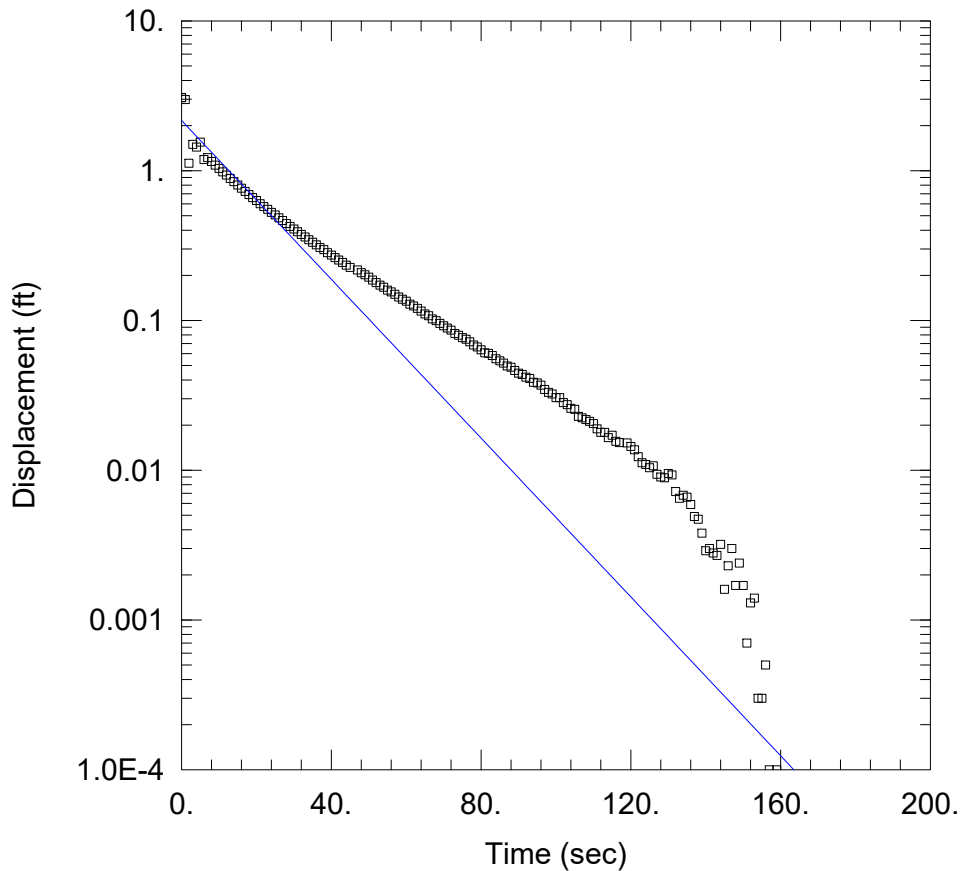
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 0.002698$ cm/sec

$y_0 = 1.645$ ft



IN-B

Data Set: Y:\...\CF-15-08_IN-B-BR.aqt

Date: 08/19/16

Time: 14:24:13

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-08

Test Date: 05/16/2016

AQUIFER DATA

Saturated Thickness: 20.05 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-15-08)

Initial Displacement: 3.077 ft

Static Water Column Height: 22.61 ft

Total Well Penetration Depth: 41. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

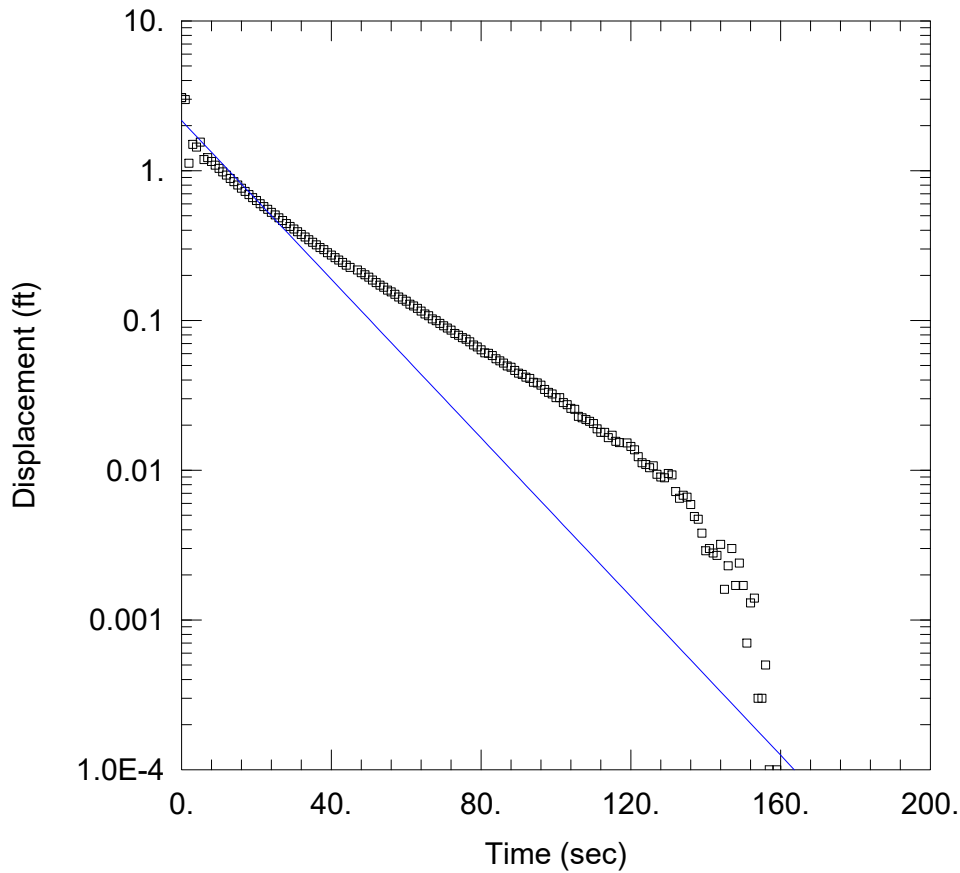
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

K = 0.002179 cm/sec

y0 = 2.164 ft



IN-B

Data Set: Y:\...\CF-15-08_IN-B-H.aqt

Date: 08/19/16

Time: 14:25:06

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-08

Test Date: 05/16/2016

AQUIFER DATA

Saturated Thickness: 20.05 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-08)

Initial Displacement: 3.077 ft

Static Water Column Height: 22.61 ft

Total Well Penetration Depth: 41. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

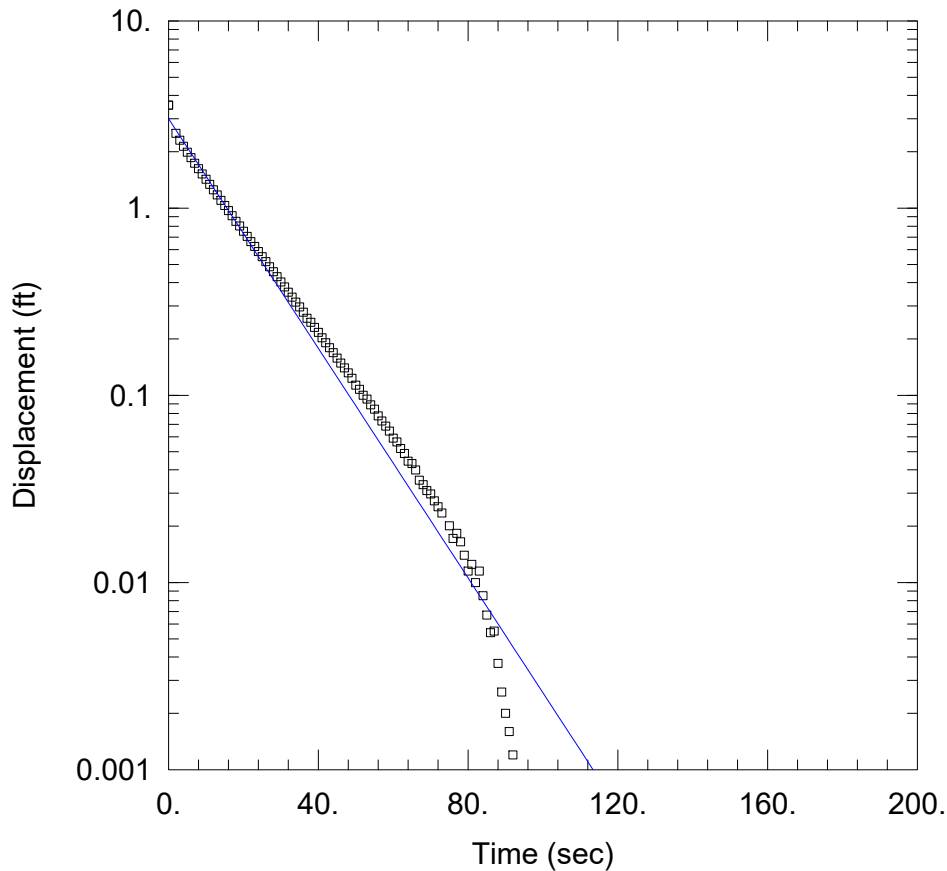
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 0.002622$ cm/sec

$y_0 = 2.163$ ft



OUT-A

Data Set: Y:\...\CF-15-08_OUT-A-BR.aqt

Date: 08/19/16

Time: 14:25:52

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-08

Test Date: 05/16/2016

AQUIFER DATA

Saturated Thickness: 20.05 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-08)

Initial Displacement: 3.549 ft

Static Water Column Height: 22.6 ft

Total Well Penetration Depth: 41. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

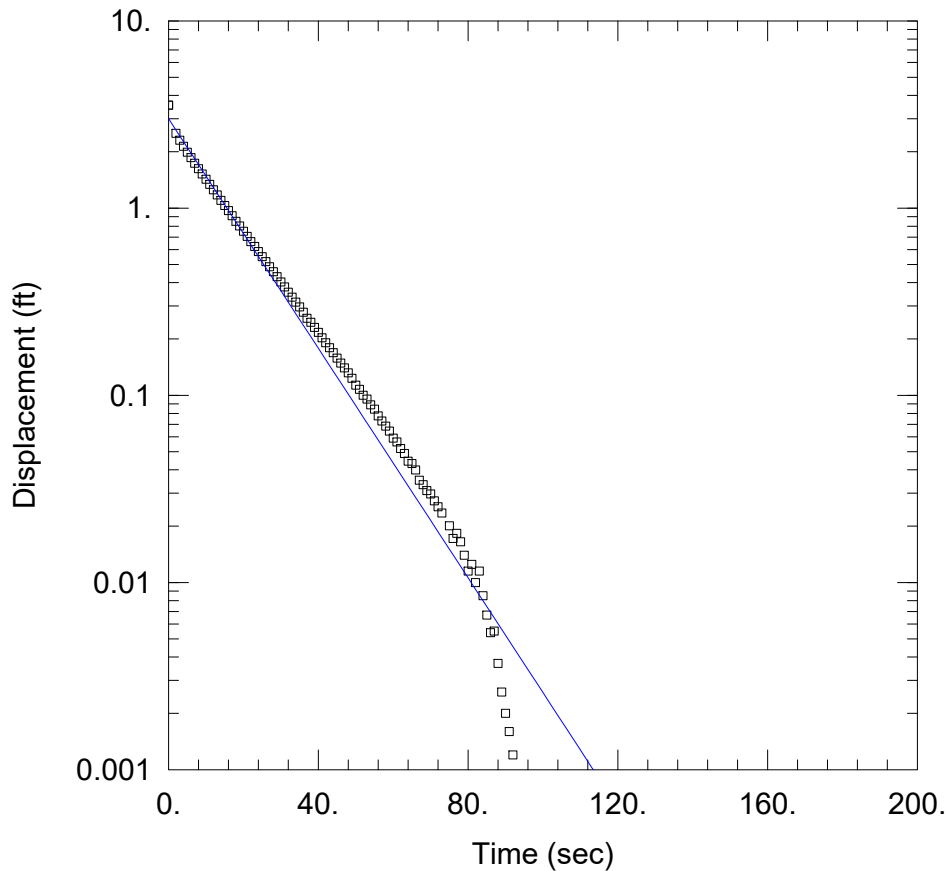
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

$K = 0.002521$ cm/sec

$y_0 = 3.006$ ft



OUT-A

Data Set: Y:\...\CF-15-08_OUT-A-H.aqt

Date: 08/19/16

Time: 14:26:41

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-08

Test Date: 05/16/2016

AQUIFER DATA

Saturated Thickness: 20.05 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-08)

Initial Displacement: 3.549 ft

Static Water Column Height: 22.6 ft

Total Well Penetration Depth: 41. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

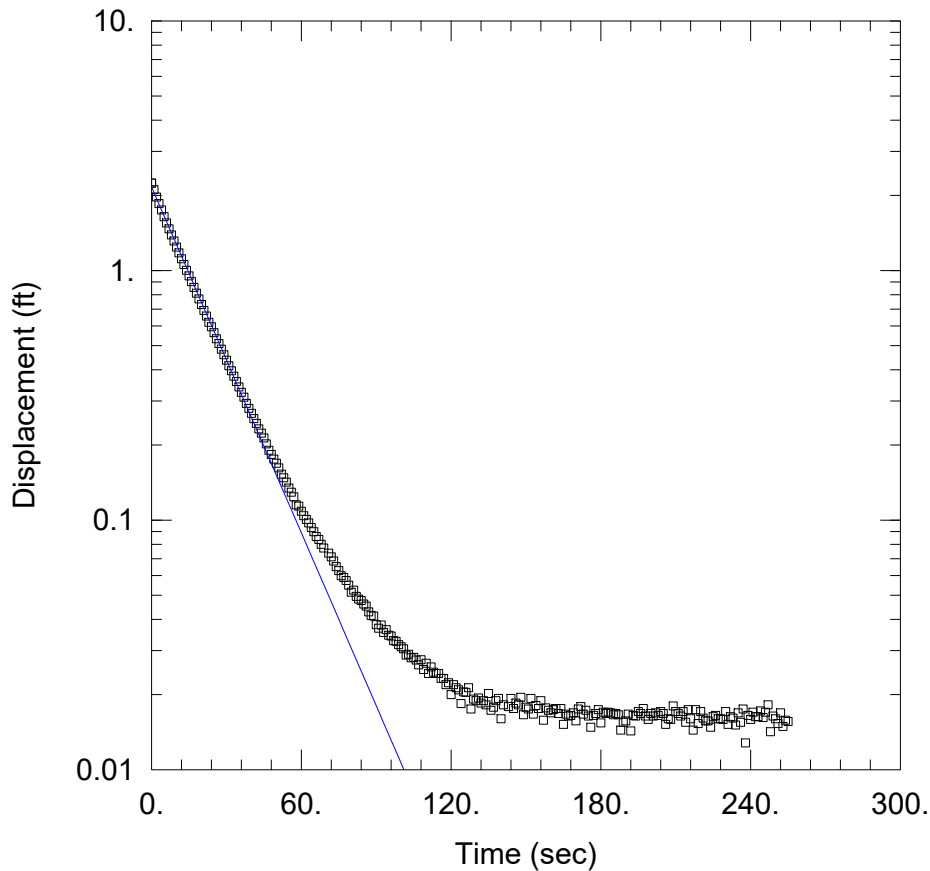
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 0.003035$ cm/sec

$y_0 = 3.005$ ft



OUT-B

Data Set: Y:\...\CF-15-08_OUT-B-BR.aqt

Date: 08/19/16

Time: 14:27:29

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-08

Test Date: 05/16/2016

AQUIFER DATA

Saturated Thickness: 20.05 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-08)

Initial Displacement: 2.239 ft

Static Water Column Height: 22.6 ft

Total Well Penetration Depth: 41. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

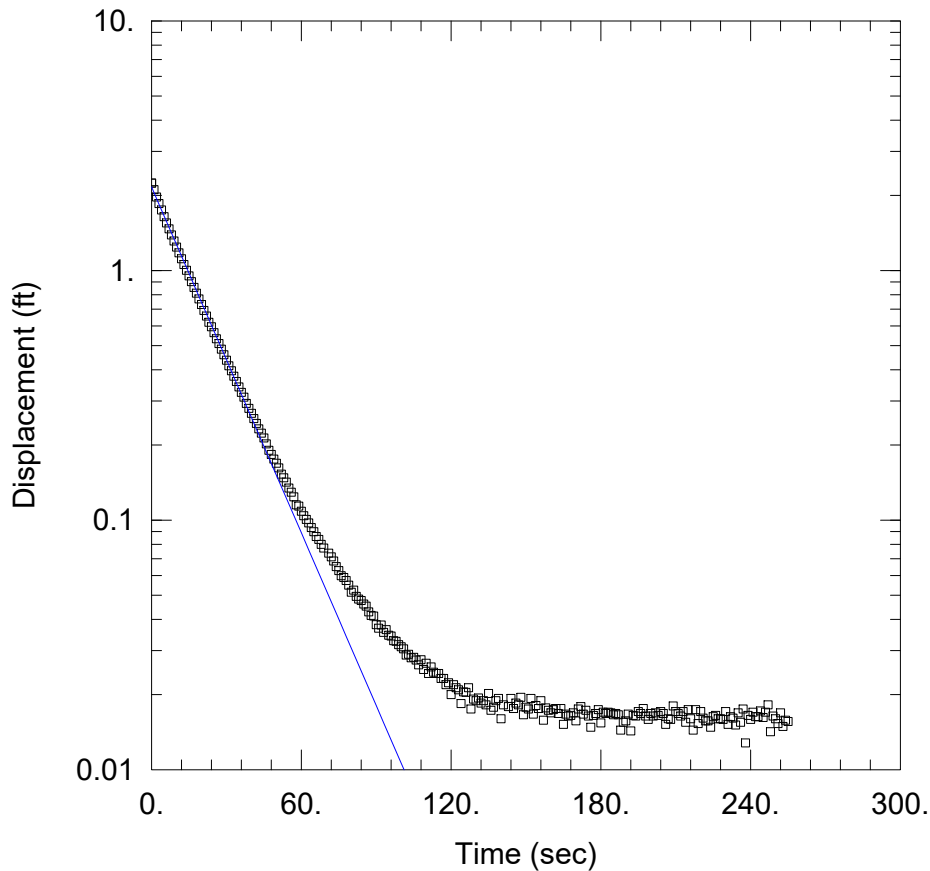
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

$K = 0.001898$ cm/sec

$y_0 = 2.162$ ft



OUT-B

Data Set: Y:\...\CF-15-08_OUT-B-H.aqt

Date: 08/19/16

Time: 14:28:16

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: CF-15-08

Test Date: 05/16/2016

AQUIFER DATA

Saturated Thickness: 20.05 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (CF-15-08)

Initial Displacement: 2.239 ft

Static Water Column Height: 22.6 ft

Total Well Penetration Depth: 41. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

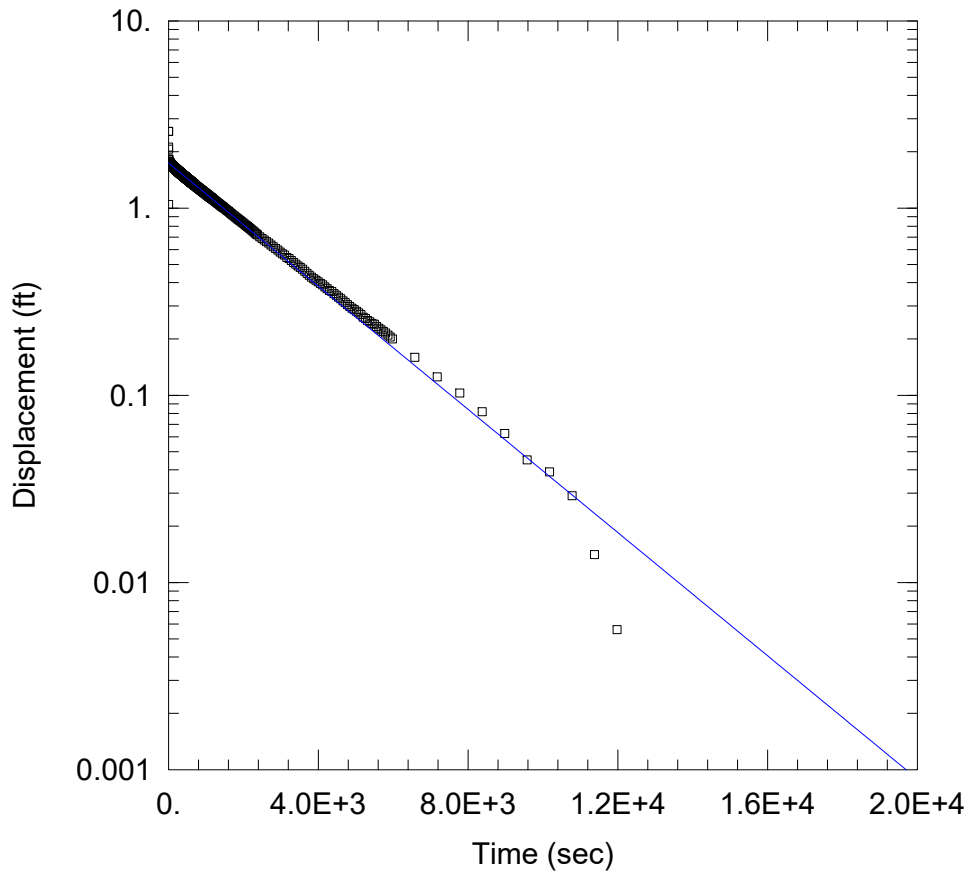
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 0.002285$ cm/sec

$y_0 = 2.161$ ft



IN-B

Data Set: Y:\...\WBSP-15-02_IN-B-BR.aqt

Date: 08/19/16

Time: 14:30:08

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-02

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 17.61 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (WBSP-15-02)

Initial Displacement: 2.57 ft

Static Water Column Height: 17.83 ft

Total Well Penetration Depth: 24. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

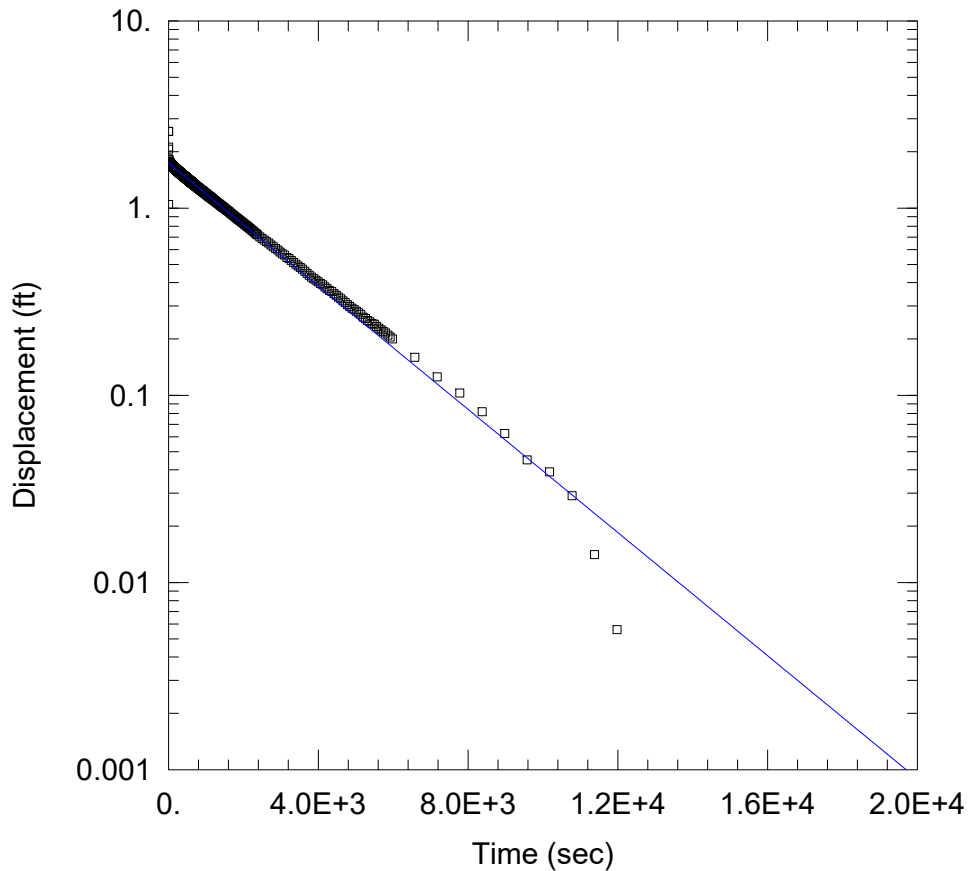
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

K = 1.232E-5 cm/sec

y0 = 1.741 ft



IN-B

Data Set: Y:\...\WBSP-15-02_IN-B-H.aqt

Date: 08/19/16

Time: 14:30:41

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-02

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 17.61 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-02)

Initial Displacement: 2.57 ft

Static Water Column Height: 17.83 ft

Total Well Penetration Depth: 24. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

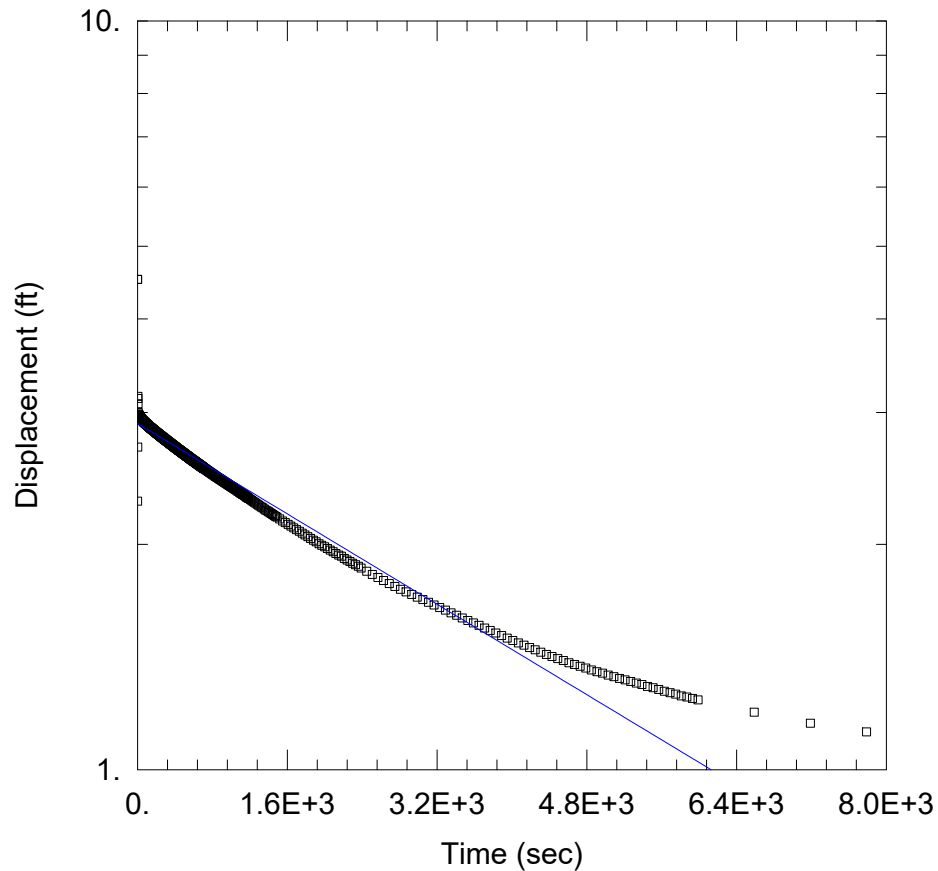
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 1.629E-5$ cm/sec

$y_0 = 1.741$ ft



OUT-A

Data Set: Y:\...\WBSP-15-02_OUT-A-BR.aqt

Date: 08/19/16

Time: 14:31:45

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-02

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 17.61 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-02)

Initial Displacement: 4.516 ft

Static Water Column Height: 20.8 ft

Total Well Penetration Depth: 24. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

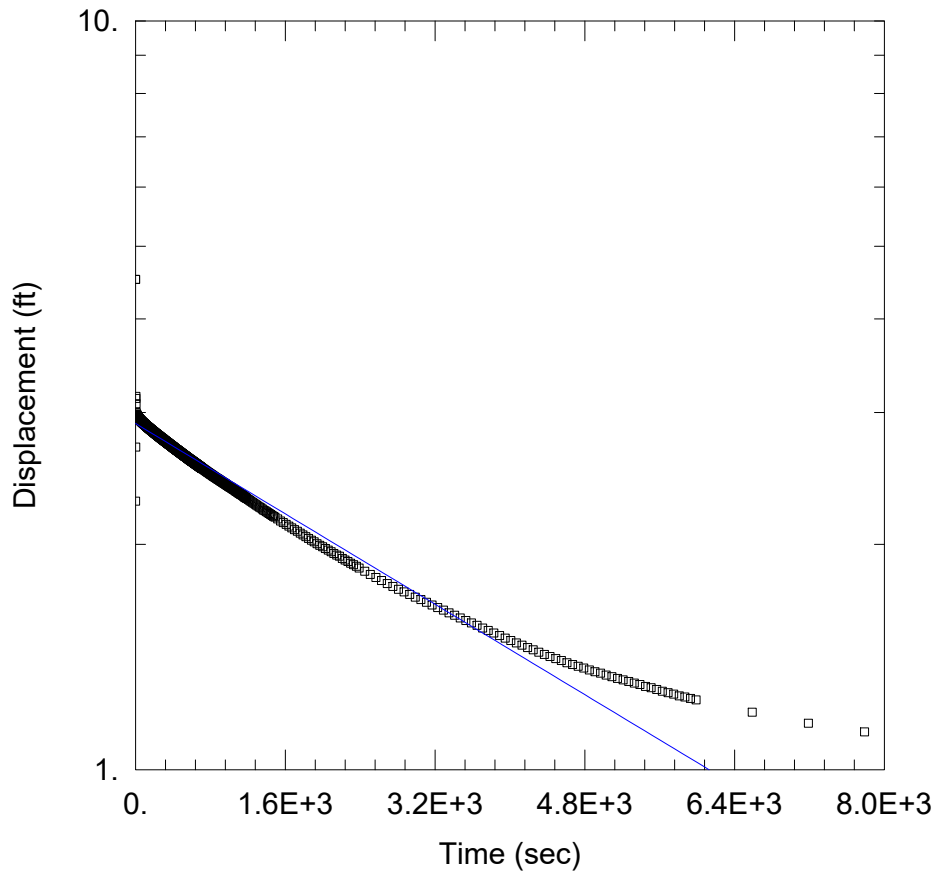
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

$K = 5.652E-6$ cm/sec

$y_0 = 2.9$ ft



OUT-A

Data Set: Y:\...\WBSP-15-02_OUT-A-H.aqt

Date: 08/19/16

Time: 14:32:32

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-02

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 17.61 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-02)

Initial Displacement: 4.516 ft

Static Water Column Height: 20.8 ft

Total Well Penetration Depth: 24. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

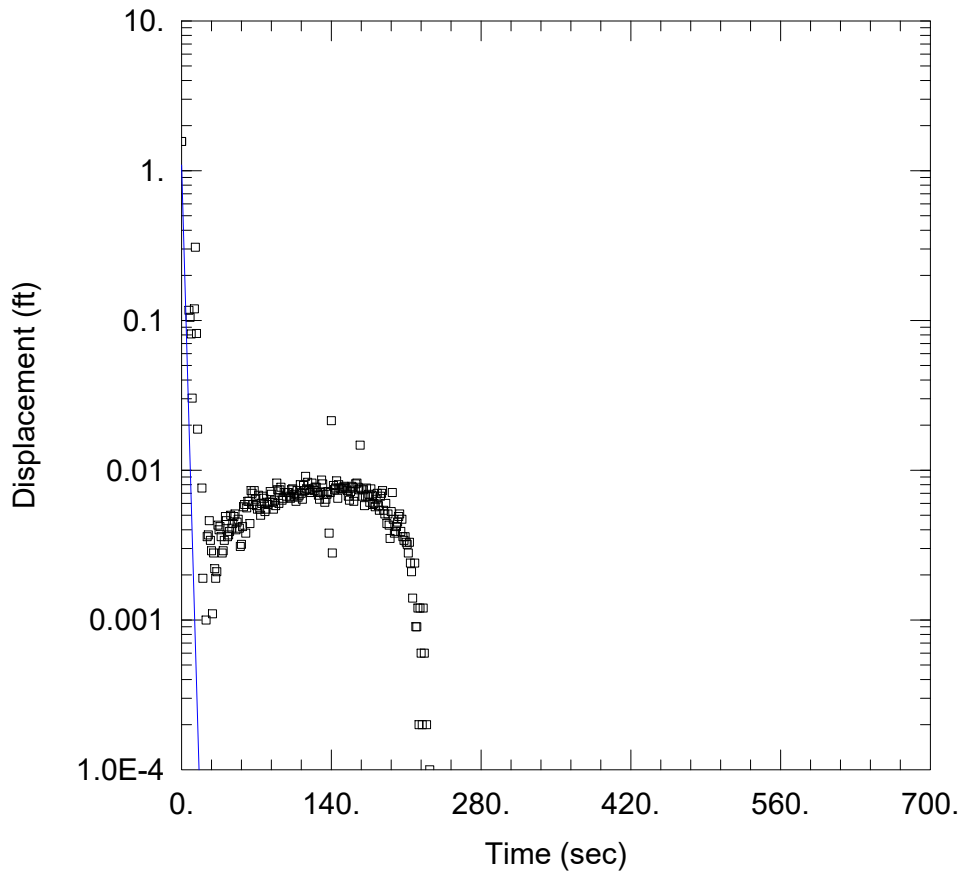
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 7.471E-6$ cm/sec

$y_0 = 2.9$ ft



IN-A

Data Set: Y:\...\WBSP-15-06_IN-A-BR.aqt

Date: 08/19/16

Time: 14:33:29

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-06

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 40.81 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-06)

Initial Displacement: 1.565 ft

Static Water Column Height: 26.69 ft

Total Well Penetration Depth: 89. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

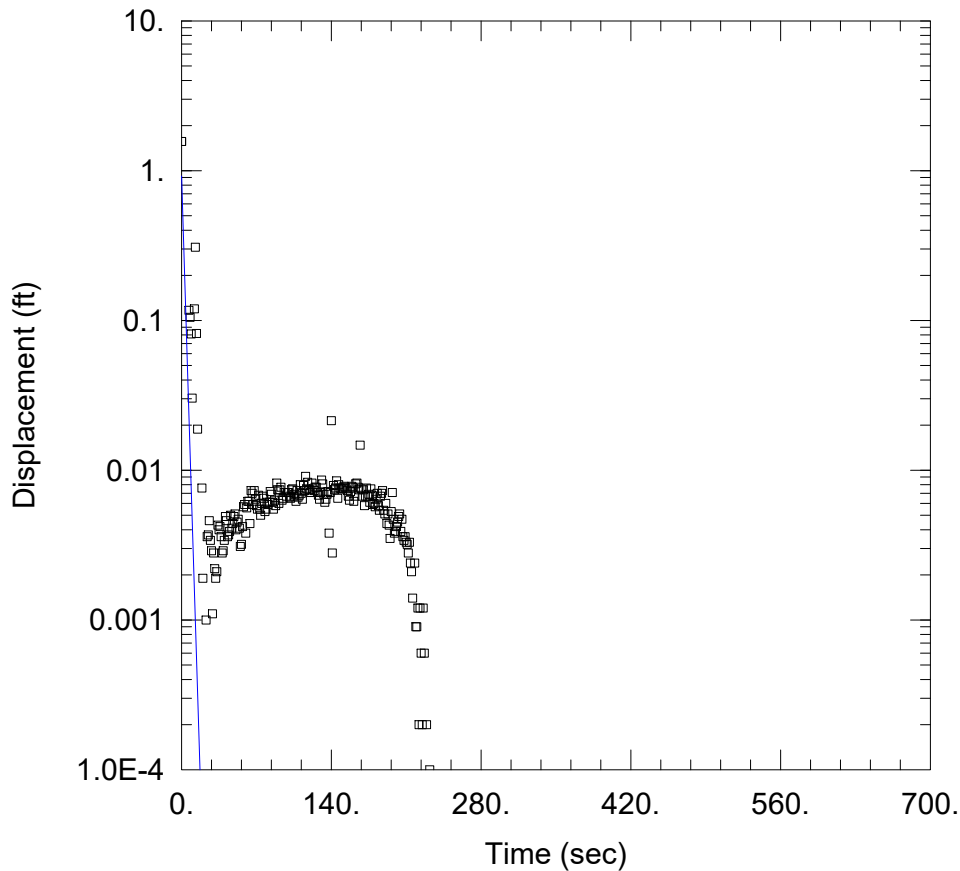
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

$K = 0.02271$ cm/sec

$y_0 = 1.09$ ft



IN-A

Data Set: Y:\...\WBSP-15-06_IN-A-H.aqt

Date: 08/19/16

Time: 14:34:42

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-06

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 40.81 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-06)

Initial Displacement: 1.565 ft

Static Water Column Height: 26.69 ft

Total Well Penetration Depth: 89. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

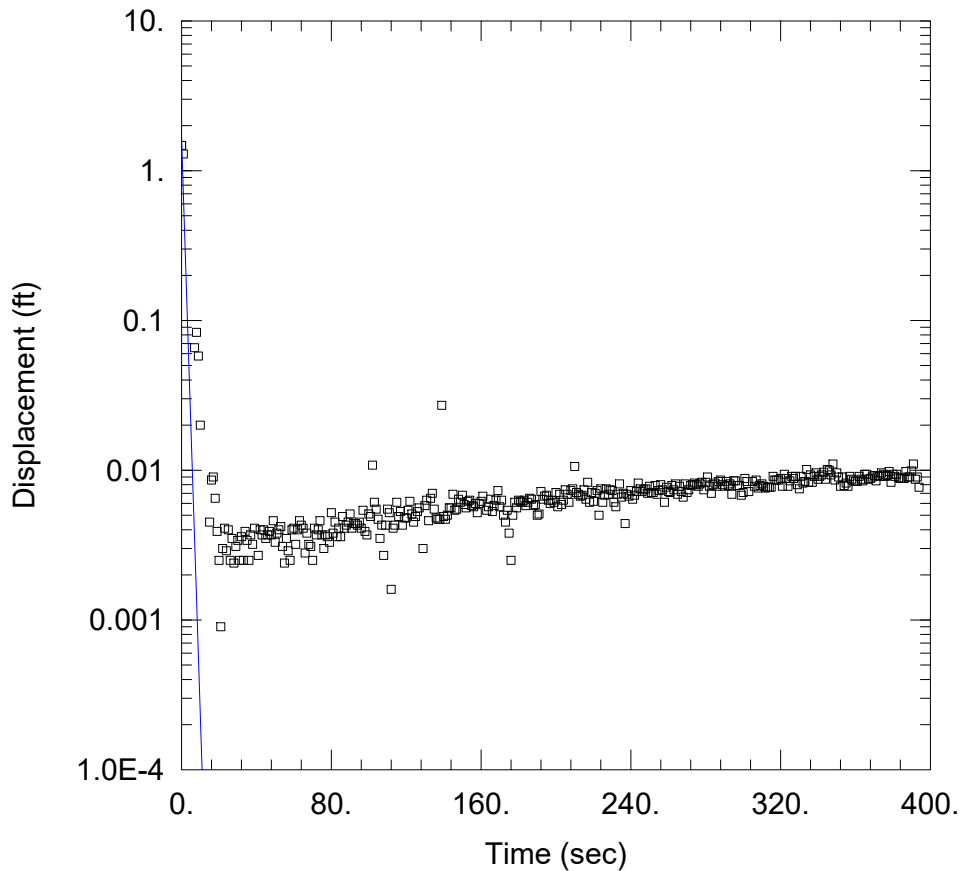
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 0.02271$ cm/sec

$y_0 = 0.922$ ft



IN-B

Data Set: Y:\...\WBSP-15-06_IN-B-BR.aqt

Date: 08/19/16

Time: 14:35:56

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-06

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 40.81 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-06)

Initial Displacement: 1.472 ft

Static Water Column Height: 26.64 ft

Total Well Penetration Depth: 89. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

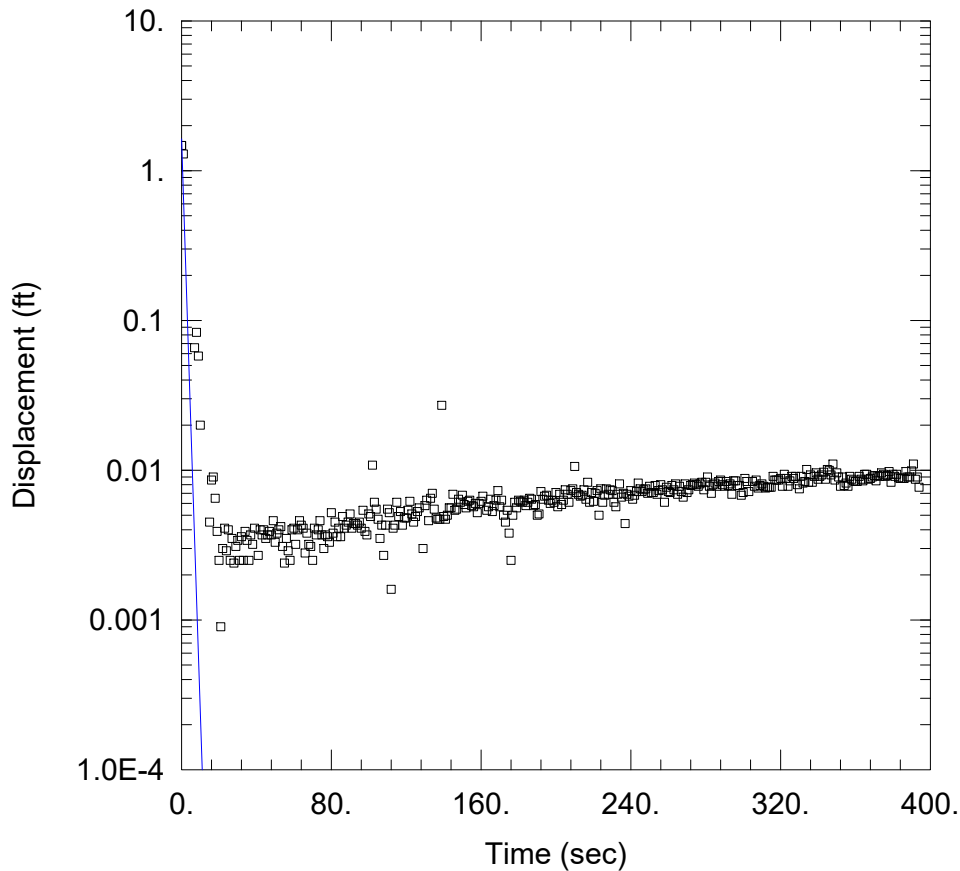
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

$K = 0.03521$ cm/sec

$y_0 = 1.629$ ft



IN-B

Data Set: Y:\...\WBSP-15-06_IN-B-H.aqt

Date: 08/19/16

Time: 14:37:05

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-06

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 40.81 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-06)

Initial Displacement: 1.472 ft

Static Water Column Height: 26.64 ft

Total Well Penetration Depth: 89. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

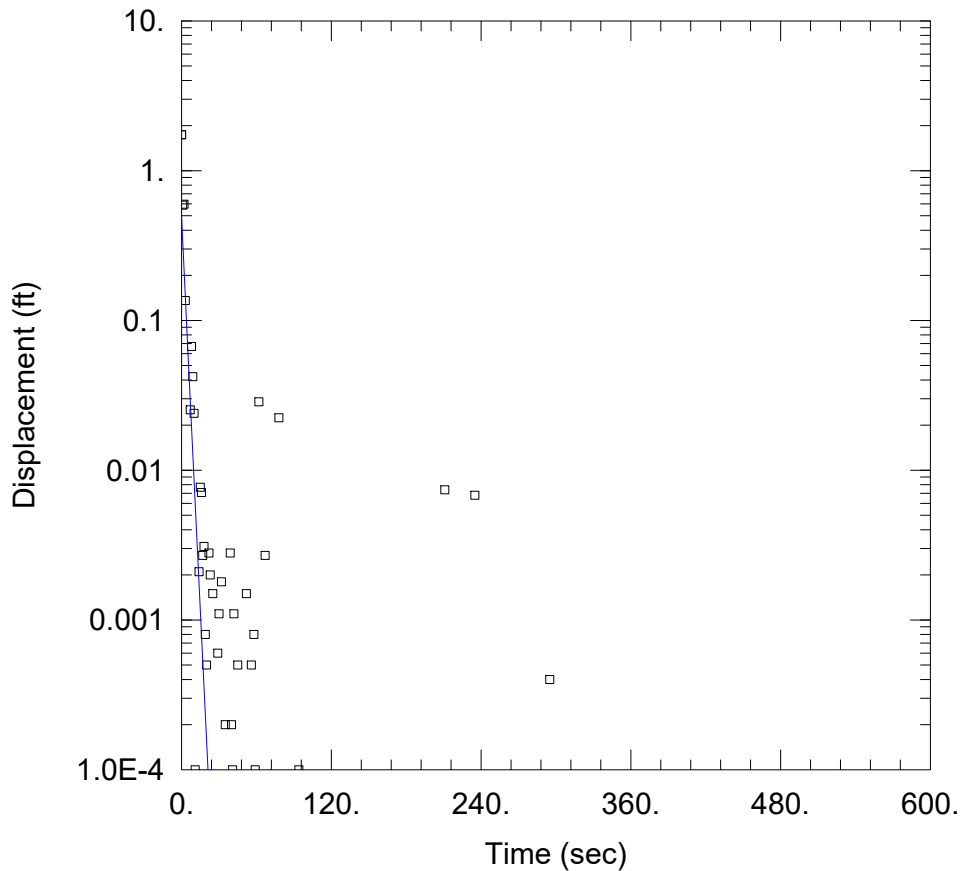
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 0.03781$ cm/sec

$y_0 = 1.628$ ft



OUT-A

Data Set: Y:\...\WBSP-15-06_OUT-A-BR.aqt

Date: 08/19/16

Time: 14:38:02

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-06

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 40.81 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-06)

Initial Displacement: 1.737 ft

Static Water Column Height: 26.6 ft

Total Well Penetration Depth: 89. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

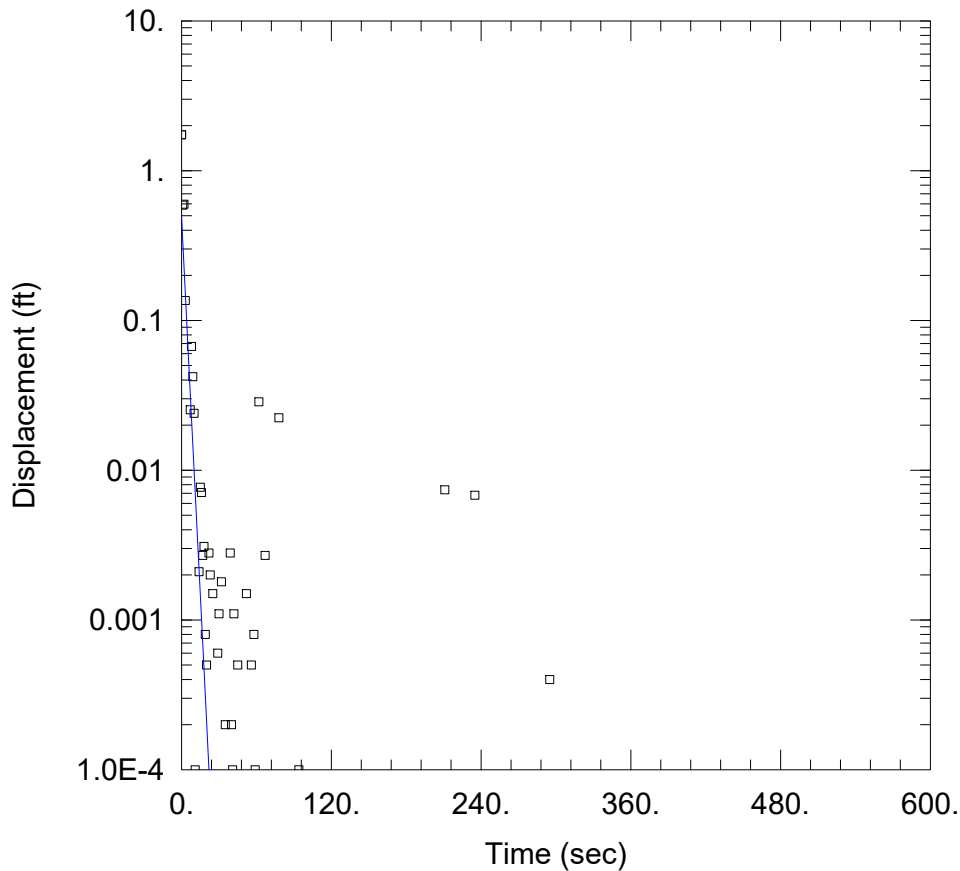
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

$K = 0.01605$ cm/sec

$y_0 = 0.4891$ ft



OUT-A

Data Set: Y:\...\WBSP-15-06_OUT-A-H.aqt

Date: 08/19/16

Time: 14:38:52

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-06

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 40.81 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-06)

Initial Displacement: 1.737 ft

Static Water Column Height: 26.6 ft

Total Well Penetration Depth: 89. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

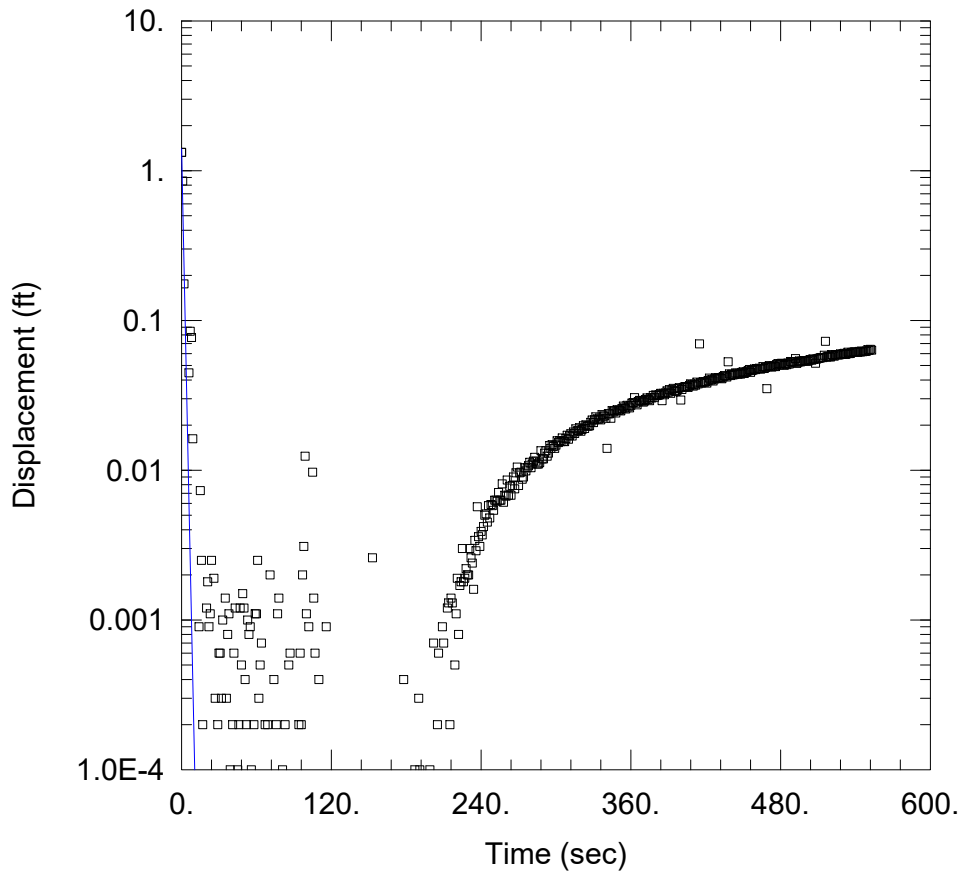
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 0.01657$ cm/sec

$y_0 = 0.4891$ ft



OUT-B

Data Set: Y:\...\WBSP-15-06_OUT-B-BR.aqt

Date: 08/19/16

Time: 14:39:38

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-06

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 40.81 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-06)

Initial Displacement: 1.326 ft

Static Water Column Height: 26.66 ft

Total Well Penetration Depth: 89. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

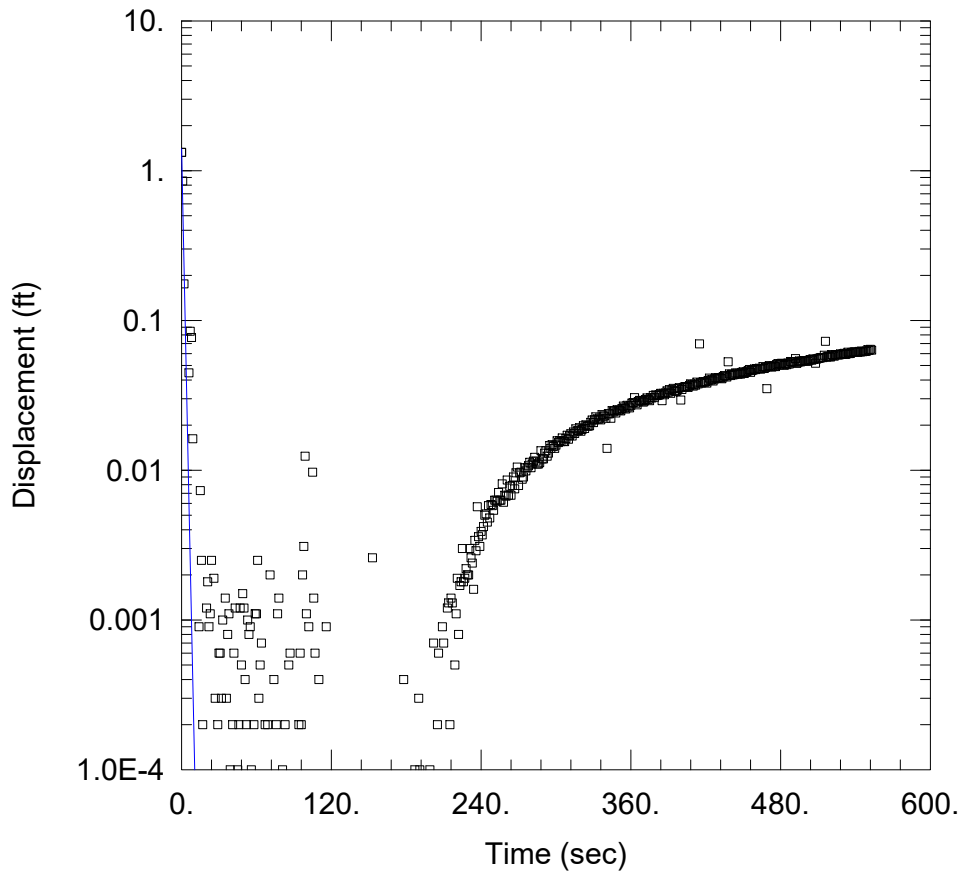
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

$K = 0.03628$ cm/sec

$y_0 = 1.404$ ft



OUT-B

Data Set: Y:\...\WBSP-15-06_OUT-B-H.aqt

Date: 08/19/16

Time: 14:40:26

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-06

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 40.81 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-06)

Initial Displacement: 1.326 ft

Static Water Column Height: 26.66 ft

Total Well Penetration Depth: 89. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

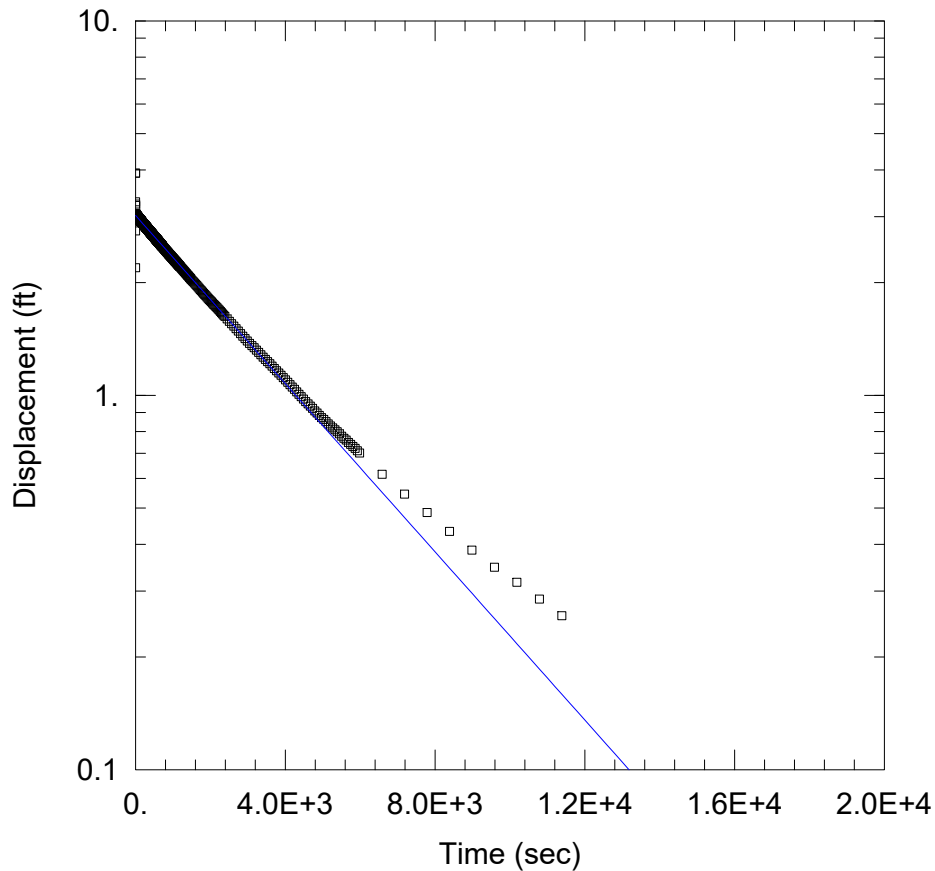
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 0.03906$ cm/sec

$y_0 = 1.404$ ft



IN-A

Data Set: Y:\...\WBSP-15-07_IN-A-BR.aqt

Date: 08/19/16

Time: 14:41:16

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-07

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 15.17 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-07)

Initial Displacement: 3.919 ft

Static Water Column Height: 16.94 ft

Total Well Penetration Depth: 55. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

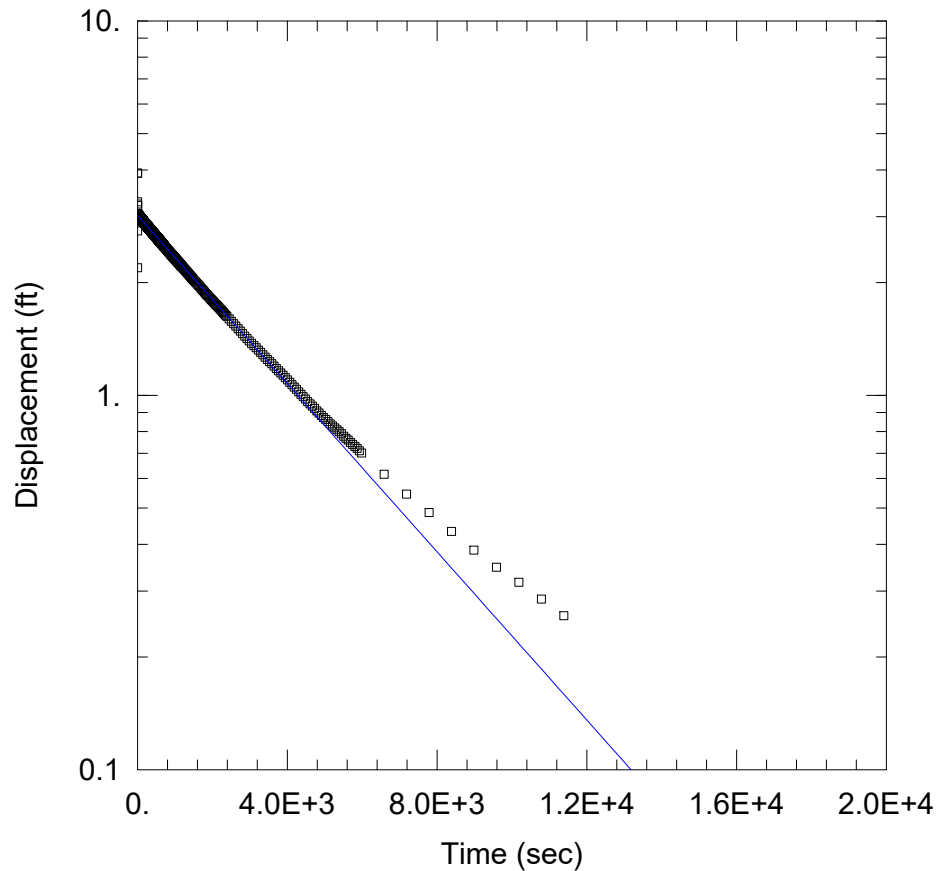
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

$K = 9.663E-6$ cm/sec

$y_0 = 3.024$ ft



IN-A

Data Set: Y:\...\WBSP-15-07_IN-A-H.aqt

Date: 08/19/16

Time: 14:41:57

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-07

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 15.17 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-07)

Initial Displacement: 3.919 ft

Static Water Column Height: 16.94 ft

Total Well Penetration Depth: 55. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

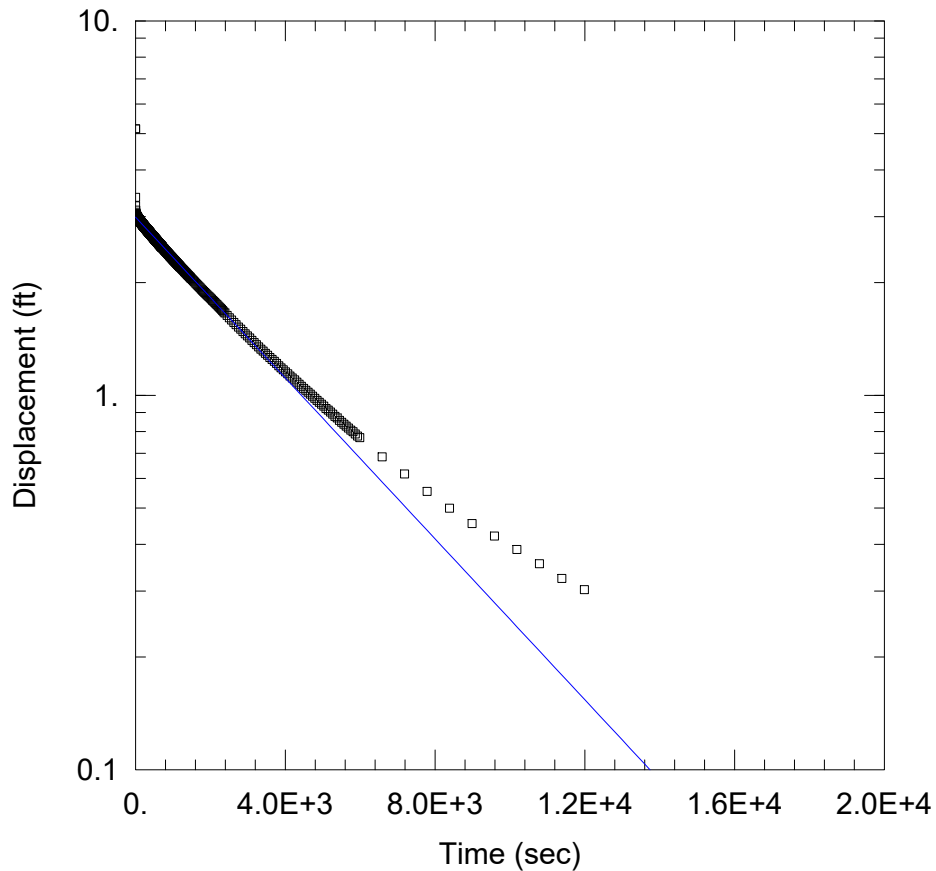
SOLUTION

Aquifer Model: Confined

Solution Method: Hvorslev

$K = 1.112E-5$ cm/sec

$y_0 = 3.024$ ft



OUT-B

Data Set: Y:\...\WBSP-15-07_OUT-B-BR.aqt

Date: 08/19/16

Time: 14:42:48

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-07

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 15.17 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-07)

Initial Displacement: 5.152 ft

Static Water Column Height: 17.19 ft

Total Well Penetration Depth: 55. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

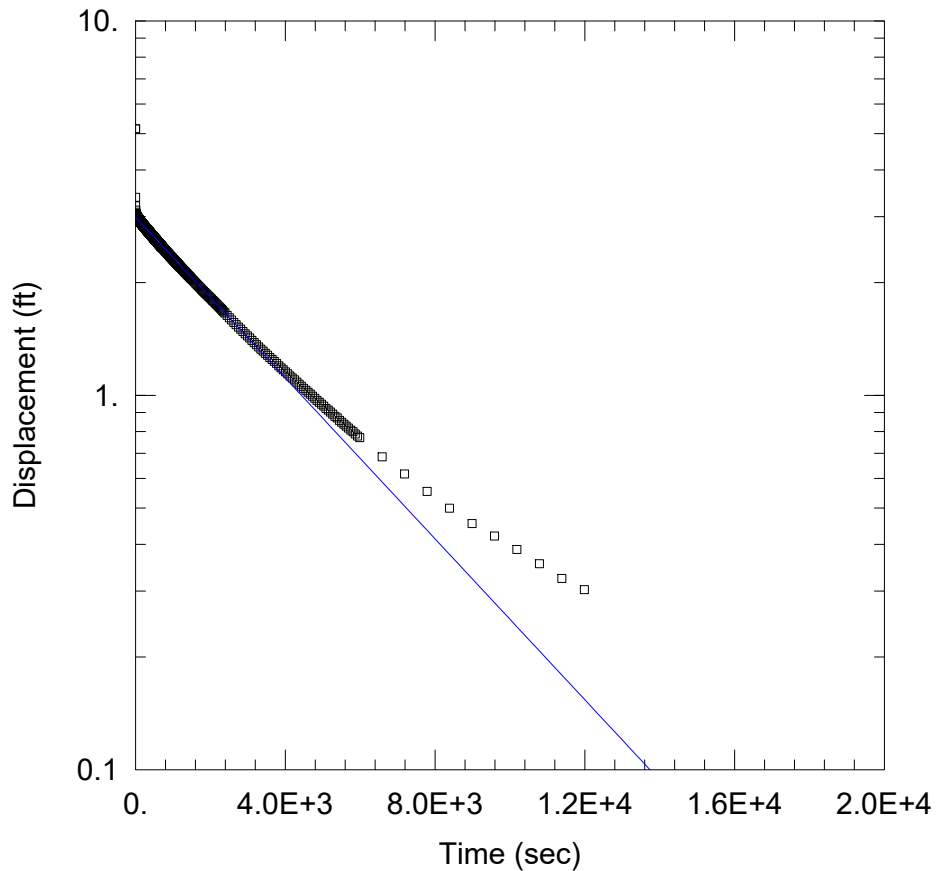
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

$K = 9.242E-6$ cm/sec

$y_0 = 2.992$ ft



OUT-B

Data Set: Y:\...\WBSP-15-07_OUT-B-H.aqt

Date: 08/19/16

Time: 14:43:40

PROJECT INFORMATION

Company: AGES, Inc.

Client: OVEC

Project: 2016002

Location: Clifty Creek Station

Test Well: WBSP-15-07

Test Date: 05/17/2016

AQUIFER DATA

Saturated Thickness: 15.17 ft

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (WBSP-15-07)

Initial Displacement: 5.152 ft

Static Water Column Height: 17.19 ft

Total Well Penetration Depth: 55. ft

Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.333 ft

SOLUTION

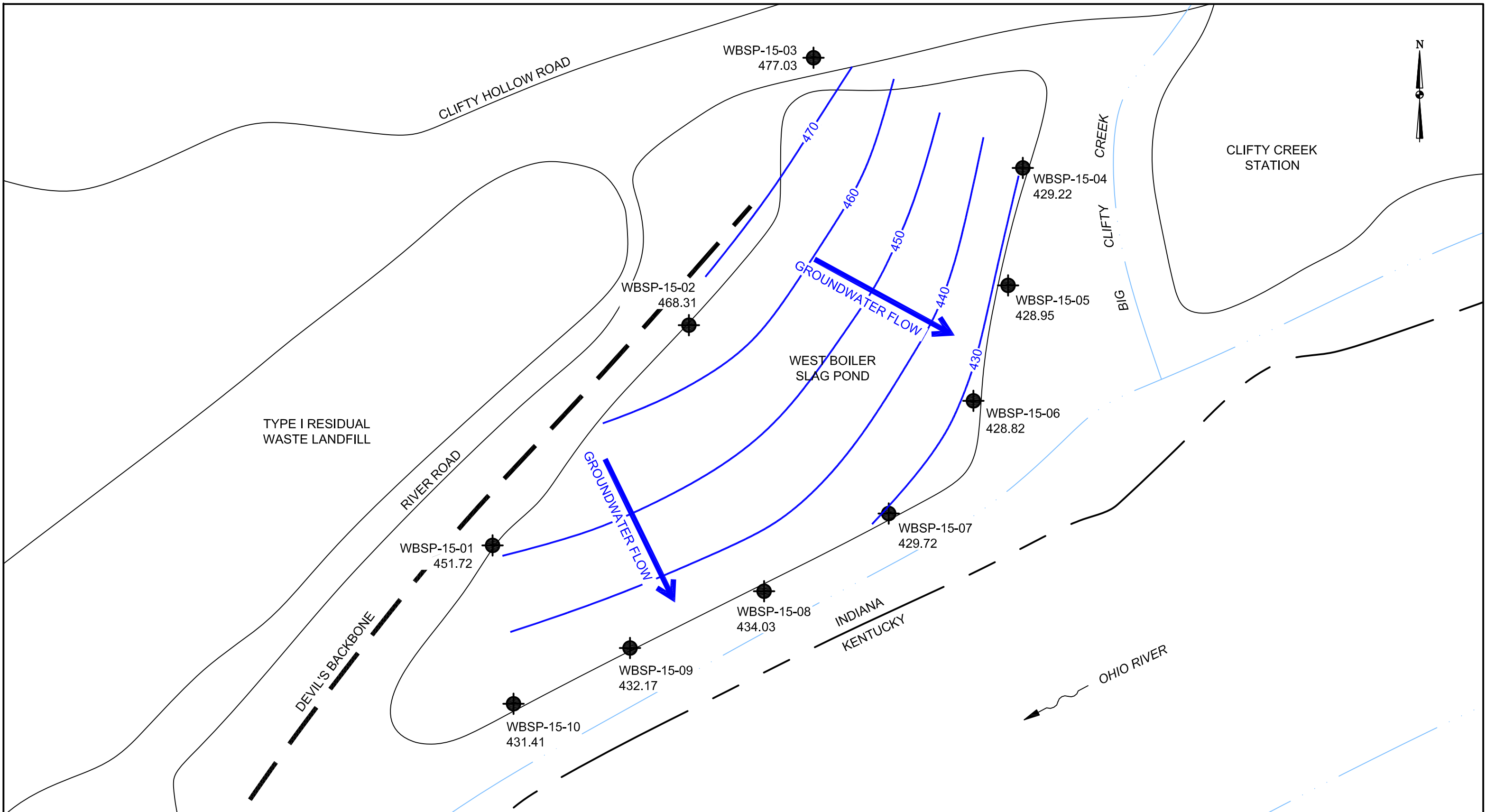
Aquifer Model: Confined

Solution Method: Hvorslev

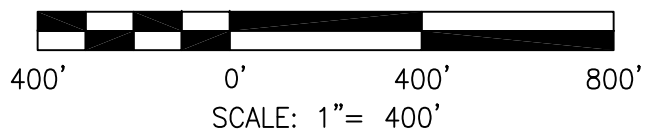
$K = 1.064E-5$ cm/sec

$y_0 = 2.992$ ft

APPENDIX E2 – GROUNDWATER CONTOUR MAPS



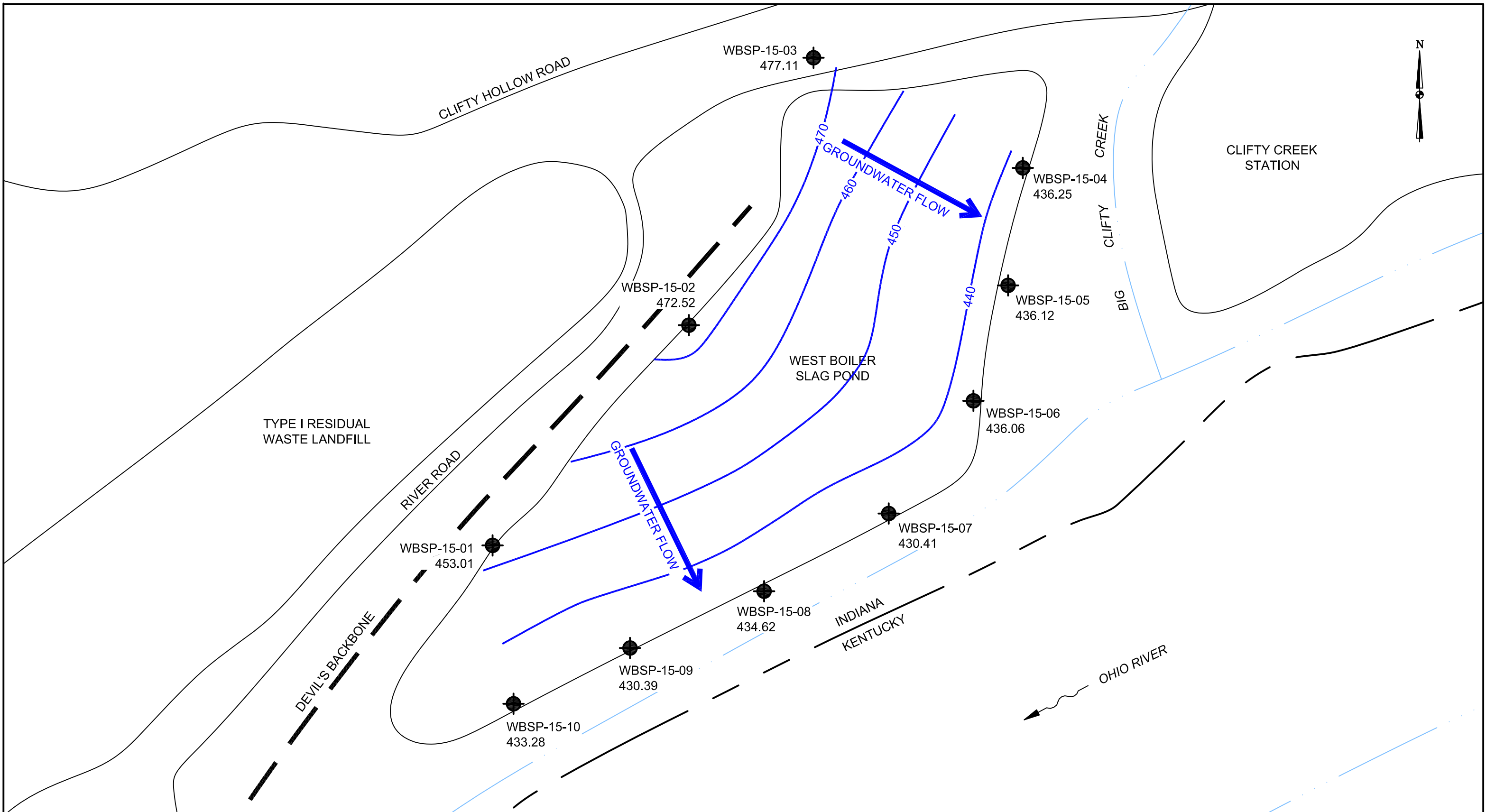
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION



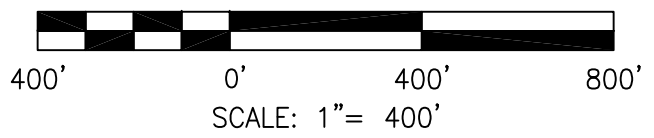
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DATE	
CHECKED BY	
JOB NO.	2017114-CLI
DWG FILE	IKEC_Clifty_Corrective Action_Appx B_Jan16 b01.dwg
DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS & FLOW DIRECTION - JANUARY 2016	
DRAWING NAME	FIGURE B-19
REV.	0



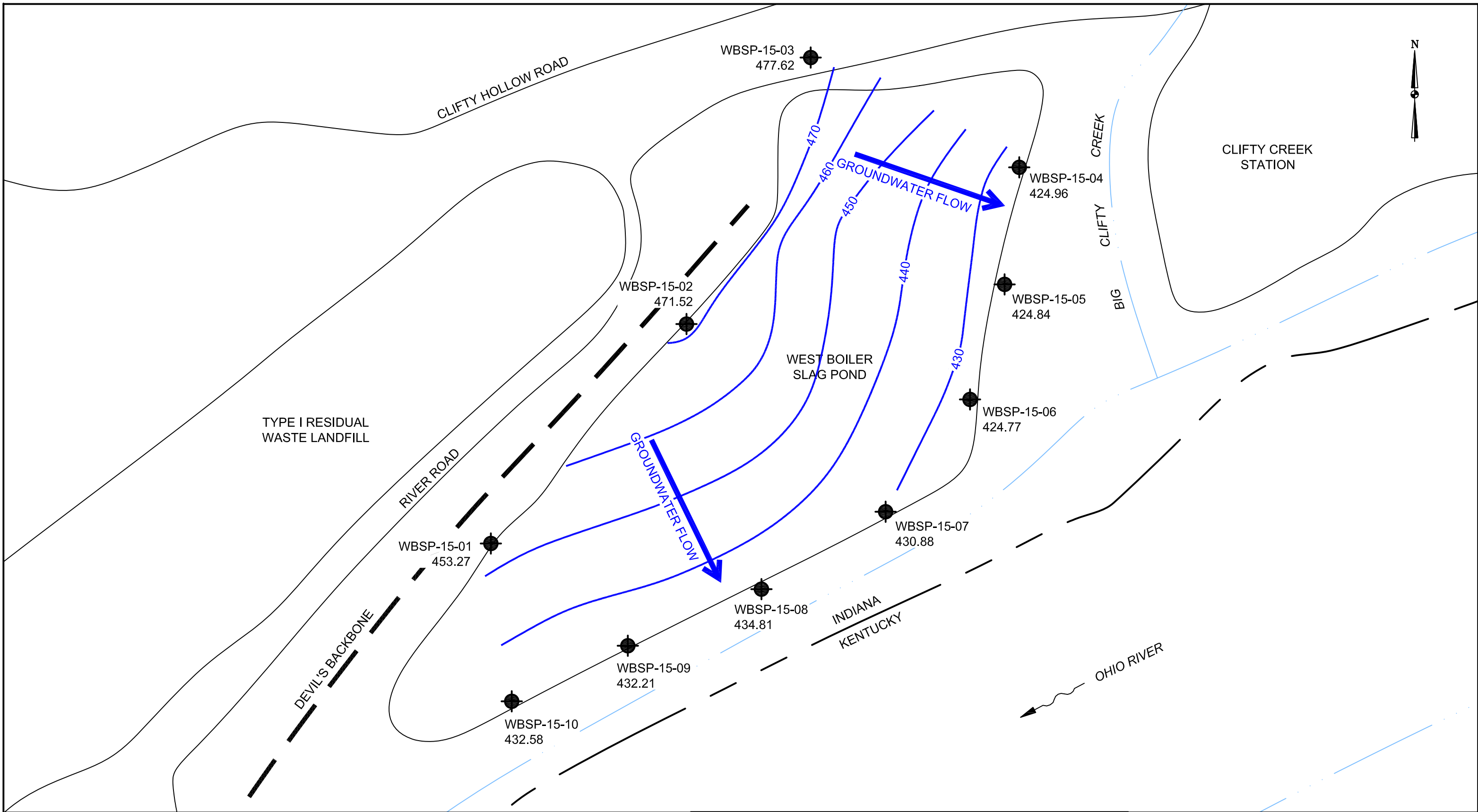
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION



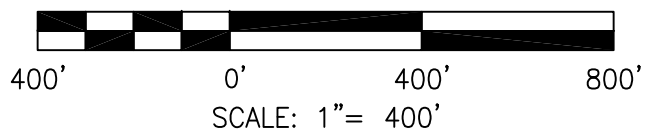
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JOB NO.	2017114-CLI
DWG FILE	IKEC_Clifty_Corrective Action_Appx B_Mar16 b02.dwg
DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS & FLOW DIRECTION - MARCH 2016	
DRAWING NAME	FIGURE B-20
REV.	0



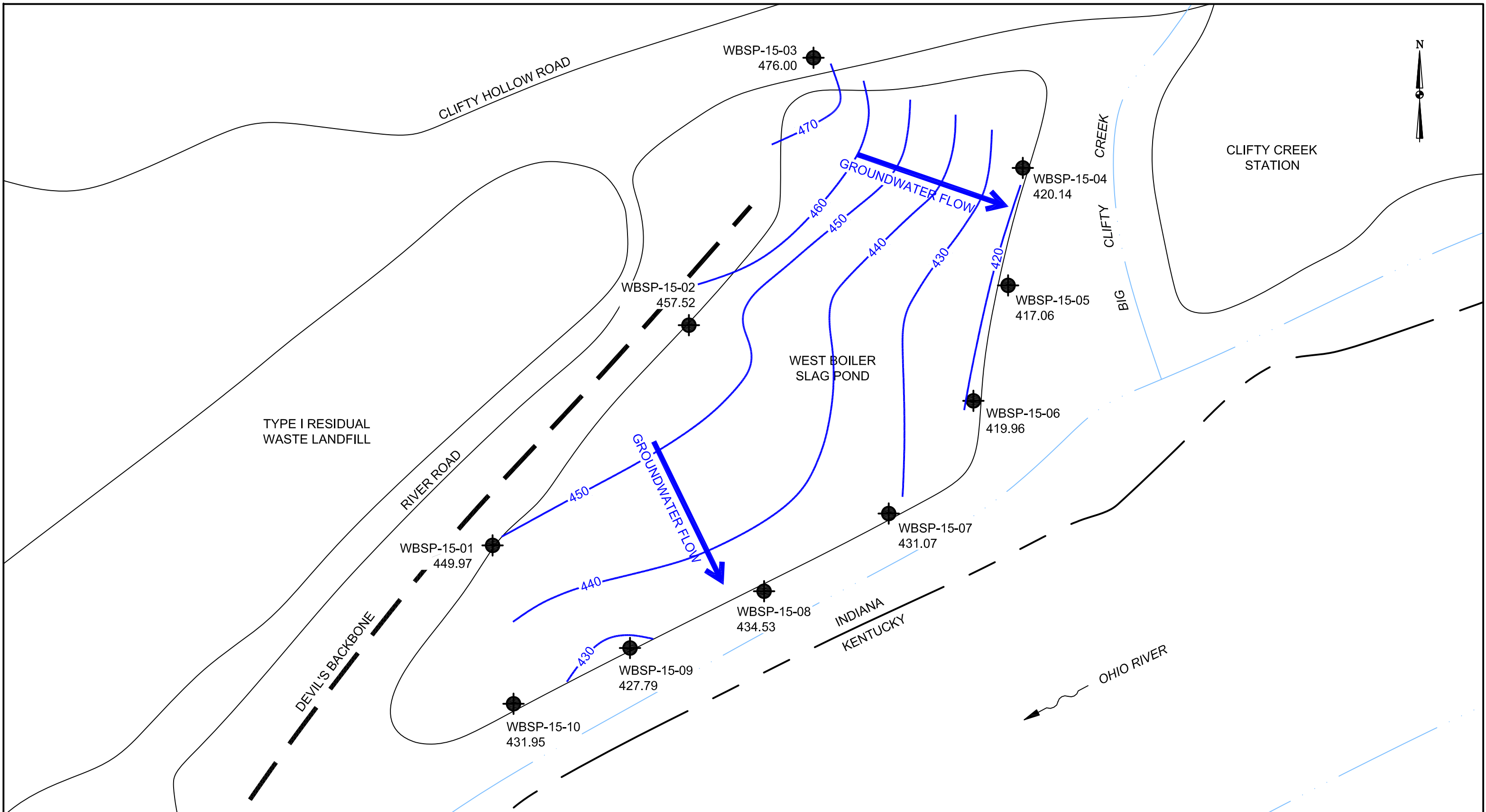
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION



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DATE	
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JOB NO.	2017114-CLI
DWG FILE	IKEC_Clifty_Corrective Action_Appx B_May16 b03.dwg
DRAWING SCALE	AS SHOWN

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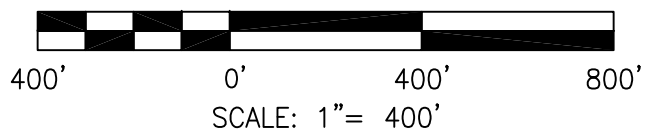
INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS & FLOW DIRECTION - MAY 2016	
DRAWING NAME	FIGURE B-21
REV.	0



LEGEND:

● MONITORING WELL LOCATION

← GROUNDWATER FLOW DIRECTION

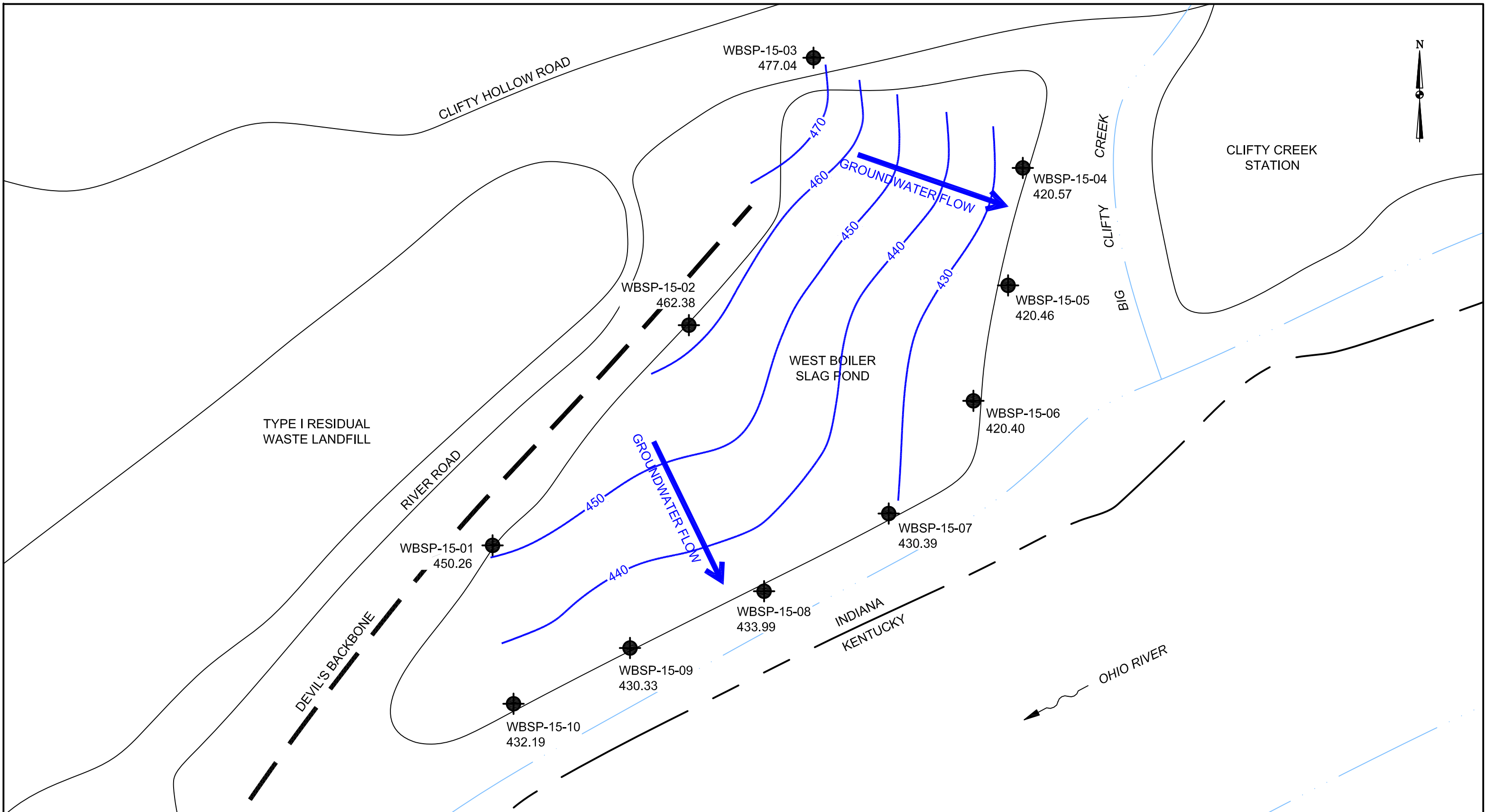


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JOB NO.	2017114-CLI
DWG FILE	IKEC_Clifty_Corrective Action_Appx B_July16 b04.dwg
DRAWING SCALE	AS SHOWN

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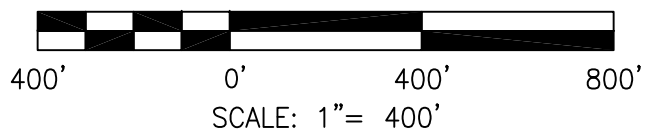
INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS & FLOW DIRECTION - JULY 2016	
DRAWING NAME	FIGURE B-22
REV.	0



LEGEND:

● MONITORING WELL LOCATION

← GROUNDWATER FLOW DIRECTION

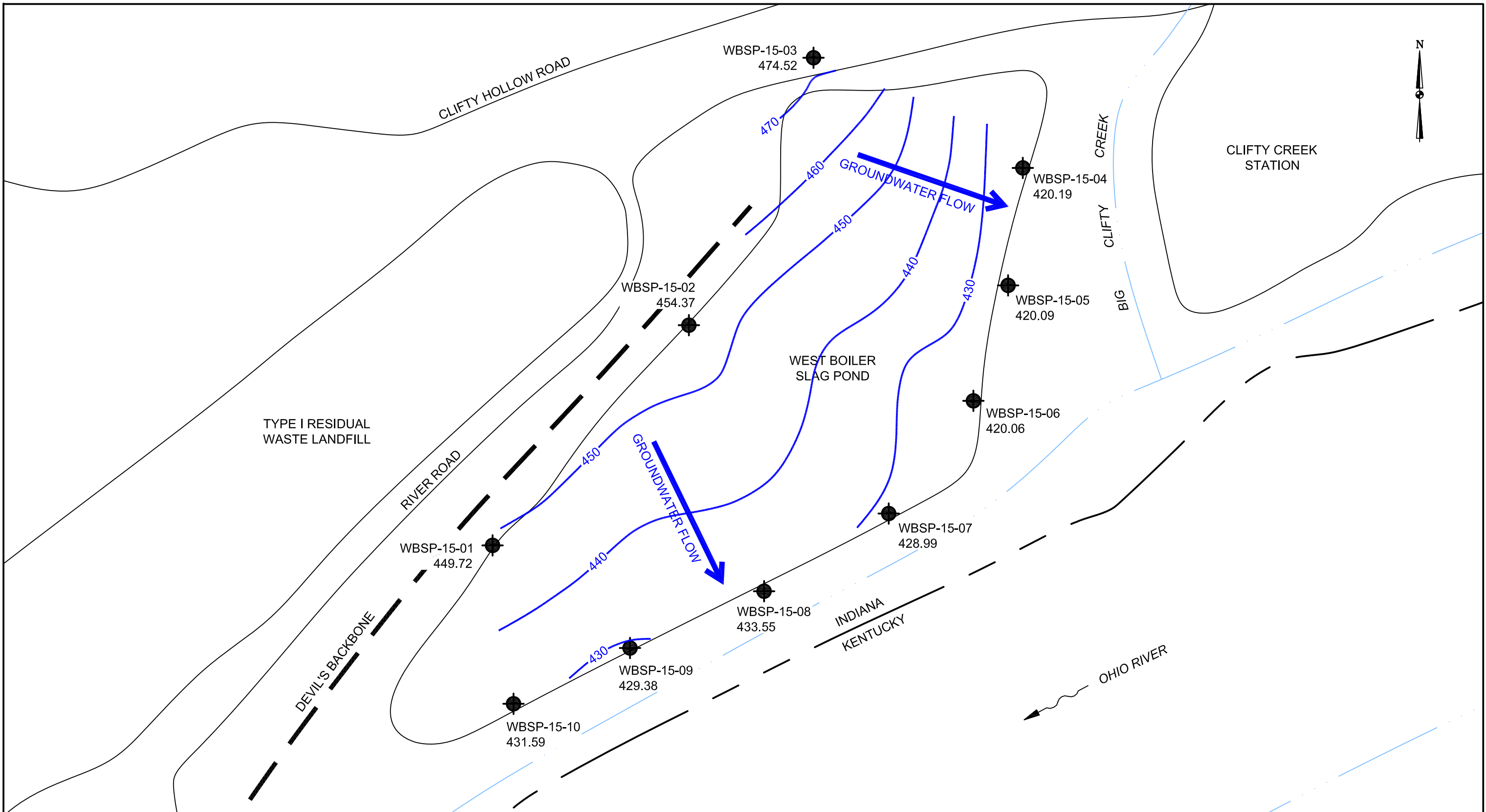


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JOB NO.	2017114-CLI
DWG FILE	IKEC_Clifty_Corrective Action_Appx B_Aug16 b05.dwg
DRAWING SCALE	AS SHOWN

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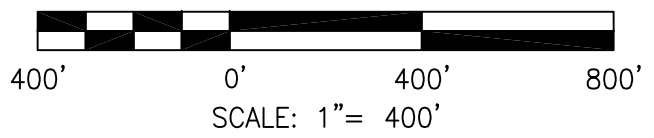
INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS & FLOW DIRECTION - AUGUST 2016	
DRAWING NAME	FIGURE B-23
REV.	0



LEGEND:

● MONITORING WELL LOCATION

← GROUNDWATER FLOW DIRECTION

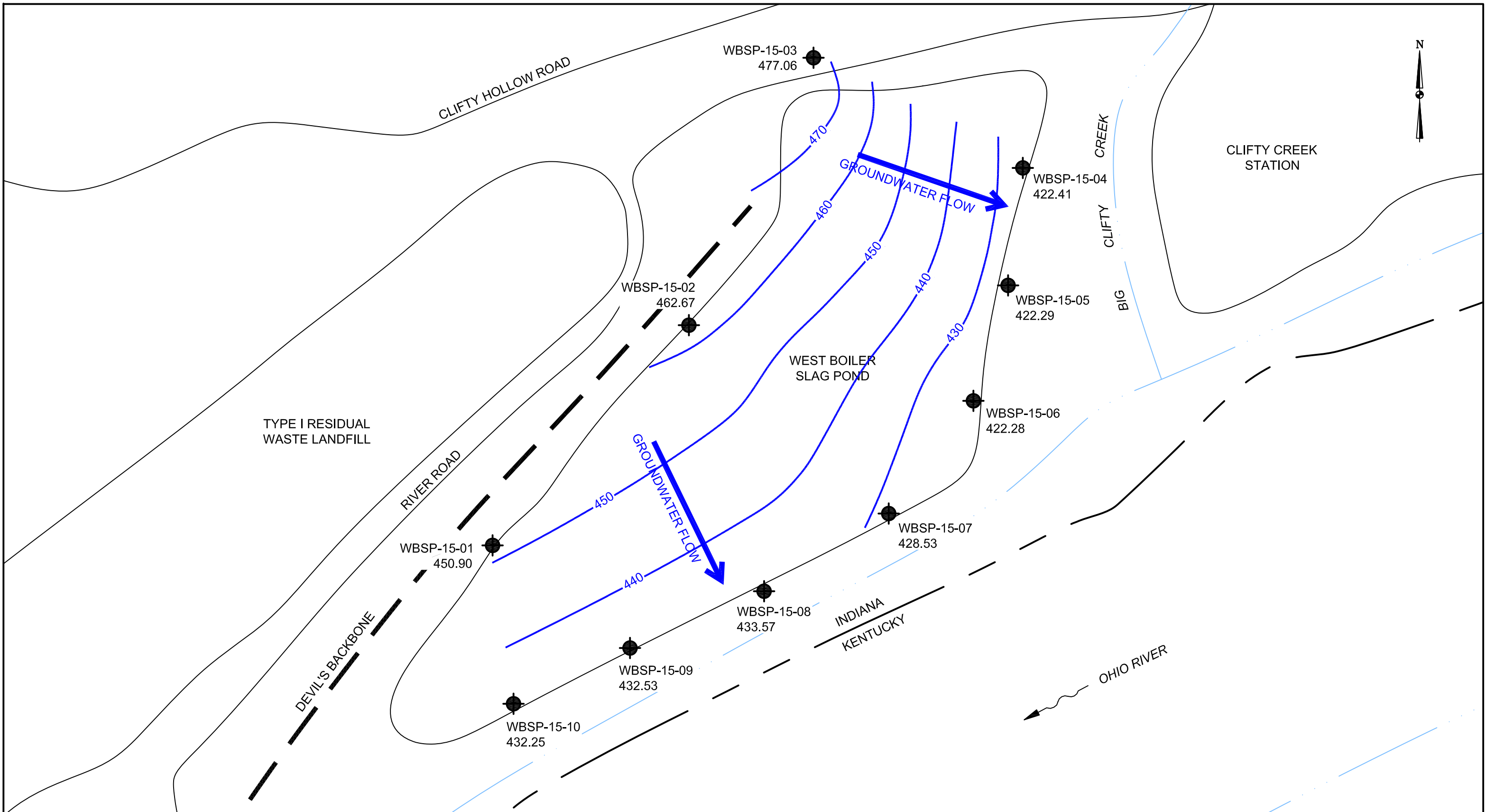


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DRAWING SCALE	AS SHOWN

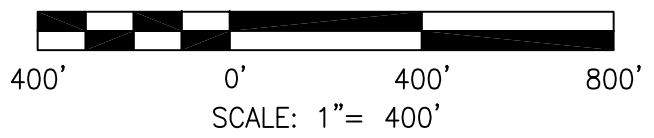
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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS & FLOW DIRECTION - NOVEMBER 2016	
DRAWING NAME	FIGURE B-24
REV.	0



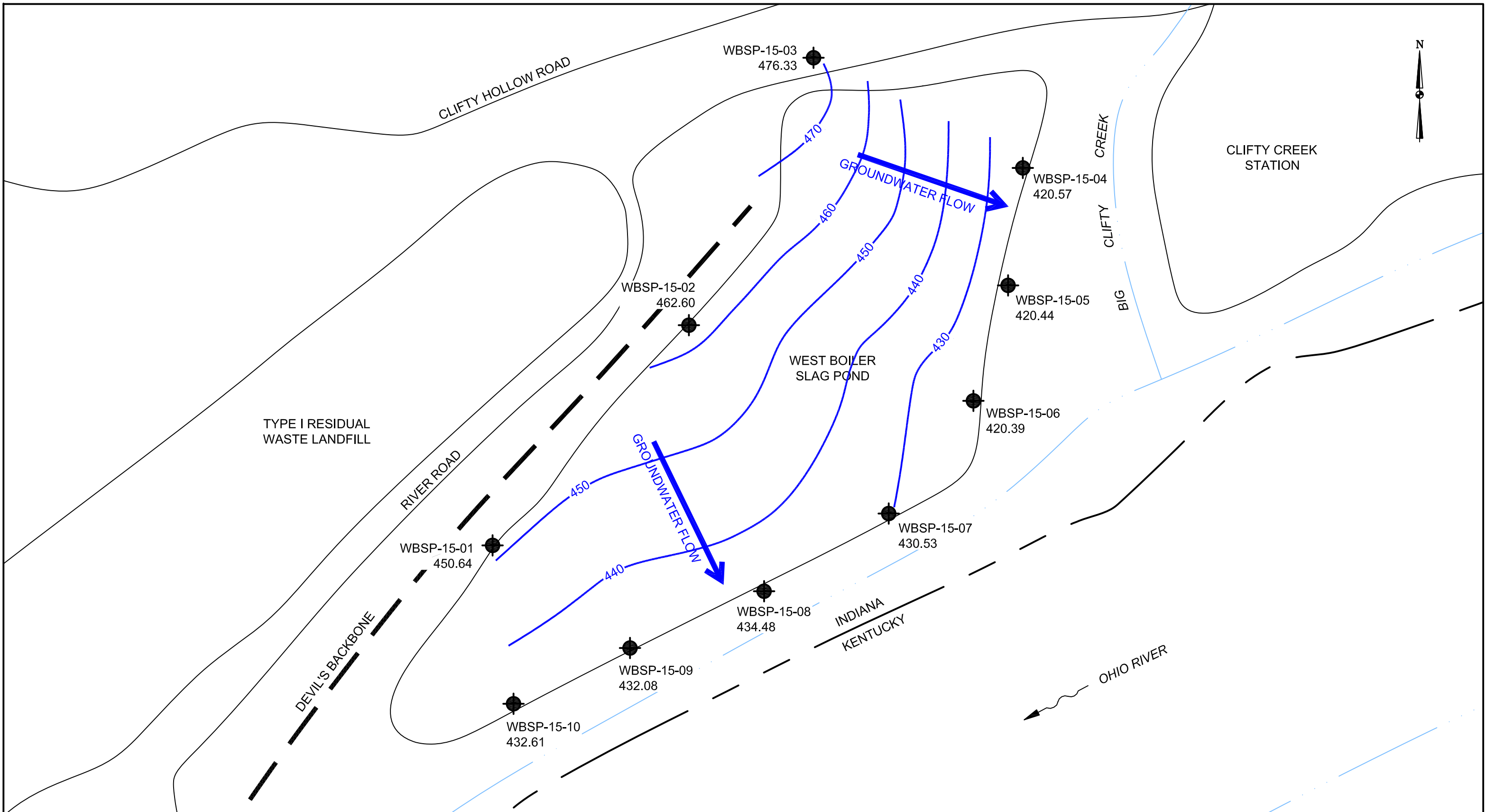
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION



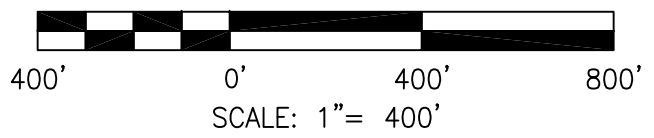
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CHECKED BY	
JOB NO.	2017114-CLI
DWG FILE	IKEC_Clifty_Corrective Action_Appx B_Feb17 b07.dwg
DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS & FLOW DIRECTION - FEBRUARY 2017	
DRAWING NAME	FIGURE B-25
REV.	0



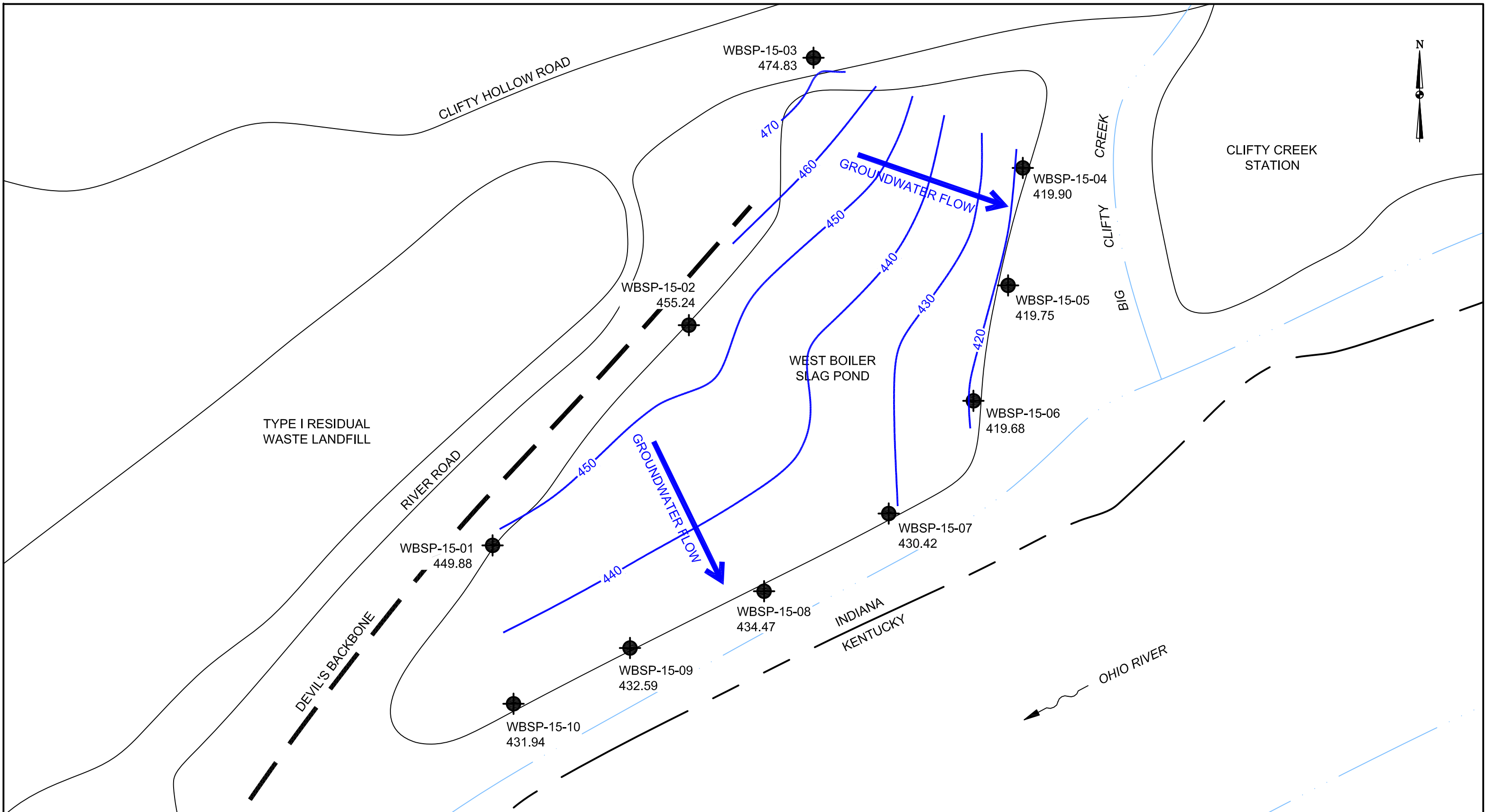
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION



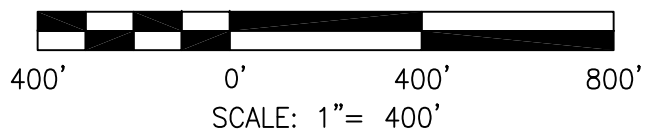
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DATE	
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JOB NO.	2017114-CLI
DWG FILE	IKEC_Clifty_Corrective Action_Appx B_Jun17 b08.dwg
DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS & FLOW DIRECTION - JUNE 2017	
DRAWING NAME	FIGURE B-26
REV.	0



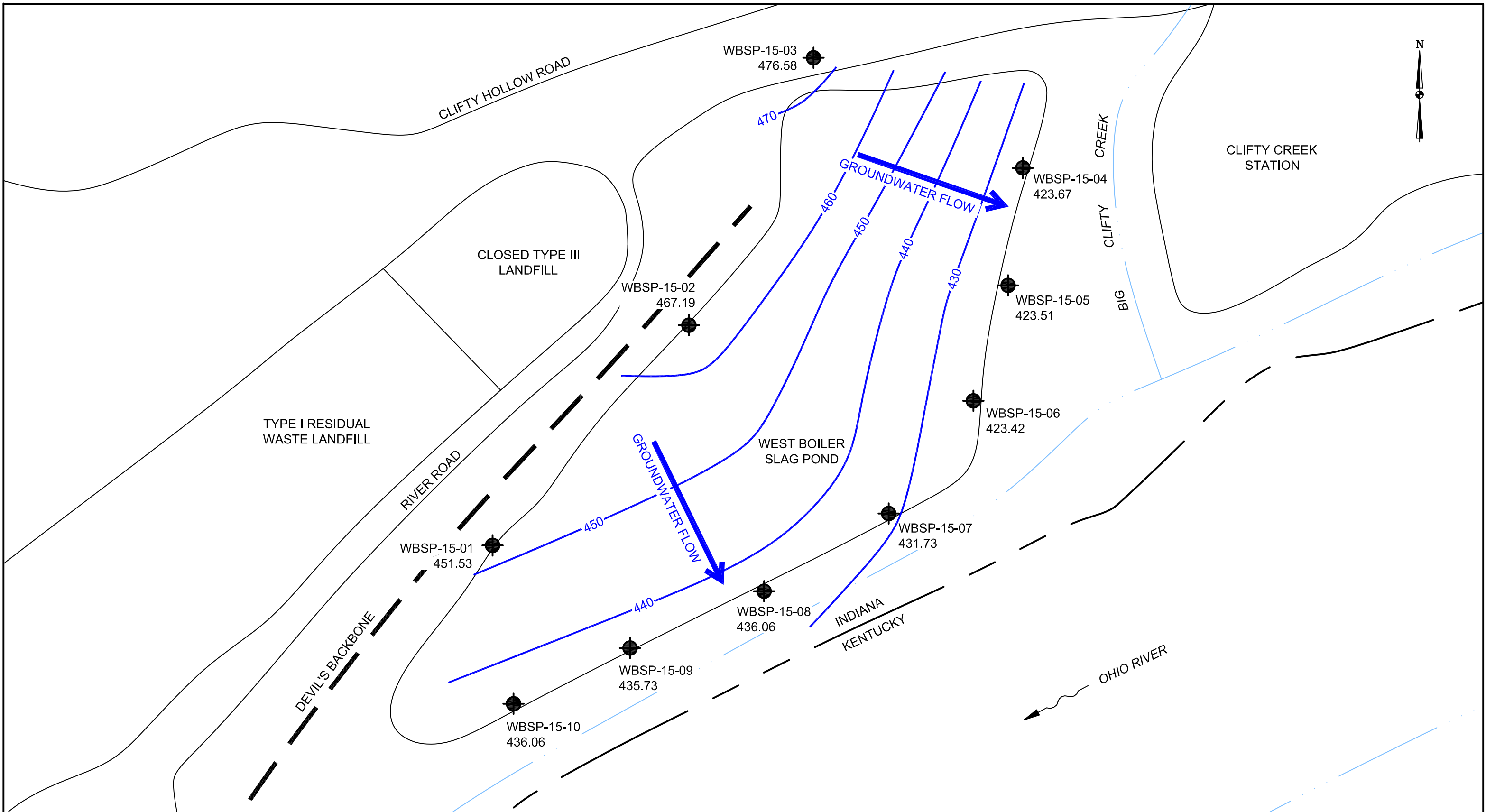
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION



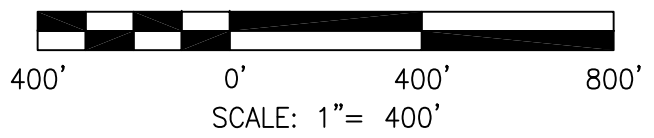
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DATE	
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JOB NO.	2017114-CLI
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DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS & FLOW DIRECTION - AUGUST 2017	
DRAWING NAME	FIGURE B-27
REV.	0



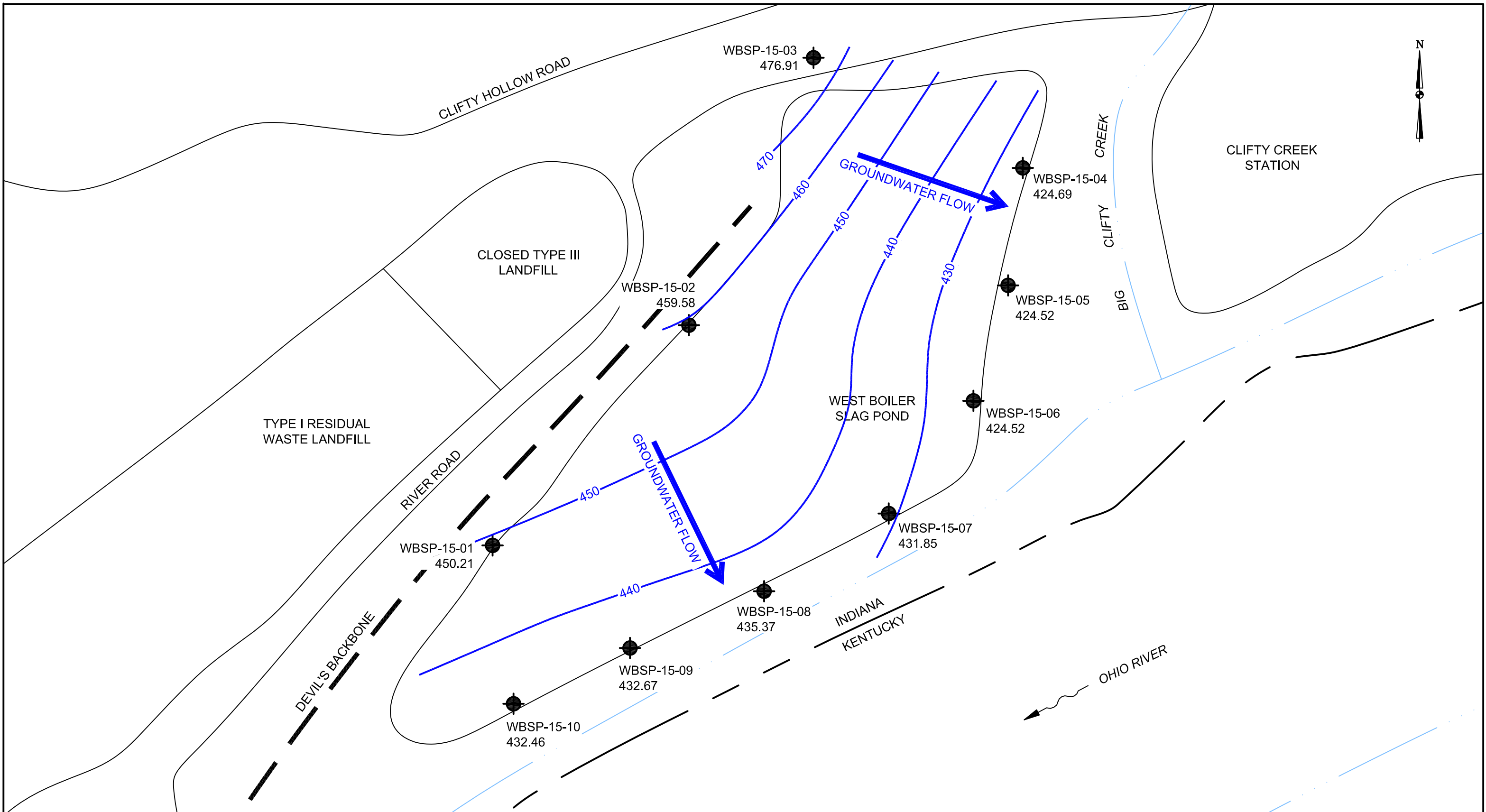
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION



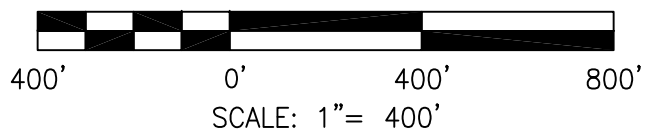
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DATE	
CHECKED BY	
JOB NO.	2017114-CLI
DWG. FILE	2018_IKEC_Clifty_Corrective Action_Appx B_MAR18 b10.dwg
DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS & FLOW DIRECTION - MARCH 2018	
DRAWING NAME	FIGURE B-2
REV.	0



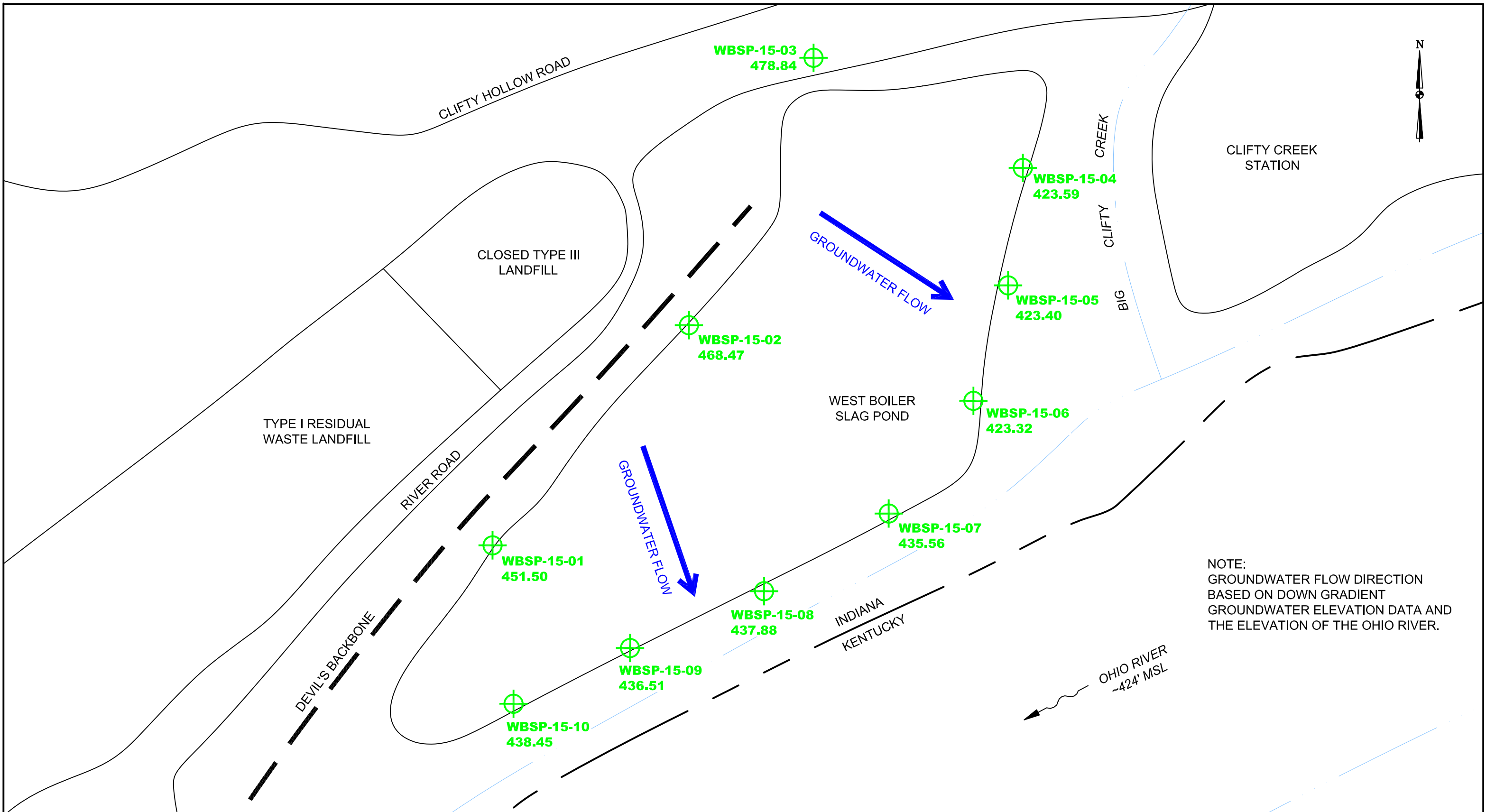
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION



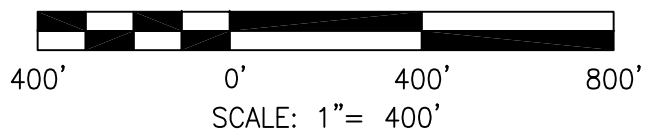
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CHECKED BY	
JOB NO.	2017114-CLI
DWG. FILE	2018_IKEC_Clifty_Corrective Action_Appx B_OCT18 b11.dwg
DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS & FLOW DIRECTION - OCTOBER 2018	
DRAWING NAME	FIGURE B-4
REV.	0



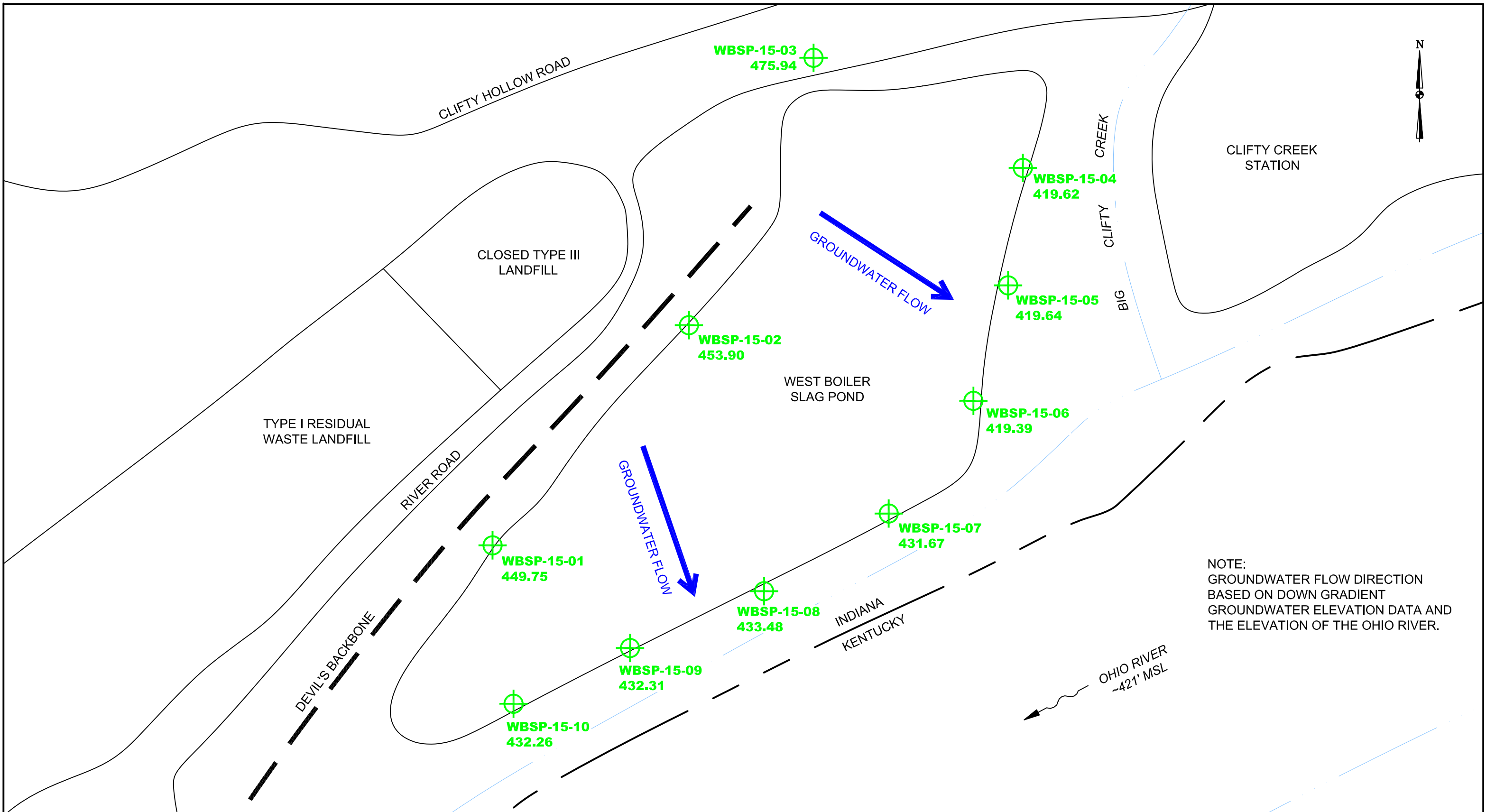
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION



DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019008-CLI
DWG. FILE	2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_MAR19_WBSP.dwg
DRAWING SCALE	AS SHOWN

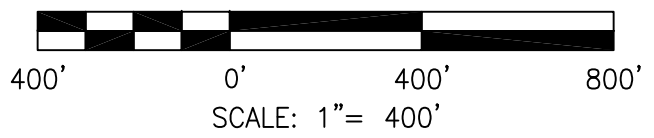
2402 Hookstown Grade Road, Suite 200
 Clinton, PA 15026
 412.264.6453

INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS AND FLOW DIRECTION MARCH 2019	
DRAWING NAME	FIGURE B-4
REV.	0



NOTE:
GROUNDWATER FLOW DIRECTION
BASED ON DOWN GRADIENT
GROUNDWATER ELEVATION DATA AND
THE ELEVATION OF THE OHIO RIVER.

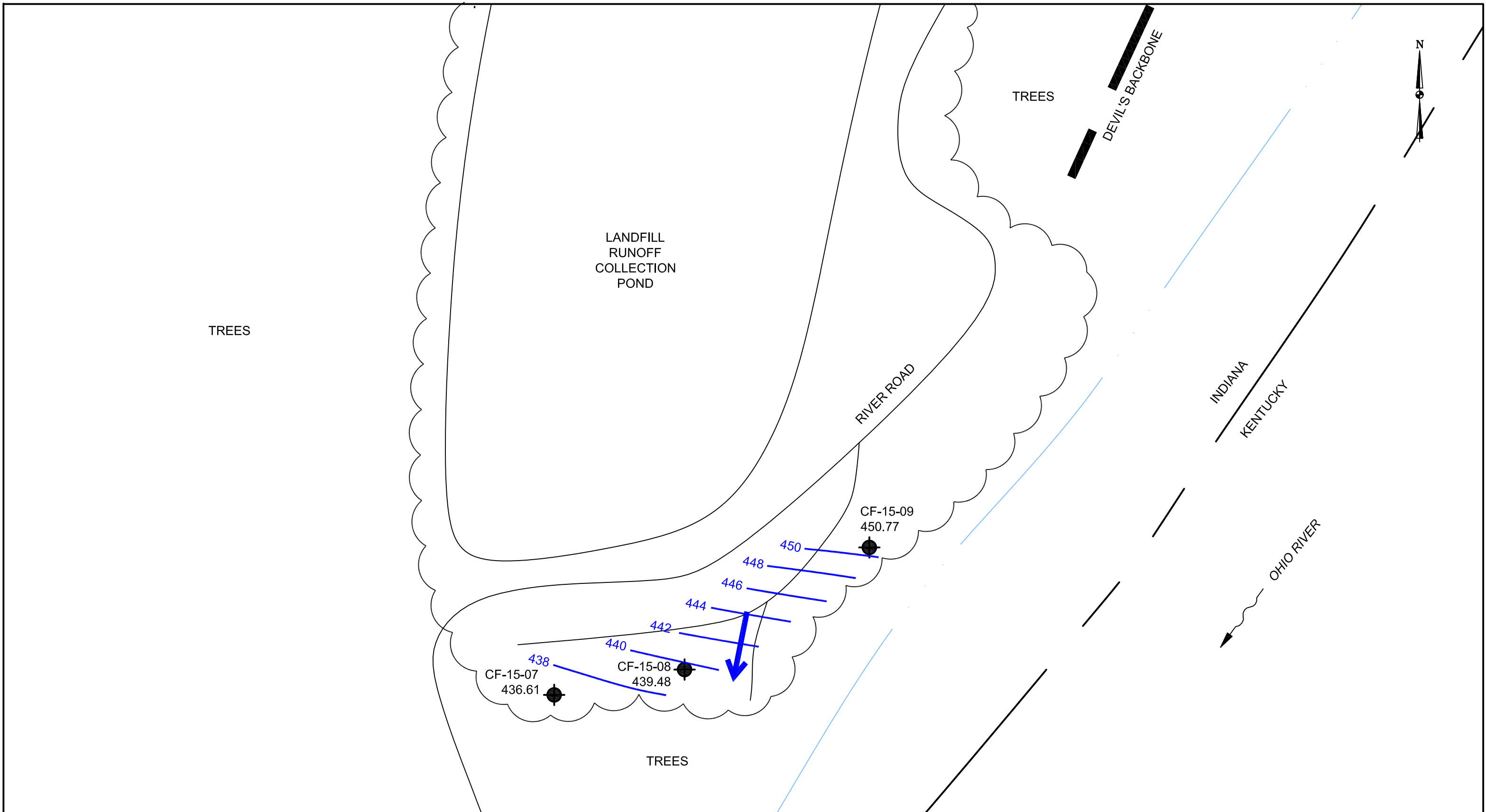
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION





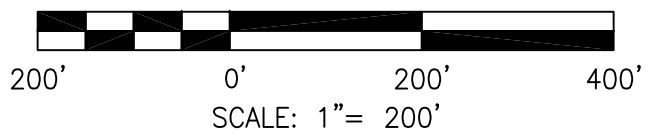
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CHECKED BY	
JOB NO.	2019008-CLI
DWG. FILE	2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_OCT19_WBSP.dwg
DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GROUNDWATER LEVELS AND FLOW DIRECTION OCTOBER 2019	
DRAWING NAME	FIGURE B-5
REV.	0



LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION

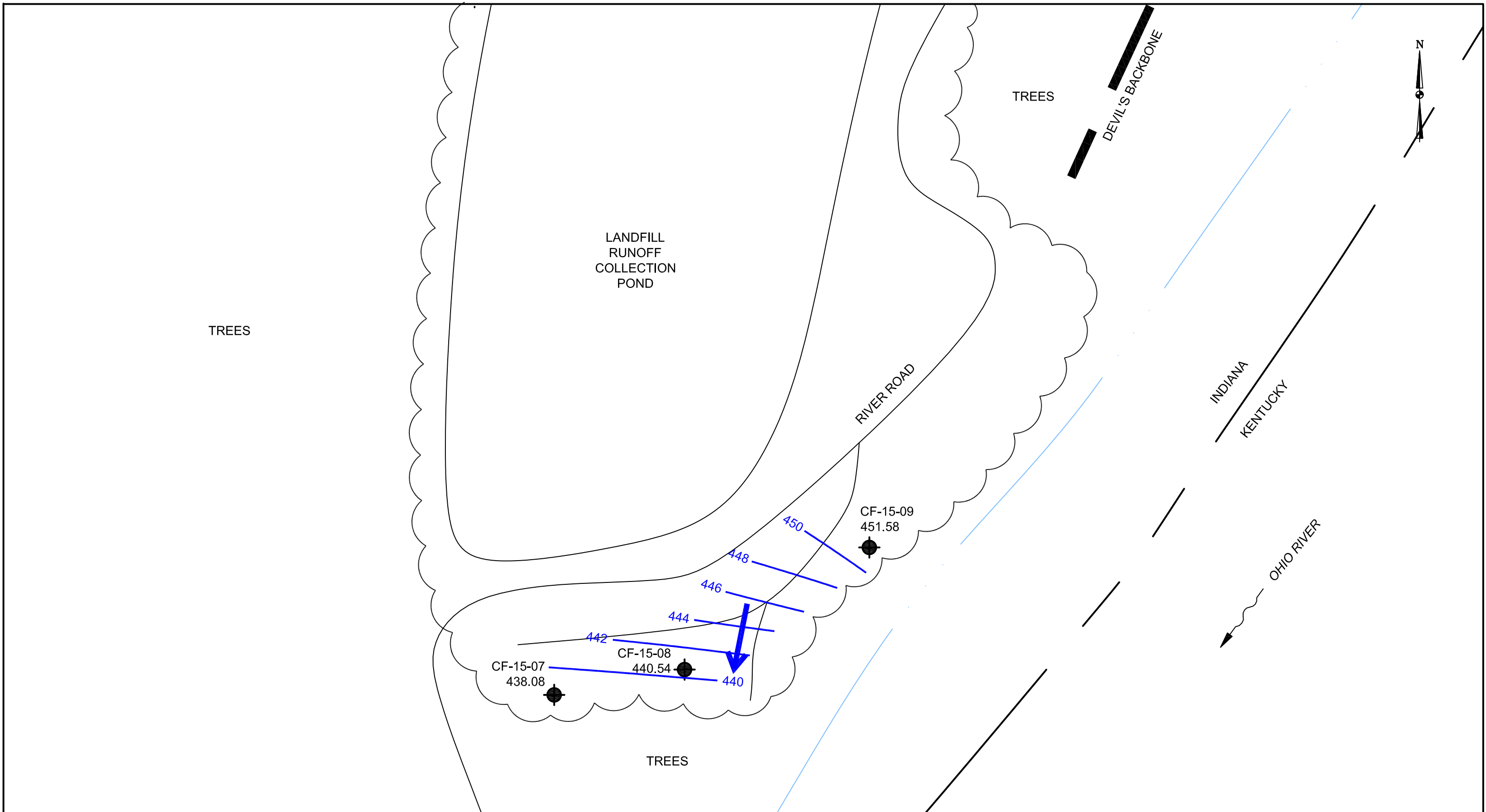


DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2017114-CLI
DWG FILE	IKEC_Clifty_Corrective Action_Appx B_Jan16 b01.dwg
DRAWING SCALE	AS SHOWN

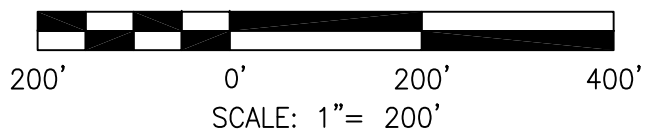


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CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND - SOUTHWEST END GROUNDWATER LEVELS & FLOW DIRECTION - JANUARY 2016	
DRAWING NAME	REV.
FIGURE B-10	0



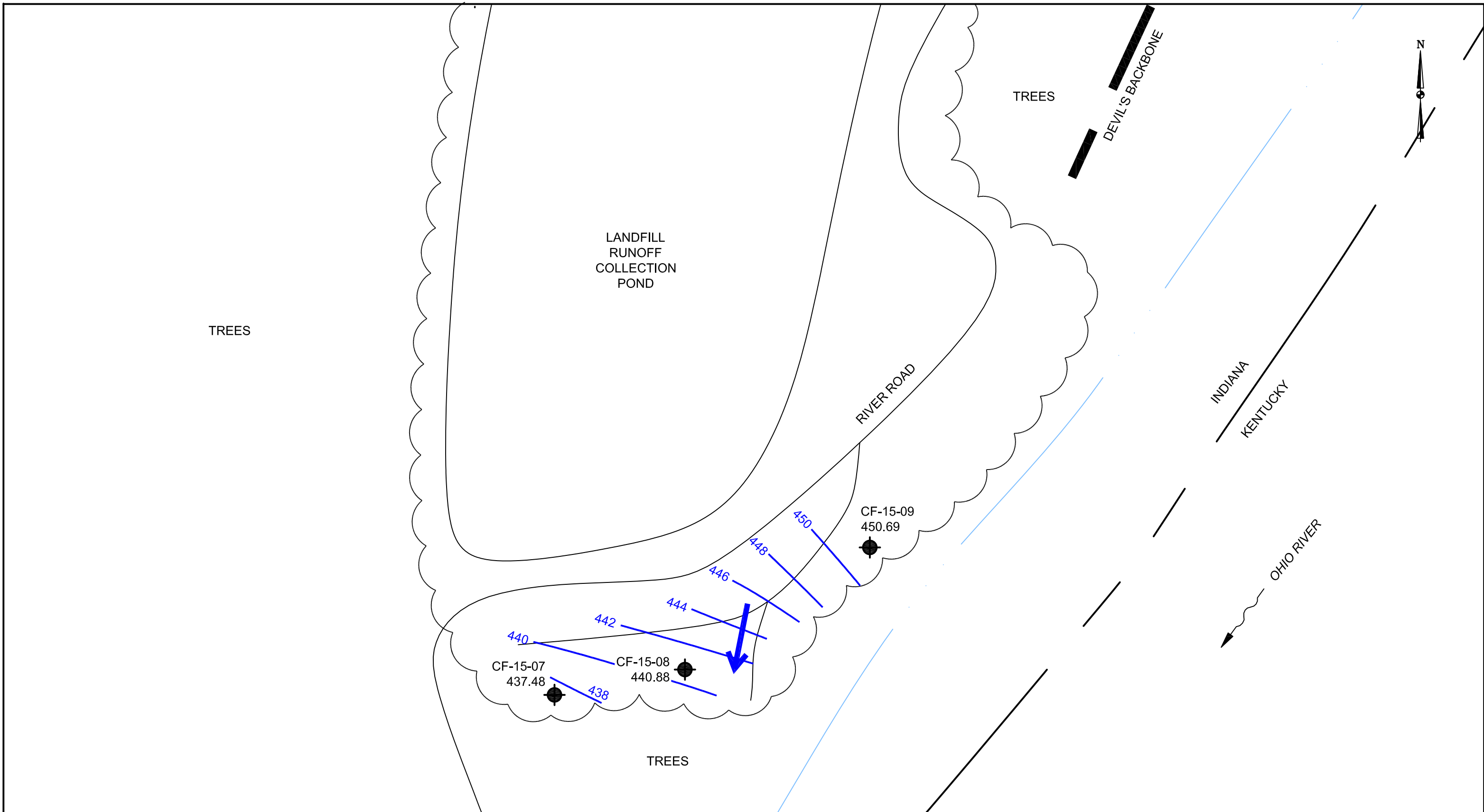
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION





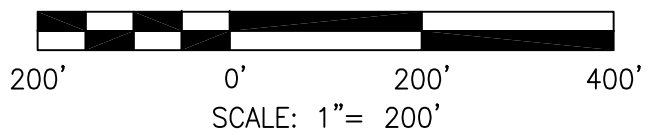
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JOB NO.	2017114-CLI
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DRAWING SCALE	AS SHOWN

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CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND - SOUTHWEST END GROUNDWATER LEVELS & FLOW DIRECTION - MARCH 2016	
DRAWING NAME	FIGURE B-11
REV.	0



LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION

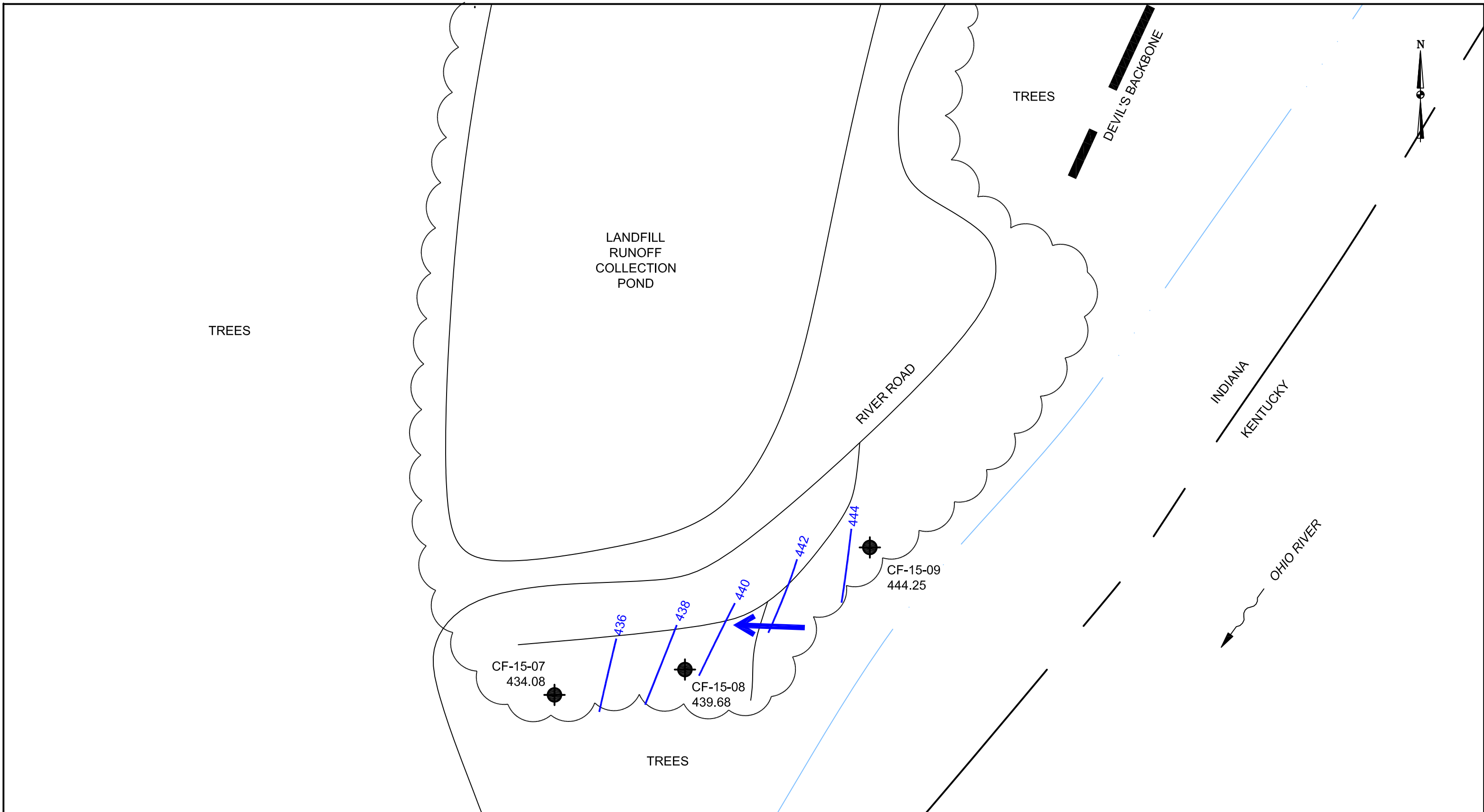




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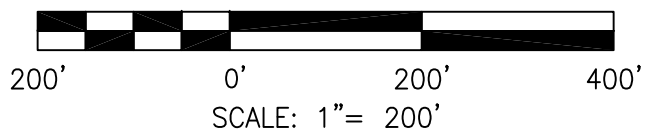


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DRAWING NAME	FIGURE B-12
REV.	0



LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION

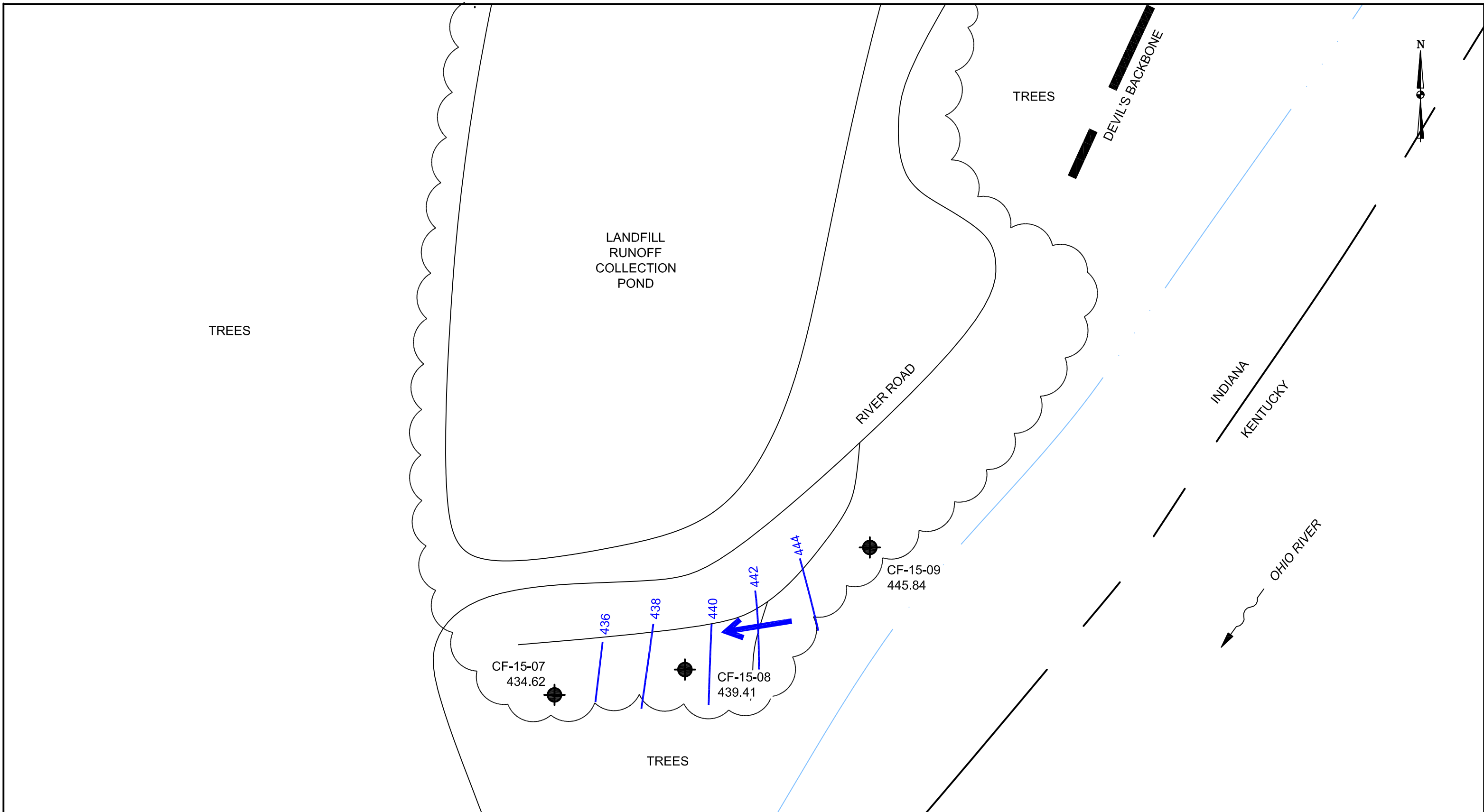




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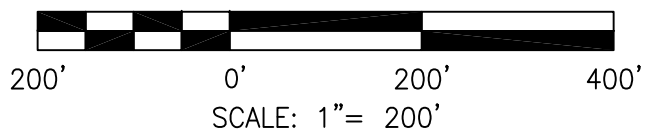


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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND - SOUTHWEST END GROUNDWATER LEVELS & FLOW DIRECTION - JULY 2016	
DRAWING NAME	REV.
FIGURE B-13	0



LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION

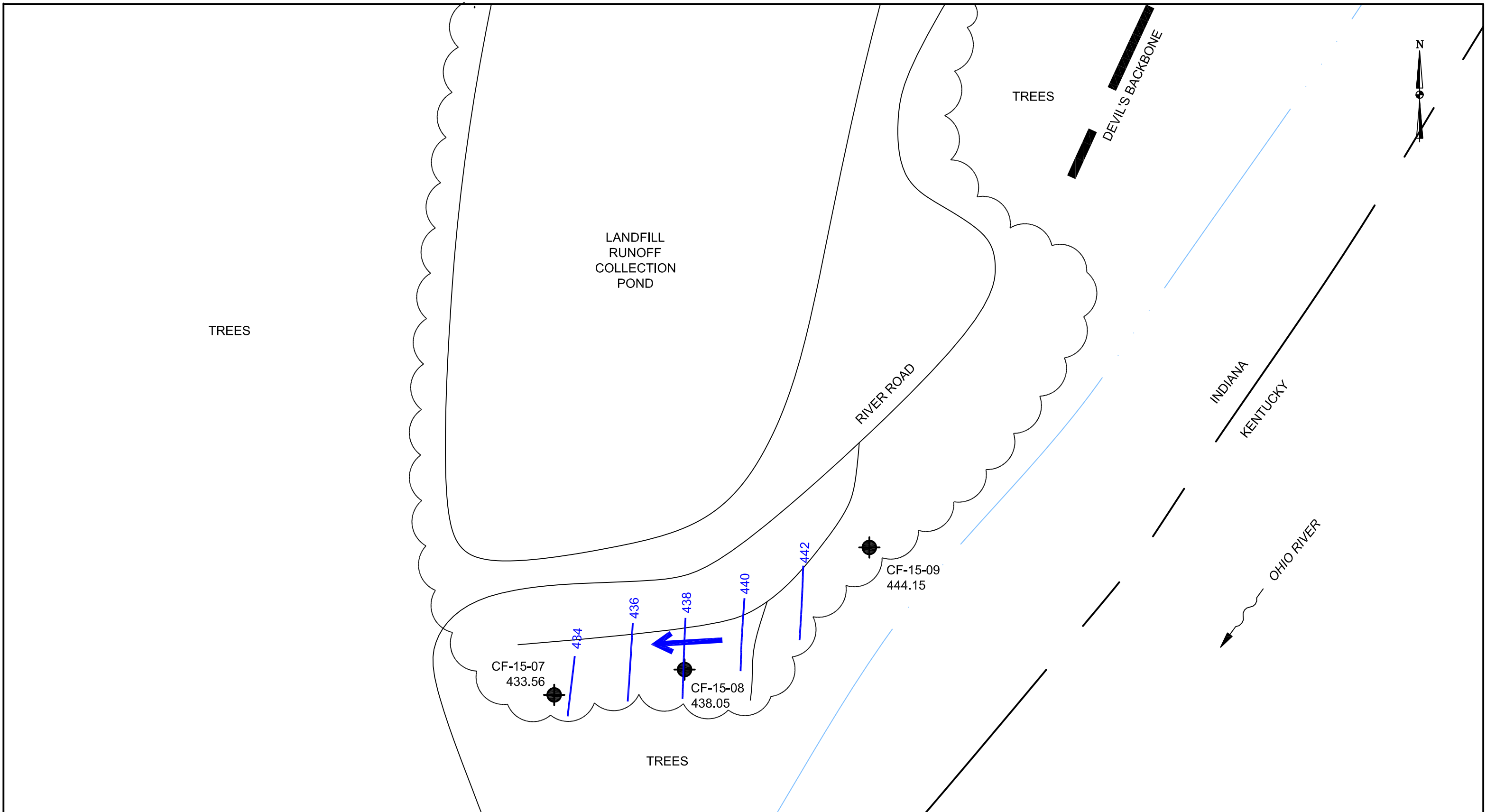


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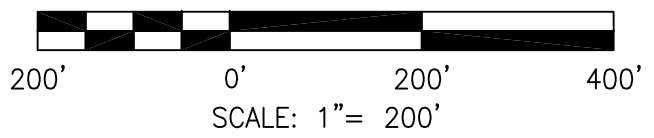


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CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND - SOUTHWEST END GROUNDWATER LEVELS & FLOW DIRECTION - AUGUST 2016	
DRAWING NAME	REV.
FIGURE B-14	0



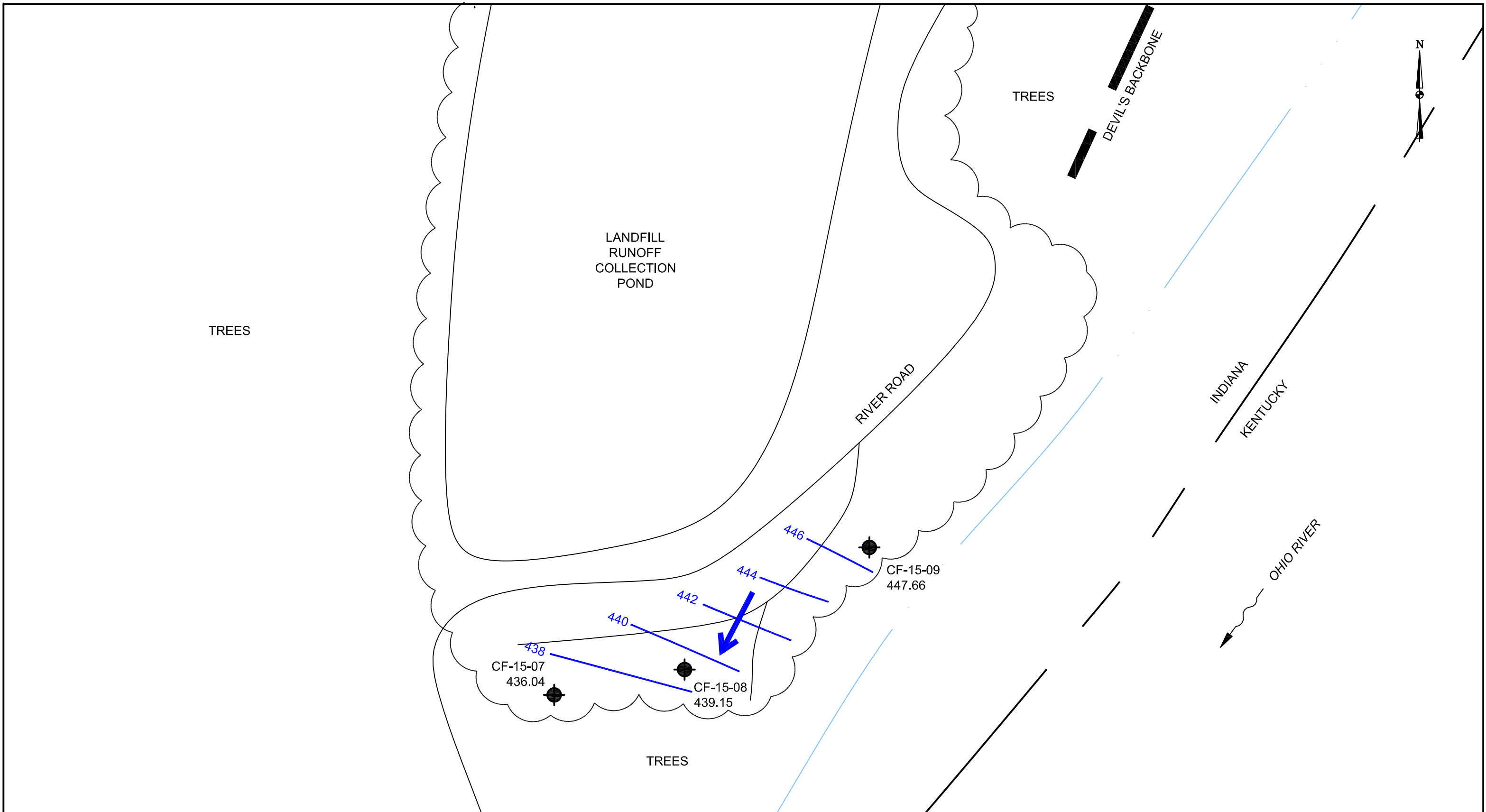
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION





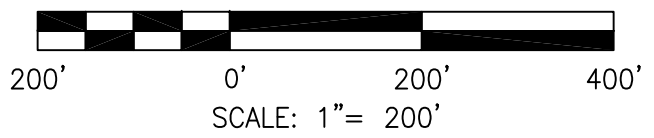
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DRAWING SCALE	AS SHOWN

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CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND - SOUTHWEST END GROUNDWATER LEVELS & FLOW DIRECTION - NOVEMBER 2016	
DRAWING NAME	REV.
FIGURE B-15	0



LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION

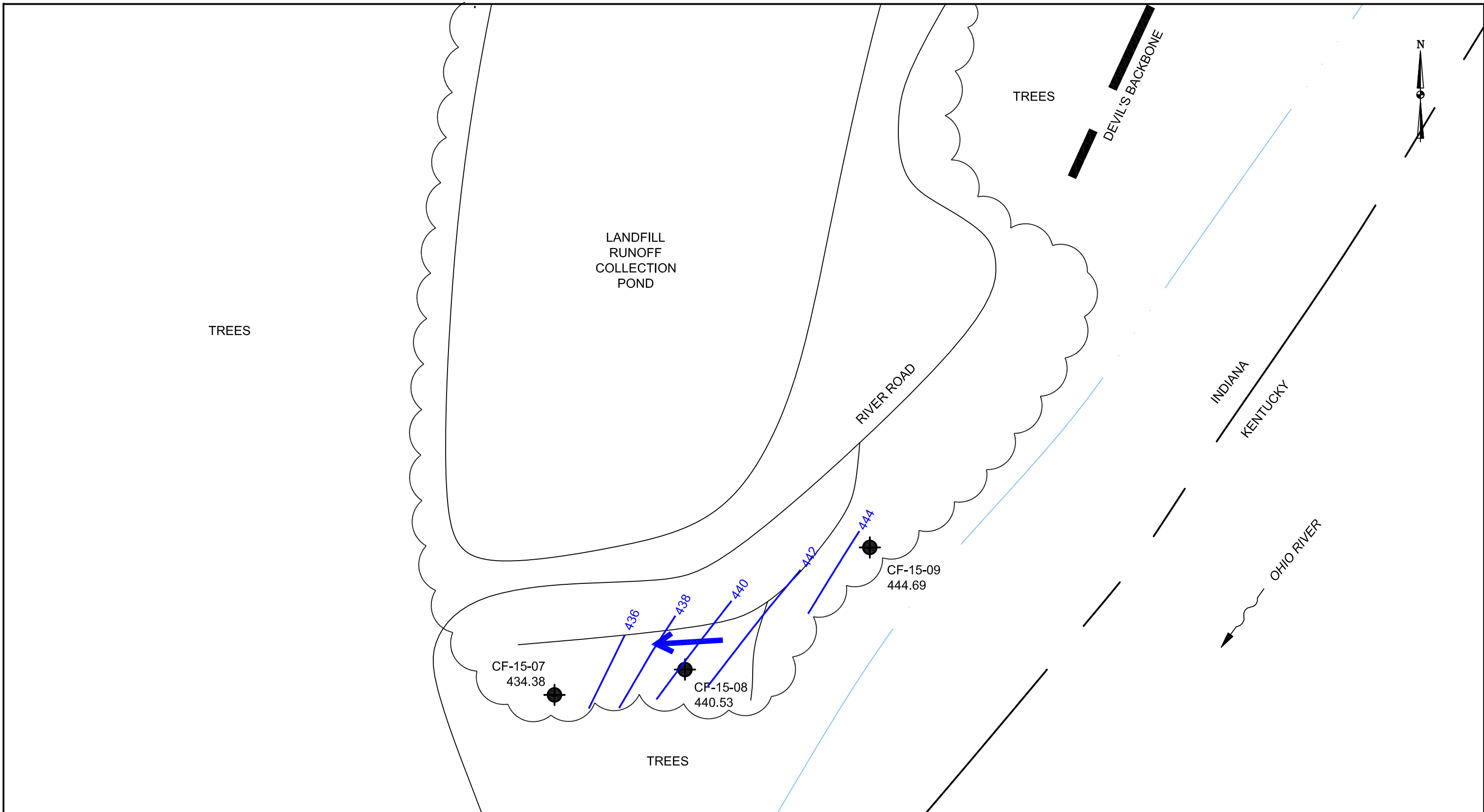




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DRAWING SCALE	AS SHOWN

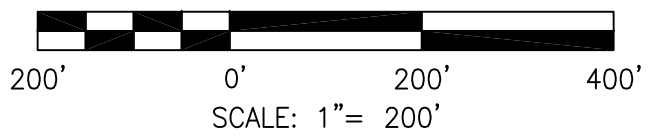


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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND - SOUTHWEST END GROUNDWATER LEVELS & FLOW DIRECTION - FEBRUARY 2017	
DRAWING NAME	FIGURE B-16
REV.	0



LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION

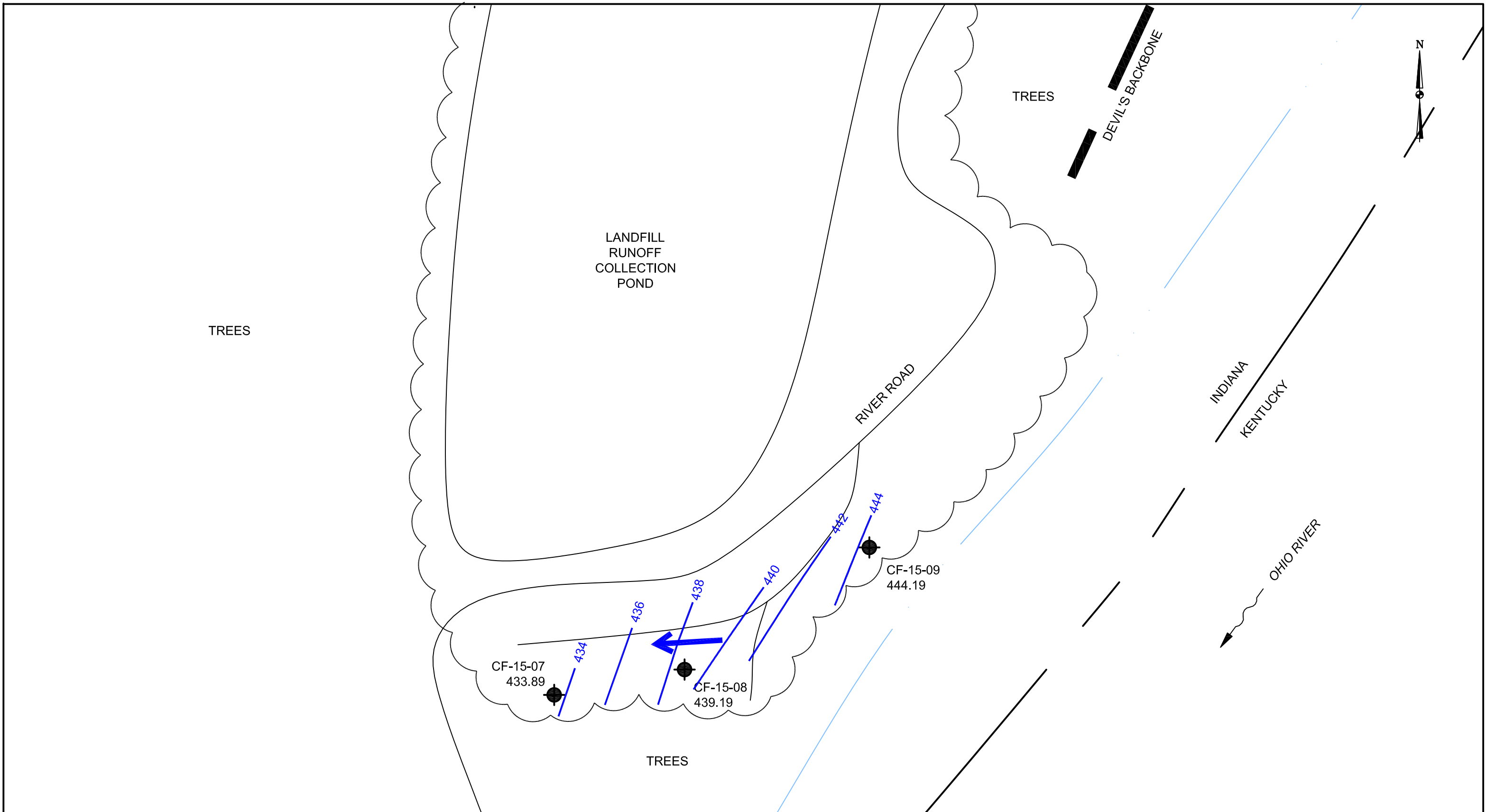




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DRAWING SCALE	AS SHOWN

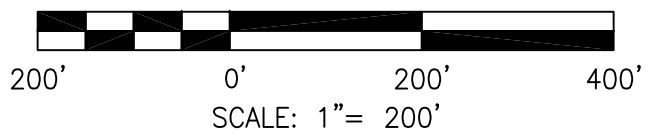


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CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND - SOUTHWEST END GROUNDWATER LEVELS & FLOW DIRECTION - JUNE 2017	
DRAWING NAME	FIGURE B-17
REV.	0



LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION

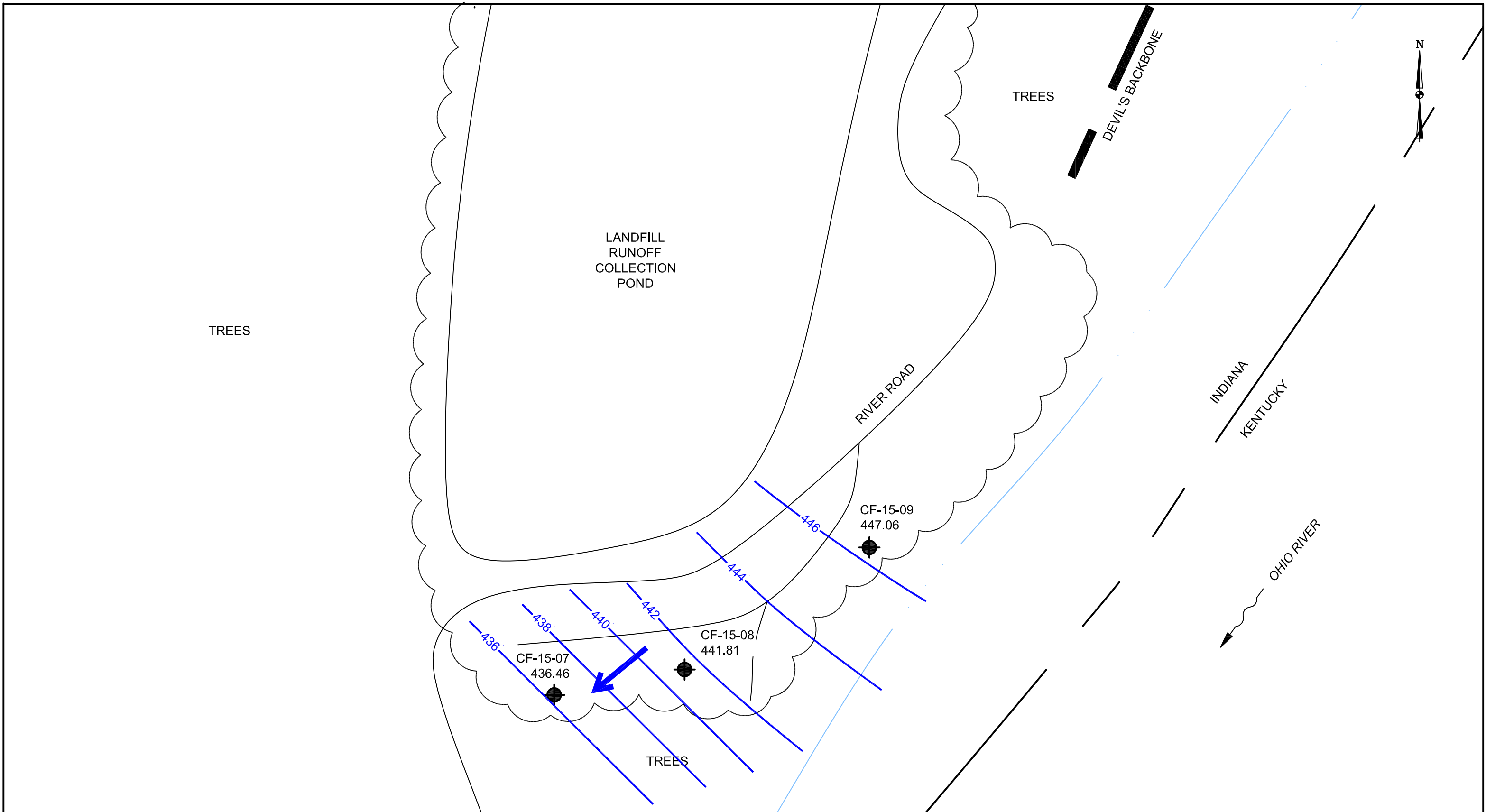


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DRAWING SCALE	AS SHOWN

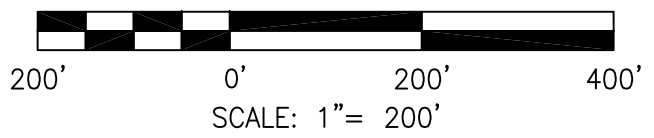


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CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND - SOUTHWEST END GROUNDWATER LEVELS & FLOW DIRECTION - AUGUST 2017	
DRAWING NAME	REV.
FIGURE B-18	0



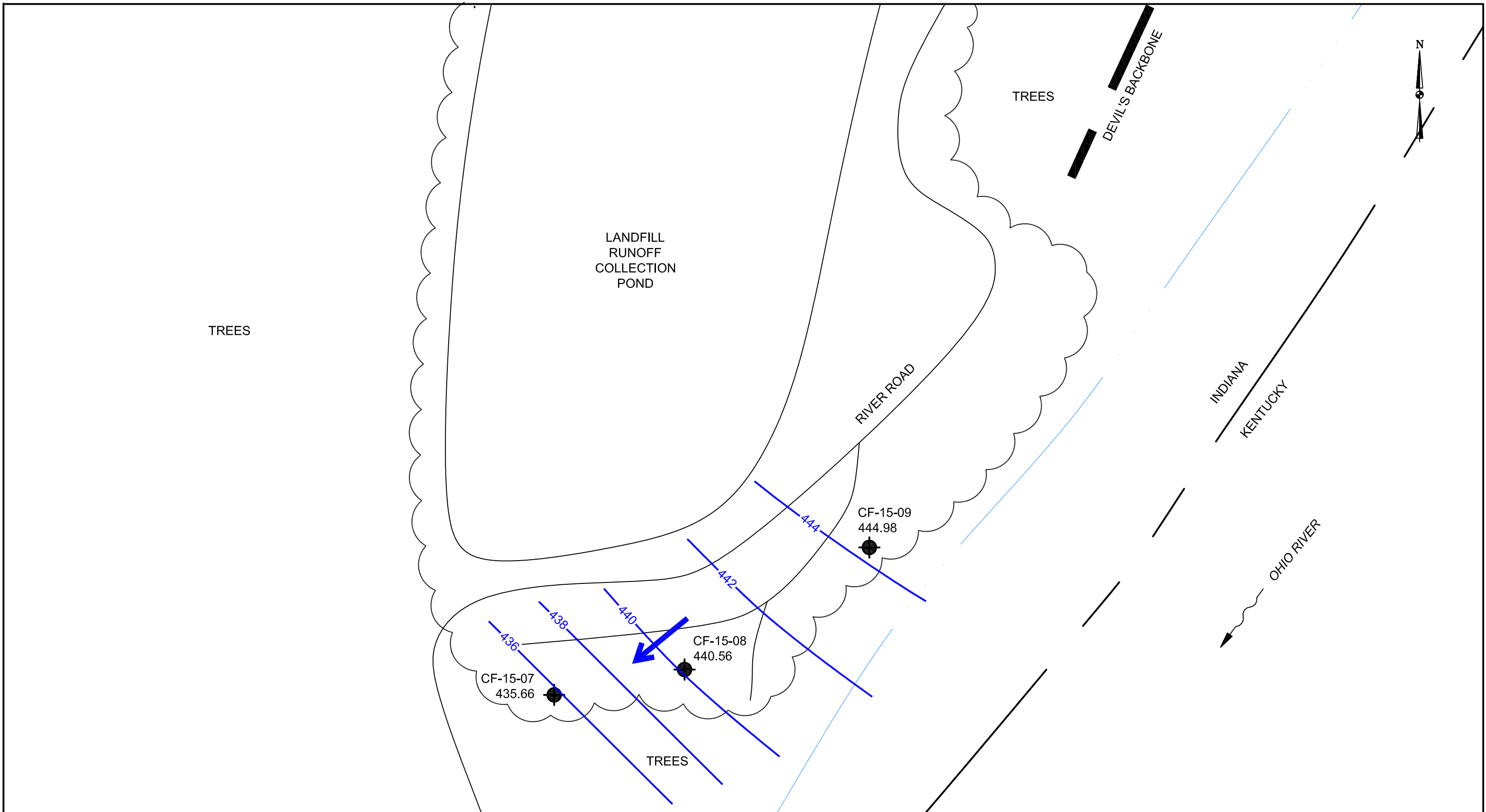
LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION





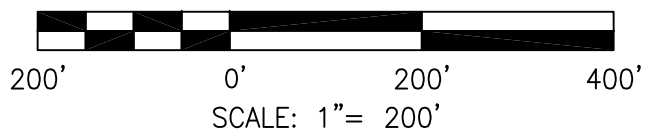
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DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND - SOUTHWEST END GROUNDWATER LEVELS & FLOW DIRECTION - MARCH 2018	
DRAWING NAME	FIGURE B-1
REV.	0



LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION

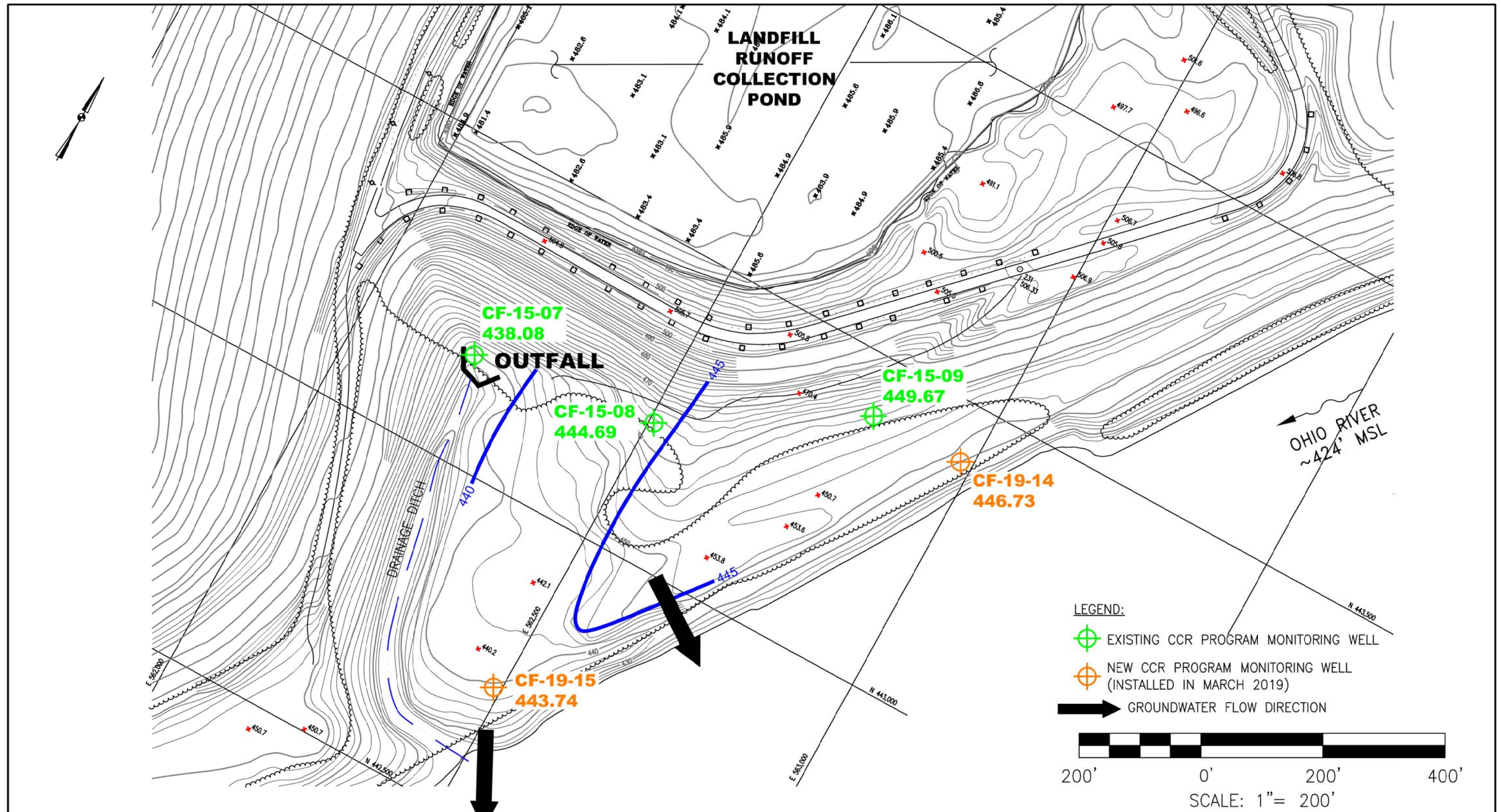


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DRAWING SCALE	AS SHOWN



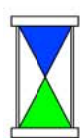
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CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND - SOUTHWEST END GROUNDWATER LEVELS & FLOW DIRECTION - OCTOBER 2018	
DRAWING NAME	FIGURE B-3
REV.	0



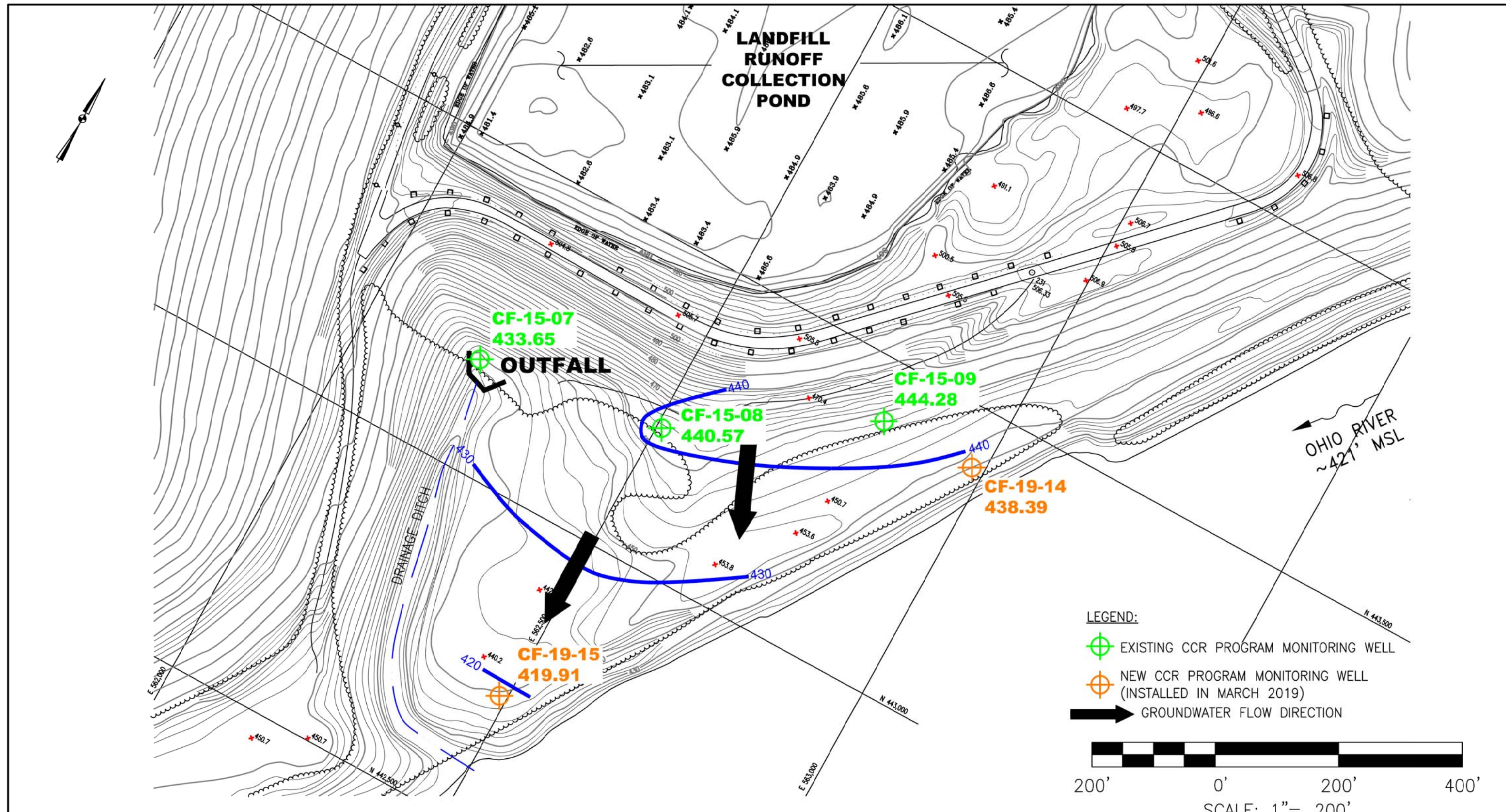
NOTE:
WELLS CF-19-14 AND CF-19-15
WERE INSTALLED IN MARCH 2019.

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JOB NO.	2019008-CLIFTY
DWG FILE	2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_MAR19.dwg
DRAWING SCALE	AS SHOWN



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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND GROUNDWATER FLOW - UPPERMOST AQUIFER MARCH 2019	
DRAWING NAME	FIGURE B-2
REV.	0



NOTE:
WELLS CF-19-14 AND CF-19-15
WERE INSTALLED IN MARCH 2019.

DRAWN BY	JM
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JOB NO.	2019008-CLIFTY
DWG. FILE	2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_OCT19.dwg
DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND GROUNDWATER FLOW - UPPERMOST AQUIFER OCTOBER 2019	
DRAWING NAME	FIGURE B-3
REV.	0

APPENDIX E3 – GROUNDWATER MONITORING RESULTS

CF-15-04
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17
Appendix III Constituents								
Boron, B	mg/L	0.052	0.035	0.028	0.047	0.055	0.043	0.023
Calcium, Ca	mg/L	67.2	56	56.2	68.9	68.1	69.2	58.1
Chloride, Cl	mg/L	19.6	40.9	21.3	31.7	20.5	32.2	32.3
Fluoride, F	mg/L	0.25 U	0.12	0.14	0.1 J	0.1 J	0.09 J	0.1 J
pH	s.u.	7.72	7.56	7.51	7.45	7.27	6.19	7.46
Sulfate, SO4	mg/L	30.1	27.7	24.6	25.4	23.4	32.2	26.8
Total Dissolved Solids (TDS)	mg/L	278	314	282	294	270	294	288
Appendix IV Constituents								
Antimony, Sb	ug/L	0.1 U	0.11	0.1	0.1	0.15	0.1	0.09
Arsenic, As	ug/L	0.33	0.69	0.33	0.36	0.46	0.52	0.38
Barium, Ba	ug/L	39.9	41.7	39.2	50.8	47.9	50.9	38.2
Beryllium, Be	ug/L	0.01 U	0.028	0.02 U	0.007 J	0.01 J	0.007 J	0.02 J
Cadmium, Cd	ug/L	0.05 U	0.02	0.007 J	0.07	0.02 J	0.009 J	0.009 J
Chromium, Cr	ug/L	0.2	0.6	0.3	0.4	0.3	0.299	0.381
Cobalt, Co	ug/L	0.086	0.53	0.094	0.115	0.157	0.176	0.106
Fluoride, F	mg/L	0.25 U	0.12	0.14	0.1 J	0.1 J	0.09 J	0.1 J
Lithium, Li	mg/L	0.005 U	0.011	0.001 U	0.018	0.003	0.001 U	0.005
Lead, Pb	ug/L	0.182	0.631	0.103	0.237	0.191	0.096	0.268
Mercury, Hg	ug/L	0.005 U	0.003 J	0.005 U	0.2 U	0.005 U	0.004 J	0.002 J
Molybdenum, Mo	ug/L	1.05	0.91	2.8	1.09	1.83	3.21	0.83
Radium 226 & 228 (combined)	pCi/L	0.0803 U	0.526 U	0.1095	0.962	0.261	0.5	0.631
Selenium, Se	ug/L	0.2	0.3	0.1	0.3	0.2	0.2	0.4
Thallium, Tl	ug/L	0.02 U	0.02 J	0.05 U	0.059	0.212	0.01 J	0.01 J

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-04
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jun-17	Aug-17	Mar-18	Oct-18	Mar-19	Oct-19	Mar-20
Appendix III Constituents								
Boron, B	mg/L	0.106	0.06	0.043	0.09 J	0.045 J	0.058 J	0.1
Calcium, Ca	mg/L	63	68.8	106	74.2	85	74	82
Chloride, Cl	mg/L	28.5	38.3	282	50.2	11	37	6.9
Fluoride, F	mg/L	0.1 J	0.1 J	0.09	0.12	0.085	0.11	0.11
pH	s.u.	6.77	7.33	10.06	7.76	6.65	7.23	6.52
Sulfate, SO4	mg/L	24.8	31.4	35.2	34.4	28	37	26
Total Dissolved Solids (TDS)	mg/L	326	304	788	377	340	360	290
Appendix IV Constituents								
Antimony, Sb	ug/L	0.11	0.09	NA	0.1 J	2 U	2 U	2 U
Arsenic, As	ug/L	0.36	0.45	NA	0.38	5 U	5 U	5 U
Barium, Ba	ug/L	48	51.3	NA	57.5	50	46	46
Beryllium, Be	ug/L	0.007 J	0.01 J	NA	0.1 U	1 U	1 U	1 U
Cadmium, Cd	ug/L	0.01 J	0.01 J	NA	0.05 U	1 U	1 U	1 U
Chromium, Cr	ug/L	0.301	0.317	NA	0.2 J	2 U	2 U	2 U
Cobalt, Co	ug/L	0.104	0.182	NA	0.114	1 U	1 U	1 U
Fluoride, F	mg/L	0.1 J	0.1 J	NA	0.12	0.085	0.11	0.11
Lithium, Li	mg/L	0.002	0.008	NA	0.009 J	1 U	1 U	0.0017 J
Lead, Pb	ug/L	0.104	0.199	NA	0.141	0.008 U	0.008 U	1 U
Mercury, Hg	ug/L	0.932	0.005 U	NA	0.003 J	0.2 U	0.2 U	0.2 U
Molybdenum, Mo	ug/L	1.07	1.29	NA	2.54	5 U	1.1 J	1.7 J
Radium 226 & 228 (combined)	pCi/L	8.02	0.1274	NA	0.62	5 U	0.519	5 U
Selenium, Se	ug/L	0.3	0.1	NA	0.2 J	5 U	5 U	5 U
Thallium, Tl	ug/L	0.01 J	0.01 J	NA	0.5 U	1 U	1 U	1 U

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-04
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Sep-20
Appendix III Constituents		
Boron, B	mg/L	0.062 J
Calcium, Ca	mg/L	73
Chloride, Cl	mg/L	30
Fluoride, F	mg/L	0.12
pH	s.u.	7.08
Sulfate, SO4	mg/L	34
Total Dissolved Solids (TDS)	mg/L	320
Appendix IV Constituents		
Antimony, Sb	ug/L	2 U
Arsenic, As	ug/L	5 U
Barium, Ba	ug/L	51
Beryllium, Be	ug/L	1 U
Cadmium, Cd	ug/L	1 U
Chromium, Cr	ug/L	2 U
Cobalt, Co	ug/L	1 U
Fluoride, F	mg/L	0.12
Lithium, Li	mg/L	0.0031 J
Lead, Pb	ug/L	1 U
Mercury, Hg	ug/L	0.2 U
Molybdenum, Mo	ug/L	1.6 J
Radium 226 & 228 (combined)	pCi/L	0.297 U
Selenium, Se	ug/L	5 U
Thallium, Tl	ug/L	1 U

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-05
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17
Appendix III Constituents								
Boron, B	mg/L	0.134	0.105	0.085	0.118	0.126	0.12	0.124
Calcium, Ca	mg/L	112	116	110	109	113	111	105
Chloride, Cl	mg/L	17.2	24.6	24.5	13.8	22.6	29.5	26.1
Fluoride, F	mg/L	0.39	0.44	0.46	0.55	0.43	0.43	0.42
pH	s.u.	7.3	6.06	7.44	7.38	7.2	6.1	6.91
Sulfate, SO4	mg/L	37.8	35.8	36.2	20.2	34.8	40.1	35.3
Total Dissolved Solids (TDS)	mg/L	472	542	524	522	520	490	530
Appendix IV Constituents								
Antimony, Sb	ug/L	0.1 U	0.06	0.12	0.08	0.04 J	0.06	0.06
Arsenic, As	ug/L	4.45	2.1	2.69	2.42	1.46	1.91	1.79
Barium, Ba	ug/L	138	97.4	106	96.4	93.9	63.2	71.2
Beryllium, Be	ug/L	0.018	0.024	0.04	0.02 J	0.02 J	0.01 J	0.02 J
Cadmium, Cd	ug/L	0.05 U	0.02 J	0.01 J	0.008 J	0.008 J	0.01 J	0.02
Chromium, Cr	ug/L	0.3	0.2	0.7	0.5	0.5	0.253	0.43
Cobalt, Co	ug/L	0.749	0.686	0.749	0.517	0.498	0.399	0.644
Fluoride, F	mg/L	0.39	0.44	0.46	0.55	0.43	0.43	0.42
Lithium, Li	mg/L	0.005	0.012	0.008	0.013	0.012	0.015	0.016
Lead, Pb	ug/L	0.266	0.433	0.691	0.325	0.323	0.175	0.356
Mercury, Hg	ug/L	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.003 J	0.005 U
Molybdenum, Mo	ug/L	4.2	1.08	1.96	4.71	6	1.3	1.6
Radium 226 & 228 (combined)	pCi/L	0.2787	0.519 U	0.563	0.879	1.101	0.695	0.169
Selenium, Se	ug/L	0.1 U	0.1	0.1	0.08 J	0.1 J	0.07 J	0.1
Thallium, Tl	ug/L	0.02 U	0.02 J	0.083	0.02 J	0.03 J	0.03 J	0.085

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-05
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jun-17	Aug-17	Mar-18	Oct-18	Mar-19	Oct-19	Mar-20
Appendix III Constituents								
Boron, B	mg/L	0.137	0.102	0.209	0.174	0.14	0.13	0.19
Calcium, Ca	mg/L	101	105	103	113	120	110	100
Chloride, Cl	mg/L	29.6	29.9	31.5	30.2	31	33	35
Fluoride, F	mg/L	0.44	0.44	0.47	0.48	0.5	0.5	0.5
pH	s.u.	7.16	7.18	9.56	7.18	6.77	7.12	7.59
Sulfate, SO4	mg/L	40.3	43.2	44.3	40.9	49	51	53
Total Dissolved Solids (TDS)	mg/L	513	520	528	502	520	520	520
Appendix IV Constituents								
Antimony, Sb	ug/L	0.03 J	0.06	NA	0.02 J	2 U	2 U	2 U
Arsenic, As	ug/L	1.16	1.35	NA	0.91	0.77 J	0.92 J	5 U
Barium, Ba	ug/L	69.2	68	NA	58.8	59	48	51
Beryllium, Be	ug/L	0.009 J	0.01 J	NA	0.1 U	0.47 J	1 U	1 U
Cadmium, Cd	ug/L	0.02	0.01 J	NA	0.04 J	1 U	1 U	1 U
Chromium, Cr	ug/L	0.17	0.269	NA	0.228	2 U	2 U	2 U
Cobalt, Co	ug/L	0.42	0.446	NA	0.463	0.49 J	0.46 J	0.92 J
Fluoride, F	mg/L	0.44	0.44	NA	0.48	0.5	0.5	0.5
Lithium, Li	mg/L	0.011	0.019	NA	0.01 J	1 U	1 U	0.017
Lead, Pb	ug/L	0.155	0.227	NA	0.21	0.014	0.016	1 U
Mercury, Hg	ug/L	0.522	0.005 U	NA	0.003 J	0.2 U	0.2 U	0.2 U
Molybdenum, Mo	ug/L	1.48	1.34	NA	2.94	5 U	5 U	3.7 J
Radium 226 & 228 (combined)	pCi/L	3.996	1.475	NA	0.484	5 U	0.46	0.439
Selenium, Se	ug/L	0.09 J	0.08 J	NA	0.06 J	5 U	5 U	5 U
Thallium, Tl	ug/L	0.02 J	0.04 J	NA	0.5 U	1 U	1 U	1 U

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-05
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Sep-20
Appendix III Constituents		
Boron, B	mg/L	0.097 J
Calcium, Ca	mg/L	100
Chloride, Cl	mg/L	25
Fluoride, F	mg/L	0.51
pH	s.u.	6.93
Sulfate, SO4	mg/L	36
Total Dissolved Solids (TDS)	mg/L	460
Appendix IV Constituents		
Antimony, Sb	ug/L	2 U
Arsenic, As	ug/L	1.7 J
Barium, Ba	ug/L	79
Beryllium, Be	ug/L	1 U
Cadmium, Cd	ug/L	1 U
Chromium, Cr	ug/L	2.2
Cobalt, Co	ug/L	1.2
Fluoride, F	mg/L	0.51
Lithium, Li	mg/L	0.013
Lead, Pb	ug/L	1.2
Mercury, Hg	ug/L	0.2 U
Molybdenum, Mo	ug/L	1.6 J
Radium 226 & 228 (combined)	pCi/L	0.961
Selenium, Se	ug/L	5 U
Thallium, Tl	ug/L	1 U

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-06
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17
Appendix III Constituents								
Boron, B	mg/L	0.179	0.083	0.083	NA	NA	NA	0.139
Calcium, Ca	mg/L	149	126	130	NA	NA	NA	125
Chloride, Cl	mg/L	8.14	5.54	5.55	NA	NA	NA	8.96
Fluoride, F	mg/L	0.16	0.2 U	0.24	NA	NA	NA	0.2
pH	s.u.	7.04	6.06	7.46	NA	NA	NA	7.54
Sulfate, SO4	mg/L	109	91	102	NA	NA	NA	104
Total Dissolved Solids (TDS)	mg/L	636	628	594	NA	NA	NA	606
Appendix IV Constituents								
Antimony, Sb	ug/L	0.1 U	0.08	0.03 J	NA	NA	NA	0.04 J
Arsenic, As	ug/L	0.56	0.42	0.32	NA	NA	NA	0.32
Barium, Ba	ug/L	57	40	33	NA	NA	NA	33.7
Beryllium, Be	ug/L	0.021	0.006 J	0.006 J	NA	NA	NA	0.02 U
Cadmium, Cd	ug/L	0.06	0.04	0.04	NA	NA	NA	0.08
Chromium, Cr	ug/L	0.7	0.4	0.5	NA	NA	NA	0.685
Cobalt, Co	ug/L	0.497	0.653	0.191	NA	NA	NA	0.163
Fluoride, F	mg/L	0.16	0.2 U	0.24	NA	NA	NA	0.2
Lithium, Li	mg/L	0.012	0.017	0.012	NA	NA	NA	0.017
Lead, Pb	ug/L	0.333	0.082	0.424	NA	NA	NA	0.187
Mercury, Hg	ug/L	0.005 U	0.005 U	0.005 U	NA	NA	NA	0.005 U
Molybdenum, Mo	ug/L	1.42	0.45	0.47	NA	NA	NA	0.96
Radium 226 & 228 (combined)	pCi/L	0.258	1.14 U	0.416	NA	NA	NA	1.357
Selenium, Se	ug/L	0.2	0.4	0.09 J	NA	NA	NA	0.2
Thallium, Tl	ug/L	0.048	0.01 J	0.03 J	NA	NA	NA	0.172

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-06
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jun-17	Aug-17	Mar-18	Oct-18	Mar-19	Oct-19	Mar-20
Appendix III Constituents								
Boron, B	mg/L	NA	NA	0.16	0.05 J	0.24	NA	0.21
Calcium, Ca	mg/L	NA	NA	125	184	120	NA	120
Chloride, Cl	mg/L	NA	NA	7.76	8.21	4.2	NA	5.1
Fluoride, F	mg/L	NA	NA	0.2	0.21	0.2	NA	0.22
pH	s.u.	NA	NA	10.36	7.89	6.99	NA	7.56
Sulfate, SO4	mg/L	NA	NA	112	102	95	NA	88
Total Dissolved Solids (TDS)	mg/L	NA	NA	630	696	560	NA	530
Appendix IV Constituents								
Antimony, Sb	ug/L	NA	NA	NA	0.07 J	2 U	NA	2 U
Arsenic, As	ug/L	NA	NA	NA	1.21	5 U	NA	5 U
Barium, Ba	ug/L	NA	NA	NA	149	30	NA	30
Beryllium, Be	ug/L	NA	NA	NA	0.934	1 U	NA	1 U
Cadmium, Cd	ug/L	NA	NA	NA	0.3	1 U	NA	1 U
Chromium, Cr	ug/L	NA	NA	NA	6.81	1.1 J	NA	0.98 J
Cobalt, Co	ug/L	NA	NA	NA	8.27	0.22 J	NA	0.59 J
Fluoride, F	mg/L	NA	NA	NA	0.21	0.2	NA	0.22
Lithium, Li	mg/L	NA	NA	NA	0.02 J	1 U	NA	0.014
Lead, Pb	ug/L	NA	NA	NA	15.7	0.015 B	NA	0.48 J
Mercury, Hg	ug/L	NA	NA	NA	0.006	0.2 U	NA	0.2 U
Molybdenum, Mo	ug/L	NA	NA	NA	3.02	5 U	NA	23
Radium 226 & 228 (combined)	pCi/L	NA	NA	NA	NA	5 U	NA	0.449
Selenium, Se	ug/L	NA	NA	NA	1.9	5 U	NA	5 U
Thallium, Tl	ug/L	NA	NA	NA	0.5 U	1 U	NA	1 U

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-06
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Sep-20
Appendix III Constituents		
Boron, B	mg/L	NA
Calcium, Ca	mg/L	NA
Chloride, Cl	mg/L	NA
Fluoride, F	mg/L	NA
pH	s.u.	NA
Sulfate, SO4	mg/L	NA
Total Dissolved Solids (TDS)	mg/L	NA
Appendix IV Constituents		
Antimony, Sb	ug/L	NA
Arsenic, As	ug/L	NA
Barium, Ba	ug/L	NA
Beryllium, Be	ug/L	NA
Cadmium, Cd	ug/L	NA
Chromium, Cr	ug/L	NA
Cobalt, Co	ug/L	NA
Fluoride, F	mg/L	NA
Lithium, Li	mg/L	NA
Lead, Pb	ug/L	NA
Mercury, Hg	ug/L	NA
Molybdenum, Mo	ug/L	NA
Radium 226 & 228 (combined)	pCi/L	NA
Selenium, Se	ug/L	NA
Thallium, Tl	ug/L	NA

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-07
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17
Appendix III Constituents								
Boron, B	mg/L	0.057	0.032	0.022	0.045	0.046	0.053	0.021
Calcium, Ca	mg/L	174	146	152	159	160	159	159
Chloride, Cl	mg/L	5.24	5.67	5.34	5.57	5.15	5.52	5.07
Fluoride, F	mg/L	0.25 U	0.2 U	0.22	0.23	0.2	0.19	0.23
pH	s.u.	7.44	6.78	7.4	7.17	7.48	7.87	6.99
Sulfate, SO4	mg/L	4.7	6.4	7.1	8	7.1	3.5	2.1
Total Dissolved Solids (TDS)	mg/L	630	608	602	596	584	578	602
Appendix IV Constituents								
Antimony, Sb	ug/L	0.1 U	0.04 J	0.05 J	0.04 J	0.05	0.03 J	0.04 J
Arsenic, As	ug/L	4.08	2.51	4.47	4.83	5.4	6.12	6.22
Barium, Ba	ug/L	80.2	73.6	71.8	74.9	81.2	77.3	79.1
Beryllium, Be	ug/L	0.038	0.02 J	0.02 J	0.02 J	0.029	0.01 J	0.021
Cadmium, Cd	ug/L	0.05 U	0.02 J	0.02	0.02 J	0.02	0.02 J	0.01 J
Chromium, Cr	ug/L	1	0.3	0.3	0.5	0.7	0.299	0.395
Cobalt, Co	ug/L	3.95	3.35	2.94	2.81	3.11	2.61	3.03
Fluoride, F	mg/L	0.25 U	0.2 U	0.22	0.23	0.2	0.19	0.23
Lithium, Li	mg/L	0.005 U	0.002 J	0.001 U	0.001 U	0.004	0.001 U	0.007
Lead, Pb	ug/L	0.809	0.197	0.207	0.258	0.452	0.158	0.298
Mercury, Hg	ug/L	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.002 J	0.003 J
Molybdenum, Mo	ug/L	2.18	1.99	1.57	3.2	2.6	3.03	2.49
Radium 226 & 228 (combined)	pCi/L	0.111	0.77 U	0.3301	1.4843	0.296	0.781	0.2136
Selenium, Se	ug/L	0.3	0.1	0.1 J	0.1	0.2	0.1	0.1
Thallium, Tl	ug/L	0.031	0.04 J	0.03 J	0.02 J	0.063	0.03 J	0.02 J

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-07
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jun-17	Aug-17	Mar-18	Oct-18	Mar-19	Oct-19	Mar-20
Appendix III Constituents								
Boron, B	mg/L	0.05	0.059	0.204	0.112	0.045 J	0.08 J	0.42
Calcium, Ca	mg/L	144	151	123	168	150	160	150
Chloride, Cl	mg/L	5.25	5.13	10.6	5.34	5.6	5	11
Fluoride, F	mg/L	0.21	0.21	0.2	0.24	0.21	0.26	0.22
pH	s.u.	6.69	7.14	10.12	7.29	7.04	7.02	7.49
Sulfate, SO4	mg/L	2.5	2.8	32.7	2.7	11	5.9	63
Total Dissolved Solids (TDS)	mg/L	606	592	548	1240	620	600	620
Appendix IV Constituents								
Antimony, Sb	ug/L	0.02 J	0.03 J	NA	0.06 J	2 U	2 U	2 U
Arsenic, As	ug/L	5.07	5.32	NA	6.81	4.6 J	7.5	3.7 J
Barium, Ba	ug/L	77.8	77.2	NA	92.4	81	80	74
Beryllium, Be	ug/L	0.01 J	0.007 J	NA	0.1 U	1 U	1 U	1 U
Cadmium, Cd	ug/L	0.02	0.007 J	NA	0.07	1 U	1 U	1 U
Chromium, Cr	ug/L	0.144	0.187	NA	0.36	2 U	2 U	2 U
Cobalt, Co	ug/L	2.8	2.82	NA	2.41	2.4	2.6	2.1
Fluoride, F	mg/L	0.21	0.21	NA	0.24	0.21	0.26	0.22
Lithium, Li	mg/L	0.002	0.006	NA	0.03 U	1 U	1 U	0.005 J
Lead, Pb	ug/L	0.12	0.11	NA	0.336	0.0017 J	0.0031 J	1 U
Mercury, Hg	ug/L	1.12	0.005 U	NA	0.004 J	0.2 U	0.2 U	0.2 U
Molybdenum, Mo	ug/L	1.69	2.86	NA	12.8	4.9 J	9.5 B	110
Radium 226 & 228 (combined)	pCi/L	14.215	0.4738	NA	0.387	2.34	0.329 U	0.884
Selenium, Se	ug/L	0.2	0.1	NA	0.2 J	5 U	5 U	1.1 J
Thallium, Tl	ug/L	0.01 J	0.01 J	NA	0.5 U	1 U	1 U	1 U

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-07
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jun-20	Sep-20
Appendix III Constituents			
Boron, B	mg/L	NA	0.047 J
Calcium, Ca	mg/L	NA	160
Chloride, Cl	mg/L	NA	16
Fluoride, F	mg/L	NA	0.42
pH	s.u.	NA	6.81
Sulfate, SO4	mg/L	NA	240
Total Dissolved Solids (TDS)	mg/L	NA	560
Appendix IV Constituents			
Antimony, Sb	ug/L	NA	2 U
Arsenic, As	ug/L	NA	7.6
Barium, Ba	ug/L	NA	81
Beryllium, Be	ug/L	NA	1 U
Cadmium, Cd	ug/L	NA	1 U
Chromium, Cr	ug/L	NA	0.98 J
Cobalt, Co	ug/L	NA	2.8
Fluoride, F	mg/L	NA	0.42
Lithium, Li	mg/L	NA	0.008 U
Lead, Pb	ug/L	NA	5.1
Mercury, Hg	ug/L	NA	0.2 U
Molybdenum, Mo	ug/L	10	5.3
Radium 226 & 228 (combined)	pCi/L	NA	0.808
Selenium, Se	ug/L	NA	5 U
Thallium, Tl	ug/L	NA	1 U

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-08
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17
Appendix III Constituents								
Boron, B	mg/L	8.64	8.24	9.34	9.65	9.63	10.9	9.29
Calcium, Ca	mg/L	119	126	131	138	138	133	143
Chloride, Cl	mg/L	18.3	16	15.6	17.5	17.8	17.4	15.9
Fluoride, F	mg/L	0.41	0.42	0.41	0.27	0.38	0.36	0.34
pH	s.u.	7.69	6.83	7.5	7.49	7.53	6.64	7.28
Sulfate, SO4	mg/L	225	199	223	247	247	238	203
Total Dissolved Solids (TDS)	mg/L	606	626	662	644	632	582	626
Appendix IV Constituents								
Antimony, Sb	ug/L	0.19	0.11	0.11	0.09	0.1	0.08	0.09
Arsenic, As	ug/L	1.99	1.32	0.99	0.72	0.83	0.66	0.82
Barium, Ba	ug/L	95.6	93	80.8	71	67.8	61.7	64.1
Beryllium, Be	ug/L	0.011	0.01 J	0.01 J	0.007 J	0.01 J	0.008 J	0.01 J
Cadmium, Cd	ug/L	0.05 U	0.07	0.03	0.07	0.04	0.02	0.04
Chromium, Cr	ug/L	0.3	0.4	0.4	0.2	0.3	0.242	0.261
Cobalt, Co	ug/L	1.38	2.08	0.649	0.416	0.45	0.327	0.49
Fluoride, F	mg/L	0.41	0.42	0.41	0.27	0.38	0.36	0.34
Lithium, Li	mg/L	0.014	0.011	0.014	0.017	0.017	0.017	0.025
Lead, Pb	ug/L	0.427	0.947	0.419	0.217	0.331	0.159	0.289
Mercury, Hg	ug/L	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.004 J	0.005 U
Molybdenum, Mo	ug/L	196	266	317	303	315	500	311
Radium 226 & 228 (combined)	pCi/L	0.299	0.335 U	0.4	0.715	0.304	0.901	8.401
Selenium, Se	ug/L	0.1	0.1	0.08 J	0.07 J	0.08 J	0.08 J	0.06 J
Thallium, Tl	ug/L	0.074	0.065	0.063	0.101	0.101	0.05 J	0.04 J

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-08
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jun-17	Aug-17	Mar-18	May-18	Oct-18	Mar-19	Jun-19
Appendix III Constituents								
Boron, B	mg/L	7.62	9.04	8.5	8.6	11.9	9.8	8.5
Calcium, Ca	mg/L	114	136	123	NA	145	140	NA
Chloride, Cl	mg/L	14.1	17.1	14.7	NA	17.4	14	NA
Fluoride, F	mg/L	0.34	0.36	0.41	NA	0.41	0.37	NA
pH	s.u.	7.24	7.21	10.21	7.45	7.53	7.05	NA
Sulfate, SO4	mg/L	178	233	203	NA	257	240	NA
Total Dissolved Solids (TDS)	mg/L	564	594	588	NA	636	680	NA
Appendix IV Constituents								
Antimony, Sb	ug/L	0.05	0.07	NA	NA	0.07 J	2 U	NA
Arsenic, As	ug/L	0.6	0.93	NA	NA	0.94	5 U	NA
Barium, Ba	ug/L	56.4	58.4	NA	NA	51.4	60	NA
Beryllium, Be	ug/L	0.009 J	0.01 J	NA	NA	0.1 U	1 U	NA
Cadmium, Cd	ug/L	0.02	0.05	NA	NA	0.02 J	1 U	NA
Chromium, Cr	ug/L	0.189	0.403	NA	NA	0.385	2 U	NA
Cobalt, Co	ug/L	0.29	0.537	NA	NA	0.547	0.19 J	NA
Fluoride, F	mg/L	0.34	0.36	NA	NA	0.41	0.37	NA
Lithium, Li	mg/L	0.015	0.022	NA	NA	0.02 J	1 U	NA
Lead, Pb	ug/L	0.156	0.457	NA	NA	0.457	0.017	NA
Mercury, Hg	ug/L	1.26	0.005 U	NA	NA	0.004 J	0.2 U	NA
Molybdenum, Mo	ug/L	391	425	NA	NA	524	380	360
Radium 226 & 228 (combined)	pCi/L	0.792	0.583	NA	NA	0.437	0.413	NA
Selenium, Se	ug/L	0.04 J	0.07 J	NA	NA	0.07 J	5 U	NA
Thallium, Tl	ug/L	0.05 J	0.056	NA	NA	0.5 U	1 U	NA

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-08
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Oct-19	Nov-19	Mar-20	Jun-20	Sep-20
Appendix III Constituents						
Boron, B	mg/L	11	9	8.2	9.6	10
Calcium, Ca	mg/L	140	NA	130	NA	120
Chloride, Cl	mg/L	16	NA	15	NA	16
Fluoride, F	mg/L	0.4	NA	0.43	NA	0.42
pH	s.u.	7.29	NA	7.79	NA	6.71
Sulfate, SO4	mg/L	230	NA	240	NA	240
Total Dissolved Solids (TDS)	mg/L	650	NA	640	NA	640
Appendix IV Constituents						
Antimony, Sb	ug/L	2 U	NA	2 U	NA	2 U
Arsenic, As	ug/L	1.3 J	NA	0.76 J	NA	5 U
Barium, Ba	ug/L	59	NA	56	NA	48
Beryllium, Be	ug/L	0.76 J B	NA	0.4 J	NA	1 U
Cadmium, Cd	ug/L	0.24 J	NA	0.27 J	NA	1 U
Chromium, Cr	ug/L	2 U	NA	2 U	NA	2 U
Cobalt, Co	ug/L	0.48 J	NA	0.57 J	NA	0.27 J
Fluoride, F	mg/L	0.4	NA	0.43	NA	0.42
Lithium, Li	mg/L	0.5 J	NA	0.017	NA	0.018
Lead, Pb	ug/L	0.019	NA	1 U	NA	1 U
Mercury, Hg	ug/L	0.2 U	NA	0.2 U	NA	0.2 U
Molybdenum, Mo	ug/L	390 B	360	240	400	400
Radium 226 & 228 (combined)	pCi/L	0.329 U	NA	5 U	NA	0.242 U
Selenium, Se	ug/L	1 J	NA	5 U	NA	5 U
Thallium, Tl	ug/L	0.76 J B	NA	0.54 J	NA	0.25 J

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-09
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17
Appendix III Constituents								
Boron, B	mg/L	6.86	5.78	6.58	7.01	6.73	NA	6.78
Calcium, Ca	mg/L	203	165	186	394	202	NA	179
Chloride, Cl	mg/L	6.59	5.09	4.49	4.6	4.11	NA	2.58
Fluoride, F	mg/L	0.28	0.27	0.24	0.28	0.28	NA	0.33
pH	s.u.	7.58	7.1	7.44	7.48	7.65	NA	7.18
Sulfate, SO4	mg/L	359	299	286	363	309	NA	0.4
Total Dissolved Solids (TDS)	mg/L	792	743	758	1100	740	NA	200 J
Appendix IV Constituents								
Antimony, Sb	ug/L	0.13	0.09	0.08	0.11	0.09	NA	0.05 J
Arsenic, As	ug/L	0.57	0.44	0.41	3.9	0.41	NA	0.33
Barium, Ba	ug/L	28.4	22.6	21	45.3	22.2	NA	13.5
Beryllium, Be	ug/L	0.01 U	0.02 U	0.006 J	0.206	0.008 J	NA	0.008 J
Cadmium, Cd	ug/L	0.05 U	0.03	0.03	0.11	0.02	NA	0.02 J
Chromium, Cr	ug/L	0.3	0.5	0.6	7.1	0.6	NA	0.226
Cobalt, Co	ug/L	0.416	0.112	0.121	5.44	0.139	NA	0.042
Fluoride, F	mg/L	0.28	0.27	0.24	0.28	0.28	NA	0.33
Lithium, Li	mg/L	0.011	0.009	0.009	0.025	0.013	NA	0.017
Lead, Pb	ug/L	0.045	0.073	0.15	6.75	0.163	NA	0.027
Mercury, Hg	ug/L	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	NA	0.005 U
Molybdenum, Mo	ug/L	87.8	87.6	82.6	38.2	90.3	NA	82.5
Radium 226 & 228 (combined)	pCi/L	0.1	1.54 U	0.4485	1.126	0.3095	NA	0.823
Selenium, Se	ug/L	0.2	0.1	0.1	1.4	0.2	NA	0.04 J
Thallium, Tl	ug/L	0.031	0.02 J	0.02 J	0.076	0.05 J	NA	0.01 J

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-09
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jun-17	Aug-17	May-18	Oct-18	Mar-19	Jun-19	Oct-19
Appendix III Constituents								
Boron, B	mg/L	6.3	6.81	6.1	7.59	6.7	NA	NA
Calcium, Ca	mg/L	182	392	NA	250	160	NA	NA
Chloride, Cl	mg/L	4.12	3.77	NA	3.47	3	NA	NA
Fluoride, F	mg/L	0.27	0.26	NA	0.32	0.31	NA	NA
pH	s.u.	7.91	6.99	7.09	7.05	7.19	NA	NA
Sulfate, SO4	mg/L	305	422	NA	274	260	NA	NA
Total Dissolved Solids (TDS)	mg/L	790	970	NA	790	620	NA	NA
Appendix IV Constituents								
Antimony, Sb	ug/L	0.06	0.12	NA	0.16	2 U	NA	NA
Arsenic, As	ug/L	0.4	6.17	NA	4.67	5 U	NA	NA
Barium, Ba	ug/L	18.7	44.3	NA	38.2	14	NA	NA
Beryllium, Be	ug/L	0.007 J	0.317	NA	0.261	1.5	NA	NA
Cadmium, Cd	ug/L	0.02 J	0.08	NA	0.05 J	0.23 J	NA	NA
Chromium, Cr	ug/L	1.21	13.7	NA	14.9	2 U	NA	NA
Cobalt, Co	ug/L	0.184	13.7	NA	7.45	0.38 J	NA	NA
Fluoride, F	mg/L	0.27	0.26	NA	0.32	0.31	NA	NA
Lithium, Li	mg/L	0.012	0.035	NA	0.02 J	1 U	NA	NA
Lead, Pb	ug/L	0.191	10.2	NA	6.25	0.0087	NA	NA
Mercury, Hg	ug/L	0.005 U	0.005 U	NA	0.007	0.2 U	NA	NA
Molybdenum, Mo	ug/L	73.6	47.1	NA	85.9	100	87	NA
Radium 226 & 228 (combined)	pCi/L	0.869	NA	NA	NA	5 U	NA	NA
Selenium, Se	ug/L	0.1	2	NA	1.3	1.2 J	NA	NA
Thallium, Tl	ug/L	0.01 J	0.085	NA	0.5 U	0.2 J	NA	NA

Notes:

NA: Sampling not required for this parameter or well dry.

CF-15-09
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-20	Jun-20	Sep-20
Appendix III Constituents				
Boron, B	mg/L	5.7	5.9	6.9
Calcium, Ca	mg/L	170	NA	240
Chloride, Cl	mg/L	2.7	NA	2.8
Fluoride, F	mg/L	0.3	NA	0.32
pH	s.u.	7.59	NA	7.57
Sulfate, SO4	mg/L	280	NA	260
Total Dissolved Solids (TDS)	mg/L	640	NA	690
Appendix IV Constituents				
Antimony, Sb	ug/L	2 U	NA	2 U
Arsenic, As	ug/L	5 U	NA	9.5
Barium, Ba	ug/L	18	NA	60
Beryllium, Be	ug/L	1 U	NA	0.64 J
Cadmium, Cd	ug/L	1 U	NA	1 U
Chromium, Cr	ug/L	1.1 J	NA	43
Cobalt, Co	ug/L	1 U	NA	12
Fluoride, F	mg/L	0.3	NA	0.32
Lithium, Li	mg/L	0.0081	NA	0.029
Lead, Pb	ug/L	1 U	NA	13
Mercury, Hg	ug/L	0.2 U	NA	0.2 U
Molybdenum, Mo	ug/L	85	NA	100
Radium 226 & 228 (combined)	pCi/L	5 U	NA	2.01
Selenium, Se	ug/L	5 U	NA	5 U
Thallium, Tl	ug/L	1 U	NA	1 U

Notes:

NA: Sampling not required for this parameter or well dry.

CF-19-14
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Oct-19	Mar-20
Appendix IV Constituents			
Molybdenum, Mo	ug/L	15	9.5

CF-19-15
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Oct-19	Mar-20	Sep-20
Appendix IV Constituents				
Molybdenum, Mo	ug/L	1.1 J	6.1	1.4 J

WBSP-15-01
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17
Appendix III Constituents								
Boron, B	mg/L	0.112	0.094	0.064	0.09	0.134	NA	0.133
Calcium, Ca	mg/L	143	150	182	180	160	NA	163
Chloride, Cl	mg/L	11.5	8.49	8.01	17.9	37.4	NA	42.5
Fluoride, F	mg/L	0.25 U	0.22	0.26	0.23	0.25	NA	0.27
pH	s.u.	7.47	7.21	6.75	6.67	6.17	NA	6.85
Sulfate, SO4	mg/L	97.2	120	123	169	165	NA	168
Total Dissolved Solids (TDS)	mg/L	546	642	636	750	734	NA	708
Appendix IV Constituents								
Antimony, Sb	ug/L	0.14	0.07	0.05	0.14	0.1 J	NA	0.09
Arsenic, As	ug/L	0.88	0.32	2.9	3.22	0.49	NA	1.08
Barium, Ba	ug/L	36.9	18.6	14.7	38.5	25	NA	30.4
Beryllium, Be	ug/L	0.052	0.02 U	0.007 J	0.176	0.02 J	NA	0.072
Cadmium, Cd	ug/L	0.05 U	0.008 J	0.007 J	0.07	0.05	NA	0.04
Chromium, Cr	ug/L	1.5	0.2	0.4	8.4	1.3	NA	3.43
Cobalt, Co	ug/L	0.778	0.064	0.022	4.03	0.6	NA	1.61
Fluoride, F	mg/L	0.25 U	0.22	0.26	0.23	0.25	NA	0.27
Lithium, Li	mg/L	0.007	0.013	0.021	0.029	0.024	NA	0.033
Lead, Pb	ug/L	1.14	0.044	0.233	3.74	0.585	NA	1.74
Mercury, Hg	ug/L	0.005 U	0.005 U	0.005 U	0.004 J	0.005 U	NA	0.005 U
Molybdenum, Mo	ug/L	2.26	0.88	0.74	1.26	1.18	NA	0.81
Radium 226 & 228 (combined)	pCi/L	0.137	0.524 U	3.2607	NA	NA	NA	NA
Selenium, Se	ug/L	0.2	0.1 J	0.1 U	0.5	0.1 J	NA	0.2
Thallium, Tl	ug/L	0.025	0.01 J	0.02 J	0.074	0.03 J	NA	0.04 J

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-01
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jun-17	Aug-17	Mar-18	Oct-18	Mar-19	Oct-19	Mar-20
Appendix III Constituents								
Boron, B	mg/L	0.108	NA	0.1	0.134	0.082 J	NA	0.066 J
Calcium, Ca	mg/L	154	NA	157	164	160	NA	160
Chloride, Cl	mg/L	11.3	NA	9.45	25.3	7.1	NA	6.7
Fluoride, F	mg/L	0.25	NA	0.27	0.31	0.24	NA	0.26
pH	s.u.	6.82	NA	6.65	6.37	6.76	NA	6.81
Sulfate, SO4	mg/L	133	NA	139	146	130	NA	120
Total Dissolved Solids (TDS)	mg/L	696	NA	685	711	670	NA	630
Appendix IV Constituents								
Antimony, Sb	ug/L	0.05 J	NA	NA	0.09 J	2 U	NA	NA
Arsenic, As	ug/L	0.46	NA	NA	1.52	5 U	NA	NA
Barium, Ba	ug/L	19.1	NA	NA	25.3	13	NA	NA
Beryllium, Be	ug/L	0.022	NA	NA	0.144	1.1	NA	NA
Cadmium, Cd	ug/L	0.01 J	NA	NA	0.03 J	1 U	NA	NA
Chromium, Cr	ug/L	0.98	NA	NA	4.76	1.7 J	NA	NA
Cobalt, Co	ug/L	0.441	NA	NA	2.91	0.78 J	NA	NA
Fluoride, F	mg/L	0.25	NA	NA	0.31	0.24	NA	NA
Lithium, Li	mg/L	0.03	NA	NA	0.034	0.76 J	NA	NA
Lead, Pb	ug/L	0.447	NA	NA	2.63	0.021	NA	NA
Mercury, Hg	ug/L	1.12	NA	NA	NA	0.2 U	NA	NA
Molybdenum, Mo	ug/L	0.47	NA	NA	0.7 J	5 U	NA	NA
Radium 226 & 228 (combined)	pCi/L	NA	NA	NA	NA	5 U	NA	NA
Selenium, Se	ug/L	0.2	NA	NA	0.6	5 U	NA	NA
Thallium, Tl	ug/L	0.02 J	NA	NA	0.5 U	1 U	NA	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-01
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Sep-20
Appendix III Constituents		
Boron, B	mg/L	0.13
Calcium, Ca	mg/L	170
Chloride, Cl	mg/L	19
Fluoride, F	mg/L	0.25
pH	s.u.	6.85
Sulfate, SO4	mg/L	140
Total Dissolved Solids (TDS)	mg/L	650
Appendix IV Constituents		
Antimony, Sb	ug/L	NA
Arsenic, As	ug/L	NA
Barium, Ba	ug/L	NA
Beryllium, Be	ug/L	NA
Cadmium, Cd	ug/L	NA
Chromium, Cr	ug/L	NA
Cobalt, Co	ug/L	NA
Fluoride, F	mg/L	NA
Lithium, Li	mg/L	NA
Lead, Pb	ug/L	NA
Mercury, Hg	ug/L	NA
Molybdenum, Mo	ug/L	NA
Radium 226 & 228 (combined)	pCi/L	NA
Selenium, Se	ug/L	NA
Thallium, Tl	ug/L	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-02
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17
Appendix III Constituents								
Boron, B	mg/L	5.02	3.92	3.04	4.39	3.06	NA	4.43
Calcium, Ca	mg/L	284	262	246	119	257	NA	254
Chloride, Cl	mg/L	12.3	12.3	13.1	14.7	12	NA	13.8
Fluoride, F	mg/L	0.2	0.31	0.24	0.38	0.32	NA	0.34
pH	s.u.	7.51	7.12	7.13	6.99	6.79	NA	6.78
Sulfate, SO4	mg/L	634	566	508	584	517	NA	558
Total Dissolved Solids (TDS)	mg/L	1290	1230	1160	1250	1140	NA	1240
Appendix IV Constituents								
Antimony, Sb	ug/L	0.13	0.36	0.17	0.1	0.13	NA	0.16
Arsenic, As	ug/L	0.71	0.6	4.47	3.9	0.47	NA	0.62
Barium, Ba	ug/L	33.6	33.7	30.9	91	28.1	NA	31.5
Beryllium, Be	ug/L	0.01 U	0.008 J	0.007 J	0.02 U	0.005 J	NA	0.01 J
Cadmium, Cd	ug/L	0.05 U	0.02 J	0.02	0.009 J	0.01 J	NA	0.03
Chromium, Cr	ug/L	0.6	0.8	0.3	0.2	0.5	NA	1.03
Cobalt, Co	ug/L	0.126	0.175	0.359	0.18	0.141	NA	0.476
Fluoride, F	mg/L	0.2	0.31	0.24	0.38	0.32	NA	0.34
Lithium, Li	mg/L	0.098	0.102	0.087	0.009	0.088	NA	0.093
Lead, Pb	ug/L	0.091	0.181	0.131	0.041	0.122	NA	0.441
Mercury, Hg	ug/L	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	NA	0.005 U
Molybdenum, Mo	ug/L	5	3.73	2.65	62.4	2.33	NA	7.72
Radium 226 & 228 (combined)	pCi/L	0.183	1.61 U	0.2887	1.98	1.48	NA	0.879
Selenium, Se	ug/L	0.1	0.2	0.05 J	0.09 J	0.08 J	NA	0.1
Thallium, Tl	ug/L	0.02 U	0.02 J	0.02 J	0.089	0.02 J	NA	0.03 J

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-02
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jun-17	Aug-17	Mar-18	Oct-18	Mar-19	Oct-19	Mar-20
Appendix III Constituents								
Boron, B	mg/L	3.58	3.72	3.98	4.36	3.3	NA	4
Calcium, Ca	mg/L	249	266	231	277	250	NA	270
Chloride, Cl	mg/L	11.4	11.7	12.1	11.3	6.5	NA	10
Fluoride, F	mg/L	0.3	0.32	0.37	0.36	0.35	NA	0.37
pH	s.u.	7.07	6.95	7.34	6.64	6.85	NA	7.35
Sulfate, SO4	mg/L	573	581	607	515	500	NA	520
Total Dissolved Solids (TDS)	mg/L	1220	1180	1200	1190	1100	NA	1200
Appendix IV Constituents								
Antimony, Sb	ug/L	0.22	0.27	NA	0.14	2 U	NA	NA
Arsenic, As	ug/L	0.97	0.78	NA	0.44	5 U	NA	NA
Barium, Ba	ug/L	33	32.6	NA	22.6	19	NA	NA
Beryllium, Be	ug/L	0.03	0.03	NA	0.1 U	1 U	NA	NA
Cadmium, Cd	ug/L	0.06	0.02	NA	0.03 J	1 U	NA	NA
Chromium, Cr	ug/L	2.5	2.14	NA	0.788	2 U	NA	NA
Cobalt, Co	ug/L	0.497	0.564	NA	0.081	1 U	NA	NA
Fluoride, F	mg/L	0.3	0.32	NA	0.36	0.35	NA	NA
Lithium, Li	mg/L	0.091	0.103	NA	0.088	1 U	NA	NA
Lead, Pb	ug/L	0.699	0.64	NA	0.09 J	0.071 B	NA	NA
Mercury, Hg	ug/L	1.16	0.005 U	NA	0.002 J	0.2 U	NA	NA
Molybdenum, Mo	ug/L	3	4.4	NA	2.45	2.3 J	NA	NA
Radium 226 & 228 (combined)	pCi/L	2.235	0.737	NA	0.3588	5 U	NA	NA
Selenium, Se	ug/L	0.2	0.1	NA	0.06 J	5 U	NA	NA
Thallium, Tl	ug/L	0.02 J	0.03 J	NA	0.5 U	1 U	NA	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-02
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Sep-20
Appendix III Constituents		
Boron, B	mg/L	3
Calcium, Ca	mg/L	220
Chloride, Cl	mg/L	8
Fluoride, F	mg/L	0.31
pH	s.u.	7.41
Sulfate, SO4	mg/L	490
Total Dissolved Solids (TDS)	mg/L	1000
Appendix IV Constituents		
Antimony, Sb	ug/L	NA
Arsenic, As	ug/L	NA
Barium, Ba	ug/L	NA
Beryllium, Be	ug/L	NA
Cadmium, Cd	ug/L	NA
Chromium, Cr	ug/L	NA
Cobalt, Co	ug/L	NA
Fluoride, F	mg/L	NA
Lithium, Li	mg/L	NA
Lead, Pb	ug/L	NA
Mercury, Hg	ug/L	NA
Molybdenum, Mo	ug/L	NA
Radium 226 & 228 (combined)	pCi/L	NA
Selenium, Se	ug/L	NA
Thallium, Tl	ug/L	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-03
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17
Appendix III Constituents								
Boron, B	mg/L	0.147	0.067	0.069	0.115	0.169	0.09	0.136
Calcium, Ca	mg/L	171	78.9	99	105	134	119	137
Chloride, Cl	mg/L	84.3	142	159	69	68.4	47.4	92.1
Fluoride, F	mg/L	0.23	0.27	0.25	0.27	0.29	0.19	0.22
pH	s.u.	7.61	7.39	7.19	7.36	7.46	6.76	6.78
Sulfate, SO4	mg/L	310	62.9	80.4	76.3	125	109	193
Total Dissolved Solids (TDS)	mg/L	810	514	580	468	640	564	664
Appendix IV Constituents								
Antimony, Sb	ug/L	0.1 U	0.07	0.08	0.09	0.06 J	0.06	0.07
Arsenic, As	ug/L	0.45	0.17	3.37	0.17	0.15	0.17	0.32
Barium, Ba	ug/L	15.8	7.6	11.6	12.7	13.2	11.9	12.4
Beryllium, Be	ug/L	0.027	0.02 U	0.02 U	0.02 U	0.04 U	0.02 U	0.01 J
Cadmium, Cd	ug/L	0.05 U	0.02 U	0.02 U	0.008 J	0.04 U	0.008 J	0.006 J
Chromium, Cr	ug/L	1.9	0.1	0.2	0.1	0.1	0.108	0.32
Cobalt, Co	ug/L	0.33	0.066	0.021	0.021	0.02 J	0.019	0.21
Fluoride, F	mg/L	0.23	0.27	0.25	0.27	0.29	0.19	0.22
Lithium, Li	mg/L	0.033	0.011	0.007	0.006	0.016	0.008	0.016
Lead, Pb	ug/L	0.385	0.063	0.037	0.047	0.04 J	0.007 J	0.233
Mercury, Hg	ug/L	0.005 U	0.005 U	0.005 U	0.2 U	0.005 U	0.003 J	0.005 U
Molybdenum, Mo	ug/L	1.74	3.28	3.2	2.78	3.25	4.56	2.2
Radium 226 & 228 (combined)	pCi/L	0.124	0.546 U	0.60324	0.401	1.392	0.891	1.143
Selenium, Se	ug/L	0.3	0.2	0.06 J	0.7	0.2 J	1	0.2
Thallium, Tl	ug/L	0.02 U	0.05 U	0.01 J	0.03 J	0.03 J	0.02 J	0.02 J

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-03
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jun-17	Aug-17	Mar-18	Oct-18	Mar-19	Oct-19	Mar-20
Appendix III Constituents								
Boron, B	mg/L	0.112	0.167	0.08	0.167	0.067 J	0.22	0.29
Calcium, Ca	mg/L	68.8	155	66.2	112	100	210	97
Chloride, Cl	mg/L	51	55.5	108	63.8	110	66	55
Fluoride, F	mg/L	0.22	0.29	0.22	0.26	0.21	0.3	0.23
pH	s.u.	7.38	6.99	7.05	7.7	6.85	7.08	6.57
Sulfate, SO4	mg/L	49.6	130	59.1	98	120	330	140
Total Dissolved Solids (TDS)	mg/L	379	672	402	564	540	970	530
Appendix IV Constituents								
Antimony, Sb	ug/L	0.11	0.04 J	NA	NA	NA	NA	NA
Arsenic, As	ug/L	0.15	0.23	NA	NA	NA	NA	NA
Barium, Ba	ug/L	8.85	13.6	NA	NA	NA	NA	NA
Beryllium, Be	ug/L	0.02 U	0.006 J	NA	NA	NA	NA	NA
Cadmium, Cd	ug/L	0.006 J	0.009 J	NA	NA	NA	NA	NA
Chromium, Cr	ug/L	0.121	0.187	NA	NA	NA	NA	NA
Cobalt, Co	ug/L	0.05	0.08	NA	NA	NA	NA	NA
Fluoride, F	mg/L	0.22	0.29	NA	NA	NA	NA	NA
Lithium, Li	mg/L	0.008	0.019	NA	NA	NA	NA	NA
Lead, Pb	ug/L	0.071	0.079	NA	NA	NA	NA	NA
Mercury, Hg	ug/L	1.24	0.005 U	NA	NA	NA	NA	NA
Molybdenum, Mo	ug/L	3	1.29	NA	NA	NA	NA	NA
Radium 226 & 228 (combined)	pCi/L	0.605	0.47	NA	NA	NA	NA	NA
Selenium, Se	ug/L	0.6	0.09 J	NA	NA	NA	NA	NA
Thallium, Tl	ug/L	0.02 J	0.03 J	NA	NA	NA	NA	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-03
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Sep-20
Appendix III Constituents		
Boron, B	mg/L	0.16
Calcium, Ca	mg/L	130
Chloride, Cl	mg/L	36
Fluoride, F	mg/L	0.27
pH	s.u.	6.61
Sulfate, SO4	mg/L	170
Total Dissolved Solids (TDS)	mg/L	600
Appendix IV Constituents		
Antimony, Sb	ug/L	NA
Arsenic, As	ug/L	NA
Barium, Ba	ug/L	NA
Beryllium, Be	ug/L	NA
Cadmium, Cd	ug/L	NA
Chromium, Cr	ug/L	NA
Cobalt, Co	ug/L	NA
Fluoride, F	mg/L	NA
Lithium, Li	mg/L	NA
Lead, Pb	ug/L	NA
Mercury, Hg	ug/L	NA
Molybdenum, Mo	ug/L	NA
Radium 226 & 228 (combined)	pCi/L	NA
Selenium, Se	ug/L	NA
Thallium, Tl	ug/L	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-04
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17	Jun-17
Appendix III Constituents									
Boron, B	mg/L	4.55	4.11	4.36	3.49	4.24	4.52	5.11	4.62
Calcium, Ca	mg/L	106	94.4	106	287	125	110	95.5	95.1
Chloride, Cl	mg/L	70.5	66.2	71.1	13.4	78.2	71.8	67	77.5
Fluoride, F	mg/L	0.25 U	0.2 U	0.2	0.33	0.15	0.1 J	0.18	0.17
pH	s.u.	8.45	8.61	8.82	8.31	7.34	9.07	7.62	7.85
Sulfate, SO4	mg/L	193	196	212	549	237	191	175	187
Total Dissolved Solids (TDS)	mg/L	456	496	520	1180	594	428	500	507
Appendix IV Constituents									
Antimony, Sb	ug/L	0.1 U	0.14	0.31	0.5	0.19	0.12	0.13	0.11
Arsenic, As	ug/L	3.34	3.27	0.15	2.33	3.16	3.74	4.86	4.79
Barium, Ba	ug/L	92.7	91.1	89.1	49.5	92.9	79.5	78.3	84.2
Beryllium, Be	ug/L	0.01 U	0.02 U	0.02 U	0.128	0.02 J	0.02 U	0.02 U	0.02 U
Cadmium, Cd	ug/L	0.05 U	0.02 U	0.02 U	0.07	0.01 J	0.02 U	0.006 J	0.02 U
Chromium, Cr	ug/L	0.3	0.1	0.2	5.7	2.5	0.135	0.265	0.114
Cobalt, Co	ug/L	0.421	0.251	0.172	2.85	0.467	0.24	0.29	0.251
Fluoride, F	mg/L	0.25 U	0.2 U	0.2	0.33	0.15	0.1 J	0.18	0.17
Lithium, Li	mg/L	0.005	0.022	0.007	0.086	0.013	0.008	0.012	0.011
Lead, Pb	ug/L	0.247	0.075	0.03	3.16	0.373	0.041	0.079	0.042
Mercury, Hg	ug/L	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.004 J	0.005 U	0.894
Molybdenum, Mo	ug/L	52	55.9	63.6	3.1	62.8	66.4	60.1	55.5
Radium 226 & 228 (combined)	pCi/L	0.1142	0.614 U	0.283	3.504	0.90792	0.461	1.067	0.635
Selenium, Se	ug/L	0.1	0.08 J	0.3	0.5	0.1 J	0.07 J	0.1	0.09 J
Thallium, Tl	ug/L	0.02 U	0.05 U	0.01 J	0.07	0.07 J	0.01 J	0.209	0.01 J

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-04
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Aug-17	Mar-18	Oct-18	Mar-19	Oct-19	Mar-20	Sep-20
Appendix III Constituents								
Boron, B	mg/L	4.65	4.61	4.59	5.6	5.5	5	5.3
Calcium, Ca	mg/L	110	94.1	121	130	110	100	120
Chloride, Cl	mg/L	83.7	63.2	113	130	92	92	120
Fluoride, F	mg/L	0.17	0.19	0.18	0.17	0.18	0.19	0.18
pH	s.u.	7.92	7.89	8.55	8.03	7.27	7.58	7.51
Sulfate, SO4	mg/L	209	193	205	240	210	190	210
Total Dissolved Solids (TDS)	mg/L	492	426	570	600	550	500	540
Appendix IV Constituents								
Antimony, Sb	ug/L	0.11	NA	NA	NA	NA	NA	NA
Arsenic, As	ug/L	4.55	NA	NA	NA	NA	NA	NA
Barium, Ba	ug/L	88.9	NA	NA	NA	NA	NA	NA
Beryllium, Be	ug/L	0.02 U	NA	NA	NA	NA	NA	NA
Cadmium, Cd	ug/L	0.008 J	NA	NA	NA	NA	NA	NA
Chromium, Cr	ug/L	0.112	NA	NA	NA	NA	NA	NA
Cobalt, Co	ug/L	0.245	NA	NA	NA	NA	NA	NA
Fluoride, F	mg/L	0.17	NA	NA	NA	NA	NA	NA
Lithium, Li	mg/L	0.008	NA	NA	NA	NA	NA	NA
Lead, Pb	ug/L	0.049	NA	NA	NA	NA	NA	NA
Mercury, Hg	ug/L	0.005 U	NA	NA	NA	NA	NA	NA
Molybdenum, Mo	ug/L	64.8	NA	NA	NA	NA	NA	NA
Radium 226 & 228 (combined)	pCi/L	0.698	NA	NA	NA	NA	NA	NA
Selenium, Se	ug/L	0.08 J	NA	NA	NA	NA	NA	NA
Thallium, Tl	ug/L	0.02 J	NA	NA	NA	NA	NA	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-05
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17	Jun-17
Appendix III Constituents									
Boron, B	mg/L	2.58	2.71	2.88	2.96	2.92	2.99	2.88	2.6
Calcium, Ca	mg/L	94.9	101	113	118	117	121	104	108
Chloride, Cl	mg/L	71.7	66.9	67.9	65.7	64.9	60.8	56.7	61.3
Fluoride, F	mg/L	0.26	0.28	0.25	0.19	0.18	0.15	0.16	0.15
pH	s.u.	7.89	8.12	8.36	8.14	7.43	8.26	7.57	7.67
Sulfate, SO4	mg/L	176	190	223	234	231	217	209	219
Total Dissolved Solids (TDS)	mg/L	492	516	502	508	548	490	540	561
Appendix IV Constituents									
Antimony, Sb	ug/L	0.45	0.6	0.09	0.07	0.16	0.11	0.06	0.03 J
Arsenic, As	ug/L	7.27	6.12	0.61	2.95	3.32	2.49	2.76	3.85
Barium, Ba	ug/L	160	208	171	148	131	131	135	125
Beryllium, Be	ug/L	0.027	0.02 J	0.02 U	0.02 U	0.03 J	0.005 J	0.005 J	0.01 J
Cadmium, Cd	ug/L	0.05 U	0.02	0.02	0.04	0.06	0.04	0.03	0.02 J
Chromium, Cr	ug/L	0.8	0.4	1.2	0.2	1.1	0.189	0.26	0.424
Cobalt, Co	ug/L	0.98	1.76	1.24	1.16	1.49	1.19	1.26	1.17
Fluoride, F	mg/L	0.26	0.28	0.25	0.19	0.18	0.15	0.16	0.15
Lithium, Li	mg/L	0.005 U	0.005 J	0.0007 J	0.004	0.006	0.001	0.002	0.002
Lead, Pb	ug/L	0.753	0.272	0.052	0.081	0.534	0.192	0.147	0.142
Mercury, Hg	ug/L	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.004 J	0.005 U	1.16
Molybdenum, Mo	ug/L	150	139	118	102	100	97.5	92.8	78.9
Radium 226 & 228 (combined)	pCi/L	0.236	1	0.889	1.96	1.264	1.135	0.43	2.179
Selenium, Se	ug/L	0.1	0.1	0.2	0.05 J	0.2	0.04 J	0.05 J	0.05 J
Thallium, Tl	ug/L	0.022	0.02 J	0.05 U	0.01 J	0.05 J	0.02 J	0.072	0.05 U

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-05
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Aug-17	Mar-18	Oct-18	Mar-19	Oct-19	Mar-20	Sep-20
Appendix III Constituents								
Boron, B	mg/L	0.107	3.14	3.19	3.6	3	3.2	3
Calcium, Ca	mg/L	28.9	123	119	130	130	140	130
Chloride, Cl	mg/L	60.3	62.7	60.2	60	59	64	65
Fluoride, F	mg/L	0.17	0.17	0.16	0.15	0.16	0.15	0.13
pH	s.u.	6.92	7.02	7.48	7.41	7.75	7.05	7.58
Sulfate, SO4	mg/L	229	240	235	250	240	210	240
Total Dissolved Solids (TDS)	mg/L	498	560	562	600	600	590	610
Appendix IV Constituents								
Antimony, Sb	ug/L	0.04 J	NA	NA	NA	NA	NA	NA
Arsenic, As	ug/L	2.65	NA	NA	NA	NA	NA	NA
Barium, Ba	ug/L	111	NA	NA	NA	NA	NA	NA
Beryllium, Be	ug/L	0.02 U	NA	NA	NA	NA	NA	NA
Cadmium, Cd	ug/L	0.02	NA	NA	NA	NA	NA	NA
Chromium, Cr	ug/L	0.113	NA	NA	NA	NA	NA	NA
Cobalt, Co	ug/L	1.13	NA	NA	NA	NA	NA	NA
Fluoride, F	mg/L	0.17	NA	NA	NA	NA	NA	NA
Lithium, Li	mg/L	0.001 U	NA	NA	NA	NA	NA	NA
Lead, Pb	ug/L	0.024	NA	NA	NA	NA	NA	NA
Mercury, Hg	ug/L	0.005 U	NA	NA	NA	NA	NA	NA
Molybdenum, Mo	ug/L	82.4	NA	NA	NA	NA	NA	NA
Radium 226 & 228 (combined)	pCi/L	1.351	NA	NA	NA	NA	NA	NA
Selenium, Se	ug/L	0.1 U	NA	NA	NA	NA	NA	NA
Thallium, Tl	ug/L	0.01 J	NA	NA	NA	NA	NA	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-06
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17	Jun-17
Appendix III Constituents									
Boron, B	mg/L	2.74	2.64	2.79	2.91	2.72	2.89	0.042	2.72
Calcium, Ca	mg/L	103	101	113	119	122	122	55.4	111
Chloride, Cl	mg/L	47.2	49.3	58.3	62.7	64.1	69.5	70	75.5
Fluoride, F	mg/L	0.14	0.2 U	0.19	0.15	0.1 J	0.14	0.16	0.15
pH	s.u.	7.82	7.61	8.02	7.9	7.25	7.94	7.78	6.95
Sulfate, SO4	mg/L	196	197	215	220	217	214	224	225
Total Dissolved Solids (TDS)	mg/L	476	506	504	536	540	508	530	589
Appendix IV Constituents									
Antimony, Sb	ug/L	0.25	0.1	0.04 J	0.04 J	0.11	0.04 J	0.07	0.06
Arsenic, As	ug/L	3.31	3.01	0.27	2.1	2.3	2.04	2.27	1.83
Barium, Ba	ug/L	90.6	76.8	73.7	64.7	63.9	64.4	63.5	63.6
Beryllium, Be	ug/L	0.017	0.02 U	0.02 U	0.02 U	0.02 J	0.006 J	0.01 J	0.021
Cadmium, Cd	ug/L	0.05 U	0.06	0.02	0.04	0.07	0.03	0.05	0.08
Chromium, Cr	ug/L	0.7	0.1	0.3	0.2	0.8	0.158	0.631	0.654
Cobalt, Co	ug/L	2.61	3.09	2.51	2.51	2.97	2.56	2.56	2.31
Fluoride, F	mg/L	0.14	0.2 U	0.19	0.15	0.1 J	0.14	0.16	0.15
Lithium, Li	mg/L	0.005 U	0.005	0.001 U	0.002	0.004	0.002	0.001 U	0.002
Lead, Pb	ug/L	0.456	0.085	0.062	0.109	0.684	0.089	0.448	0.575
Mercury, Hg	ug/L	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.004 J	0.005 U	0.694
Molybdenum, Mo	ug/L	86.6	85.9	83.6	78.9	77.2	79.2	74.7	71.5
Radium 226 & 228 (combined)	pCi/L	0.428 U	0.291 U	0.4065	1.4354	0.30378	0.736	1.261	2.801
Selenium, Se	ug/L	0.1 U	0.03 J	0.08 J	0.1 U	0.2 J	0.04 J	0.06 J	0.1
Thallium, Tl	ug/L	0.02 U	0.05 U	0.05 U	0.02 J	0.04 J	0.07	0.05 J	0.03 J

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-06
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Aug-17	Mar-18	Oct-18	Mar-19	Oct-19	Mar-20	Sep-20
Appendix III Constituents								
Boron, B	mg/L	2.78	2.37	2.81	3.8	3.8	3.8	3.8
Calcium, Ca	mg/L	117	102	111	140	130	130	130
Chloride, Cl	mg/L	75.2	56	80.1	84	86	80	83
Fluoride, F	mg/L	0.15	0.18	0.18	0.16	0.19	0.18	0.17
pH	s.u.	7.47	7.32	7.3	7.34	7.73	7.09	7.17
Sulfate, SO4	mg/L	232	141	216	260	220	250	210
Total Dissolved Solids (TDS)	mg/L	534	454	564	630	620	600	600
Appendix IV Constituents								
Antimony, Sb	ug/L	0.04 J	NA	NA	NA	NA	NA	NA
Arsenic, As	ug/L	1.39	NA	NA	NA	NA	NA	NA
Barium, Ba	ug/L	61.3	NA	NA	NA	NA	NA	NA
Beryllium, Be	ug/L	0.01 J	NA	NA	NA	NA	NA	NA
Cadmium, Cd	ug/L	0.09	NA	NA	NA	NA	NA	NA
Chromium, Cr	ug/L	0.295	NA	NA	NA	NA	NA	NA
Cobalt, Co	ug/L	2.32	NA	NA	NA	NA	NA	NA
Fluoride, F	mg/L	0.15	NA	NA	NA	NA	NA	NA
Lithium, Li	mg/L	0.007	NA	NA	NA	NA	NA	NA
Lead, Pb	ug/L	0.274	NA	NA	NA	NA	NA	NA
Mercury, Hg	ug/L	0.005 U	NA	NA	NA	NA	NA	NA
Molybdenum, Mo	ug/L	79.8	NA	NA	NA	NA	NA	NA
Radium 226 & 228 (combined)	pCi/L	0.789	NA	NA	NA	NA	NA	NA
Selenium, Se	ug/L	0.06 J	NA	NA	NA	NA	NA	NA
Thallium, Tl	ug/L	0.03 J	NA	NA	NA	NA	NA	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-07
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17	Jun-17
Appendix III Constituents									
Boron, B	mg/L	0.093	0.057	0.031	0.044	0.032	0.043	0.863	0.061
Calcium, Ca	mg/L	137	143	166	178	179	171	258	179
Chloride, Cl	mg/L	16.1	15.8	13.9	12.7	12.7	12.6	11.6	12.6
Fluoride, F	mg/L	0.25 U	0.28	0.31	0.3	0.33	0.24	0.31	0.28
pH	s.u.	7.54	6.93	7.01	7.07	6.62	7.07	7.65	7.7
Sulfate, SO4	mg/L	52.6	39.7	33.4	28.2	25	14.9	9.8	6.3
Total Dissolved Solids (TDS)	mg/L	754	760	750	742	728	718	748	771
Appendix IV Constituents									
Antimony, Sb	ug/L	0.37	0.44	0.14	0.1	0.09	0.21	0.3	0.1
Arsenic, As	ug/L	2.83	8.31	8.46	11.8	18.2	29.4	21.5	35.9
Barium, Ba	ug/L	196	231	225	224	284	375	378	551
Beryllium, Be	ug/L	0.02	0.021	0.028	0.008 J	0.02 J	0.008 J	0.021	0.004 J
Cadmium, Cd	ug/L	0.05 U	0.03	0.01 J	0.008 J	0.01 J	0.01 J	0.008 J	0.02 U
Chromium, Cr	ug/L	0.2	0.4	0.5	0.2	0.4	0.238	0.667	0.11
Cobalt, Co	ug/L	2.58	4.03	4.87	4.4	5.92	6.86	5.87	5.03
Fluoride, F	mg/L	0.25 U	0.28	0.31	0.3	0.33	0.24	0.31	0.28
Lithium, Li	mg/L	0.005 U	0.016	0.002	0.003	0.006	0.001 J	0.006	0.008
Lead, Pb	ug/L	0.233	0.336	0.326	0.092	0.264	0.092	0.34	0.178
Mercury, Hg	ug/L	0.005 U	0.002 J	0.005 U	0.005 U	0.005 U	0.003 J	0.005 U	1.01
Molybdenum, Mo	ug/L	10.1	10.5	7.28	6.85	8.88	12	9.48	9.39
Radium 226 & 228 (combined)	pCi/L	0.399 U	0.899	1.585	2.178	0.761	0.901	1.606	15.37
Selenium, Se	ug/L	0.3	0.3	0.1	0.1	0.2	0.2	0.2	0.3
Thallium, Tl	ug/L	0.04	0.03 J	0.03 J	0.02 J	0.02 J	0.02 J	0.052	0.02 J

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-07
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Aug-17	Mar-18	Oct-18	Mar-19	Oct-19	Mar-20	Sep-20
Appendix III Constituents								
Boron, B	mg/L	0.051	0.003 J	0.05 J	0.025 J	0.1 U	0.1 U	0.03 J
Calcium, Ca	mg/L	183	167	176	200	180	180	190
Chloride, Cl	mg/L	12.7	12.9	12.5	13	11	12	12
Fluoride, F	mg/L	0.29	0.37	0.32	0.33	0.27	0.29	0.3
pH	s.u.	7.27	6.95	6.75	6.82	6.95	6.75	7.17
Sulfate, SO4	mg/L	4.7	2.5	3.9	15	23	14	12
Total Dissolved Solids (TDS)	mg/L	752	777	770	840	760	740	640
Appendix IV Constituents								
Antimony, Sb	ug/L	0.12	NA	NA	NA	NA	NA	NA
Arsenic, As	ug/L	29.9	NA	NA	NA	NA	NA	NA
Barium, Ba	ug/L	561	NA	NA	NA	NA	NA	NA
Beryllium, Be	ug/L	0.02 J	NA	NA	NA	NA	NA	NA
Cadmium, Cd	ug/L	0.01 J	NA	NA	NA	NA	NA	NA
Chromium, Cr	ug/L	0.446	NA	NA	NA	NA	NA	NA
Cobalt, Co	ug/L	4.78	NA	NA	NA	NA	NA	NA
Fluoride, F	mg/L	0.29	NA	NA	NA	NA	NA	NA
Lithium, Li	mg/L	0.007	NA	NA	NA	NA	NA	NA
Lead, Pb	ug/L	0.328	NA	NA	NA	NA	NA	NA
Mercury, Hg	ug/L	0.005 U	NA	NA	NA	NA	NA	NA
Molybdenum, Mo	ug/L	10.3	NA	NA	NA	NA	NA	NA
Radium 226 & 228 (combined)	pCi/L	1.66	NA	NA	NA	NA	NA	NA
Selenium, Se	ug/L	0.4	NA	NA	NA	NA	NA	NA
Thallium, Tl	ug/L	0.057	NA	NA	NA	NA	NA	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-08
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17
Appendix III Constituents								
Boron, B	mg/L	0.039	0.042	0.021	0.041	0.043	0.027	0.03
Calcium, Ca	mg/L	88.1	79.6	83.2	87.3	85.6	83.1	79.2
Chloride, Cl	mg/L	15.4	16.5	16	16.5	16	15.8	15.3
Fluoride, F	mg/L	0.25 U	0.2 U	0.23	0.18	0.21	0.1 J	0.24
pH	s.u.	6.85	6.5	6.83	6.87	6.49	6.62	6.48
Sulfate, SO4	mg/L	1 U	0.2 J	0.2 J	0.1 U	0.2 U	0.2 U	0.2 U
Total Dissolved Solids (TDS)	mg/L	356	440	364	394	348	324	280
Appendix IV Constituents								
Antimony, Sb	ug/L	0.23	0.13	0.09	0.08	0.1 J	0.14	0.11
Arsenic, As	ug/L	51.3	65.6	69.3	71.9	76.8	72.7	59.7
Barium, Ba	ug/L	368	395	466	393	386	387	333
Beryllium, Be	ug/L	0.064	0.081	0.052	0.098	0.059	0.068	0.068
Cadmium, Cd	ug/L	0.05 U	0.02	0.02 J	0.04	0.02 J	0.02 J	0.02
Chromium, Cr	ug/L	1.4	1.8	1	1.1	1.4	1.41	1.39
Cobalt, Co	ug/L	4.1	2.7	1.75	2.18	1.83	1.83	1.95
Fluoride, F	mg/L	0.25 U	0.2 U	0.23	0.18	0.21	0.1 J	0.24
Lithium, Li	mg/L	0.005 U	0.002 J	0.001 U	0.001 U	0.003	0.001 U	0.001 U
Lead, Pb	ug/L	1.41	1.47	0.905	2.72	1.13	1.18	1.24
Mercury, Hg	ug/L	0.005 U	0.002 J	0.005 U	0.003 J	0.005 U	0.004 J	0.003 J
Molybdenum, Mo	ug/L	4.66	2.24	1.44	0.82	1.75	1.83	1.25
Radium 226 & 228 (combined)	pCi/L	0.246 U	0.821 U	1.212	2.995	0.521	1.949	1.044
Selenium, Se	ug/L	0.3	0.4	0.3	0.4	0.4	0.3	0.3
Thallium, Tl	ug/L	0.02 U	0.02 J	0.02 J	0.02 J	0.1 U	0.03 J	0.02 J

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-08
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jun-17	Aug-17	Mar-18	Oct-18	Mar-19	Oct-19	Mar-20
Appendix III Constituents								
Boron, B	mg/L	0.083	0.113	0.005 U	0.132	0.027 J	0.028 J	0.1 U
Calcium, Ca	mg/L	73.9	77	74.6	72.2	78	80	85
Chloride, Cl	mg/L	16	16.3	16.5	16.6	17	16	16
Fluoride, F	mg/L	0.22	0.2	0.26	0.19	0.16	0.19	0.19
pH	s.u.	8.03	7.92	7.08	6.35	6.42	7.89	7.05
Sulfate, SO4	mg/L	0.2 U	0.2 U	0.2	0.4 U	8.1	1.8	4
Total Dissolved Solids (TDS)	mg/L	368	340	380	336	350	340	330
Appendix IV Constituents								
Antimony, Sb	ug/L	0.07	0.07	NA	NA	NA	NA	NA
Arsenic, As	ug/L	79.2	75.8	NA	NA	NA	NA	NA
Barium, Ba	ug/L	383	362	NA	NA	NA	NA	NA
Beryllium, Be	ug/L	0.03	0.02 J	NA	NA	NA	NA	NA
Cadmium, Cd	ug/L	0.008 J	0.02 U	NA	NA	NA	NA	NA
Chromium, Cr	ug/L	0.675	0.607	NA	NA	NA	NA	NA
Cobalt, Co	ug/L	1.48	1.36	NA	NA	NA	NA	NA
Fluoride, F	mg/L	0.22	0.2	NA	NA	NA	NA	NA
Lithium, Li	mg/L	0.008	0.006	NA	NA	NA	NA	NA
Lead, Pb	ug/L	0.457	0.232	NA	NA	NA	NA	NA
Mercury, Hg	ug/L	1.04	0.005 U	NA	NA	NA	NA	NA
Molybdenum, Mo	ug/L	0.94	2.03	NA	NA	NA	NA	NA
Radium 226 & 228 (combined)	pCi/L	1.223	0.7782	NA	NA	NA	NA	NA
Selenium, Se	ug/L	0.2	0.3	NA	NA	NA	NA	NA
Thallium, Tl	ug/L	0.05 U	0.05 U	NA	NA	NA	NA	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-08
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Sep-20
Appendix III Constituents		
Boron, B	mg/L	0.03 J
Calcium, Ca	mg/L	76
Chloride, Cl	mg/L	17
Fluoride, F	mg/L	0.17
pH	s.u.	6.81
Sulfate, SO4	mg/L	0.82 J
Total Dissolved Solids (TDS)	mg/L	360
Appendix IV Constituents		
Antimony, Sb	ug/L	NA
Arsenic, As	ug/L	NA
Barium, Ba	ug/L	NA
Beryllium, Be	ug/L	NA
Cadmium, Cd	ug/L	NA
Chromium, Cr	ug/L	NA
Cobalt, Co	ug/L	NA
Fluoride, F	mg/L	NA
Lithium, Li	mg/L	NA
Lead, Pb	ug/L	NA
Mercury, Hg	ug/L	NA
Molybdenum, Mo	ug/L	NA
Radium 226 & 228 (combined)	pCi/L	NA
Selenium, Se	ug/L	NA
Thallium, Tl	ug/L	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-09
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17
Appendix III Constituents								
Boron, B	mg/L	0.014	0.048	0.006	0.021	0.023	0.031	0.124
Calcium, Ca	mg/L	62.2	75	50	47.7	49.9	51.1	47.4
Chloride, Cl	mg/L	4.94	4.78	3.57	3.26	3.12	3.2	3.98
Fluoride, F	mg/L	0.33	0.32	0.32	0.38	0.31	0.33	0.25
pH	s.u.	6.62	6.81	6.78	7.38	6.51	6.75	7.05
Sulfate, SO4	mg/L	4.5	6.2	3.8	4	3.6	1.8	282
Total Dissolved Solids (TDS)	mg/L	248	244	280	176	230	200	728
Appendix IV Constituents								
Antimony, Sb	ug/L	0.41	0.1	0.15	0.09	0.05 J	0.15	0.04 J
Arsenic, As	ug/L	7.35	5.88	21.6	26.5	19.1	20.4	25.4
Barium, Ba	ug/L	157	193	209	222	194	204	189
Beryllium, Be	ug/L	0.039	0.009 J	0.022	0.025	0.01 J	0.01 J	0.02 J
Cadmium, Cd	ug/L	0.05 J	0.04	0.01 J	0.05	0.02 J	0.005 J	0.006 J
Chromium, Cr	ug/L	0.4	0.2	0.6	0.8	0.3	0.358	0.479
Cobalt, Co	ug/L	2.57	6.06	3.79	3.8	3.24	3.25	2
Fluoride, F	mg/L	0.33	0.32	0.32	0.38	0.31	0.33	0.25
Lithium, Li	mg/L	0.004 J	0.005 U	0.001 U	0.024	0.001 U	0.001 U	0.014
Lead, Pb	ug/L	0.291	0.127	0.326	0.522	0.164	0.179	0.238
Mercury, Hg	ug/L	0.005 U	0.005 U	0.005 U	0.2 U	0.005 U	0.004 J	0.005 U
Molybdenum, Mo	ug/L	2.66	3.39	4.92	6.49	4.89	12.4	4.66
Radium 226 & 228 (combined)	pCi/L	0.114	0.426 U	0.448	0.663	1.047	0.4799	NA
Selenium, Se	ug/L	0.1	0.1	0.2	0.1	0.2 J	0.1	0.06 J
Thallium, Tl	ug/L	0.01 J	0.03 J	0.02 J	0.05 J	0.1 U	0.02 J	0.05 U

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-09
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jun-17	Aug-17	Mar-18	Oct-18	Mar-19	Oct-19	Mar-20
Appendix III Constituents								
Boron, B	mg/L	0.07	0.048	0.054	0.291	0.042 J	0.038 J	0.091 J
Calcium, Ca	mg/L	44.6	48.6	48.6	56	48	53	47
Chloride, Cl	mg/L	2.23	2.52	3.35	2.05	1.7	2.4	2.5
Fluoride, F	mg/L	0.32	0.38	0.22	0.43	0.32	0.47	0.46
pH	s.u.	7.77	7.3	7.22	6.48	6.71	7.49	7.95
Sulfate, SO4	mg/L	0.2 J	0.5	55.3	4.7	17	5.7	2.7
Total Dissolved Solids (TDS)	mg/L	223	206	221	239	210	240	200
Appendix IV Constituents								
Antimony, Sb	ug/L	0.04 J	0.05 J	NA	NA	NA	NA	NA
Arsenic, As	ug/L	28.1	19.5	NA	NA	NA	NA	NA
Barium, Ba	ug/L	192	183	NA	NA	NA	NA	NA
Beryllium, Be	ug/L	0.01 J	0.01 J	NA	NA	NA	NA	NA
Cadmium, Cd	ug/L	0.005 J	0.02 J	NA	NA	NA	NA	NA
Chromium, Cr	ug/L	0.26	0.4	NA	NA	NA	NA	NA
Cobalt, Co	ug/L	1.58	1.47	NA	NA	NA	NA	NA
Fluoride, F	mg/L	0.32	0.38	NA	NA	NA	NA	NA
Lithium, Li	mg/L	0.004	0.005	NA	NA	NA	NA	NA
Lead, Pb	ug/L	0.135	0.21	NA	NA	NA	NA	NA
Mercury, Hg	ug/L	0.668	0.005 U	NA	NA	NA	NA	NA
Molybdenum, Mo	ug/L	3.39	5.65	NA	NA	NA	NA	NA
Radium 226 & 228 (combined)	pCi/L	1.443	0.708	NA	NA	NA	NA	NA
Selenium, Se	ug/L	0.1	0.1	NA	NA	NA	NA	NA
Thallium, Tl	ug/L	0.05 U	0.05 U	NA	NA	NA	NA	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-09
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Sep-20
Appendix III Constituents		
Boron, B	mg/L	0.1 U
Calcium, Ca	mg/L	58
Chloride, Cl	mg/L	2.7
Fluoride, F	mg/L	0.54
pH	s.u.	7.87
Sulfate, SO4	mg/L	0.48 J
Total Dissolved Solids (TDS)	mg/L	250
Appendix IV Constituents		
Antimony, Sb	ug/L	NA
Arsenic, As	ug/L	NA
Barium, Ba	ug/L	NA
Beryllium, Be	ug/L	NA
Cadmium, Cd	ug/L	NA
Chromium, Cr	ug/L	NA
Cobalt, Co	ug/L	NA
Fluoride, F	mg/L	NA
Lithium, Li	mg/L	NA
Lead, Pb	ug/L	NA
Mercury, Hg	ug/L	NA
Molybdenum, Mo	ug/L	NA
Radium 226 & 228 (combined)	pCi/L	NA
Selenium, Se	ug/L	NA
Thallium, Tl	ug/L	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-10
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jan-16	Mar-16	May-16	Jul-16	Aug-16	Nov-16	Feb-17
Appendix III Constituents								
Boron, B	mg/L	0.023	0.058	0.018	0.032	0.08	0.055	0.088
Calcium, Ca	mg/L	85.3	75.2	91.4	87.8	94.8	88.2	75.9
Chloride, Cl	mg/L	18.3	19.8	21	21	21.1	20.8	20.6
Fluoride, F	mg/L	0.2 J	0.25	0.27	0.28	0.23	0.24	0.25
pH	s.u.	6.73	6.88	6.82	7.4	6.65	6.72	7.11
Sulfate, SO4	mg/L	61.4	51.5	41	43.1	58.6	45.1	35.3
Total Dissolved Solids (TDS)	mg/L	350	400	370	376	370	328	314
Appendix IV Constituents								
Antimony, Sb	ug/L	0.23	0.17	0.2	0.29	0.16	0.21	0.15
Arsenic, As	ug/L	1.73	4.27	8.35	5.52	3.66	12.5	6.92
Barium, Ba	ug/L	196	203	225	198	208	273	216
Beryllium, Be	ug/L	0.032	0.041	0.077	0.037	0.02 J	0.306	0.077
Cadmium, Cd	ug/L	0.06	0.04	0.03	0.03	0.03 J	0.1	0.03
Chromium, Cr	ug/L	0.3	0.8	1.2	0.9	0.4	6.45	1.84
Cobalt, Co	ug/L	2.81	2.68	3.18	2.19	2.17	6.47	2.39
Fluoride, F	mg/L	0.2 J	0.25	0.27	0.28	0.23	0.24	0.25
Lithium, Li	mg/L	0.003 J	0.005 U	0.001 U	0.004	0.003	0.013	0.016
Lead, Pb	ug/L	0.342	0.455	1.04	0.622	0.392	4.91	0.943
Mercury, Hg	ug/L	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.011	0.002 J
Molybdenum, Mo	ug/L	2.51	3.84	3.58	4.52	16.4	29.9	3.86
Radium 226 & 228 (combined)	pCi/L	0.0206	0.857 U	0.288	1.374	1.274	1.336	0.6692
Selenium, Se	ug/L	0.1	0.1	0.3	0.1	0.1 J	0.9	0.2
Thallium, Tl	ug/L	0.01 J	0.04 J	0.02 J	0.02 J	0.02 J	0.095	0.03 J

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-10
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Jun-17	Aug-17	Mar-18	Oct-18	Mar-19	Oct-19	Mar-20
Appendix III Constituents								
Boron, B	mg/L	0.111	0.061	0.005 U	0.16	0.037 J	0.03 J	0.024 J
Calcium, Ca	mg/L	66.1	72.6	70.4	78.6	71	67	68
Chloride, Cl	mg/L	21	21.3	24	20.9	22	21	22
Fluoride, F	mg/L	0.25	0.25	0.28	0.29	0.28	0.29	0.3
pH	s.u.	7.49	7.53	6.95	6.39	6.98	7.38	7.42
Sulfate, SO4	mg/L	38.6	37.1	44.7	38.8	44	38	40
Total Dissolved Solids (TDS)	mg/L	328	288	329	316	310	30	310
Appendix IV Constituents								
Antimony, Sb	ug/L	0.15	0.14	NA	NA	NA	NA	NA
Arsenic, As	ug/L	10.6	7.27	NA	NA	NA	NA	NA
Barium, Ba	ug/L	292	236	NA	NA	NA	NA	NA
Beryllium, Be	ug/L	0.276	0.071	NA	NA	NA	NA	NA
Cadmium, Cd	ug/L	0.11	0.03	NA	NA	NA	NA	NA
Chromium, Cr	ug/L	5.63	1.75	NA	NA	NA	NA	NA
Cobalt, Co	ug/L	5.67	2.59	NA	NA	NA	NA	NA
Fluoride, F	mg/L	0.25	0.25	NA	NA	NA	NA	NA
Lithium, Li	mg/L	0.011	0.009	NA	NA	NA	NA	NA
Lead, Pb	ug/L	4.56	1.1	NA	NA	NA	NA	NA
Mercury, Hg	ug/L	1.2	0.005 U	NA	NA	NA	NA	NA
Molybdenum, Mo	ug/L	2.7	5.6	NA	NA	NA	NA	NA
Radium 226 & 228 (combined)	pCi/L	0.2395	0.859	NA	NA	NA	NA	NA
Selenium, Se	ug/L	1	0.2	NA	NA	NA	NA	NA
Thallium, Tl	ug/L	0.069	0.03 J	NA	NA	NA	NA	NA

Notes:

NA: Sampling not required for this parameter or well dry.

WBSP-15-10
SUMMARY OF 2015-2020 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Sep-20
Appendix III Constituents		
Boron, B	mg/L	0.042 J
Calcium, Ca	mg/L	79
Chloride, Cl	mg/L	23
Fluoride, F	mg/L	0.26
pH	s.u.	7.47
Sulfate, SO4	mg/L	52
Total Dissolved Solids (TDS)	mg/L	370
Appendix IV Constituents		
Antimony, Sb	ug/L	NA
Arsenic, As	ug/L	NA
Barium, Ba	ug/L	NA
Beryllium, Be	ug/L	NA
Cadmium, Cd	ug/L	NA
Chromium, Cr	ug/L	NA
Cobalt, Co	ug/L	NA
Fluoride, F	mg/L	NA
Lithium, Li	mg/L	NA
Lead, Pb	ug/L	NA
Mercury, Hg	ug/L	NA
Molybdenum, Mo	ug/L	NA
Radium 226 & 228 (combined)	pCi/L	NA
Selenium, Se	ug/L	NA
Thallium, Tl	ug/L	NA

Notes:

NA: Sampling not required for this parameter or well dry.



OHIO VALLEY ELECTRIC CORPORATION

3932 U. S. Route 23
P. O. Box 468
Piketon, Ohio 45661
740-289-7200

WRITER'S DIRECT DIAL NO:
740-897-7768

July 8, 2019

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. Bruno Pigott, Commissioner
Indiana Department of Environmental Management
100 N. Senate Avenue
Mail Code 50-01
Indianapolis, IN 46204-2251

Dear Mr. Pigott:

Re: Indiana-Kentucky Electric Corporation
Notification of Successful ASD- Clifty Creek Station Landfill

As required by 40 CFR 257.106(h)(6), the Indiana-Kentucky Electric Corporation (IKEC) previously notified the Commissioner (State Director) of the Indiana Department of Environmental Management on February 14, 2019 that a statistically significant levels of Molybdenum, an Appendix IV constituent, have been detected and confirmed to be above Groundwater Protection Standards (GWPS) established for the Clifty Creek Station Landfill and the Landfill Runoff Collection Pond.

The Clifty Creek Station Landfill and Landfill Runoff Collection Pond share a monitoring network, and therefore both entered Assessment Monitoring as prescribed by 40 CFR 257.96(a) on February 14, 2019. Subsequently, on May 15, 2019 it was determined that a successful Alternative Source Demonstration (ASD) argument could be made for the Clifty Creek Station Landfill, and that the unit would remain in Detection Monitoring. A copy of the ASD report, certified by IKEC's Qualified Professional Engineer, has been posted to IKEC's publically accessible internet site at:
<https://www.ovec.com/CCRCompliance.php>.

If you have any questions, or require any additional information, please call me at (740) 897-7768.

Sincerely,

A handwritten signature in black ink that reads "Tim Fulk". The signature is written in a cursive style.

Tim Fulk
Engineer II

TLF:klr



Stantec Consulting Services Inc.
11687 Lebanon Road, Cincinnati OH 45241-2012

July 3, 2019
File: 175534018, 200.201

Indiana-Kentucky Electric Corporation
Attention: Mr. Gabriel Coriell
3932 U.S. Route 23
P.O. Box 468
Piketon, Ohio 45661

**Reference: Alternate Source Demonstration Report
March 2018 Detection Monitoring Event
CCR Landfill and Landfill Runoff Collection Pond
EPA Final Coal Combustion Residuals (CCR) Rule
Clifty Creek Station
Madison, Jefferson County, Indiana**

Dear Mr. Coriell,

This letter documents Stantec Consulting Services Inc.'s (Stantec's) certification of the alternate source demonstration report for the March 2018 detection monitoring event for the Indiana-Kentucky Electric Corporation (IKEC) Clifty Creek Station's CCR Landfill and Landfill Runoff Collection Pond (LRCP) multiunit groundwater system in accordance with 40 CFR 257.94(e)(2).

The *Disposal of Coal Combustion Residuals From Electric Utilities* rule (CCR Rule) was signed by the U.S. Environmental Protection Agency (EPA) Administrator on December 19, 2014 and published in the Federal Register on April 17, 2014. IKEC contracted Applied Geology and Environmental Science, Inc. (AGES) to administer the Clifty Creek Station's CCR Rule groundwater monitoring program based on AGES's history with the site and the Indiana groundwater program. IKEC enlisted Stantec to provide engineering support for the demonstrations required under the CCR Rule. Stantec has worked with the Clifty Creek Station since 2005 and is the design engineer and engineer of record for the station's CCR Landfill. Ongoing coordination for the three companies during the CCR Rule groundwater schedule has included biweekly conference calls and in-person meetings.

Stantec personnel (the certifying professional engineer and a senior hydrogeologist) have reviewed the *Coal Combustion Residuals Regulation, Alternate Source Demonstration Report, March 2018 Detection Monitoring Event, Indiana Kentucky Electric Corporation, Clifty Creek Plant, Type I Residual Waste Landfill and Landfill Runoff Collection Pond, Madison, Jefferson County, Indiana* (AGES, June 2019).

I, Jacqueline S. Harmon, being a Professional Engineer in good standing in the State of Indiana, do hereby certify, to the best of my knowledge, information, and belief:

1. that the information contained in this report was prepared in accordance with the reasonable skill and diligence required by customarily accepted professional practices and procedures normally provided in the performance of the services at the time when and the location in which the services were performed and

Reference: **Alternate Source Demonstration Report**
March 2018 Detection Monitoring Event
CCR Landfill and Landfill Runoff Collection Pond
EPA Final Coal Combustion Residuals (CCR) Rule
Clifty Creek Station
Madison, Jefferson County, Indiana

2. that the alternate source demonstration for boron for the March 2018 detection monitoring event at the IKEC Clifty Creek Station's CCR Landfill meets the requirements specified in 40 CFR 257.94(e)(2).

SIGNATURE *Jacqueline S. Harmon*

DATE 7/3/2019

ADDRESS: Stantec Consulting Services Inc.
11687 Lebanon Road
Cincinnati, Ohio 45241

TELEPHONE: (513) 842-8200

ATTACHMENTS: Applied Geology and Environmental Science, Inc. (AGES) (2019). Coal Combustion Residuals Regulation, Alternate Source Demonstration Report, March 2018 Detection Monitoring Event, Indiana Kentucky Electric Corporation, Clifty Creek Plant, Type I Residual Waste Landfill and Landfill Runoff Collection Pond, Madison, Jefferson County, Indiana. June.

c. John Griggs, John McInnes (Stantec)

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AGES
Applied Geology And Environmental Science, Inc.

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Clinton, PA 15026

www.appliedgeology.net

P 412. 264. 6453

F 412. 264. 6567

**COAL COMBUSTION RESIDUALS REGULATION
ALTERNATE SOURCE DEMONSTRATION REPORT
MARCH 2018 DETECTION MONITORING EVENT**

**INDIANA KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK PLANT
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
MADISON, JEFFERSON COUNTY, INDIANA**

June 2019

Prepared for:

INDIANA KENTUCKY ELECTRIC CORPORATION (IKEC)

By:

APPLIED GEOLOGY AND ENVIRONMENTAL SCIENCE, INC.

**ALTERNATE SOURCE DEMONSTRATION REPORT
MARCH 2018 DETECTION MONITORING EVENT
INDIANA KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK PLANT
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
MADISON, JEFFERSON COUNTY, INDIANA**

June 2019

Prepared for:

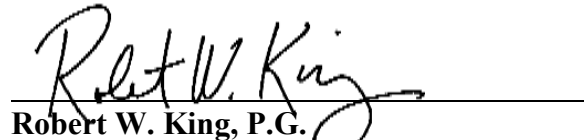
INDIANA KENTUCKY ELECTRIC CORPORATION (IKEC)

Prepared By:

Applied Geology and Environmental Science, Inc.



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**ALTERNATE SOURCE DEMONSTRATION REPORT
MARCH 2018 DETECTION MONITORING EVENT
INDIANA KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK PLANT
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
MADISON, JEFFERSON COUNTY, INDIANA**

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1.0 INTRODUCTION

On December 19, 2014, the United States Environmental Protection Agency (U.S. EPA) issued their final Coal Combustion Residuals (CCR) regulation which regulates CCR as a non-hazardous waste under Subtitle D of the Resource Conservation and Recovery Act (RCRA) and became effective six (6) months from the date of its publication (April, 2015) in the Federal Register, referred to as the “CCR Rule.”

The Indiana Kentucky Electric Corporation (IKEC) contracted with Applied Geology and Environmental Science, Inc. (AGES) to administer the CCR Rule groundwater monitoring program at the Clifty Creek Station located in Madison, Jefferson County, Indiana. There are three (3) CCR units at the Clifty Creek Station (Figure 1):

- Type I Residual Waste Landfill (Type I Landfill);
- Landfill Runoff Collection Pond (LRCP); and,
- West Boiler Slag Pond (WBSP).

Statistically Significant Increases (SSIs) were not identified at the WBSP during the March 2018 Detection Monitoring event. Therefore, the WBSP is not discussed further in this report.

During the March 2018 Detection Monitoring event, Boron SSIs were confirmed in two (2) wells located downgradient of the Type I Landfill and LRCP and these CCR units entered into Assessment Monitoring on September 11, 2018. As presented in this report, OVEC has determined that the Type I Landfill is not the source of the Boron. Therefore, the Type I Landfill will return to Detection Monitoring. As an alternate source for Boron at the LRCP could not be established, the LRCP will remain in Assessment Monitoring.

Details regarding this evaluation are presented in this report.

1.1 Background

In accordance with §257.91(d) of the CCR Rule, as detailed in the Well Installation Report (AGES 2016b), because the LRCP is directly adjacent to the southwest (downgradient) of the Type I Landfill, and because of the hydrogeologic conditions of the site, IKEC installed a

multiunit groundwater monitoring system to monitor groundwater quality directly downgradient of the Type I Landfill & LRCP. In accordance with §257.94 of the CCR Rule, IKEC completed the groundwater monitoring requirements of the Detection Monitoring Program at the Type I Landfill & LRCP as described below.

The first round of Detection Monitoring groundwater samples was collected from monitoring wells at the Type I Landfill & LRCP at the Clifty Creek Station between March 19 and 22, 2018 in accordance with §257.94(a) of the CCR Rule (Figure 1). All samples were collected in accordance with the Groundwater Monitoring Program Plan (GMPP) (AGES 2016a) and analyzed for all Appendix III constituents.

Upon receipt, the groundwater monitoring data were statistically evaluated in accordance with §257.93(f) of the CCR Rule and the Statistical Analysis Plan (SAP) (Stantec 2018) for the Clifty Creek Station CCR groundwater monitoring program. The initial statistical evaluation identified potential SSIs of one (1) or more Appendix III constituents in monitoring wells CF-15-07 through CF-15-09 at the Landfill and LRCP. The results of the statistical evaluation are summarized in Table 1.

In accordance with the SAP, IKEC resampled the wells for those constituents with potential SSIs on May 21 and May 22, 2018. Based on the results of the resampling event, SSIs for Boron were confirmed in monitoring wells CF-15-08 and CF-15-09 (Table 1).

1.2 Purpose of This Report

The purpose of this report is to present an Alternate Source Demonstration (ASD) and provide sufficient evidence that the SSIs identified for Boron in wells CF-15-08 and CF-15-09 resulted from a source other than the active Type I Landfill & LRCP.

The CCR Rule does not contain specific requirements for an ASD beyond what is stated, as follows, in §257.94(e)(2):

“The owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The owner or operator must complete the written demonstration within 90 days of detecting a statistically significant increase over background levels to include obtaining a certification from a qualified professional engineer verifying the accuracy of the information in the report. If a successful demonstration is completed within the 90-day period, the owner or operator of the CCR unit may continue with a detection monitoring program under this section. If a successful demonstration is not completed within the 90-day period, the owner or operator of the CCR unit must initiate an assessment monitoring program as required under § 257.95. The owner or operator must also include the demonstration in the

annual groundwater monitoring and corrective action report required by § 257.90(e), in addition to the certification by a qualified professional engineer.”

In addition to the above requirements of the CCR Rule, this ASD has been conducted and presented using guidance and documentation recommendations included in the U.S. EPA document *Solid Waste Disposal Facility Criteria Technical Manual EPA 530-R-93-017* (U.S. EPA 1993).

A detailed discussion of the confirmed SSIs, and a technical justification that the exceedances result from a source other than the Type I Landfill & LRCP are presented in the following sections of this report.

2.0 DESCRIPTION OF THE TYPE I LANDFILL & LRCP

2.1 Unit Description

The active Type I Landfill occupies an approximately 200-acre area situated within an eroded bedrock channel. 109 acres were approved as a Type I residual waste landfill by the Indiana Department of Environmental Management (IDEM) in 2007. The remaining 91 acres consist of the LRCP located at the southwest end of the Type I Landfill (Figures 1 and 2).

Beginning in 1955, ash products were sluiced to disposal ponds located in the bedrock channel at the plant site. To allow for more disposal capacity, an on-site fly ash pond was developed into a Type III residual landfill in 1988. All required permits for the Type III Residual Waste Landfill (Type III Landfill) were obtained from IDEM. The Type III Landfill was permitted to be constructed, and to serve as closure for the historic fly ash ponds. The Type III Landfill is located at the northeast end of the bedrock channel and went operational in 1991.

After IDEM approval, IKEC upgraded the Type III Landfill to a Type I residual waste landfill (Type I Landfill). As a result, the Type III Landfill was closed and the Type I Landfill was designed and constructed to serve as the cap for the closed Type III Landfill. The Type I Landfill, which went operational in 2011, is completely separated from the closed Type III Landfill by a geosynthetic liner and a compacted clay liner.

The LRCP is an unlined pond located at the southern edge of the station. It is bordered by the Type I Landfill to the north, natural grade to the east and west, and by a dam to the south that runs along the bank of the Ohio River. Approximately 508 acres of both landfill contact water and stormwater runoff drain to the LRCP (Stantec 2016). The base of the LRCP consists of historic hydraulically-placed fly ash. The LRCP does not receive CCR and any CCR within the LRCP is not being actively managed. Therefore, the LRCP is identified as an inactive unit under the CCR Rule.

2.2 Hydrogeology

Based on information in the Hydrogeologic Study Report (AGES 2007), bedrock beneath the Type I Landfill & LRCP and the closed Type III Landfill consists of impermeable limestone and shale of the Ordovician Dillsboro formation, which is overlain by approximately 20 to 35 feet of gray clay. The gray clay is directly overlain by fly ash that had been historically hydraulically placed in the area. A generalized cross section showing the proposed final limits of the Type I Landfill & LRCP, the location and limits of the closed Type III Landfill, and the extent of the historic hydraulically placed fly ash is presented in Figure 3. A limestone ridge known as the Devil's Backbone runs northeast to southwest along the length of the Type I Landfill & LRCP and the closed Type III Landfill. The Devil's Backbone acts as an impermeable barrier that forces groundwater passing beneath both of the landfills to flow either toward the northeast or toward the southwest. A detailed hydrogeologic study determined that a groundwater flow divide is present near the northeast end of the bedrock channel and that all groundwater beneath the active Type I Landfill flows toward the southwest (AGES 2007) (Figure 4). As detailed in the Monitoring Well Installation Report (AGES 2016b), an aquifer does not exist beneath either of the landfills. Therefore, alluvial deposits located southwest of the LRCP are designated as the uppermost aquifer for the Type I Landfill & LRCP.

The Type I Landfill was constructed using a geosynthetic liner and a compacted clay liner to prevent water from the Type I Landfill from entering the underlying layers. Water in the Type I Landfill is collected by an underground leachate system and is currently discharged into the West Boiler Slag Pond (WBSP) where it mixes with surface water runoff from the surrounding 510-acre drainage area.

In November and December 2015, six (6) monitoring wells were installed at the Type I Landfill & LRCP (Figure 1). Three (3) monitoring wells (CF-15-07, CF-15-08 and CF-15-09) were installed in the alluvial deposits (uppermost aquifer) located southwest of the LRCP (Figure 1). Based on exploratory soil borings and historical data, there were no suitable upgradient locations for the Type I Landfill & LRCP. CF-15-04 was installed northeast of and outside the hydrologic influence of the Type I Landfill & LRCP and the closed Type III Landfill to serve as the required background monitoring well. CF-15-06 was installed to serve as a second background monitoring well and CF-15-05 was installed as a background/intermediate monitoring well to ensure groundwater from the West Boiler Slag Pond is not impacting groundwater at well CF-15-06. Wells WBSP-15-01 and WBSP-15-02 are located southeast of the impermeable Devil's Backbone and are hydraulically separated from groundwater flowing beneath the Type I Landfill & LRCP. Because these wells are outside the hydraulic influence of the Type I Landfill & LRCP, these wells were designated as background wells. Table 2 presents construction details for the monitoring wells in the groundwater monitoring network for the Type I Landfill & LRCP.

Based on groundwater levels measured from each well from January through March 2018, groundwater beneath the Type I Landfill & LRCP flows to the southwest toward the Ohio River. Appendix A presents a groundwater contour map for March 2018.

3.0 ALTERNATE SOURCE DEMONSTRATION

As noted above, Boron was identified as a confirmed SSI in wells CF-15-08 and CF-15-09 downgradient of the Type I Landfill & LRCP. Based on a review of the current and historic data, AGES/IKEC have determined that the active Type I Landfill is not the source of the Boron SSIs reported in the CCR monitoring wells and that historic fly ash that had been sluiced into the valley beginning in 1955 is the alternate source for the Boron SSIs. As discussed in detail below, this conclusion is based on the following lines of evidence:

- Ash that was historically sluiced into the bedrock valley in the 1950s is a known source of Boron and is hydraulically connected to groundwater downgradient of the Type I Landfill and LRCP;
- Boron has been detected in groundwater downgradient from the hydraulically-placed ash (and the Type I Landfill & LRCP) in IDEM program wells CF-9405, CF-9406 and CF-9407 (located near wells CF-15-08 and CF-15-09) since 1994, which is 17 years prior to operation of the Type I Landfill; and
- Given the extremely low groundwater flow velocity at the landfill, the travel time for a release of Boron from the Type I Landfill to reach wells CF-15-08 and CF-15-09 is estimated at 120 years. As the Type I Landfill has only been in operation for seven (7) years, the landfill cannot be the source of the Boron.

Details to support these conclusions are presented below.

3.1 Alternate Source Demonstration Method

The evaluation of the alternate source for Boron in wells CF-15-08 and CF-15-09 was assessed in general accordance with guidelines presented in the *Solid Waste Disposal Facility Criteria Technical Manual* (U.S. EPA 1993) using the following methods:

- Identify a potential alternate source;
- Establish that a hydraulic connection exists between the alternate source and the wells with the confirmed SSIs;
- Establish that constituents of concern are present at the alternate source; and
- Establish that the concentrations observed in the compliance wells could not have resulted from the CCR unit given the hydrogeologic conditions at the site.

3.2 Alternate Source Identification

The initial groundwater investigation conducted for the former Type III Landfill (beginning in 1994) focused on the fly ash that had been hydraulically placed in the bedrock channel beginning in 1955. The Type III Landfill was permitted to serve as the closure for the hydraulically placed fly ash.

After IDEM approval, IKEC upgraded the Type III Landfill to a Type I Landfill and the Type I Landfill was permitted as the closure for the Type III Landfill. The active Type I Landfill was constructed with a geosynthetic liner, and an engineered clay liner on top of the Type III Landfill to serve as a cap. The two (2) liners prevent migration of groundwater from the active Type I Landfill to the closed Type III Landfill. The closed Type III Landfill is not a CCR unit and is not subject to regulation under the CCR Rule.

Both landfills were constructed on top of the historic hydraulically placed fly ash, which extends the length of the bedrock channel (Figure 3) beneath the LRCP to the embankment at the southwestern end of the LRCP (Figure 5). Although the base of the LRCP contains historic hydraulically placed fly ash, the LRCP does not receive CCR and the existing historic CCR is not actively managed. Therefore, the LRCP is considered an inactive CCR unit.

Due to the age and extent of the historic, hydraulically placed ash, this material was identified as the alternate source for the Boron detected in wells CF-15-08 and CF-15-09.

3.3 Establish a Hydraulic Connection

A review of the permit drawings, construction drawings, and a figure from the *Initial Structural Stability Assessment, Landfill Runoff Collection Pond* report (Stantec 2016) (Appendix C), indicated that material from the closed Type III Landfill and the historic hydraulically placed fly ash are located entirely beneath the active Type I Landfill & LRCP (Figure 3). The base of the layer of “hydraulically placed fly ash” is located between elevations 445 ft msl and 500 ft msl.

When the fly ash was originally emplaced in the bedrock channel, there were no impermeable liners constructed to separate the fly ash from the underlying “foundation soils.” The CCR and IDEM groundwater monitoring wells are screened in these “foundation soils,” which consist of alluvial deposits of silt, sand and gravel. These alluvial deposits extend from beneath the LRCP and the hydraulically placed fly ash southwest to the Ohio River and provide a direct hydraulic connection between the historic hydraulically placed fly ash and the groundwater monitoring wells (Figure 5).

3.4 Constituents Are Present at the Alternate Source

Both the closed Type III Landfill and the Type I Landfill are currently being monitored under an IDEM groundwater monitoring program. In 1994, three (3) monitoring wells (CF-9405, CF-9406 and CF-9407) were installed south of the LRCP as a condition of a pH Variance for the former Type III Landfill granted by IDEM. Since 1994, routine semi-annual and quarterly monitoring of these wells has been conducted. In 2009, three (3) additional wells (CF-07-06D, CF-07-08 and CF-07-09) were installed per IDEM to monitor groundwater quality during the year prior to the start of operations of the Type I Landfill in 2011. Wells in the IDEM groundwater monitoring network are located south of the LRCP and screened in the same “foundation soils” as the wells in the CCR monitoring network (Figure 6).

As shown on Table 3 and Figure 7, Boron was detected in wells CF-9406 (9.0 mg/L to 17.1 mg/L) and CF-9407 (1.19 mg/L to 7.7 mg/L) from 1995 through 2011 (Table 3 and Figure 7). This demonstrates that Boron was present in groundwater downgradient of the eventual location of the Type I Landfill 17 years prior to its operation. Boron concentrations in downgradient CCR wells have ranged from 7.62 mg/L to 10.9 mg/L in well CF-15-08, and from 5.78 mg/L to 7.01 mg/L in CF-15-09 (Table 3 and Figure 7). These concentrations are similar to historic Boron concentrations observed in wells CF-9506 and CF-9407 from 1994 through 2011.

Because Boron concentrations similar to those observed in CCR wells CF-15-08 and CF-15-09 were detected in IDEM wells CF-9406 and CF-9407 prior to construction of the Type I Landfill, the historic hydraulically placed ash is the source of the detected Boron.

3.5 Hydrogeologic Conditions and Groundwater Flow Velocity

As presented in the *Evaluation of Potential Risk to Supply Well Fields* report (AGES 2006), a groundwater flow velocity of 45 feet per year (ft/yr) was calculated for alluvial deposits, which are designated as the uppermost aquifer for these CCR units. Based on the most recent topographical survey conducted of the Type I Landfill (Appendix B), the current limit of waste for the active Type I Landfill is located approximately 5,400 feet (more than one (1) mile) northeast of the three (3) CCR groundwater monitoring wells (CF-15-07, CF-15-08 and CF-15-09) (Figure 8). Based on this data, it was calculated that it will take 120 years for groundwater to flow from the current limit of waste in the Type I Landfill to the CCR monitoring wells. Waste placement in the Type I Landfill began in early 2011. Given the two (2) constructed liners, the distance and the flow rate, water from the Type I Landfill is not able to enter the groundwater, and groundwater has not had enough time to reach the CCR monitoring wells.

Based on the calculations presented above, the active Type I Landfill cannot be the source of Boron detected in the CCR monitoring wells.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The ASD has been completed in general accordance with guidelines presented in the *Solid Waste Disposal Facility Criteria Technical Manual* (U.S. EPA 1993).

Based on a review of the current and historic data, AGES/IKEC have determined that the Type I Landfill is not the source of Boron detected in the CCR monitoring wells. This conclusion is supported by the following evidence:

- “Foundation soils” that extend from beneath the LRCF and the hydraulically placed fly ash southwest to the Ohio River provide a direct hydraulic connection between the historic hydraulically placed fly ash and the CCR groundwater monitoring wells CF-15-08 and CF-15-09.
- Historic data from the IDEM groundwater monitoring program indicate that Boron concentrations similar to those observed in CCR wells CF-15-08 and CF-15-09 were detected in IDEM wells CF-9406 and CF-9407 for 17 years prior to operation of the Type I Landfill, indicating that the Boron is associated with the historic hydraulically placed fly ash.
- Using the previously calculated groundwater flow velocity of 45 ft/yr, it is estimated that it would take 120 years for groundwater flowing beneath the Type I Landfill to reach the CCR monitoring wells.

Based on the demonstration presented above, the Type I Landfill is not the source of the Boron detected in CCR monitoring wells. Therefore, it is recommended that the Type I Landfill return to Detection Monitoring.

Because the LRCF is unlined and the historic hydraulically placed fly ash extends beneath the LRCF to the embankment, it is recommended that the LRCF remain in Assessment Monitoring.

5.0 REFERENCES

Applied Geology and Environmental Science, Inc. (AGES), 2006. Evaluation of Potential Risk to Supply Well Fields, Clifty Creek Coal Ash Landfill, Clifty Creek Station, Madison, Indiana. June 2006.

Applied Geology and Environmental Science, Inc. (AGES), 2007. Hydrogeologic Study Report, Clifty Creek Coal Ash Landfill, Clifty Creek Station, Madison, Indiana. November, 2006.

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Applied Geology and Environmental Science, Inc. (AGES), 2016b. Coal Combustion Residuals Regulation Monitoring Well Installation Report. Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. October, 2016.

Stantec Consulting Services, Inc. (Stantec), 2016. Coal Combustion Residuals Regulation Initial Structural Stability Assessment, Landfill Runoff Collection Pond, Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. October 2016.

Stantec Consulting Services, Inc. (Stantec), 2018. Coal Combustion Residuals Regulation Statistical Analysis Plan, Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. January 2018.

United States Environmental Protection Agency (U.S. EPA) 1993. Solid Waste Disposal Criteria Technical Manual, EPA 530-R-93-017. November 1993.

TABLES

TABLE 1
CCR DETECTION MONITORING
SUMMARY OF POTENTIAL AND CONFIRMED STATISTICALLY SIGNIFICANT INCREASES
CLIFTY CREEK STATION
MADISON, INDIANA

Well Id	UPL (mg/L)	1st Detection Monitoring Event		Detection Monitoring Resampling	
		Potential SSI	Result (mg/L)	Confirmed SSI (Yes/No)	Result (mg/L)
Type I Residual Waste Landfill & Landfill Runoff Collection Pond					
CF-15-07	5.957 - 7.904 (s.u.)	pH	10.12	No	7.12
CF-15-08	5.02	Boron	8.5	Yes	8.6
	5.957 - 7.904 (s.u.)	pH	10.21	No	7.45
CF-15-09	5.02	Boron	5.86	Yes	6.1
	5.957 - 7.904 (s.u.)	pH	10.85	No	7.09

SSI: Statistically Significant Increase
UPL: Upper Prediction Limit
mg/L: Milligrams per liter
s.u.: Standard Units

**TABLE 2
GROUNDWATER MONITORING NETWORK
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA**

Monitoring Well ID	Designation	Date of Installation	Coordinates		Ground Elevation (ft) ²	Top of Casing Elevation (ft) ²	Top of Screen Elevation (ft)	Base of Screen Elevation (ft)	Total Depth From Top of Casing (ft)
			Northing	Easting					
CF-15-04	Background	12/3/2015	451482.81	569307.19	465.55	468.03	439.55	429.55	38.48
CF-15-05	Background	12/1/2015	447491.91	565533.64	439.85	442.58	422.85	412.85	29.73
CF-15-06	Background	11/30/2015	447026.92	565190.31	437.49	440.40	431.49	421.49	18.91
CF-15-07	Downgradient	11/23/2015	443135.08	562259.25	438.61	441.11	432.61	422.61	18.50
CF-15-08	Downgradient	11/19/2015	443219.57	562537.29	460.33	462.79	430.33	420.33	42.46
CF-15-09	Downgradient	11/25/2015	443445.96	562871.69	456.73	459.45	447.73	442.73	16.72
WBSP-15-01	Background	11/30/2015	449072.27	566322.12	466.93	469.36	458.93	448.93	20.43
WBSP-15-02	Background	11/11/2015	449803.91	566987.30	473.83	476.76	457.83	452.83	23.93

Notes:

1. The Well locations are referenced to the North American Datum (NAD83), east zone coordinate system.
2. Elevations are referenced to the North American Vertical Datum (NAVD) 1988

**TABLE 3
HISTORIC BORON CONCENTRATIONS
IDEM WELLS CF-9406 & CF-9407 AND
CCR WELLS CF-15-08 AND CF-15-09**

Boron Concentrations in IDEM Wells (1994 through 2015)					
Date	CF-9406	CF-9407	Date	CF-9406	CF-9407
6/8/1994	10	2.9	11/19/2002	16.2	5.92
6/22/1994	9.8	4.7	5/14/2003	13.7	3.83
7/6/1994	11	6.3	11/12/2003	14.7	5.4
7/20/1994	12	8.4	5/11/2004	14.2	3.86
8/3/1994	10	6.3	11/9/2004	17.1	5.28
8/17/1994	9	6.4	5/9/2005	15.2	7.16
8/31/1994	12	7.7	11/8/2005	14.3	DRY
9/14/1994	9.8	6.9	5/17/2006	12.8	7.4
9/28/1994	9.7	5.9	11/15/2006	15	5.69
10/12/1994	12	7.3	5/9/2007	13.7	4.71
10/26/1994	12	6.8	11/14/2007	14.6	DRY
11/9/1994	11	6.7	5/13/2008	15	3.21
11/30/1994	11	5	11/12/2008	15.6	DRY
12/7/1994	10	3.6	5/19/2009	14.7	4.75
12/21/1994	11	2.5	11/16/2009	14.7	7.23
1/18/1995	11	3	12/16/2009	NM	NM
2/22/1995	13	3.6	01/14/2010	NM	NM
6/14/1995	13	4.5	02/23/2010	NM	NM
12/21/1995	14	4.7	03/16/2010	NM	NM
6/26/1996	14	3.3	04/15/2010	NM	NM
12/23/1996	12	5.3	5/19/2010	14.1	6.77
4/30/1997	9.9	6.9	06/23/2010	NM	NM
6/30/1997	12	5.9	07/15/2010	NM	NM
10/7/1997	15	DRY	08/24/2010	NM	NM
12/16/1997	14	7.5	09/14/2010	NM	NM
4/16/1998	14	6.5	10/19/2010	NM	NM
6/24/1998	13	6.5	11/3/2010	16.9	DRY
9/23/1998	14	DRY	Type I Landfill Operational		
1/21/1999	13	5.1	5/17/2011	12.3	4.21
3/31/1999	12	4.3	11/28/2011	16.2	1.19
6/30/1999	13	7.5	5/7/2012	14.5	5.09
10/7/1999	DRY	DRY	11/13/2012	15.9	DRY
1/6/2000	15	4.4	3/30/2013	15	5.25
6/6/2000	15	7.2	9/23/2013	14.2	DRY
1/10/2001	16	7.4	5/21/2014	12.63	5.646
5/15/2001	15	6.6	11/11/2014	14.58	DRY
11/26/2001	18	7.3	5/9/2015	15.47	DRY
5/15/2002	13.5	5.1	11/3/2015	13.8	DRY

TABLE 3
HISTORIC BORON CONCENTRATIONS
IDEM WELLS CF-9406 & CF-9407 AND
CCR WELLS CF-15-08 AND CF-15-09

Boron Concentrations IDEM & CCR Wells (January 2016 through May 2018)				
Date	CF-9406	CF-9407	CF-15-08	CF-15-09
1/11/2016	NM	NM	8.64	6.86
3/7/2016	NM	NM	8.24	5.78
5/11/2016	10.6	2.48	NM	NM
5/16/2016	NM	NM	9.34	6.58
7/25/2016	NM	NM	9.65	7.01
8/29/2016	NM	NM	9.63	DR
11/9/2016	15.3	DRY	NM	NM
11/28/2016	NM	NM	10.9	DRY
2/27/2017	NM	NM	9.29	6.78
5/8/2017	7.46	5.4	NM	NM
6/12/2017	NM	NM	7.62	6.3
8/28/2017	NM	NM	9.04	6.81
11/14/2017	11.7	7.58	NM	NM
3/1/2018	NM	NM	8.5	5.86
5/7/2018	13.8	7.25	8.6	6.1

Notes:

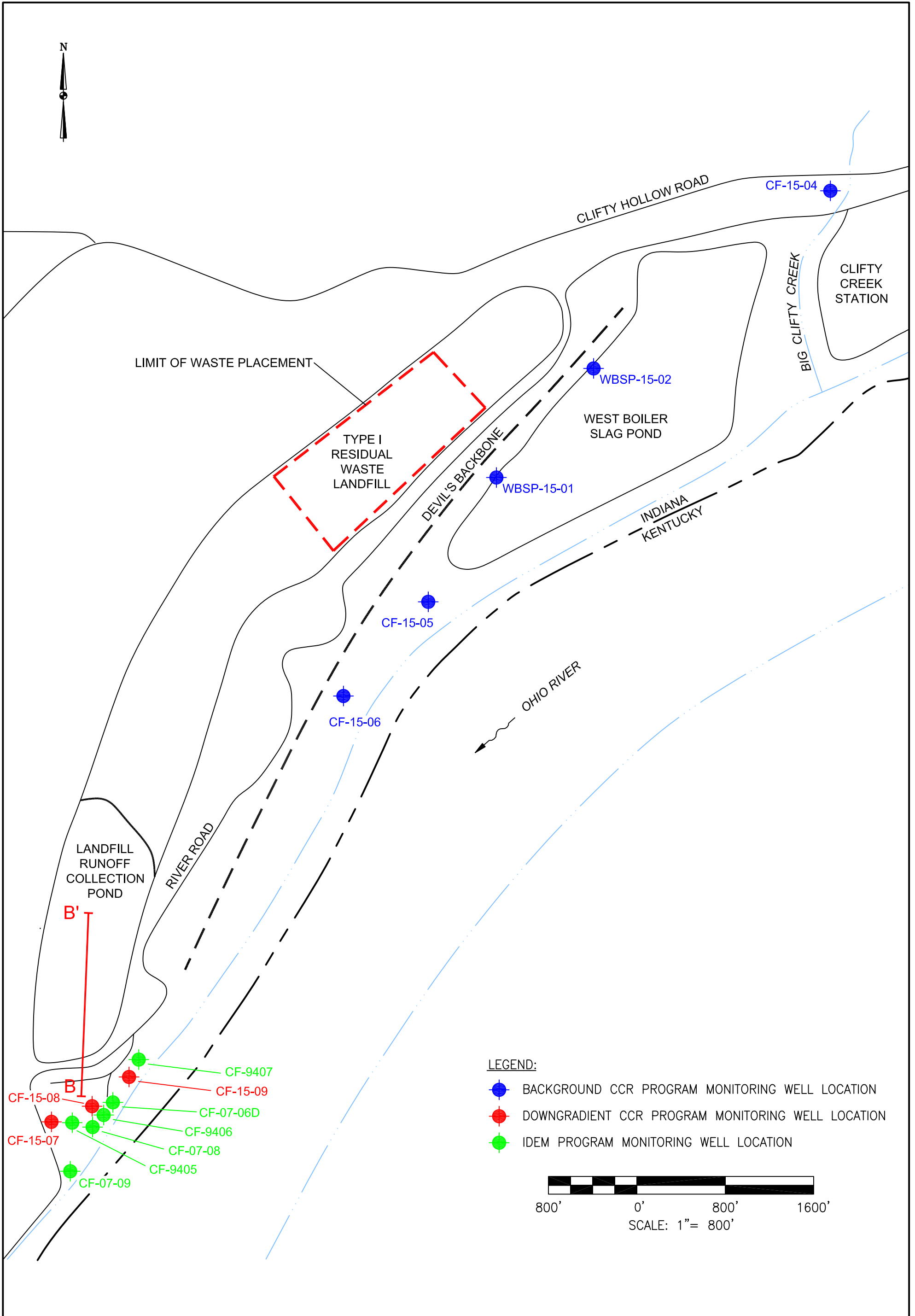
All concentrations are mg/L

NM: Well was not monitored on this date

DRY: Well was dry and not able to be sampled

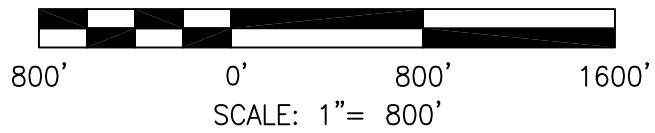
Maximum and minimum Boron results for each well are shown in **Bold**.

FIGURES



LEGEND:

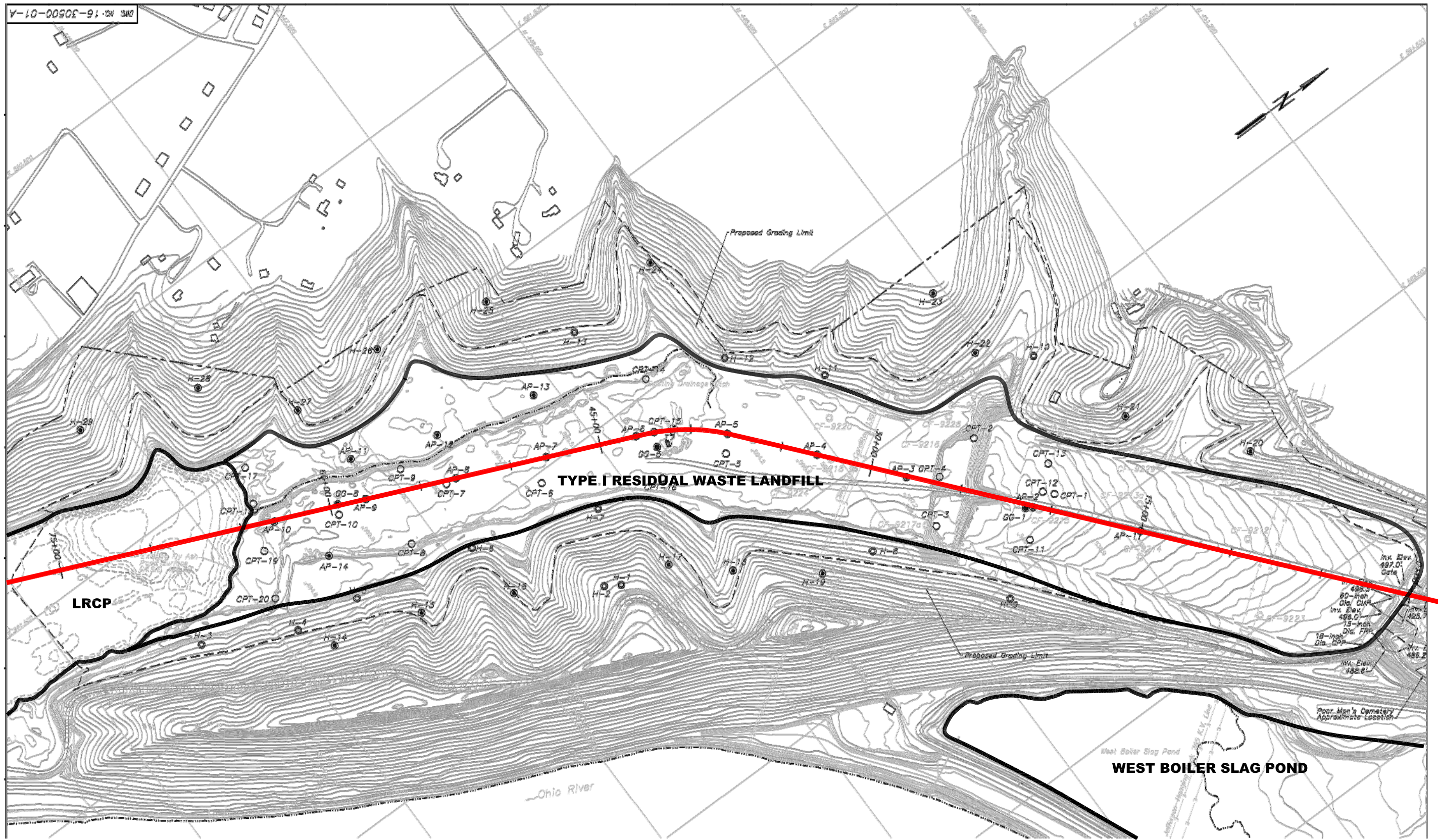
- BACKGROUND CCR PROGRAM MONITORING WELL LOCATION
- DOWNGRAIDENT CCR PROGRAM MONITORING WELL LOCATION
- IDEM PROGRAM MONITORING WELL LOCATION



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DATE	
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JOB NO.	2017114-CLI
DWG FILE	IKEC_Clifty_ASD_MW Locs_b03.dwg
DRAWING SCALE	NOT TO SCALE

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL MONITORING WELL LOCATIONS	
DRAWING NAME	FIGURE 1
REV.	0



A

A'

LEGEND:

A-A' CROSS SECTION TRANSECT

SOURCE: CLIFTY CREEK PERMIT DRAWINGS (FMSM, NOVEMBER 2006)

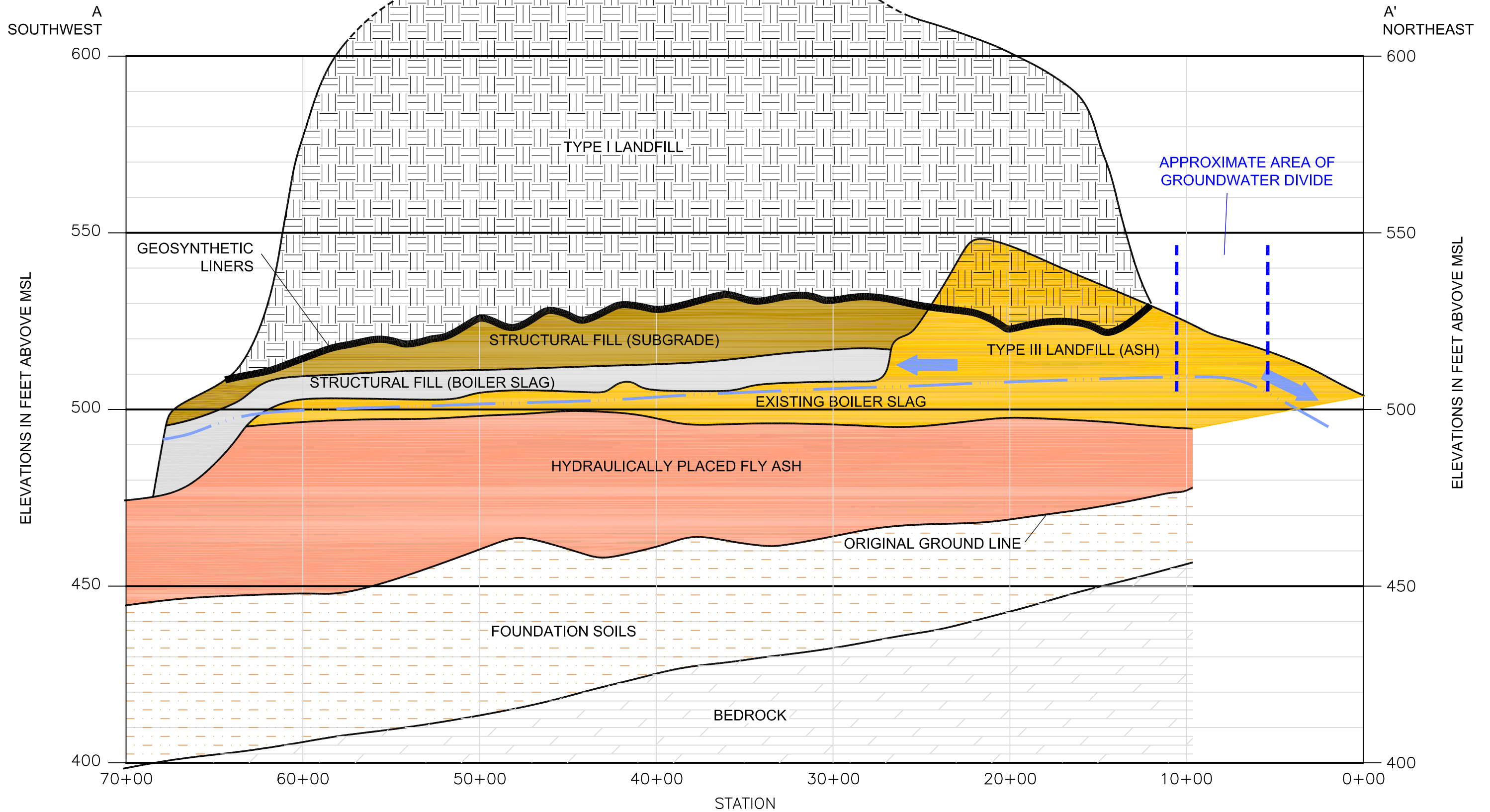
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JOB NO.	2017116-CLI
DWG FILE	Clifty_ASD_Boring Plan b04.dwg
DRAWING SCALE	NOT TO SCALE



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CLIFTY CREEK STATION
MADISON, INDIANA
OVERVIEW OF TYPE I LANDFILL AND LRCP

DRAWING NAME	FIGURE 2	REV.	0
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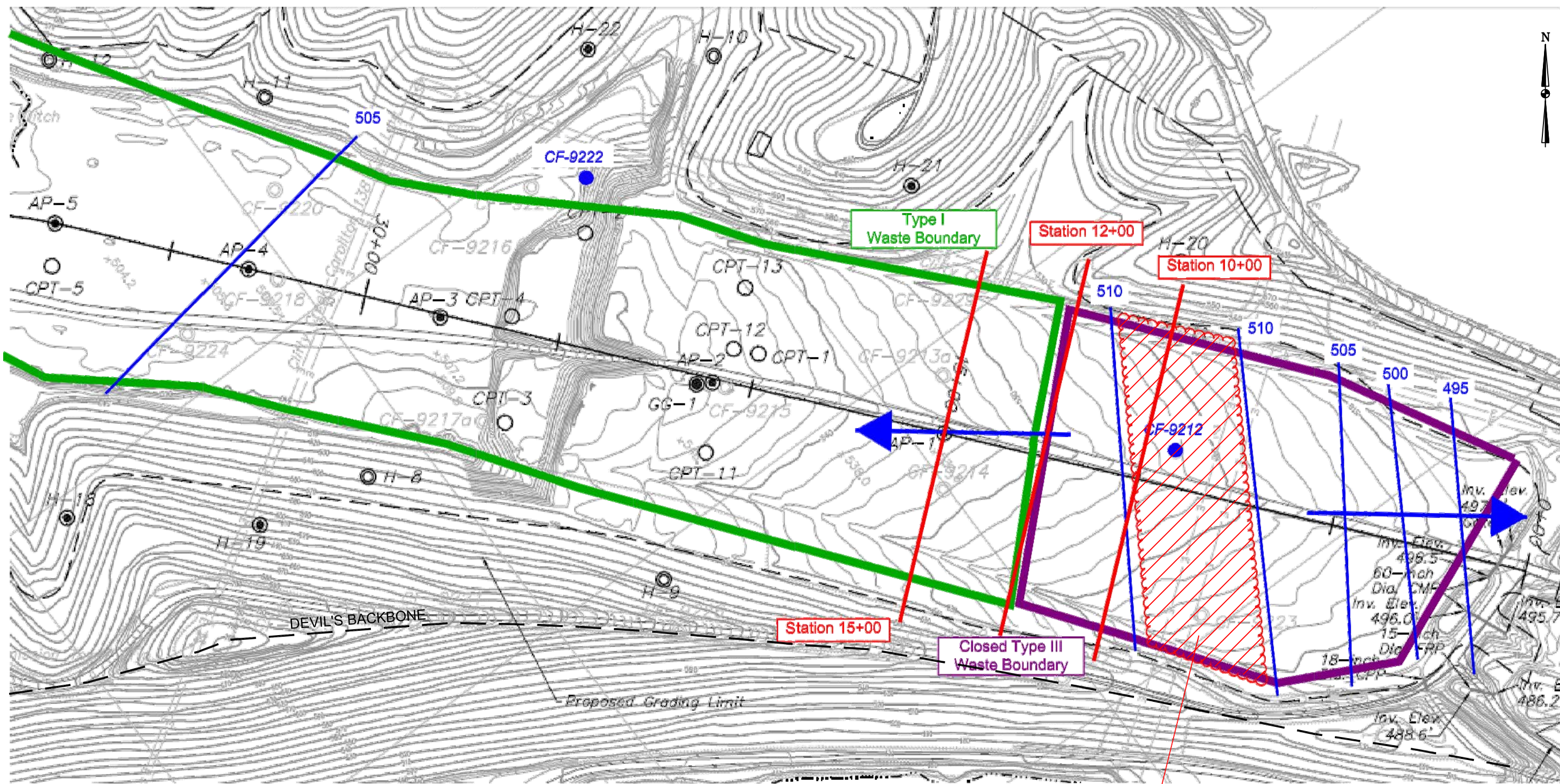
 APPROXIMATE PHREATIC SURFACE
 GROUNDWATER FLOW DIRECTION

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JOB NO.	2017116-CLI
DWG FILE	Clifty_ASD_Cross Sec b02.dwg
DRAWING SCALE	NOT TO SCALE



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CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL GENERALIZED GEOLOGIC CROSS-SECTION A-A' (SOUTHWEST-NORTHEAST)	
DRAWING NAME	FIGURE 3
REV.	0



505 → January 2006 Groundwater Contour
 → Groundwater Flow Direction

APPROXIMATE LOCATION OF GROUNDWATER DIVIDE,
 BETWEEN STATIONS 7+00 AND 10+00.

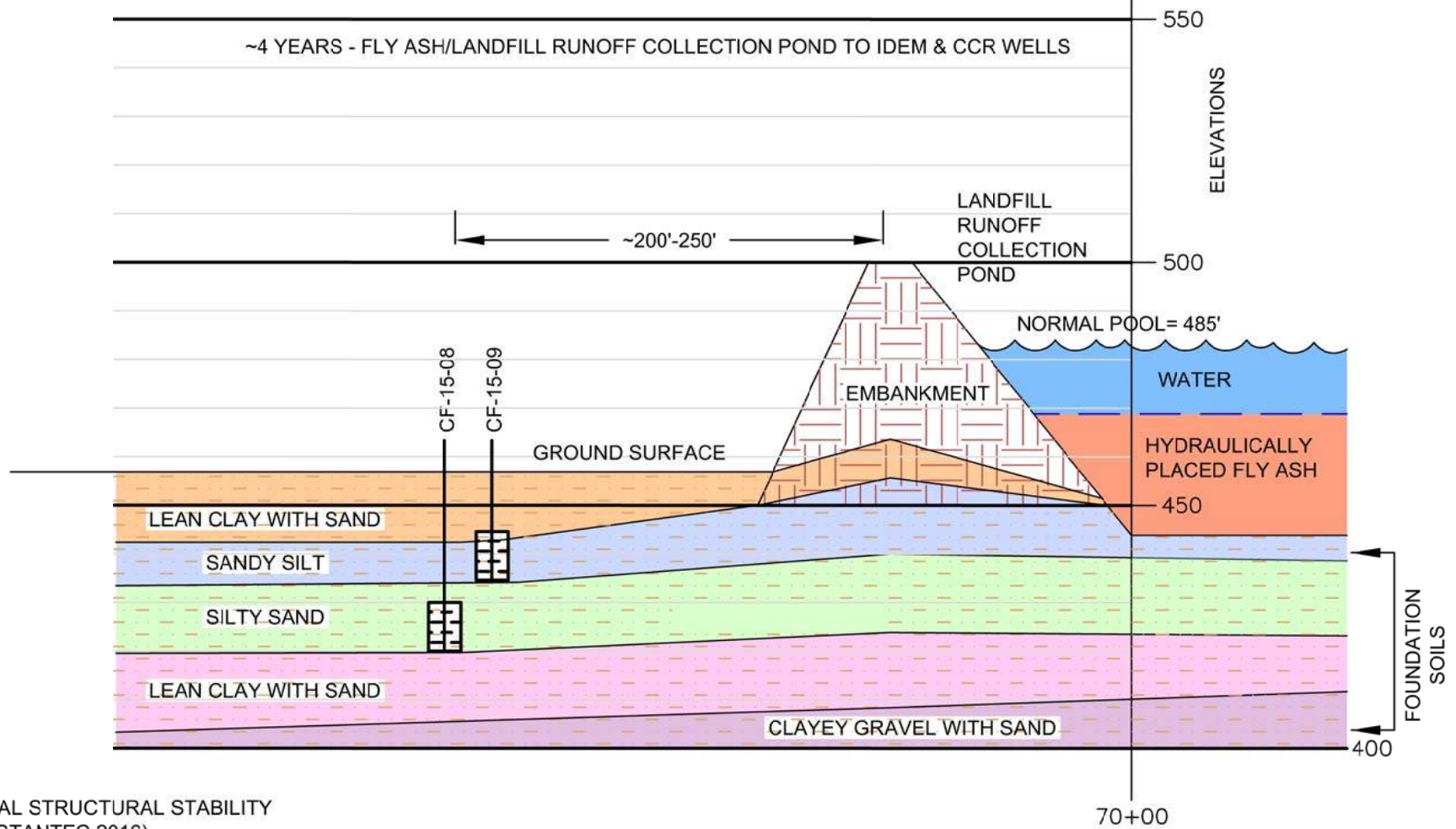
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DATE	
CHECKED BY	
JOB NO.	2017116-CLI
DWG FILE	Clifty_GW Divide b01.dwg
DRAWING SCALE	NOT TO SCALE

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA GROUNDWATER FLOW AT NORTHEAST END OF BEDROCK CHANNEL	
DRAWING NAME	FIGURE 4
REV.	0

SOUTHWEST
B'

NORTHEAST
B



NOTES:
BASED ON INITIAL STRUCTURAL STABILITY
ASSESSMENT (STANTEC 2016).

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2017114-CLI
DWG FILE	Clifty_ASD_X-Sec Pond-Wells a06.dwg
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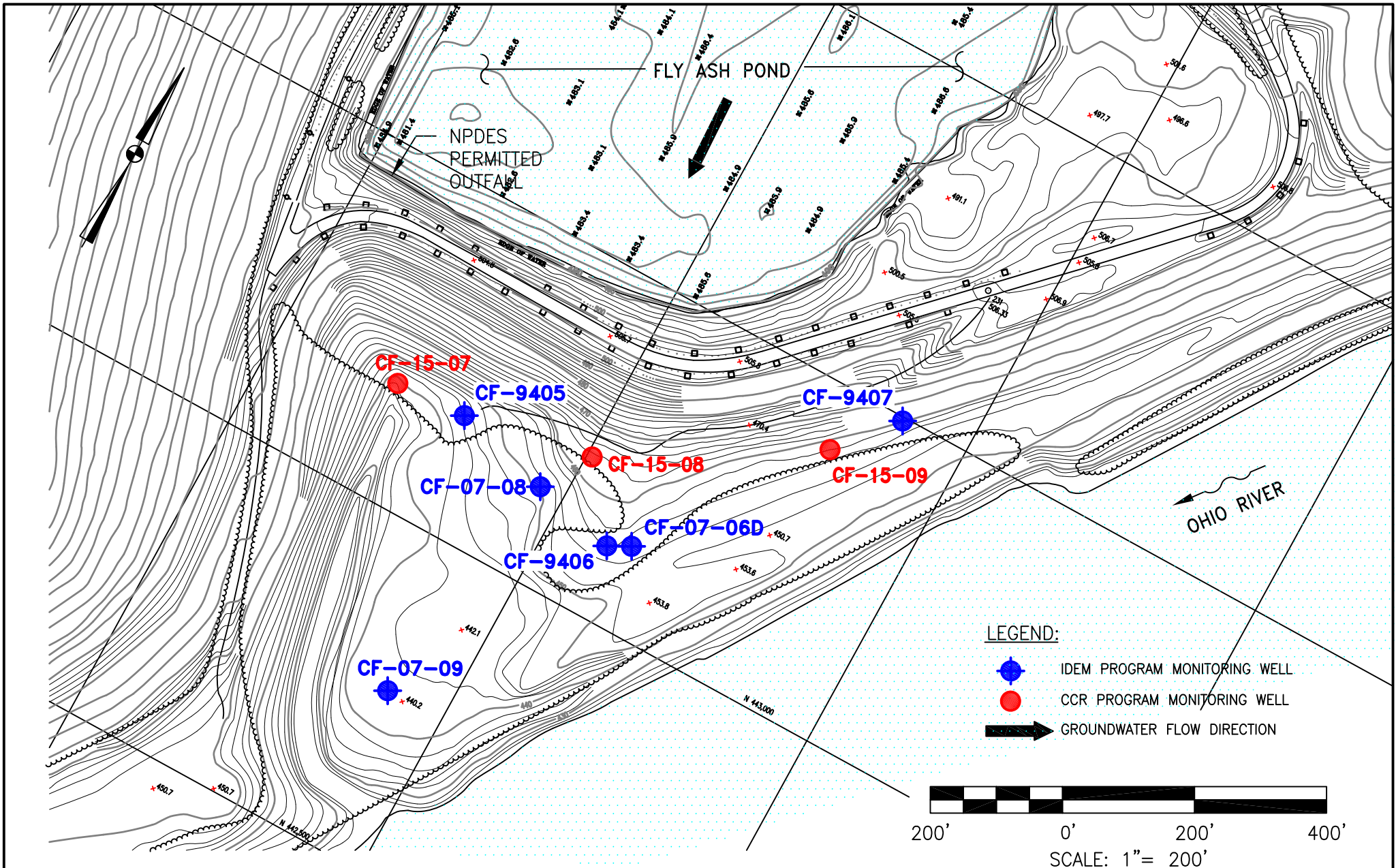
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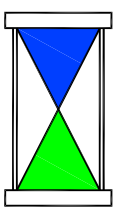
INDIANA-KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
GENERALIZED CROSS-SECTION
LANDFILL RUNOFF COLLECTION POND TO
CCR MONITORING WELLS

DRAWING NAME	FIGURE 5	REV.	0
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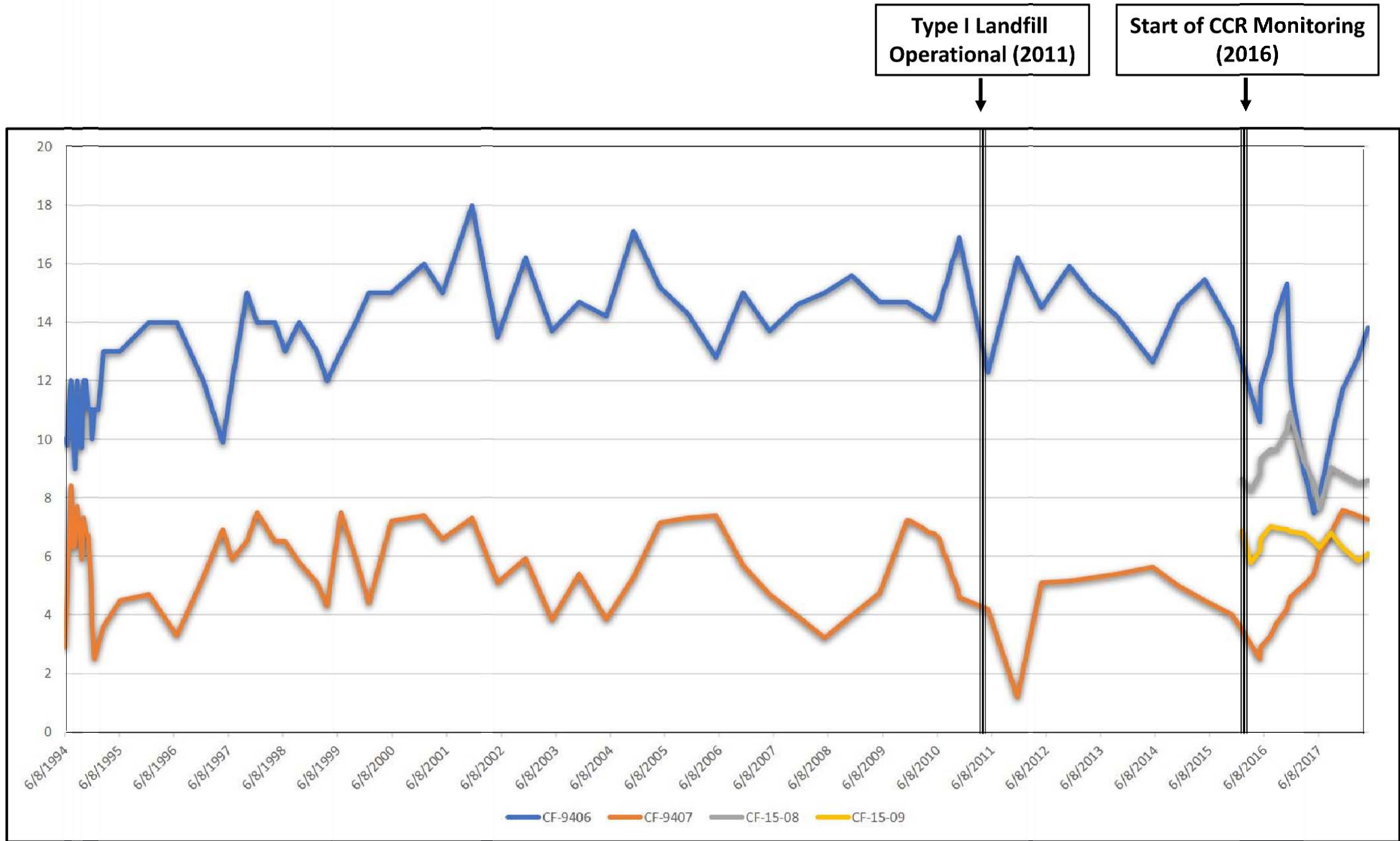


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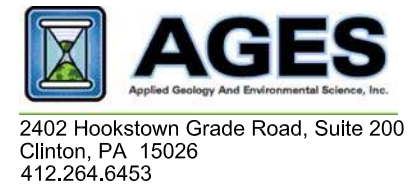


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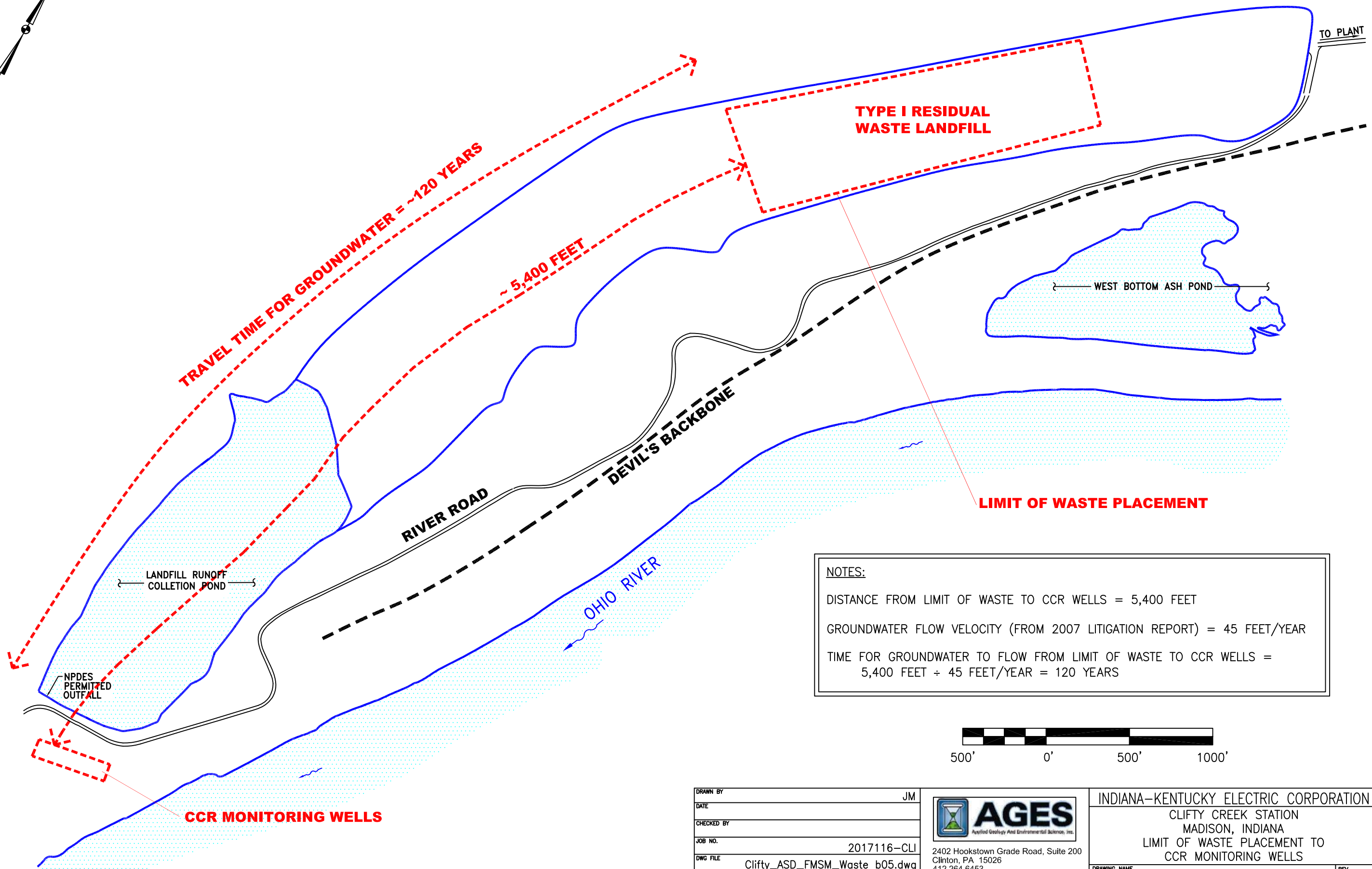
INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK PLANT MADISON, INDIANA CCR PROGRAM AND IDEM PROGRAM MONITORING WELL LOCATION MAP	
DRAWING NAME	FIGURE 6
REV.	0



DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2017116-CLI
DWG FILE	Clifty_ASD_Boron-Time Graph b07.dwg
DRAWING SCALE	NOT TO SCALE



INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA	
TIME SERIES DATA FOR BORON (mg/L) CF-9406, CF-9407, CF-15-08 AND CF-15-09	
DRAWING NAME	FIGURE 7
REV.	0



NOTES:

DISTANCE FROM LIMIT OF WASTE TO CCR WELLS = 5,400 FEET

GROUNDWATER FLOW VELOCITY (FROM 2007 LITIGATION REPORT) = 45 FEET/YEAR

TIME FOR GROUNDWATER TO FLOW FROM LIMIT OF WASTE TO CCR WELLS =
 $5,400 \text{ FEET} \div 45 \text{ FEET/YEAR} = 120 \text{ YEARS}$



DRAWN BY	JM
DATE	
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JOB NO.	2017116-CLI
DWG FILE	Clifty_ASD_FMSM_Waste_b05.dwg
DRAWING SCALE	1" = 555'

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CLIFTY CREEK STATION MADISON, INDIANA	
LIMIT OF WASTE PLACEMENT TO CCR MONITORING WELLS	
DRAWING NAME	FIGURE 8
REV.	0

APPENDIX A

**Groundwater Flow Map
March 2018**



TREES

LANDFILL
RUNOFF
COLLECTION
POND

RIVER ROAD

TREES

DEVIL'S BACKBONE

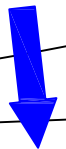
INDIANA
KENTUCKY

OHIO RIVER

CF-15-07
436.46

CF-15-08
441.81

CF-15-09
447.06

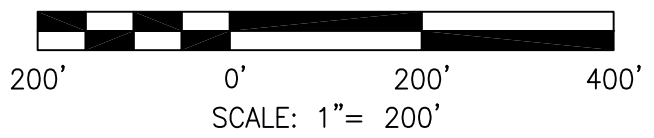


TREES

LEGEND:

MONITORING WELL LOCATION

GROUNDWATER FLOW DIRECTION



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JOB NO.	2018070-2-CLI
DWG FILE	Clifty GW Elev 3-19-18 b07.dwg
DRAWING SCALE	AS SHOWN



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CLIFTY CREEK STATION
MADISON, INDIANA
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
GROUNDWATER ELEVATIONS
MARCH 19, 2018

DRAWING NAME	FIGURE A-1	REV.	0
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APPENDIX B

**PHASE I EXISTING CONDITIONS
TOPOGRAPHIC MAP
(Stantec 2018)**

Revised: 06/13/2018, 11:27 AM. User: jennings. Location: C:\Users\jennings\Documents\175538039.dwg

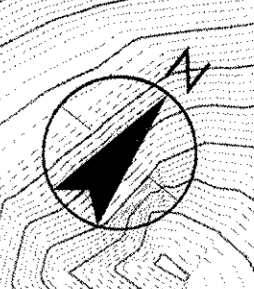


Legend

- Utility Pole
- Transmission Line
- Transmission Tower
- Vegetation
- Edge of Water
- Property Line
- Waste Boundary
- Grading Limits

Notes

1. Topographic mapping supplied by Henderson Aerial Surveys, Inc., Grove City, Ohio (November 10, 2008). Mapping updated using surveys supplied by the Owner for April 2018, and additional field surveys performed by Stantec (May 2018).
2. Information presented in Indiana State Plane coordinate system (NAD27/NAVD88 Indiana East, feet).
3. Other basemap information based on original design plan sheets.
4. Cells with temporary soil cover are mulched and seeded.



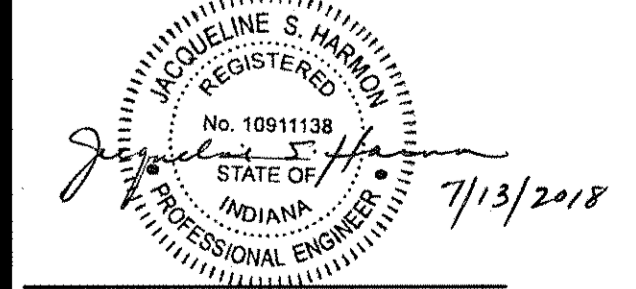
11687 Lechmere Road
Cincinnati, Ohio 45241-2012
www.stantec.com
The Company and its employees are not responsible for all dimensions, quantities, or other information shown on this drawing. The user is responsible for verifying all information shown on this drawing. The user is responsible for obtaining all necessary permits and approvals for this project. The user is responsible for obtaining all necessary information for this project.

Client/Project
INDIANA-KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK COAL ASH LANDFILL
MODIFICATION
JEFFERSON COUNTY, MADISON TOWNSHIP, INDIANA

Title
PHASE 1 EXISTING CONDITIONS
(JUNE 2018)

Permit-Seal



Project Number: 175538039

Drawing No. 1
Revision Sheet

APPENDIX C

**FIGURE FROM STABILITY ASSESSMENT REPORT
(Stantec 2016)**

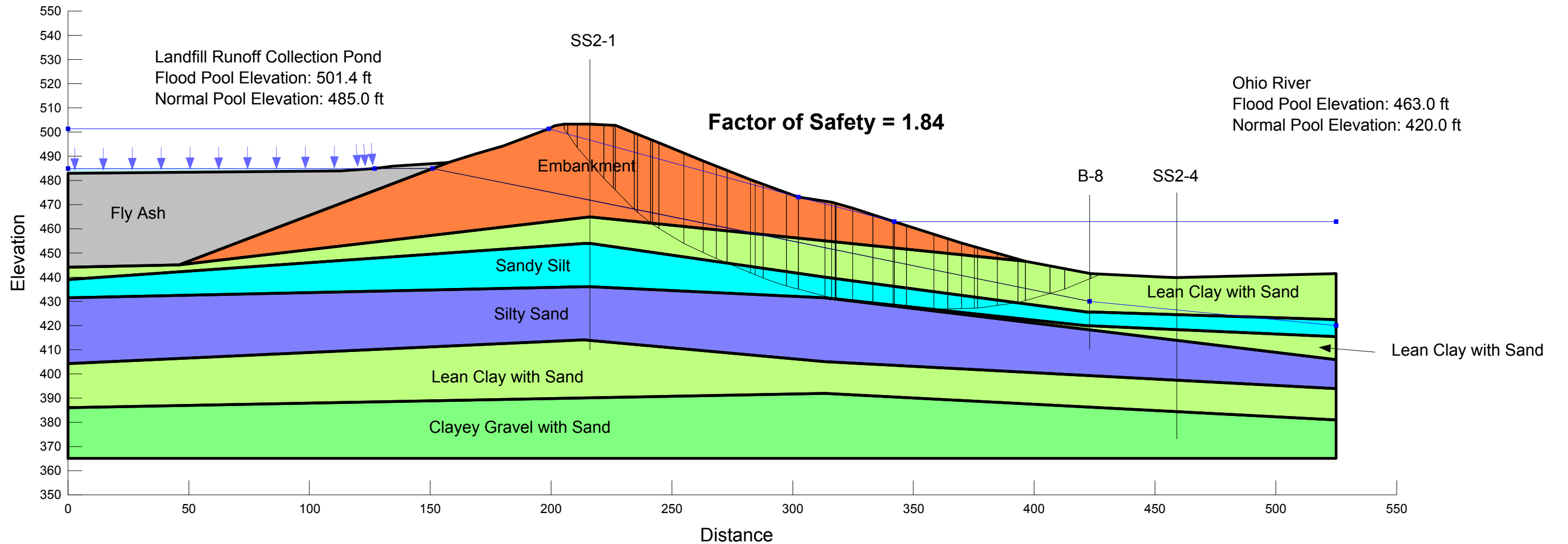
**Indiana-Kentucky Electric Corporation
Clifty Creek Station
Landfill Runoff Collection Pond Dam
Madison, Indiana
Section D-D'**

**Existing Geometry
Sudden Drawdown
Undrained, Sudden Drawdown Strengths**

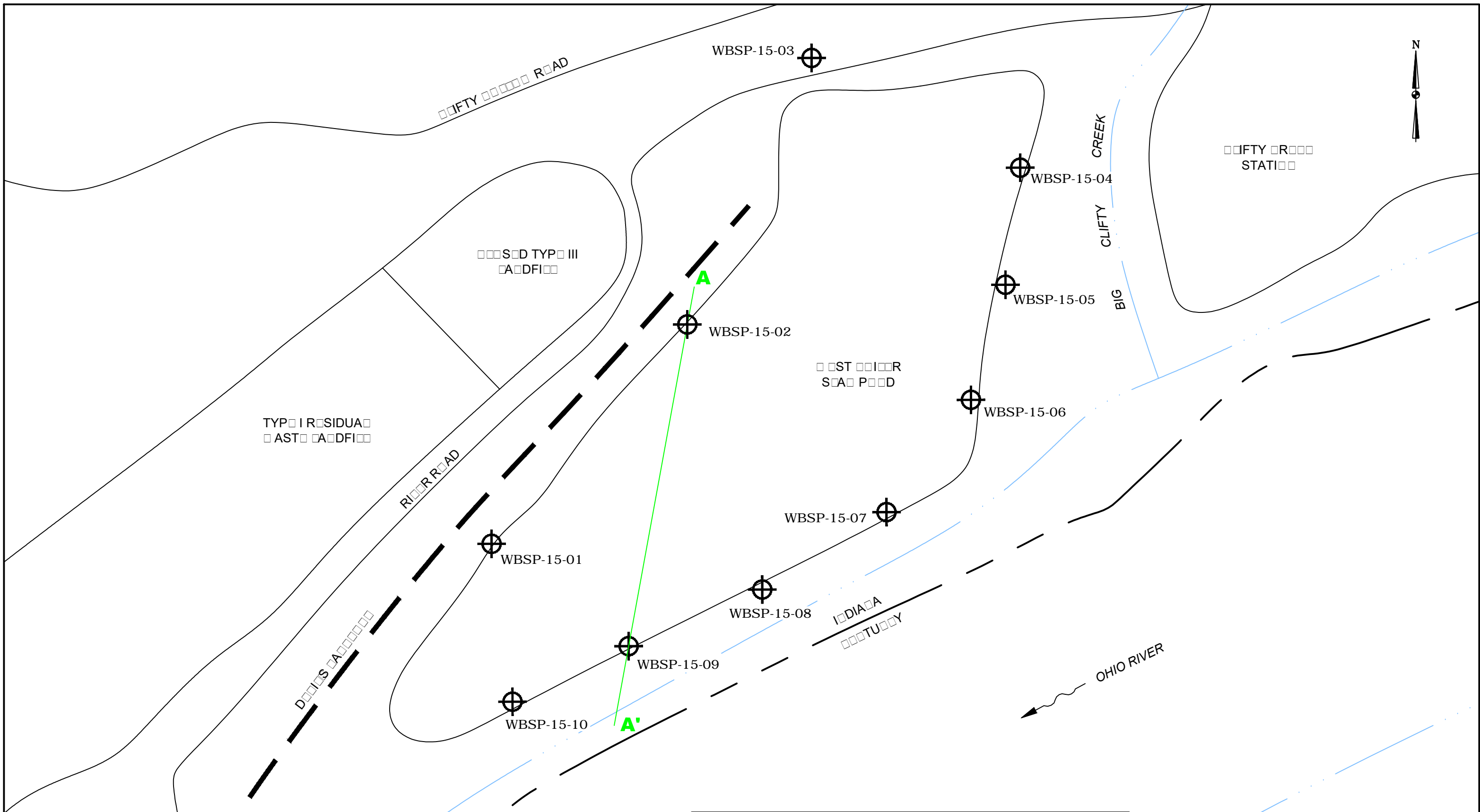
Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Sudden Drawdown

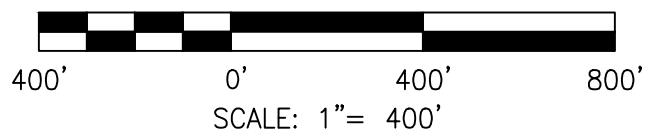
Material Type	Unit Weight	Effective - c'	Effective - phi	Total - c	Total - phi
Embankment (SDD)	129 pcf	198 psf	27.5 °	1400 psf	21 °
Lean Clay with Sand (SDD)	127 pcf	206 psf	28 °	1200 psf	17 °
Sandy Silt (SDD)	125 pcf	0 psf	30 °	0 psf	30 °
Silty Sand (SDD)	94 pcf	0 psf	30 °	0 psf	30 °
Clayey Gravel with Sand (SDD)	130 pcf	0 psf	35 °	0 psf	35 °
Fly Ash (SDD)	115 pcf	0 psf	25 °	0 psf	25 °




APPENDIX E4 – STRATIGRAPHIC CROSS-SECTIONS



LEGEND:
 MONITORING WELL LOCATION



DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	CLIFTY
DWG FILE	GC--IKEC_Clifty_XSEC LOCS_WBSP.dwg
DRAWING SCALE	AS SHOWN

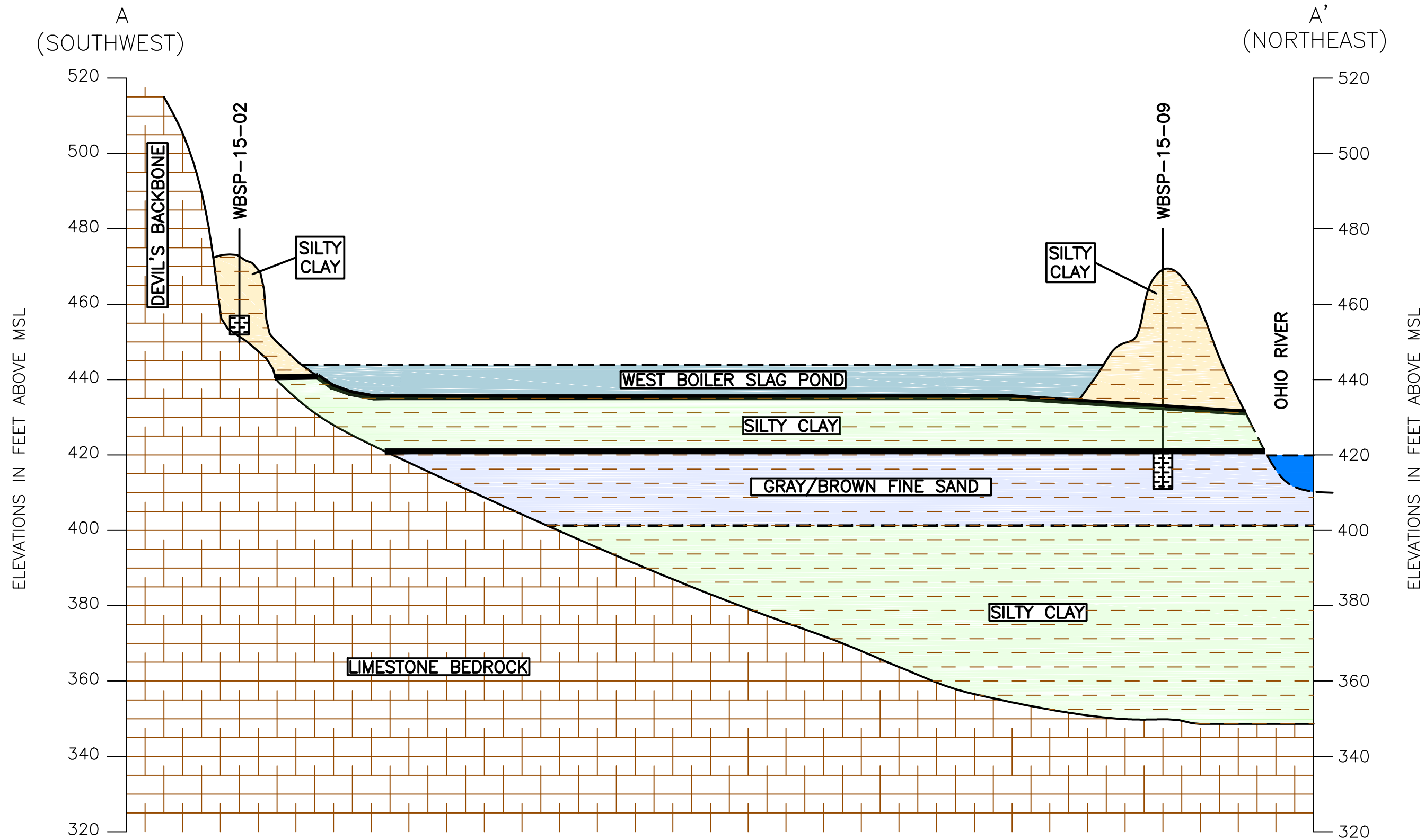


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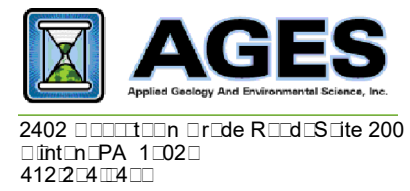
2402

 412.244.4

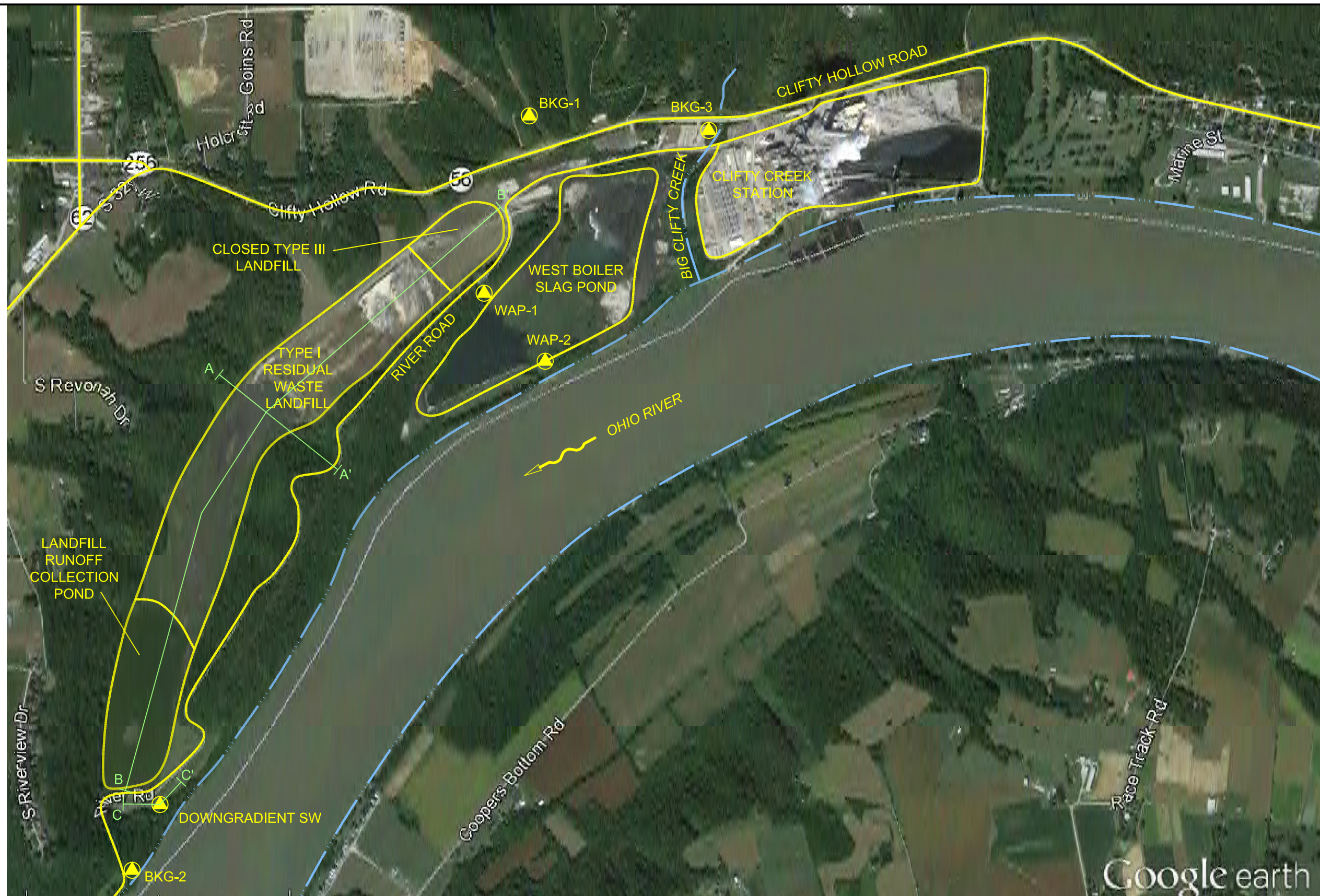
INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND LOCATION OF GENERALIZED GEOLOGIC CROSS-SECTION A-A'	
DRAWING NAME	REV. 0



DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	CLIFTY
DWG FILE	GC--IKEC_Clifty_WBSP_Cross Sec.dwg
DRAWING SCALE	NOT TO SCALE

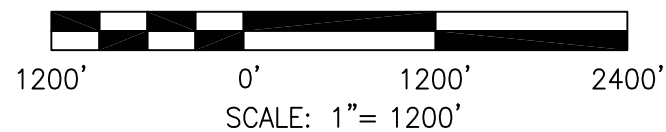


INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA WEST BOILER SLAG POND GENERALIZED GEOLOGIC CROSS-SECTION A-A'	
DRAWING NAME	REV. 0



LEGEND:

SOIL BORING LOCATION



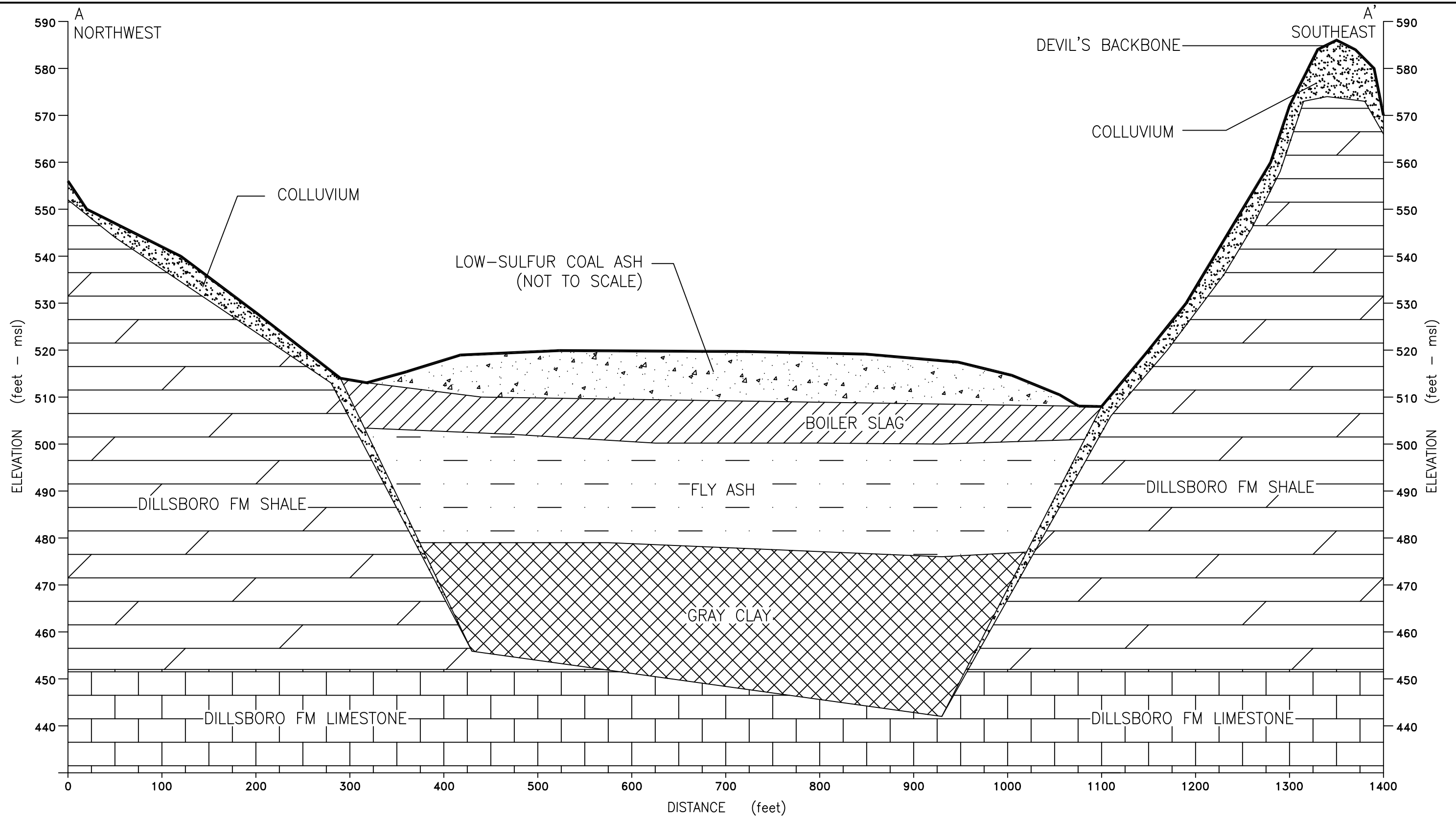
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JOB NO.	2015067-CLI
DWG. FILE	IKEC_Clifty MW Install_Site Loc b01.dwg
DRAWING SCALE	AS SHOWN

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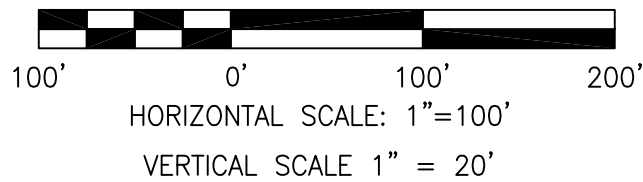
CLIFTY CREEK STATION
MADISON, INDIANA
SITE LOCATION MAP AND SOIL BORING LOCATIONS

DRAWING NAME	FIGURE 1	REV.	0
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NOTE:
CROSS-SECTION LOCATION SHOWN
ON FIGURE 1.

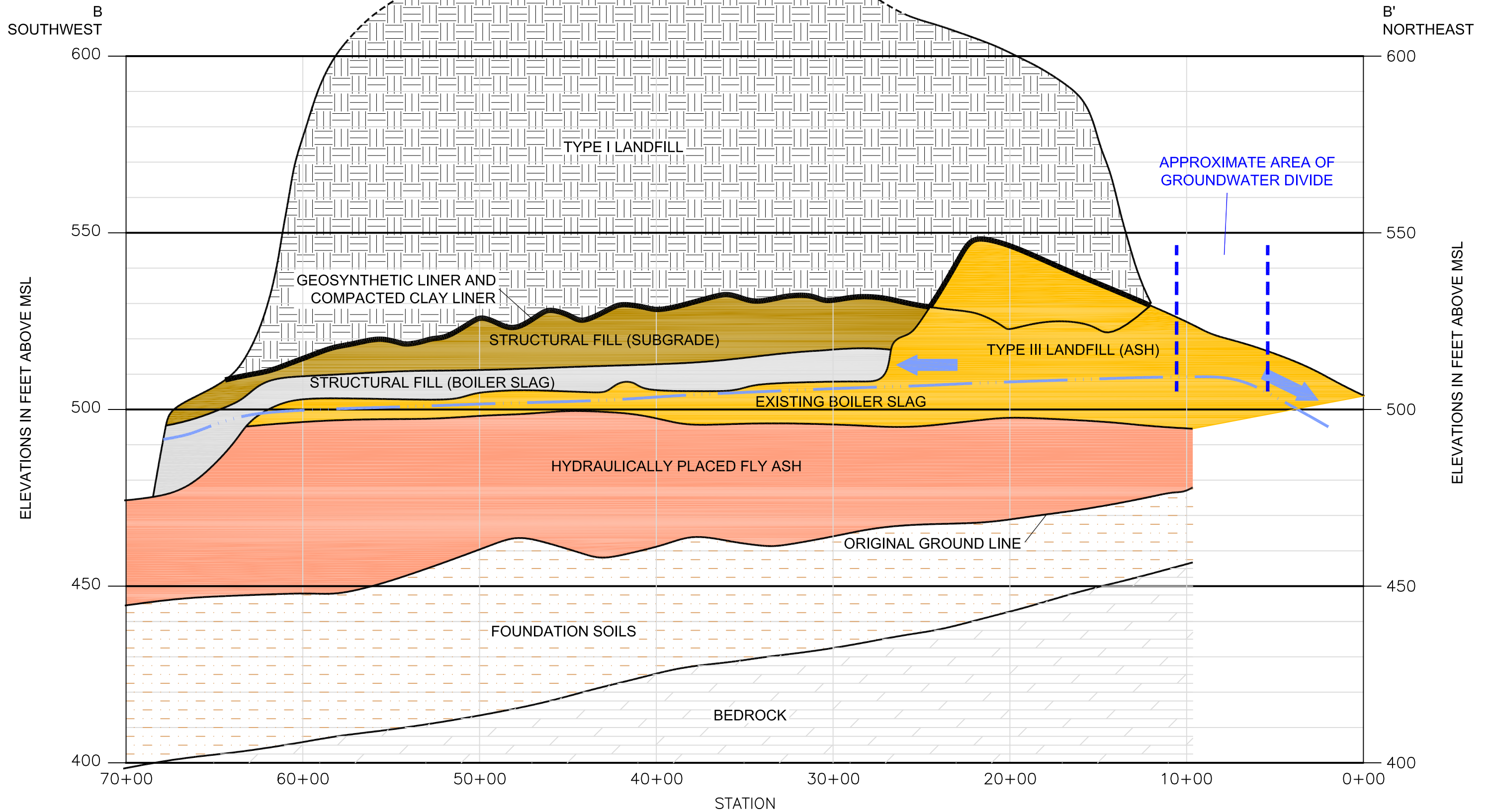
SOURCE: HYDROGEOLOGIC STUDY REPORT,
AGES, APRIL 2007.



DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2015067-CLIF
DWG FILE	IKEC_Clifty MW Install_Gen XSection b06.dwg
DRAWING SCALE	AS SHOWN

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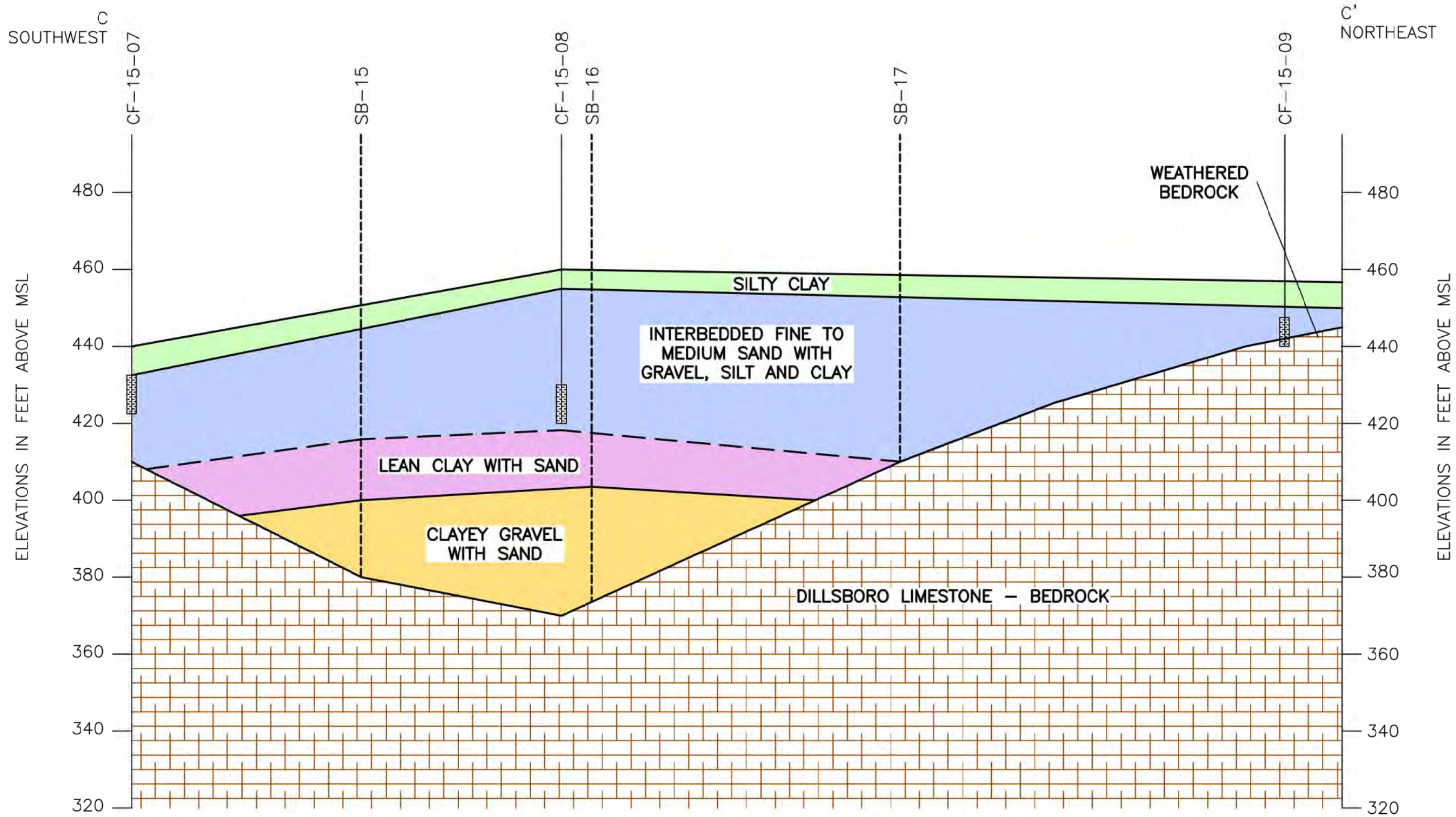
INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND GENERALIZED GEOLOGIC CROSS-SECTION A-A' (NORTHWEST-SOUTHEAST)	
DRAWING NAME	FIGURE 4
REV.	0



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JOB NO.	2018070-2-CLI
DWG FILE	IKEC_Clifty MW Install_Cross Sec b08.dwg
DRAWING SCALE	NOT TO SCALE

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CLIFTY CREEK STATION MADISON, INDIANA	
TYPE I RESIDUAL WASTE LANDFILL GENERALIZED GEOLOGIC CROSS-SECTION B-B' (SOUTHWEST-NORTHEAST)	
DRAWING NAME	FIGURE 3
REV.	0



NOTES:

- 1) CROSS-SECTION LOCATION SHOWN ON FIGURE 1.
- 2) SOIL BORINGS SB-15, SB-16 AND SB-17 WERE DRILLED FOR THE 2006 LITIGATION REPORT TO DETERMINE DEPTH TO BEDROCK ONLY - DETAILED GEOLOGIC LOGS WERE NOT MAINTAINED (AGES 2006).
- 3) THE LEAN CLAY WITH SAND LAYER AND THE CLAYEY GRAVEL WITH SAND LAYER BASED ON DATA FROM THE STANTEC LRCP STABILITY ASSESSMENT REPORT (STANTEC 2016).

DRAWN BY	JM
DATE	
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JOB NO.	2018070-2-CLIF
DWG FILE	IKEC_Clifty MW Install_X-Sec C-C' b09.dwg
DRAWING SCALE	NOT TO SCALE

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CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND GENERALIZED GEOLOGIC CROSS-SECTION C-C'	
DRAWING NAME	FIGURE 5
REV.	0

**APPENDIX E5 – ASSESSMENT OF CORRECTIVE MEASURES
REPORT (LRCP)**



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**COAL COMBUSTION RESIDUALS REGULATION
ASSESSMENT OF CORRECTIVE MEASURES REPORT**

**LANDFILL RUNOFF COLLECTION POND (LRCP)
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA**

**SEPTEMBER 2019
NOVEMBER 2020 REVISION 1.0**

Prepared for:

INDIANA-KENTUCKY ELECTRIC CORPORATION (IKEC)

By:

APPLIED GEOLOGY AND ENVIRONMENTAL SCIENCE, INC.

**COAL COMBUSTION RESIDUALS REGULATION
ASSESSMENT OF CORRECTIVE MEASURES REPORT
LANDFILL RUNOFF COLLECTION POND (LRCP)
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA**

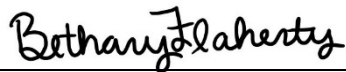
**SEPTEMBER 2019
NOVEMBER 2020 REVISION 1.0**

Prepared for:

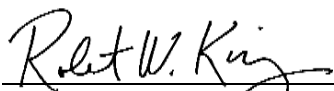
INDIANA-KENTUCKY ELECTRIC CORPORATION (IKEC)

Prepared By:

APPLIED GEOLOGY AND ENVIRONMENTAL SCIENCE, INC.



Bethany Flaherty
Senior Scientist I



Robert W. King, P.G.
President/Chief Hydrogeologist

**COAL COMBUSTION RESIDUALS REGULATION
ASSESSMENT OF CORRECTIVE MEASURES REPORT
LANDFILL RUNOFF COLLECTION POND (LRCP)
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA**

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**COAL COMBUSTION RESIDUALS REGULATION
ASSESSMENT OF CORRECTIVE MEASURES REPORT
LANDFILL RUNOFF COLLECTION POND (LRCP)
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA**

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**COAL COMBUSTION RESIDUALS REGULATION
ASSESSMENT OF CORRECTIVE MEASURES REPORT
LANDFILL RUNOFF COLLECTION POND (LRCP)
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA**

**T A B L E O F C O N T E N T S
(continued)**

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**COAL COMBUSTION RESIDUALS REGULATION
ASSESSMENT OF CORRECTIVE MEASURES REPORT
LANDFILL RUNOFF COLLECTION POND (LRCP)
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA**

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(continued)**

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LIST OF ACRONYMS

°C	Degrees Celsius
ACM	Assessment of Corrective Measures
AGES	Applied Geology and Environmental Science, Inc.
ASD	Alternate Source Demonstration
ASTM	American Society for Testing and Materials
bgs	Below Ground Surface
CCR	Coal Combustion Residuals
ft/day	Feet per Day
ft/sec	Feet per Second
ft/yr	Feet per Year
GMPP	Groundwater Monitoring Program Plan
gpm	Gallons per minute
GWPS	Groundwater Protection Standard
IDEM	Indiana Department of Environmental Management
IKEC	Indiana-Kentucky Electric Corporation
K	Hydraulic Conductivity
LRCP	Landfill Runoff Collection Pond
MCL	Maximum Contaminant Level
mg/kg	Milligrams per Kilogram
mm	Millimeter
MNA	Monitored Natural Attenuation
MW	Megawatt
NPDES	National Pollution Discharge Elimination System
NTU	Nephelometric Turbidity Unit
O&M	Operations and Maintenance
ORP	Oxidation Reduction Potential
OVEC	Ohio Valley Electric Corporation
PRB	Permeable Reactive Barrier
PVC	Polyvinyl Chloride
RCRA	Resource Conservation and Recovery Act
SSI	Statistically Significant Increase
Stantec	Stantec Consulting Services, Inc.
StAP	Statistical Analysis Plan
SU	Standard Unit
Type I Landfill	Type I Residual Waste Landfill
U.S. EPA	United States Environmental Protection Agency
ug/L	Micrograms per Liter
WBSP	West Boiler Slag Pond

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1.0 INTRODUCTION

On December 19, 2014, the United States Environmental Protection Agency (U.S. EPA) issued their final Coal Combustion Residuals (CCR) regulation which regulates CCR as a non-hazardous waste under Subtitle D of Resource Conservation and Recovery Act (RCRA) and became effective six (6) months from the date of its publication (April 17, 2015) in the Federal Register, referred to as the “CCR Rule.” The rule applies to new and existing landfills, and surface impoundments used to dispose of or otherwise manage CCR generated by electric utilities and independent power producers. Because the rule was promulgated under Subtitle D of RCRA, it does not require regulated facilities to obtain permits, does not require state adoption, and cannot be enforced by U.S. EPA.

The CCR Rule in 40 CFR § 257.96(a) requires that an owner or operator initiate an Assessment of Corrective Measures (ACM) to prevent further release, to remediate any releases, and to restore affected area(s) to original conditions in the event that any Appendix IV constituent has been detected at a Statistically Significant Level (SSL) greater than a Groundwater Protection Standard (GWPS). The ACM must be completed within 90 days after initiation. The CCR Rule allows up to an additional 60 days to complete the ACM if a demonstration shows that more time is needed because of site-specific conditions or circumstances. A certification from a qualified professional engineer attesting that the demonstration is accurate is required. As required by 40 CFR § 257.90(e), the demonstration showing that more time was needed will be included in the 2019 Groundwater Monitoring and Corrective Action Report.

This ACM Report has been prepared to comply with 40 CFR § 257.90(c) of the CCR Rule and documents the results that are the basis for the evaluation of potential corrective measure remedial technologies. This report includes a summary of groundwater monitoring conducted to date, along with the results of site characterization activities. Finally, potential remedial technologies are identified in this report and evaluated against requirements, as specified in the CCR Rule.

2.0 SITE BACKGROUND

The Clifty Creek Station, located in Madison, Indiana, is a 1,304-megawatt (MW) coal-fired generating plant operated by the Indiana-Kentucky Electric Corporation (IKEC), a subsidiary of

the Ohio Valley Electric Corporation (OVEC). The Clifty Creek Station has six (6) 217.26-MW generating units and has been in operation since 1955. Beginning in 1955, ash products were sluiced to disposal ponds located in the plant site. During the course of plant operations, CCRs have been managed and disposed of in various units at the station.

There are three (3) CCR units at the Clifty Creek Station (Figure 2-1):

- Type I Residual Waste Landfill (Type I Landfill);
- Landfill Runoff Collection Pond (LRCP); and
- West Boiler Slag Pond (WBSP).

Under the CCR program, IKEC installed a groundwater monitoring system at each unit in accordance with the requirements of the CCR Rule; the Type I Landfill and LRCP are included in a multi-unit monitoring system. From January 2016 through August 2017, nine (9) rounds of background groundwater monitoring were conducted at all of the CCR units. The first round of Detection Monitoring was performed in March 2018. Based on groundwater monitoring conducted to date, no Statistically Significant Increases (SSIs) have been identified for Appendix III constituents at the WBSP. Therefore, this unit has remained in Detection Monitoring under the CCR program.

During the March 2018 Detection Monitoring event, SSIs were identified for the Type I Landfill and LRCP and both entered into Assessment Monitoring in September 2018. Further action was therefore required for both units under the CCR program. Details regarding these efforts are presented in the following sections of this report.

3.0 GEOLOGY AND HYDROGEOLOGY

3.1 Regional Setting

The site lies in the Central Lowland Physiographic Province along the western flanks of the Cincinnati Arch and within the Central Stable Region. The stratigraphic sequence in the regional area consists of widespread discontinuous layers of Quaternary deposits of alluvial and glacial origin overlying sedimentary rocks generally consisting of limestones, dolomites and interbedded shale. The exposed sedimentary rocks range in age from Mississippian to Ordovician. The Quaternary deposits are largely of glacial origin and consist of loess, till and outwash. Glacial outwash is present in nearly all of the stream valleys north of and including the Ohio River valley. The outwash is covered, in some cases, by a veneer of recent alluvial deposits from active streams.

Unconsolidated alluvial sediments deposited along the Ohio River valley, near or adjacent to the river constitute the major aquifer of the region. These deposits are normally found only within the Ohio River valley and the tributary streams north and northeast of the river. Wells installed in this aquifer typically yield 100 to 1,000 gallons per minute (gpm) depending upon their location and

construction. The Ohio River valley is incised into Ordovician bedrock. The low permeability bedrock forms the lateral and underlying confinement to the aquifer.

3.2 Unit-Specific Setting

Bedrock beneath the Type I Landfill and LRCP consists of impermeable limestone and shale of the Ordovician Dillsboro formation, which is overlain by approximately 20 feet of clayey gravel with sand (Applied Geology and Environmental Science, Inc. [AGES] 2018a). The clayey gravel with sand is overlain by a lean clay with sand, which is overlain by a fine to medium sand with gravel, silt and clay (Figure 3-1). The uppermost unit in the area is a surficial layer of silty clay. A limestone ridge known as the Devil's Backbone runs northeast to southwest along the length of the Type I Landfill & LRCP (Figure 3-2). The Devil's Backbone acts as an impermeable barrier that forces groundwater passing beneath the Type I Landfill to flow either toward the northeast or toward the southwest (Figure 3-3).

Based on historic aquifer testing conducted at the site, the upper lean clay deposits exhibit low permeability, do not yield adequate quantities of water to wells, and are considered to be an aquitard. The underlying fine-medium sand with silt is considered to be an unconfined or possibly semi-confined aquifer and is therefore designated as the uppermost aquifer at the LRCP.

4.0 SUMMARY OF GROUNDWATER MONITORING PROGRAM: TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND

In accordance with 40 CFR § 257.90(e) of the CCR Rule, annual Groundwater Monitoring and Corrective Action Reports have been prepared for the Clifty Creek Station for CCR program activities conducted in 2017 (AGES 2018a) and 2018 (AGES 2019a). The reports documented the status of the groundwater monitoring and corrective action program for each CCR unit, summarized the key actions completed during 2017 and 2018, described any problems encountered, discussed actions to resolve the problems, and projected key activities for the upcoming year. Applicable details of the reports are presented below in Sections 4.1, 4.2 and 4.3.

4.1 Groundwater Monitoring Network

As detailed in the Monitoring Well Installation Report (AGES 2018b), the CCR groundwater monitoring network for the Type I Landfill and LRCP consists of the following eight (8) monitoring wells:

- CF-15-04 (Background);
- CF-15-05 (Background);
- CF-15-06 (Background);
- CF-15-07 (Downgradient);

- CF-15-08 (Downgradient);
- CF-15-09 (Downgradient);
- WBSP-15-01 (Background); and
- WBSP-15-02 (Background).

The locations of all the wells in the groundwater monitoring network are shown on Figure 4-1. As listed above and shown on Table 4-1, the CCR groundwater monitoring network includes five (5) background and three (3) downgradient monitoring wells, which satisfies the requirements of the CCR Rule. Generalized groundwater flow maps (including the Ohio River) for March and October 2018 are included in Appendix A.

4.2 Groundwater Sampling

In accordance with 40 CFR § 257.94 of the CCR Rule, the first round of Detection Monitoring was conducted in March 2018. Based on the results of the statistical evaluation of the Detection Monitoring data, the Type I Landfill and LRCP entered into Assessment Monitoring in September 2018 and the first round of Assessment Monitoring samples was collected in October 2018.

All groundwater samples were collected in accordance with the Groundwater Monitoring Program Plan (GMPP) (AGES 2018c). The Detection Monitoring samples were analyzed for all Appendix III constituents and the Assessment Monitoring samples were analyzed for all Appendix III and Appendix IV constituents. All samples were shipped to an analytical laboratory to be analyzed for all of the parameters listed in Appendix III and/or Appendix IV of the CCR Rule.

4.3 Analytical Results

The analytical results for groundwater samples collected in 2018 are summarized in Appendix B. Upon receipt, the March 2018 Detection Monitoring data were statistically evaluated in accordance with 40 CFR § 257.93(f) of the CCR Rule and the Statistical Analysis Plan (StAP) (Stantec Consulting Services, Inc. [Stantec] 2018) for the CCR program. This initial statistical evaluation of the Detection Monitoring data identified potential SSIs for pH and Boron (Appendix III constituents) in three (3) wells (CF-15-07, CF-15-08 and CF-15-09). As discussed in the 2018 Groundwater Monitoring and Corrective Action Report, a faulty pH meter was suspected of causing the SSIs for pH. In accordance with the StAP, the wells were re-sampled for pH and Boron in May 2018. Based on the results of the re-sampling, the SSIs were only confirmed for Boron in wells CF-15-08 and CF-15-09 (Table 4-2).

Upon receipt, the October 2018 Assessment Monitoring results were statistically evaluated in accordance with 40 CFR § 257.93(f) of the CCR Rule and the StAP (Stantec 2018). The initial statistical evaluation identified potential SSIs for Boron (Appendix III constituent) in wells CF-15-08 and CF-15-09. In accordance with the StAP, the wells were re-sampled for those constituents in December 2018. Based on the results of the re-sampling, the SSIs for Boron

(Appendix III) were confirmed at CF-15-08 and CF-15-09 (Table 4-2). As Appendix IV constituents were also detected in all three (3) downgradient wells, IKEC began the process of establishing a GWPS for any detected Appendix IV constituent.

4.4 Alternate Source Demonstration for Type I Landfill

Based on a review of current and historic data, the Type I Landfill was not believed to be the source of Boron in groundwater in the area. An ASD was therefore completed in general accordance with guidelines presented in the *Solid Waste Disposal Facility Criteria Technical Manual* (U.S. EPA 1993). Based on the ASD, it was concluded that the Type I Landfill was not the source of Boron detected in the area. This conclusion was supported by the following evidence:

- “Foundation soils” that extend from beneath the LRCP and the hydraulically placed fly ash southwest to the Ohio River provide a direct hydraulic connection between the historic hydraulically placed fly ash and the CCR groundwater monitoring wells CF-15-08 and CF-15-09.
- Historic data from the Indiana Department of Environmental Management (IDEM) groundwater monitoring program indicate that Boron concentrations similar to those observed in CCR wells CF-15-08 and CF-15-09 were detected in IDEM wells CF-9406 and CF-9407 for 17 years prior to operation of the Type I Landfill, indicating that the Boron is associated with the historic hydraulically placed fly ash.
- Using the previously calculated groundwater flow velocity of 45 feet per year (ft/yr), it is estimated that it would take 120 years for groundwater flowing beneath the Type I Landfill to reach the CCR monitoring wells.

The ASD Report for the March 2018 Detection Monitoring (AGES 2019b) was completed in June 2019 and was certified on July 3, 2019. Based on the successful ASD, an ACM was not required at the Type I Landfill. By definition of the CCR Rule, the LRCP is unlined and the historic hydraulically placed fly ash extends beneath the LRCP to the embankment; therefore, an ACM was conducted at the LRCP.

4.5 Groundwater Protection Standards-LRCP

In accordance with 40 CFR § 257.95(h)(1) through 40 CFR § 257.95(h)(3), IKEC established a GWPS for each Appendix IV constituent that was detected in groundwater (Table 4-3). Results for all Appendix IV constituents were less than the applicable GWPSs, except for Molybdenum in CF-15-08 in October 2018 (524 micrograms per liter [ug/L]) and December 2018 (429 ug/L) (Appendix B). Both results exceeded the GWPS for Molybdenum of 100 ug/L. Molybdenum in CF-15-09 in October 2018 (85.9 ug/L) and December 2018 (87.1 ug/L) did not exceed the GWPS. Molybdenum in CF-15-07 in October 2018 (12.8 ug/L) also did not exceed the GWPS.

Based on these results, IKEC proceeded to characterize the nature and extent of the release, completed required notifications, and initiated an ACM in accordance with 40 CFR § 257.95(g). Results of these activities are presented in the following sections of this report.

5.0 CCR SITE CHARACTERIZATION ACTIVITIES

As specified in the CCR Rule in 40 CFR § 257.95(g)(1), further characterization of the nature and extent of the release to groundwater at the LRCP was required. The objectives of the characterization were to:

- Install additional monitoring wells necessary to define the contaminant plume(s);
- Collect data on the nature of material released including specific information on Molybdenum and the levels at which the constituent is present in the material released;
- Install at least one (1) additional monitoring well at the facility boundary in the direction of contaminant migration and sample this well in accordance with § 257.95 (d)(1); and
- Sample all wells in accordance with § 257.95 (d)(1) to characterize the nature and extent of the release.

This section details the work conducted in between February and May 2019 to collect additional data to aid in characterization of the release and assessment of corrective measures. To evaluate the extent of Molybdenum impacts, two (2) additional wells (CF-19-14 and CF-19-15) were installed in the uppermost aquifer at the property boundary downgradient from the LRCP (Figure 5-1). To confirm that Molybdenum had not migrated into the deep aquifer, two (2) other wells (CF-19-08D and CF-19-15D) were also installed in the deep aquifer (clayey gravel with sand) (Figure 5-1). All of these wells were developed, hydraulically tested and sampled for analysis of Molybdenum.

Details regarding this work are presented in the following sections of this report.

5.1 Grain Size Analysis and Monitoring Well Design

The CCR Rule requires that unfiltered groundwater samples be submitted for laboratory analysis. According to the preamble to the CCR Rule, the unfiltered sample requirement assumes that groundwater samples with a turbidity of less than 5 nephelometric turbidity units (NTUs) can be obtained from a properly designed monitoring well. The proper design of the sand pack and well screen in each unconsolidated CCR well is therefore critical to obtaining representative samples.

The four (4) new monitoring wells were designed and installed using the same methods and materials used during the installation of the other wells in the CCR groundwater monitoring network and in accordance with the GMPP (AGES 2018c). During installation, representative samples of the aquifer material from both the uppermost and deep aquifers were collected from

well borings CF-19-08D and CF-19-15D. These soil samples were submitted to a geotechnical laboratory for grain-size analysis per American Society for Testing and Materials (ASTM) Methods D421 and D422. The results of the grain size analyses were used to confirm that the design of the well screens and filter packs was appropriate for the CCR monitoring program. In accordance with U.S. EPA monitoring well design guidelines (U.S. EPA 1991), the grain size of the filter pack was chosen by multiplying the 70% retention (or 30% passing) size of the formation, as determined by the grain size analysis, by a factor of 3 (for fine uniform formations) to 6 (for coarse, non-uniform formations). Table 5-1 summarizes the results of the grain-size analysis and the 70% retention size for each of the samples collected from each boring. The laboratory reports are included in Appendix C.

Two (2)-inch diameter 0.01" slotted Schedule 40 polyvinyl chloride (PVC) pre-packed screens designed specifically for sampling metals in groundwater were selected for use in the wells at the LRCP to reduce turbidity. The pre-packed well screens were constructed using an inner filter pack consisting of 0.40 millimeter (mm) clean quartz filter sand between two layers of food-grade plastic mesh to reduce sample turbidity by filtering out smaller particles than is possible with standard filter packed wells and prepack screens. No metal components were used in the construction of the pre-packed well screens, thus eliminating potential interference with metals analysis.

5.2 Monitoring Well Installation, Development, Sampling, and Testing

5.2.1 Monitoring Well Installation

From March 4 through 21, 2019, a total of four (4) additional monitoring wells were installed at the LRCP using hollow stem auger drilling methods. During drilling, the drill bit was simultaneously pushed down and rotated. Continuous split-spoon samples were logged by the AGES geologist. The augers were used to advance each boring to the desired depth and were kept in place to keep the borehole open during well installation. The augers were then removed as the well installation progressed.

Once each borehole was advanced to the desired depth, a 5-foot or 10-foot pre-packed well screen was set into the borehole. An outer filter pack consisting of 0.40 mm clean quartz sand was installed directly around the pre-packed well screen. The sand was placed as the augers were pulled back in one (1)- to two (2)- foot increments to reduce caving effects and ensure proper placement of the filter pack. The filter pack extended one (1)-foot above the top of the screen.

A two (2)-foot thick annular bentonite seal was installed above the filter pack in each well. Once in place, the bentonite seal was allowed to hydrate before the remainder of the annular space around each monitoring well was backfilled using a grout consisting of Portland cement and bentonite. Each monitoring well was completed with an above-ground protective steel casing and

a locking well cap. Following installation, each monitoring well was surveyed for elevation and location by IKEC personnel.

Well construction details for the four (4) new wells installed at the LRCP are presented in Table 5-2. All well boring and construction logs are included in Appendix D.

5.2.2 Monitoring Well Development

Well development was initiated at least 48 hours after installation of each of the monitoring wells. Development consisted of alternating surging and pumping with a submersible pump. During development of the monitoring wells, field parameters including temperature, specific conductance, pH, and turbidity were recorded at regular intervals. Development continued until each parameter stabilized and turbidity was less than 5 NTUs. Well development data for each well is summarized on Table 5-3.

5.2.3 Groundwater Sampling

On March 26 and March 28, 2019, the four (4) new monitoring wells were sampled in accordance with the GMPP (AGES 2018c) for Molybdenum. The monitoring wells were purged using a pump to remove stagnant water in the casing and to ensure that a representative groundwater sample was collected.

Samples were collected in laboratory provided, pre-preserved (if necessary) bottleware. All bottles were labeled with the unique sample number, time and date of sample collection, and the identity of the sampling fraction. Field parameters were measured and recorded on purging forms at the time of sample collection.

Following sample collection, the samples were packed in ice in coolers insulated to four degrees centigrade (4°C) and shipped to the TestAmerica analytical laboratory located in Canton, Ohio.

5.2.4 Aquifer Testing

In April 2019, slug tests were conducted on all of the new wells (CF-19-08D, CF-19-14, CF-19-15 and CF-19-15D) to obtain data to calculate the saturated hydraulic conductivity (K) for the shallow and deep aquifers beneath the LRCP. Both rising and falling head slug tests were performed on each well. The falling head tests were performed by lowering a pre-fabricated solid slug with a known volume, into the water column of the well and recording the drop in head over time. The rising head tests were performed by removing the solid slug and recording the rise in head over time. The change of head over time was recorded using a data logger and pressure transducer. Dedicated rope was used for each well and the slug was decontaminated using the procedures specified in the GMPP for the Clifty Creek Station (AGES 2018c).

The slug test data were evaluated using AQTESOLV, a commercially available software package. Data from each monitoring well were analyzed using both the Bouwer-Rice and Hvorslev slug test solutions (with automatic curve matching) which are straight-line analytical techniques commonly used to analyze rising and falling head slug test data. The AQTESOLV data for each well are presented in Appendix E.

5.3 Results of Site Characterization

5.3.1 Site Geology Updates

Based on the results of the site characterization, an update to the understanding of the geology at the unit is not necessary. The boring logs maintained during monitoring well installation confirmed that a fine-medium sand is the uppermost aquifer and confirmed the presence of a clay layer at a depth of 35 to 40 feet below ground surface (bgs) that separates the uppermost aquifer from the deep aquifer. The unconsolidated deposits overlay limestone bedrock of the Dillsboro Formation at depths ranging from 15 to 90 feet bgs.

5.3.2 Groundwater Flow

A complete round of groundwater level data was collected in March 2019 from the wells south of the LRCP (Table 5-4). A groundwater flow map generated using these data indicates that groundwater in the uppermost aquifer beneath the LRCP flows to the south toward the Ohio River (Figure 5-2). Groundwater in the deep aquifer also flows from the north (CF-19-08D; groundwater elevation of 442.16 ft msl) to south (CF-19-15D; groundwater elevation of 428.77 ft msl) toward the Ohio River. Historic groundwater elevation data indicates that groundwater flow beneath the LRCP is affected by the flow and water level in the Ohio River and evidence of several flow reversals have been observed in the historic data (AGES 2018a).

5.3.3 Slug Testing

Slug test results from testing completed in May 2016 and April 2019 are summarized on Table 5-5. The revised mean K for the uppermost aquifer beneath the LRCP is 8.23×10^{-4} feet per second (ft/sec). The mean K for the deep aquifer is 1.31×10^{-5} ft/sec. Published literature indicates that these are reasonable K values for these type of unconsolidated deposits (Fetter 1980).

5.3.4 Groundwater Flow Velocity

Using water level data collected in March 2019 and hydraulic conductivity data from the recent slug tests (Tables 5-4 and 5-5), the average groundwater velocity for the uppermost and deep aquifers beneath the LRCP was estimated. The calculated average groundwater velocity for the shallow aquifer is 7.43 feet per day (ft/day) (Table 5-6). With this flow velocity and a distance

between wells CF-15-08 and CF-19-15 (at the property boundary) of approximately 523 feet, the travel time for groundwater to flow between CF-15-08 and CF-19-15 is approximately 70 days.

The calculated average groundwater velocity for the deep aquifer is 0.1446 ft/day (Table 5-6). With this flow velocity and a distance between wells CF-19-08D and CF-19-15D (at the property boundary) of approximately 523 feet, the travel time for groundwater to flow between CF-19-08D and CF-19-15D is approximately 3,617 days.

5.3.5 Groundwater Sampling Results

Analytical results for Molybdenum in the four (4) new wells are presented on Table 5-7.

In the uppermost aquifer, Molybdenum concentrations south of the LRCP ranged from 4.9 ug/L in CF-15-07 to 380 ug/L in CF-15-08 (Figure 5-3). Molybdenum concentrations in the two (2) new shallow wells at the property boundary were 1.1 ug/L in CF-19-15 and 12 ug/L in CF-19-14. Based on these results, Molybdenum concentrations in the uppermost aquifer exceeding the GWPS of 100 ug/L are confined to the site and are not reaching the Ohio River. However, to address Molybdenum concentrations in the uppermost aquifer an ACM is required.

In the deep aquifer, Molybdenum concentrations were 31 ug/L in CF-19-08D and 49 ug/L in CF-19-15D (Figure 5-3). Based on these results, Molybdenum impacts are confined to the uppermost aquifer as these concentrations are less than the GWPS of 100 ug/L. Further evaluation of Molybdenum in the deep aquifer is therefore not required.

6.0 ASSESSMENT OF CORRECTIVE MEASURES

Groundwater monitoring of the uppermost aquifer at the LRCP has identified Molybdenum (an Appendix IV constituent) at concentrations that exceed the GWPS defined under 40 CFR § 257.95(h); therefore, an ACM is necessary. The ACM will require identification and evaluation of technologies and methods that may be used as elements of remedial actions to meet the requirements of the CCR Rule. These elements include potential source control methods and various groundwater remedial technologies that may be applicable to the LRCP. Additional remedial technologies may also be evaluated at a later date, if determined to be applicable and appropriate.

Presented below is a discussion of the objectives of the ACM, the potential source control measures, a list of remedial technologies, a summary of the assessment process, and the detailed ACM evaluation.

6.1 Objectives of Remedial Technology Evaluation

Per 40 CFR § 257.96(a), the objectives of the corrective measures evaluated in this ACM Report are “to prevent further releases, to remediate any releases, and to restore affected area to original conditions.” As required in 40 CFR § 257.97(b), corrective measures, at minimum, must:

- (1) *Be protective of human health and the environment;*
- (2) *Attain the groundwater protection standard as specified pursuant to § 257.95(h);*
- (3) *Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV to this part into the environment;*
- (4) *Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems;*
- (5) *Comply with standards for management of wastes as specified in § 257.98(d).*

6.2 Potential Source Control Measures

The objective of source control measures is to prevent further releases from the source (i.e., the LRCP). According to 40 CFR § 257:

“Remedies must control the source of the contamination to reduce or eliminate further releases by identifying and locating the cause of the release. Source control measures may include the following: Modifying the operational procedures (e.g., banning waste disposal); undertaking more extensive and effective maintenance activities (e.g., excavate waste to repair a liner failure); or, in extreme cases, excavation of deposited wastes for treatment and/ or offsite disposal. Construction and operation requirements also should be evaluated.”

The detailed evaluation of source control measures at the LRCP is provided in Table 6-1. Three (3) technologies are included in this evaluation:

- Dewatering of Pond Water;
- Engineered Cover System; and
- Excavation of Ash.

Per state and federal regulatory requirements and timelines, IKEC tentatively plans to close the LRCP. The method and timing of closure of the unit will depend on receipt of approval from the IDEM. Source control through closure will likely initially include the cessation of ongoing wastewater and storm water discharge into the LRCP, a combination of passive and active

decanting of ponded water within the unit, and interstitial dewatering of ash pore-water within the unit.

Groundwater quality near the LRCP is anticipated to significantly improve over time as a result of the above-referenced closure activities. Terminating wastewater and storm water discharge to the LRCP, coupled with decanting of ponded water, will significantly decrease the hydraulic head in the LRCP and thereby significantly reduce infiltration of water from the unit to the underlying groundwater. Dewatering of the ash will also reduce the contact-time for Molybdenum with the ash pore-water, which should reduce the mobility of the Molybdenum. Groundwater monitoring over time is necessary to fully evaluate the positive impact that closure of the LRCP will have on groundwater quality.

6.3 Potential Remedial Technologies

The focus of corrective measures for the LRCP is to address Molybdenum in groundwater that exceeded the GWPS. To accomplish this, the following three (3) types of technologies will be presented in Sections 6.3.1 through 6.3.3:

- In-Situ Groundwater Remedial Technologies;
- Ex-Situ Groundwater Remedial Technologies; and
- Treatment of Extracted Groundwater.

As described in Section 6.2, groundwater quality near the LRCP is anticipated to significantly improve over time as a result of planned closure activities. Therefore, a flexible and adaptive approach to groundwater remediation that begins with post-closure groundwater monitoring at the unit is planned. During the post-closure monitoring period, the positive impacts of closure and the effects of natural attenuation on groundwater quality will be fully evaluated. The need for more active remedial measures (as discussed below) will be determined after sufficient post-closure groundwater quality data has been collected and evaluated. The final selection of a remedy will be made based on the results of the post-closure groundwater monitoring program.

The detailed ACM evaluation is provided in Table 6-2 and summarized below in Section 6.4. Additional remedial technologies may also be evaluated if determined to be applicable and appropriate.

6.3.1 In-Situ Groundwater Remedial Technologies

In-situ groundwater remediation approach involves treating the groundwater where it is presently situated, rather than removing and transferring it elsewhere for treatment and disposal. Long-term groundwater monitoring would be required to evaluate the effectiveness of any of these technologies. In-situ groundwater remediation technologies are discussed below.

6.3.1.1 Monitored Natural Attenuation (MNA)

MNA is a strategy and set of procedures used to demonstrate that physical, chemical and/or biological processes in an aquifer will reduce concentrations of constituents to levels below applicable standards. These processes attenuate the concentrations of inorganics in groundwater by physical and chemical means (e.g., dispersion, dilution, sorption, and/or precipitation). Dilution from recharge to shallow groundwater, mineral precipitation, and constituent adsorption will occur over time, which will further reduce constituent concentrations through attenuation. Regular monitoring of select groundwater monitoring wells is conducted to ensure constituent concentrations in groundwater are attenuating over time.

6.3.1.2 Groundwater Migration Barriers

Low permeability barriers can be installed below the ground surface to prevent groundwater flow from reaching locations that pose a threat to receptors. Barriers can be installed with continuous trenching techniques using bentonite or other slurries as a barrier material to prevent migration of groundwater. Barriers of cement/concrete and sheet piling can also be used.

Barriers are most effective at preventing flow to relatively small areas or to protect specific receptors. Protecting larger areas is possible if the constituent of concern is not highly soluble and cannot follow a diverted groundwater flow pattern. The barrier will change the groundwater flow conditions, and at some point the increased head (pressure) will cause a change in flow patterns. This will generally be around the flanks or beneath the barrier. To ensure that groundwater will not flow beneath the barrier, it must be sealed at an underlying impermeable layer such as a clay layer.

Groundwater migration barriers are often used in conjunction with groundwater extraction systems. The barriers are used to restrict flow to allow extraction systems upgradient of the barrier to collect groundwater. However, the challenges discussed above for creating a competent seal with any underlying unit may still apply.

6.3.1.3 Permeable Reactive Barriers (PRBs)

Permeable reactive barriers (PRBs) can be an effective in-situ groundwater treatment technology. General design involves excavation of a narrow trench perpendicular to groundwater flow similar to migration barriers and then backfilling the trench with a reactive material that either removes or transforms the constituents as the groundwater passes through the PRB. Unlike simple barriers, the PRB can be designed to include impermeable sections to funnel the flow through a more narrow and permeable reactive zone. The ability to maintain adequate and reactive reagent concentrations at depth over an extended period of time is a significant operational and performance assurance challenge. As with other in-situ approaches, reconstruction or regeneration may be needed on a periodic basis.

6.3.1.4 In-Situ Chemical Stabilization

The placement of chemical reactants to immobilize dissolved phase constituents through precipitation or sorption can be an effective approach to reducing downgradient migration. Reagents such as ferrous sulfate, calcium polysulfide, zero-valent iron, organo-phosphorous mixtures, and sodium dithionate have been evaluated as potentially effective for coal ash related constituents.

Two (2) issues that must be considered with this technology are permanence of the reaction product insolubility and the ability to inject the reactants sufficiently to ensure adequate contact with the constituents. Most stabilization reactions can be reversible depending on environmental conditions such as pH and oxidation state. Given the long periods of time for which the reaction products must remain insoluble, it may be difficult to predict future conditions sufficiently to ensure permanence of this technology. Recurring treatment, based on routine testing, may be an option. Contact between reagents and the constituents must also be evaluated. This technology may need to be considered more as a source reduction technology than a capture or barrier technology, as the reactants may not be viable over an extended period of time.

6.3.2 Ex-Situ Groundwater Remedial Technologies

Ex-situ remedial technologies require groundwater extraction to remove constituent mass from the groundwater and can provide hydraulic control to reduce or prevent groundwater constituent migration. Groundwater can be removed from the aquifer through the use of conventional vertical extraction wells, horizontal wells, collection trenches and associated pumping systems. The type of well or trench system selected is based upon site-specific conditions. Long-term groundwater monitoring would be required to evaluate the effectiveness of any of these technologies. Ex-situ groundwater remediation technologies are discussed below.

6.3.2.1 Conventional Vertical Well System

Conventional vertical wells can usually be used in most cases unless accessibility is an issue. Well spacing and depths depend upon the aquifer characteristics. If flow production from the aquifer is extremely limited, conventional wells may not be feasible due to the extremely close spacing that would be required. Vertical wells may be used at any depth and can be screened in unconsolidated soils or completed as open-hole borings in bedrock.

6.3.2.2 Horizontal Well Systems

The use of horizontal recovery wells has increased due to development of more efficient horizontal drilling techniques. These systems can cover a significant horizontal cross-section and may be much more efficient than conventional vertical wells. They are not well suited to aquifers with wide variation in water levels, as the horizontal well may end up being dry.

6.3.2.3 Trenching Systems

Horizontal collection trenches function similarly to horizontal wells but are installed with excavation techniques. They can be more effective at shallow depths and with higher flow regimes. However, they may not be practical for deeper installations.

6.3.3 Treatment of Extracted Groundwater

Several technologies exist for treatment of extracted groundwater to remove or immobilize constituents ex-situ. The following technologies would be considered if treatment of extracted groundwater became necessary prior to a permitted discharge. As presented in the following sections, there are three (3) primary treatment technologies that are applicable to Molybdenum:

- Filtration;
- Ion Exchange; and
- Other Adsorbents.

6.3.3.1 Filtration Technologies

There are a number of permeable membrane technologies that can be used to treat impacted groundwater for metals and other constituents. The most common is reverse osmosis, although microfiltration, ultrafiltration, and nanofiltration are also used. All of these technologies use pressure to force impacted water through a permeable membrane, which filters out the target constituents. The differences in the technologies are based on the filtration size and the corresponding pressure needed to operate the system. These membrane technologies can capture a number of target compounds simultaneously and can achieve low effluent concentrations, but they are also very sensitive to fouling and often require a pretreatment step. Membrane technologies can result in a relatively high volume reject effluent, which may require additional treatment prior to disposal.

6.3.3.2 Exchange Technologies

Ion exchange is a well proven technology for removing metals from groundwater. With some constituents, ion exchange can achieve very low effluent concentrations. Ion exchange is a physical process in which ions held electrostatically on the surface of a solid are exchanged for target ions

of similar charge in a solution. The medium used for ion exchange is typically a resin made from synthetic organic materials, inorganic materials, or natural polymeric materials that contain ionic functional groups to which exchangeable ions are attached. The resin must be regenerated routinely, which involves treatment of the resin with a concentrated solution, often containing sodium or hydrogen ions (acid). There must be a feasible method to dispose of the regeneration effluent for this technology. Pretreatment may be required, based on site specific conditions.

6.3.3.3 Adsorption Technologies

Groundwater containing dissolved constituents can be treated with adsorption media to reduce their concentration. However, the column must be regenerated or disposed of and replaced with new media on a routine basis. Common adsorbent media include activated alumina, copper-zinc granules, granular ferric hydroxide, ferric oxide-coated sand, greensand, zeolite, and other proprietary materials. This technology may also generate a significant regeneration waste stream.

6.4 Evaluation to Meet Requirements in 40 CFR § 257.96(c)

For this evaluation, each of the potential remedial technologies identified above will be screened against evaluation criteria requirements in 40 CFR § 257.96(c) listed below:

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

- (1) The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;*
- (2) The time required to begin and complete the remedy;*
- (3) The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy(s).*

The ACM evaluation is provided in Table 6-2 and detailed below.

6.4.1 Performance

This criterion includes the ability of the technology to effectively achieve the specified goal of corrective measures to prevent further releases, to remediate any releases, and to restore the affected area to original conditions.

6.4.1.1 In-Situ Groundwater Remedial Technologies

MNA is a proven technology that can be implemented to reduce constituent concentrations over time through natural processes of geochemical and physical attenuation. Typical attenuation mechanisms that could affect Molybdenum would include adsorption, precipitation, and dispersion. Molybdenum is highly sensitive to changes in oxidation-reduction conditions in groundwater. It is more mobile at higher Oxidation Reduction Potential (ORP) values; it is weakly adsorbed with minimal mineral formation (precipitation) at pH values in the range of 6.5 to 7.5 (Smedley and Kinniburgh 2017). At the LRCP, ORP values varied significantly in 2018 with ranges of -50 millivolts (mV) to 34.7 mV at CF-15-07; -47.7 mV to 335 mV at CF-15-08; and -50.4 mV to 325.1 mV at CF-15-09 (AGES 2019a). The pH values at the LRCP were more consistent ranging from 7.05 to 7.61 Standard Units (SU) at all three (3) wells over the course of 2018. The wide range of ORP values are likely related to flood events when the groundwater flow direction reverses and water from the Ohio River recharges groundwater at the site. Within this range of values, the mobility of Molybdenum would vary (due to ORP variations) and there would be limited adsorption and precipitation (due to the pH range).

Dispersion, the mixing and spreading of constituents due to microscopic variations in velocity within and between interstitial voids in the aquifer, and dilution would reduce Molybdenum concentrations but would not destroy the Molybdenum. Given groundwater flow conditions, with periodic flood events and flow reversals, dispersion and dilution of Molybdenum would likely be a major factor in natural attenuation.

At the LRCP, the existing well network would be used to monitor constituent trends over time. Given that Molybdenum concentrations are less than the GWPS at the property boundary, a long-term timeframe would likely be acceptable.

Although migration barriers, PRBs, and in-situ chemical stabilization are proven technologies, conditions at the LRCP would limit the performance of each of these approaches. To be effective, a migration barrier would need to be tied into a lower competent unit at the LRCP; either the lean clay layer at approximately 40 feet bgs or bedrock at 80 to 90 feet bgs. Given that the LRCP is located within an impermeable bedrock valley, these conditions would be conducive to this approach. Under these conditions, any altered flow paths due to the presence of the barrier could likely be managed. Note that periodic flooding of the area by the Ohio River would also impact the performance of these technologies.

A groundwater extraction system may also be coupled with this technology to increase its long-term effectiveness. Similar to the migration barrier, a PRB could also be installed at the LRCP. However, maintaining adequate reagent concentrations at depth over time is a significant issue. In addition, the effectiveness of this approach to treat Molybdenum is not well tested or established.

Given site conditions, in-situ chemical stabilization reagents could be injected into the uppermost aquifer and distributed to where impacts occur. It would be critical to fully evaluate future groundwater conditions (i.e., pH, ORP, etc.) to maintain this approach. The effectiveness of this approach to treat Molybdenum is not well tested or established.

6.4.1.2 Ex-Situ Groundwater Remedial Technologies

Groundwater extraction is a proven technology that has been successfully implemented for decades at many sites. Conventional vertical wells are the most often used approach; although the use of horizontal wells has been increasing. At the LRCP, a series of vertical recovery wells can likely be installed and operated to address impacted groundwater. Horizontal wells operate in a similar manner to vertical wells but are less effective in areas with significant water level fluctuations, like the LRCP. The performance of both types of wells would be significantly impacted by the Iron content of groundwater, which can lead to clogging. Significant levels of operation and maintenance would likely be necessary.

Trenching systems are often used when groundwater impacts are encountered in a shallow unit. The depth to groundwater at the LRCP is 15 to 20 feet bgs and the depth to the lean clay layer is 40 feet bgs. Although these depths are not ideal for a trench, they do not preclude the use of a trench at the LRCP.

Note that periodic flooding of the area by the Ohio River would also impact the performance of these ex-situ technologies.

6.4.1.3 Treatment of Extracted Groundwater

Groundwater treatment is required as a supplemental technology to be used in conjunction with groundwater extraction. The need for treatment depends on permit requirements for discharge of the treated water via a National Pollution Discharge Elimination System (NPDES) permit. The concentrations of Molybdenum would need to be reduced to less than the required permit limits. Treatment for other constituents may also be required based on permit requirements.

Treatment of extracted groundwater can be performed, although Molybdenum is one of the more difficult constituents to remove from water. Molybdenum removal can be accomplished in both continuous and sequential batch processes. A typical batch operation would consist of chemical storage and dosing modules; a primary reactor and pretreatment holding tank; a solids dewatering device (if needed); and miscellaneous temperature and pH controls. Prior to design, bench scale testing should be conducted to fully evaluate site-specific conditions. Pilot testing would also likely be performed, if favorable results are obtained from the bench scale testing, prior to design and construction of a full-scale treatment system.

6.4.2 Reliability

This criterion includes the degree of certainty that the technology will consistently work toward and achieve the specified goal of corrective measures over time.

6.4.2.1 In-Situ Groundwater Remedial Technologies

As the process of MNA is based on natural processes, this approach would be considered to be reliable. However, as groundwater geochemistry can vary over time, routine monitoring is required to evaluate conditions and ensure the ongoing effectiveness of the MNA process. Geochemical changes in groundwater could significantly impact the effectiveness of MNA, which could lead to the need to implement other remedial measures at the LRCP.

Migration barriers and PRBs are typically reliable technologies; the primary issue being the potential for altered groundwater flow directions and further migration of constituents. In addition, maintaining adequate and reactive reagent concentrations at depth over an extended period of time in a PRB can also be a significant operational and maintenance issue.

For in-situ chemical stabilization, reagents must be injected uniformly and consistently to adequately distribute them into the aquifer. Lack of a uniform and consistent approach could lead to reliability issues. Finally, changes in the geochemistry of the aquifer can lead to the need for adjustments in reagent type, concentrations and injection approach.

6.4.2.2 Ex-Situ Groundwater Remedial Technologies

Groundwater extraction solutions are generally considered reliable at controlling and removing constituents from the subsurface. At the LRCP, conventional vertical wells would be the more reliable approach, as the large water level fluctuations at the unit would significantly impact the reliability of horizontal wells. There can be significant operation and maintenance issues associated with both conventional vertical or horizontal wells but these issues are well understood and can be readily addressed. Once in the place, trenching systems would also be reliable at the LRCP although long term Operations and Maintenance (O&M) would be required.

6.4.2.3 Treatment of Extracted Groundwater

Treatment of Molybdenum in extracted groundwater would be reliable as long as the bench-scale/pilot-test process outlined above is properly implemented.

6.4.3 Ease of Implementation

This criterion includes the ease with which the technologies can be implemented at the LRCP.

6.4.3.1 In-Situ Groundwater Remedial Technologies

MNA is among the easiest of corrective measures to implement at a site. A sufficient number of monitoring wells already exist at the LRCP, which could be used to monitor the effectiveness of MNA.

Due to the significant amount of time, effort, and disturbance required for implementation at the LRCP, migration barriers, in-situ chemical stabilization and PRBs implementation would be difficult. Difficulties in construction would be related to the depth of installation and the need to install a barrier into the lean clay layer at the site at a depth of 40-feet bgs. Once constructed, the barrier technology would be passive and would operate immediately. The PRB would likely require periodic recharging with appropriate reagents. In-situ chemical stabilization may require less time and effort than with a migration barrier or PRB.

6.4.3.2 Ex-Situ Technologies for Groundwater Extraction

Implementation of both conventional vertical and horizontal wells at the LRCP would require drilling and limited field construction; however, the conventional vertical wells would be the more easily implemented. The orientation of the horizontal wells could present potential installation issues. Trenching systems would require significant construction and would be difficult to implement at the LRCP.

6.4.3.3 Treatment of Extracted Groundwater

Treatment of Molybdenum in extracted groundwater can be implemented but would require the bench-scale/pilot-test process outlined above.

6.4.4 Potential Safety Impacts

This criterion includes potential safety impacts that may result from implementation and use of the technology at the LRCP.

6.4.4.1 In-Situ Groundwater Remedial Technologies

Potential safety impacts associated with MNA are very minimal; especially as no additional well installation is required. Minimal safety concerns are therefore associated with the ongoing groundwater monitoring program.

Migration barriers and PRBs require a significant construction effort and use of construction equipment, which would entail a relatively high risk of potential safety impacts. However, neither technology would have any potential significant safety impacts following construction. Potential safety concerns related to in-situ chemical stabilization are moderate. The potential for incidents

during injection well construction or unintended worker contact with the chemicals used for treatment would be the primary safety concerns with this technology.

6.4.4.2 Ex-Situ Groundwater Remedial Technologies

Groundwater extraction through use of wells (conventional vertical or horizontal) would involve drilling, construction, and installation of extraction wells, pumps, and associated control wiring and piping. Potential safety concerns exist with the activities associated with installation of these wells, as well as the ongoing operations and maintenance of the system, including inspection, maintenance, or replacement of the various system components.

Trenching systems would require use of significant construction equipment and present worker safety concerns, especially with the depth of the trench. Ongoing operation of the system would present minimal safety concerns.

6.4.4.3 Treatment of Extracted Groundwater

Treatment of extracted Molybdenum in groundwater would have minimal safety concerns.

6.4.5 Potential Cross-Media Impacts

This criterion includes the ability to control cross-media impacts during implementation and use of the technology at the LRCP.

6.4.5.1 In-Situ Groundwater Remedial Technologies

MNA poses no significant cross-media impact potential. Migration barriers and PRBs pose minimal risk of cross-media impacts, as they primarily involve an intended modification in groundwater flow. For a barrier technology, there could be some risk with the migration of impacted groundwater to other areas of the site; this concern is minimal. In the case of PRBs, constituents are removed from the groundwater through use of reagents; this includes minimal potential for cross-media impacts.

6.4.5.2 Ex-Situ Groundwater Remedial Technologies

Well and trench systems pose a moderate risk of cross-media impacts.

6.4.5.3 Treatment of Extracted Groundwater

Treatment of extracted groundwater would pose minimal risk of cross-media impacts.

6.4.6 Potential Impacts from Control of Exposure to Residual Constituents

This criterion includes the ability to control exposure of humans and the environment to residual constituents through implementation and use of the technology at the LRCP.

6.4.6.1 In-Situ Groundwater Remedial Technologies

MNA poses no significant potential for human or environmental exposure to impacted groundwater. Overall, in-situ technologies involve placement or injection of a structure or reagent to treat impacted groundwater in-place. Consequently, there is no increased risk of exposure of humans and the environment to residual contamination.

6.4.6.2 Ex-Situ Groundwater Remedial Technologies

Groundwater extraction involves bringing impacted groundwater from the subsurface to the surface for potential treatment and discharge. This would slightly increase the potential for exposure of humans or the environment to impacted groundwater. The groundwater would be conveyed through an engineered system designed to prevent the release of water into the environment and to limit the potential for human or environmental exposure to the impacted groundwater. The potential for exposure to residual contamination associated with this technology is therefore unlikely.

6.4.6.3 Treatment of Extracted Groundwater

Treatment of extracted groundwater would pose minimal risk of exposure to residual contamination.

6.4.7 Time Required to Begin Remedy

This criterion includes the time necessary for planning, pilot testing, design, permitting, procurement, installation, and startup of this technology at the LRCP. Timeframes presented below and in Table 6-2 reflect the time required to implement the remedy after closure of the unit.

6.4.7.1 In-Situ Groundwater Remedial Technologies

A MNA program could be implemented at the LRCP within three (3) months, as a sufficient monitoring well network already exists at the site and a monitoring program is already established. This potential remedy would require the least amount of time to implement of the technologies considered.

Migration barriers, in-situ chemical stabilization, and PRBs could take a significant amount of time to design and install. Either technology would also involve a significant amount of regulatory permitting. The design and implementation time could take 1 to 1.5 years.

6.4.7.2 Ex-Situ Groundwater Remedial Technologies

Design and installation of groundwater extraction systems could be completed in six (6) months to one (1) year. This could vary depending on potential groundwater modeling efforts and regulatory approval and permitting.

6.4.7.3 Treatment of Extracted Groundwater

Design and installation of the system, including bench-scale and pilot testing, could be completed in six (6) months to one (1) year. This would depend on the regulatory approval and permitting process.

6.4.8 Time Required to Complete Remedy

This criterion includes the estimated time necessary to achieve the stated goals of corrective measures to prevent further releases from the LRCP, to remediate any releases, and to restore the affected area to original conditions.

6.4.8.1 In-Situ Groundwater Remedial Technologies

As MNA does not require additional physical or chemical remedial treatment, the timeframe is the longest period to reach remedial goals. A groundwater model would be useful to more accurately predict the anticipated time required to complete the remediation.

A significant amount of time is expected to be required to meet remedial goals with migration barriers and PRB. However, as groundwater modeling has not been performed for the site, an accurate estimate cannot be developed at this time. If in-situ chemical stabilization option can effectively treat Molybdenum at the unit boundary, this approach has the potential to treat groundwater more quickly than a barrier or PRB.

6.4.8.2 Ex-Situ Groundwater Remedial Technologies

A significant amount of time is expected to be required to meet remedial goals with ex-situ technologies. However, as groundwater modeling has not been performed for the site, an accurate estimate cannot be developed at this time.

6.4.8.3 Treatment of Extracted Groundwater

The time required to meet remedial goals depends on the type of groundwater extraction system implemented. The time required for treatment of extracted groundwater is insignificant.

6.4.9 State, Local, or Other Environmental Permit Requirements That May Impact Implementation

This criterion includes anticipation of any state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the technology at the LRCP.

6.4.9.1 In-Situ Groundwater Remedial Technologies

A MNA program would likely require coordination with IDEM but likely not formal approval. Therefore, it could be implemented in as little as (3) months, as a sufficient monitoring well network already exists at the site.

Migration barriers, in-situ chemical stabilization, and PRBs would require installation of barrier walls and associated components in the aquifer and/or chemical injections, which may require permitting through IDEM. This would require an anticipated minimum of 1 to 1.5 years of review and approval.

6.4.9.2 Ex-Situ Groundwater Remedial Technologies

A groundwater extraction system would require the installation of new wells and a treatment system at the LRCP, which may require permitting through IDEM. This would require an anticipated minimum of 1 to 1.5 years of review and approval.

6.4.9.3 Treatment of Extracted Groundwater

The selection of a treatment system may require permitting through IDEM, especially if a NPDES permit is required. This would require an anticipated minimum of 1 to 1.5 years of review and approval.

6.5 Conclusions

For this evaluation, several in-situ and ex-situ remedial technologies to address Molybdenum in groundwater at the LRCP were screened against evaluation criteria requirements in 40 CFR § 257.96(c). As presented in Table 6-2, during the screening, the technologies were ranked as High, Medium or Low using professional judgement and past experience. Based on these rankings, the two (2) technologies that appear to be most likely for selection as a remedy were:

- MNA; and
- Conventional Vertical Well System (Groundwater Extraction) (Ex-Situ).

Groundwater treatment would be required as a supplemental technology in conjunction with a Conventional Vertical Well System. The selection of a treatment technology would be based on conditions at the time of selection of a final remedy.

The technologies that appear to be less likely for selection as a remedy were:

- Groundwater Migration Barriers (In-Situ);
- PRB (In-Situ);
- In-Situ Chemical Stabilization (In-Situ);
- Horizontal Well Systems (Ex-Situ); and
- Trenching Systems (Ex-Situ).

As groundwater quality near the LRCP is anticipated to significantly improve over time as a result of planned closure activities, a flexible and adaptive approach to groundwater remediation that begins with post-closure groundwater monitoring at the unit is planned. During the post-closure monitoring period, the positive impacts of closure and the effects of natural attenuation on groundwater quality will be fully evaluated. The need for more active remedial measures will be determined after sufficient post-closure groundwater quality data has been collected and evaluated. The final selection of a remedy will be made based on the results of post-closure groundwater monitoring program.

Additional remedial technologies may also be evaluated at a later date if determined to be applicable and appropriate.

7.0 SELECTION OF REMEDY PROCESS

The remedy selection begins following completion of the ACM Report. Per 40 CFR § 257.97(a):

Based on the results of the corrective measures assessment conducted under § 257.96, the owner or operator must, as soon as feasible, select a remedy that, at a minimum, meets the standards listed in paragraph (b) of this section. This requirement applies to, not in place of, any applicable standards under the Occupational Safety and Health Act. The owner or operator must prepare a semiannual report describing the progress in selecting and designing the remedy. Upon selection of a remedy, the owner or operator must prepare a final report describing the selected remedy and how it meets the standards specified in paragraph (b) of this section. The owner or operator must obtain a certification from a qualified professional engineer that the remedy selected meets the requirements of this section. The report has been completed when it is placed in the operating record as required by § 257.105(h)(12).

This ACM Report provided a high-level assessment of groundwater remedial technologies that could potentially address Molybdenum concentrations in groundwater that exceed the GWPS at the LRCP. With the submittal of this report, IKEC began the remedy selection process and will ultimately select a remedy. The remedy selection process and selected remedy will satisfy standards listed in 40 CFR § 257.97(b) with consideration to evaluation factors listed in 40 CFR § 257.97(c). The progress toward selecting a remedy will be documented in semiannual reports.

Over the course of 2020, the ongoing groundwater monitoring program continued at the site. The results of this program have been used to develop a 2020 Update on Groundwater Conditions at the unit (Appendix F). This update includes a detailed evaluation of groundwater flow and Molybdenum concentrations and mass at the LRCP and the impact that these conditions have on the remedy selection process.

7.1 Data Gaps

Based on a review of data to date, the following recommendations for additional data collection/evaluation have been identified:

- With the results of the monitoring program from 2018 through 2020, sufficient data is now available to develop a three-dimensional (3-D) groundwater model of the site using Modflow or another commercially available software. This model would be useful in supporting the evaluation of the positive impact of the closure of the LRCP and ongoing natural attenuation on groundwater quality and the application of various potential remedial techniques at the site.
- Ongoing sampling of monitoring wells prior to and after closure of the LRCP should continue to evaluate whether Molybdenum concentrations in groundwater are increasing, decreasing or are asymptotic. This data will be useful in supporting potential groundwater modeling efforts and the final selection of a remedy for the LRCP.
- Additional hydraulic testing near the LRCP would provide more accurate data regarding the hydraulic conductivity and storage coefficient of the uppermost aquifer. This data will be useful in supporting the potential groundwater modeling effort.
- Given the dynamic nature of groundwater flow at the LRCP, additional depth-to-groundwater data from wells in the area would be useful to support the potential groundwater modeling effort.

7.2 Selection of Remedy

As noted above, IKEC began the process of selecting a remedy following submittal of the ACM Report. Per 40 CFR § 257.97, the remedy will be selected and implemented as soon as feasible and progress toward selecting the remedy will be documented in semiannual reports. As part of the process, one or more preferred remedial approaches will be developed based upon technology effectiveness under site conditions, implementability, and other considerations. As discussed above, a flexible and adaptive approach to groundwater remediation that begins with post-closure monitoring is planned.

7.3 Public Meeting Requirement in 40 CFR § 257.96(e)

Per 40 CFR § 257.96(e), IKEC held a public meeting in November 2019 to discuss ACM results, the remedy selection process, and selection of one or more preferred remedial approaches. The public meeting was conducted at least 30 days prior to selection of a final remedy, in accordance with the above-referenced rule. Prior to the meeting, citizen and governmental stakeholders were formally notified as to the schedule for the public meeting.

7.4 Final Remedy Selection

After selection of a remedy, a report documenting the remedy selection process will be prepared. The report will demonstrate how the remedy selection process was performed and how the selected remedial approach satisfies 40 CFR § 257.97 requirements.

8.0 REFERENCES

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TABLES

**TABLE 4-1
GROUNDWATER MONITORING NETWORK
TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA**

Monitoring Well ID	Designation	Date of Installation	Coordinates		Ground Elevation (ft) ²	Top of Casing Elevation (ft) ²	Top of Screen Elevation (ft)	Base of Screen Elevation (ft)	Total Depth From Top of Casing (ft)
			Northing	Easting					
CF-15-04	Background	12/3/2015	451482.81	569307.19	465.55	468.03	439.55	429.55	38.48
CF-15-05	Background	12/1/2015	447491.91	565533.64	439.85	442.58	422.85	412.85	29.73
CF-15-06	Background	11/30/2015	447026.92	565190.31	437.49	440.40	431.49	421.49	18.91
CF-15-07	Downgradient	11/23/2015	443135.08	562259.25	438.61	441.11	432.61	422.61	18.50
CF-15-08	Downgradient	11/19/2015	443219.57	562537.29	460.33	462.79	430.33	420.33	42.46
CF-15-09	Downgradient	11/25/2015	443445.96	562871.69	456.73	459.45	447.73	442.73	16.72
WBSP-15-01	Background	11/30/2015	449072.27	566322.12	466.93	469.36	458.93	448.93	20.43
WBSP-15-02	Background	11/11/2015	449803.91	566987.30	473.83	476.76	457.83	452.83	23.93

Notes:

1. The Well locations are referenced to the North American Datum (NAD83), east zone coordinate system.
2. Elevations are referenced to the North American Vertical Datum (NAVD) 1988

TABLE 4-2
SUMMARY OF POTENTIAL AND CONFIRMED APPENDIX III SSIs
TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

Well Id	Parameter	1st Detection Monitoring Event	1st Detection Monitoring Resampling May 2018	1st Assessment Monitoring Event	1st Assessment Monitoring Resampling December 2018
		Potential SSI	Confirmed SSI (Yes/No)	Potential SSI	Confirmed SSI (Yes/No)
Type I Residual Waste Landfill & Landfill Runoff Collection Pond					
CF-15-07	pH	Yes	No	No	--
CF-15-08	Boron	Yes	Yes	Yes	Yes
	pH	Yes	No	No	--
CF-15-09	Boron	Yes	Yes	Yes	Yes
	pH	Yes	No	No	--

SSI: Statistically Significant Increase
mg/L: Milligrams per liter
-- : Not evaluated

**TABLE 4-3
GROUNDWATER PROTECTION STANDARDS
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA**

Appendix IV Constituents			
Constituent	Background	MCL/SMCL	Groundwater Protection Standard
Antimony, Sb	0.2185 (µg/L)	6 (µg/L)	6 (µg/L)
Arsenic, As	4.47 (µg/L)	10 (µg/L)	10 (µg/L)
Barium, Ba	116.7 (µg/L)	2000 (µg/L)	2000 (µg/L)
Beryllium, Be	0.176 (µg/L)	4 (µg/L)	4 (µg/L)
Cadmium, Cd	0.08 (µg/L)	5 (µg/L)	5 (µg/L)
Chromium, Cr	8.4 (µg/L)	100 (µg/L)	100 (µg/L)
Cobalt, Co	2.578 (µg/L)	6 (µg/L)*	6 (µg/L)
Fluoride, F	0.5532 (mg/L)	4 (mg/L)	4 (mg/L)
Lithium, Li	0.103 (µg/L)	40 (µg/L)*	40 (µg/L)
Lead, Pb	2.023 (µg/L)	15 (µg/L)*	15 (µg/L)
Mercury, Hg	1.33 (µg/L)	2 (µg/L)	2 (µg/L)
Molybdenum, Mo	62.4 (µg/L)	100 (µg/L)*	100 (µg/L)
Radium 226 & 228 (combined)	8.02 (pCi/L)	5 (pCi/L)	8.02 (pCi/L)
Selenium, Se	0.44 (µg/L)	50 (µg/L)	50 (µg/L)
Thallium, Tl	0.1788 (µg/L)	2 (µg/L)	2 (µg/L)

* Established by EPA as part of 2018 decision.

**TABLE 5-1
GRAIN SIZE ANALYSIS RESULTS
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA**

Boring No.	Sample Depth (feet)	70% Retention (30% Passing) Size (mm)	Filter Pack Size (mm)	Screen Mesh (inches)	Unified Soil Classification Symbol & Description	
CF-19-08D	30 - 40	0.0095	0.40	0.01	SM	Silty Sand
CF-19-08D	84 - 89	0.14	0.40	0.01	GC	Clayey Gravel with Sand
CF-19-15D	22 - 33	0.006	0.40	0.01	CL	Lean Clay with Sand
CF-19-15D	64 - 70	0.011	0.40	0.01	CL	Sandy Lean Clay with Gravel

Notes:

mm: Millimeters

**TABLE 5-2
NEW MONITORING WELL CONSTRUCTION DETAILS
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA**

Monitoring Well ID	Designation	Date of Installation	Coordinates ⁽¹⁾		Ground Elevation ² (feet)	Top of Casing Elevation ² (feet)	Top of Screen BGS (feet)	Base of Screen BGS (feet)	Total Depth BGS (feet)
			Northing	Easting					
CF-19-08D	Downgradient	3/5-8/2019	443224.617	562551.003	460.68	463.49	84.00	89.00	89.00
CF-19-14	Downgradient	3/7-8/2019	443401.75	562901.929	452.29	454.88	10.00	20.00	20.00
CF-19-15	Downgradient	3/13/2019	442704.784	562483.023	441.10	443.61	23.00	33.00	33.00
CF-19-15D	Downgradient	3/11-12/2019	442713.897	562487.596	441.78	444.34	65.00	70.00	70.00

Notes:

1. The Well locations are referenced to the North American Datum (NAD83), east zone coordinate system.

2. Elevations are referenced to the North American Vertical Datum (NAVD) 1988

bgs: Below Ground Surface

TABLE 5-3
SUMMARY OF WELL DEVELOPMENT DATA
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

Well/Piezometer	Dates	Method	Volume (gallons)	Final Turbidity (NTU)
CF-19-08D	3/14-20/2019	Pump	52	4.75
CF-19-14	3/14-20/2019	Pump	16.5	3.84
CF-19-15	3/14-21/2019	Pump	24	4.35
CF-19-15D	3/14-21/2019	Pump	48	4.53

Notes:

NTU: Nephelometric Turbidity Unit

TABLE 5-4
SUMMARY OF GROUNDWATER ELEVATION DATA
MARCH 2019
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

Monitoring Well Designation	Top of Casing Elevation (feet)	Depth to Groundwater (feet)	Groundwater Elevation (feet)
CF-15-07	441.11	3.03	438.08
CF-15-08	462.79	18.10	444.69
CF-15-09	459.45	9.78	449.67
CF-19-14	454.88	8.15	446.73
CF-19-15	443.61	9.87	433.74
CF-19-08D	463.49	21.33	442.16
CF-19-15D	444.34	15.57	428.77

**TABLE 5-5
SUMMARY OF SLUG TEST RESULTS
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA**

Well ID	Test	Analytical Method	K (ft/sec)	Mean K
Uppermost Aquifer				
Slug test performed May 2016				
CF-15-08	Falling Head #1	Bouwer-Rice	2.24E-03	2.44E-03
		Hvorslev	2.70E-03	
	Rising Head #1	Bouwer-Rice	2.52E-03	
		Hvorslev	3.04E-03	
	Falling Head #2	Bouwer-Rice	2.18E-03	
		Hvorslev	2.62E-03	
	Rising Head #2	Bouwer-Rice	1.90E-03	
		Hvorslev	2.29E-03	
Slug test performed April 2019				
CF-19-14	Falling Head #1	Bouwer-Rice	4.10E-06	3.80E-06
		Hvorslev	5.35E-06	
	Rising Head #2	Bouwer-Rice	2.50E-06	
		Hvorslev	3.26E-06	
CF-19-15	Falling Head #1	Bouwer-Rice	2.89E-05	3.02E-05
		Hvorslev	3.36E-05	
	Rising Head #1	Bouwer-Rice	2.67E-05	
		Hvorslev	3.25E-05	
	Falling Head #2	Bouwer-Rice	2.75E-05	
		Hvorslev	3.36E-05	
	Rising Head #2	Bouwer-Rice	2.64E-05	
		Hvorslev	3.22E-05	
Mean K (ft/sec)				8.23E-04
Deep Aquifer				
CF-19-15D	Falling Head #1	Bouwer-Rice	4.73E-05	1.72E-05
		Hvorslev	5.16E-05	
	Rising Head #1	Bouwer-Rice	1.30E-06	
		Hvorslev	1.42E-06	
	Falling Head #2	Bouwer-Rice	1.54E-05	
		Hvorslev	1.67E-05	
	Rising Head #2	Bouwer-Rice	1.98E-06	
		Hvorslev	2.16E-06	
CF-19-08D	Falling Head #1	Bouwer-Rice	1.36E-05	8.96E-06
		Hvorslev	1.43E-05	
	Rising Head #1	Bouwer-Rice	4.00E-06	
		Hvorslev	4.20E-06	
	Falling Head #2	Bouwer-Rice	1.15E-05	
		Hvorslev	1.21E-05	
	Rising Head #2	Bouwer-Rice	5.82E-06	
		Hvorslev	6.12E-06	
Mean K (ft/sec)				1.31E-05

TABLE 5-6
SUMMARY OF GROUNDWATER VELOCITY CALCULATIONS
MARCH 2019
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

Well Pair		h ₁ (feet)	h ₂ (feet)	d (feet)	K (feet/day)	n	i	V (feet/day)
Uppermost Aquifer								
CF-15-08 (h ₁)	CF-19-15 (h ₂)	444.69	433.74	523	71.11	0.2	0.0209	7.43
Deep Aquifer								
CF-19-08D (h ₁)	CF-19-15D (h ₂)	442.16	428.77	523	1.13	0.2	0.0256	0.1446

h₁ = Head elevation in well #1

h₂ = Head elevation in well #2

d = distance between wells

K = Hydraulic conductivity

n = effective porosity

i = Horizontal Hydraulic Gradient

V = Groundwater Velocity

Horizontal Hydraulic Gradient:

$$i = \frac{h_1 - h_2}{d}$$

Groundwater Velocity:

$$V = K \left(\frac{i}{n} \right)$$

TABLE 5-7
SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
MARCH 2019
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

Parameter	Units	GWPS	CF-15-07	CF-15-08	CF-15-09	CF-19-08D	CF-19-14	CF-19-15	CF-19-15D
Appendix III Constituents									
Boron, B	mg/L	--	0.045 J	9.8	6.7	--	--	--	--
Calcium, Ca	mg/L	--	150	140	160	--	--	--	--
Chloride, Cl	mg/L	--	5.6	14	3	--	--	--	--
Fluoride, F	mg/L	--	0.21	0.37	0.31	--	--	--	--
pH	s.u.	--	7.04	7.05	7.19	--	--	--	--
Sulfate, SO ₄	mg/L	--	11	240	260	--	--	--	--
Total Dissolved Solids (TDS)	mg/L	--	620	680	620	--	--	--	--
Appendix IV Constituents									
Antimony, Sb	ug/L	6	<2.0	<2.0	<2.0	--	--	--	--
Arsenic, As	ug/L	10	4.6 J	<5.0	<5.0	--	--	--	--
Barium, Ba	ug/L	2000	81	60	14	--	--	--	--
Beryllium, Be	ug/L	4	<1.0	<1.0	1.5	--	--	--	--
Cadmium, Cd	ug/L	5	<1.0	<1.0	0.23 J	--	--	--	--
Chromium, Cr	ug/L	100	<2.0	<2.0	<2.0	--	--	--	--
Cobalt, Co	ug/L	9.745	2.4	0.19 J	0.38 J	--	--	--	--
Fluoride, F	mg/L	4	0.21	0.37	0.31	--	--	--	--
Lithium, Li	mg/L	0.04	<1.0	<1.0	<1.0	--	--	--	--
Lead, Pb	ug/L	15	0.0017 J	0.017	0.0087	--	--	--	--
Mercury, Hg	ug/L	2	<0.20	<0.20	<0.20	--	--	--	--
Molybdenum, Mo	ug/L	100	4.9 J	380	100	31	12	1.1 J	49
Radium 226 & 228 (combined)	pCi/L	5	2.34	0.413	<5.0	--	--	--	--
Selenium, Se	ug/L	50	<5.0	<5.0	1.2 J	--	--	--	--
Thallium, Tl	ug/L	2	<1.0	<1.0	0.2 J	--	--	--	--

Notes:

--: Not applicable
mg/L: Milligrams per liter
s.u.: Standard Units
ug/L: Micrograms per liter
pCi/L: Picocuries per liter

TABLE 6-1
SOURCE CONTROL TECHNOLOGIES SCREENING MATRIX - 40 CFR § 257.96(c) REQUIREMENTS
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

	<i>Source Control Technologies</i>		
	Dewatering of Pond Water	Engineered Cover System	Excavation of Ash
257.96(c)(1)			
Performance	Low	Medium	High
Reliability	Low	Medium	High
Ease of Implementation	Low Water Removal, Treatment & Discharge Required	Medium Field Construction Required	High Field Construction Required
Potential Safety Impacts	Low Field Construction Required	Medium Field Construction Required	High Field Construction Required
Potential Cross-Media Impacts	Medium	Low	Medium
Potential Impacts from Control of Exposure to Residual Constituents	Low	Low	Low
257.96(c)(2)			
Time To Begin Remedy	6 months to 1 year	1 to 1.5 years	1 to 1.5 years
Time To Complete Remedy	2 to 3 years	2 to 3 years	5 to 7 years
257.96(c)(3)			
State, Local or other Environmental Permit Requirements that May Impact Implementation	Requires Approval from IDEM	Requires Approval from IDEM	Requires Approval from IDEM
Additional Information	Required for In-Place Closure or Closure by Removal	Ash Remains in Place as Long-Term Source for Groundwater	Groundwater Issues Need to be Addressed

Notes:

Relative assessments (low, medium, high) are based on experience and professional judgement

TABLE 6-2
IN-SITU AND EX-SITU GROUNDWATER REMEDIAL TECHNOLOGIES SCREENING MATRIX - 40 CFR § 257.96(c) REQUIREMENTS
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

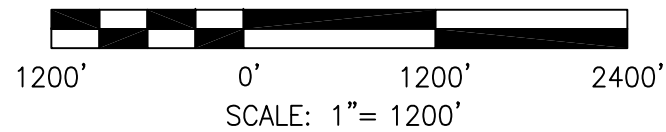
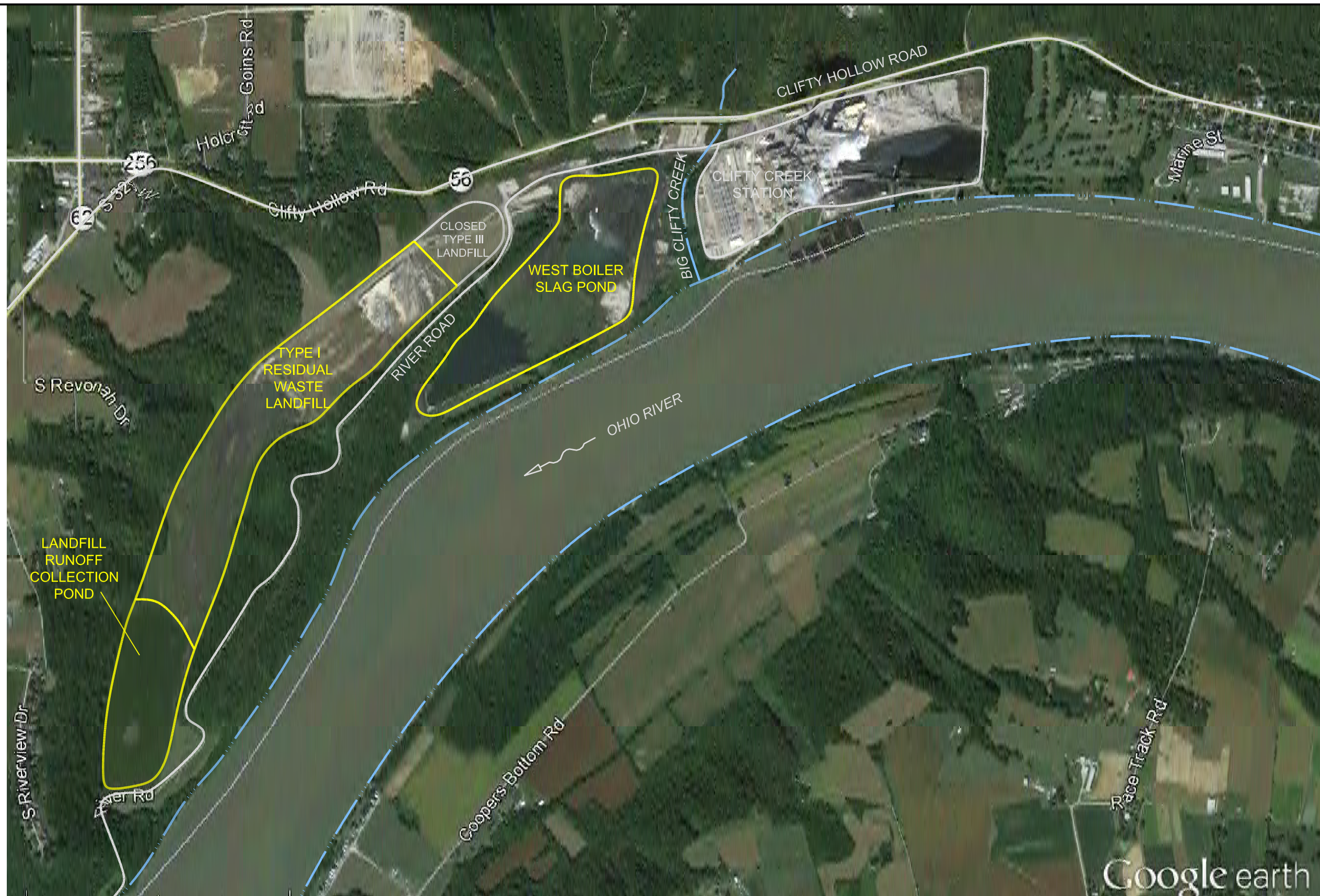
	<i>In-Situ Groundwater Remedial Technologies</i>				<i>Ex-Situ Groundwater Remedial Technologies</i>		
	Monitored Natural Attenuation	Groundwater Migration Barriers	In-situ Chemical Stabilization	Permeable Reactive Barrier	Conventional Well System	Horizontal Well System	Trenching System
257.96(c)(1)							
Performance	High	Low	Low	Low	High	Low Significant Water Level Fluctuations Reduce Effectiveness of Horizontal Wells	High
Reliability	High	Low	Medium	Medium	High Long Term O&M Required	Low Significant Issues with Water Level Fluctuations	High Long Term O&M Required
Ease of Implementation	High	Low	Low	Low	High Drilling and Limited Field Construction Required	Medium Drilling and Limited Field Construction Required	Low Trench Construction Required
Potential Safety Impacts	Low	Medium Field Construction Required	Medium Field Construction Required	Medium Field Construction Required	Medium Drilling Required	Medium Drilling Required	Medium Trench Construction Required
Potential Cross-Media Impacts	Low	Medium	Low	Low	Medium	Medium	Medium
Potential Impacts from Control of Exposure to Residual Constituents	Low	Low	Low	Low	Low	Low	Low
257.96(c)(2)							
Time To Begin Remedy*	3 months	1 to 1.5 years	1 to 1.5 years	1 to 1.5 years	6 months to 1 year	6 months to 1 year	6 months to 1 year
Time To Complete Remedy	Highly Variable Further Evaluation Required	Highly Variable Further Evaluation Required	Highly Variable Further Evaluation Required	Highly Variable Further Evaluation Required	Highly Variable Further Evaluation Required	Highly Variable Further Evaluation Required	Highly Variable Further Evaluation Required
257.96(c)(3)							
State, Local or other Environmental Permit Requirements that May Impact Implementation	Requires Coordination with IDEM	Requires Approval from IDEM	Requires Approval from IDEM	Requires Approval from IDEM	Requires Approval from IDEM	Requires Approval from IDEM	Requires Approval from IDEM
Additional Information	Groundwater F&T Modeling Required to Evaluate the Timing for This Approach for Molybdenum	Groundwater Flow Modeling Required to Fully Evaluate This Approach	Bench Scale Testing Required to Further Evaluate Applicability for Molybdenum	Bench Scale Testing Required to Further Evaluate Applicability for Molybdenum	Groundwater Flow Modeling Required to Fully Evaluate This Approach	Groundwater Flow Modeling Required to Fully Evaluate This Approach	Groundwater Flow Modeling Required to Fully Evaluate This Approach

Notes:

Relative assessments (low, medium, high) are based on experience and professional judgement

*The time to begin the remedy is based on the time after closure of the unit.

FIGURES



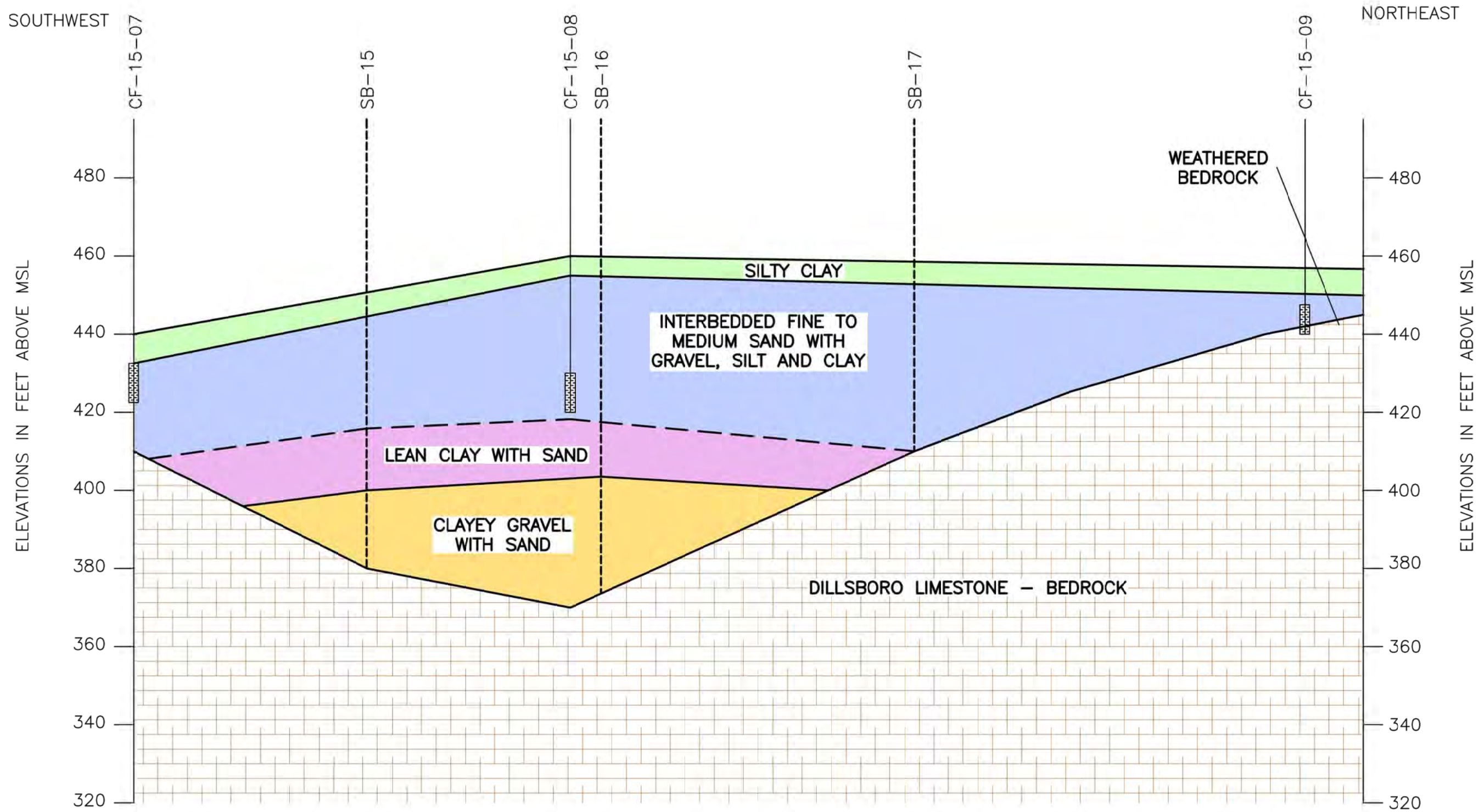
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DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
SITE LOCATION MAP

DRAWING NAME	FIGURE 2-1	REV.	0
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NOTES:

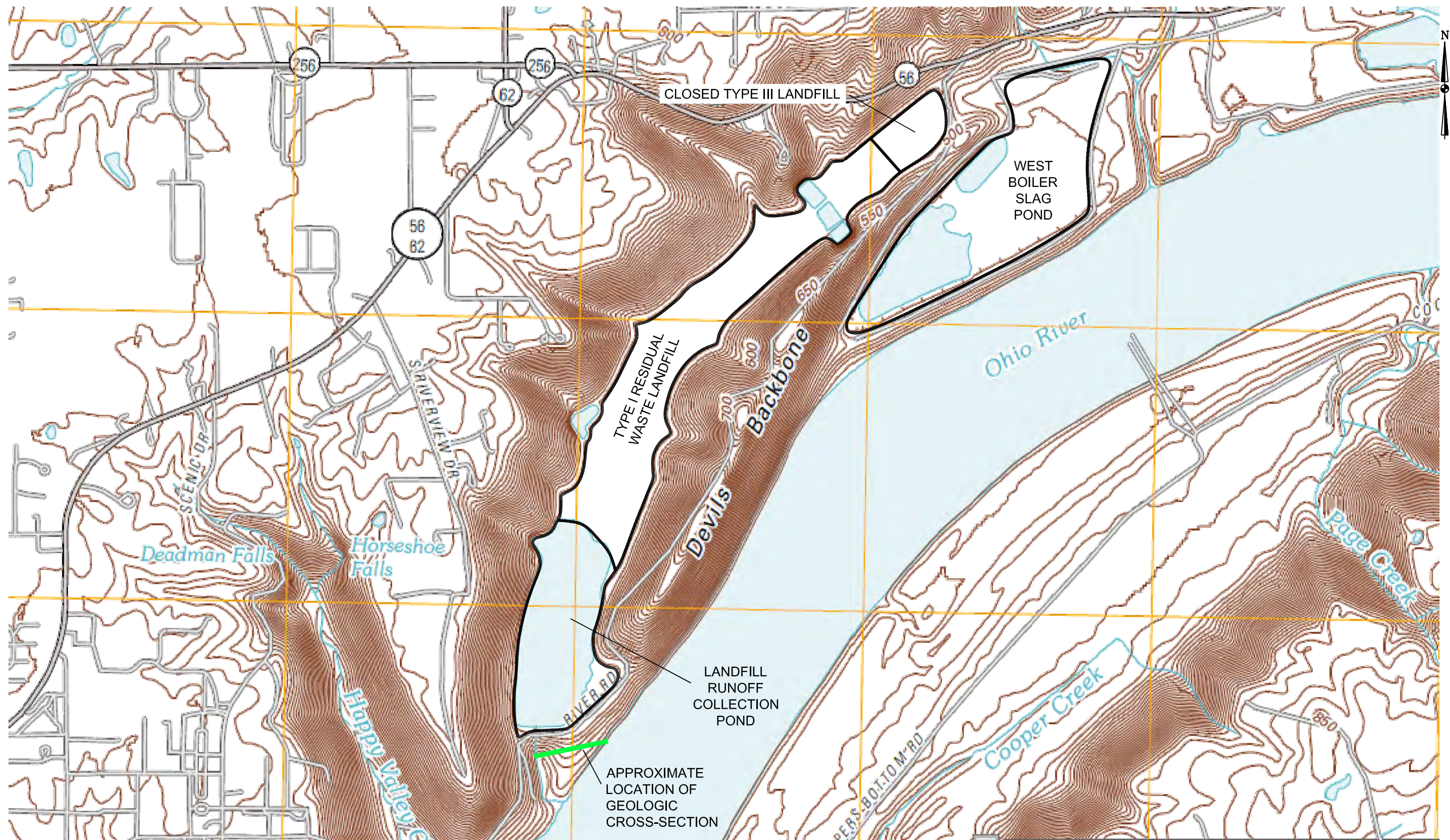
1) CROSS-SECTION COMPILED USING AGES BORING AND WELL LOGS, SOIL BORING INFORMATION FROM THE 2007 LITIGATION REPORT AND STANTEC DATA FROM THE LRCP STABILITY ASSESSMENT REPORT.

2) THE APPROXIMATE LOCATION OF THE CROSS-SECTION IS ILLUSTRATED ON FIGURE 3-2.

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA GEOLOGIC CROSS-SECTION AT LANDFILL RUNOFF COLLECTION POND	
DRAWING NAME	FIGURE 3-1
REV.	0



— APPROXIMATE LOCATION OF THE GEOLOGIC CROSS-SECTION (FIGURE 3-1).

SOURCE: USGS MADISON WEST 7.5 MINUTE TOPOGRAPHIC QUADRANGLE, 2010.

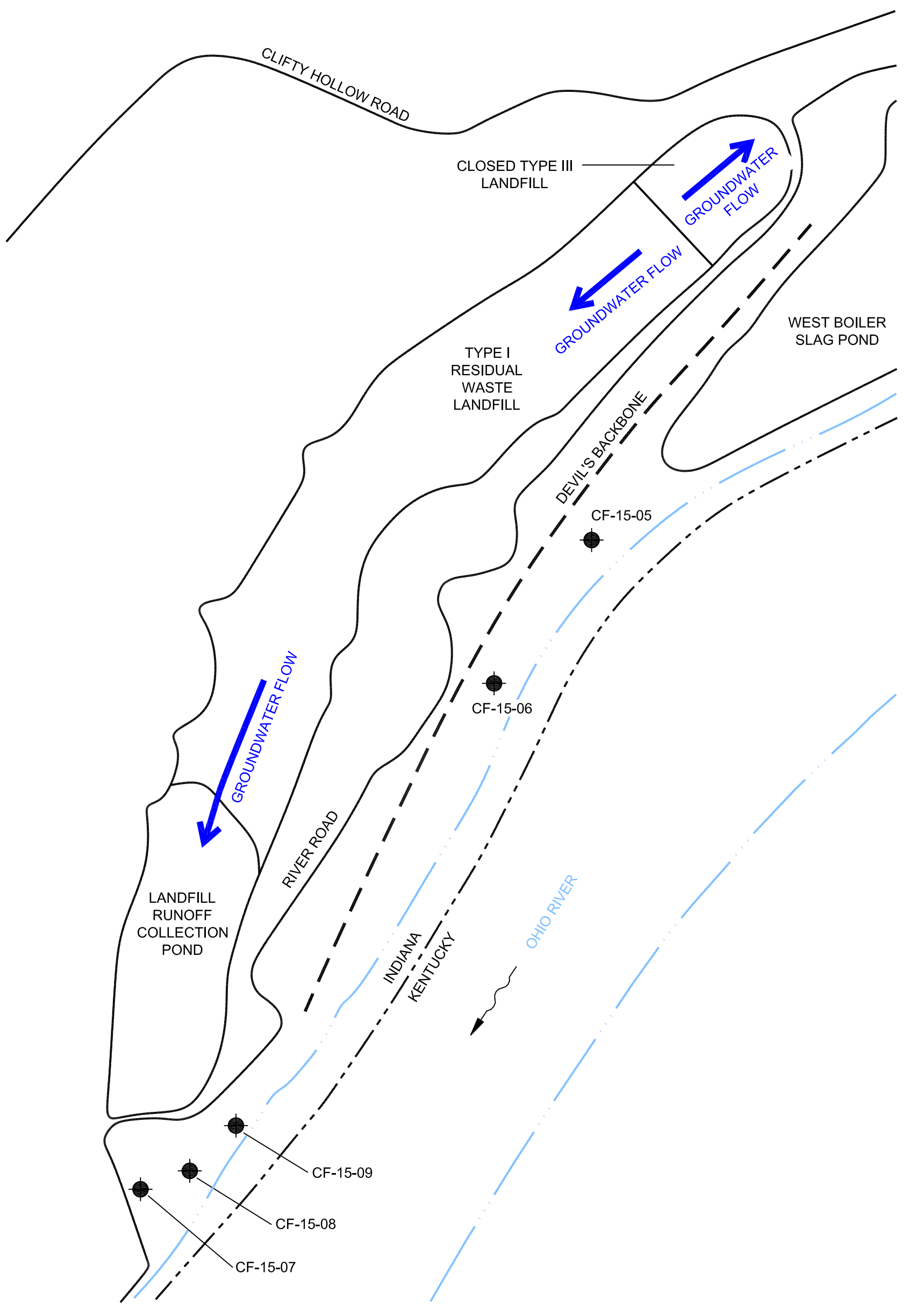
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CLIFTY CREEK STATION
MADISON, INDIANA
TOPOGRAPHIC MAP


DRAWING NAME	FIGURE 3-2	REV.	0
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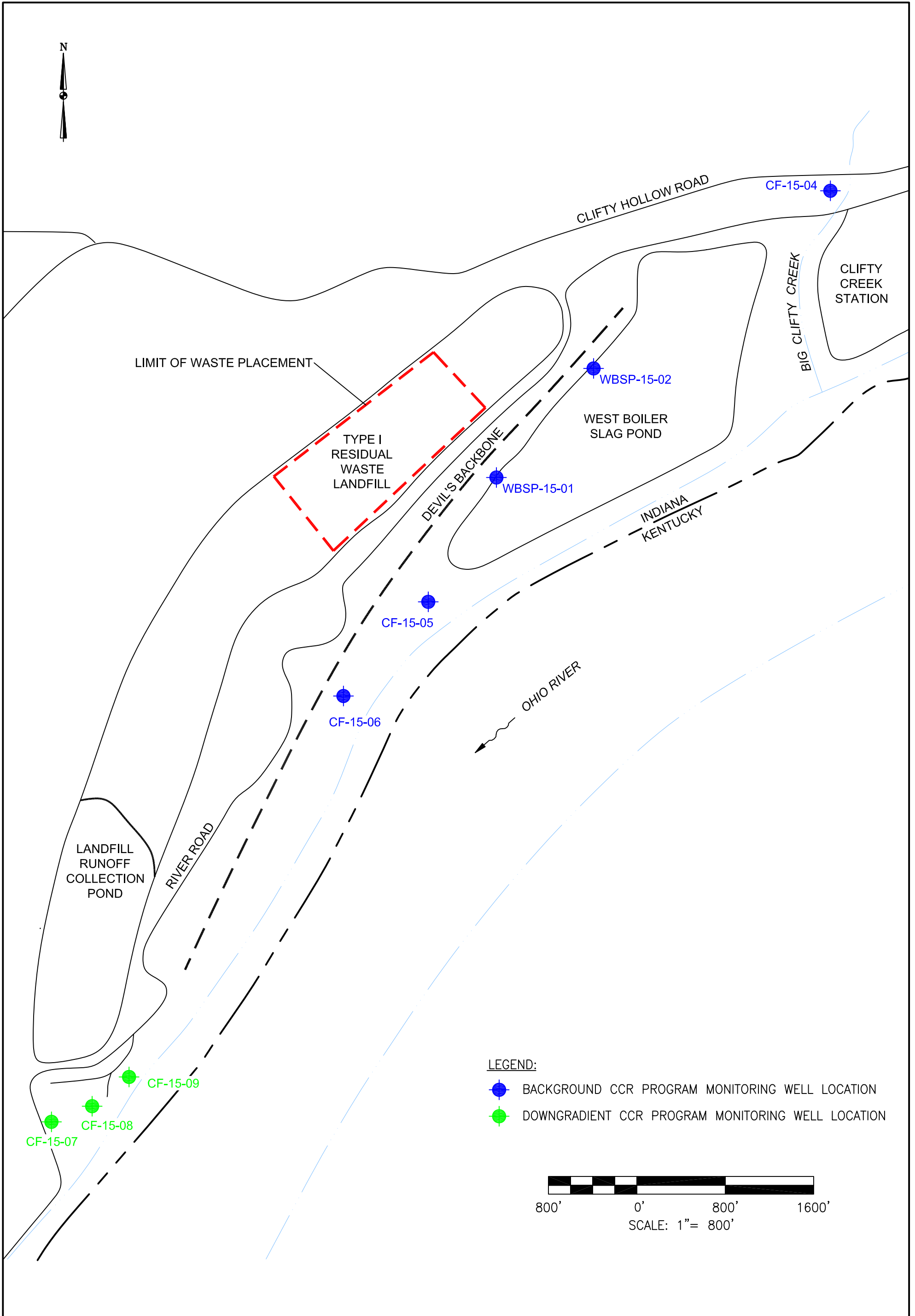
 MONITORING WELL LOCATION

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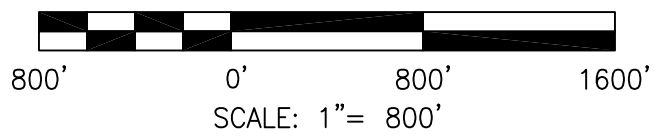
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CLIFTY CREEK STATION MADISON, INDIANA	
TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND	
EXISTING MONITORING WELL LOCATIONS AND GENERALIZED GROUNDWATER FLOW MAP	
DRAWING NAME	FIGURE 3-3
REV.	0



LEGEND:

-  BACKGROUND CCR PROGRAM MONITORING WELL LOCATION
-  DOWNGRAIDENT CCR PROGRAM MONITORING WELL LOCATION



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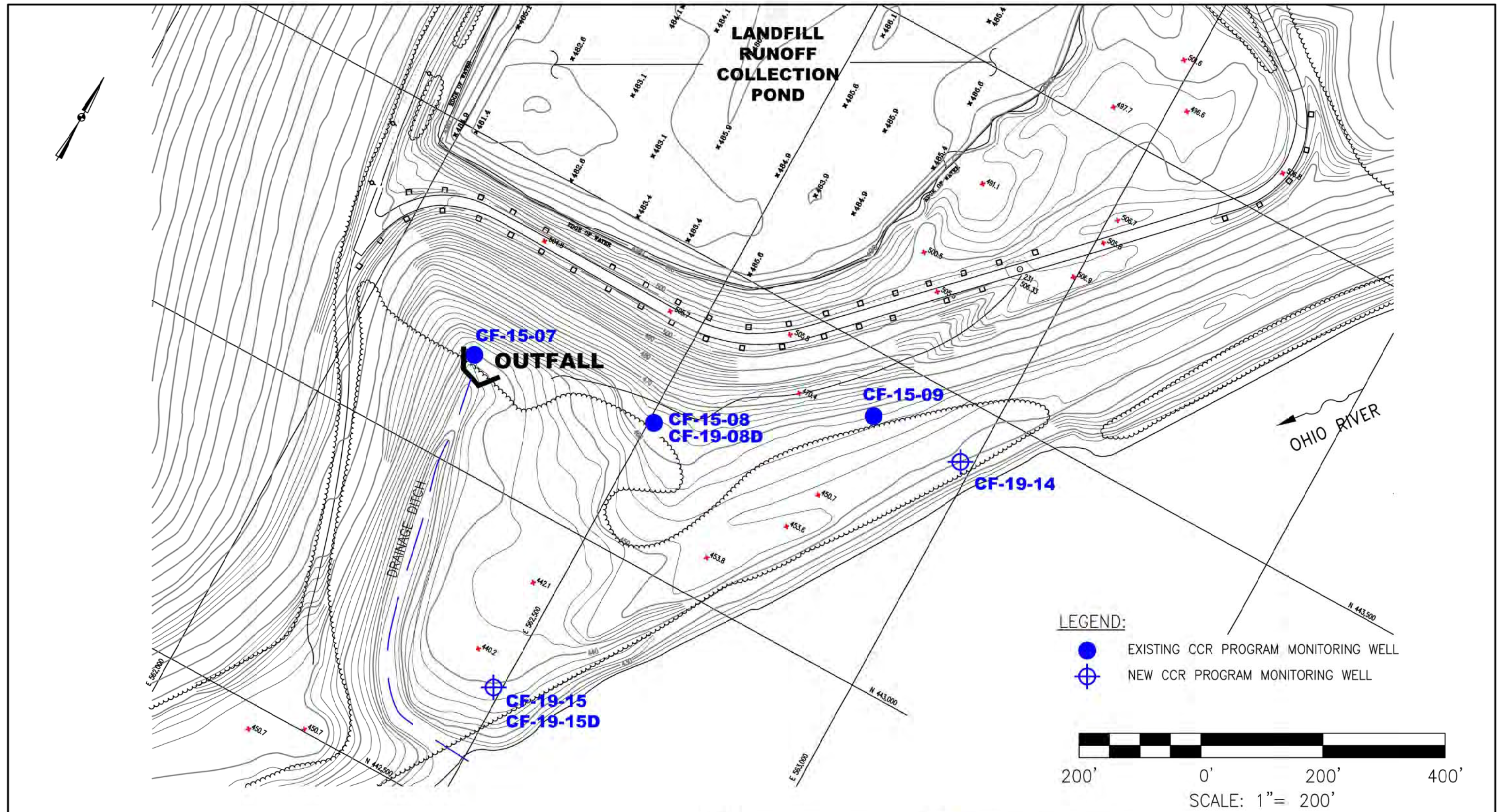
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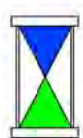
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CLIFTY CREEK STATION
MADISON, INDIANA
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
EXISTING MONITORING WELL LOCATIONS

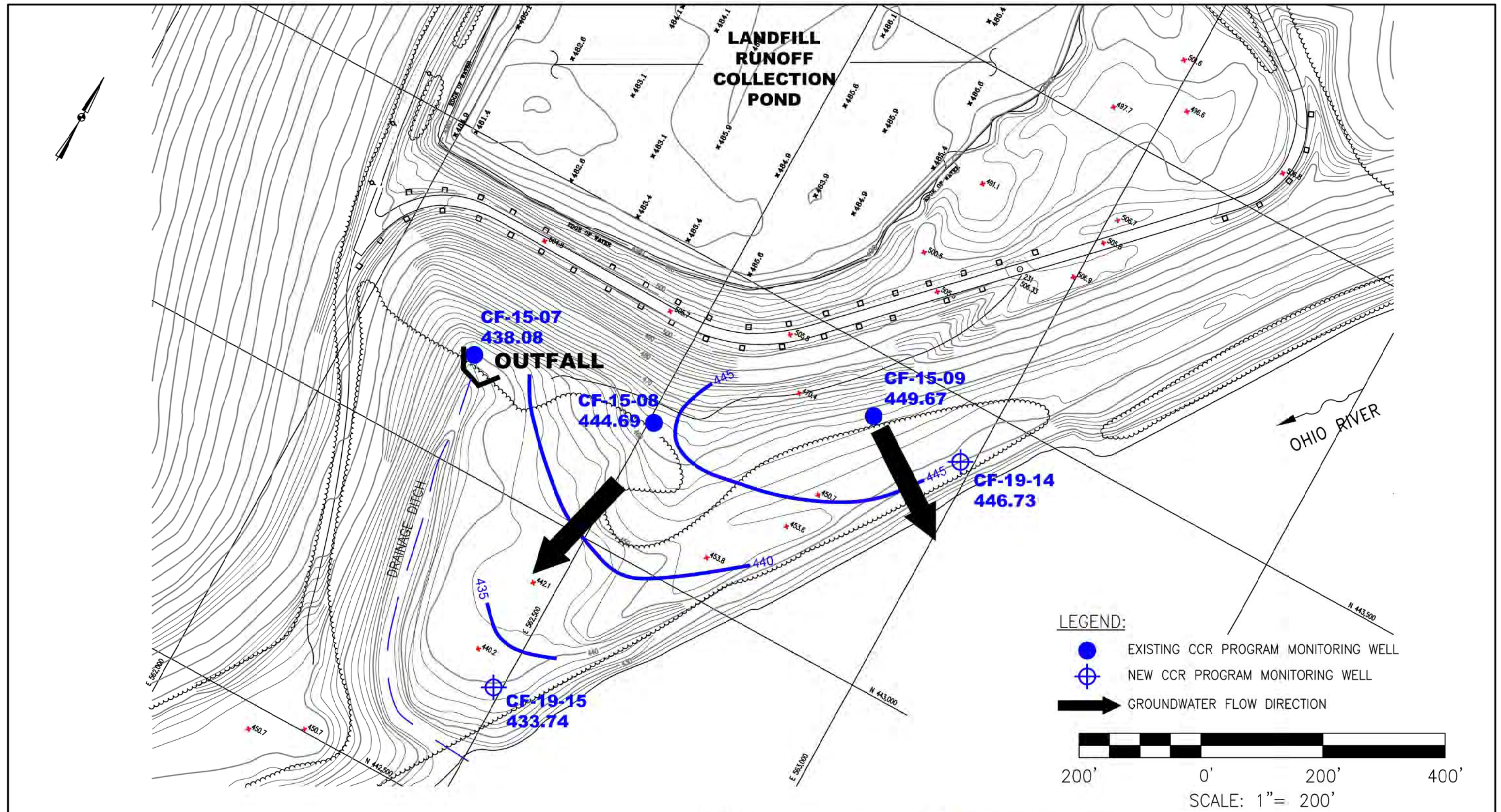
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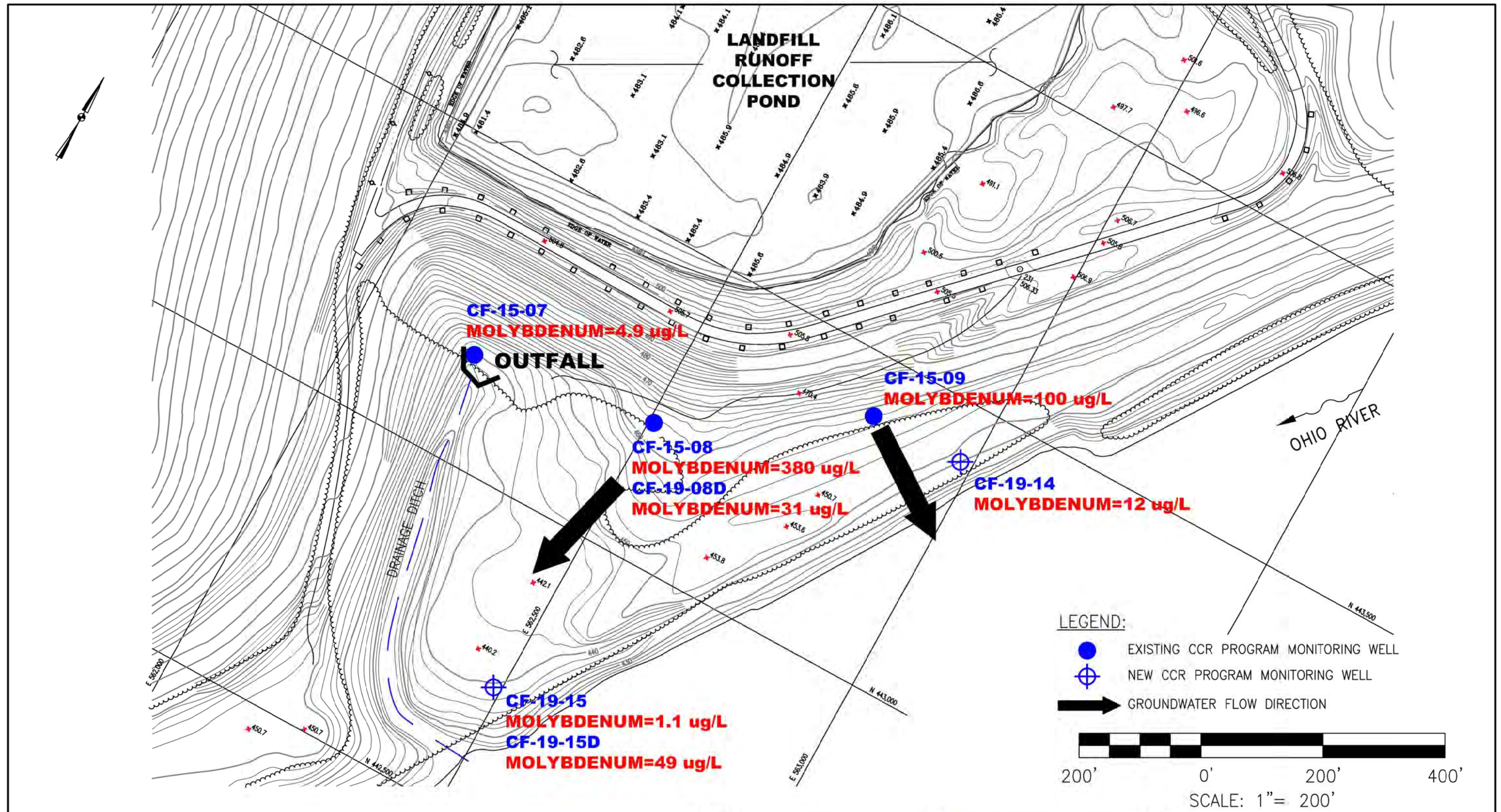
INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM EXISTING AND NEW MONITORING WELL LOCATIONS	
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REV.	0



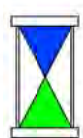
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CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM	
GROUNDWATER FLOW - UPPERMOST AQUIFER MARCH 2019	
DRAWING NAME	FIGURE 5-2
REV.	0



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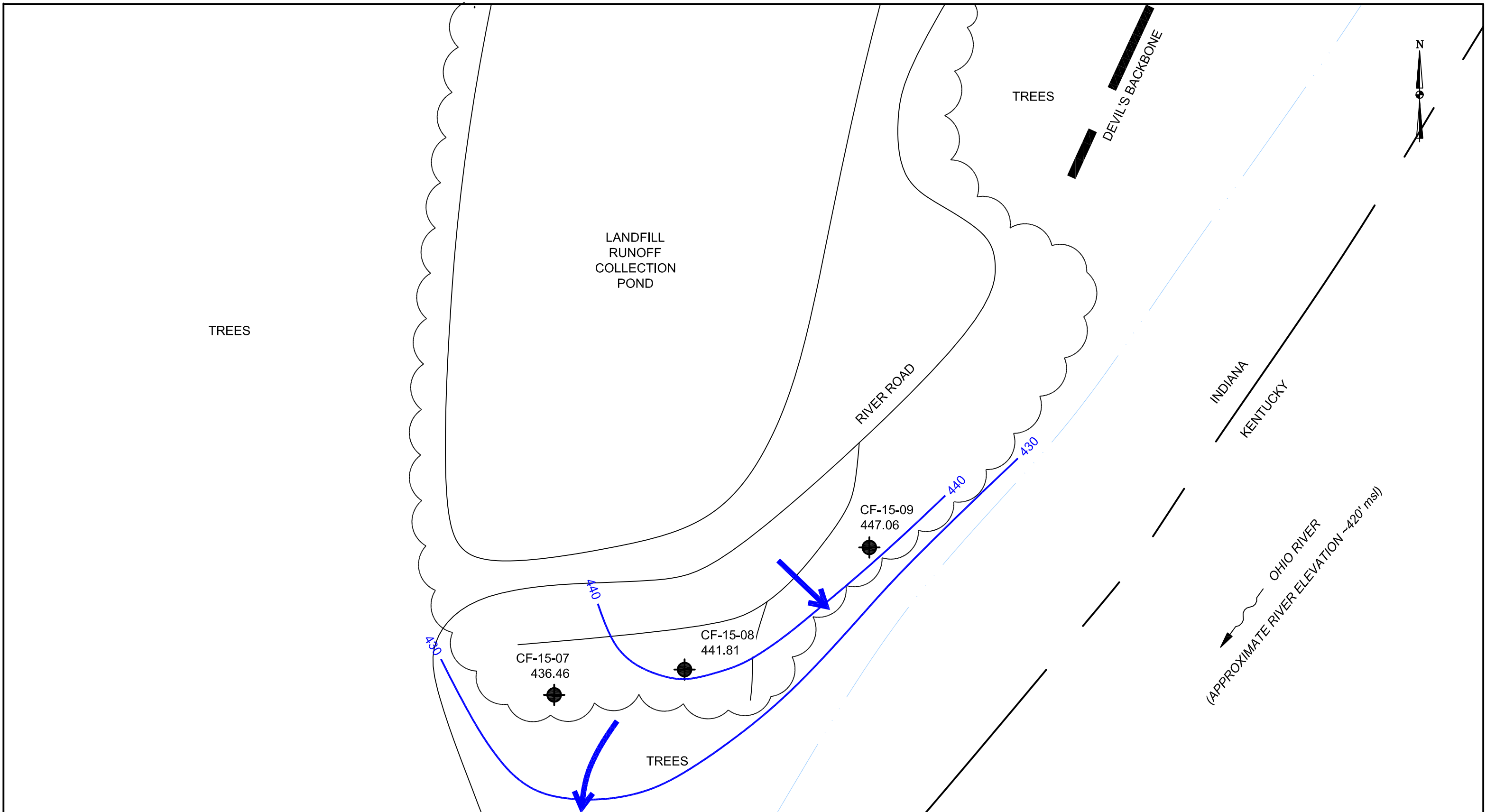




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 412.264.6453

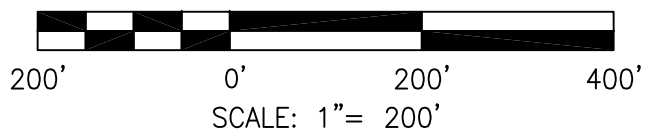
INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM	
MOLYBDENUM CONCENTRATIONS IN GROUNDWATER MARCH 2019	
DRAWING NAME	FIGURE 5-3
REV.	0

APPENDIX A


GENERALIZED GROUNDWATER FLOW MAPS FOR 2018



LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION

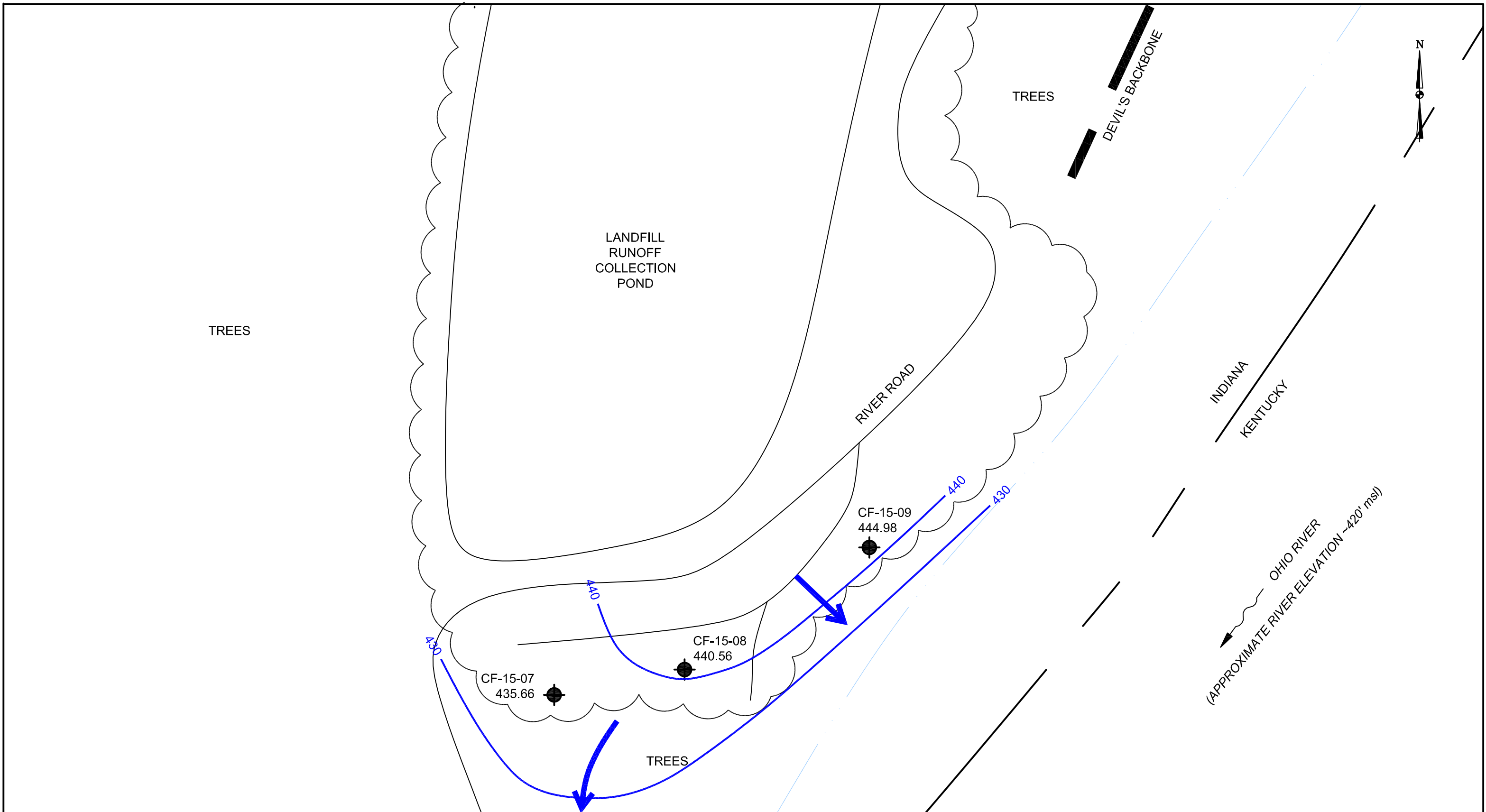




DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019042-8-CLIFTY
DWG FILE	2019_IKEC_Clifty_ACM_Appx A_MAR18.dwg
DRAWING SCALE	AS SHOWN

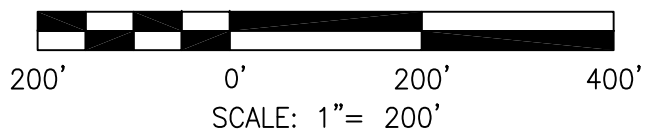


AGES
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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA LANDFILL RUNOFF COLLECTION POND GENERALIZED GROUNDWATER FLOW MAP MARCH 2018	
DRAWING NAME	FIGURE A-1
REV.	0



LEGEND:
 MONITORING WELL LOCATION
 GROUNDWATER FLOW DIRECTION



DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019042-8-CLIFTY
DWG FILE	2019_IKEC_Clifty_ACM_Appx A_OCT18.dwg
DRAWING SCALE	AS SHOWN



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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA LANDFILL RUNOFF COLLECTION POND GENERALIZED GROUNDWATER FLOW MAP OCTOBER 2018	
DRAWING NAME	FIGURE A-2
REV.	0

APPENDIX B

ANALYTICAL RESULTS FOR 2018 GROUNDWATER MONITORING

CF-15-04
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	Oct-18
Appendix III Constituents				
Boron, B (mg/L)	5.02	--	0.043	0.09 J
Calcium, Ca (mg/L)	314.4	--	106	74.2
Chloride, Cl (mg/L)	282	--	282	50.2
Fluoride, F (mg/L)	0.5477	--	0.09	0.12
pH (s.u.)	5.57 - 10.36	--	10.06	7.76
Sulfate, SO4 (mg/L)	634	--	35.2	34.4
Total Dissolved Solids (TDS) (mg/L)	1290	--	788	377
Appendix IV Constituents				
Antimony, Sb (ug/L)	0.2556	6	NA	0.1 J
Arsenic, As (ug/L)	4.47	10	NA	0.38
Barium, Ba (ug/L)	129.1	2000	NA	57.5
Beryllium, Be (ug/L)	0.934	4	NA	0.1 U
Cadmium, Cd (ug/L)	0.3	5	NA	0.05 U
Chromium, Cr (ug/L)	8.4	100	NA	0.2 J
Cobalt, Co (ug/L)	4.01	6	NA	0.114
Fluoride, F (ug/L)	0.5477	4	NA	0.12
Lithium, Li (ug/L)	0.2443	40	NA	0.009 J
Lead, Pb (ug/L)	3.703	15	NA	0.141
Mercury, Hg (ug/L)	1.16	2	NA	0.003 J
Molybdenum, Mo (ug/L)	62.4	100	NA	2.54
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	0.62
Selenium, Se (ug/L)	1.9	50	NA	0.2 J
Thallium, Tl (ug/L)	0.25	2	NA	0.5 U

Notes:

NA = Sample not analyzed for the parameter

UTL: Upper Threshold Limit

GWPS: Groundwater Protection Standard

CF-15-05
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	Oct-18
Appendix III Constituents				
Boron, B (mg/L)	5.02	--	0.209	0.174
Calcium, Ca (mg/L)	314.4	--	103	113
Chloride, Cl (mg/L)	282	--	31.5	30.2
Fluoride, F (mg/L)	0.5477	--	0.47	0.48
pH (s.u.)	5.57 - 10.36	--	9.56	7.18
Sulfate, SO4 (mg/L)	634	--	44.3	40.9
Total Dissolved Solids (TDS) (mg/L)	1290	--	528	502
Appendix IV Constituents				
Antimony, Sb (ug/L)	0.2556	6	NA	0.02 J
Arsenic, As (ug/L)	4.47	10	NA	0.91
Barium, Ba (ug/L)	129.1	2000	NA	58.8
Beryllium, Be (ug/L)	0.934	4	NA	0.1 U
Cadmium, Cd (ug/L)	0.3	5	NA	0.04 J
Chromium, Cr (ug/L)	8.4	100	NA	0.228
Cobalt, Co (ug/L)	4.01	6	NA	0.463
Fluoride, F (ug/L)	0.5477	4	NA	0.48
Lithium, Li (ug/L)	0.2443	40	NA	0.01 J
Lead, Pb (ug/L)	3.703	15	NA	0.21
Mercury, Hg (ug/L)	1.16	2	NA	0.003 J
Molybdenum, Mo (ug/L)	62.4	100	NA	2.94
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	0.484
Selenium, Se (ug/L)	1.9	50	NA	0.06 J
Thallium, Tl (ug/L)	0.25	2	NA	0.5 U

Notes:

NA = Sample not analyzed for the parameter

UTL: Upper Threshold Limit

GWPS: Groundwater Protection Standard

CF-15-06
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	Oct-18
Appendix III Constituents				
Boron, B (mg/L)	5.02	--	0.16	0.05 J
Calcium, Ca (mg/L)	314.4	--	125	184
Chloride, Cl (mg/L)	282	--	7.76	8.21
Fluoride, F (mg/L)	0.5477	--	0.2	0.21
pH (s.u.)	5.57 - 10.36	--	10.36	7.89
Sulfate, SO4 (mg/L)	634	--	112	102
Total Dissolved Solids (TDS) (mg/L)	1290	--	630	696
Appendix IV Constituents				
Antimony, Sb (ug/L)	0.2556	6	NA	0.07 J
Arsenic, As (ug/L)	4.47	10	NA	1.21
Barium, Ba (ug/L)	129.1	2000	NA	149
Beryllium, Be (ug/L)	0.934	4	NA	0.934
Cadmium, Cd (ug/L)	0.3	5	NA	0.3
Chromium, Cr (ug/L)	8.4	100	NA	6.81
Cobalt, Co (ug/L)	4.01	6	NA	8.27
Fluoride, F (ug/L)	0.5477	4	NA	0.21
Lithium, Li (ug/L)	0.2443	40	NA	0.02 J
Lead, Pb (ug/L)	3.703	15	NA	15.7
Mercury, Hg (ug/L)	1.16	2	NA	0.006
Molybdenum, Mo (ug/L)	62.4	100	NA	3.02
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	NA
Selenium, Se (ug/L)	1.9	50	NA	1.9
Thallium, Tl (ug/L)	0.25	2	NA	0.5 U

Notes:

NA = Sample not analyzed for the parameter

UTL: Upper Threshold Limit

GWPS: Groundwater Protection Standard

CF-15-07
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	Oct-18	Dec-18
Appendix III Constituents					
Boron, B (mg/L)	5.02	--	0.204	0.112	NA
Calcium, Ca (mg/L)	314.4	--	123	168	NA
Chloride, Cl (mg/L)	282	--	10.6	5.34	NA
Fluoride, F (mg/L)	0.5477	--	0.2	0.24	NA
pH (s.u.)	5.57 - 10.36	--	10.12	7.29	NA
Sulfate, SO4 (mg/L)	634	--	32.7	2.7	NA
Total Dissolved Solids (TDS) (mg/L)	1290	--	548	1240	NA
Appendix IV Constituents					
Antimony, Sb (ug/L)	0.2556	6	NA	0.06 J	NA
Arsenic, As (ug/L)	4.47	10	NA	6.81	2.49
Barium, Ba (ug/L)	129.1	2000	NA	92.4	NA
Beryllium, Be (ug/L)	0.934	4	NA	0.1 U	NA
Cadmium, Cd (ug/L)	0.3	5	NA	0.07	NA
Chromium, Cr (ug/L)	8.4	100	NA	0.36	NA
Cobalt, Co (ug/L)	4.01	6	NA	2.41	NA
Fluoride, F (ug/L)	0.5477	4	NA	0.24	NA
Lithium, Li (ug/L)	0.2443	40	NA	0.03 U	NA
Lead, Pb (ug/L)	3.703	15	NA	0.336	NA
Mercury, Hg (ug/L)	1.16	2	NA	0.004 J	NA
Molybdenum, Mo (ug/L)	62.4	100	NA	12.8	NA
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	0.387	NA
Selenium, Se (ug/L)	1.9	50	NA	0.2 J	NA
Thallium, Tl (ug/L)	0.25	2	NA	0.5 U	NA

Notes:

NA = Sample not analyzed for the parameter

UTL: Upper Threshold Limit

GWPS: Groundwater Protection Standard

CF-15-08
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	May-18	Oct-18	Dec-18
Appendix III Constituents						
Boron, B (mg/L)	5.02	--	8.5	8.6	11.9	11.9
Calcium, Ca (mg/L)	314.4	--	123	NA	145	NA
Chloride, Cl (mg/L)	282	--	14.7	NA	17.4	NA
Fluoride, F (mg/L)	0.5477	--	0.41	NA	0.41	NA
pH (s.u.)	5.57 - 10.36	--	10.21	7.45	7.53	NA
Sulfate, SO4 (mg/L)	634	--	203	NA	257	NA
Total Dissolved Solids (TDS) (mg/L)	1290	--	588	NA	636	NA
Appendix IV Constituents						
Antimony, Sb (ug/L)	0.2556	6	NA	NA	0.07 J	NA
Arsenic, As (ug/L)	4.47	10	NA	NA	0.94	NA
Barium, Ba (ug/L)	129.1	2000	NA	NA	51.4	NA
Beryllium, Be (ug/L)	0.934	4	NA	NA	0.1 U	NA
Cadmium, Cd (ug/L)	0.3	5	NA	NA	0.02 J	NA
Chromium, Cr (ug/L)	8.4	100	NA	NA	0.385	NA
Cobalt, Co (ug/L)	4.01	6	NA	NA	0.547	NA
Fluoride, F (ug/L)	0.5477	4	NA	NA	0.41	NA
Lithium, Li (ug/L)	0.2443	40	NA	NA	0.02 J	NA
Lead, Pb (ug/L)	3.703	15	NA	NA	0.457	NA
Mercury, Hg (ug/L)	1.16	2	NA	NA	0.004 J	NA
Molybdenum, Mo (ug/L)	62.4	100	NA	NA	524	429
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	NA	0.437	NA
Selenium, Se (ug/L)	1.9	50	NA	NA	0.07 J	NA
Thallium, Tl (ug/L)	0.25	2	NA	NA	0.5 U	NA

Notes:

NA = Sample not analyzed for the parameter

UTL: Upper Threshold Limit

GWPS: Groundwater Protection Standard

CF-15-09
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	May-18	Oct-18	Dec-18
Appendix III Constituents						
Boron, B (mg/L)	5.02	--	5.86	6.1	7.59	7.41
Calcium, Ca (mg/L)	314.4	--	184	NA	250	NA
Chloride, Cl (mg/L)	282	--	3.52	NA	3.47	NA
Fluoride, F (mg/L)	0.5477	--	0.3	NA	0.32	NA
pH (s.u.)	5.57 - 10.36	--	10.85	7.09	7.05	NA
Sulfate, SO4 (mg/L)	634	--	287	NA	274	NA
Total Dissolved Solids (TDS) (mg/L)	1290	--	710	NA	790	NA
Appendix IV Constituents						
Antimony, Sb (ug/L)	0.2556	6	NA	NA	0.16	NA
Arsenic, As (ug/L)	4.47	10	NA	NA	4.67	0.26
Barium, Ba (ug/L)	129.1	2000	NA	NA	38.2	NA
Beryllium, Be (ug/L)	0.934	4	NA	NA	0.261	<0.02
Cadmium, Cd (ug/L)	0.3	5	NA	NA	0.05 J	NA
Chromium, Cr (ug/L)	8.4	100	NA	NA	14.9	0.419
Cobalt, Co (ug/L)	4.01	6	NA	NA	7.45	0.04
Fluoride, F (ug/L)	0.5477	4	NA	NA	0.32	NA
Lithium, Li (ug/L)	0.2443	40	NA	NA	0.02 J	NA
Lead, Pb (ug/L)	3.703	15	NA	NA	6.25	0.03
Mercury, Hg (ug/L)	1.16	2	NA	NA	0.007	NA
Molybdenum, Mo (ug/L)	62.4	100	NA	NA	85.9	87.1
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	NA	NA	NA
Selenium, Se (ug/L)	1.9	50	NA	NA	1.3	0.1
Thallium, Tl (ug/L)	0.25	2	NA	NA	0.5 U	NA

Notes:

NA = Sample not analyzed for the parameter

UTL: Upper Threshold Limit

GWPS: Groundwater Protection Standard

WBSP-15-01
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	Oct-18
Appendix III Constituents				
Boron, B (mg/L)	5.02	--	0.1	0.134
Calcium, Ca (mg/L)	314.4	--	157	164
Chloride, Cl (mg/L)	282	--	9.45	25.3
Fluoride, F (mg/L)	0.5477	--	0.27	0.31
pH (s.u.)	5.57 - 10.36	--	6.65	6.37
Sulfate, SO4 (mg/L)	634	--	139	146
Total Dissolved Solids (TDS) (mg/L)	1290	--	685	711
Appendix IV Constituents				
Antimony, Sb (ug/L)	0.2556	6	NA	0.09 J
Arsenic, As (ug/L)	4.47	10	NA	1.52
Barium, Ba (ug/L)	129.1	2000	NA	25.3
Beryllium, Be (ug/L)	0.934	4	NA	0.144
Cadmium, Cd (ug/L)	0.3	5	NA	0.03 J
Chromium, Cr (ug/L)	8.4	100	NA	4.76
Cobalt, Co (ug/L)	4.01	6	NA	2.91
Fluoride, F (ug/L)	0.5477	4	NA	0.31
Lithium, Li (ug/L)	0.2443	40	NA	0.034
Lead, Pb (ug/L)	3.703	15	NA	2.63
Mercury, Hg (ug/L)	1.16	2	NA	NA
Molybdenum, Mo (ug/L)	62.4	100	NA	0.7 J
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	NA
Selenium, Se (ug/L)	1.9	50	NA	0.6
Thallium, Tl (ug/L)	0.25	2	NA	0.5 U

Notes:

NA = Sample not analyzed for the parameter

UTL: Upper Threshold Limit

GWPS: Groundwater Protection Standard

WBSP-15-02
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	Oct-18
Appendix III Constituents				
Boron, B (mg/L)	5.02	--	3.98	4.36
Calcium, Ca (mg/L)	314.4	--	231	277
Chloride, Cl (mg/L)	282	--	12.1	11.3
Fluoride, F (mg/L)	0.5477	--	0.37	0.36
pH (s.u.)	5.57 - 10.36	--	7.34	6.64
Sulfate, SO4 (mg/L)	634	--	607	515
Total Dissolved Solids (TDS) (mg/L)	1290	--	1200	1190
Appendix IV Constituents				
Antimony, Sb (ug/L)	0.2556	6	NA	0.14
Arsenic, As (ug/L)	4.47	10	NA	0.44
Barium, Ba (ug/L)	129.1	2000	NA	22.6
Beryllium, Be (ug/L)	0.934	4	NA	0.1 U
Cadmium, Cd (ug/L)	0.3	5	NA	0.03 J
Chromium, Cr (ug/L)	8.4	100	NA	0.788
Cobalt, Co (ug/L)	4.01	6	NA	0.081
Fluoride, F (ug/L)	0.5477	4	NA	0.36
Lithium, Li (ug/L)	0.2443	40	NA	0.088
Lead, Pb (ug/L)	3.703	15	NA	0.09 J
Mercury, Hg (ug/L)	1.16	2	NA	0.002 J
Molybdenum, Mo (ug/L)	62.4	100	NA	2.45
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	0.3588
Selenium, Se (ug/L)	1.9	50	NA	0.06 J
Thallium, Tl (ug/L)	0.25	2	NA	0.5 U

Notes:

NA = Sample not analyzed for the parameter

UTL: Upper Threshold Limit

GWPS: Groundwater Protection Standard

APPENDIX C

GRAIN SIZE ANALYSIS LAB REPORTS

Project Name IKEC Clifty Creek
 Source CF-19-150-22-33

 Project Number 175534018
 Lab ID 5

 Sample Type SPT

 Date Received 3-18-19
 Date Reported 3-28-19
Test Results
Natural Moisture Content

 Test Method: ASTM D 2216
 Moisture Content (%): 26.4
Particle Size Analysis

 Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	
	N/A	Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	98.6
3/8"	9.5	98.3
No. 4	4.75	97.6
No. 10	2	95.3
No. 40	0.425	93.4
No. 200	0.075	80.6
	0.02	50.6
	0.005	27.9
	0.002	19.5
estimated	0.001	14.9

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	2.4	4.7
Coarse Sand	2.3	1.9
Medium Sand	1.9	---
Fine Sand	12.8	12.8
Silt	52.7	61.1
Clay	27.9	19.5

Atterberg Limits

 Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: 35
 Plastic Limit: 20
 Plasticity Index: 15
 Activity Index: 0.8
Moisture-Density Relationship

 Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A
California Bearing Ratio

 Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A
Specific Gravity

 Estimated
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.70
Classification

 Unified Group Symbol: CL
 Group Name: Lean clay with sand
 AASHTO Classification: A-6 (11)

Comments: _____

 _____ Reviewed By JS

Project IKEC Clifty Creek
 Source CF-19-150-22-33

 Project No. 175534018

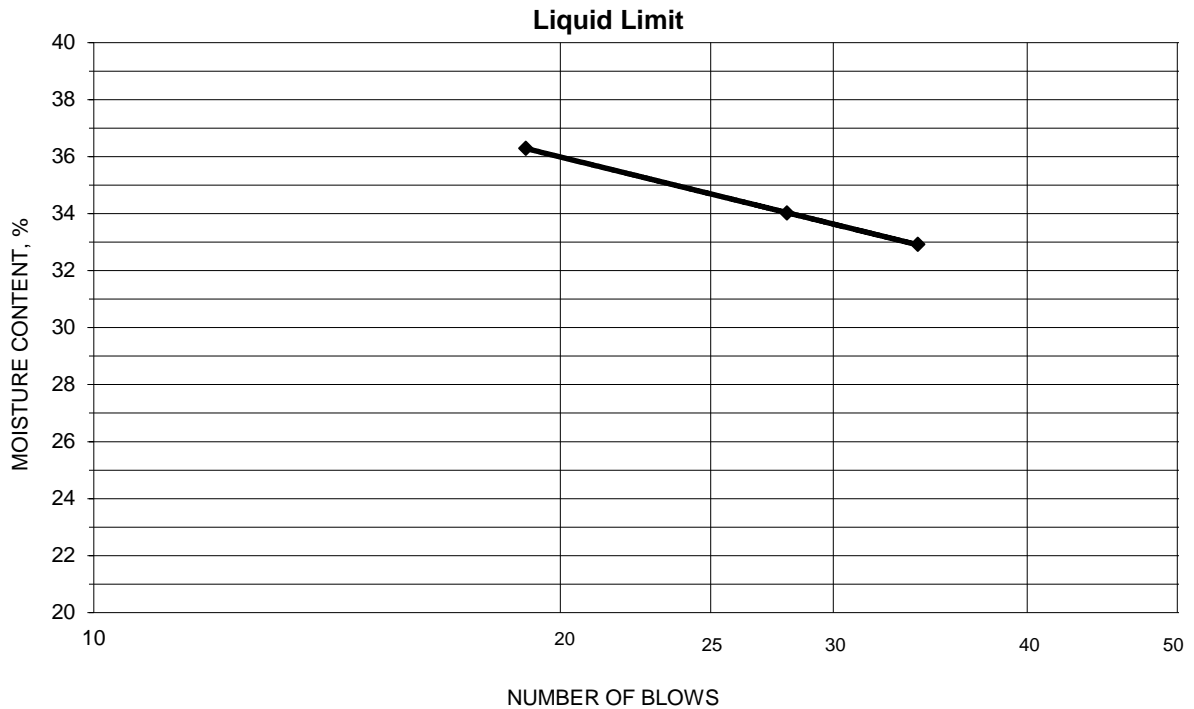
 Lab ID 5

 % + No. 40 7

 Tested By MP Test Method ASTM D 4318 Method A
 Test Date 03-19-2019 Prepared Dry

 Date Received 03-18-2019

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
23.87	20.70	11.07	34	32.9	35
22.90	19.76	10.53	28	34.0	
22.84	19.69	11.01	19	36.3	


PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
18.25	16.96	10.67	20.5	20	15
18.05	16.90	11.09	19.8		

 Remarks: _____

 Reviewed By JS



Project Name IKEC Clifty Creek
 Source CF-19-150-22-33

Project Number 175534018
 Lab ID 5

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method ASTM D 422
 Prepared using ASTM D 421

Particle Shape Angular
 Particle Hardness: Hard and Durable

Tested By MP
 Test Date 03-18-2019
 Date Received 03-18-2019

Sieve Size	% Passing
1 1/2"	100.0
3/4"	98.6
3/8"	98.3
No. 4	97.6
No. 10	95.3

Maximum Particle size: 1 1/2" Sieve

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

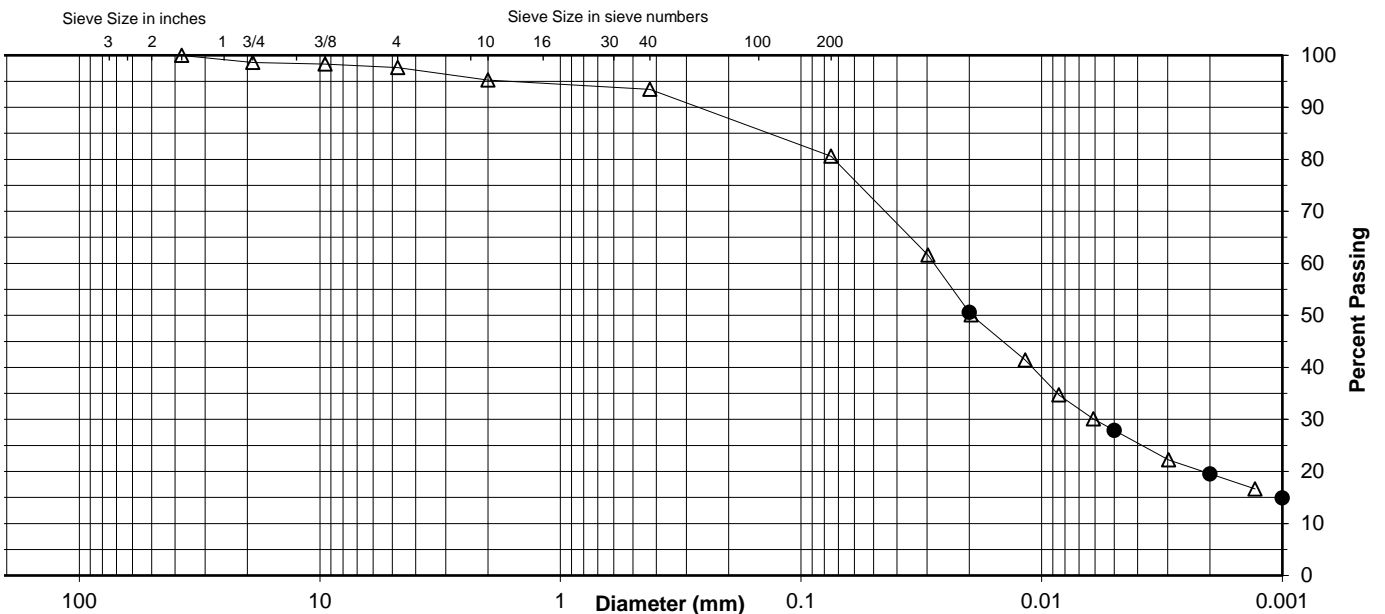
Specific Gravity 2.7

Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	93.4
No. 200	80.6
0.02 mm	50.6
0.005 mm	27.9
0.002 mm	19.5
0.001 mm	14.9

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	1.4	1.0	2.3	1.9	12.8	52.7	27.9
AASHTO	Gravel		Coarse Sand		Fine Sand	Silt	Clay
	4.7		1.9		12.8	61.1	19.5



Comments _____

Reviewed By JS

Project Name IKEC Clifty Creek
 Source CF-19-150-64-70

 Project Number 175534018
 Lab ID 6

 Sample Type SPT

 Date Received 3-18-19
 Date Reported 3-28-19
Test Results
Natural Moisture Content

 Test Method: ASTM D 2216
 Moisture Content (%): 17.7
Particle Size Analysis

 Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		% Passing
Sieve Size	(mm)	
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	92.8
3/8"	9.5	84.2
No. 4	4.75	77.2
No. 10	2	69.1
No. 40	0.425	62.1
No. 200	0.075	53.5
	0.02	39.6
	0.005	22.5
	0.002	16.1
estimated	0.001	12.6

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	22.8	30.9
Coarse Sand	8.1	7.0
Medium Sand	7.0	---
Fine Sand	8.6	8.6
Silt	31.0	37.4
Clay	22.5	16.1

Atterberg Limits

 Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: 34
 Plastic Limit: 20
 Plasticity Index: 14
 Activity Index: 0.9
Moisture-Density Relationship

 Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A
California Bearing Ratio

 Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A
Specific Gravity

 Estimated
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.70
Classification

 Unified Group Symbol: CL
 Group Name: Sandy lean clay with gravel
 AASHTO Classification: A-6 (5)

Comments: _____

 _____ Reviewed By JS

Project IKEC Clifty Creek
 Source CF-19-150-64-70

 Project No. 175534018

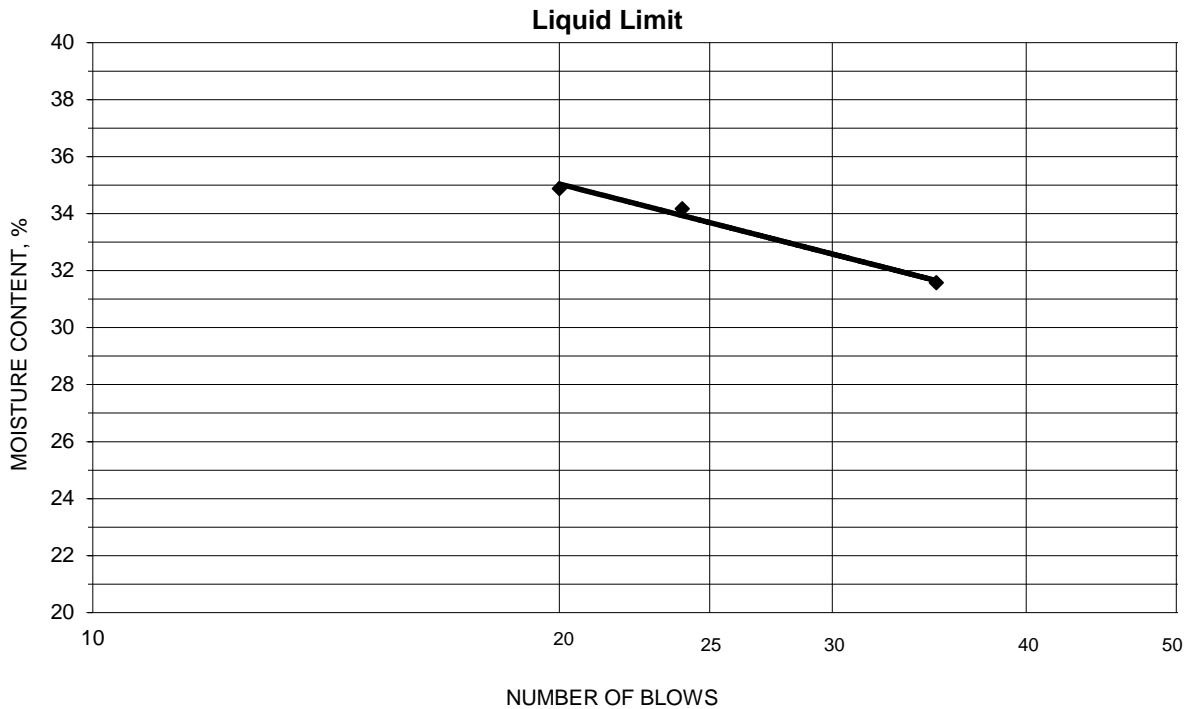
 Lab ID 6

 % + No. 40 38

 Tested By MP Test Method ASTM D 4318 Method A
 Test Date 03-19-2019 Prepared Dry

 Date Received 03-18-2019

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
27.17	23.17	10.50	35	31.6	34
24.96	21.30	10.59	24	34.2	
24.74	21.20	11.05	20	34.9	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
18.45	17.25	11.05	19.4	20	14
18.47	17.25	11.07	19.7		

 Remarks: _____

 Reviewed By JS

Project Name IKEC Clifty Creek
 Source CF-19-150-64-70

 Project Number 175534018
 Lab ID 6
Sieve analysis for the Portion Coarser than the No. 10 Sieve

 Test Method ASTM D 422
 Prepared using ASTM D 421

 Particle Shape Angular
 Particle Hardness: Hard and Durable

 Tested By GW
 Test Date 03-18-2019
 Date Received 03-18-2019

Sieve Size	% Passing
1 1/2"	100.0
3/4"	92.8
3/8"	84.2
No. 4	77.2
No. 10	69.1

Maximum Particle size: 1 1/2" Sieve

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

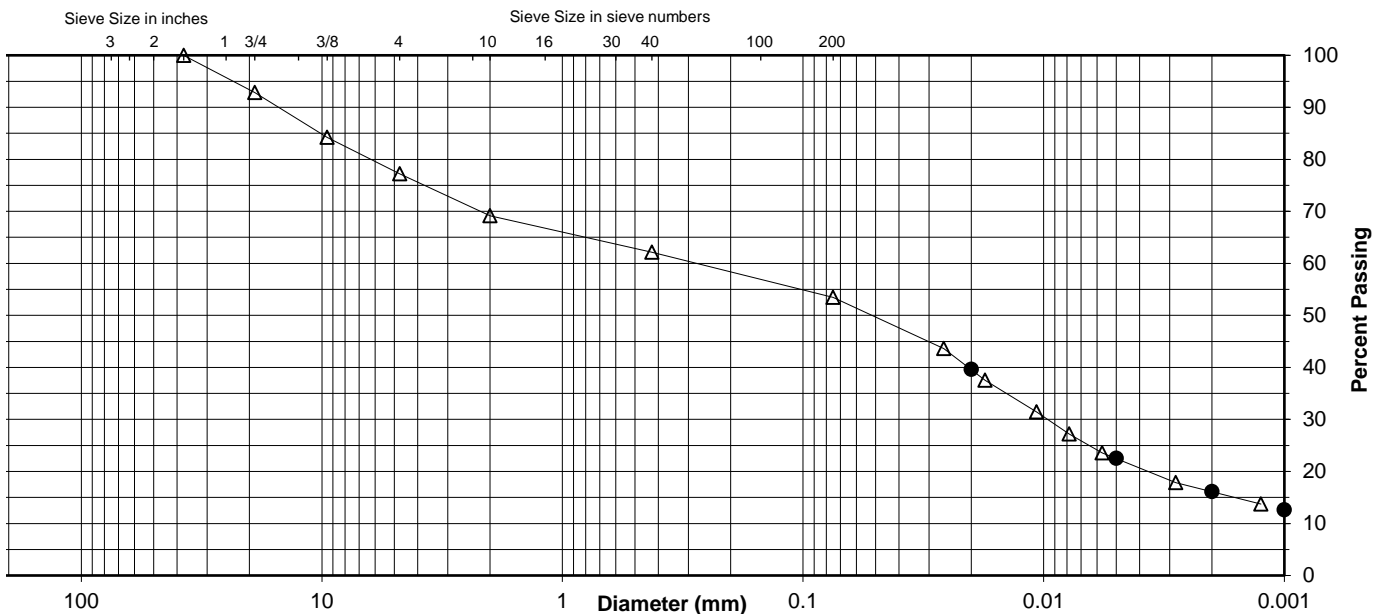
 Specific Gravity 2.7

Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	62.1
No. 200	53.5
0.02 mm	39.6
0.005 mm	22.5
0.002 mm	16.1
0.001 mm	12.6

Particle Size Distribution

ASTM	Coarse Gravel 7.2	Fine Gravel 15.6	C. Sand 8.1	Medium Sand 7.0	Fine Sand 8.6	Silt 31.0	Clay 22.5
AASHTO	Gravel 30.9		Coarse Sand 7.0		Fine Sand 8.6	Silt 37.4	Clay 16.1



Comments _____

 Reviewed By JS

Project Name IKEC Clifty Creek
 Source CF-19-80-30-40

 Project Number 175534018
 Lab ID 7

 Sample Type SPT

 Date Received 3-18-19
 Date Reported 3-28-19
Test Results
Natural Moisture Content

 Test Method: ASTM D 2216
 Moisture Content (%): 18.2
Particle Size Analysis

 Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		% Passing
Sieve Size	(mm)	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
3/8"	9.5	100.0
No. 4	4.75	99.6
No. 10	2	97.7
No. 40	0.425	88.4
No. 200	0.075	21.0
	0.02	8.6
	0.005	3.4
	0.002	2.0
estimated	0.001	1.1

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.4	2.3
Coarse Sand	1.9	9.3
Medium Sand	9.3	---
Fine Sand	67.4	67.4
Silt	17.6	19.0
Clay	3.4	2.0

Atterberg Limits

 Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: NP
 Plastic Limit: NP
 Plasticity Index: NP
 Activity Index: N/A
Moisture-Density Relationship

 Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A
California Bearing Ratio

 Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A
Specific Gravity

 Estimated
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.70
Classification

 Unified Group Symbol: SM
 Group Name: Silty sand
 AASHTO Classification: A-2-4 (0)

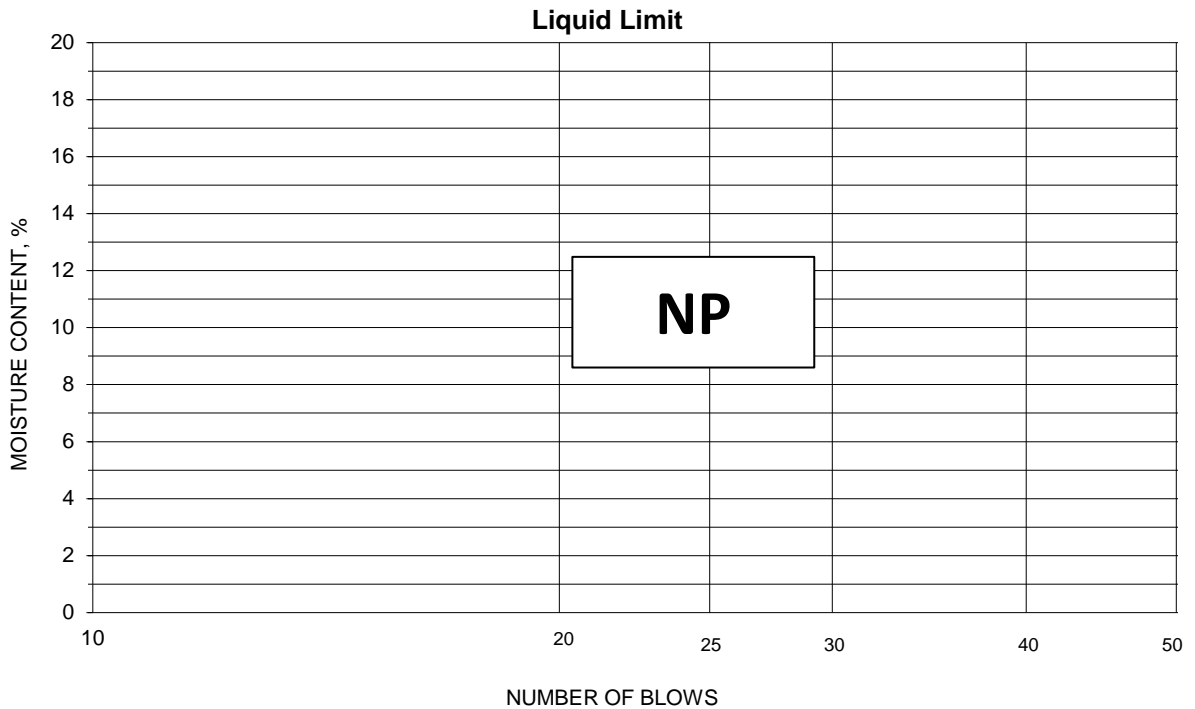
 Comments: _____

 Reviewed By JS

Project IKEC Clifty Creek
 Source CF-19-80-30-40
 Tested By MP Test Method ASTM D 4318 Method A
 Test Date 03-19-2019 Prepared Dry

Project No. 175534018
 Lab ID 7
 % + No. 40 12
 Date Received 03-18-2019

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index

Remarks: _____

Reviewed By JS

Project Name IKEC Clifty Creek
 Source CF-19-80-30-40

 Project Number 175534018
 Lab ID 7
Sieve analysis for the Portion Coarser than the No. 10 Sieve

 Test Method ASTM D 422
 Prepared using ASTM D 421
 Particle Shape Angular
 Particle Hardness: Hard and Durable
 Tested By GW
 Test Date 03-18-2019
 Date Received 03-18-2019

Sieve Size	% Passing
3/8"	100.0
No. 4	99.6
No. 10	97.7

Maximum Particle size: 3/8" Sieve

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

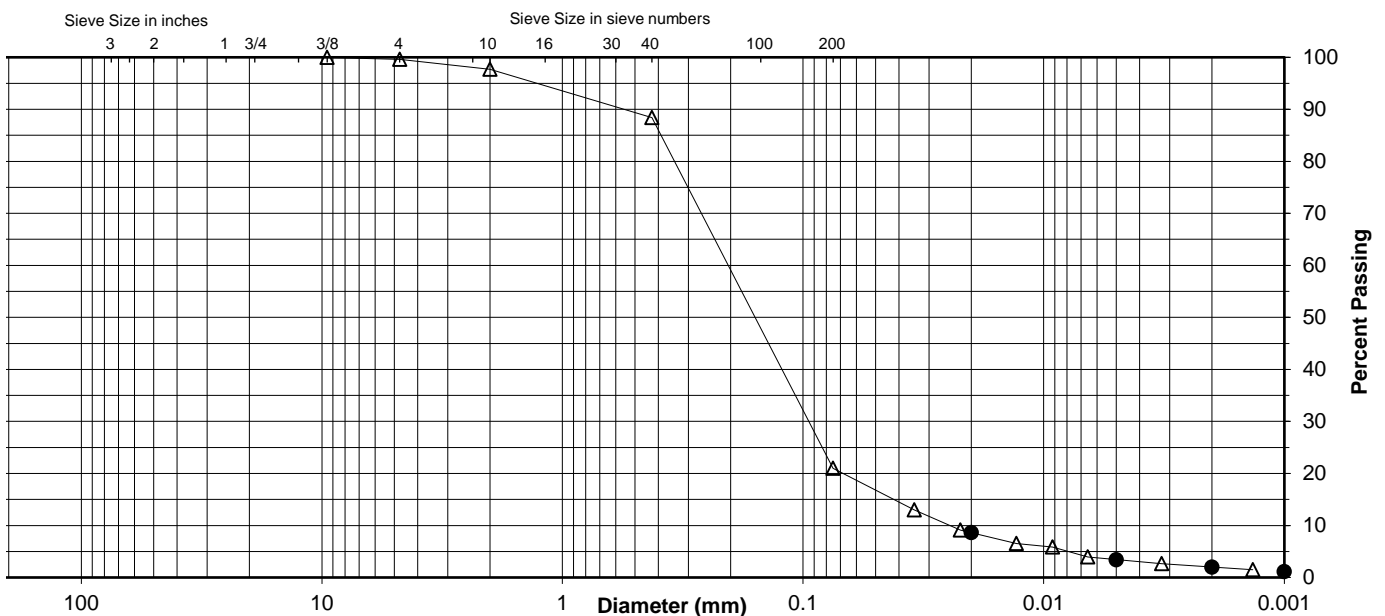
 Specific Gravity 2.7

Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	88.4
No. 200	21.0
0.02 mm	8.6
0.005 mm	3.4
0.002 mm	2.0
0.001 mm	1.1

Particle Size Distribution

ASTM	Coarse Gravel 0.0	Fine Gravel 0.4	C. Sand 1.9	Medium Sand 9.3	Fine Sand 67.4	Silt 17.6	Clay 3.4
AASHTO	Gravel 2.3		Coarse Sand 9.3	Fine Sand 67.4	Silt 19.0	Clay 2.0	



Comments _____

 Reviewed By JS



Summary of Soil Tests

Project Name IKEC Clifty Creek
 Source CF-19-80-84-89

Project Number 175534018
 Lab ID 8

Sample Type SPT

Date Received 3-18-19
 Date Reported 3-28-19

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
 Moisture Content (%): 10.5

Atterberg Limits

Test Method: ASTM D 4318 Method A
 Prepared: Dry

Liquid Limit: 27
 Plastic Limit: 16
 Plasticity Index: 11
 Activity Index: 1.7

Particle Size Analysis

Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		% Passing
Sieve Size	(mm)	
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	78.9
3/8"	9.5	61.7
No. 4	4.75	50.7
No. 10	2	41.1
No. 40	0.425	34.5
No. 200	0.075	28.0
	0.02	18.8
	0.005	9.4
	0.002	6.4
estimated	0.001	4.8

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	49.3	58.9
Coarse Sand	9.6	6.6
Medium Sand	6.6	---
Fine Sand	6.5	6.5
Silt	18.6	21.6
Clay	9.4	6.4

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity

Estimated

Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: GC
 Group Name: Clayey gravel with sand

AASHTO Classification: A-2-6 (0)

Comments: _____

Reviewed By JS

Project IKEC Clifty Creek
 Source CF-19-80-84-89

 Project No. 175534018

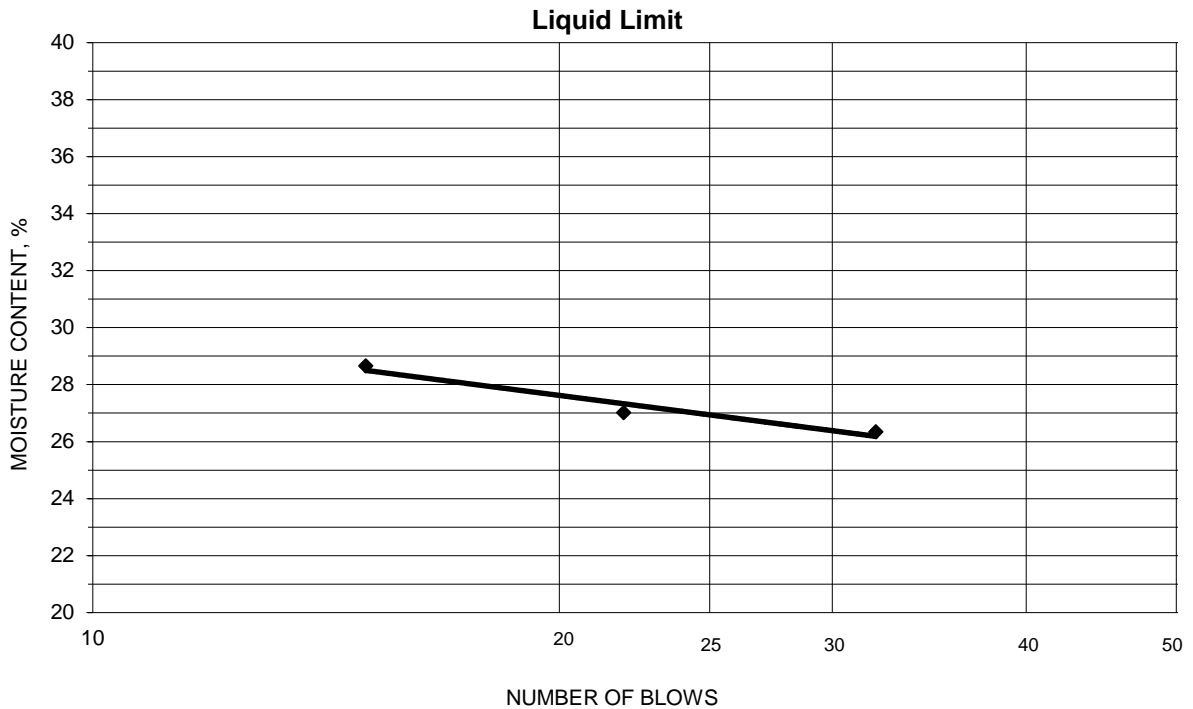
 Lab ID 8

 % + No. 40 65

 Tested By MP Test Method ASTM D 4318 Method A
 Test Date 03-19-2019 Prepared Dry

 Date Received 03-18-2019

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
22.33	19.98	11.06	32	26.3	27
22.20	19.82	11.01	22	27.0	
21.89	19.46	10.98	15	28.7	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
17.57	16.65	11.10	16.6	16	11
17.04	16.20	11.02	16.2		

 Remarks: _____

 Reviewed By JS

Project Name IKEC Clifty Creek
 Source CF-19-80-84-89

Project Number 175534018
 Lab ID 8

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method ASTM D 422
 Prepared using ASTM D 421

Particle Shape Angular
 Particle Hardness: Hard and Durable

Tested By GW
 Test Date 03-18-2019
 Date Received 03-18-2019

Sieve Size	% Passing
1 1/2"	100.0
3/4"	78.9
3/8"	61.7
No. 4	50.7
No. 10	41.1

Maximum Particle size: 1 1/2" Sieve

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

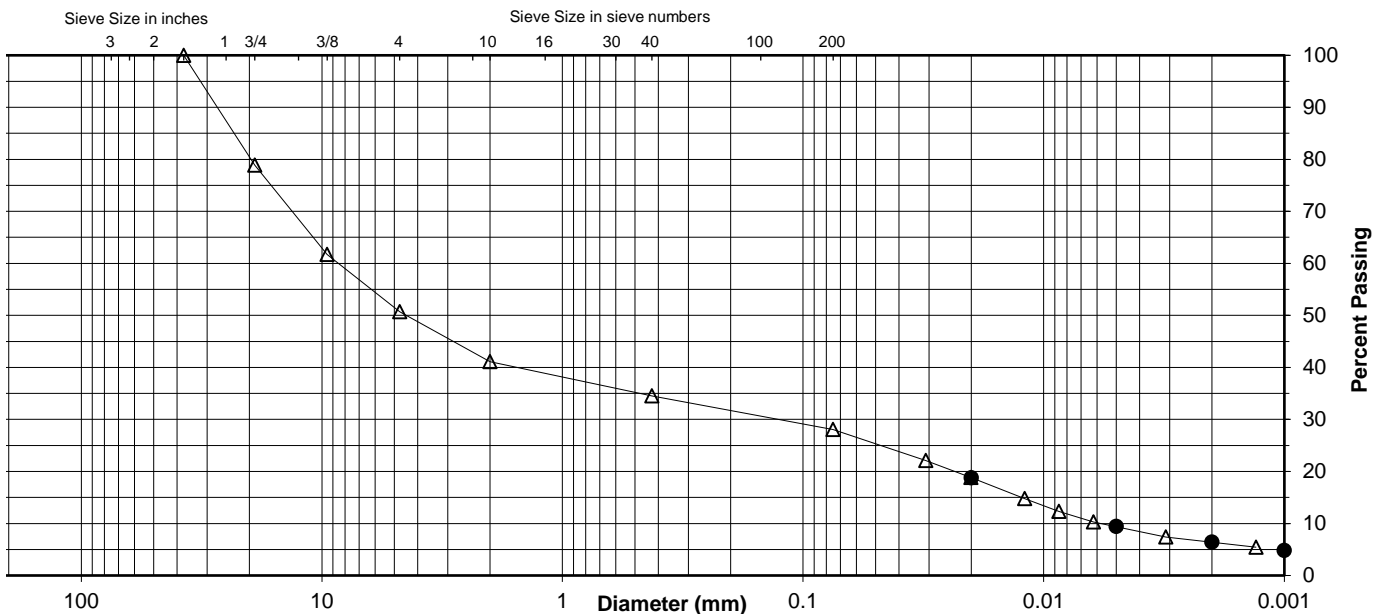
Specific Gravity 2.7

Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	34.5
No. 200	28.0
0.02 mm	18.8
0.005 mm	9.4
0.002 mm	6.4
0.001 mm	4.8

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	21.1	28.2	9.6	6.6	6.5	18.6	9.4
AASHTO	Gravel		Coarse Sand		Fine Sand	Silt	Clay
	58.9		6.6		6.5	21.6	6.4



Comments _____

Reviewed By JS

APPENDIX D

WELL BORING AND CONSTRUCTION LOGS

BORING NO. CF-19-08D
SAMPLE/CORE LOG

Project Number: <u>2019042</u>	Log Page <u>1</u> of <u>2</u>
Project Location: <u>Clifty Creek Plant</u> <u>LRCP</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>3/5/2019-3/6/2019</u>	Geologist: <u>Michael Gelles</u>
Drilling Method: <u>Hollow Stem Auger</u>	Coring Device Size: <u>NA</u> Hammer Wt. <u>160lb</u> and Drop <u>2ft</u>
Sampling Method: <u>Split Spoon</u>	Borehole Diameter: <u>6"</u> Drilling Fluid Used: <u>Water</u>
Sampling Interval: <u>2'</u>	Borehole Depth: <u>89'</u> Surface Elevation: <u>460.68' MSL</u>
NOTES/COMMENTS: _____ _____	

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-2	1.5	3-2-2-3	Orange brown sandy clay, moist	N/A
2-4	1.5	2-3-2-2	Orange brown sandy clay, moist	N/A
4-6	2	2-2-3-3	Orange brown sandy clay, moist	N/A
6-8	1.5	2-3-3-4	Orange brown sandy clay, moist	N/A
8-10	2	5-4-4-4	Orange brown sandy clay, moist	N/A
10-12	2	4-5-5-6	Orange brown sandy clay, moist	N/A
12-14	2	5-5-6-8	Orange brown sandy clay, moist	N/A
14-16	1.5	6-7-6-8	Orange brown sandy clay, wet; water at 14 feet	N/A
16-18	1.5	4-4-8-8	Orange brown sandy clay, wet	N/A
18-20	1.5	6-6-7-8	Orange brown sandy clay, wet	N/A
20-22	2	5-5-5-7	Orange brown silty clay, fine sand, wet	N/A
22-24	2	3-2-3-4	Orange brown silty clay, fine sand, wet	N/A
24-26	2	2-4-6-7	Orange brown silty clay, fine sand, wet	N/A
26-28	2	6-7-7-18	26-27 orange brown silty clay, fine sand, wet; 27-28 orange brown till clay, very stiff, plastic, moist	N/A
28-30	2	3-3-8-8	Orange brown silty clay, fine sand, wet	N/A
30-32	2	7-8-11-16	Orange brown fine sand, some silt, wet	N/A
32-34	2	6-7-11-13	Orange brown fine sand, some silt, wet	N/A
34-36	2	6-6-8-10	Orange brown fine sand, some silt, wet	N/A

**CONTINUED SAMPLE/CORE LOG
BORING CF-19-08D**

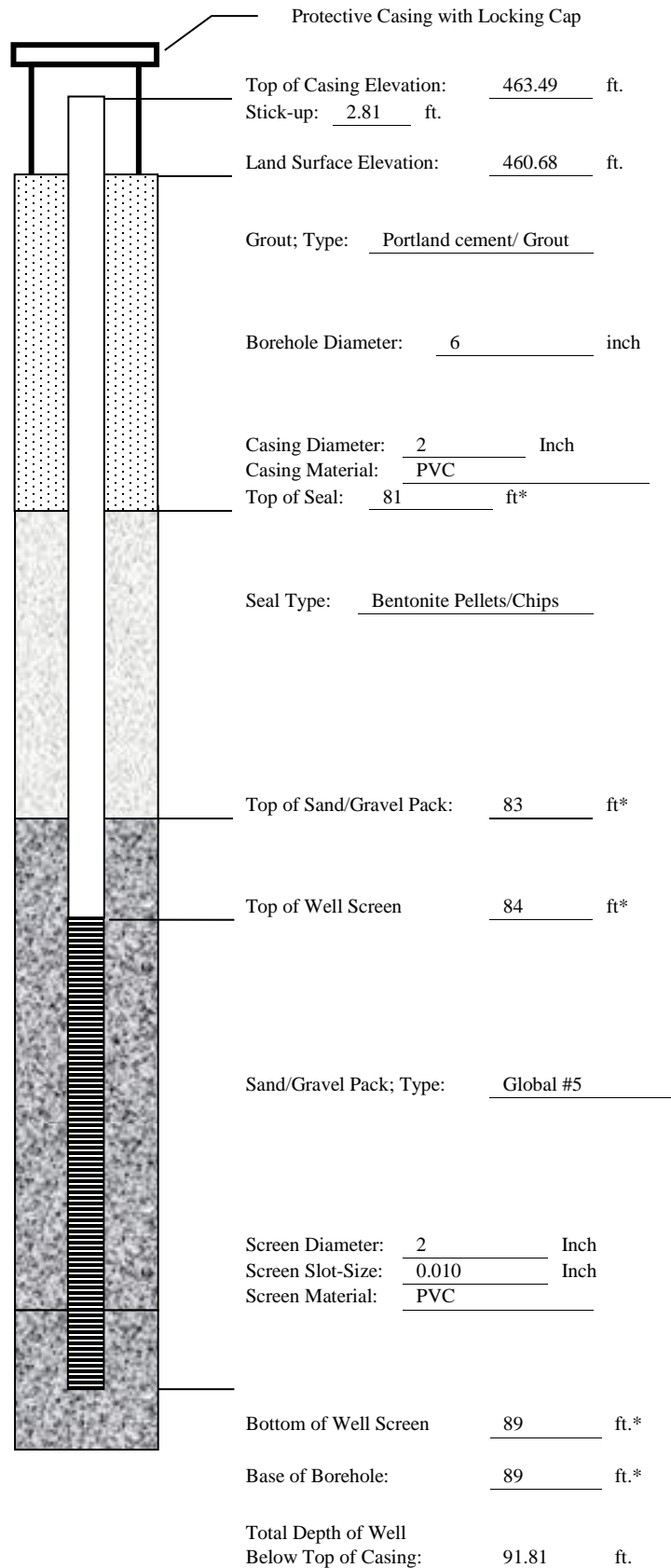
Project No: 2019042 Geologist: Michael Gelles Page 2 of 2

36-38	2	6-8-6-10	Orange brown fine sand, some silt, wet	N/A
38-40	2	14-11-6-18	Orange brown fine sand, some silt, wet	N/A
40-42	2	6-8-9-11	Orange brown fine sand, some silt, wet	N/A
42-44	2	4-3-3-5	Orange brown fine sand, some silt, wet	N/A
44-46	1	2-3-4-7	Gray clay, lean, moist	N/A
46-48	1	6-7-8-4	Gray clay, lean, moist	N/A
48-50	0.6	4-5-6-4	Gray clay, lean, moist	N/A
50-52	1	3-4-5-6	Gray clay, lean, moist	N/A
52-54	1	2-3-4-3	Gray clay, lean, moist	N/A
54-56	1.5	3-3-3-3	Gray clay, lean, moist	N/A
56-58	2	2-4-6-6	Gray clay, lean, moist	N/A
58-60	2	3-5-8-8	Gray clay, lean, moist	N/A
60-62	2	5-6-7-8	Gray clay, lean, moist	N/A
62-64	1	1-1-1-1	Gray clay, lean, moist	N/A
64-66	1	1-1-1-2	Gray clay, lean, moist	N/A
66-68	2	4-6-7-6	Gray clay, lean, moist	N/A
68-70	2	5-4-5-9	Gray clay, lean, moist	N/A
70-72	2	5-7-9-9	Gray clay, lean, some silt and sand, moist	N/A
72-74	2	4-5-8-9	Gray clay, lean, some silt and sand, moist	N/A
74-76	2	7-6-7-8	Gray clay, lean, some silt and sand, moist	N/A
76-78	2	5-6-8-9	Gray clay, lean, some silt and sand, moist	N/A
78-80	2	8-4-8-6	Gray clay, lean, some silt and sand, trace gravel, moist	N/A
80-82	1.5	7-8-9-5	Gray clay, lean, some silt and sand, trace gravel, moist	N/A
82-84	2	3-4-4-4	Gray clay, lean, some silt, trace sand, moist	N/A
84-86	0.8	13-15-15-22	Orange brown silty clay, gravel, wet	N/A
86-88	1.2	10-12-15-20	Orange brown silty clay, gravel, wet	N/A
88-89	0.75	8-100/2	88-88.5 orange brown silty clay, gravel, wet; 88.5-88.75 refusal gray limestone	N/A

WELL CONSTRUCTION LOG

WELL NO. CF-19-08D

Project Number:	<u>2019042</u>
Project Location:	<u>Clifty Creek Plant – LRCP</u>
Installation Date(s):	<u>3/5/2019-3/8/2019</u>
Drilling Method:	<u>Hollow Stem Auger</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>3/14/2019-3/20/2019</u>
Development Method:	<u>Submersible Pump and Bladder Pump</u>
Field parameters stabilized.	
Volume Purged:	<u>52 gallons</u>
Static Water-Level*:	<u>20.71'</u>
Top of Well Casing Elevation:	<u>463.49'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>443224.617</u>
Easting (X):	<u>562551.033</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u>
	<u>5 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Michael Gelles</u>



CONSTRUCTION MATERIALS USED:	
<u>3.5</u>	Bags of Sand
<u>1</u>	Bags/Buckets Bentonite Pellets
<u>10</u>	Bags Portland for Grout
<u> </u>	Bags Concrete/Sakrete

*Indicates Depth Below Land Surface

BORING NO. CF-19-14
SAMPLE/CORE LOG

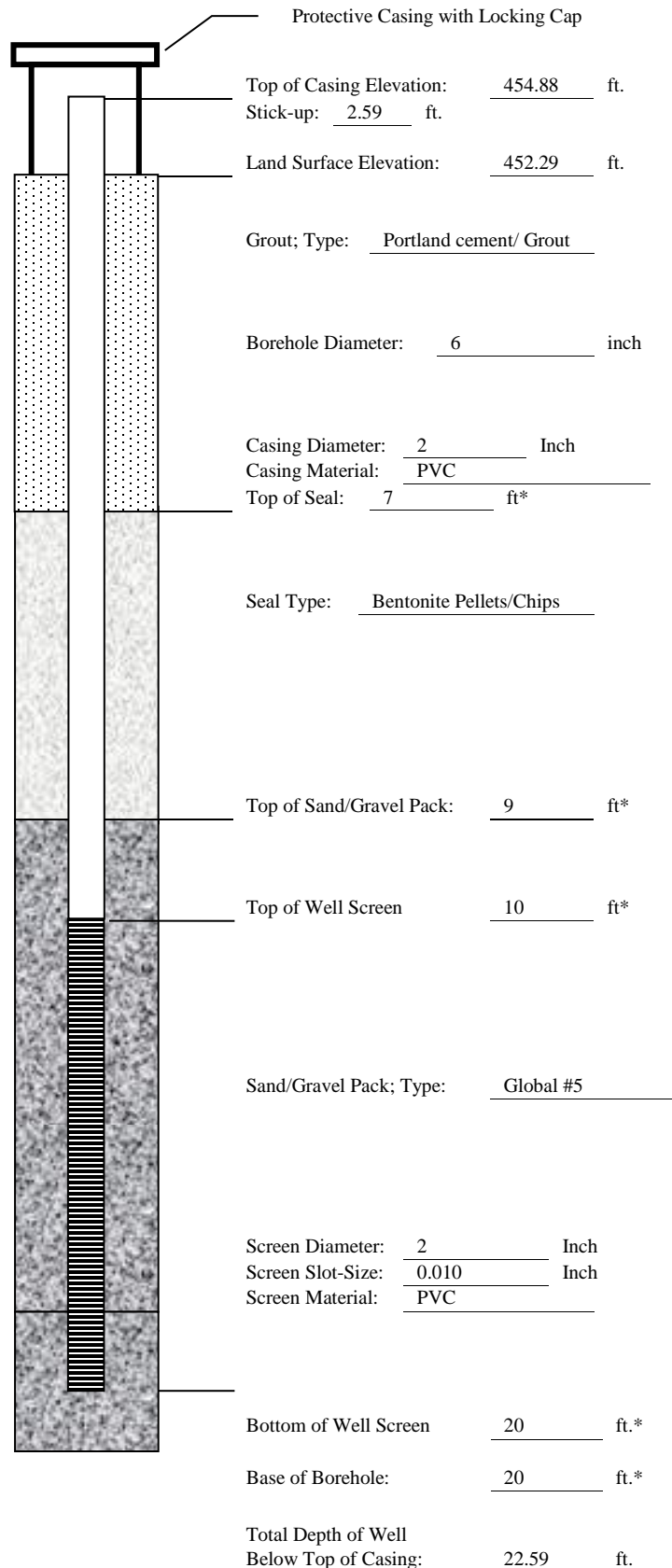
Project Number: <u>2019042</u> Project Location: <u>Clifty Creek Plant</u> Drilling Date(s): <u>LRCF</u> <u>3/7/2019</u>	Log Page <u>1</u> of <u>1</u> Drilling Contractor: <u>Bowser Morner</u> Geologist: <u>Michael Gelles</u>
Drilling Method: <u>Hollow Stem Auger</u> Coring Device Size: <u>NA</u> Hammer Wt. <u>160lb</u> and Drop <u>2ft</u> Sampling Method: <u>Split Spoon</u> Borehole Diameter: <u>6"</u> Drilling Fluid Used: <u>Water</u> Sampling Interval: <u>2'</u> Borehole Depth: <u>20'</u> Surface Elevation: <u>452.29' msl</u>	
NOTES/COMMENTS: _____ _____	

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-2	1.5	1-2-2-2	Brown silty clay, moist	N/A
2-4	1.5	3-3-6-7	Brown silty clay, moist	N/A
4-6	2	3-4-6-7	Brown silty clay, moist	N/A
6-8	2	7-8-6-7	Orange brown silty clay, moist	N/A
8-10	2	4-6-5-6	Orange brown silty clay, moist	N/A
10-12	2	2-3-4-3	Orange brown silty clay, moist	N/A
12-14	1.5	2-2-3-4	Orange brown silty clay, moist	N/A
14-16	2	3-2-2-3	Orange brown silty clay, wet, water at 14 feet	N/A
16-18	2	3-2-2-3	Orange brown silty clay, wet	N/A
18-20	1.5	6-1-3-100/4	Orange brown silty clay, wet; refusal gray limestone	N/A

WELL CONSTRUCTION LOG

WELL NO. CF-19-14

Project Number:	<u>2019042</u>
Project Location:	<u>Clifty Creek Plant – LRPC</u>
Installation Date(s):	<u>3/7/2019-3/8/2019</u>
Drilling Method:	<u>Hollow Stem Auger</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>3/14/2019-3/20/2019</u>
Development Method:	<u>Submersible Pump and Bladder Pump</u>
Field parameters stabilized.	
Volume Purged:	<u>16.5 gallons</u>
Static Water-Level*:	<u>7.09'</u>
Top of Well Casing Elevation:	<u>454.88'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>443401.75</u>
Easting (X):	<u>562901.929</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u>
	<u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Michael Gelles</u>



CONSTRUCTION MATERIALS USED:	
<u>6.5</u>	Bags of Sand
<u>1</u>	Bags/Buckets Bentonite Pellets
<u>2</u>	Bags Portland for Grout
<u> </u>	Bags Concrete/Sakrete

*Indicates Depth Below Land Surface

BORING NO. CF-19-15
SAMPLE/CORE LOG

Project Number: <u>2019042</u> Clifty Creek Plant	Log Page <u>1</u> of <u>1</u>
Project Location: <u>LRCP</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): _____	Geologist: <u>Michael Gelles</u>

Drilling Method: <u>Hollow Stem Auger</u>	Coring Device Size: <u>NA</u>	Hammer Wt. <u>160lb</u>	and Drop <u>2ft</u>
Sampling Method: <u>Split Spoon</u>	Borehole Diameter: <u>6"</u>	Drilling Fluid Used: <u>Water</u>	
Sampling Interval: <u>2'</u>	Borehole Depth: <u>33'</u>	Surface Elevation: <u>441.10' msl</u>	

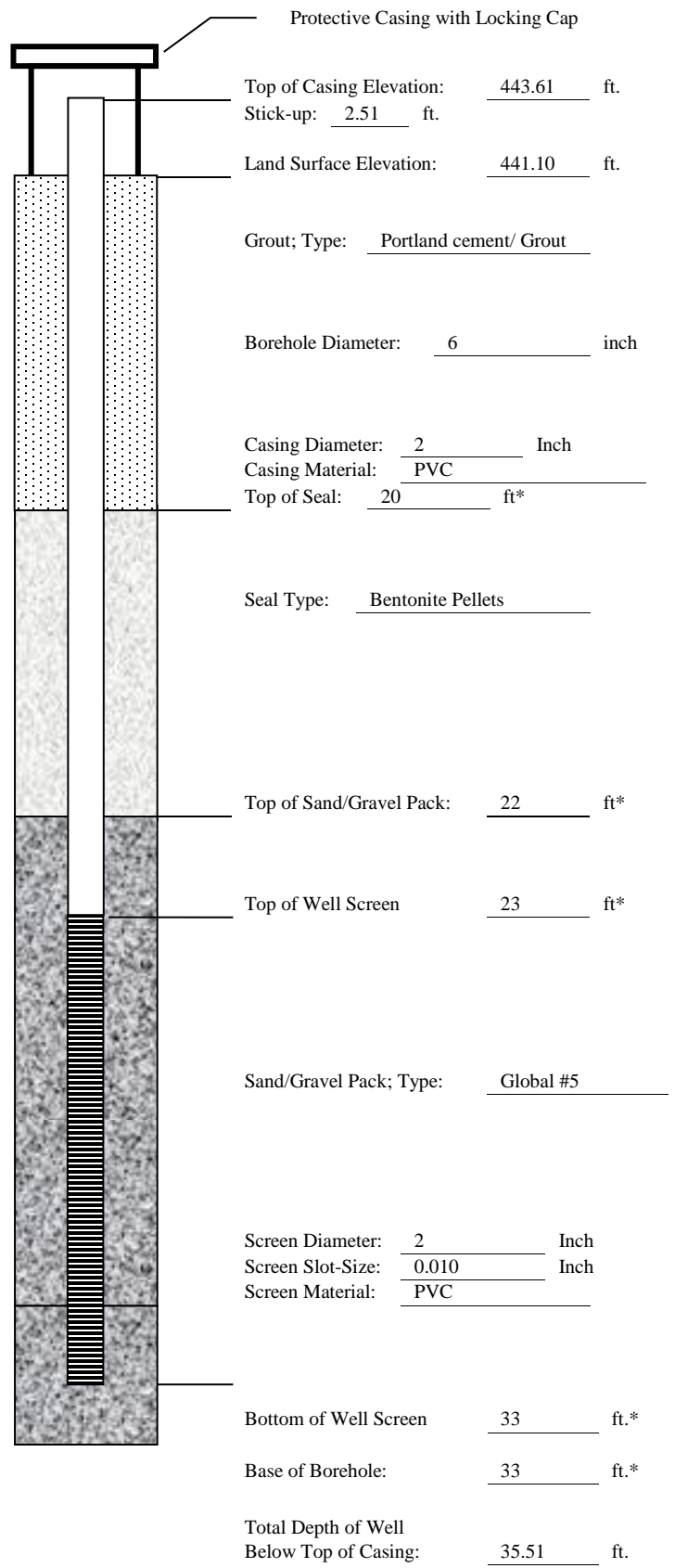
NOTES/COMMENTS: _____

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-33	NA	NA	Advanced augers – no samples (see CF-19-15D log)	N/A

WELL CONSTRUCTION LOG

WELL NO. CF-19-15

Project Number:	<u>2019042</u>
Project Location:	<u>Clifty Creek Plant – LRCP</u>
Installation Date(s):	<u>3/13/2019</u>
Drilling Method:	<u>Hollow Stem Auger</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>3/14/2019-3/21/2019</u>
Development Method:	<u>Submersible Pump and Bladder Pump</u>
Field parameters stabilized.	
Volume Purged:	<u>24 gallons</u>
Static Water-Level*:	<u>9.90'</u>
Top of Well Casing Elevation:	<u>443.61'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>442704.784</u>
Easting (X):	<u>562483.023</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u>
	<u>10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Michael Gelles</u>



- CONSTRUCTION MATERIALS USED:**
- 6 Bags of Sand
 - 1 Bags/Buckets Bentonite Pellets
 - 3 Bags Portland for Grout
 - Bags Concrete/Sakrete

*Indicates Depth Below Land Surface

BORING NO. CF-19-15D
SAMPLE/CORE LOG

Project Number: <u>2019042</u>	Log Page <u>1</u> of <u>2</u>
Project Location: <u>Clifty Creek Plant</u> <u>LRCP</u>	Drilling Contractor: <u>Bowser Morner</u>
Drilling Date(s): <u>3/11/2019-3/12/2019</u>	Geologist: <u>Michael Gelles</u>

Drilling Method: <u>Hollow Stem Auger</u>	Coring Device Size: <u>NA</u>	Hammer Wt. <u>160lb</u>	and Drop <u>2ft</u>
Sampling Method: <u>Split Spoon</u>	Borehole Diameter: <u>6"</u>	Drilling Fluid Used: <u>Water</u>	
Sampling Interval: <u>2'</u>	Borehole Depth: <u>72'</u>	Surface Elevation: <u>441.78' MSL</u>	

NOTES/COMMENTS: _____

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-2	1.5	1-1-3-3	Brown silty clay, sand, moist	N/A
2-4	1.5	2-2-3-3	Brown silty clay, sand, moist	N/A
4-6	1.5	1-2-4-5	Brown silty clay, sand, moist	N/A
6-8	1.5	1-3-4-5	Brown silty clay, sand, moist	N/A
8-10	2	4-4-6-8	Brown silty clay, sand, moist	N/A
10-12	2	4-3-5-7	Brown silty clay, sand, moist	N/A
12-14	2	2-3-5-7	Orange brown silty clay, sand, moist	N/A
14-16	2	3-4-5-5	Orange brown silty clay, sand, moist	N/A
16-18	2	4-5-5-6	Orange brown silty clay, sand, moist	N/A
18-20	2	2-4-5-6	Orange brown silty clay, sand, moist	N/A
20-22	2	2-3-3-5	Orange brown silty clay, sand, moist	N/A
22-24	2	2-3-4-5	Gray silty clay, sand, moist	N/A
24-26	2	2-2-3-4	Gray silty clay, sand, moist	N/A
26-28	2	2-3-3-4	Orange brown silty clay, sand, gravel, wet	N/A
28-30	2	1-2-3-5	Orange brown silty clay, sand, gravel, wet	N/A
30-32	2	3-4-7-8	Orange brown silty clay, sand, gravel, wet	N/A
32-34	2	3-2-6-4	32-33 orange brown silty clay, sand, gravel, wet; 33-34 gray clay, lean, moist	N/A
34-36	2	4-4-4-5	Gray clay, lean, moist	N/A

**CONTINUED SAMPLE/CORE LOG
BORING CF-19-15D**

Project No: 2019042 Geologist: Michael Gelles Page 2 of 2

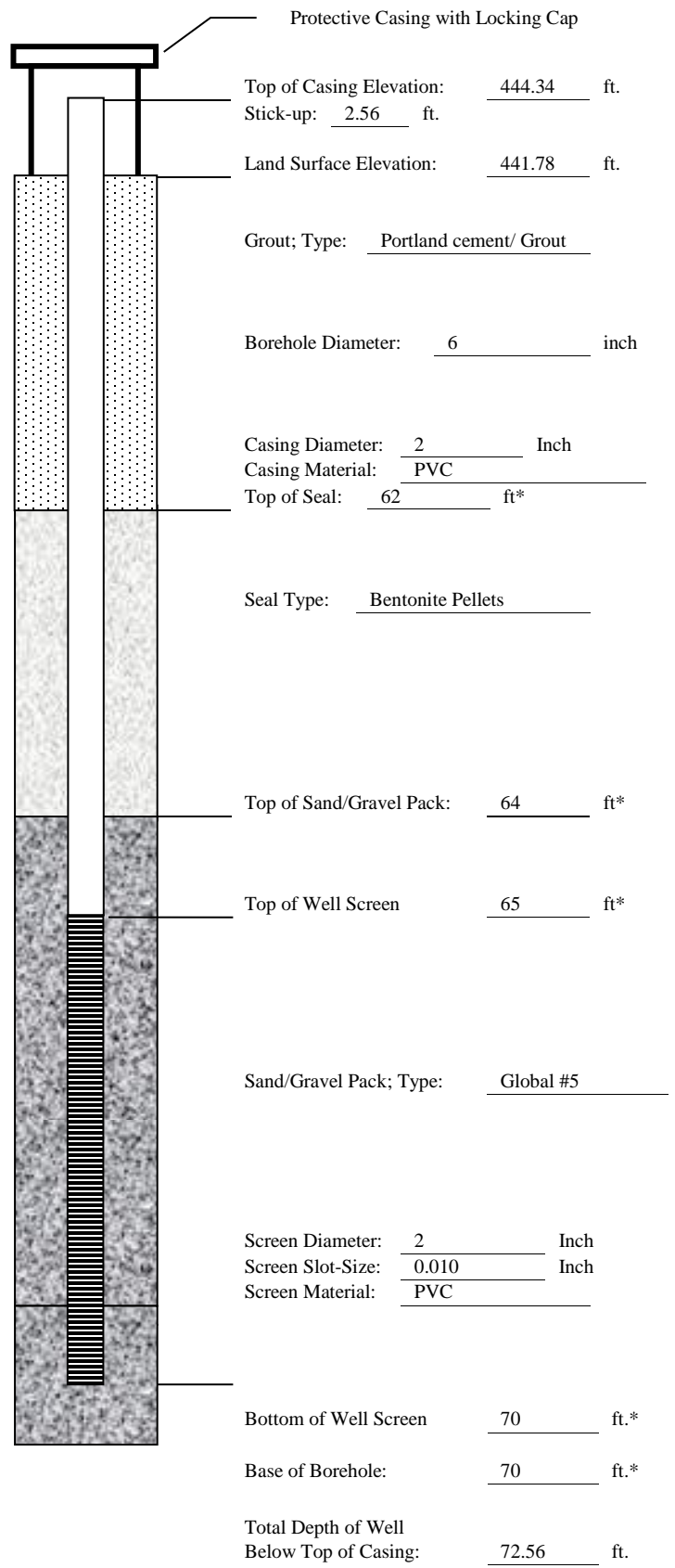
36-38	2	4-5-4-5	Gray clay, lean, moist	N/A
38-40	0.5	4-4-4-5	Gray clay, lean, moist	N/A
40-42	2	3-4-6-7	Gray clay, lean, moist	N/A
42-44	2	3-4-6-8	Gray clay, lean, moist	N/A
44-46	2	3-3-5-6	Gray clay, lean, moist	N/A
46-48	2	6-6-7-8	Gray clay, lean, moist	N/A
48-50	2	6-5-7-8	Gray clay, lean, moist	N/A
50-52	2	3-4-4-5	Gray clay, lean, moist	N/A
52-54	2	8-7-5-5	Gray clay, lean, moist	N/A
54-56	2	2-2-2-4	Gray clay, lean, moist	N/A
56-58	2	3-3-4-5	Gray clay, lean, moist	N/A
58-60	2	4-6-7-8	Gray clay, lean, moist	N/A
60-62	1.5	8-7-7-7	Gray clay, lean, moist	N/A
62-64	2	7-5-7-9	Gray clay, lean, moist	N/A
64-66	2	9-7-8-7	Gray silty clay, gravel, sand, wet; water at 64 feet	N/A
66-68	2	9-10-8-15	Gray silty clay, gravel, sand, wet	N/A
68-70	1	12-15-18-50	Gray silty clay, gravel, sand, wet	N/A
70-72	0.1	100/2	Refusal gray limestone	N/A

WELL CONSTRUCTION LOG
WELL NO. CF-19-15D

Project Number:	<u>2019042</u>
Project Location:	<u>Clifty Creek Plant – LRCP</u>
Installation Date(s):	<u>3/11/2019-3/12/2019</u>
Drilling Method:	<u>Hollow Stem Auger</u>
Drilling Contractor:	<u>Bowser Morner</u>
Development Date(s):	<u>3/14/2019-3/21/2019</u>
Development Method:	<u>Submersible Pump and Bladder Pump</u>
Field parameters stabilized.	
Volume Purged:	<u>48 gallons</u>
Static Water-Level*:	<u>15.51'</u>
Top of Well Casing Elevation:	<u>444.34'</u>
Well Purpose:	<u>Groundwater Monitoring</u>
Northing (Y):	<u>442713.897</u>
Easting (X):	<u>562487.596</u>
Comments/Notes:	<u>2 inch PVC riser and screen</u>
	<u>5 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.</u>
Inspector:	<u>Michael Gelles</u>

CONSTRUCTION MATERIALS USED:

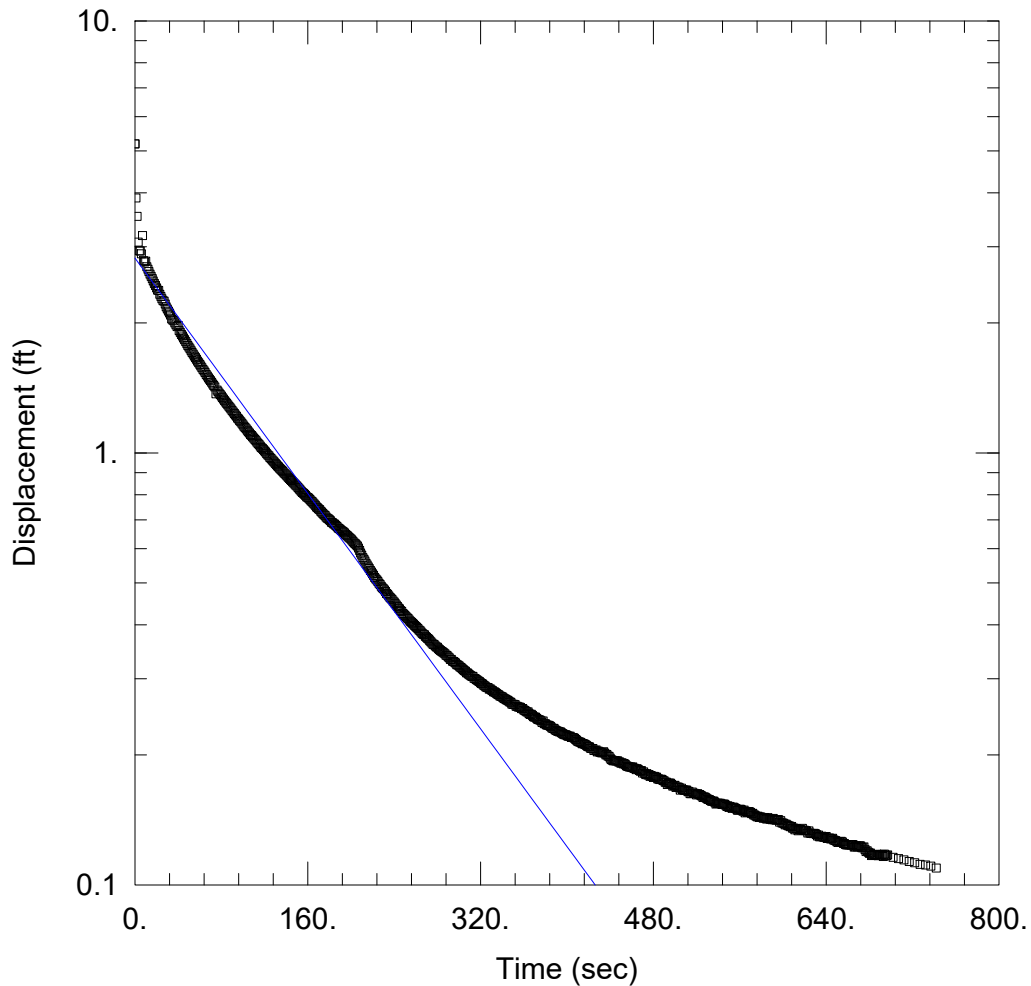
<u>3.5</u>	Bags of Sand
<u>1</u>	Bags/Buckets Bentonite Pellets
<u>6</u>	Bags Portland for Grout
<u> </u>	Bags Concrete/Sakrete



Top of Casing Elevation: 444.34 ft.
Stick-up: 2.56 ft.
Land Surface Elevation: 441.78 ft.
Grout; Type: Portland cement/ Grout
Borehole Diameter: 6 inch
Casing Diameter: 2 Inch
Casing Material: PVC
Top of Seal: 62 ft*
Seal Type: Bentonite Pellets
Top of Sand/Gravel Pack: 64 ft*
Top of Well Screen: 65 ft*
Sand/Gravel Pack; Type: Global #5
Screen Diameter: 2 Inch
Screen Slot-Size: 0.010 Inch
Screen Material: PVC
Bottom of Well Screen: 70 ft.*
Base of Borehole: 70 ft.*
Total Depth of Well Below Top of Casing: 72.56 ft.

*Indicates Depth Below Land Surface

APPENDIX E
SLUG TEST RESULTS



CF-19-08D-IN1

Data Set: \...\CF-19-08D-IN1.aqt
 Date: 05/31/19

Time: 14:23:10

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-08D
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-08D)

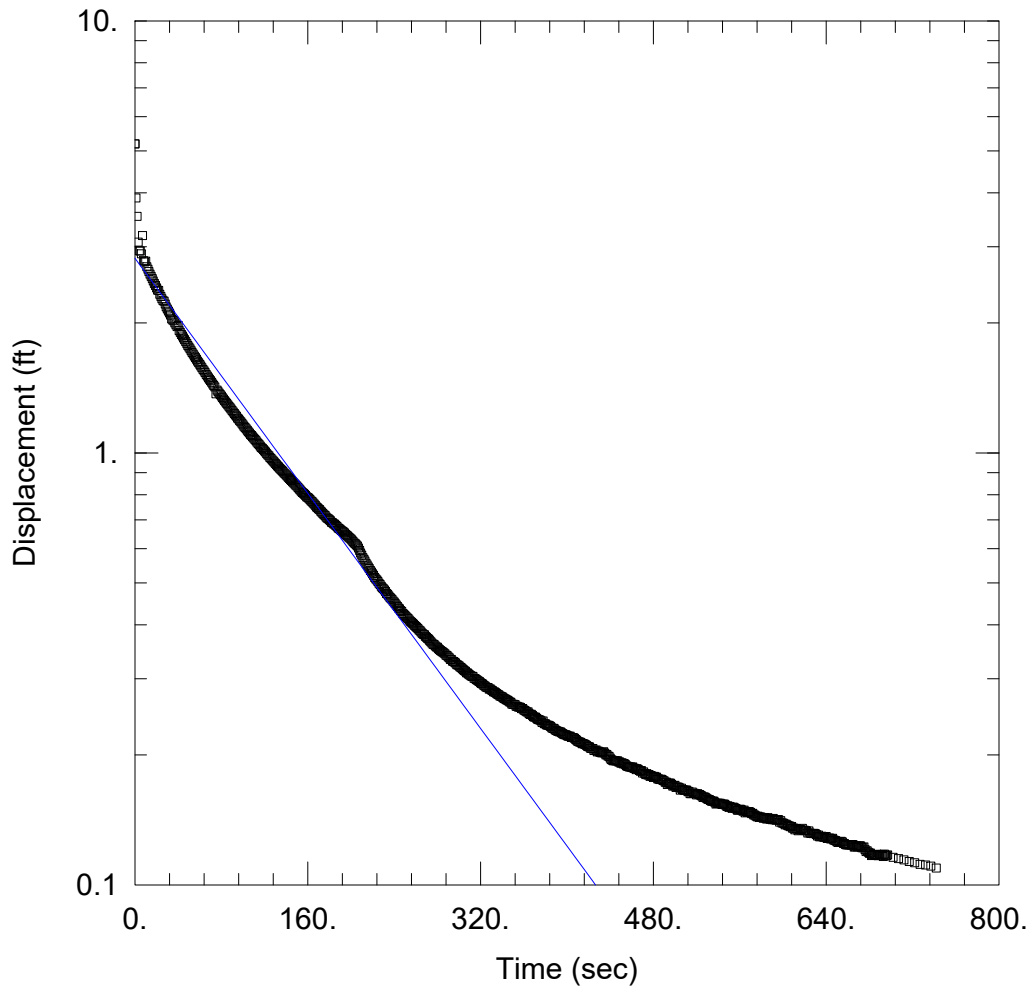
Initial Displacement: 5.191 ft
 Total Well Penetration Depth: 89.9 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 65.31 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 1.361E-5 ft/sec

Solution Method: Bower-Rice
 y0 = 2.823 ft



CF-19-08D-IN1

Data Set: \\...\CF-19-08D-IN1.aqt
 Date: 05/31/19

Time: 14:23:38

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-08D
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-08D)

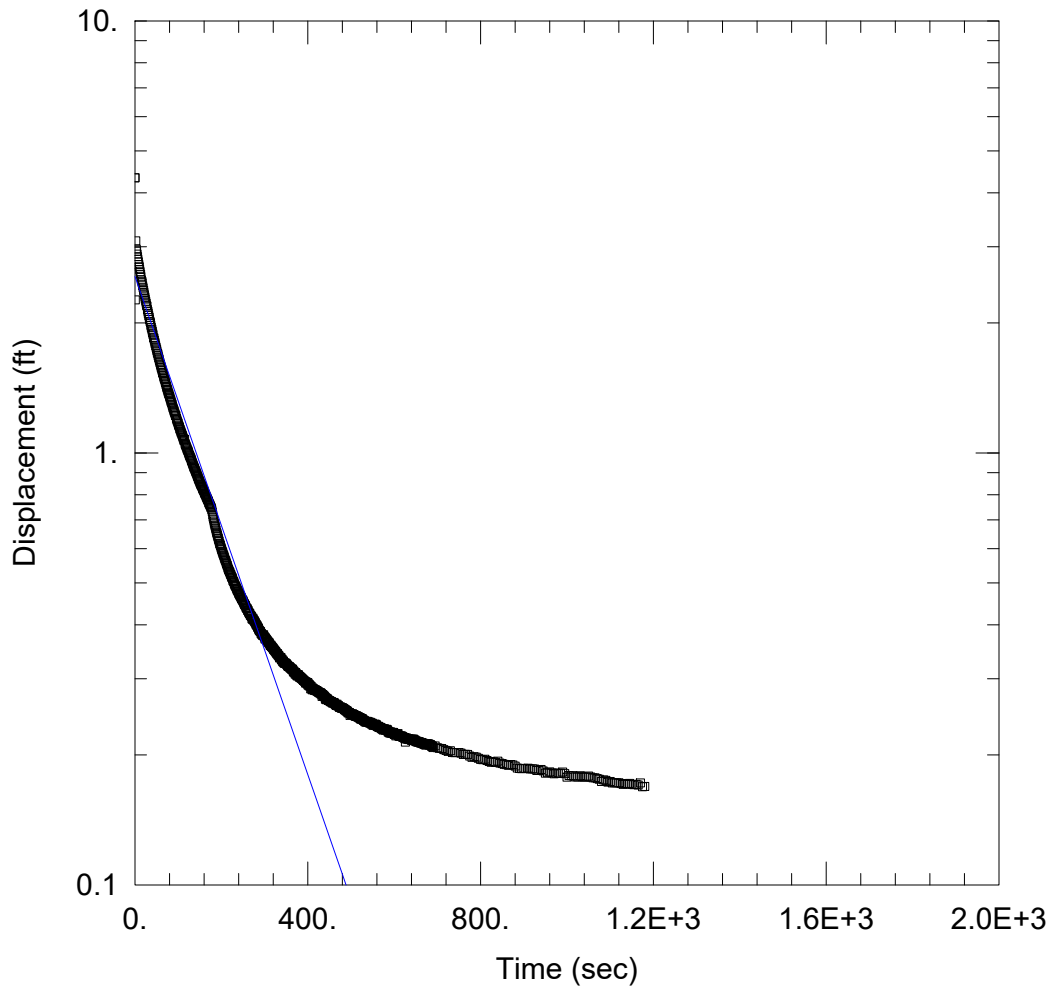
Initial Displacement: 5.191 ft
 Total Well Penetration Depth: 89.9 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 65.31 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 1.429E-5 ft/sec

Solution Method: Hvorslev
 y0 = 2.822 ft



CF-19-08D-IN2

Data Set: \...\CF-19-08D-IN2.aqt
 Date: 05/31/19

Time: 14:27:00

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-08D
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-08D)

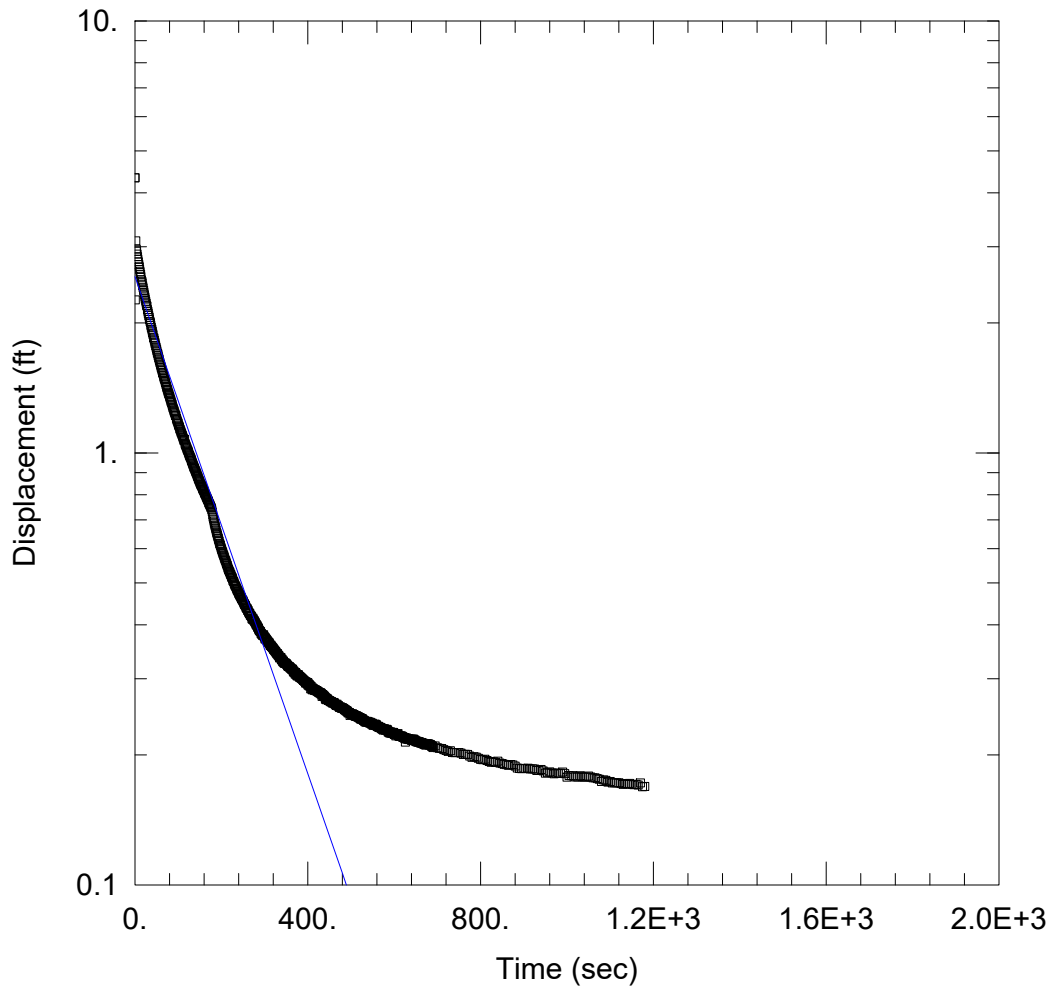
Initial Displacement: 4.335 ft
 Total Well Penetration Depth: 89.9 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 65.31 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 1.152E-5 ft/sec

Solution Method: Bouwer-Rice
 y0 = 2.561 ft



CF-19-08D-IN2

Data Set: \...\CF-19-08D-IN2.aqt
 Date: 05/31/19

Time: 14:27:28

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-08D
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-08D)

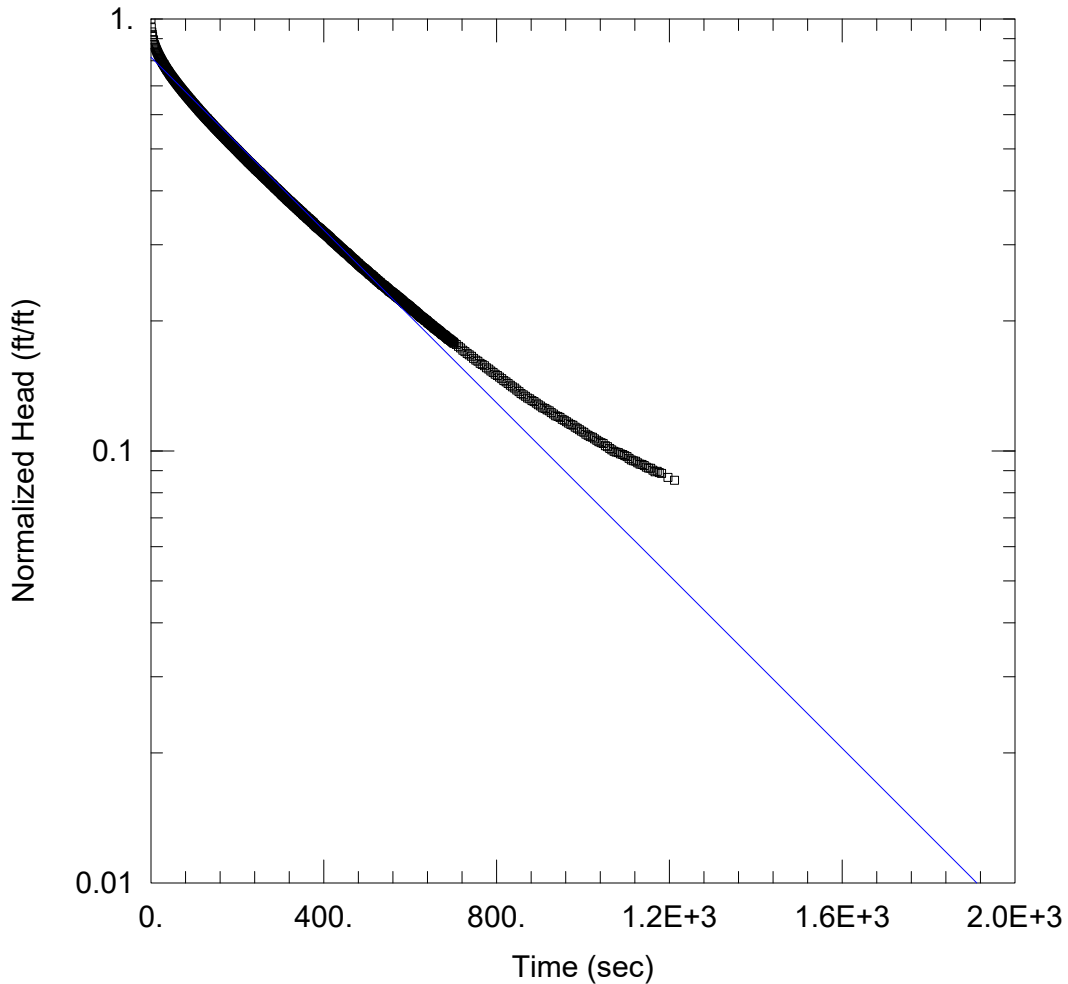
Initial Displacement: 4.335 ft
 Total Well Penetration Depth: 89.9 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 65.31 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 1.209E-5 ft/sec

Solution Method: Hvorslev
 y0 = 2.559 ft



CF-19-08D-OUT1

Data Set: \...\CF-19-08D-OUT1.aqt
 Date: 05/31/19

Time: 14:18:00

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-08D
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-08D)

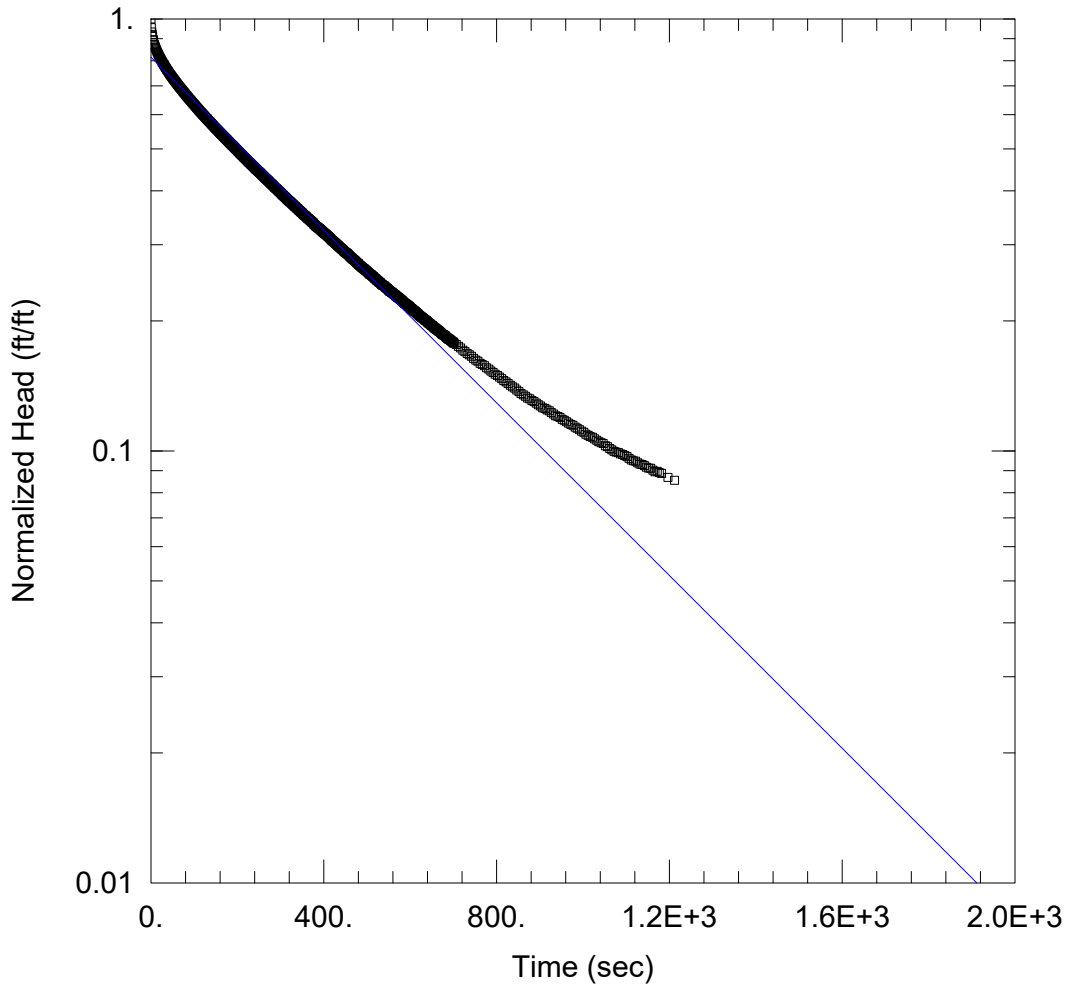
Initial Displacement: -3.113 ft
 Total Well Penetration Depth: 89.9 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 65.31 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 3.995E-6 ft/sec

Solution Method: Bouwer-Rice
 y0 = -2.537 ft



CF-19-08D-OUT1

Data Set: \...\CF-19-08D-OUT1.aqt
Date: 05/31/19

Time: 14:19:05

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-08D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-08D)

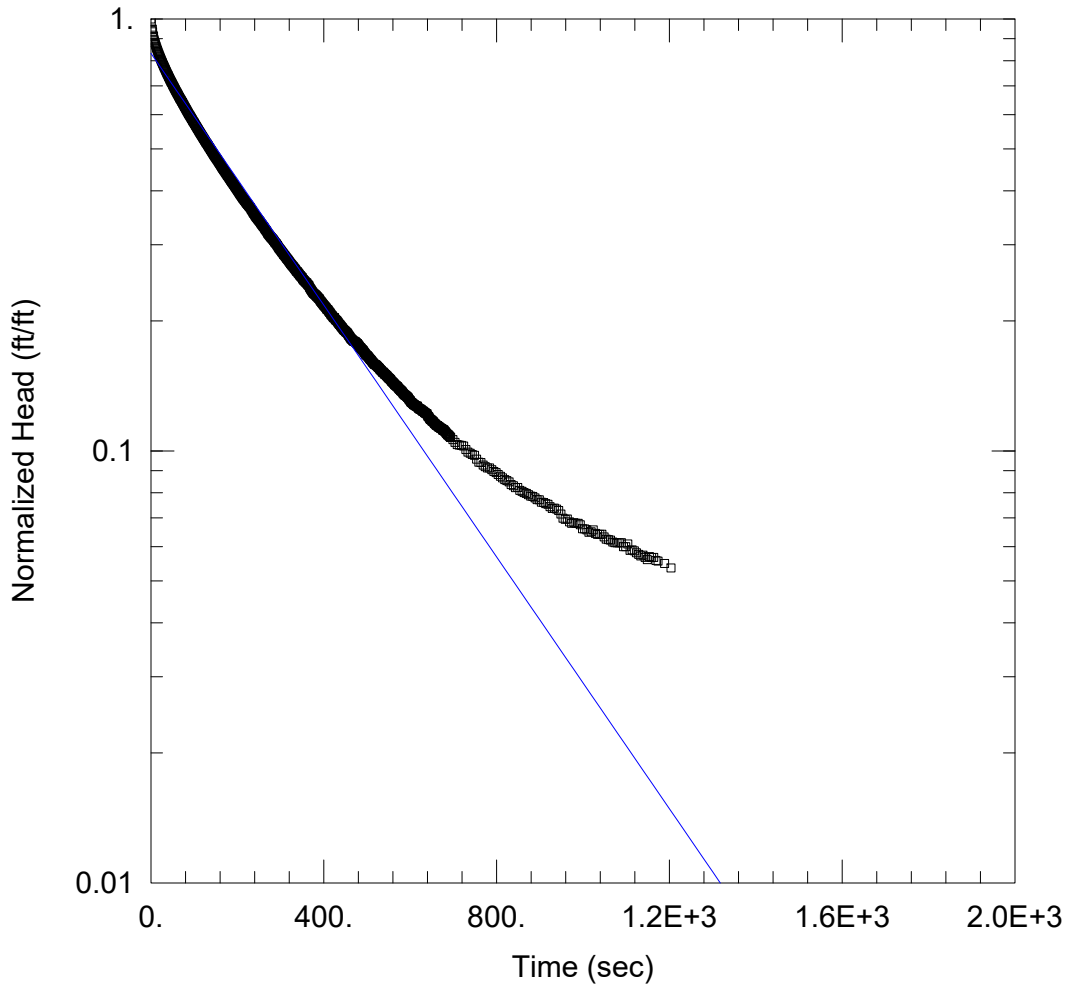
Initial Displacement: -3.113 ft
Total Well Penetration Depth: 89.9 ft
Casing Radius: 0.083 ft

Static Water Column Height: 65.31 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
K = 4.201E-6 ft/sec

Solution Method: Hvorslev
y0 = -2.537 ft



CF-19-08D-OUT2

Data Set: \...\CF-19-08D-OUT2.aqt
 Date: 05/31/19

Time: 14:34:49

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-08D
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-08D)

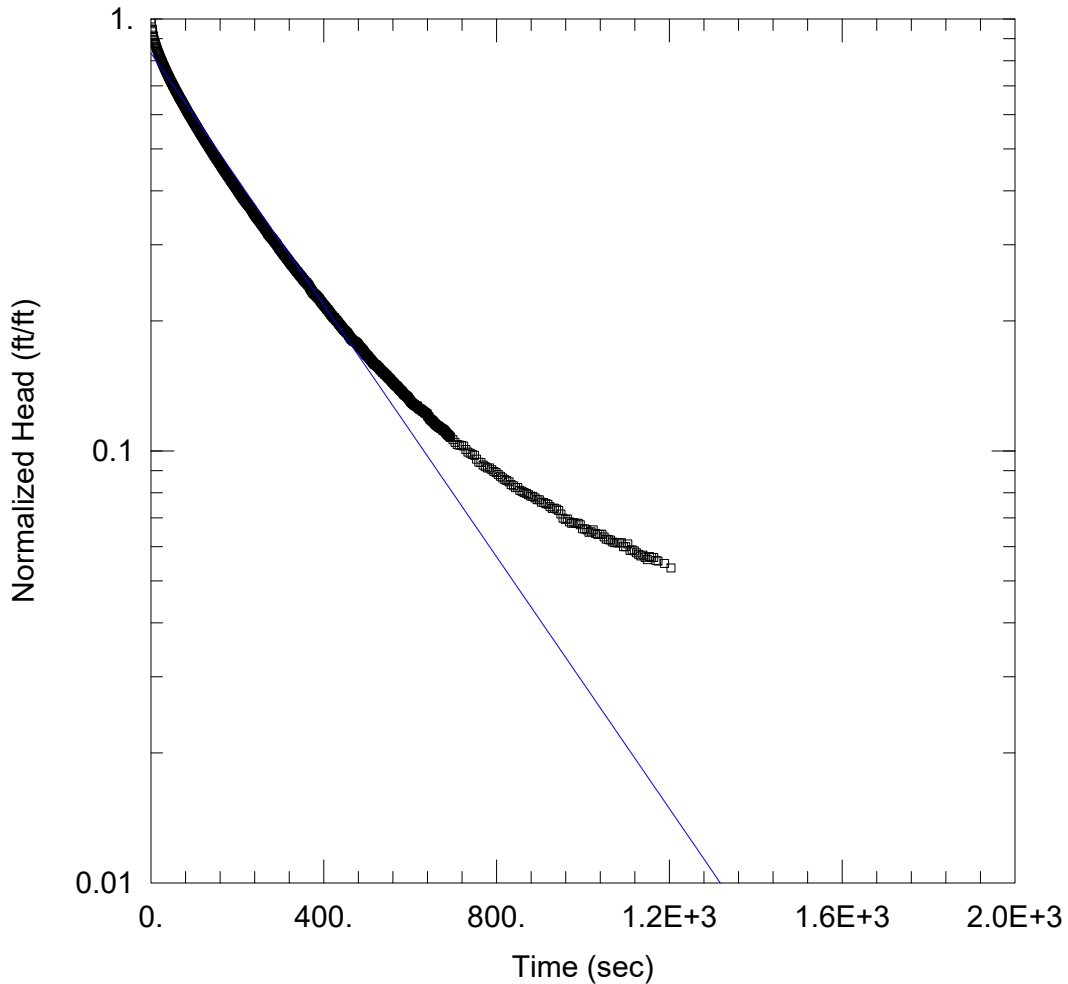
Initial Displacement: -2.969 ft
 Total Well Penetration Depth: 89.9 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 65.31 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 5.823E-6 ft/sec

Solution Method: Bouwer-Rice
 y0 = -2.472 ft



CF-19-08D-OUT2

Data Set: \...\CF-19-08D-OUT2.aqt
 Date: 05/31/19

Time: 14:35:28

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-08D
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-08D)

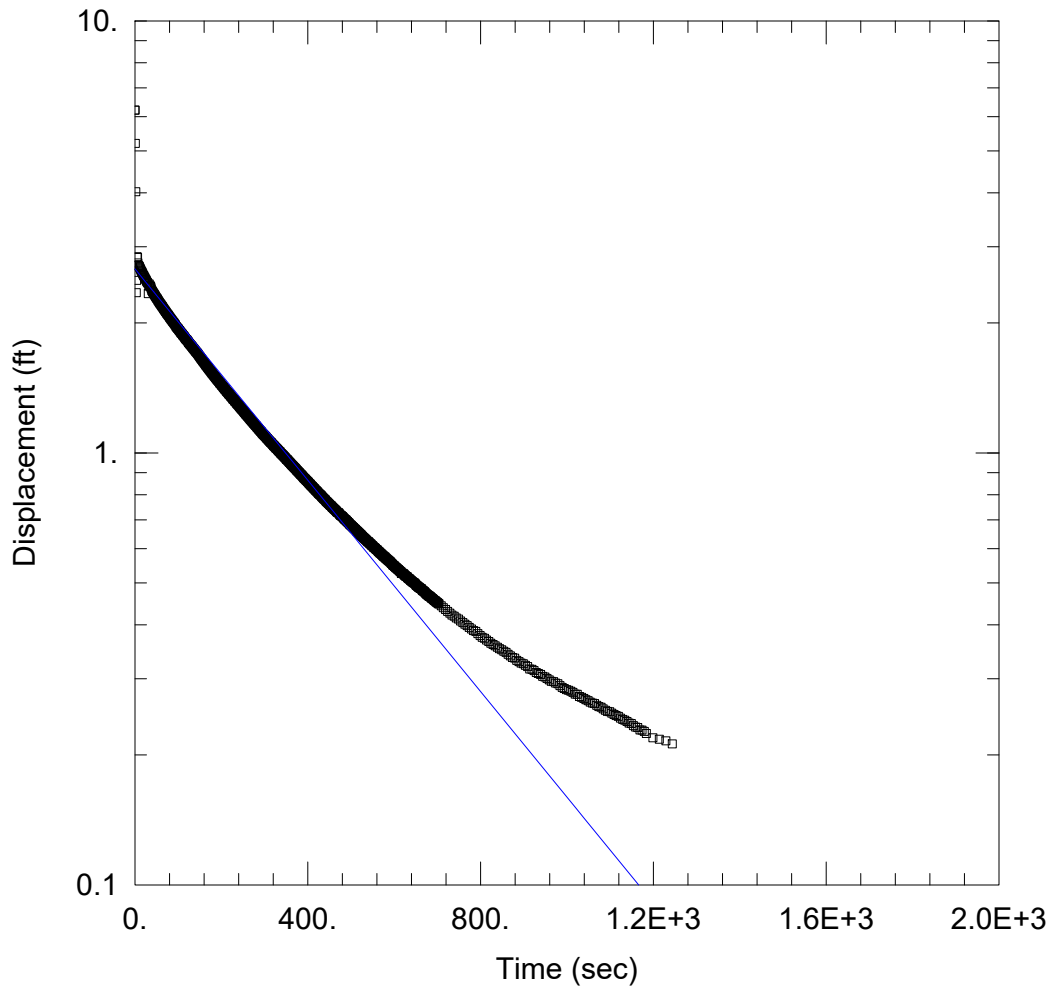
Initial Displacement: -2.969 ft
 Total Well Penetration Depth: 89.9 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 65.31 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 6.122E-6 ft/sec

Solution Method: Hvorslev
 y0 = -2.471 ft



CF-19-14-IN1

Data Set: \...\cf-19-14-in1.aqt
 Date: 05/30/19

Time: 14:52:50

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-14
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 14.05 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-14)

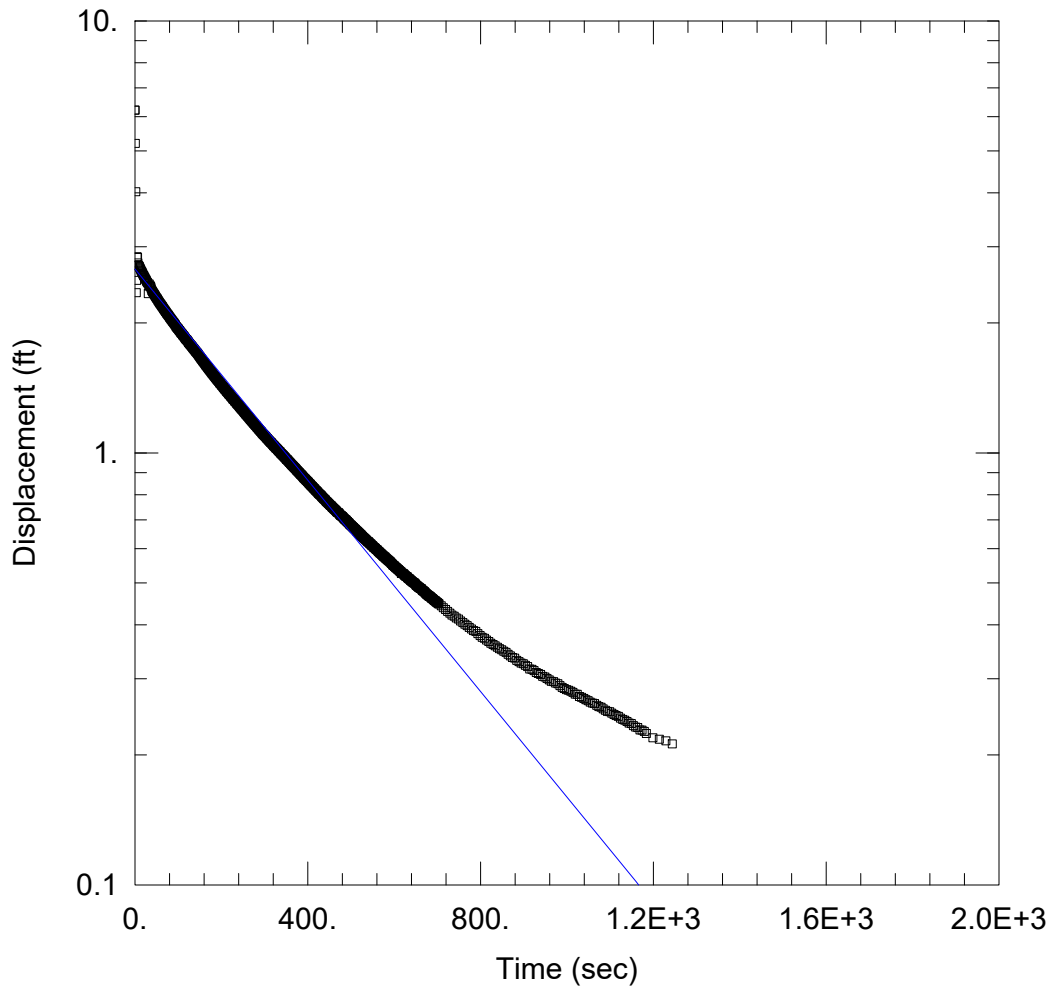
Initial Displacement: 6.214 ft
 Total Well Penetration Depth: 22. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 14.05 ft
 Screen Length: 10. ft
 Well Radius: 0.0833 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 4.099E-6 ft/sec

Solution Method: Bouwer-Rice
 y0 = 2.666 ft



CF-19-14-IN1

Data Set: \...\cf-19-14-in1.aqt
 Date: 05/30/19

Time: 14:53:35

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-14
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 14.05 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-14)

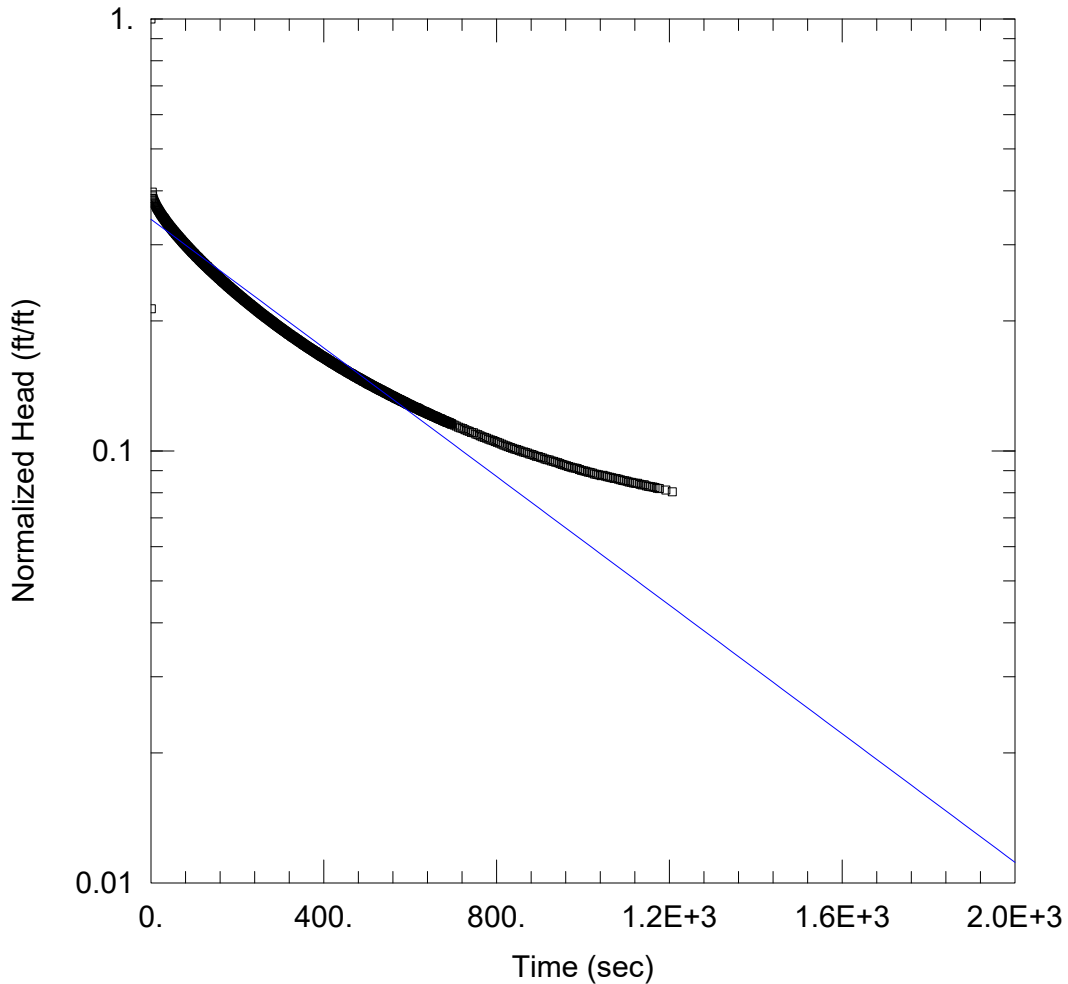
Initial Displacement: 6.214 ft
 Total Well Penetration Depth: 22. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 14.05 ft
 Screen Length: 10. ft
 Well Radius: 0.0833 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 5.354E-6 ft/sec

Solution Method: Hvorslev
 y0 = 2.666 ft



CF-19-14-OUT2

Data Set: \...\CF-19-14-OUT2.aqt
 Date: 05/30/19

Time: 14:57:13

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-14
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 14.05 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-14)

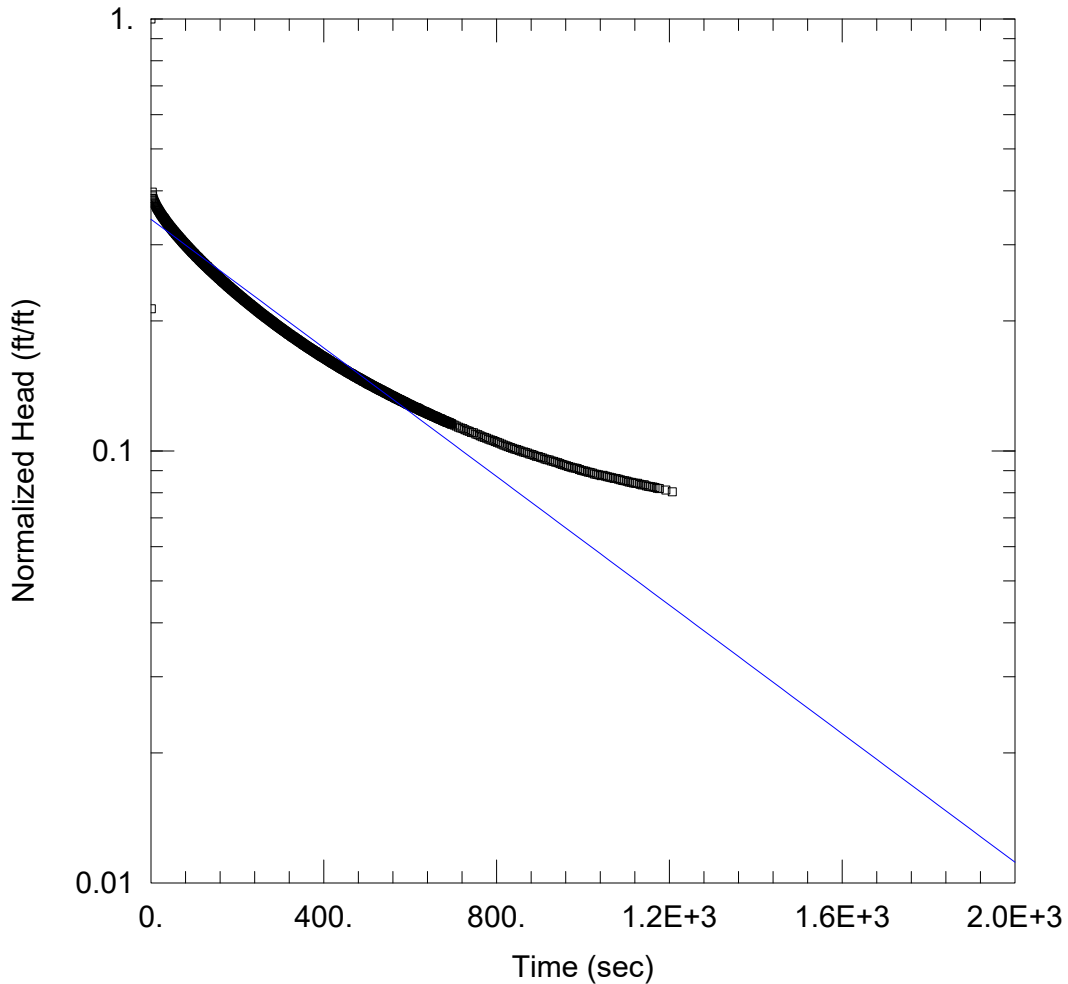
Initial Displacement: -7.572 ft
 Total Well Penetration Depth: 22.24 ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 14.05 ft
 Screen Length: 10. ft
 Well Radius: 0.0833 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 2.498E-6 ft/sec

Solution Method: Bouwer-Rice
 y0 = -2.602 ft



CF-19-14-OUT2

Data Set: \...\CF-19-14-OUT2.aqt
Date: 05/30/19

Time: 14:58:10

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-14
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 14.05 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-14)

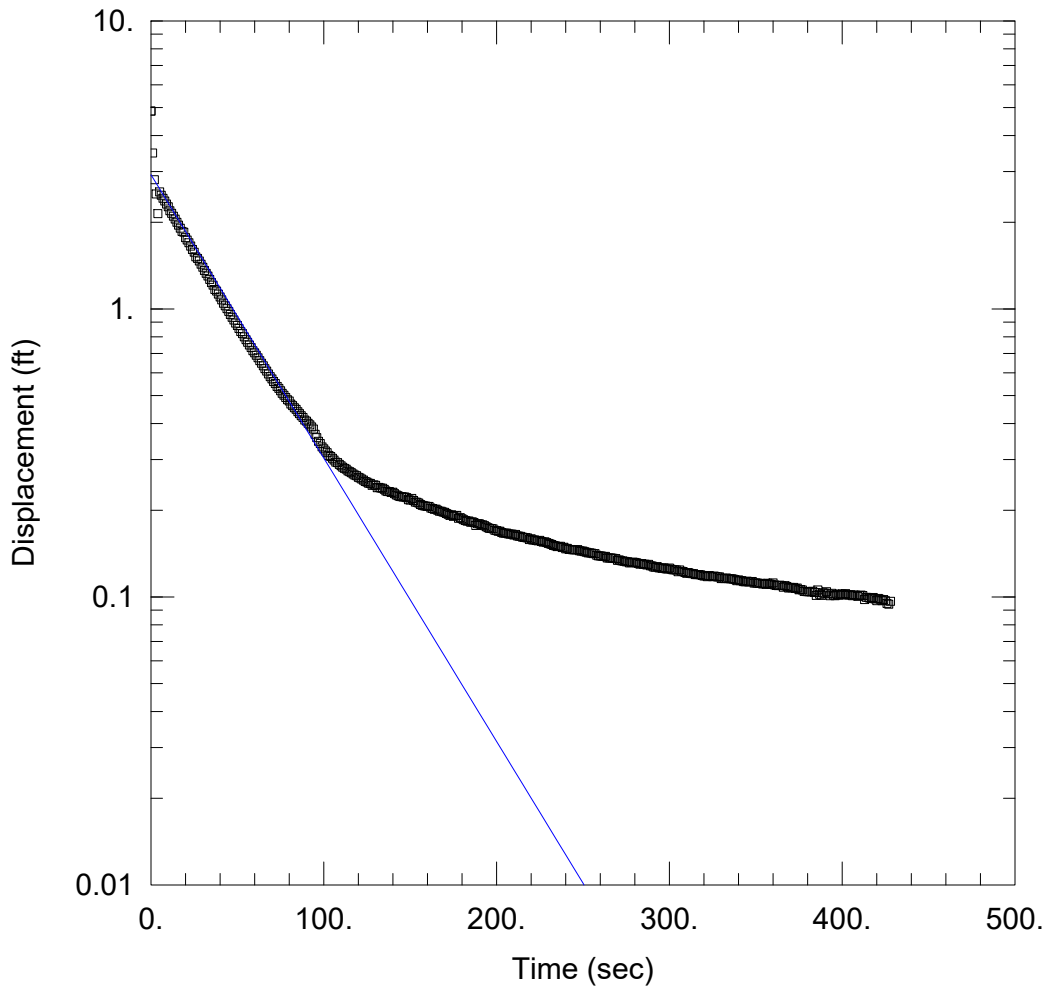
Initial Displacement: -7.572 ft
Total Well Penetration Depth: 22.24 ft
Casing Radius: 0.0833 ft

Static Water Column Height: 14.05 ft
Screen Length: 10. ft
Well Radius: 0.0833 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
K = 3.258E-6 ft/sec

Solution Method: Hvorslev
y0 = -2.602 ft



CF-19-15D-IN1

Data Set: \\...\CF-19-15DIN1.aqt
 Date: 05/31/19

Time: 13:51:42

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-15D
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15D)

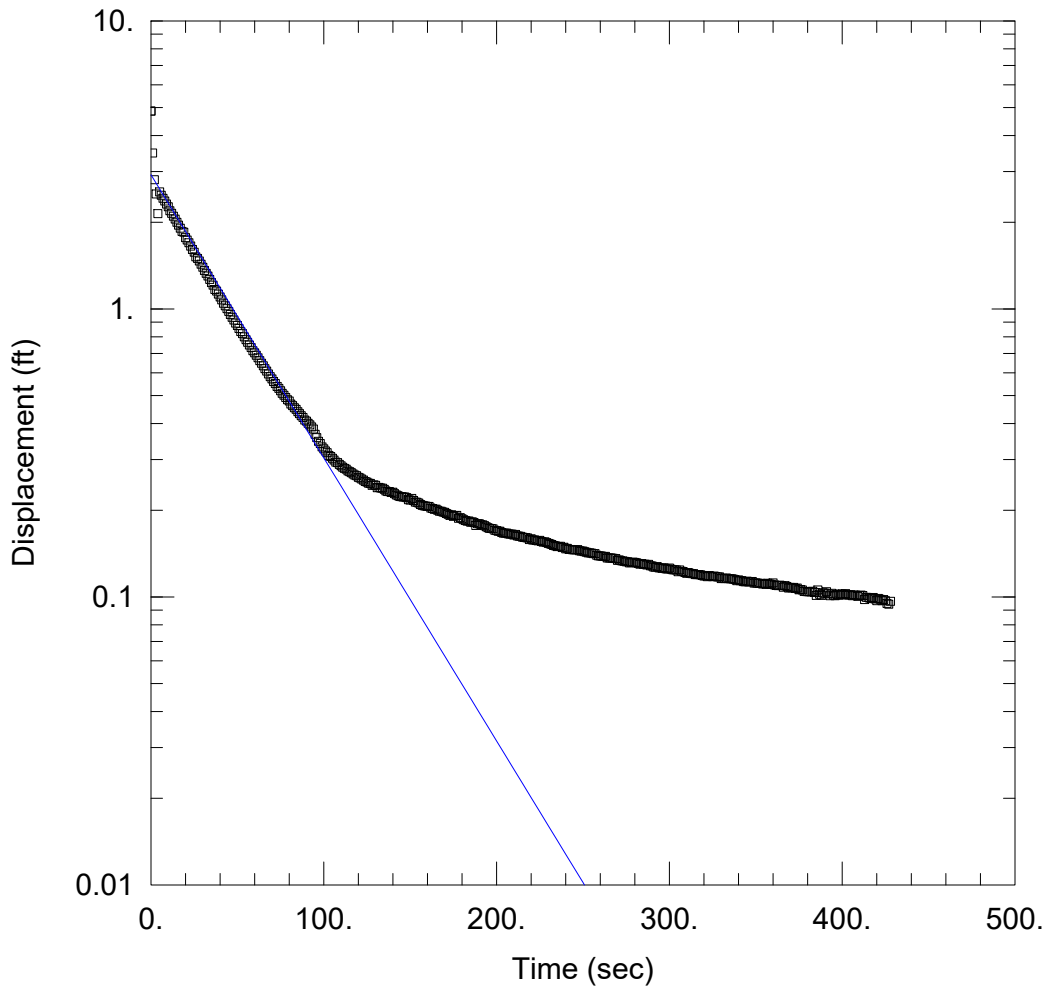
Initial Displacement: 4.865 ft
 Total Well Penetration Depth: 72.07 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 53.91 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 4.728E-5 ft/sec

Solution Method: Bouwer-Rice
 y0 = 2.923 ft



CF-19-15D-IN1

Data Set: \...\CF-19-15DIN1.aqt
 Date: 05/31/19

Time: 13:52:37

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-15D
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15D)

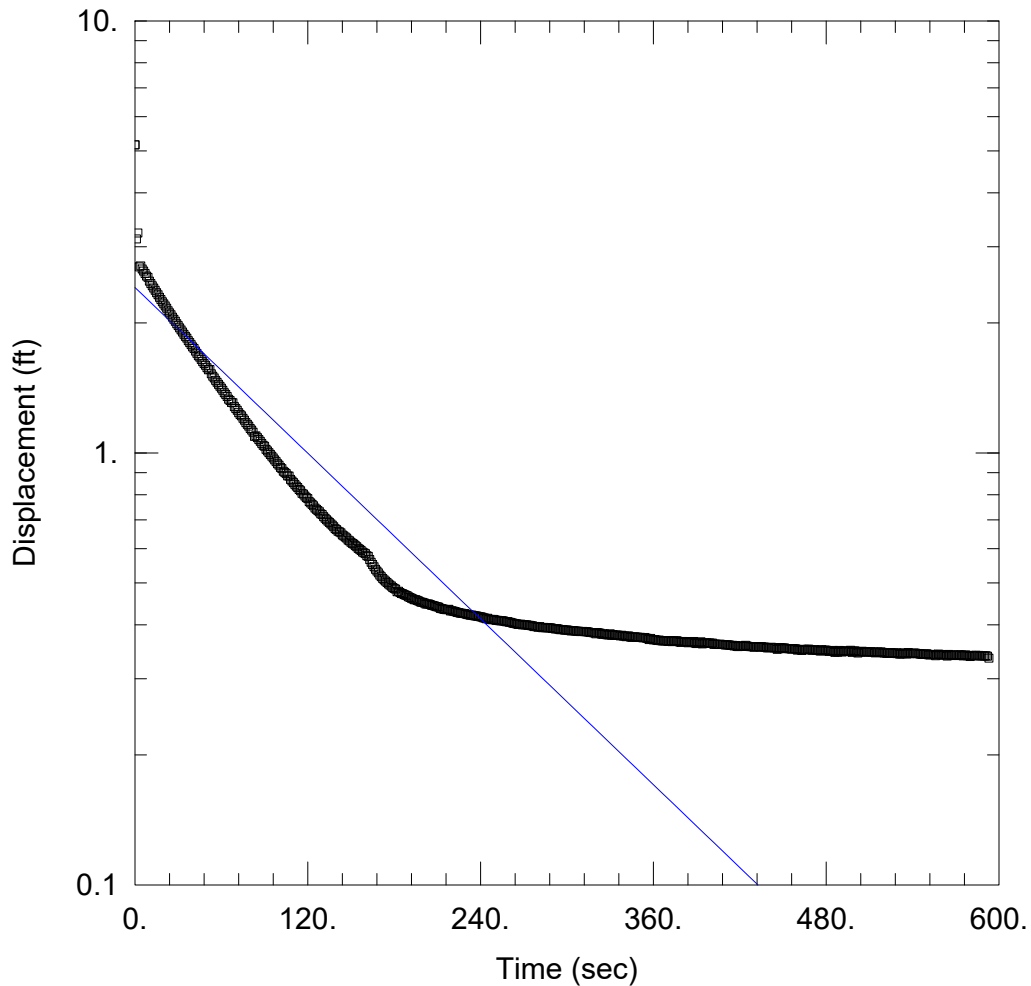
Initial Displacement: 4.865 ft
 Total Well Penetration Depth: 72.07 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 53.91 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 5.163E-5 ft/sec

Solution Method: Hvorslev
 y0 = 2.922 ft



CF-19-15D-IN2

Data Set: \...\CF-19-15D-IN2.aqt
 Date: 05/31/19

Time: 13:55:33

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-15D
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15D)

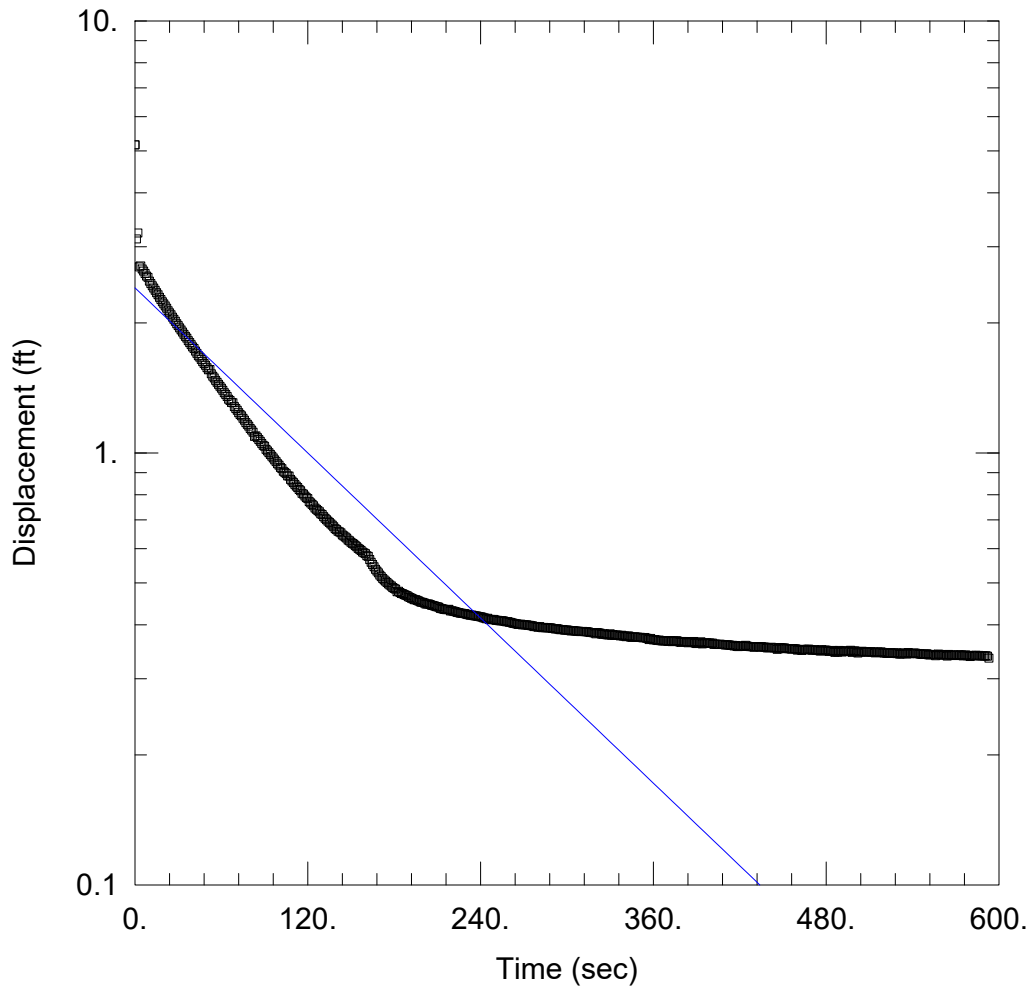
Initial Displacement: 5.168 ft
 Total Well Penetration Depth: 72.07 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 53.91 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 1.536E-5 ft/sec

Solution Method: Bower-Rice
 y0 = 2.415 ft



CF-19-15D-IN2

Data Set: \...\CF-19-15D-IN2.aqt
 Date: 05/31/19

Time: 13:56:41

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-15D
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15D)

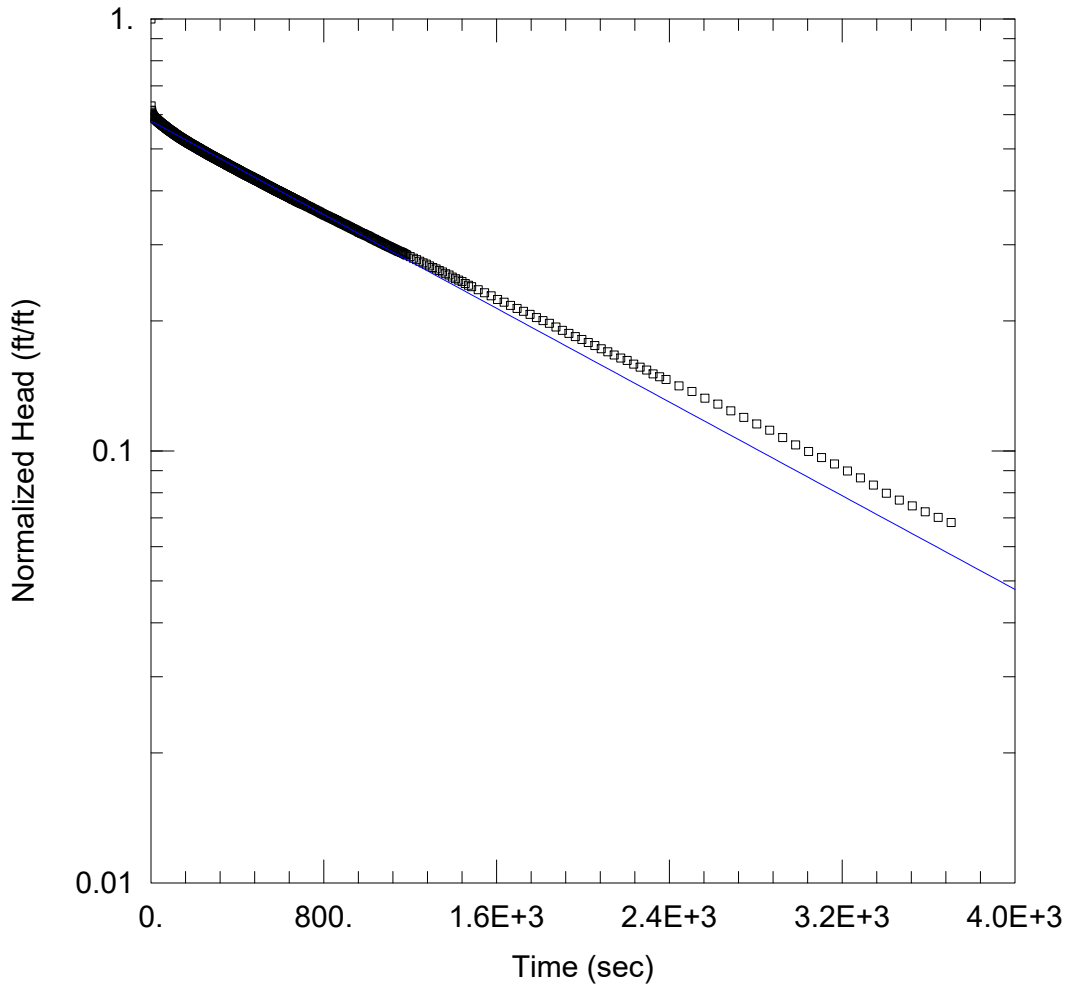
Initial Displacement: 5.168 ft
 Total Well Penetration Depth: 72.07 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 53.91 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 1.673E-5 ft/sec

Solution Method: Hvorslev
 y0 = 2.41 ft



CF-15D-OUT1

Data Set: \...\CF-19-15D-OUT1.aqt
 Date: 05/31/19

Time: 14:05:05

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-15D
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15D)

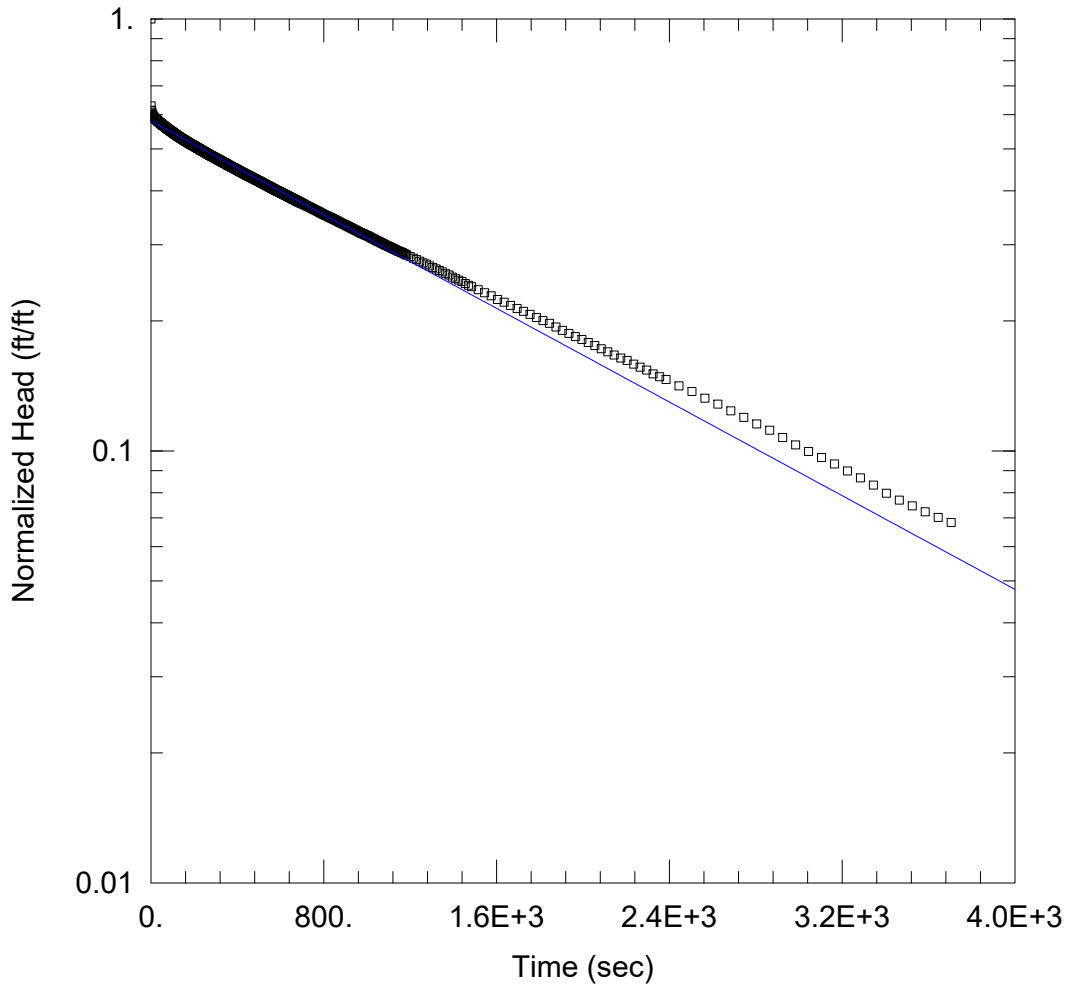
Initial Displacement: -5.008 ft
 Total Well Penetration Depth: 72.07 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 53.91 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 1.303E-6 ft/sec

Solution Method: Bower-Rice
 y0 = -2.906 ft



CF-15D-OUT1

Data Set: \...\CF-19-15D-OUT1.aqt
 Date: 05/31/19

Time: 14:05:43

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-15D
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15D)

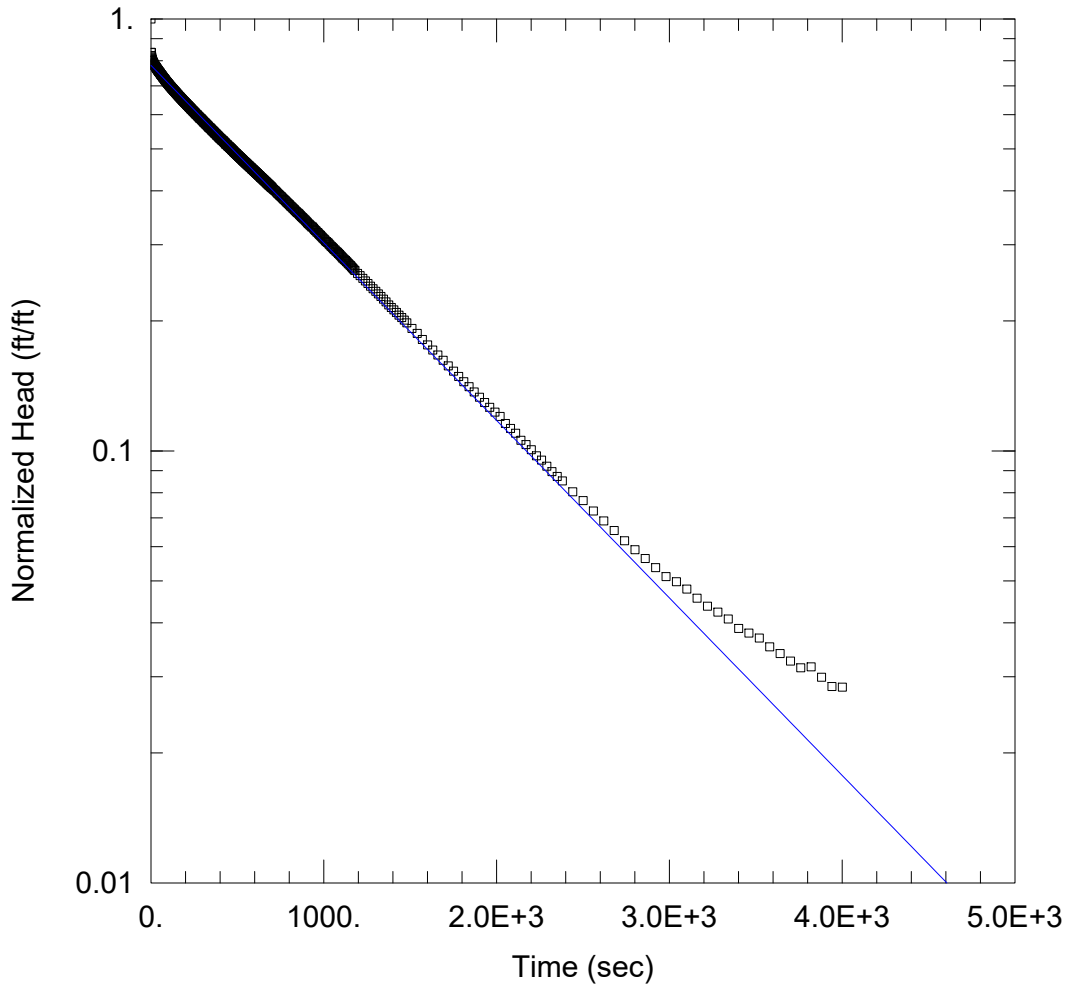
Initial Displacement: -5.008 ft
 Total Well Penetration Depth: 72.07 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 53.91 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 1.424E-6 ft/sec

Solution Method: Hvorslev
 y0 = -2.906 ft



CF-19-15D-OUT2

Data Set: \...\CF-19-15D-OUT2.aqt
Date: 05/31/19

Time: 14:13:00

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15D)

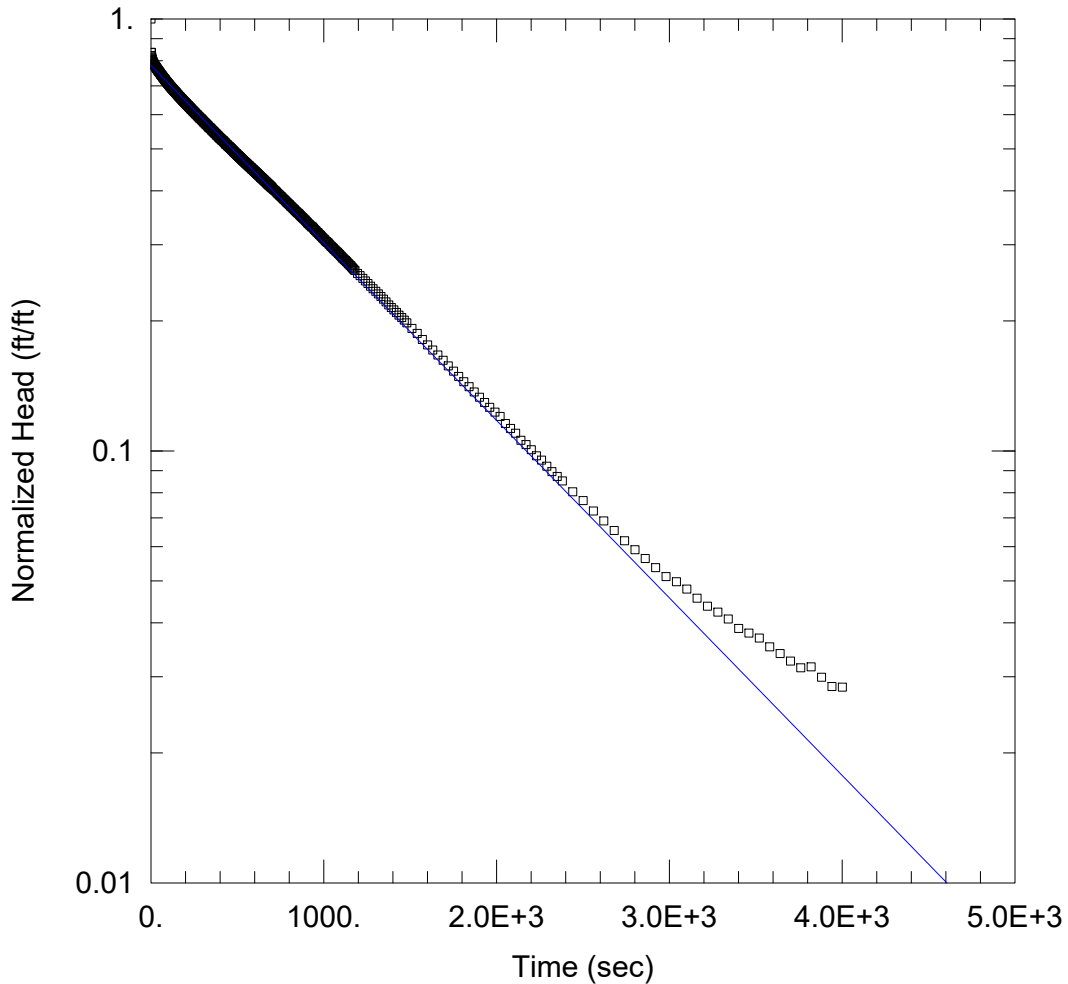
Initial Displacement: -3.748 ft
Total Well Penetration Depth: 72.07 ft
Casing Radius: 0.083 ft

Static Water Column Height: 53.91 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
K = 1.975E-6 ft/sec

Solution Method: Bouwer-Rice
y0 = -2.925 ft



CF-19-15D-OUT2

Data Set: \...\CF-19-15D-OUT2.aqt
Date: 05/31/19

Time: 14:13:52

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15D)

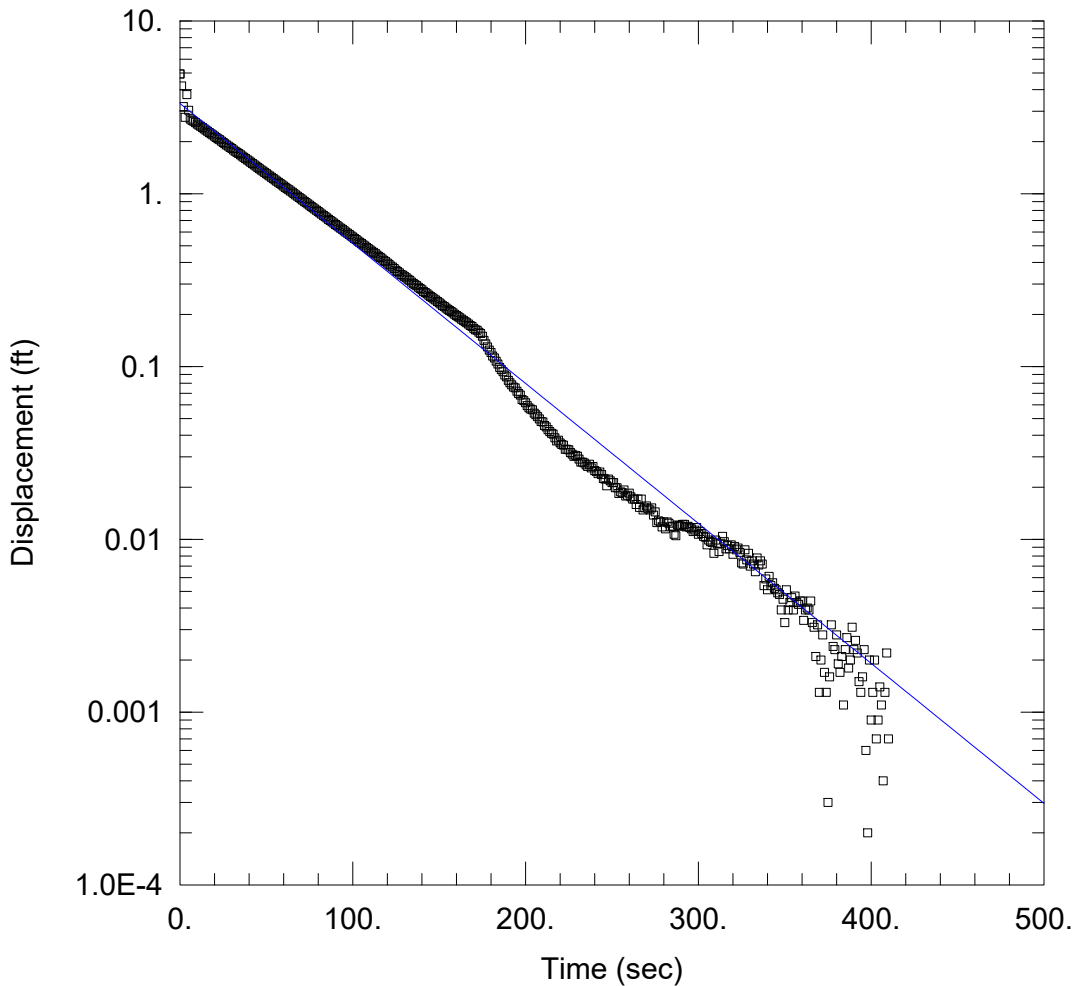
Initial Displacement: -3.748 ft
Total Well Penetration Depth: 72.07 ft
Casing Radius: 0.083 ft

Static Water Column Height: 53.91 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
K = 2.158E-6 ft/sec

Solution Method: Hvorslev
y0 = -2.925 ft



CF-19-15-IN1

Data Set: \...\CF-19-15-IN1.aqt
 Date: 05/30/19

Time: 15:13:07

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-15
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15)

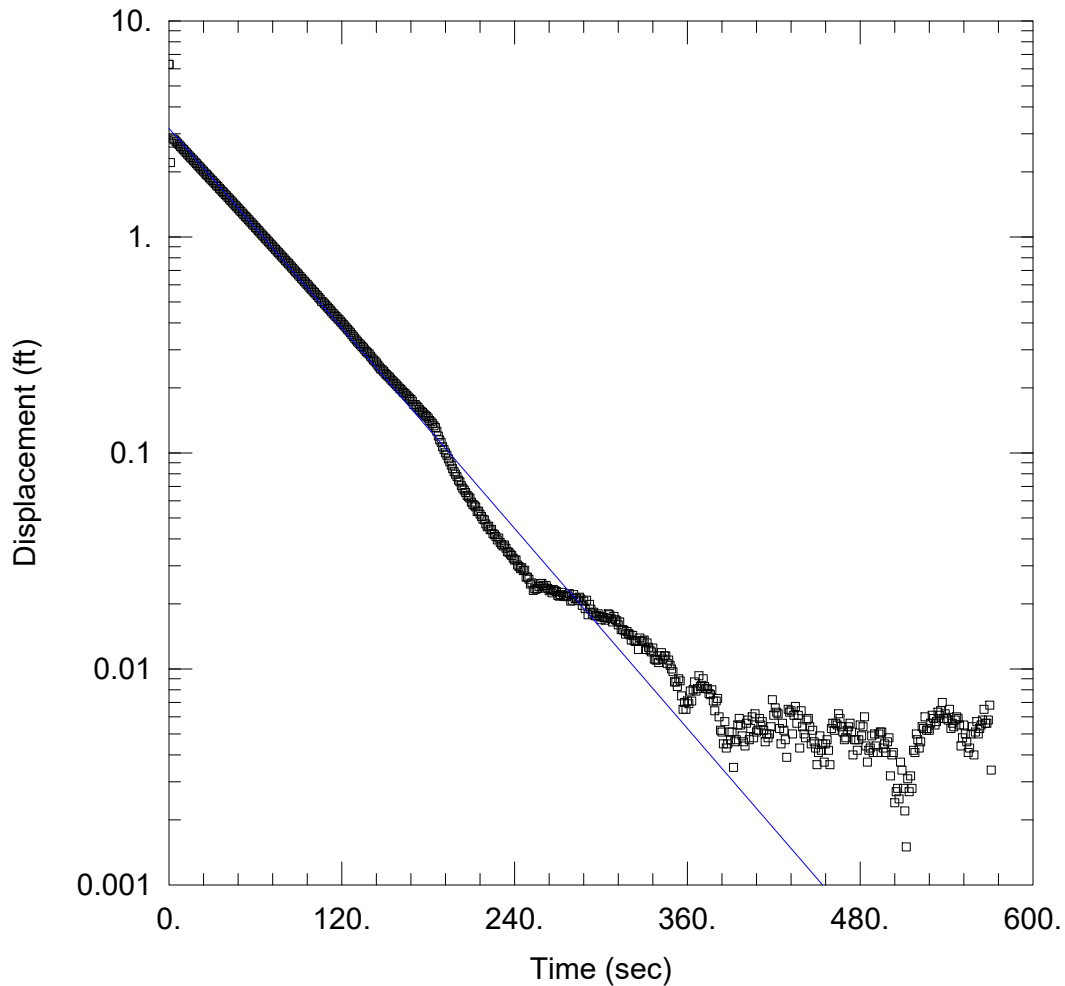
Initial Displacement: 4.937 ft
 Total Well Penetration Depth: 35.91 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 17.88 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 2.89E-5 ft/sec

Solution Method: Bower-Rice
 y0 = 3.327 ft



CF-19-15-IN2

Data Set: \...\CF-19-15-IN2.aqt
 Date: 05/30/19

Time: 15:43:33

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-15
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15)

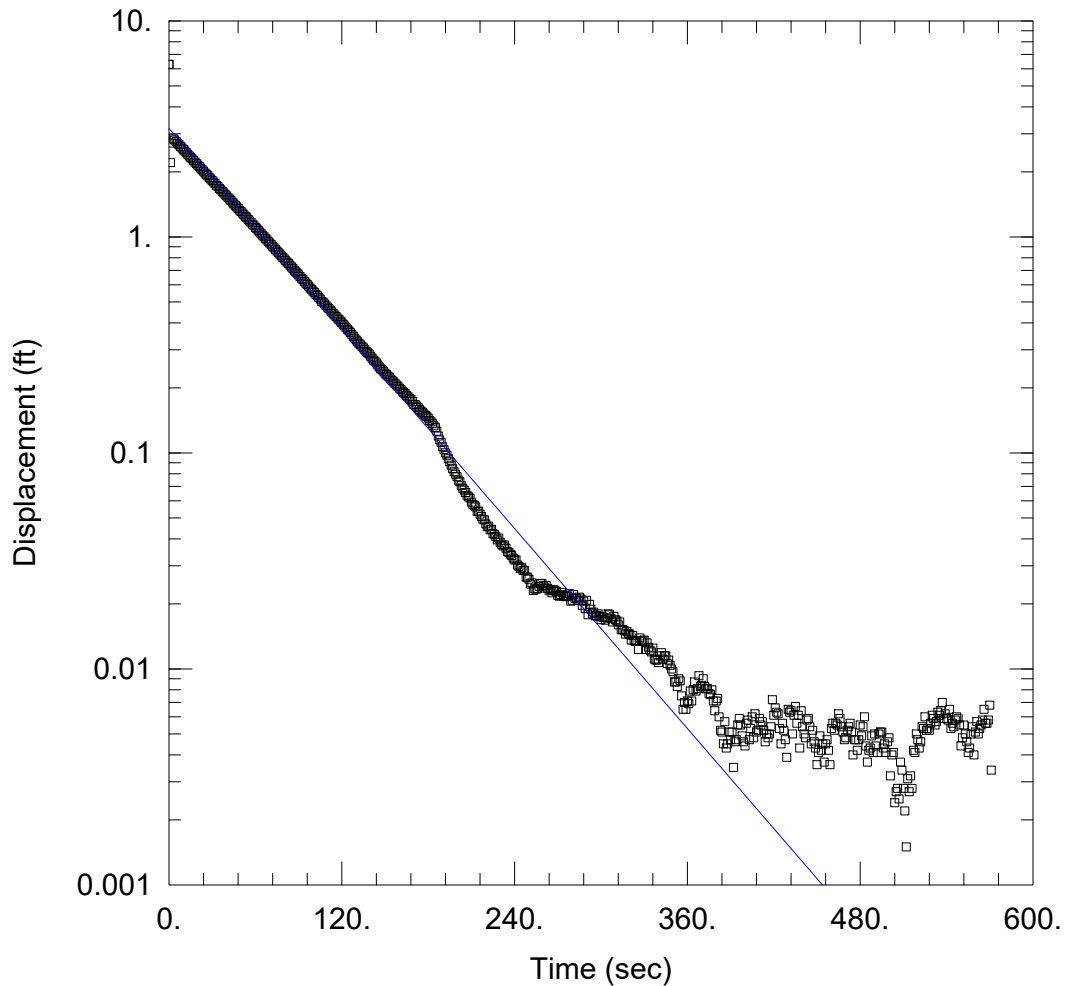
Initial Displacement: 6.297 ft
 Total Well Penetration Depth: 35.91 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 17.88 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 3.356E-5 ft/sec

Solution Method: Hvorslev
 y0 = 3.176 ft



CF-19-15-IN2

Data Set: \...\CF-19-15-IN2.aqt
Date: 05/31/19

Time: 13:41:24

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15)

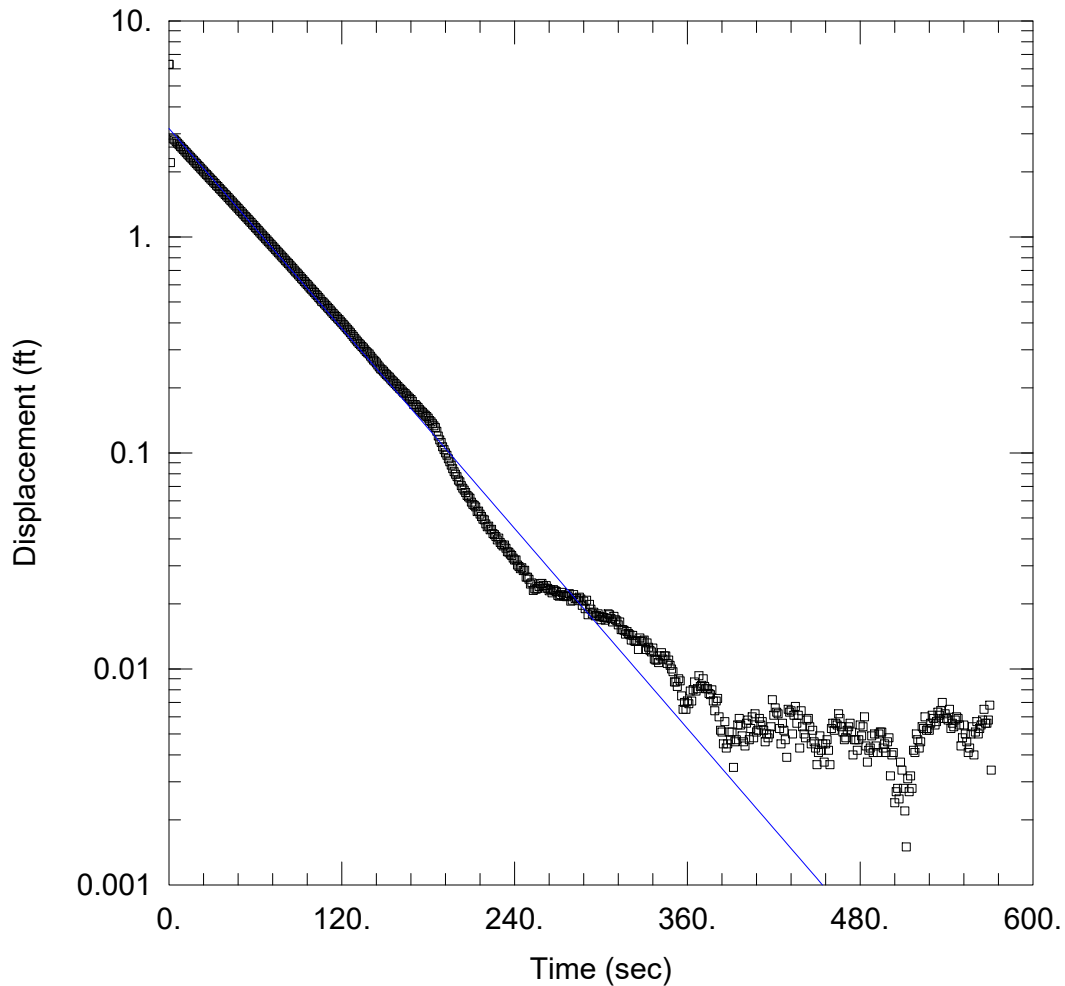
Initial Displacement: 6.297 ft
Total Well Penetration Depth: 35.91 ft
Casing Radius: 0.083 ft

Static Water Column Height: 17.88 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
K = 2.753E-5 ft/sec

Solution Method: Bower-Rice
y0 = 3.177 ft



CF-19-15-IN2

Data Set: \...\CF-19-15-IN2.aqt
 Date: 05/31/19

Time: 13:42:16

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-15
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15)

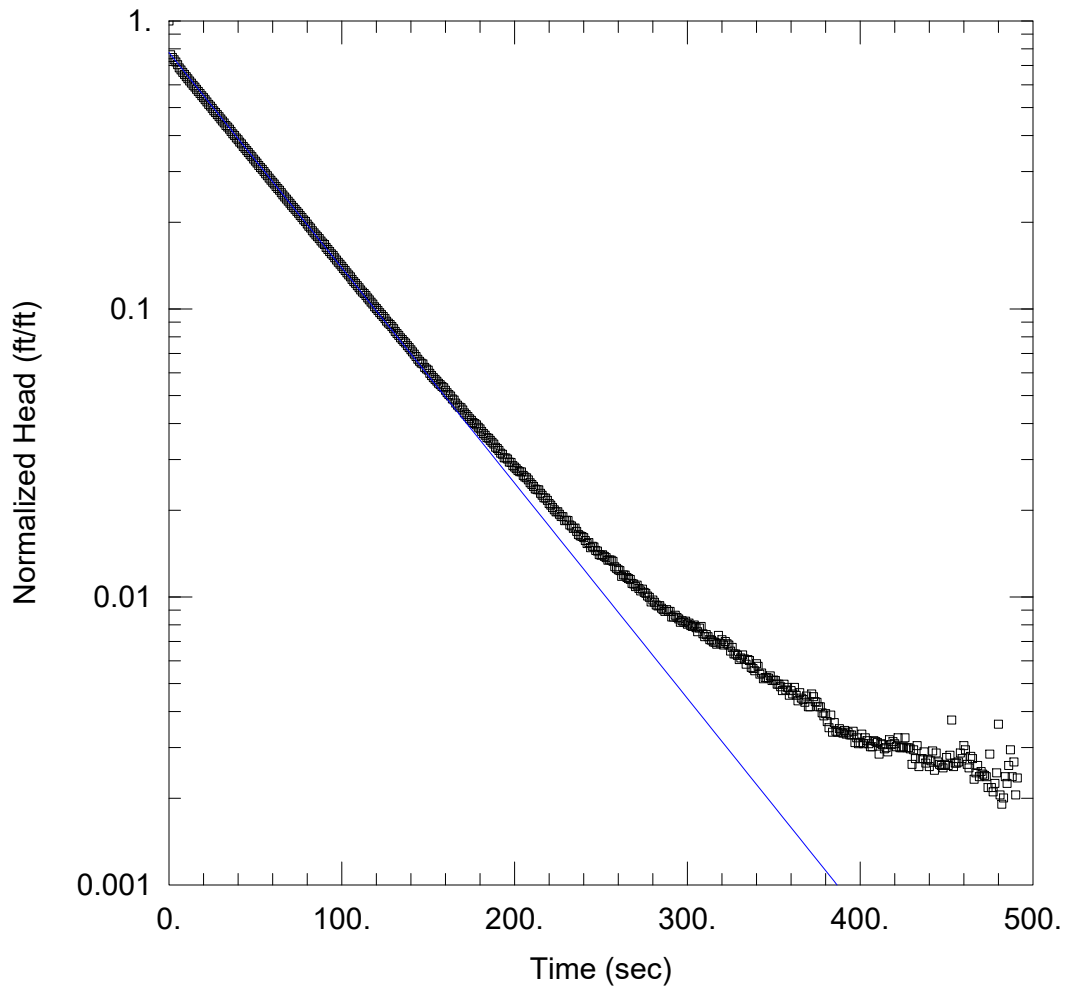
Initial Displacement: 6.297 ft
 Total Well Penetration Depth: 35.91 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 17.88 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 3.356E-5 ft/sec

Solution Method: Hvorslev
 y0 = 3.176 ft



CF-19-15-OUT1

Data Set: \\...\CF-19-15-OUT1.aqt
 Date: 05/31/19

Time: 13:45:04

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-15
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15)

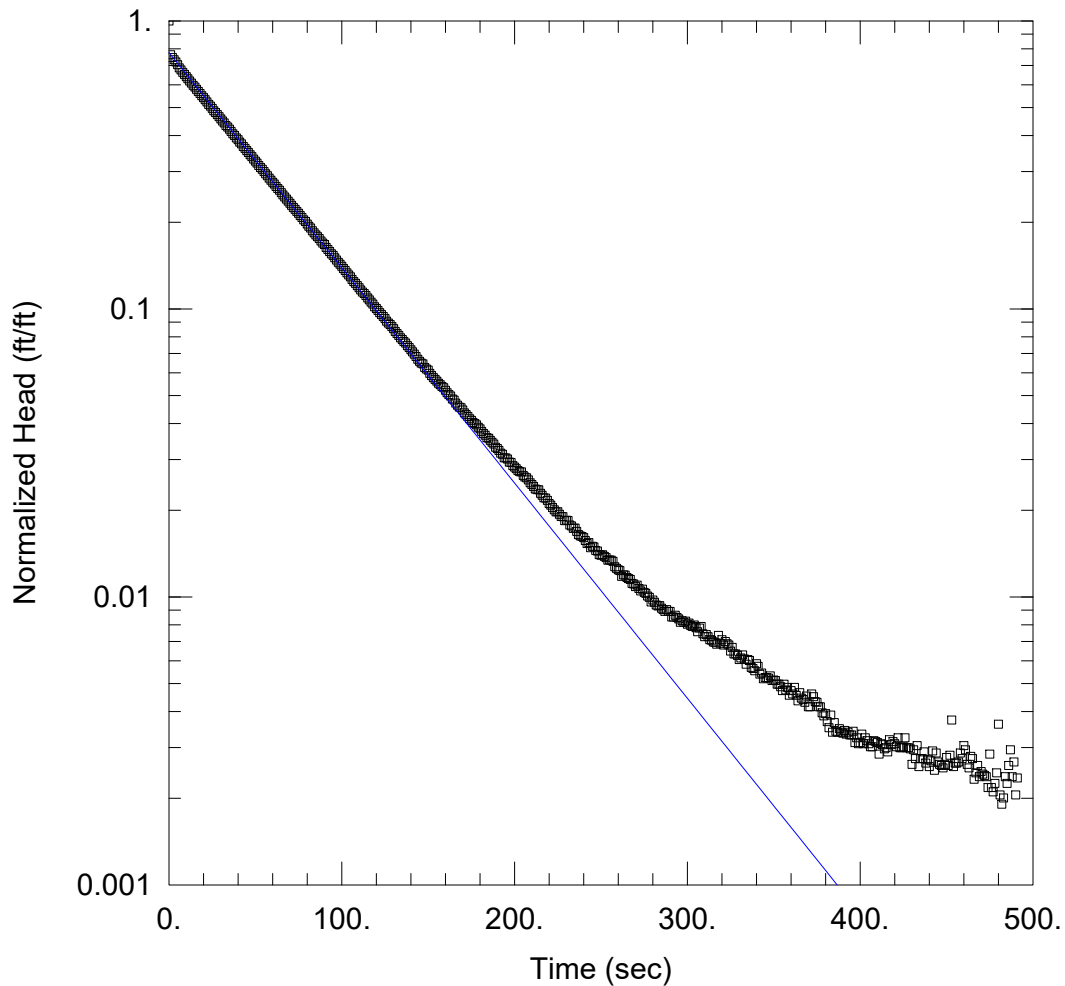
Initial Displacement: -4.041 ft
 Total Well Penetration Depth: 35.91 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 17.88 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 2.667E-5 ft/sec

Solution Method: Bower-Rice
 y0 = -3.137 ft



CF-19-15-OUT1

Data Set: \\...\CF-19-15-OUT1.aqt
 Date: 05/31/19

Time: 13:46:00

PROJECT INFORMATION

Company: AGES, Inc.
 Client: OVEC
 Project: 2019042-07
 Location: Clifty Creek
 Test Well: CF-19-15
 Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15)

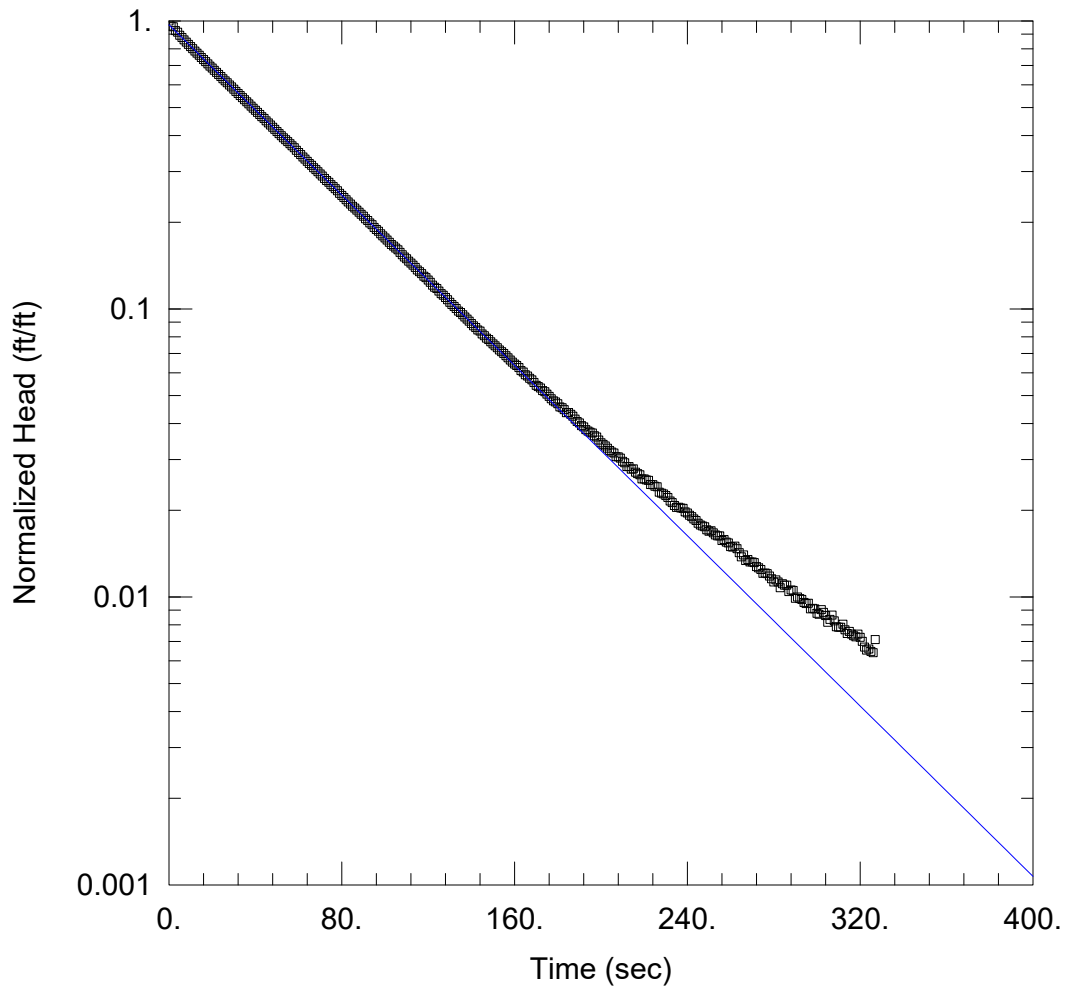
Initial Displacement: -4.041 ft
 Total Well Penetration Depth: 35.91 ft
 Casing Radius: 0.083 ft

Static Water Column Height: 17.88 ft
 Screen Length: 10. ft
 Well Radius: 0.083 ft
 Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
 K = 3.251E-5 ft/sec

Solution Method: Hvorslev
 y0 = -3.137 ft



CF-19-15-OUT2

Data Set: \...\CF-19-15-OUT2.aqt
Date: 05/31/19

Time: 13:48:21

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15)

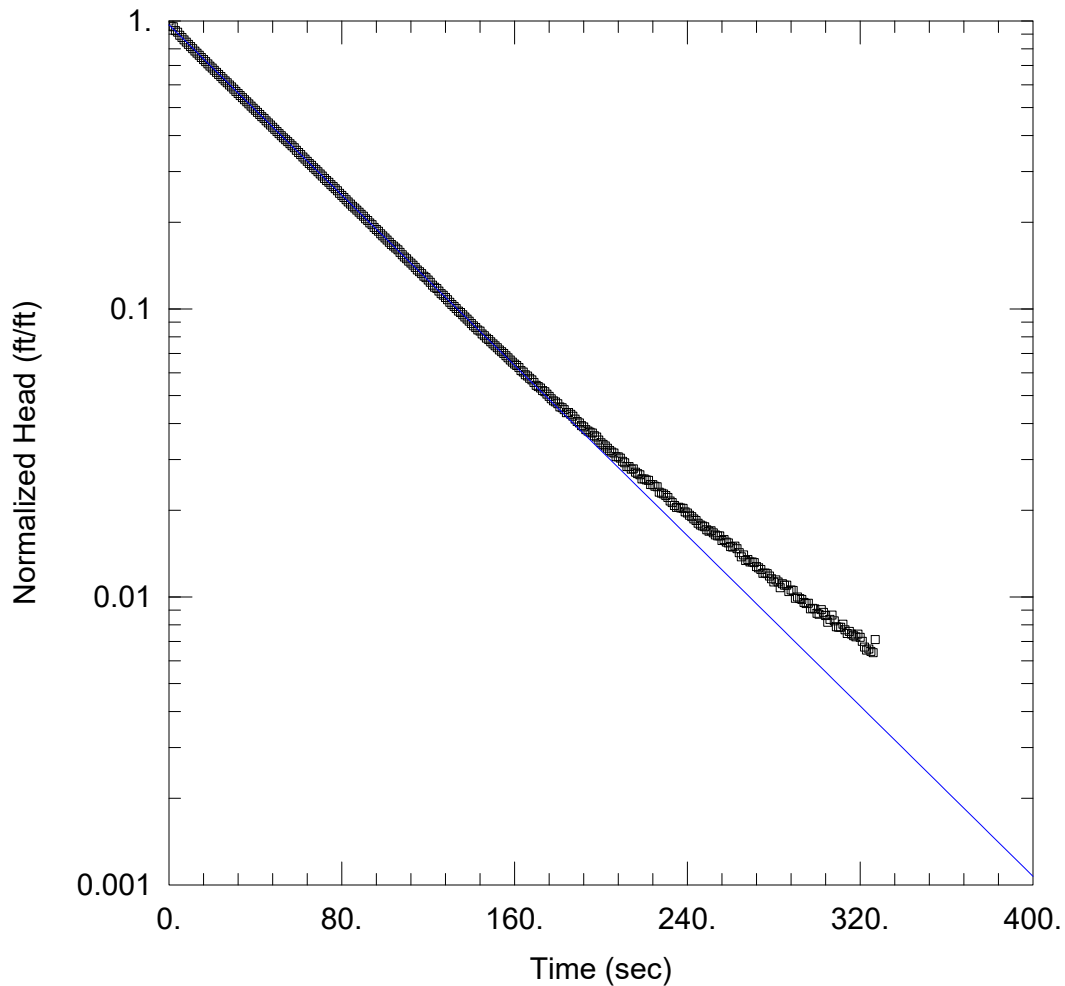
Initial Displacement: -3.123 ft
Total Well Penetration Depth: 35.91 ft
Casing Radius: 0.083 ft

Static Water Column Height: 17.88 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
K = 2.637E-5 ft/sec

Solution Method: Bouwer-Rice
y0 = -3.027 ft



CF-19-15-OUT2

Data Set: \...\CF-19-15-OUT2.aqt
Date: 05/31/19

Time: 13:49:06

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15)

Initial Displacement: -3.123 ft
Total Well Penetration Depth: 35.91 ft
Casing Radius: 0.083 ft

Static Water Column Height: 17.88 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
K = 3.215E-5 ft/sec

Solution Method: Hvorslev
y0 = -3.027 ft

APPENDIX F

**2020 UPDATE ON GROUNDWATER CONDITIONS
LRCP**

**2020 UPDATE ON GROUNDWATER CONDITIONS
LANDFILL RUNOFF COLLECTION POND (LRCP)
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA**

1.0 INTRODUCTION

The purpose of this 2020 Update Report is to provide an update on groundwater conditions at the Landfill Runoff Collection Pond (LRCP) at the Clifty Creek Station, located in Madison, Indiana. An Assessment of Corrective Measures (ACM) Report for the LRCP was prepared in September 2019 to comply with 40 CFR § 257.90(c) of the CCR Rule. That report documented the results of site characterization activities and ongoing monitoring that were the basis for the evaluation of potential corrective measure remedial technologies to address Molybdenum in shallow groundwater at the LRCP.

A groundwater monitoring program has been ongoing at the site since 2016; the locations of CCR wells at the site are shown on Figure F-1. As required by the CCR Rule, the results of these events have been documented in annual groundwater monitoring and corrective action reports and in the ACM Report for the LRCP. This 2020 Update Report includes an evaluation of results of groundwater monitoring conducted during the characterization event at the LRCP in March/April 2019 and monitoring events conducted a year later in March 2020 and September 2020, and the impact of these results on selection of a remedy to address Molybdenum in shallow groundwater at the site.

Presented below are an evaluation of shallow groundwater flow (including impacts of flooding from the nearby Ohio River) and a discussion of the extent of Molybdenum in shallow groundwater/the stability of the plume from March/April 2019 through September 2020. A discussion of the impact that these results have on the selection of remedy process at the site is then presented.

2.0 UPDATE ON SITE GEOLOGY & HYDROGEOLOGY

As presented in Section 3 of the ACM Report, the LRCP is located within a bedrock valley that consists of impermeable limestone and shale of the Ordovician Dillsboro formation, which is overlain by approximately 20 feet of clayey gravel with sand. The clayey gravel with sand is overlain by a lean clay with sand, which is overlain by a fine to medium sand with gravel, silt and clay (Figure F-2). The uppermost unit in the area is a surficial layer of silty clay.

A limestone ridge known as the Devil's Backbone runs northeast to southwest along the length of the Type I Landfill & LRCP (Figure F-3). The Devil's Backbone acts as an impermeable barrier

that forces groundwater passing beneath the Type I Landfill to flow either toward the northeast or toward the southwest. The area southwest of the LRCP is also located within the bedrock valley with the Devil's Backbone to the east and a very steep bedrock wall to the west (Figure F-4).

Based on historic aquifer testing conducted at the site, the upper silty clay deposits exhibit low permeability, do not yield adequate quantities of water to wells, and are considered to be an aquitard. The underlying fine-medium sand is considered to be an unconfined or possibly semi-confined aquifer and is therefore designated as the uppermost aquifer at the LRCP.

Groundwater monitoring wells were not installed on the north side of the LRCP as the area lies within an impermeable bedrock valley/channel that directs all groundwater flow toward the Ohio River through a relatively small area near the LRCP (Figure F-4). Based on extensive investigation, the Devil's Backbone extends beyond the dam of the LRCP and directs groundwater in this manner. Groundwater is further confined by the very steep bedrock wall that runs approximately parallel to the Devil's Backbone, on the west side of the area (Figure F-4). This bedrock configuration precludes the flow of groundwater to the east or west, even during flood events in the nearby Ohio River.

A deep aquifer is present at the site and is separated from the uppermost aquifer by a continuous layer of lean clay with sand, which acts as a hydraulic barrier between the units (Figure F-2). Two (2) wells (CF-19-08D and CF-19-15D) were installed in this aquifer during site characterization activities. Based on groundwater monitoring results, no impacts from Molybdenum have been observed in the deep aquifer; no further action is therefore required to evaluate the vertical extent of groundwater issues at the site.

3.0 REVIEW OF GROUNDWATER FLOW AT THE SITE

Complete rounds of groundwater level data were collected in the areas south of the LRCP in March/April 2019 (the site characterization event) and during routine monitoring in March 2020 and September 2020 (Attachment F-1). Groundwater flow maps generated using these data indicates that groundwater in the uppermost aquifer beneath the LRCP flows to the south/southeast toward the Ohio River (Attachment F-2). Historic groundwater elevation data indicates that groundwater flow beneath the LRCP is affected by the flow and water level in the Ohio River and, as discussed above, evidence of several flow reversals have been observed in the historic data (AGES 2018). The extent of the flow reversals is mitigated by the configuration of the bedrock valley at the site (Figure F-4).

Based on previous slug tests at the site, the mean K (hydraulic conductivity) value for the uppermost aquifer beneath the LRCP is 71.11 ft/day (AGES 2019). Using water level data collected in March/April 2019, March 2020 and September 2020 and this mean K value, the groundwater velocity for the uppermost aquifer beneath the LRCP was calculated using the following equation:

$$V=K (i/n)$$

Where:

K=Hydraulic Conductivity (ft/day)

i=Gradient (Dimensionless)

n=20% (Effective Porosity-From Fetter 1980)

The results are summarized below:

Sampling Event	Groundwater Flow Velocity (ft/day)
March/April 2019	7.4
March 2020	14.2
September 2020	6.3
Mean	9.3

With a mean flow velocity of 9.3 ft/day and a distance between wells CF-15-08 and CF-19-15 (at the property boundary) of approximately 523 feet, the travel time for groundwater to flow between CF-15-08 and CF-19-15 is approximately 56 days. Calculations of groundwater flow velocity were performed using the same approach as presented in Section 5 of the ACM Report.

4.0 EXTENT AND MASS OF MOLYBDENUM IN UPPERMOST AQUIFER

Monitoring wells at the LRCP were sampled for analysis of Molybdenum during the three (3) events noted below:

Molybdenum Concentrations in ug/L					
Sampling Event	CF-15-07	CF-15-08	CF-15-09	CF-19-14	CF-19-15
March/April 2019	4.9	380	100	12	1.1
March 2020	110	240	85	9.5	6.1
September 2020	5.3	400	100	9	1.4 J

Note: ug/L = micrograms per liter.

In March/April 2019, Molybdenum concentrations south of the LRCP ranged from 1.1 micrograms per liter (ug/L) in CF-19-15 to 380 ug/L in CF-15-08 (Figure F-5). In March 2020, Molybdenum concentrations in the area ranged from 6.1 ug/L in CF-19-15 to 240 ug/L in CF-15-08 (Figure F-5). In September 2020, Molybdenum concentrations in the area ranged from 1.4 ug/L in CF-19-15 to 400 ug/L in CF-15-08 (Figure F-5). All Molybdenum results for the two (2) shallow wells at the property boundary (CF-19-14 and CF-19-15) were less than the Groundwater Protection Standard (GWPS) of 100 ug/L during all events. Based on these results, Molybdenum

concentrations in the uppermost aquifer exceeding the GWPS of 100 ug/L are confined to the site and are not reaching the Ohio River.

To evaluate Molybdenum concentrations in groundwater over time, time-series graphs for groundwater monitoring wells CF-15-07, CF-15-08 and CF-15-09 were developed for 2016 through 2020 and are presented in Attachment F-3. As shown, Molybdenum concentrations in the wells were relatively stable. With the exception of one (1) event (March 2020) at well CF-15-07, Molybdenum concentrations ranged 1.57 to 12.8 ug/L. In March 2020, the Molybdenum concentration at CF-15-07 was 110 ug/L; however, the well was resampled in June 2020 and the result was 10 ug/L. At well CF-15-08, Molybdenum results ranged from 196 ug/L to 524 ug/L; at well CF-15-09, results ranged from 38.2 ug/L to 100 ug/L. No significant downward or upward trends are apparent in the data, indicating relatively stable plume conditions in the area.

To develop a rough approximation of the mass of Molybdenum in groundwater at the LRCP, iso-concentration maps with a contour interval of 100 ug/L were first developed for the plume area for each of the monitoring events (Attachment F-4). The plume area was defined as the entire area of the uppermost aquifer between the steep bedrock valley and the Devil's Backbone. The areas between the iso-concentration lines were then assigned the mean value from the adjacent lines. The square footage for each area was then estimated from a map and multiplied by 20 feet, which is the average saturated thickness of the uppermost aquifer in the area; this provided the total volume of the uppermost aquifer in each area in cubic feet. The volume of groundwater was then calculated by multiplying the aquifer volume by the estimated porosity of the aquifer (20%); this value was then converted to liters. To estimate the mass of Molybdenum, the total volume of groundwater in each area (liters) was then multiplied by the assigned concentration in micrograms per liter. The resulting value was then converted to a tonnage:

Sampling Event	Tons of Molybdenum
March/April 2019	9.23
March 2020	6.74
September 2020	9.25

Note that these approximated mass calculations for Molybdenum are driven primarily by well CF-15-08, which exhibits the greatest Molybdenum concentration at the site. As with the other hydrogeologic characteristics in the area, the tonnage values appear to be relatively stable from March/April 2019 to September 2020, indicating stable plume conditions.

5.0 IMPACT OF RESULTS ON SELECTION OF REMEDY PROCESS

As presented in the ACM Report, the two (2) technologies that appear to be most likely for selection as a remedy were:

- Monitored Natural Attenuation (MNA); and
- Conventional Vertical Well System (Groundwater Extraction) (Ex-Situ).

Groundwater treatment would be required as a supplemental technology in conjunction with a Conventional Vertical Well System. The selection of a treatment technology would be based on conditions at the time of selection of a final remedy.

5.1 Review of MNA

As detailed above, the Molybdenum plume at the LRCP appears to be stable with neither a significant downward or upward trend in Molybdenum concentrations over the past years. In addition, the mass of Molybdenum in groundwater also appears to be stable from March/April 2019 through September 2020. These observed plume conditions indicate that natural attenuation, likely via dispersion and the mixing and spreading of constituents due to microscopic variations in velocity within and between interstitial voids in the uppermost aquifer, and dilution are likely acting to reduce Molybdenum concentrations in groundwater.

The LRCP is likely a current and ongoing source of Molybdenum to groundwater in the area. Upon closure of the LRCP, Molybdenum levels in groundwater would be anticipated to significantly decrease as a result. In combination with the observed natural attenuation processes, closure of the LRCP should provide a flexible and effective approach to groundwater remediation at the site. During the post-closure monitoring period, the positive impacts of closure and the effects of natural attenuation on groundwater quality can be fully evaluated and, if needed, other remedial technologies may be evaluated.

5.2 Review of Groundwater Extraction (Ex-Situ)

As discussed above, groundwater elevation data indicates that groundwater flow beneath the LRCP is affected by the flow and water level of the Ohio River and, as discussed above, evidence of several flow reversals and routine flooding of the land surface have been observed at the site. This type of flooding would have a significant impact on any groundwater extraction system that was installed south of the LRCP. While a conventional well system can be designed to accommodate fluctuations in groundwater elevations, flooding at the land surface would overrun the system and allow for a breakthrough impacted groundwater. In addition, land surface flooding would result in extreme maintenance issues with operation of the system and its reliability. This type of issue would effectively preclude the installation of an effective groundwater extraction system at the LRCP. Due to these same issues, it was not appropriate to install a temporary groundwater extraction system at the site but to work toward final closure of the LRCP.

Based on data collected to date, the uppermost aquifer south of the LRCP does not appear to be capable of supporting pumping rates likely need for an effective groundwater extraction system. Well CF-15-08 exhibits a K value of 71.11 ft/day and saturated thickness of approximately 20 feet;

this well is located within the center of the bedrock valley (Figure F-2) and might support an effective pumping rate. However, the hydraulic conductivity of the aquifer at well CF-19-14 (near CF-15-09) is only 0.01 ft/day. (Hydraulic testing data for wells CF-15-07 and CF-15-09 is not available.) This is likely due to differences in the depositional environment between the bedrock valley center and along the bedrock valley walls. Due to the bedrock valley walls, the saturated aquifer thickness for wells CF-15-07 and CF-15-09 is also less than 5 feet. Given these conditions, the aquifer in these areas would not likely support a pumping rate required for groundwater extraction.

5.3 Additional Groundwater Monitoring Well System Revision

In 2019, IKEC was notified by the Indiana Department of Environmental Management (IDEM) that additional groundwater monitoring wells would be required at the LRCP as part of the permit renewal for the Type I Restricted Waste Landfill. In March 2020, IKEC submitted to IDEM a work plan with the proposed additional wells; to date, final approval of the work plan from IDEM has not been received. These additional wells, with locations selected primarily by IDEM, are anticipated to provide additional information that may be pertinent to the final selected remedy once installation, development and sampling are complete. These new wells are anticipated to be installed early in 2021, as site conditions permit. Data from these wells will be used to support the selection of a final remedy at the LRCP, as appropriate.

5.4 Planned Work

Additional work needs to be performed to fully support the selection of the appropriate remedy for the site. That work will include, but may not be limited to:

- Continued sampling and analysis as part of the routine semi-annual program;
- Development of a three-dimensional site model;
- Continued evaluation of the effects of flood events on the site;
- Installation, development and sampling of additional wells, as required by IDEM;
- Continued development of time-series graphs to support site evaluation; and,
- Investigation of site geology and hydrogeology, as needed, to support the final closure and selection of a final remedy.

5.5 Conclusion

Based on the results of monitoring conducted from March/April 2019 through September 2020, the use of MNA as the selected remedy for the site is still supported; the use of groundwater extraction appears to be a less applicable technology. Data collected during the ongoing monitoring programs will be useful in confirming these conclusions.

6.0 REFERENCES

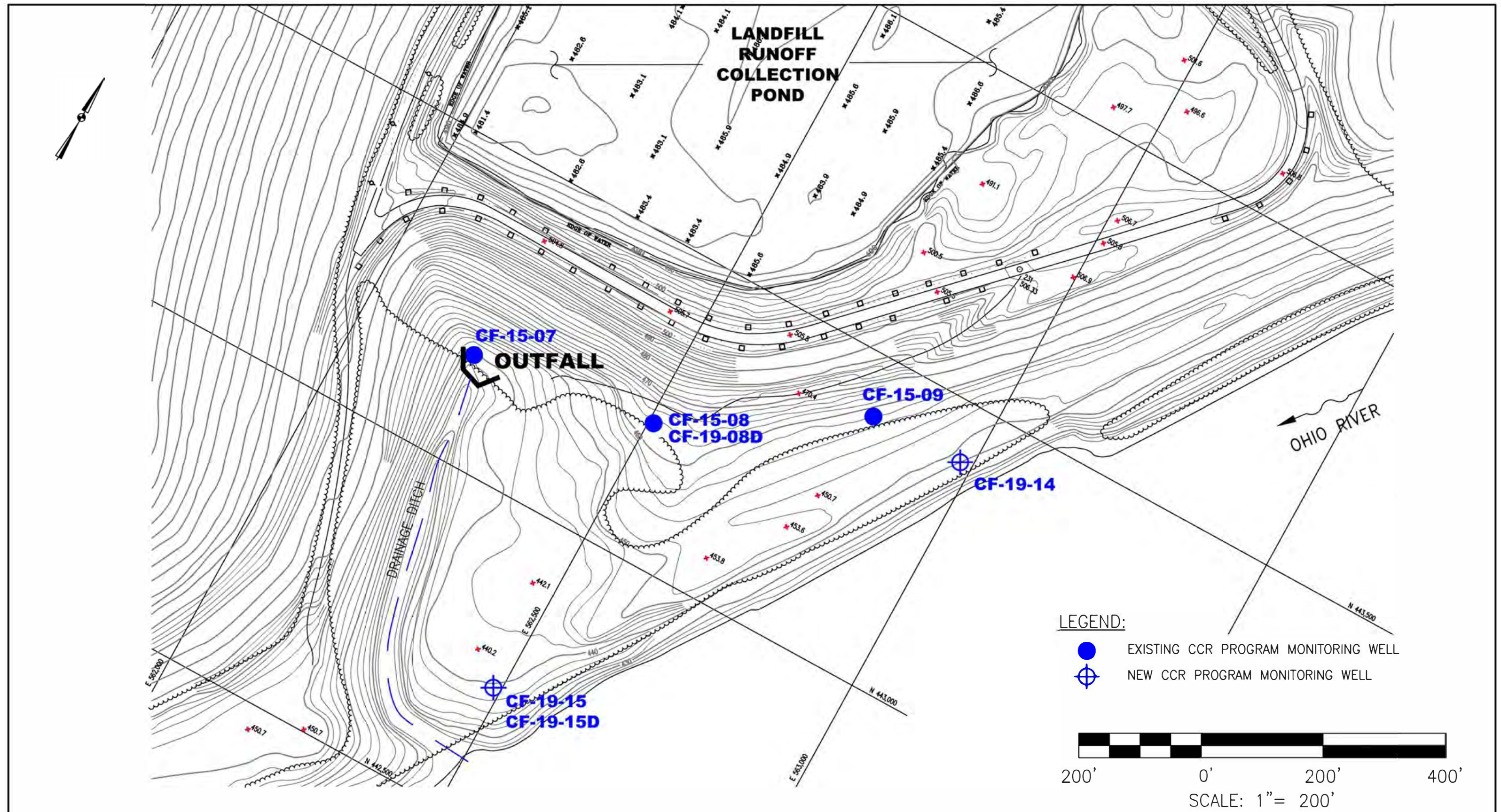
Applied Geology and Environmental Science, Inc. (AGES) 2018. Coal Combustion Residuals Regulation 2017 Groundwater Monitoring and Corrective Action Report. Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. January 2018.

Applied Geology and Environmental Science, Inc. (AGES) 2019. Coal Combustion Residuals Regulation 2017 Assessment of Corrective Measures Report. Indiana Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana, September 2019.

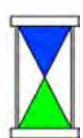
Fetter, Charles W. 1980. Applied Hydrogeology. Merrill, 1980.

ATTACHMENT F

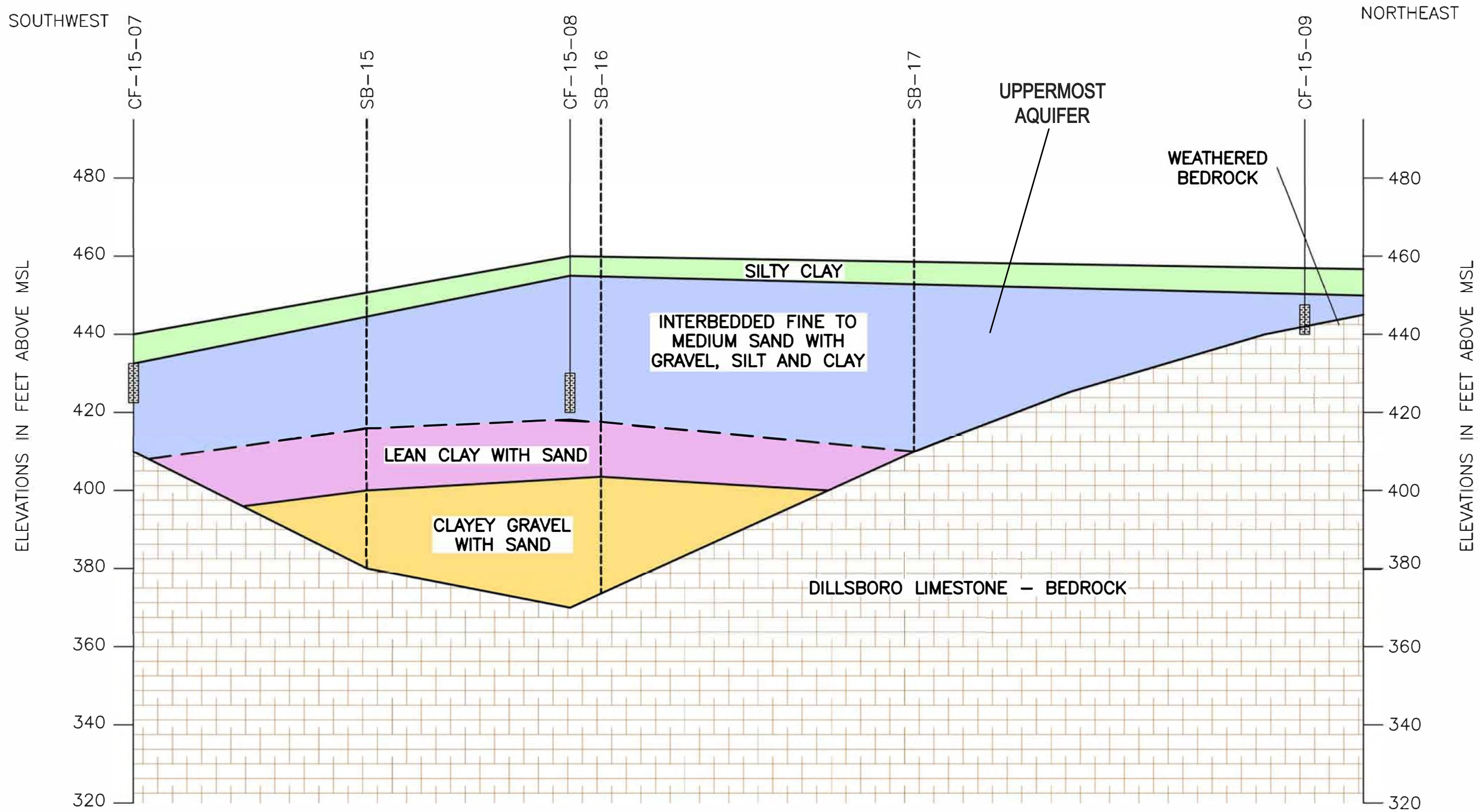
FIGURES



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JOB NO.	2019042-8-CLIFTY
DWG FILE	2019_IKEC_Clifty_ACM_Fig 5-1_MW locs.dwg
DRAWING SCALE	AS SHOWN


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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM EXISTING AND NEW MONITORING WELL LOCATIONS	
DRAWING NAME	FIGURE F-1
REV.	0



NOTES:

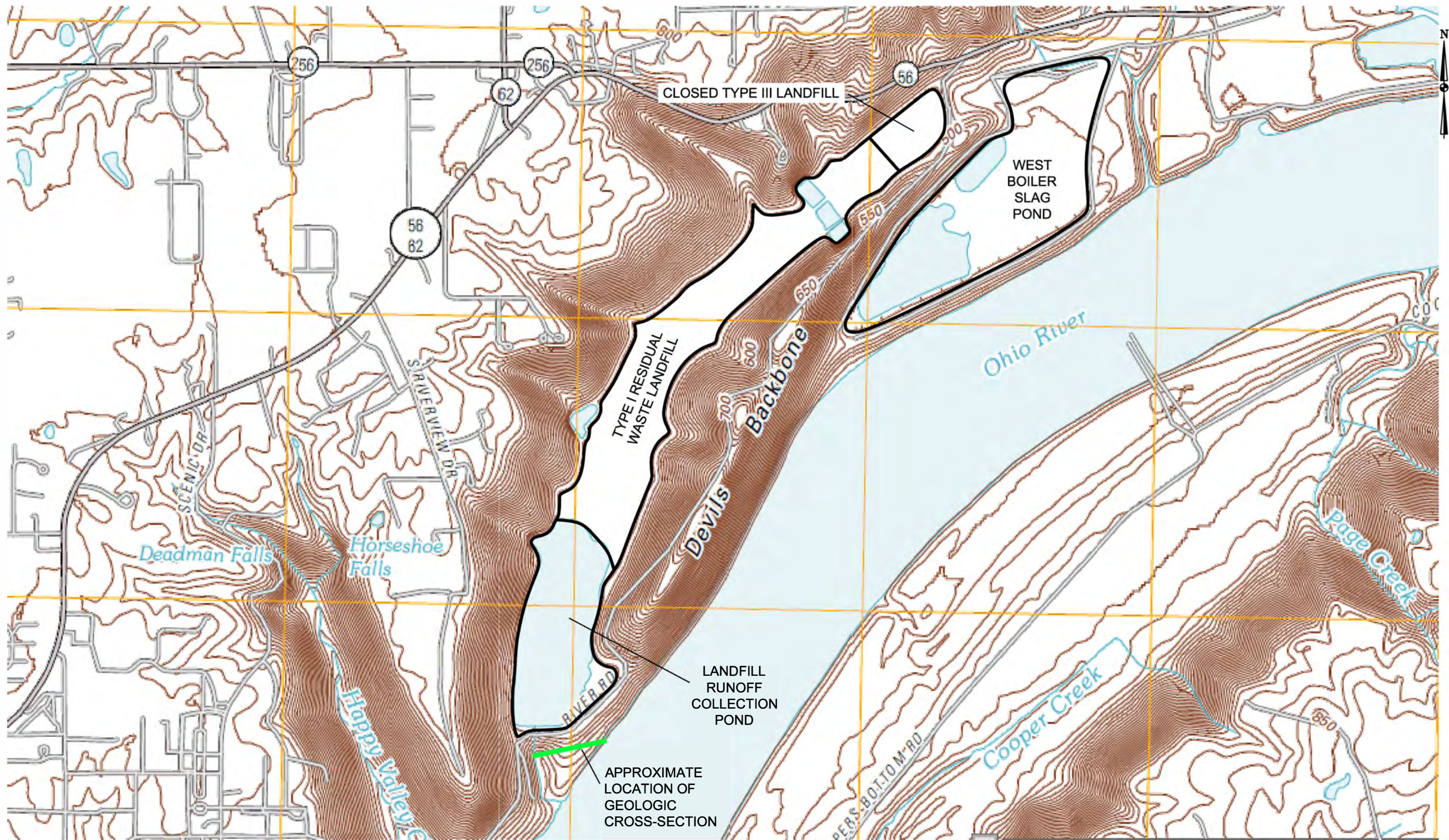
1) CROSS-SECTION COMPILED USING AGES BORING AND WELL LOGS, SOIL BORING INFORMATION FROM THE 2007 LITIGATION REPORT AND STANTEC DATA FROM THE LRCP STABILITY ASSESSMENT REPORT.

2) THE APPROXIMATE LOCATION OF THE CROSS-SECTION IS ILLUSTRATED ON FIGURE F-3.

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JOB NO.	2019042-8-CLIFTY
DWG FILE	2019_IKEC_Clifty_ACM_Fig 3-1_X-Section_LRCP.dwg
DRAWING SCALE	NOT TO SCALE

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA GEOLOGIC CROSS-SECTION AT LANDFILL RUNOFF COLLECTION POND	
DRAWING NAME	FIGURE F-2
REV.	0



APPROXIMATE LOCATION OF THE GEOLOGIC CROSS-SECTION (FIGURE F-2).

SOURCE: USGS MADISON WEST 7.5 MINUTE TOPOGRAPHIC QUADRANGLE, 2010.

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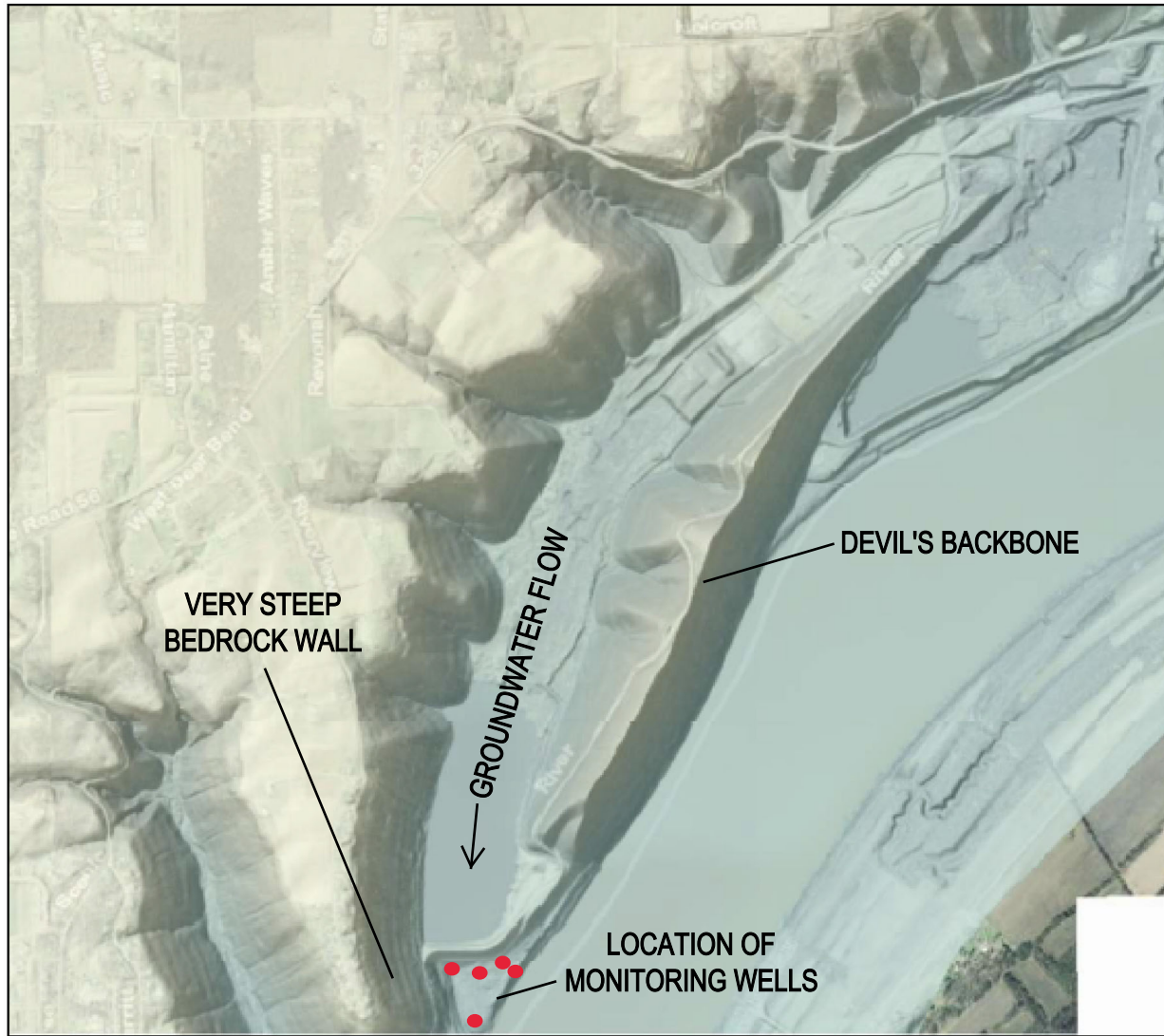
INDIANA-KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
TOPOGRAPHIC MAP

DRAWING NAME	FIGURE F-3	REV.	0
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Indiana LiDAR Color Hillshade

Date: 3/1/2018



Author:



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JOB NO.	2020246-CLIFTY
DWG FILE	IKEC_Clifty_ACM_Fig F-4_LiDAR.dwg
DRAWING SCALE	As Shown



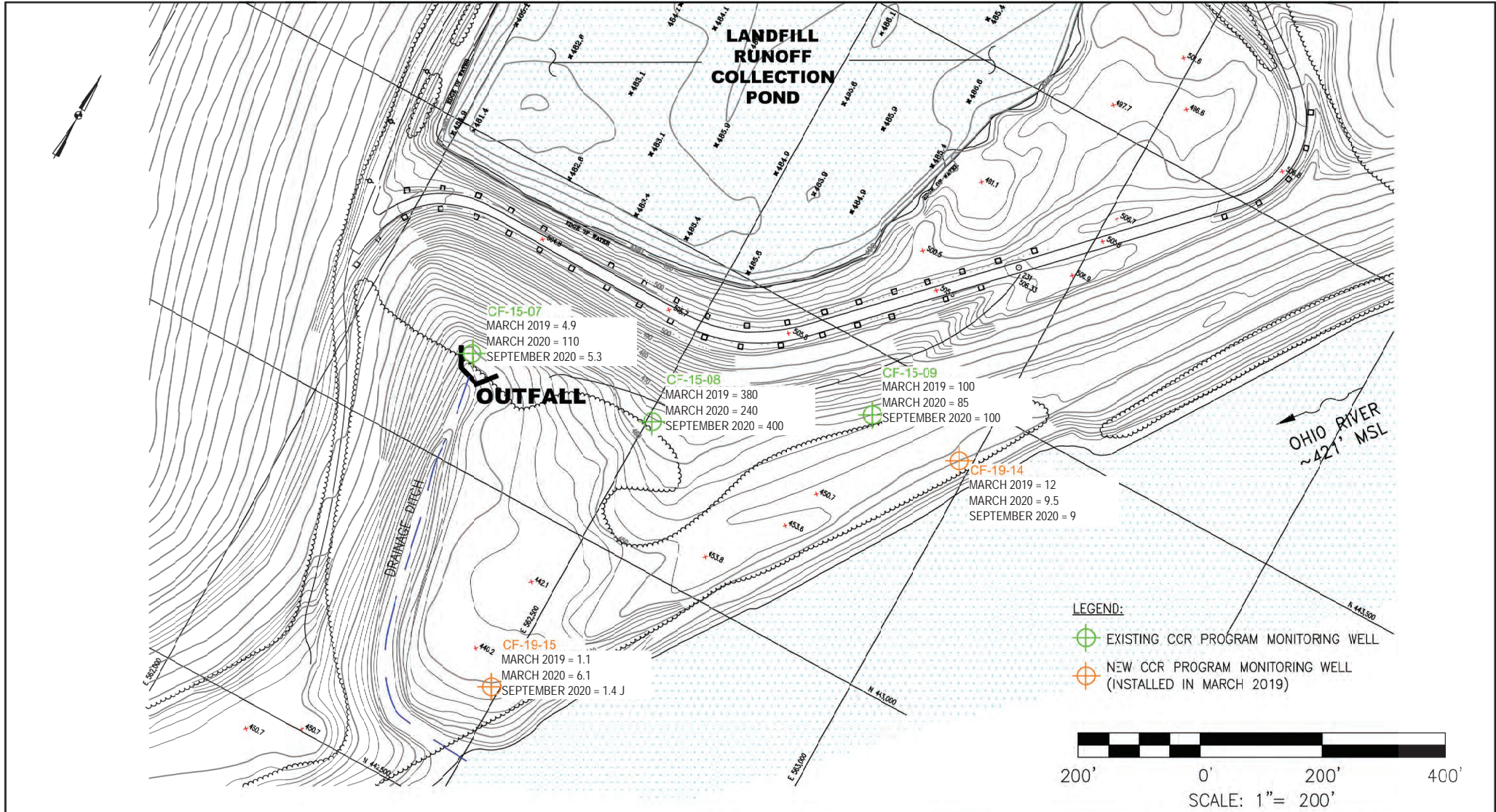
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CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
VIEW OF BEDROCK VALLEY

DRAWING NAME	FIGURE F-4	REV.	0
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JCB NO.	2020246-CLIFTY
DWG FILE	2020_IKEC_Clifty_ACM_Fig F-5_Mo.dwg
DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM MOLYBDENUM CONCENTRATIONS IN GROUNDWATER MARCH 2020 THROUGH SEPTEMBER 2020	
DRAWING NAME	FIGURE F-5
REV.	0

ATTACHMENT F-1

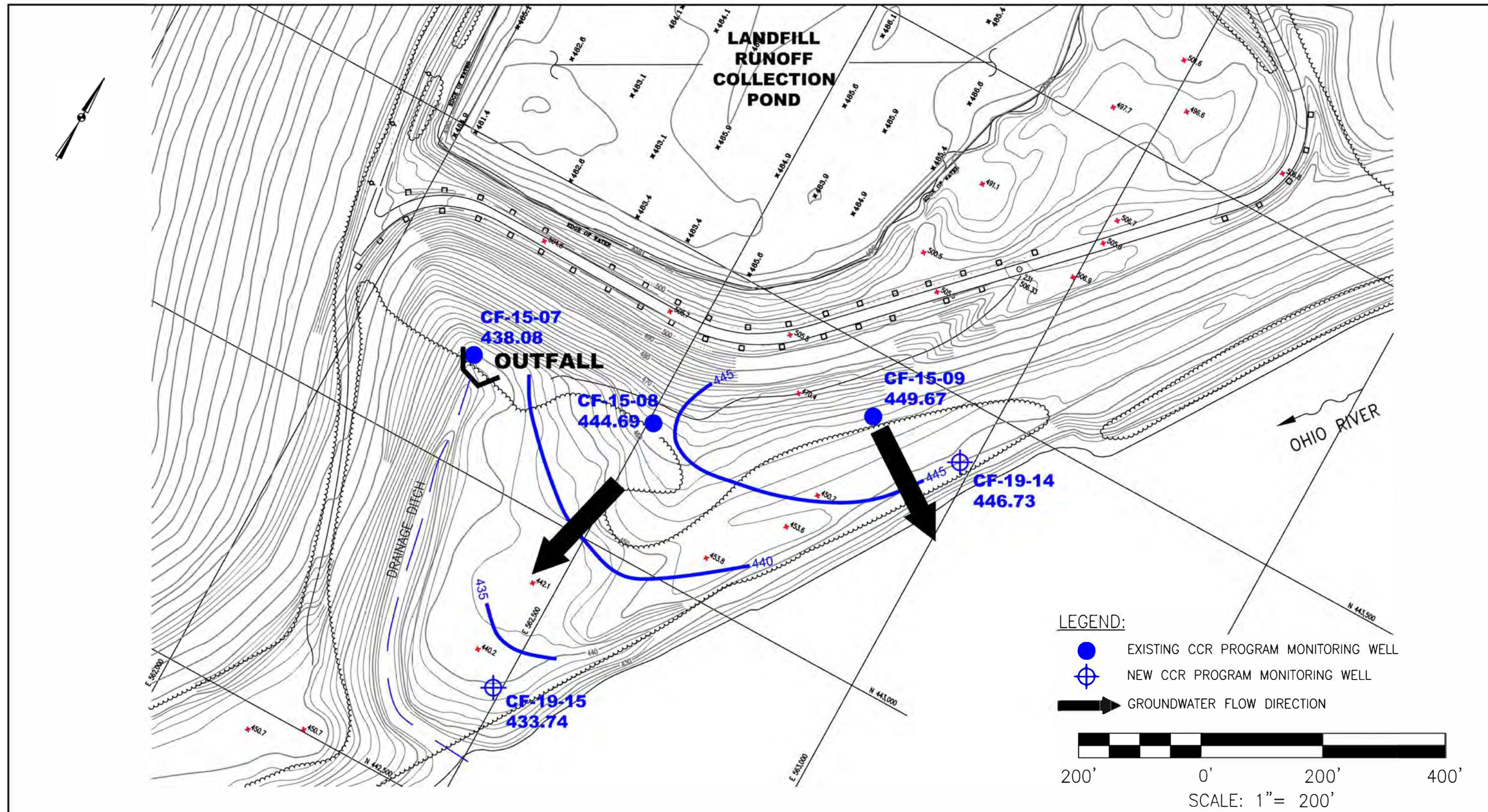
GROUNDWATER ELEVATION DATA

**ATTACHMENT F-1
SUMMARY OF GROUNDWATER ELEVATION DATA
LANDFILL RUNOFF COLLECTION POND
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA**

Well ID	Mar-19	Mar-20	Sep-20
	Groundwater Elevation (ft)	Groundwater Elevation (ft)	Groundwater Elevation (ft)
CF-15-07	438.08	Flooded	430.83
CF-15-08	444.69	442.07	440.45
CF-15-09	449.67	445.76	446.52
CF-19-14	446.73	439.82	442.91
CF-19-15	433.74	421.05	431.19

ATTACHMENT F-2

GENERALIZED GROUNDWATER FLOW MAPS

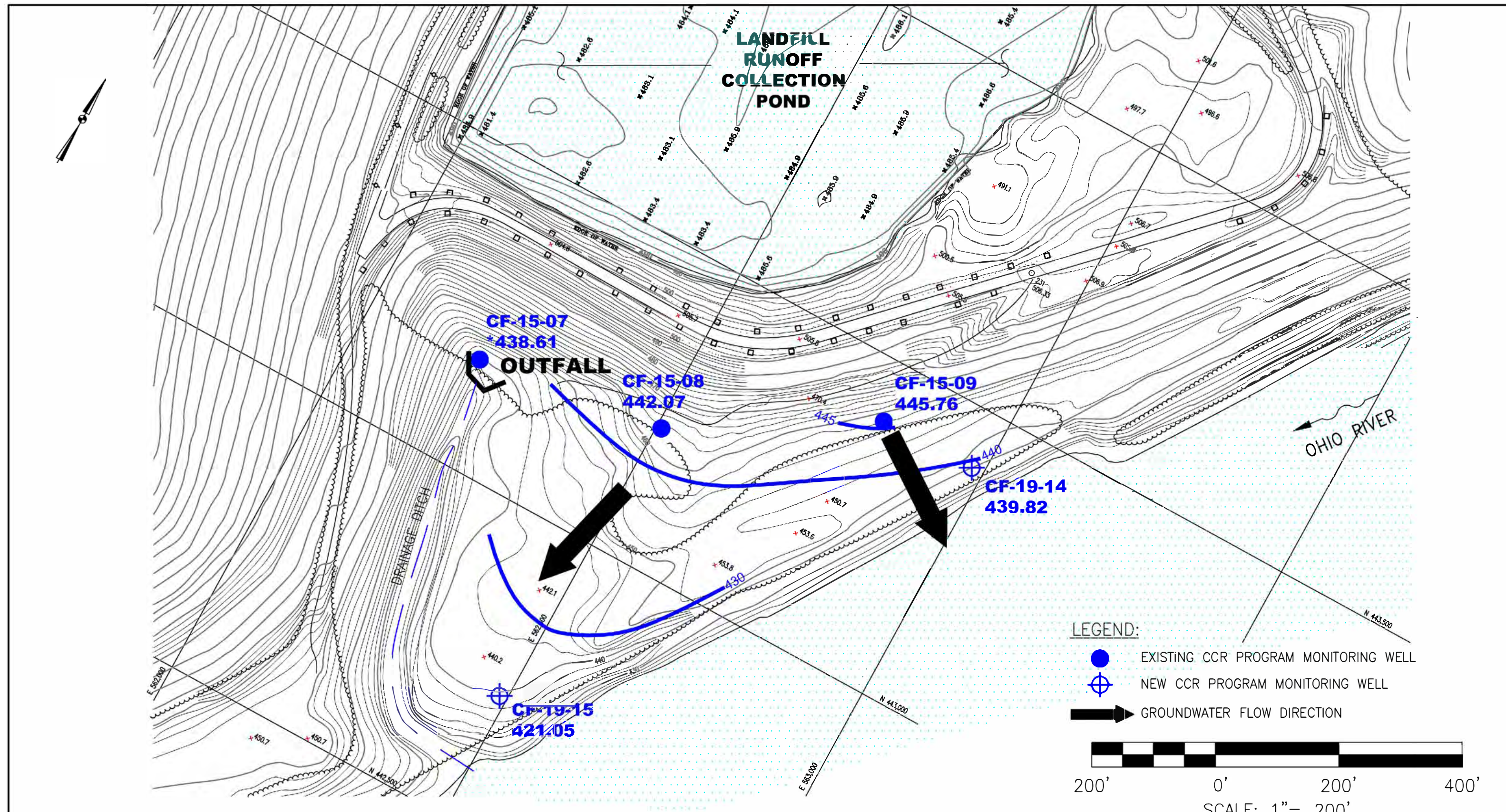


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JOB NO.	2019108-CLIFTY
DWG. FILE	2019_IKEC_Clifty_ACM_Fig 5-2_GW Flow-Upper Aquifer.dwg
DRAWING SCALE	AS SHOWN

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INDIANA-KENTUCKY ELECTRIC CORPORATION	
CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM GROUNDWATER FLOW - UPPERMOST AQUIFER MARCH 2019	
DRAWING NAME	ATTACHMENT F-2 FIGURE 1
REV.	0



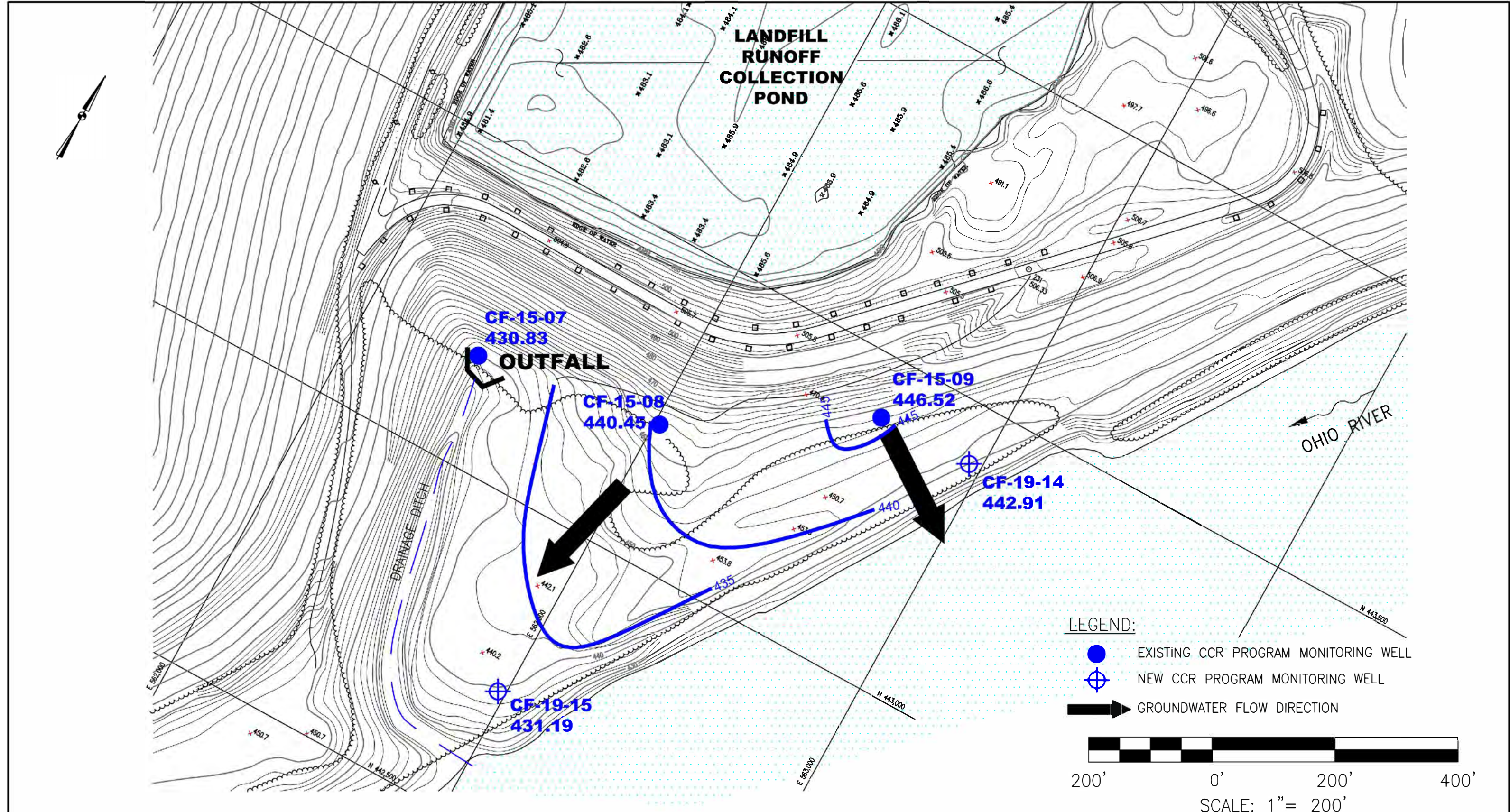
NOTE:

* Monitoring Well CF-15-07 was flooded at the time of sampling, ground level elevation is depicted.

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JOB NO.	2020246-CLIFTY
DWG. FILE	March_2020_IKEC_Clifty_ACM_Fig F-1_GW Flow-Upper Aquifer.dwg
DRAWING SCALE	AS SHOWN

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CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM	
GROUNDWATER FLOW - UPPERMOST AQUIFER MARCH 2020	
DRAWING NAME	ATTACHMENT F-2 FIGURE 2
REV.	0



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JOB NO.	2020246-CLIFTY
DWG. FILE	Sept_2020_IKEC_Clifty_ACM_Fig F-2_GW Flow-Upper Aquifer.dwg
DRAWING SCALE	AS SHOWN

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CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM	
GROUNDWATER FLOW - UPPERMOST AQUIFER SEPTEMBER 2020	
DRAWING NAME	ATTACHMENT F-2 FIGURE 3
REV.	0

ATTACHMENT F-3
TIME-SERIES GRAPHS

ATTACHMENT F-3
SUMMARY OF MOLYBDENUM CONCENTRATIONS IN GROUNDWATER
LANDFILL RUNOFF COLLECTION POND
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

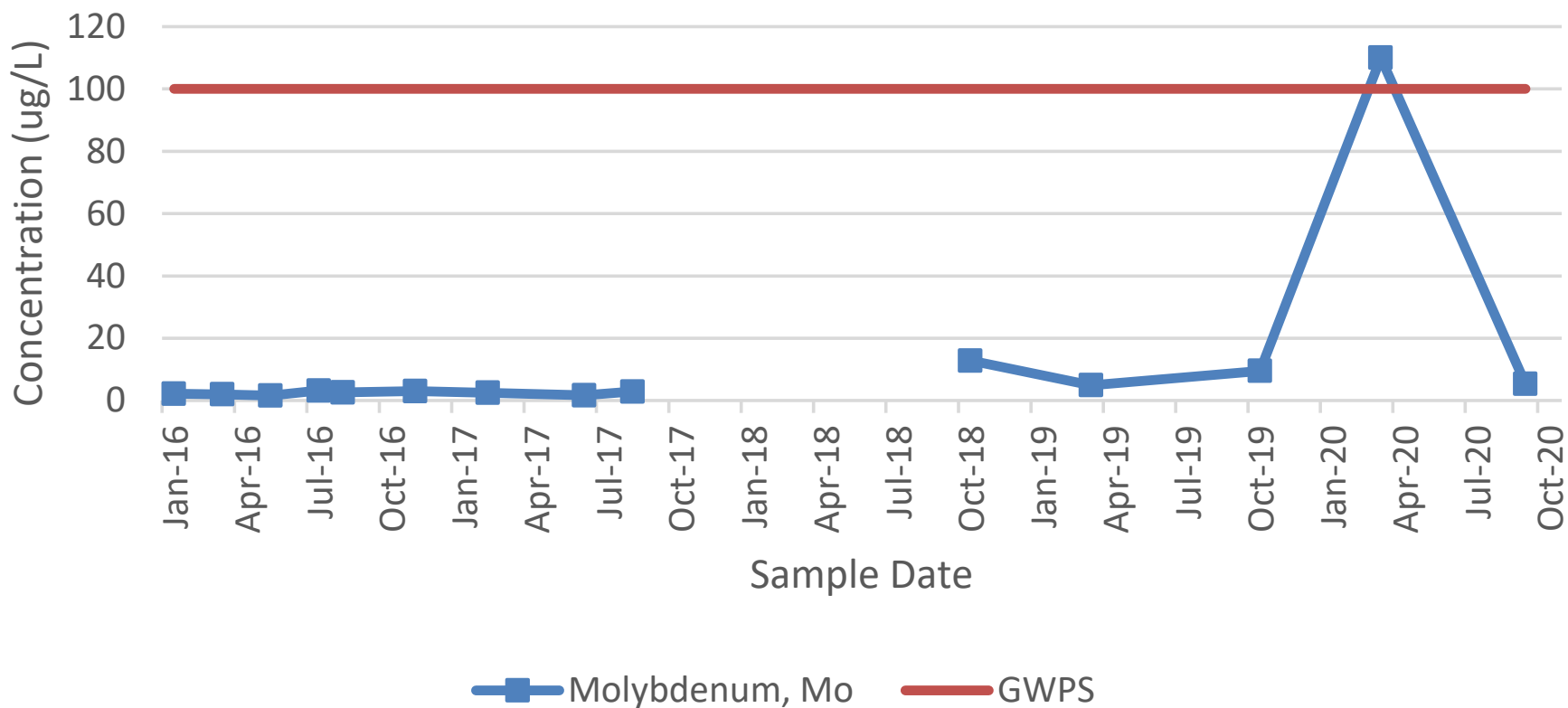
Well ID	CF-15-07	CF-15-08	CF-15-09
Sampling Event			
Jan-16	2.18	196	87.8
Mar-16	1.99	266	87.6
May-16	1.57	317	82.6
Jul-16	3.2	303	38.2
Aug-16	2.6	315	90.3
Nov-16	3.03	500	DRY
Feb-17	2.49	311	82.5
Jun-17	1.69	391	73.6
Aug-17	2.86	425	47.1
Oct-18	12.8	524	85.9
Mar-19	4.9	380	100
Oct-19	9.5	390	87
Mar-20	110	240	85
Sep-20	5.3	400	100

Notes:

1. Concentrations are provided in ug/L.
2. The results from SSI resampling event are not included.

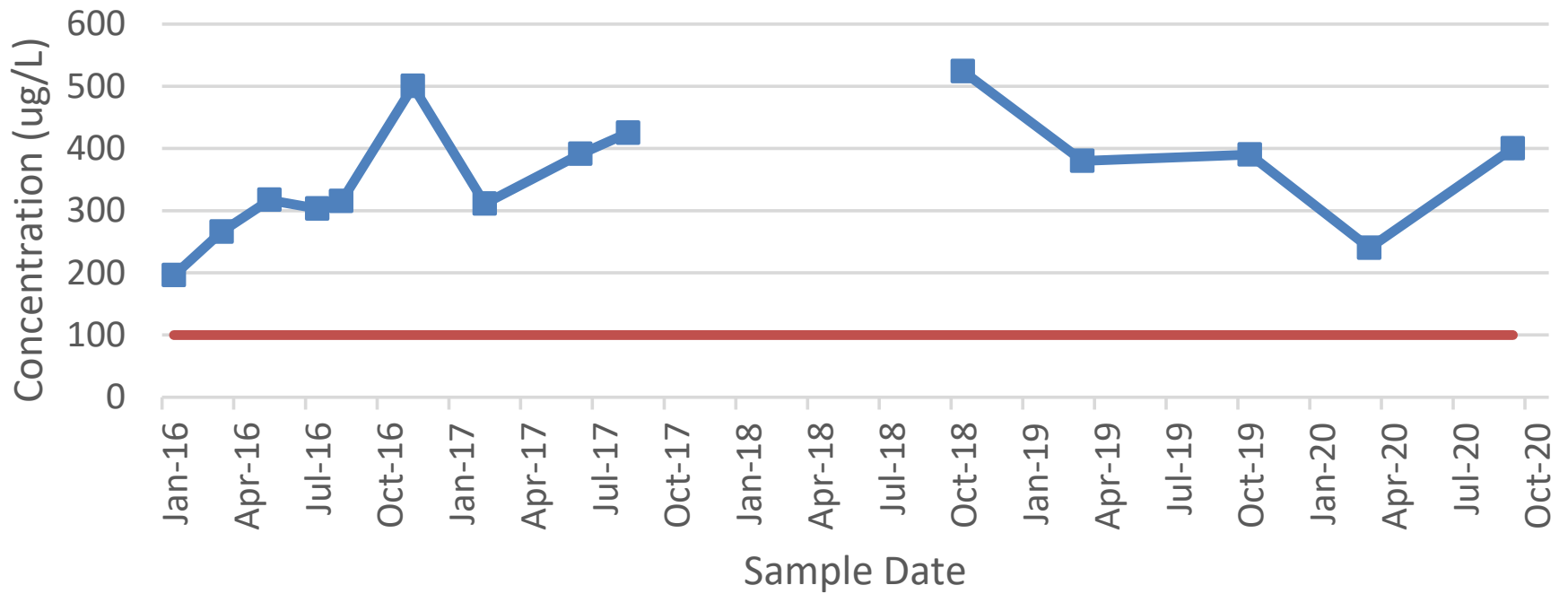
Clifty Creek Station, LRCP

Well ID: CF-15-07



Clifty Creek Station, LRCP

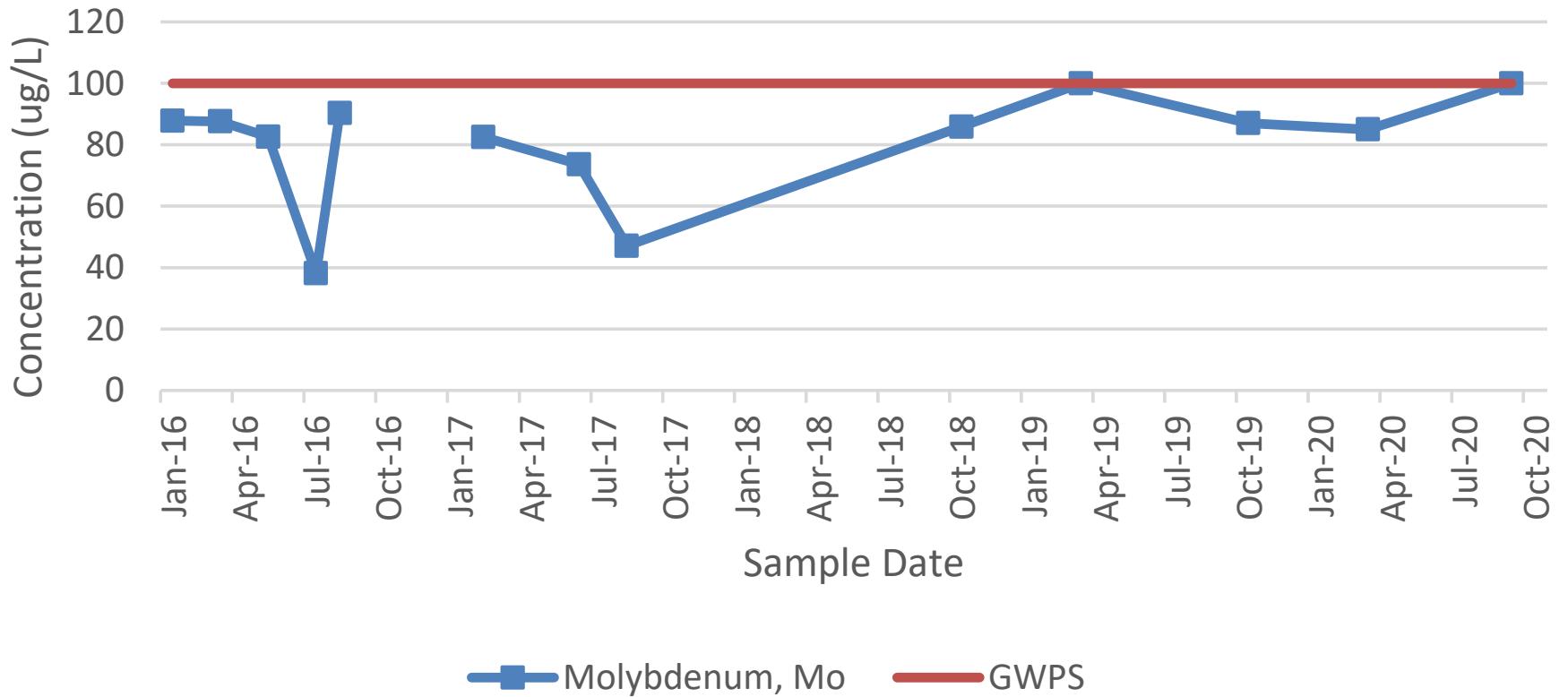
Well ID: CF-15-08



■ Molybdenum, Mo — GWPS

Clifty Creek Station, LRCP

Well ID: CF-15-09



ATTACHMENT F-4

SUPPORTING DATA

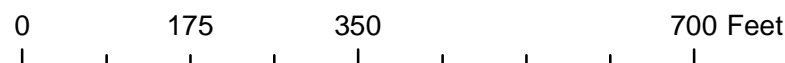
MOLYBDENUM MASS CALCULATIONS

**Mass Calculations- Molybdenum
LRCP-March/April 2019**

ug/l Molybdenum	Area ft2	Area Calc Ft2	Total Volume Aquifer ft3	Total Volume Groundwater ft3	Total Volume Water Liters	Mass Calc Mo ug	Mass Calc Mo Kilograms	Mass Calc Mo Tons
50	536000	244940	4898801	979760	27743672	1387183576	1387	1.39
150	291060	109959	2199186	439837	12454784	1868217536	1868	1.87
250	181101	98301	1966019	393204	11134272	2783568032	2784	2.78
340	82800	82800	1655998	331200	9378514	3188694702	3189	3.19
		536,000.19	10,720,003.86	2,144,000.77	60,711,241.05	9,227,663,846.02	9,227.66	9.23



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



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SCALE	1:2,400



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COMPANY	INDIANA-KENTUCKY ELECTRIC CORPORATION
SITE / ADDRESS	CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM
FIGURE NAME	MOLYBDENUM GROUNDWATER CONTOURS March/April 2019
REV.	0

**Mass Calculations- Molybdenum
LRCP-March 2020**

ug/l Molybdenum	Area ft2	Area Calc Ft2	Total Volume Aquifer ft3	Total Volume Groundwater ft3	Volume Groundwater Liters	Mass Calc Mo ug	Mass Calc Mo Kilograms	Mass Mo Calc Tons
50	536000	266584	5331681	1066336	30195230	1509761489	1510	1.51
150	269416	186616	3732325	746465	21137497	3170624615	3171	3.17
220	82800	82800	1655998	331200	9378514	2063273042	2063	2.06
		536,000.19	10,720,003.86	2,144,000.77	60,711,241.05	6,743,659,146.75	6,743.66	6.74



0 175 350 700 Feet

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JOB NO.	2020246
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SCALE	1:2,400

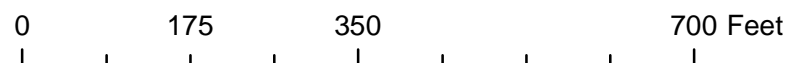


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COMPANY	INDIANA-KENTUCKY ELECTRIC CORPORATION
SITE / ADDRESS	CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM
FIGURE NAME	MOLYBDENUM GROUNDWATER CONTOURS MARCH 2020
REV.	0

**Mass Calculations- Molybdenum
LRCP-September 2020**

ug/l Molybdenum	Area ft2	Area Calc Ft2	Total Volume Aquifer Ft3	Total Volume Groundwater ft3	Volume Groundwater Liters	Mass Calc Mo ug	Mass Calc Mo Kilograms	Mass Calc Mo Tons
50	536000	251611	5032214	1006443	28499240	1424961987	1425	1.42
150	284389	103289	2065773	413155	11699215	1754882303	1755	1.75
250	181101	98301	1966019	393204	11134272	2783568032	2784	2.78
350	82800	82800	1655998	331200	9378514	3282479840	3282	3.28
		536,000.19	10,720,003.86	2,144,000.77	60,711,241.05	9,245,892,161.68	9,245.89	9.25



CREATED BY	IF
DATE	11/25/2020
CHECKED BY	-
JOB NO.	2020246
GIS FILE	Mass Calculations Maps Sept 2020
SCALE	1:2,400



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COMPANY	INDIANA-KENTUCKY ELECTRIC CORPORATION
SITE / ADDRESS	CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM MOLYBDENUM GROUNDWATER CONTOURS SEPT 2020
FIGURE NAME	REV. 0

**APPENDIX E6 – 2020 SEMI-ANNUAL SELECTION OF REMEDY
PROGRESS REPORT (LRCP)**



INDIANA-KENTUCKY ELECTRIC CORPORATION

3932 U. S. Route 23
P. O. Box 468
Piketon, Ohio 45661
740-289-7200

WRITER'S DIRECT DIAL NO:
740-897-7768

June 1, 2020

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. Bruno Pigott, Commissioner
Indiana Department of Environmental Management
100 N. Senate Avenue
Mail Code 50-01
Indianapolis, IN 46204-2251

Dear Mr. Pigott:

**Re: Indiana-Kentucky Electric Corporation
2020 Semi-Annual Selection of Remedy Report**

As required by 40 CFR 257.106(h)(9), the Indiana-Kentucky Electric Corporation is providing notification to the Commissioner of the Indiana Department of Environmental Management that the first Semi-Annual Selection of Remedy report has been completed in compliance with 40 CFR 257.97(a) for Clifty Creek Station's Landfill Runoff Collection Pond (LRCP). The intent of the report is to provide a six-month update on the progress of selecting a remedy for confirmed Appendix IV SSIs above the groundwater protection standard in the groundwater at the LRCP. The report has been placed in the facility's operating record in accordance with 40 CFR 257.105(h)(12), as well as, on the company's publicly accessible internet site in accordance with 40 CFR 257.107(h)(9), which can be viewed at <https://www.ovec.com/CCRCCompliance.php>.

If you have any questions, or require any additional information, please call me at (740) 897-7768.

Sincerely,

A handwritten signature in black ink that reads "Tim Fulk".

Tim Fulk
Engineer II

TLF:klr

Semiannual Report on the Progress of Remedy Selection

40 CFR 257.97(a)

Landfill Run-off Collection Pond

Clifty Creek Station
Madison, Indiana

May 2020

Prepared by: Indiana-Kentucky Electric Corporation

3932 U.S. Route 23

Piketon, OH 45661



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1.2	Report Contents.....	4
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2.1	Unit Specific Geology and Hydrogeology.....	5
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1 INTRODUCTION

In accordance with 40 CFR § 257.97(a), the Indiana-Kentucky Electric Corporation (IKEC) has prepared this Semi-Annual report to document progress toward remedy selection, design and implementation of corrective actions associated with groundwater monitoring exceedances at the Clifty Creek Station's Landfill Runoff Collection Pond (LRCP). This report summarizes activities during the period of December 7, 2019, through June 7, 2020. Updates to the report will be published semi-annually, until such time a remedy has been selected. Upon selection, a final report will be prepared describing the selected remedy and how it meets the standards specified in the rule.

1.1 REGULATORY BACKGROUND

On December 19, 2014, the United States Environmental Protection Agency (U.S. EPA) issued their final Coal Combustion Residuals (CCR) regulation which regulates CCR as a non-hazardous waste under Subtitle D of Resource Conservation and Recovery Act (RCRA) and became effective six (6) months from the date of its publication (April 17, 2015) in the Federal Register, referred to as the "CCR Rule." The rule applies to new and existing landfills, and surface impoundments used to dispose of or otherwise manage CCR generated by electric utilities and independent power producers. The rule includes requirements for monitoring groundwater and assessing corrective measures if constituents listed in Appendix IV of the rule are detected in groundwater samples collected from downgradient monitoring wells at Statistically Significant Levels (SSL) greater than the established GWPS.

In May 2019, IKEC initiated an Assessment of Corrective (ACM) measures at the Clifty Creek LRCP as a result of a confirmed SSL of Appendix IV constituent Molybdenum in monitoring wells CC-15-08 and CC-15-09 during September 2018 Assessment Monitoring Activities, as required by 40 CFR § 257.97(a). An additional SSL for constituent Boron was also confirmed, but an Alternative Source Demonstration was pursued and determined to be successful. In accordance with 40 CFR § 257.96(a), IKEC prepared an ACM report for the Clifty Creek LRCP. It was placed in the facility's operating record and uploaded to IKEC's Publicly Accessible Internet Site on September 19, 2019. The ACM Report provided an assessment of the effectiveness of potential corrective measures in achieving the criteria provided in 40 CFR § 257.96(c). Multiple strategies were evaluated to address groundwater exhibiting concentrations of Molybdenum above the GWPS, with two technically feasible options identified. Both feasible options require the removal of free water from the pond, followed by the execution of an engineered cap and closure of the LRCP facility, and are as follows:

- Monitored Natural Attenuation (MNA); and
- Conventional Vertical Well System (Groundwater Extraction and Treatment) (Ex-Situ)

Following the completion of the ACM Report, IKEC hosted a public meeting to present the options for remediation on November 7, 2019, in Madison, Indiana. IKEC then observed a 30-day public comment period, per 40 CFR § 257.97(a), prior to beginning the process of selecting a remedy. No comments were received during this time period.

Semi-annual reports are required pursuant to 40 CFR § 257.97(a) to document progress toward remedy selection and design. The CCR Rule provides flexibility for more field investigation, data analysis and consideration prior to the selection of a remedy. IKEC will continue to review new data as it becomes available and implement changes to the groundwater monitoring and corrective action program as necessary to maintain compliance with the rule.

1.2 REPORT CONTENTS

The first semi-annual progress report provides regulatory background, an overview of site characteristics and ACM findings, and summarizes activities supporting the selection and implementation of a remedy during the period of December 7, 2019, through June 7, 2020.

2 SITE BACKGROUND

The Clifty Creek Station, located in Madison, Indiana, is a 1.3-gigawatt coal-fired generating plant operated by IKEC, a subsidiary of the Ohio Valley Electric Corporation (OVEC). The Clifty Creek Station has six (6) 217.26-MW generating units and has been in operation since 1955. Ash products were sluiced to disposal ponds located in the plant site since it began operation. During the course of plant operations, CCRs have been managed and disposed of in various units at the station. The Type I Landfill and LRCP occupy an approximately 200-acre area situated within an eroded bedrock channel. To allow for more disposal capacity, an on-site fly ash pond was developed into a Type III Landfill in 1988. All required permits for the Type III Landfill were obtained from the Indiana Department of Environmental Management (IDEM) and the Type III Landfill went operational in 1991. In March 1994, IDEM approved a pH variance for the disposal of low-sulfur coal ash in the fly ash Type III Landfill. Emplacement of low-sulfur coal ash in the Type III Landfill began in January 1995. In April 2007, IKEC submitted a permit application to IDEM to upgrade the former Type III landfill to a Type I landfill. In 2013, IDEM issued a renewed permit and approved IKEC's request to upgrade the landfill to a Type I landfill.

The Type I Landfill consists of approximately 109 acres, and has been approved by IDEM as a Type I Residual Waste Landfill. The remaining 91 acres consist of the LRCP located at the southwest end of the Type I Landfill. The Type I Landfill and the LRCP occupy an approximately 200-acre area situated within an eroded bedrock channel.

2.1 UNIT SPECIFIC GEOLOGY AND HYDROGEOLOGY

Bedrock beneath the LRCP consists of impermeable limestone and shale of the Ordovician Dillsboro formation, which is overlain by approximately 20 feet of clayey gravel with sand (Applied Geology and Environmental Science, Inc. [AGES] 2018a). The clayey gravel with sand is overlain by a lean clay with sand, which is overlain by a fine to medium sand with gravel, silt and clay. The uppermost unit in the area is a surficial layer of silty clay. A limestone ridge known as the Devil's Backbone runs northeast to southwest along the length of the Type I Landfill & LRCP. The Devil's Backbone acts as an impermeable barrier that forces groundwater passing beneath the Type I Landfill to flow either toward the northeast or toward the southwest.

Based on historic aquifer testing conducted at the site, the upper lean clay deposits exhibit low permeability, do not yield adequate quantities of water to wells, and are considered to be an aquitard. The underlying fine-medium sand with silt is considered to be an unconfined or possibly semi-confined aquifer and is therefore designated as the uppermost aquifer at the LRCP (AGES, 2018).

2.2 POTENTIAL RECEPTOR REVIEW

IKEC completed an assessment of the proximity of public and private drinking water supplies to the LRCP in response to SSLs above the GWPS. It was determined that the withdrawal wells designated by the Indiana Department of Natural Resources (IDNR) as drinking water wells within a one-mile radius were not hydraulically connected to the groundwater at the LRCP facility or are located upgradient from the facility.

3 GROUNDWATER ASSESSMENT MONITORING PROGRAM

Groundwater assessment monitoring for the Clifty Creek LRCP is conducted in accordance with 40 CFR § 257.95.

3.1 GROUNDWATER MONITORING WELL NETWORK

In compliance with 40 CFR § 257.91, the CCR groundwater monitoring network for the LRCP consists of the following eight (8) wells:

- CF-15-04 (Background);
- CF-15-05 (Background);
- CF-15-06 (Background);
- CF-15-07 (Downgradient);
- CF-15-08 (Downgradient);
- CF-15-09 (Downgradient);
- WBSP-15-01 (Background); and
- WBSP-15-02 (Background).

Additionally, four (4) monitoring wells that were installed as part of the additional assessment activities for the LRCP were added to the CCR groundwater monitoring network for the LRCP as follows:

- CC-19-08D (Downgradient);
- CC-19-14 (Downgradient);
- CC-19-15 (Downgradient); and
- CC-19-15D (Downgradient).

3.2 TYPE I LANDFILL ALTERNATIVE SOURCE DEMONSTRATION

The Type I Landfill and LRCP share a common monitoring network. Due to this fact, upon verification of an exceedance above the GWPS, an Alternative Source Demonstration was pursued. Based on a review of current and historic data, the Type I Landfill was not believed to be the source of Boron in groundwater in the area. An ASD was completed in general accordance with guidelines presented in the *Solid Waste Disposal Facility Criteria Technical Manual* (U.S. EPA 1993). It was concluded that the Type I Landfill was not the source of Boron detected in the area. This conclusion was supported by the following evidence:

- “Foundation soils” that extend from beneath the LRCP and the hydraulically placed fly ash southwest to the Ohio River provide a direct hydraulic connection between the historic hydraulically placed fly ash and the CCR groundwater monitoring wells CF-15-08 and CF-15-09.
- Historic data from the IDEM groundwater monitoring program indicate that Boron concentrations similar to those observed in CCR wells CF-15-08 and CF-15-09 were detected in IDEM wells CF-9406 and CF-9407 for 17 years prior to operation of the Type I Landfill, indicating that the Boron is associated with the historic hydraulically placed fly ash.
- Using the previously calculated groundwater flow velocity of 45 feet per year (ft/yr), it is estimated that it would take 120 years for groundwater flowing beneath the Type I Landfill to reach the CCR monitoring wells.

The ASD Report for the March 2018 Detection Monitoring Event (AGES 2019b) was completed in June 2019, and was certified on July 3, 2019. Based on the successful ASD, an ACM was not required at the Type I Landfill. By definition of the CCR Rule, the LRCP is unlined and the historic hydraulically placed fly ash extends beneath the LRCP to the embankment; therefore, an ACM was conducted at the LRCP.

3.3 GROUNDWATER CHARACTERIZATION

Groundwater assessment monitoring was first conducted at the Clifty Creek LRCP during September 2018 sampling. Molybdenum, an Appendix IV constituent, was detected and confirmed to exceed the GWPS of 100 µg/L at wells CC-15-08 and CC-

15-09. In response, IKEC was required to characterize the extent of the release, pursuant to 40 CFR § 257.95(g)(1), and installed additional monitoring wells at the property boundary (wells CC-19-08D, CC-19-14, CC-19-15, and CC-19-15D). It was determined that Molybdenum was not leaving the property at levels higher than the GWPS, and therefore the potential remediation zone was confined to the LRCP complex (AGES, 2019).

4 ASSESSMENT OF CORRECTIVE MEASURES

In accordance with 40 CFR § 257.96(a), IKEC prepared an ACM report for the Clifty Creek LRCP and placed it in the facility's operating record as well as uploaded it to the IKEC's Publicly Accessible Internet Site on September 19, 2019. The ACM Report provided an assessment of the effectiveness of potential corrective measures in achieving the criteria provided in 40 CFR § 257.96(c).

4.1 PLANNED SOURCE CONTROL MEASURES

Per 40 CFR § 257.96(a), the objectives of the corrective measures evaluated in this ACM Report are "to prevent further releases, to remediate any releases, and to restore affected area to original conditions." As required in 40 CFR § 257.97(b), corrective measures, at minimum, must:

- (1) Be protective of human health and the environment;*
- (2) Attain the groundwater protection standard as specified pursuant to § 257.95(h);*
- (2) Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV to this part into the environment;*
- (3) Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems;*
- (5) Comply with standards for management of wastes as specified in § 257.98(d).*

During the ACM development process, several in-situ and ex-situ remedial technologies were evaluated to address Molybdenum in groundwater at the LRCP, and screened against evaluation criteria requirements in 40 CFR § 257.96(c). The two (2)

technologies that appear to be most technically feasible, and therefore most likely for selection as a remedy are:

- Monitored Natural Attenuation; and
- Conventional Vertical Well System (Groundwater Extraction) (Ex-Situ).

Both feasible options require removal of free water from the pond, followed by the execution of an engineered cap and closure of the LRCP facility. IKEC is committed to continued compliance with the requirements and timeframes of the CCR Rule, and will close the Clifty LRCP in accordance with 40 CFR § 257.102 prior to implementation of further groundwater remediation measures. Construction efforts for LRCP closure cannot proceed until such time IKEC can design and construct controls to redirect a significant volume of offsite stormwater around the LRCP, develops a closure plan and receives approval from Indiana Department of Environmental Management to proceed. IKEC is presently working with the site's Qualified Professional Engineer to develop the designs in advance of preparing the applicable permitting package.

The initial closure methods described above will reduce the potential for releases and migration of CCR constituents. Groundwater assessment monitoring as required by 40 CFR § 257.96(b) will continue until a remedy is selected and implemented. The monitoring will be conducted to track changes in groundwater conditions as a result of these closures and operational changes. These data will also be considered in the selection and design of a remedy in accordance with 40 CFR § 257.97.

4.2 POTENTIAL REMEDIAL TECHNOLOGIES

As a source control measure, the Clifty Creek LRCP will be closed in accordance with CFR § 257.102 prior to implementation of further groundwater remediation efforts. In addition to source control measures, two primary strategies were identified to address groundwater exhibiting concentrations of Molybdenum above the GWPS, including:

- Monitored Natural Attenuation; and
- Conventional Vertical Well System (Groundwater Extraction) (Ex-Situ).

The ACM report titled "Clifty Creek LRCP- Assessment of Corrective Measures Report", (AGES, 2019), which is available on IKEC's publicly accessible internet site, provides a more detailed description of these corrective measures. The effectiveness of each potential corrective measure was assessed in accordance with 40 CFR § 257.96 (c). Both options listed above are considered technically feasible, and appropriate for groundwater remediation efforts at the LRCP.

5 SELECTION OF REMEDY: CURRENT PROGRESS

As noted in the ACM Report, IKEC determined that source control would be best achieved by leaving the CCR material in place and installing a CCR compliant cap system.

During the period covered by this semi-annual report, IKEC evaluated the construction duration and constraints associated with closure in place. A preliminary cost estimate and project schedule has been developed for this portion of corrective measure activities.

IKEC's hydrogeologist conducted the semi-annual groundwater sampling and testing during this report period. In addition to sampling the monitoring wells in the CCR groundwater monitoring network, the sentinel wells installed to aid in ACM activities were also sampled. A total of 11 wells (8 Network and 3 Sentinel) were sampled near the LRCP and the results summarized in the report, "2019 – Clifty Creek CCR Annual Groundwater Monitoring and Corrective Action Report, (AGES, 2019)"

5.1 PLANNED WORK

IKEC's consultant or hydrogeologist will sample and test all of the monitoring wells as part of the semi-annual requirement.

IKEC will develop a closure plan for the LRCP, and submit to Indiana Department of Environmental Management for approval prior to proceeding with closure efforts.

IKEC and their CCR hydrogeologist will continue to evaluate the technology options identified in the ACM, and engage the site's Qualified Professional Engineer to ensure the alternatives meet the criteria set forth in 40 CFR 257.97.

IKEC will submit the next progress report by December 6, 2020.

A final report will be prepared after the remedy is selected. This report will describe the proposed solution and how it meets the standards specified in 40 CFR § 257.97(b) and 257.97(c). Recordkeeping requirements specified in 40 CFR § 257.105(h), notification requirements specified in 40 CFR § 257.106(h), and internet requirements specified in 40 CFR § 257.107(h) will be complied with as required by 40 CFR § 257.96(f).

APPENDIX E7 – STRUCTURAL STABILITY ASSESSMENT



Stantec Consulting Services Inc.
11687 Lebanon Road, Cincinnati OH 45241

October 17, 2016
File: 175534018
Revision 0

Indiana-Kentucky Electric Corporation
3932 U.S. Route 23
P.O. Box 468
Piketon, Ohio 45661

**RE: Initial Structural Stability Assessment
West Boiler Slag Pond
EPA Final Coal Combustion Residuals (CCR) Rule
Clifty Creek Station
Madison, Jefferson County, Indiana**

1.0 PURPOSE

This letter documents Stantec's certification of the initial structural stability assessment for the Indiana-Kentucky Electric Corporation (IKEC) Clifty Creek Station's West Boiler Slag Pond. Based on this assessment, the West Boiler Slag Pond is in compliance with the structural stability requirements in the EPA Final CCR Rule at 40 CFR 257.73(d).

2.0 INITIAL STRUCTURAL STABILITY ASSESSMENT

As described in 40 CFR 257.73(d), documentation is required on how the West Boiler Slag Pond has been designed, constructed, operated, and maintained according to the structural stability requirements listed in the section. The combined capacity of all spillways must also be designed, constructed, operated, and maintained to adequately manage flow from the 1,000-year storm event based upon a hazard potential classification of "significant."

3.0 SUMMARY OF FINDINGS

The attached report presents the initial structural stability assessment of the West Boiler Slag Pond. The results show that the impoundment meets the structural stability requirements set forth in 40 CFR 257.73(d)(1)-(2).

4.0 QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION

I, Stan A. Harris, being a Professional Engineer in good standing in the State of Indiana, do hereby certify, to the best of my knowledge, information, and belief:

1. that the information contained in this certification is prepared in accordance with the accepted practice of engineering;



October 17, 2016
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Re: **Initial Structural Stability Assessment
West Boiler Slag Pond
EPA Final Coal Combustion Residuals (CCR) Rule
Clifty Creek Station
Madison, Jefferson County, Indiana**

2. that the information contained herein is accurate as of the date of my signature below;
and
3. that the initial structural stability assessment for the IKEC Clifty Creek Station's West Boiler Slag Pond meets the requirements specified in 40 CFR 257.73(d)(1)-(2).

SIGNATURE



DATE 10/17/16

ADDRESS: Stantec Consulting Services Inc.
11687 Lebanon Road
Cincinnati, Ohio 45241

TELEPHONE: (513) 842-8200

ATTACHMENTS: Clifty Creek West Boiler Slag Pond Initial Structural Stability Assessment Report



Initial Structural Stability Assessment

Clifty Creek Station
West Boiler Slag Pond
Madison, Jefferson County, Indiana



Prepared for:
Indiana-Kentucky Electric Corporation
Piketon, Ohio

Prepared by:
Stantec Consulting Services Inc.
Cincinnati, Ohio

October 17, 2016

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INITIAL STRUCTURAL STABILITY ASSESSMENT

Project Background
October 17, 2016

1.0 PROJECT BACKGROUND

On April 17, 2015 the "Disposal of Coal Combustion Residuals (CCR) from Electric Utilities" (EPA Final CCR Rule) was published in the Federal Register. Stantec Consulting Services, Inc. (Stantec) was contracted by the Indiana-Kentucky Electric Corporation (IKEC) to analyze the structural stability of the Clifty Creek Station's West Boiler Slag Pond (WBSP) evaluate its compliance with §257.73 of the EPA Final CCR Rule.

As required by §257.73 of the EPA Final CCR Rule, an initial structural integrity evaluation is required by October 17, 2016 and must include an initial structural stability assessment for each existing CCR surface impoundment that meets the conditions of paragraph (b) as follows:

1. Has a height of five feet or more and a storage volume of 20 acre-feet or more or
2. Has a height of 20 feet or more.

2.0 UNIT DESCRIPTION

The Clifty Creek Station is located on the north shore of the Ohio River downstream of Madison, Indiana. The station consists of six coal-fired electric generating units, each nominally rated at 217 megawatts. The Clifty Creek Station is directly accessible from State Route 56. A plan view of the station is included in Appendix A.

The West Boiler Slag Pond is located southwest of the station. It is formed by natural grade to the north, east, and west and a dam on the south that runs along the bank of the Ohio River. The West Boiler Slag Pond serves as a settling basin for sluiced bottom ash produced at the station and receives stormwater runoff from approximately 510 acres (Stantec, 2010a). The pond contains two primary areas: the eastern portion near the sluice pipes that is actively dredged and a western portion with minimal deposition or dredging activities. A vegetation delta separates the two as a natural filtering zone. The pond discharges to the Ohio River through a principal spillway at the southern edge of the impoundment.

The subsections under §257.73(d) address conditions of appurtenances categorized as embankments, spillways, or hydraulic structures. Sections 2.1 to 2.3 below provide descriptions of the individual unit elements that fall within these appurtenance categories. Appendix A includes an overview of the Clifty Creek Station.

Note that all elevations included in this document and appendices are referenced to the North American Vertical Datum of 1988 (NAVD 88).

INITIAL STRUCTURAL STABILITY ASSESSMENT

Foundations and Abutments (§257.73(d)(1)(i))
October 17, 2016

2.1 EMBANKMENTS

2.1.1 WBSP Dam

The WBSP Dam forms the southern boundary for the pond. It is an earthen dam with a crest length roughly 2,500 feet, a crest elevation of 475 feet mean sea level (MSL), and a structural height of about 42 feet. The minimum dam crest elevation is 469 mean sea level (MSL). The WBSP Dam is not currently registered with the Indiana Department of Natural Resources (IDNR), but has been identified as a significant hazard structure by American Electric Power Service Corporation (AEPSC) (Stantec, 2010a).

The WBSP Dam has a crest width of 20 feet. The upstream embankment has a slope of 1.5H:1V to 2H:1V. The downstream embankment has a slope of approximately 2.5H:1V with a break in the slope around elevation 446 feet. Below elevation 446 feet, the downstream embankment flattens until the river edge where it transitions to 4.5H:1V down to the river (GZA, 2009).

2.2 SPILLWAYS

2.2.1 Primary Spillway System

The WBSP primary spillway is a reinforced concrete box riser structure. One side of the structure has a 3-foot wide opening that acts as a weir with water level adjusted using stop logs. The riser structure outlets to the Ohio River at elevation 426.8 feet through a 36-inch diameter, 450-foot long reinforced concrete pipe (Stantec, 2010a).

2.3 HYDRAULIC STRUCTURES

Other than the primary spillway described above, no hydraulic structures are located at the WBSP.

3.0 FOUNDATIONS AND ABUTMENTS (§257.73(d)(1)(i))

Per §257.73(d)(1)(i), the initial structural stability assessment must document whether the unit has been designed, constructed, operated, and maintained with stable foundations and abutments. The West Boiler Slag Pond has the following features that fall within this requirement:

- WBSP Dam

Assessment of the foundations and abutments associated with these features was completed considering the following criteria related to the EPA Final CCR Rule:

INITIAL STRUCTURAL STABILITY ASSESSMENT

Foundations and Abutments (§257.73(d)(1)(i))
October 17, 2016

- Review inspection reports of the facility, considering frequency of inspections, and if the inspections included review and/or assessment of features including cracking, settlement, deformation, or erosion of the foundations/abutments. Inspections should indicate that there are no significant signs of tension cracking, settlement, depressions, erosion, and/or deformations at the crest, slope, and toe of the structure.
- Confirm that an assessment of seepage conditions of the foundation, with considerations of heave and vertical exit gradient, has been performed. Verify that the seepage assessment follows appropriate methodologies (such as USACE EM 1110-2-1901) and that the foundations exhibit acceptable performance (e.g. FS for piping greater than or equal to 3.0).

3.1 WBSP DAM

3.1.1 Background

The WBSP Dam is an earthen dam tying into natural ground on both sides. Mapping of unconsolidated sediments indicate lowland areas adjacent to the Ohio River are predominantly underlain by clay, silt, sand, and gravel deposited as alluvium, lacustrine, and outwash deposits. Glacial deposits are Illinoian and Wisconsinan Quaternary age and belong to the Atherton Formation. Overlying alluvial deposits are Martinsville Formation. Bedrock underlying the site is of the Maquoketa Group, consisting of shale (about 80 percent) and limestone (about 20 percent) (Stantec, 2016). Based on Stantec (2016), the foundation of the WBSP Dam generally consists lean clay with sand and underlying foundation soils of lean clay with sand, sandy silt, or silt with sand. A layer of gravel with sand and silt was also observed underlying the dam.

3.1.2 Assessment

A qualified person performs inspections of the West Boiler Slag Pond weekly, monthly, quarterly, and annually. Regular site inspections have been conducted and documented for the West Boiler Slag Pond from 1976 to 2016. These inspections include observations related to foundation and abutment conditions with respect to observable cracking, settlement, depressions, erosion, and deformation.

AEPSC (2015) noted no significant change to the exterior slope was noted from the 2014 inspection. No settlement, misalignment, animal burrows, or seeps were observed. Signs of settlement, misalignment, and cracked were not observed on the crest.

GZA (2009) observed that the top of the dam was generally parallel to the Ohio River. Vertical alignment of the top of the dam appeared level, but noted that spot elevations of the crest ranged from 468.8 (left abutment) to 472.5 feet (right abutment).

INITIAL STRUCTURAL STABILITY ASSESSMENT

Slope Protection (§257.73(d)(1)(ii))
October 17, 2016

Seepage analysis for the original dike construction is not available. A letter from the design engineer to the owner states that the dam is constructed of relatively impervious material on a foundation of impervious material with the limited exposure to the high river stages. Special measures against seepage through and beneath the dikes were not required (A Casagrande et al, 1952).

As part of the geotechnical exploration in 2009, a seepage analysis was conducted using SEEP/W (Stantec, 2010b). This module is part of the GeoStudio 2007, Version 7.23 software package developed by GEO-SLOPE International, Ltd. of Calgary, Alberta, Canada (GEO-SLOPE International, Ltd, 2007). This package also includes SLOPE/W module for slope stability analysis. The seepage analysis indicated that the factor of safety for piping/heave was 3.0 or greater for the WBSP Dam.

3.1.1 Conclusion

Based on the assessment of the foundation and abutments for the WBSP Dam, the EPA Final CCR Rule-related criteria listed above have been met.

4.0 SLOPE PROTECTION (§257.73(d)(1)(ii))

Per §257.73(d)(1)(ii), the initial structural stability assessment must document whether the unit has been designed, constructed, operated, and maintained with adequate slope protection to protect against surface erosion, wave action, and adverse effects of sudden drawdown. The West Boiler Slag Pond has the following features that fall within this requirement:

- WBSP Dam

Assessment of the slope protection associated with these features was completed considering the following criteria related to the EPA Final CCR Rule:

1. *Regular (weekly) inspections for erosion. Inspections should show there are no significant signs of deterioration in the slope protection configuration of the Item.*
2. *Appropriate slope protection shall be provided based on anticipated flow velocities. [Hydrologic/hydraulic calculations of flow velocities on the slope of the Item for the appropriate erosive forces. Some common slope protection measures include: riprap, gabions, paving (concrete or asphalt), or appropriate vegetative cover.]*
3. *If slope protection is riprap, filter layer(s) under the riprap shall be designed according to established filter criteria. However, existing riprap cover may be evaluated based on performance and observations during inspections.*

INITIAL STRUCTURAL STABILITY ASSESSMENT

Embankment Dike Compaction (§257.73(d)(1)(iii))
October 17, 2016

4.1 WBSP DAM

4.1.1 Background

Slope protection for the WBSP Dam consists of grass or riprap on the upstream toe of the dam. The downstream slope is also vegetated and mowed. Flow from the primary spillway's discharge pipe is adequately dissipated through a gradual pipe slope and discharge elevation into the receiving stream (GZA, 2009).

4.1.1 Assessment

As reported by the GZA (2009), regular drive-by inspections are performed with a checklist inspection quarterly, and an annual inspection by AEPSC. The spillway is regularly visited to take water quality samples, while the instrumentation in the dams are read monthly. Areas of erosion are prioritized for appropriate repairs. Regular site inspections performed by a registered professional engineer have been conducted and documented for the West Boiler Slag Pond from 1976 to 2015. Site inspection reports generally indicate appropriate maintenance of slope protection features of the dam.

Portions of the upstream slope of the WBSP dam are vegetated. This is an operational pond with bottom ash interior slopes due to regular dredging operations. Slopes are dressed and maintained. Riprap has been placed the length of the dam to protect against wave erosion. The last annual dam and dike inspection observed that the interior and exterior slopes of the dike were in fair and stable condition (AEPSC, 2015).

4.1.1 Conclusion

Based on the assessment of the slope protection for the WBSP Dam, the EPA Final CCR Rule-related criteria listed above have been met.

5.0 EMBANKMENT DIKE COMPACTION (§257.73(d)(1)(iii))

Per §257.73(d)(1)(iii), the initial structural stability assessment must document whether the unit has been designed, constructed, operated, and maintained with dikes mechanically compacted to a density sufficient to withstand the range of loading conditions in the CCR unit. The West Boiler Slag Pond has the following features that fall within this requirement:

- WBSP Dam

Assessment of the dike compaction associated with these features was completed considering the following criteria related to the EPA Final CCR Rule:

INITIAL STRUCTURAL STABILITY ASSESSMENT

Embankment Dike Compaction (§257.73(d)(1)(iii))
October 17, 2016

1. Documentation showing the dike was mechanically compacted. Acceptable documentation may include construction drawings, field notes, construction photographs, correspondences, or any evidence showing the dike was mechanically compacted during construction.
2. If no construction documentation is available specific data from geotechnical explorations of dike may be used. Geotechnical borings with continuous SPTs may be used to assess compaction of the dike. Appropriate methodology correlating blow counts and compaction (density) should be used.

5.1 WBSP DAM

5.1.1 Background

The dam was designed by Arthur and Leo Casagrande of Cambridge, Massachusetts from 1952 to 1954. The firm was also retained during the construction phase and reportedly made a number of site visits as the embankment and appurtenances were being built. Only limited design drawings exist for the WBSP Dam. Technical memoranda and letters between the firm and the plant during the design and construction of the plant and other structures do exist (GZA, 2009). Construction photos are available showing period-appropriate large construction equipment working on the site. Subsurface explorations of the dike were also available that provided SPT data used in the assessment.

5.1.1 Assessment

Historical construction photographs, technical memoranda, and letters provide documentation of compaction requirements related to the construction of the LRCP Dam. Construction criteria related to dike embankment materials and dike compaction as noted on this documentation include:

- A discussion of proposed dike materials and the need for proper moisture control and compaction in thin layers with heavy, rubber-tired equipment slightly on the dry side of optimum (A. Casagrande, 1952).
- A discussion of testing the foundation clay in situ with a vane borer with supervision by L. Casagrande (A. Casagrande, 1952).
- A discussion of selection of granular borrow with laboratory data and compaction requirements (A. Casagrande, 1953).
- A discussion of compaction of the foundation fill with a modern, heavy rubber-tired roller in 9-in. layers and compacted with four passes of a roller loaded to 50 or 60 tons (A. Casagrande, 1953).

INITIAL STRUCTURAL STABILITY ASSESSMENT

Vegetated Slopes (§257.73(d)(1)(iv))
October 17, 2016

Two previous geotechnical explorations were available to review as part of this assessment (Stantec, 2010; Stantec, 2016). Each was a geotechnical exploration and slope stability evaluation of the LRCP Dam. The programs included drilling and laboratory testing.

Stantec (2010) assigned drained shear strength parameters to the existing lean clay dam of 165 psf and 33.2 degrees. Correlating these results using NAVFAC DM-7.2 indicate that appropriate compaction exists within the embankment of the LRCP Dam (NAVFAC, 1986).

Stantec (2016) performed three moisture-density tests on the embankment lean clay to compare with in-situ natural moisture contents and unit weights of the soil. Natural moisture contents within the embankment varied from 15 to 25 percent with an average of 19 percent. Dry densities ranged from 106 to 115 pounds per cubic foot (pcf) with an average of 110 pcf. The results of the tests suggested the average natural moisture content of the embankment is 3 to 5 percent above optimum moisture and that the average percent compaction of the embankment soil is approximately 94 to 97 percent of standard Proctor maximum density.

5.1.2 Conclusion

Based on the assessment of the embankment dike compaction for the WBSP Dam, the EPA Final CCR Rule-related criteria listed above have been met.

6.0 VEGETATED SLOPES (§257.73(d)(1)(iv))

Per §257.73(d)(1)(iv), the initial structural stability assessment must document whether the unit has been designed, constructed, operated, and maintained with vegetated slopes of dikes and surrounding areas, except for slopes which have an alternate form or forms of slope protection. The West Boiler Slag Pond has the following features that fall within this requirement:

- WBSP Dam

Assessment of the vegetated slopes associated with these features was completed considering the following criteria related to the EPA Final CCR Rule:

1. Regular inspection records showing vegetative cover sufficient to prevent surface erosion while allowing an unobstructed view to visually inspect the slope.

6.1 BACKGROUND

Slope protection for the LRCP Dam consists of short grass for both the interior and exterior slopes.

INITIAL STRUCTURAL STABILITY ASSESSMENT

Spillway Condition and Capacity (§257.73(d)(1)(v))
October 17, 2016

6.2 ASSESSMENT

A qualified person performs inspections of the West Boiler Slag Pond weekly, monthly, quarterly, and annually. Regular site inspections have been conducted and documented for the West Boiler Slag Pond from 1976 to 2016.

Portions of the upstream slope of the WBSP dam are vegetated. This is an operational pond with bottom ash interior slopes due to regular dredging operations. Slopes are dressed and maintained. Riprap has been placed the length of the dam to protect against wave erosion. The last annual dam and dike inspection observed that the interior and exterior slopes of the dike were in fair and stable condition (AEPSC, 2015).

6.3 CONCLUSION

Based on the assessment of the vegetated slopes for the WBSP Dam, the EPA Final CCR Rule-related criteria listed above have been met.

7.0 SPILLWAY CONDITION AND CAPACITY (§257.73(d)(1)(v))

Per §257.73(d)(1)(v), the initial structural stability assessment must document whether the unit has been designed, constructed, operated, and maintained with a single spillway or combination of spillways that meet the condition and capacity requirements as outlined in this section of the EPA Final CCR Rule. The combined capacity of all spillways are to be designed, constructed, operated, and maintained to adequately manage flow during and following the peak discharge from the event specified in this section. The West Boiler Slag Pond has the following features that fall within this requirement:

- WBSP Dam Primary Spillway System

Assessment of the spillway condition and capacity associated with these features was completed considering the following criteria related to the EPA Final CCR Rule:

1. Outlet channel must be of non-erodible material designed to carry sustained flow velocities based on the required flood events. [Estimate flow velocities and select appropriate material using hydraulic analysis for the following flood events: PMF (high hazard potential unit), 1000-year flood (Significant hazard unit), 100-year flood (low hazard potential unit).]
2. Must adequately manage flow during and following the peak discharge. [Estimate size of outlet structure based of hydraulic analysis for the following flood events: PMF (High hazard potential unit), 1000-year flood (Significant hazard potential unit), and 100-year flood (low hazard potential unit).]

INITIAL STRUCTURAL STABILITY ASSESSMENT

Spillway Condition and Capacity (§257.73(d)(1)(v))
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3. Must be structurally stable. [Assess stability of structure using stability and stress analyses according to an appropriate methodology. Some acceptable methodologies may include: EM 1110-2-2400, EM 1110-2-2100, ACI 350, etc.]
4. Must maintain structural integrity. [Structural integrity may be warranted by periodic inspections of existing conduits. Inspections must show no significant presence of deformation, distortions, cracks, joint separation, etc.]
5. Must be free from significant amounts of obstruction and anomaly which may affect the operation of the hydraulic structure [Perform periodic pipe inspections to detect deterioration, deformation, distortion, bedding deficiencies, and sediment, and debris accumulations.]

7.1 PRIMARY SPILLWAY SYSTEM

7.1.1 Background

The West Boiler Slag Pond is classified as a significant hazard structure requiring the combined capacity of all spillways be adequate to manage the flow during and following the peak discharge from a 1000-year flood.

7.1.2 Assessment

7.1.2.1 Spillway Capacity

The Inflow Design Flood Control System Plan for the West Boiler Slag Pond demonstrates the West Boiler Slag Pond meets the capacity requirements outlined in §257.73(d)(1)(v) of the EPA Final CCR Rule. During the October 2015 annual dam and dike inspection, the primary spillway's outlet structure was in good condition and flowing steadily. Flood events of the Ohio River accumulate wood debris near the discharge pipe, but not appear to impede it (AEPSC, 2015).

7.1.2.2 Structural Stability

The West Boiler Slag Pond spillway is a 30-foot reinforced concrete decant-type overflow structure built 70 feet away of the right abutment. The intake shaft is rectangular with a 3.25-foot by 3.25-foot interior cross section (GZA, 2009). The top of the structure is approximately elevation 458 feet (AEPSC, 2016).

A 36-inch extra strength reinforced concrete pipe connects to the decant structure at elevation 433.0 feet and discharges 300 feet downstream to the Ohio River (GZA, 2009).

The West Boiler Slag Pond's spillway structure is inspected monthly during water quality sampling and annually as part of the dam and dike inspection. Physical condition, flow through the pipe, and maintenance concerns are noted and addressed. Video camera inspections of the

INITIAL STRUCTURAL STABILITY ASSESSMENT

Sudden Drawdown Assessment (§257.73(d)(1)(vii))
October 17, 2016

structure were performed in 2007 and 2011. In October 2014, the first 10 joints of the discharge pipe at the outfall were sealed by an outside contractor.

7.1.3 Conclusion

Based on the assessment of the Primary Spillway System condition and capacity for the West Boiler Slag Pond, the EPA Final CCR Rule-related criteria listed above have been met.

8.0 SUDDEN DRAWDOWN ASSESSMENT (§257.73(d)(1)(vii))

Per §257.73(d)(1)(vii), the initial structural stability assessment must document whether the unit has been designed, constructed, operated, and maintained with downstream slopes that can be inundated by an adjacent water body (such as a river, stream, or lake) to determine if structural stability is maintained during low pool or sudden drawdown of the adjacent water body. The West Boiler Slag Pond has the following feature that falls within this requirement:

- WBSP Dam

Assessment of the sudden drawdown associated with these features was completed considering the following criteria related to the EPA Final CCR Rule:

1. Maintain slope stability during sudden drawdown of adjacent water body.

Guidance provided by the USEPA (2015) described the basis of the EPA Final CCR Rule's factor of safety criteria and methodology as EM 1110-2-1902 (USACE, 2003) or other appropriate methodologies. Table 3-1 of EM 1110-2-1902 (USACE, 2003) recommends a required minimum factor of safety of 1.1 for maximum surcharge pool under rapid drawdown conditions.

8.1 EMBANKMENTS

8.1.1 Background

The WBSP Dam has a potential sudden drawdown loading from the Ohio River. A sudden drawdown slope stability analysis of the downstream slope is required under the EPA Final CCR Rule §257.73(d)(1)(vii). The sudden drawdown slope stability analysis was performed in conjunction with the static safety factor assessment discussed in Stantec (2016).

8.1.2 Assessment

8.1.2.1 Material Properties

Stantec performed geotechnical explorations in 2010 and 2015 to characterize the embankments of the WBSP Dam. A laboratory testing program was performed for each

INITIAL STRUCTURAL STABILITY ASSESSMENT

Sudden Drawdown Assessment (§257.73(d)(1)(vii))
 October 17, 2016

exploration to determine the pertinent soil parameters for stability analyses. The strength parameters derived using the laboratory data and used in this sudden drawdown slope stability evaluation are presented in Table 1. The results of the laboratory testing and derivation of the strength parameters can be found in Stantec (2010b and 2016).

Table 1 Strength Parameters for Stability Analysis – WBSP Dam

Embankment	Soil Horizon	Unit Weight (pcf)	Effective Stress Strength Parameters		Total Stress Strength Parameters	
			c' (psf)	ϕ' (degrees)	c (psf)	ϕ (degrees)
West Boiler Slag Pond Dam	Embankment	130	165	33	600	13
	Lean Clay with Sand	119	160	27	1,200	5
	Gravel with Silt and Sand	130	0	35	0	35
	Sandy Silt	130	0	30	0	30
	Bottom Ash	115	0	28	0	28

8.1.2.2 Critical Cross Section Selection

Slope stability analyses were available from Stantec (2010a and 2016). Three cross sections from the WBSP Dam were analyzed under static, long-term, steady-state conditions using the maximum surcharge pool. The three sections that were analyzed are labeled Sections A-A', B-B', and C-C' and are shown in Figure 1.

INITIAL STRUCTURAL STABILITY ASSESSMENT

Sudden Drawdown Assessment (§257.73(d)(1)(vii))
 October 17, 2016

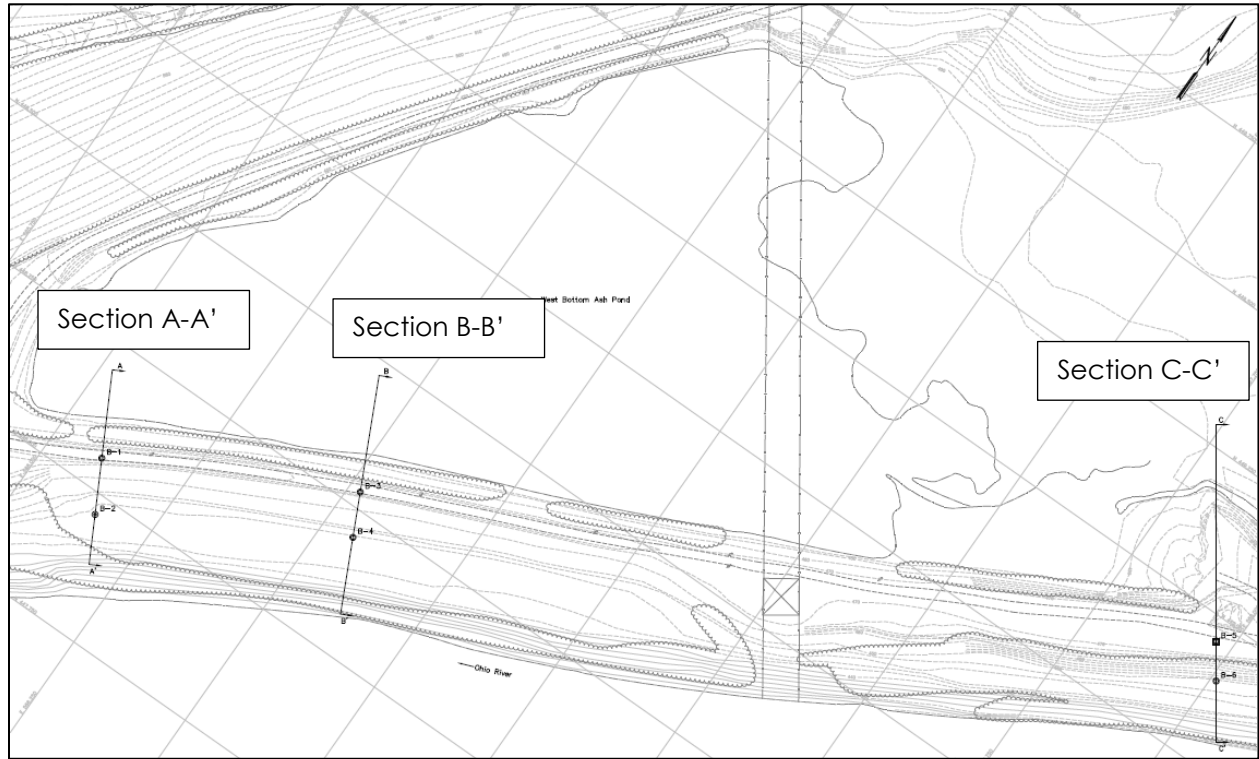


Figure 1 Clifty Creek Power Plant West Boiler Slag Pond – Plan View of Cross Sections

The summary of the static slope stability results from Stantec (2016) is listed in Table 2. The pond levels were set at the 50% PMP elevation (462.8 feet for the West Boiler Slag Pond). The tailwater was set near the elevation of the Ohio River.

Table 2 Static Slope Stability Results

Facility	Cross-Section	Drained Maximum Storage Pool Factor of Safety	Drained Maximum Surge Pool Factor of Safety	Undrained Maximum Storage Pool Factor of Safety
West Boiler Slag Pond	A-A'	2.30	2.30	1.35
	B-B'	2.44	2.44	1.30
	C-C'	2.30	2.18	1.53

A sudden drawdown stability analysis is required for the three WBSP Dam sections using the proposed water levels discussed in Section 8.1.2.3.

INITIAL STRUCTURAL STABILITY ASSESSMENT

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8.1.2.3 Water Levels

Clifty Creek Station's CCR surface impoundments are classified as a significant hazard. Under the EPA Final CCR Rule, the inflow design flood for a significant hazard potential CCR surface impoundment is the 1,000-year flood (§257.82(a)(3)(ii)). A rainfall amount for the 1,000-year storm event (7.16 inches) was obtained from the "Precipitation Frequency Atlas of the United States, NOAA Atlas 14" using a precipitation event duration of 6 hours (Bonnin et al, 2016).

Stantec (2010a) presents the reservoir routing analysis for the West Boiler Slag Pond assuming the 50-percent probable maximum precipitation (PMP) event. From NOAA (1980), a 6-hour rainfall depth (27.6 inches) for the PMP storm event as obtained. The reservoir routing model indicates that the West Boiler Slag Pond peak 50-percent PMP water surface elevation is 462.8 feet.

The sudden drawdown analysis has been performed assuming a maximum surcharge pool within the surface impoundment equal to the 50-percent PMP water surface elevation and a long-term maximum storage pool equal to the operating pool elevation reported in Stantec (2016).

Tailwater for the model is the Ohio River elevation. The 100-year flood level for the Ohio River was used for the tailwater flood pool elevation (FEMA, 2015). The normal pool for the Ohio River was determined from the elevations provided by NOAA (2016) for Madison, Indiana. Table 3 lists the headwater and tailwater elevations used for analysis.

Table 3 Clifty Creek Station Water Elevations for Stability Modeling

CCR Rule Criteria	Headwater West Boiler Slag Pond Elevation (feet)	Tailwater Ohio River Elevation (feet)
Long-term maximum storage pool loading condition	448.0	420.0
Maximum surcharge pool loading condition	462.8	463.0

8.1.2.4 Analysis Methodology

Stantec performed the sudden drawdown slope stability analyses using the GeoStudio 2007, Version 7.23 software package developed by GEO-SLOPE International, Ltd. of Calgary, Alberta, Canada (GEO-SLOPE International, Ltd., 2007). This package includes the SLOPE/W module for slope stability analysis. The analyses were performed in accordance with the recommendations and criteria outlined in the USACE Design Manual EM 1110-2-1902 "Slope Stability" (USACE, 2003).

INITIAL STRUCTURAL STABILITY ASSESSMENT

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8.1.2.5 Acceptance Criteria

A minimum factor of safety is not explicitly specified within the EPA Final CCR Rule §257.73(d)(1)(vii). In the EPA Final CCR Rule discussion, USACE (2003) is considered the basis for the slope stability analyses. Table 3-1, Minimum Required Factors of Safety: New Earth and Rock-Fill Dams, requires a factor of safety of 1.1 for a rapid drawdown condition from maximum surcharge pool.

8.1.2.6 Analysis Results

The slope stability assessments presented in this report are focused on the potential for slope failures of significant mass, which could directly impact potential release of water and CCR materials from the West Boiler Slag Pond. The search for a critical slip surface in the slope stability assessments is thus restricted to consider only potential surfaces where the depth (measured at the base of at least one slice) is more than ten feet vertically below the ground surface. Table 4 summarizes the sudden drawdown safety factor evaluation results at the West Boiler Slag Pond. The results of the analysis are included in Appendix B.

The results show that the sudden drawdown factor of safety assuming the 50-percent PMP event meets the criteria; therefore, the design is also acceptable for the 1000-year event and the requirements set forth in 40 CFR 257.73(d)(1)(vii).

Table 4 Factor of Safety Assessment Results

Facility	Cross Section	EPA Criteria	Recommended Factor of Safety Criteria	Calculated Factor of Safety
West Boiler Slag Pond	A-A'	Sudden Drawdown	1.1	1.7
	B-B'			1.8
	C-C'			1.9

8.1.3 Conclusion

Based on the assessment of the sudden drawdown for WBSP Dam, the EPA Final CCR Rule-related criteria listed above have been met.

9.0 REFERENCES

American Electric Power Service Corporation (AEPSC) (2015). *2015 Dam and Dike Inspection Report. GERS-15-018*. Clifty Creek Plant. Madison, Indiana. October 5. Inspection Date: September 3, 2015. Revision 0.

INITIAL STRUCTURAL STABILITY ASSESSMENT

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- Naval Facilities Engineering Command (NAVFAC) (1986). [NAVFAC DM7-02 Foundations and Earth Structures](#). Table 1: Typical Properties of Compacted Soils. Page 39. September.

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References

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Stantec Consulting Services Inc. (2010a). *Reservoir Routing Analysis. West Bottom Ash Pond.* Clifty Creek Power Station. City of Madison, Jefferson County, Indiana. February.

Stantec Consulting Services Inc. (2010b). *Report of Geotechnical Exploration. AEP Clifty Creek Power Plant, West Bottom Ash Pond.* Prepared for American Electric Power, Columbus, Ohio. May.

United States Army Corps of Engineers (USACE) (2003). "Slope Stability." Engineering Manual EM 1110-2-1902, Department of the Army. October 31, 2003.

INITIAL STRUCTURAL STABILITY ASSESSMENT

References
October 17, 2016

Appendix A PLAN VIEW OF CLIFTY CREEK STATION

Appendix B SUDDEN DRAWDOWN ASSESSMENT

APPENDIX A
PLAN VIEW OF CLIFTY CREEK STATION



Figure No. **A-1**
 Title **Plan View of Clifty Creek Station**

Client/Project
 Clifty Creek Station - Structural Stability
 Landfill Runoff Collection Pond and
 West Boiler Slag Pond

Project Location 175534018
 Madison Jefferson County, IN Prepared by AP on 2016-10-13
 Technical Review by JH on 2016-10-13
 Independent Review by SH on 2016-10-13

0 500 1,000 Feet
 1:6,000 (At original document size of 11x17)



- Notes**
1. Coordinate System: NAD 1927 StatePlane Indiana East FIPS 1301
 2. USDA - NAIP 2014 Ortho-Imagery
 3. Fuller, Mossbarger, Scott, & May, Inc. (FMSM) (2006b). Permit Drawings. Indiana-Kentucky Electric Corporation. Clifty Creek Coal Ash Landfill Modification. Jefferson County, Madison Township, Indiana. November. Dwg. No. 16-30500-09-A. Coal Ash Landfill. Top of Cover



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APPENDIX B
SUDDEN DRAWDOWN ASSESSMENT

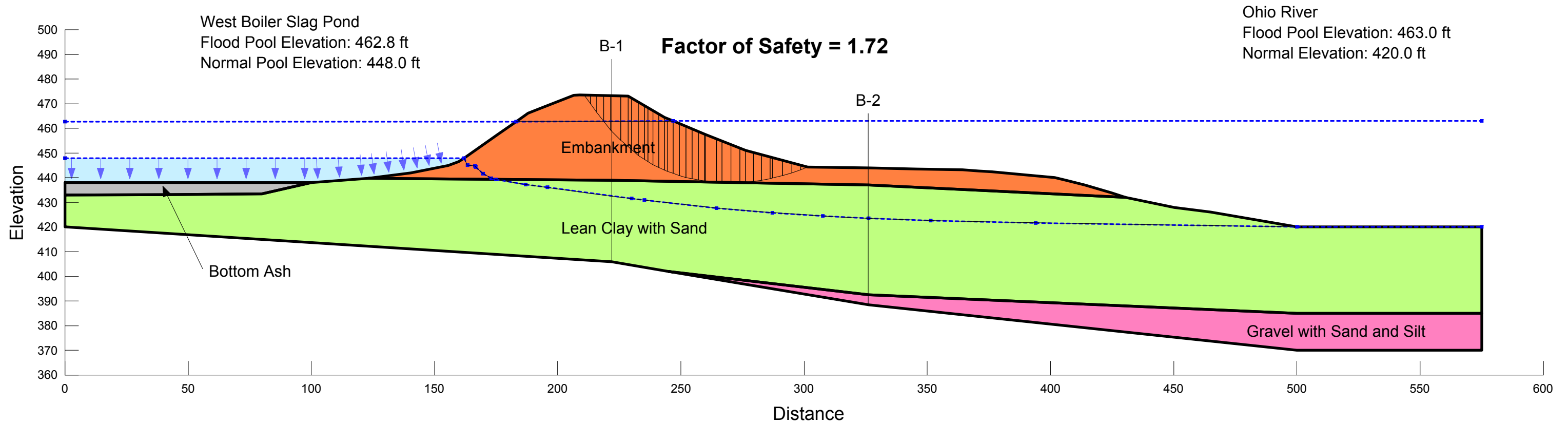
**Indiana-Kentucky Electric Corporation
Clifty Creek Station
West Boiler Slag Pond Dam
Madison, Indiana
Section A-A'**

Sudden Drawdown

**Existing Geometry
Sudden Drawdown
Undrained, Sudden Drawdown Strengths**

Material Type	Unit Weight	Effective - c'	Effective - phi'	Total - c	Total - phi
Embankment (SDD)	130 pcf	165 psf	33 °	600 psf	13 °
Lean Clay with Sand (SDD)	119 pcf	160 psf	27 °	1200 psf	5 °
Gravel With Silt and Sand (SDD)	130 pcf	0 psf	35 °	0 psf	35 °
Bottom Ash (SDD)	115 pcf	0 psf	28 °	0 psf	28 °

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.



**Indiana-Kentucky Electric Corporation
Clifty Creek Station
West Boiler Slag Pond Dam
Madison, Indiana
Section B-B'**

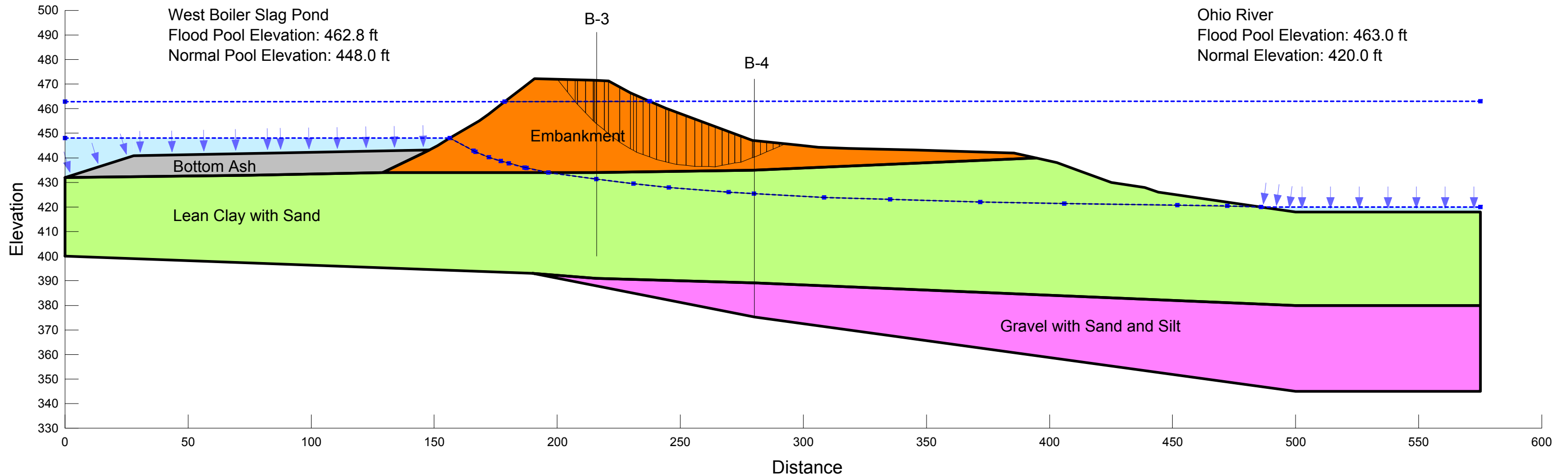
Sudden Drawdown

**Existing Geometry
Sudden Drawdown
Undrained, Sudden Drawdown Strengths**

Material	Unit Weight	Effective - c'	Effective - phi'	Total - c	Total - phi
Embankment (SDD)	130 pcf	165 psf	33 °	600 psf	13 °
Lean Clay With Sand (SDD)	119 pcf	160 psf	27 °	1200 psf	5 °
Gravel With Silt And Sand (SDD)	130 pcf	0 psf	35 °	0 psf	35 °
Bottom Ash (SDD)	115 pcf	0 psf	28 °	0 psf	28 °

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Factor of Safety = 1.83



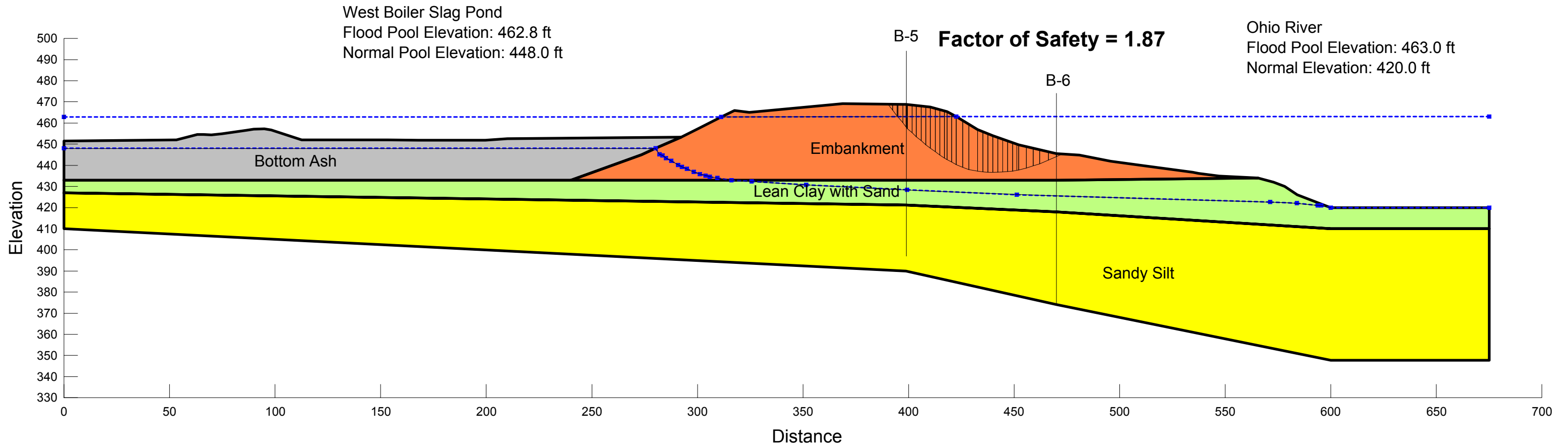
**Indiana-Kentucky Electric Corporation
Clifty Creek Station
West Boiler Slag Pond Dam
Madison, Indiana
Section C-C'**

Sudden Drawdown

**Existing Geometry
Sudden Drawdown
Undrained, Sudden Drawdown Strengths**

Material Type	Unit Weight	Effective - c'	Effective - phi	Total - c	Total - phi
Embankment (SDD)	130 pcf	165 psf	33 °	600 psf	13 °
Lean Clay with Sand (SDD)	119 pcf	160 psf	27 °	1200 psf	5 °
Sandy Silt (SDD)	130 pcf	0 psf	30 °	0 psf	30 °
Bottom Ash (SDD)	115 pcf	0 psf	28 °	0 psf	28 °

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.





Stantec Consulting Services Inc.
11687 Lebanon Road, Cincinnati OH 45241

October 17, 2016
File: 175534018
Revision 0

Indiana-Kentucky Electric Corporation
3932 U.S. Route 23
P.O. Box 468
Piketon, Ohio 45661

**RE: Initial Structural Stability Assessment
Landfill Runoff Collection Pond
EPA Final Coal Combustion Residuals (CCR) Rule
Clifty Creek Station
Madison, Jefferson County, Indiana**

1.0 PURPOSE

This letter documents Stantec's certification of the initial structural stability assessment for the Indiana-Kentucky Electric Corporation (IKEC) Clifty Creek Station's Landfill Runoff Collection Pond. Based on this assessment, the Landfill Runoff Collection Pond is in compliance with the structural stability requirements in the EPA Final CCR Rule at 40 CFR 257.73(d).

2.0 INITIAL STRUCTURAL STABILITY ASSESSMENT

As described in 40 CFR 257.73(d), documentation is required on how the Landfill Runoff Collection Pond has been designed, constructed, operated, and maintained according to the structural stability requirements listed in the section. The combined capacity of all spillways must also be designed, constructed, operated, and maintained to adequately manage flow from the 1,000-year storm event based upon a hazard potential classification of "significant."

3.0 SUMMARY OF FINDINGS

The attached report presents the initial structural stability assessment of the Landfill Runoff Collection Pond. The results show that the impoundment meets the structural stability requirements set forth in 40 CFR 257.73(d)(1)-(2).

4.0 QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION

I, Stan A. Harris, being a Professional Engineer in good standing in the State of Indiana, do hereby certify, to the best of my knowledge, information, and belief:

1. that the information contained in this certification is prepared in accordance with the accepted practice of engineering;



October 17, 2016
Page 2 of 2

Re: **Initial Structural Stability Assessment
Landfill Runoff Collection Pond
EPA Final Coal Combustion Residuals (CCR) Rule
Clifty Creek Station
Madison, Jefferson County, Indiana**

2. that the information contained herein is accurate as of the date of my signature below;
and
3. that the initial structural stability assessment for the IKEC Clifty Creek Station's Landfill Runoff Collection Pond meets the requirements specified in 40 CFR 257.73(d)(1)-(2).

SIGNATURE



DATE

10/17/16

ADDRESS:

Stantec Consulting Services Inc.
11687 Lebanon Road
Cincinnati, Ohio 45241

TELEPHONE:

(513) 842-8200

ATTACHMENTS:

Clifty Creek Landfill Runoff Collection Pond Initial Structural Stability Assessment Report



Initial Structural Stability Assessment

Clifty Creek Station
Landfill Runoff Collection Pond
Madison, Jefferson County, Indiana



Prepared for:
Indiana-Kentucky Electric Corporation
Piketon, Ohio

Prepared by:
Stantec Consulting Services Inc.
Cincinnati, Ohio

October 17, 2016

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INITIAL STRUCTURAL STABILITY ASSESSMENT

Project Background
October 17, 2016

1.0 PROJECT BACKGROUND

On April 17, 2015 the "Disposal of Coal Combustion Residuals (CCR) from Electric Utilities" (EPA Final CCR Rule) was published in the Federal Register. Stantec Consulting Services, Inc. (Stantec) was contracted by the Indiana-Kentucky Electric Corporation (IKEC) to analyze the structural stability of the Clifty Creek Station's Landfill Runoff Collection Pond (LRCP) and evaluate its compliance with §257.73 of the EPA Final CCR Rule.

As required by §257.73 of the EPA Final CCR Rule, an initial structural integrity evaluation is required by October 17, 2016 and must include an initial structural stability assessment for each existing CCR surface impoundment that meets the conditions of paragraph (b) as follows:

1. Has a height of five feet or more and a storage volume of 20 acre-feet or more, or
2. Has a height of 20 feet or more.

2.0 UNIT DESCRIPTION

The Clifty Creek Station is located on the north shore of the Ohio River downstream of Madison, Indiana. The station consists of six coal-fired electric generating units, each nominally rated at 217 megawatts. The Clifty Creek Station is directly accessible from State Route 56. A plan view of the station is included in Appendix A.

The Landfill Runoff Collection Pond is located at the southern edge of the station. It is bordered by the station's coal combustion residuals (CCR) landfill to the north, natural grade to the east and west, and by a dam to the south that runs along the bank of the Ohio River. Approximately 508 acres of both landfill contact water and stormwater runoff drain to the Landfill Runoff Collection Pond. Upon the completion of the CCR landfill, the area draining to the Landfill Runoff Collection Pond will be reduced to approximately 443 acres (Stantec, 2016b).

The subsections under §257.73(d) address conditions of appurtenances categorized as embankments, spillways, or hydraulic structures. Sections 2.1 to 2.3 below provide descriptions of the individual unit elements that fall within these appurtenance categories. Appendix A provides an overview of the Clifty Creek Station and the Landfill Runoff Collection Pond.

Note that all elevations included in this document and appendices are referenced to the North American Vertical Datum of 1988 (NAVD 88).

INITIAL STRUCTURAL STABILITY ASSESSMENT

UNIT DESCRIPTION
October 17, 2016

2.1 EMBANKMENTS

2.1.1 LRCP Dam

The LRCP Dam forms the southern boundary for the pond, approximately 700 feet from the Ohio River. It is an earthen dam with a crest length roughly 1,600 feet and a maximum height of 70 feet. The minimum dam crest elevation is 502.9 feet mean sea level (MSL) with a maximum of 505.9 feet along the left abutment (GZA, 2009). The LRCP Dam is registered with the Indiana Department of Natural Resources (IDNR) as Dam No. 39-12.

The LRCP Dam consists of the main 70-foot high dam, a 25-foot high dike on top of an adjoining ridge, a natural rock ridge, and a 15-foot high saddle dike between the rock ridge and the east abutment (AEPSC, 1985). Figure 1 provides a sketch of the components of the LRCP Dam. The main dam has a constructed downstream slope of approximately 2.7H:1V above elevation 474 feet and 3.3H:1V below elevation 474 feet and an upstream slope of about 4.4H:1V. The saddle dike has a downstream slope of 2H:1V and a length of 250 feet (GZA, 2009).

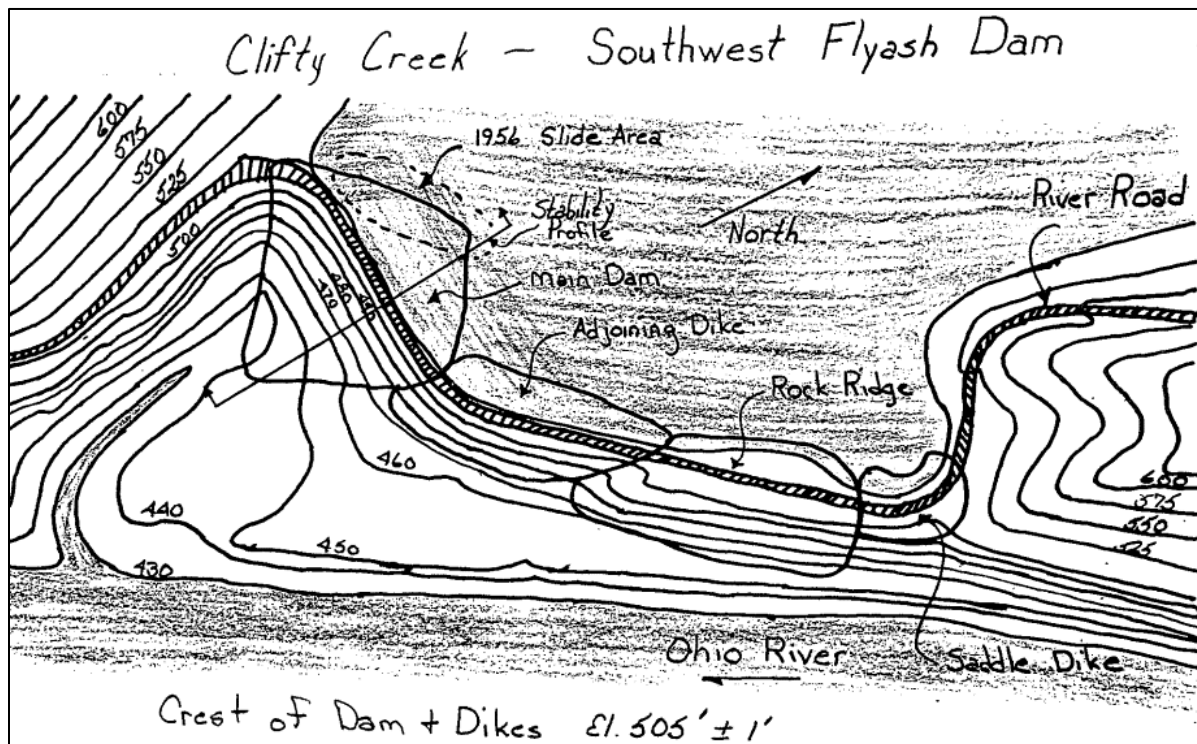


Figure 1 LRCP Dam Construction Detail (AEPSC, 1985)

INITIAL STRUCTURAL STABILITY ASSESSMENT

Foundations and Abutments (§257.73(d)(1)(i))
October 17, 2016

2.2 SPILLWAYS

2.2.1 Primary Spillway System

The LRCP primary spillway is an inclined six-foot by three-foot reinforced concrete box culvert with a riser box structure containing grated inlets at 11-foot intervals in elevation. The inclined box is connected to a 400-foot long, 72-inch diameter concrete pipe that discharges to the Ohio River (Stantec, 2016b).

2.3 HYDRAULIC STRUCTURES

Other than the primary spillway described above, no hydraulic structures are located at the LRCP.

3.0 FOUNDATIONS AND ABUTMENTS (§257.73(d)(1)(i))

Per §257.73(d)(1)(i), the initial structural stability assessment must document whether the unit has been designed, constructed, operated, and maintained with stable foundations and abutments. The Landfill Runoff Collection Pond has the following features that fall within this requirement:

- LRCP Dam

Assessment of the foundations and abutments associated with these features was completed considering the following criteria related to the EPA Final CCR Rule:

- Review inspection reports of the facility, considering frequency of inspections, and if the inspections included review and/or assessment of features including cracking, settlement, deformation, or erosion of the foundations/abutments. Inspections should indicate that there are no significant signs of tension cracking, settlement, depressions, erosion, and/or deformations at the crest, slope, and toe of the structure.
- Confirm that an assessment of seepage conditions of the foundation, with considerations of heave and vertical exit gradient, has been performed. Verify that the seepage assessment follows appropriate methodologies (such as USACE EM 1110-2-1901) and that the foundations exhibit acceptable performance (e.g. FS for piping greater than or equal to 3.0).

INITIAL STRUCTURAL STABILITY ASSESSMENT

Foundations and Abutments (§257.73(d)(1)(i))
October 17, 2016

3.1 LRCP DAM

3.1.1 Background

The LRCP Dam is an earthen dam tying into natural ground on both sides. Mapping of unconsolidated sediments indicate lowland areas adjacent to the Ohio River are predominantly underlain by clay, silt, sand, and gravel deposited as alluvium, lacustrine, and outwash deposits. Glacial deposits are Illinoian and Wisconsinan Quaternary age and belong to the Atherton Formation. Overlying alluvial deposits are Martinsville Formation. Bedrock underlying the site is of the Maquoketa Group, consisting of shale (about 80 percent) and limestone (about 20 percent) (Stantec, 2016a). Based on previous geotechnical studies (AEPSC, 1985 and Stantec, 2016a), the foundation of the LRCP Dam generally consists lean clay, silty sands with interbedded layers of silty clay with a rock ridge of limestone with layers of calcareous shale on the southwest side.

3.1.2 Assessment

A qualified person performs inspections of the Landfill Runoff Collection Pond weekly, monthly, quarterly, and annually. Regular site inspections have been conducted and documented for the Landfill Runoff Collection Pond from 1976 to 2016. These inspections include observations related to foundation and abutment conditions with respect to observable cracking, settlement, depressions, erosion, and deformation.

AEPSC (2015) noted no signs of new sloughing, depressions or areas of wetness and no seeps. A slip was being monitored near the left abutment, but appeared to have stabilized. The slip was thought to have no adverse effect on the integrity of the dam due to location and regrading of the area was discussed.

GZA (2009) observed no unusual movement and some shallow surficial erosion. The saddle dike exhibited shallow scarps on its 2H:1V slope, but the scarps were noted as healed and fully vegetated. Onsite discussions suggested that the scarps were a long-time condition and buttressing at the toe had been performed to attempt to mitigate further sloughing of the slope. This issue is noted in the previous inspections reports and continues to be monitored.

Seepage analysis for the original dike construction is not available. A letter from the design engineer to the owner states that the dam is constructed of relatively impervious material on a foundation of impervious material with the limited exposure to the high river stages. Special measures against seepage through and beneath the dikes were not required (A. Casagrande et al, 1952).

As part of the geotechnical exploration in 2009, a seepage analysis was conducted using SEEP/W (Stantec, 2010). This module is part of the GeoStudio 2007, Version 7.23 software package developed by GEO-SLOPE International, Ltd. of Calgary, Alberta, Canada (GEO-SLOPE International, Ltd, 2007). This package also includes SLOPE/W module for slope stability analysis.

INITIAL STRUCTURAL STABILITY ASSESSMENT

Slope Protection (§257.73(d)(1)(ii))
October 17, 2016

The seepage analysis indicated that the factor of safety for piping/heave was 3.0 or greater for the LRCP Dam.

3.1.3 Conclusion

Based on the assessment of the foundation and abutments for the LRCP Dam, the EPA Final CCR Rule-related criteria listed above have been met.

4.0 SLOPE PROTECTION (§257.73(d)(1)(ii))

Per §257.73(d)(1)(ii), the initial structural stability assessment must document whether the unit has been designed, constructed, operated, and maintained with adequate slope protection to protect against surface erosion, wave action, and adverse effects of sudden drawdown. The Landfill Runoff Collection Pond has the following features that fall within this requirement:

- LRCP Dam

Assessment of the slope protection associated with these features was completed considering the following criteria related to the EPA Final CCR Rule:

1. *Regular (weekly) inspections for erosion. Inspections should show there are no significant signs of deterioration in the slope protection configuration of the Item.*
2. *Appropriate slope protection shall be provided based on anticipated flow velocities. [Hydrologic/hydraulic calculations of flow velocities on the slope of the Item for the appropriate erosive forces. Some common slope protection measures include: riprap, gabions, paving (concrete or asphalt), or appropriate vegetative cover.]*
3. *If slope protection is riprap, filter layer(s) under the riprap shall be designed according to established filter criteria. However, existing riprap cover may be evaluated based on performance and observations during inspections.*

4.1 LRCP DAM

4.1.1 Background

Slope protection for the LRCP Dam consists of grass with smaller areas of riprap on the upstream slope of the dam. The downstream slope is also covered with grass. Flow from the primary spillway's discharge pipe is adequately dissipated through a gradual pipe slope and discharge elevation into the receiving stream (GZA, 2009).

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Embankment Dike Compaction (§257.73(d)(1)(iii))
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4.1.2 Assessment

As reported by the GZA (2009), regular drive-by inspections are performed with a checklist inspection quarterly, and an annual inspection by AEPSC. The spillway is regularly visited to take water quality samples, while the instrumentation in the dams are read monthly. Areas of erosion are prioritized for appropriate repairs. Regular site inspections performed by a registered professional engineer have been conducted and documented for the Landfill Runoff Collection Pond from 1976 to 2016. Site inspection reports generally indicate appropriate maintenance of slope protection features of the dam.

The upstream slope of the LRCP dam is vegetated with short grass. Small riprap has been placed above the normal pool towards the dam crest. At the water line, an area of short wetland grasses was observed (GZA, 2009). Riprap has been placed the length of the dam to protect against wave erosion. The last annual dam and dike inspection observed no erosion due to wave action and that the slope was in stable condition (AEPSC, 2015).

4.1.3 Conclusion

Based on the assessment of the slope protection for the LRCP Dam, the EPA Final CCR Rule-related criteria listed above have been met.

5.0 EMBANKMENT DIKE COMPACTION (§257.73(d)(1)(iii))

Per §257.73(d)(1)(iii), the initial structural stability assessment must document whether the unit has been designed, constructed, operated, and maintained with dikes mechanically compacted to a density sufficient to withstand the range of loading conditions in the CCR unit. The Landfill Runoff Collection Pond has the following features that fall within this requirement:

- LRCP Dam

Assessment of the dike compaction associated with these features was completed considering the following criteria related to the EPA Final CCR Rule:

1. Documentation showing the dike was mechanically compacted. Acceptable documentation may include construction drawings, field notes, construction photographs, correspondences, or any evidence showing the dike was mechanically compacted during construction.
2. If no construction documentation is available specific data from geotechnical explorations of dike may be used. Geotechnical borings with continuous SPTs may be used to assess

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Embankment Dike Compaction (§257.73(d)(1)(iii))
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compaction of the dike. Appropriate methodology correlating blow counts and compaction (density) should be used.

5.1 LRCP DAM

5.1.1 Background

The dam was designed by Arthur and Leo Casagrande of Cambridge, Massachusetts from 1952 to 1954. The firm was also retained during the construction phase and reportedly made a number of site visits as the embankment and appurtenances were being built. Only limited design drawings exist for the LRCP Dam. Technical memoranda and letters between the firm and the plant during the design and construction of the plant and other structures do exist (GZA, 2009). Construction photos are available showing period-appropriate construction equipment working on the site. Subsurface explorations and engineering analyses of the dike were also available that provided SPT data and shear strength testing results used in the assessment.

5.1.2 Assessment

Historical construction photographs, technical memoranda, and letters provide documentation of compaction requirements related to the construction of the LRCP Dam. Construction criteria related to dike embankment materials and dike compaction as noted on this documentation include:

- A discussion of proposed dike materials and the need for proper moisture control and compaction in thin layers with heavy, rubber-tired equipment slightly on the dry side of optimum (A. Casagrande, 1952).
- A discussion of testing the foundation clay in situ with a vane borer with supervision by L. Casagrande (A. Casagrande, 1952).
- A discussion of selection of granular borrow with laboratory data and compaction requirements (A. Casagrande, 1953).
- A discussion of compaction of the foundation fill with a modern, heavy rubber-tired roller in 9-inch layers and compacted with four passes of a roller loaded to 50 or 60 tons (A. Casagrande, 1953).

Three previous geotechnical explorations were available to review as part of this assessment (AEPSC, 1985; Stantec, 2010; Stantec, 2016a). Each was a geotechnical exploration and slope stability evaluation of the LRCP Dam. The programs included drilling and laboratory testing.

AEPSC (1985) assigned undrained shear strength parameters to the existing lean clay dam of 2,500 pounds per square foot (psf) cohesion and an internal friction angle of 10 degrees based on estimates and interpretation from cone penetration testing. Stantec (2016a) assigned

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Vegetated Slopes (§257.73(d)(1)(iv))
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drained shear strength parameters to the existing lean clay dam of 198 psf and 27.5 degrees with undrained shear strength parameters of 1,400 psf and 21 degrees. Correlating these results using NAVFAC DM-7.2 indicate that appropriate compaction exists within the embankment of the LRCP Dam (NAVFAC, 1986).

Stantec (2016a) performed a moisture-density test on the embankment lean clay to compare with in-situ natural moisture contents and unit weights of the soil. Natural moisture contents within the embankment varied from 17 to 24 percent with an average of 20 percent. Dry densities ranged from 99 to 114 pounds per cubic foot (pcf) with an average of 108 pcf. The results of the tests suggested the average natural moisture content of the embankment is about 3 percent above optimum moisture and that the average percent compaction of the embankment soil is approximately 98 percent of standard Proctor maximum density.

5.1.3 Conclusion

Based on the assessment of the embankment dike compaction for the LRCP Dam, the EPA Final CCR Rule-related criteria listed above have been met.

6.0 VEGETATED SLOPES (§257.73(d)(1)(iv))

Per §257.73(d)(1)(iv), the initial structural stability assessment must document whether the unit has been designed, constructed, operated, and maintained with vegetated slopes of dikes and surrounding areas, except for slopes which have an alternate form or forms of slope protection. The Landfill Runoff Collection Pond has the following features that fall within this requirement:

- LRCP Dam

Assessment of the vegetated slopes associated with these features was completed considering the following criteria related to the EPA Final CCR Rule:

1. Regular inspection records showing vegetative cover sufficient to prevent surface erosion while allowing an unobstructed view to visually inspect the slope.

6.1 BACKGROUND

Slope protection for the LRCP Dam consists of short grass with smaller riprap areas on the upstream slope of the dam above the operating pool. Small wetland grasses are present at the base of the upstream slope. The downstream slope is covered with grass.

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Spillway Condition and Capacity (§257.73(d)(1)(v))
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6.2 ASSESSMENT

Regular site inspections were conducted and documented regularly following construction of the LRCP Dam. Weekly, monthly, quarterly, and annual inspections are performed for the LRCP Dam.

In August 2015, Stantec personnel visited the site to observe existing conditions. The vegetation along the slopes of the LRCP Dam of the Landfill Runoff Collection Pond appeared mowed and maintained.

6.3 CONCLUSION

Based on the assessment of the vegetated slopes for the LRCP Dam, the EPA Final CCR Rule-related criteria listed above have been met.

7.0 SPILLWAY CONDITION AND CAPACITY (§257.73(d)(1)(v))

Per §257.73(d)(1)(v), the initial structural stability assessment must document whether the unit has been designed, constructed, operated, and maintained with a single spillway or combination of spillways that meet the condition and capacity requirements as outlined in this section of the EPA Final CCR Rule. The combined capacity of all spillways are to be designed, constructed, operated, and maintained to adequately manage flow during and following the peak discharge from the event specified in this section. The Landfill Runoff Collection Pond has the following features that fall within this requirement:

- LRCP Dam Primary Spillway System

Assessment of the spillway condition and capacity associated with these features was completed considering the following criteria related to the EPA Final CCR Rule:

1. Outlet channel must be of non-erodible material designed to carry sustained flow velocities based on the required flood events. [Estimate flow velocities and select appropriate material using hydraulic analysis for the following flood events: PMF (high hazard potential unit), 1000-year flood (Significant hazard unit), 100-year flood (low hazard potential unit).]
2. Must adequately manage flow during and following the peak discharge. [Estimate size of outlet structure based of hydraulic analysis for the following flood events: PMF (High hazard potential unit), 1000-year flood (Significant hazard potential unit), and 100-year flood (low hazard potential unit).]

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Spillway Condition and Capacity (§257.73(d)(1)(v))
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3. Must be structurally stable. [Assess stability of structure using stability and stress analyses according to an appropriate methodology. Some acceptable methodologies may include: EM 1110-2-2400, EM 1110-2-2100, ACI 350, etc.]
4. Must maintain structural integrity. [Structural integrity may be warranted by periodic inspections of existing conduits. Inspections must show no significant presence of deformation, distortions, cracks, joint separation, etc.]
5. Must be free from significant amounts of obstruction and anomaly which may affect the operation of the hydraulic structure [Perform periodic pipe inspections to detect deterioration, deformation, distortion, bedding deficiencies, and sediment, and debris accumulations.]

7.1 PRIMARY SPILLWAY SYSTEM

7.1.1 Background

The Landfill Runoff Collection Pond is classified as a significant hazard structure requiring the combined capacity of all spillways be adequate to manage the flow during and following the peak discharge from a 1000-year flood.

7.1.2 Assessment

7.1.2.1 Spillway Capacity

The Inflow Design Flood Control System Plan for the Landfill Runoff Collection Pond demonstrates the Landfill Runoff Collection Pond meets the capacity requirements outlined in §257.73(d)(1)(v) of the EPA Final CCR Rule. During the October 2015 annual dam and dike inspection, the primary spillway's outlet structure was freely discharging with no observed deficiencies or blockages (AEPSC, 2015).

7.1.2.2 Structural Stability

The Landfill Runoff Collection Pond spillway is a decant-type structure built along the natural slope near the right LRCP Dam abutment. The slope intake shaft is rectangular with a 3-foot by 6-foot cross section. It slopes at 2H:1V to 4H:1V to reflect natural ground. The top of the structure is approximately elevation 503 feet (AEPSC, 2016). There are four main intake elevations: 485.87, 490.79, 496.74, and 501.61 feet (FMSM, 2006).

A 72-inch extra strength reinforced concrete pipe connects to the decant structure at elevation 432.0 feet and discharges downstream to Panther Creek, flowing 700 feet to the Ohio River. The creek outlet is a reinforced concrete head wall with training walls with an invert at the pipe outlet of 430 feet (GZA, 2009).

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The 390-foot-long discharge pipe is set on a 7.6-foot concrete cradle at the prepared foundation elevation. A series of 54 vertical steel struts are spaced at 4-foot centers within the pipe to add reinforcement due to the embankment fill weight. The joints of the reinforced concrete discharge pipe are cemented with rubber gaskets. Three 8-inch concrete water stops are placed on the upstream portion of the discharge pipe at 30-foot centers under the LRCP Dam (GZA, 2009).

The Landfill Runoff Collection Pond's spillway structure is inspected monthly during water quality sampling and annually as part of the dam and dike inspection. Physical condition, flow through the pipe, and maintenance concerns are noted and addressed. A recent 2009 video camera inspection of the structure was performed by Zemba Brothers of Zanesville, Ohio. A minor seep within the pipe was noted and addressed by an inflatable ring to seal the zone. Manned inspections of the structure were performed prior to 2009.

7.1.3 Conclusion

Based on the assessment of the primary spillway system condition and capacity for the Landfill Runoff Collection Pond, the EPA Final CCR Rule-related criteria listed above have been met.

8.0 SUDDEN DRAWDOWN ASSESSMENT (§257.73(d)(1)(vii))

Per §257.73(d)(1)(vii), the initial structural stability assessment must document whether the unit has been designed, constructed, operated, and maintained with downstream slopes that can be inundated by an adjacent water body (such as a river, stream, or lake) to determine if structural stability is maintained during low pool or sudden drawdown of the adjacent water body. The Landfill Runoff Collection Pond has the following feature that falls within this requirement:

- LRCP Dam

Assessment of the sudden drawdown associated with these features was completed considering the following criteria related to the EPA Final CCR Rule:

1. Maintain slope stability during sudden drawdown of adjacent water body.

Guidance provided by the USEPA (2015) described the basis of the EPA Final CCR Rule's factor of safety criteria and methodology as EM 1110-2-1902 (USACE, 2003) or other appropriate methodologies. Table 3-1 of EM 1110-2-1902 (USACE, 2003) recommends a required minimum factor of safety of 1.1 for maximum surcharge pool under rapid drawdown conditions.

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8.1 EMBANKMENTS

8.1.1 Background

The LRCP Dam has a potential sudden drawdown loading from the Ohio River. A sudden drawdown slope stability analysis of the downstream slope is required under the EPA Final CCR Rule §257.73(d)(1)(vii). The sudden drawdown slope stability analysis was performed in conjunction with the static safety factor assessment discussed in Stantec (2016a).

8.1.2 Assessment

8.1.2.1 Material Properties

Stantec performed geotechnical explorations in 2010 and 2015 to characterize the embankment of the LRCP Dam. A laboratory testing program was performed for each exploration to determine the pertinent soil parameters for stability analyses. The strength parameters derived using the laboratory data and used in this sudden drawdown slope stability evaluation are presented in Table 1. The results of the laboratory testing and derivation of the strength parameters can be found in Stantec (2010 and 2016a).

Table 1 Strength Parameters for Stability Analysis – LRCP Dam

Soil Horizon	Unit Weight (pcf)	Effective Stress Strength Parameters		Total Stress Strength Parameters	
		c' (psf)	ϕ' (degrees)	c (psf)	ϕ (degrees)
Embankment	129	198	28	1,400	21
Lean Clay with Sand	127	206	28	1,200	17
Silty Sand	94	0	30	0	30
Silty Clay with Sand	118	152	34	1,000	20
Sandy Silt	125	0	30	0	30
Clayey Gravel with Sand	130	0	35	0	35
Fly Ash	115	0	25	0	25

8.1.2.2 Critical Cross Section Selection

Slope stability analyses were available from Stantec (2010 and 2016a). Two cross sections through the LRCP Dam were analyzed under static, steady-state conditions using the maximum

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surcharge pool. The two sections that were analyzed are labeled Sections D-D' and E-E' and are shown below in Figure 2.

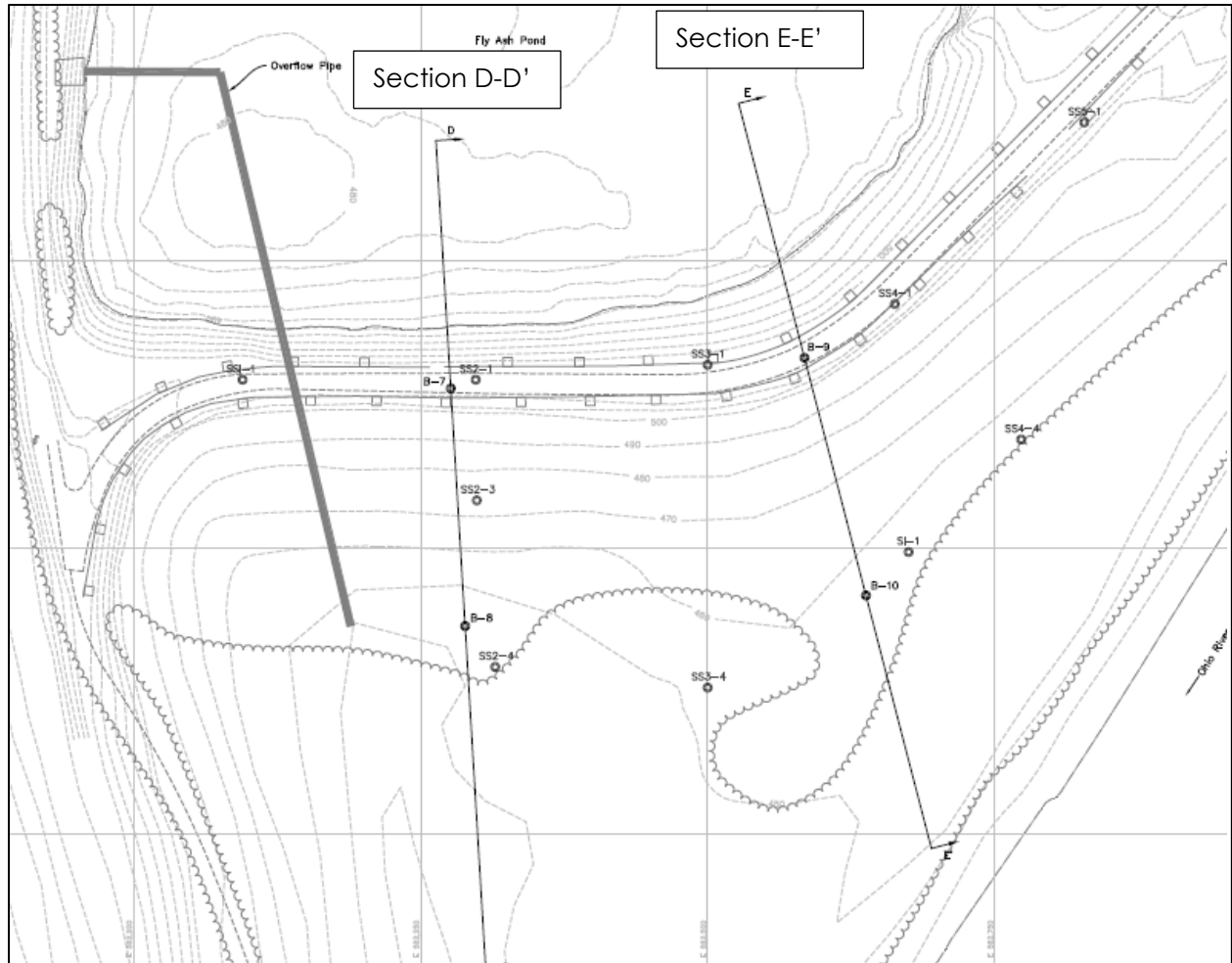


Figure 2 Clifty Creek LRCP Dam – Plan View of Cross Sections

The summary of the slope stability results from Stantec (2016a) is listed in Table 2. The pond levels were set at the 50% PMP elevation (501.4 feet for the Landfill Runoff Collection Pond). The tailwater was set near the elevation of the Ohio River.

Table 2 Slope Stability Results

Facility	Cross-Section	Maximum Surcharge Pool Factor of Safety
Landfill Runoff Collection Pond	D-D'	1.81
	E-E'	1.99

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A sudden drawdown stability analysis is required for Section D-D' as the critical cross section for the LRCP Dam using the proposed water levels discussed in Section 8.1.2.3.

8.1.2.3 Water Levels

Clifty Creek Station's CCR surface impoundments are classified as significant hazard. Under the EPA Final CCR Rule, the inflow design flood for a significant hazard potential CCR surface impoundment is the 1,000-year flood (§257.82(a)(3)(ii)). A rainfall amount for the 1,000-year storm event (7.19 inches) was obtained from the "Precipitation Frequency Atlas of the United States, NOAA Atlas 14" using a precipitation event duration of 6 hours (Bonnin et al, 2016).

Stantec (2016b) presents the reservoir routing analysis for the Landfill Runoff Collection Pond assuming the probable maximum precipitation (PMP) event for existing and future landfill conditions. From NOAA (1980), a 6-hour rainfall depth (27.6 inches) for the PMP storm event was obtained. The reservoir routing model indicates that the Landfill Runoff Collection Pond existing and proposed conditions peak PMP water surface elevations are 500.4 and 501.4 feet, respectively.

The sudden drawdown analysis has been performed assuming a maximum surcharge pool within the surface impoundment equal to the probable maximum flood (PMF) and a long-term maximum storage pool equal to the operating pool elevation reported in Stantec (2016a).

Tailwater for the model is the Ohio River elevation. The 100-year flood level for the Ohio River was used for the tailwater flood pool elevation (FEMA, 2015). The normal pool for the Ohio River was determined from the elevations provided by NOAA (2016) for Madison, Indiana. Table 3 lists the headwater and tailwater elevations used for analysis.

Table 3 Clifty Creek Station Water Elevations for Stability Modeling

CCR Rule Criteria	Headwater Landfill Runoff Collection Pond Elevation (feet)	Tailwater Ohio River Elevation (feet)
Long-term maximum storage pool loading condition	485.0	420.0
Maximum surcharge pool loading condition	501.4	463.0

8.1.2.4 Analysis Methodology

Stantec performed the sudden drawdown slope stability analyses using the GeoStudio 2007, Version 7.23 software package developed by GEO-SLOPE International, Ltd. of Calgary, Alberta, Canada (GEO-SLOPE International, Ltd., 2007). This package includes the SLOPE/W module for

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slope stability analysis. The analyses were performed in accordance with the recommendations and criteria outlined in the USACE Design Manual EM 1110-2-1902 "Slope Stability" (USACE, 2003).

8.1.2.5 Acceptance Criteria

A minimum factor of safety is not explicitly specified within the EPA Final CCR Rule §257.73(d)(1)(vii). In the EPA CCR Final Rule discussion, USACE (2003) is considered the basis for the slope stability analyses. Table 3-1, Minimum Required Factors of Safety: New Earth and Rock-Fill Dams, requires a factor of safety of 1.1 for a rapid drawdown condition from maximum surcharge pool.

8.1.2.6 Analysis Results

The slope stability assessment presented in this report is focused on the potential for slope failures of significant mass, which could directly impact potential release of water and CCR materials from the Landfill Runoff Collection Pond. The search for a critical slip surface in the slope stability assessment is thus restricted to consider only potential surfaces where the depth (measured at the base of at least one slice) is more than ten feet vertically below the ground surface. Table 4 summarizes the sudden drawdown safety factor evaluation results at the LRCP Dam Section D-D'. The results of the analysis are included in Appendix B.

The results show that the sudden drawdown factor of safety assuming the PMP event meets the criteria; therefore, the design is also acceptable for the 1000-year event and the requirements set forth in 40 CFR 257.73(d)(1)(vii).

Table 4 Factor of Safety Assessment Results

Facility	Cross Section	EPA Final CCR Rule Criteria	Recommended Factor of Safety Criteria	Calculated Factor of Safety
Landfill Runoff Collection Pond	D-D'	Sudden Drawdown	1.1	1.8

8.1.3 Conclusion

Based on the assessment of the sudden drawdown for LRCP Dam, the EPA Final CCR Rule-related criteria listed above has been met.

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References
October 17, 2016

Appendix A PLAN VIEW OF CLIFTY CREEK STATION

Appendix B SUDDEN DRAWDOWN ASSESSMENT

APPENDIX A
PLAN VIEW OF CLIFTY CREEK STATION



Figure No. **A-1**
 Title **Plan View of Clifty Creek Station**

Client/Project
 Clifty Creek Station - Structural Stability
 Landfill Runoff Collection Pond and
 West Boiler Slag Pond

Project Location 175534018
 Madison Jefferson County, IN Prepared by AP on 2016-10-13
 Technical Review by JH on 2016-10-13
 Independent Review by SH on 2016-10-13

0 500 1,000 Feet
 1:6,000 (At original document size of 11x17)



- Notes**
1. Coordinate System: NAD 1927 StatePlane Indiana East FIPS 1301
 2. USDA - NAIP 2014 Ortho-Imagery
 3. Fuller, Mossbarger, Scott, & May, Inc. (FMSM) (2006b). Permit Drawings. Indiana-Kentucky Electric Corporation. Clifty Creek Coal Ash Landfill Modification. Jefferson County, Madison Township, Indiana. November. Dwg. No. 16-30500-09-A. Coal Ash Landfill. Top of Cover



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APPENDIX B
SUDDEN DRAWDOWN ASSESSMENT

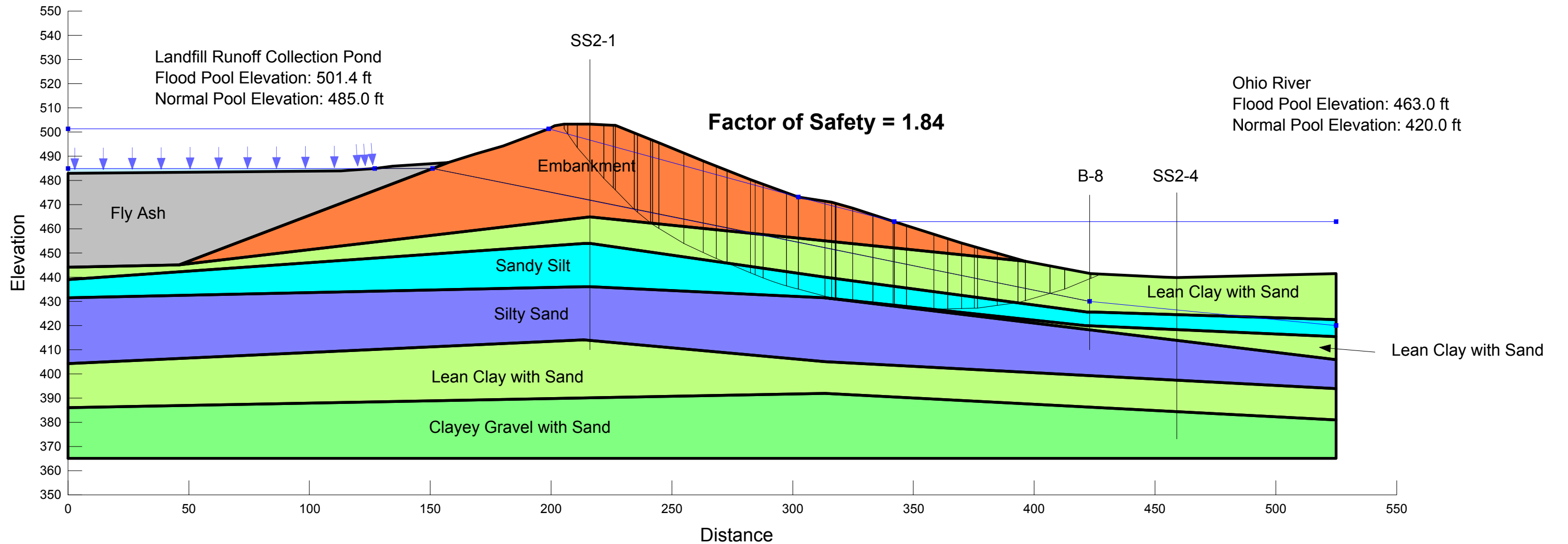
**Indiana-Kentucky Electric Corporation
Clifty Creek Station
Landfill Runoff Collection Pond Dam
Madison, Indiana
Section D-D'**

**Existing Geometry
Sudden Drawdown
Undrained, Sudden Drawdown Strengths**

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Sudden Drawdown

Material Type	Unit Weight	Effective - c'	Effective - phi	Total - c	Total - phi
Embankment (SDD)	129 pcf	198 psf	27.5 °	1400 psf	21 °
Lean Clay with Sand (SDD)	127 pcf	206 psf	28 °	1200 psf	17 °
Sandy Silt (SDD)	125 pcf	0 psf	30 °	0 psf	30 °
Silty Sand (SDD)	94 pcf	0 psf	30 °	0 psf	30 °
Clayey Gravel with Sand (SDD)	130 pcf	0 psf	35 °	0 psf	35 °
Fly Ash (SDD)	115 pcf	0 psf	25 °	0 psf	25 °



APPENDIX E8 – SAFETY FACTOR ASSESSMENT

**Report of CCR Rule Stability
Analyses
AEP Clifty Creek Power Plant
Boiler Slag Pond Dam and
Landfill Runoff Collection Pond**

Madison, Jefferson County,
Indiana



Prepared for:
American Electric Power
Columbus, Ohio

Prepared by:
Stantec Consulting Services Inc.
Cincinnati, Ohio

February 16, 2016

**REPORT OF CCR RULE STABILITY ANALYSES
AEP CLIFTY CREEK POWER PLANT
BOILER SLAG POND DAM AND LANDFILL RUNOFF COLLECTION POND**

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Executive Summary

The Clifty Creek Power Station's Boiler Slag Pond Dam, owned and operated by the Indiana and Kentucky Electric Corporation (IKEC), is located in the city of Madison, Indiana along the northern bank of the Ohio River. The Boiler Slag Pond currently serves as a settling facility for sluiced bottom ash produced at the plant. In addition to the process flows from the plant, approximately 510 acres drain to the facility. The pond is formed by natural grade to the north, east, and west; as well as a southern dike that runs along the bank of the Ohio River.

The Landfill Runoff Collection Pond serves as a collection pond for the Coal Combustion Byproducts Landfill. The pond is formed by natural grades to the north, east, and west; as well as a southern dam that runs along the bank of the Ohio River. The drainage area of the pond is approximately 443 acres. The Indiana Department of Natural Resources (IDNR) has designated this dam as No. 39-12, which was registered as a High Hazard Structure in 2010.

Stantec Consulting Services Inc. (Stantec) was contracted to perform a geotechnical exploration, stability analysis, and liquefaction assessment of the dike for these facilities in 2009 (Landfill Runoff Collection Pond) and in 2010 (Boiler Slag Pond Dam). The intent of the explorations was to develop subsurface data at cross-sections along the dike for the Boiler Slag Pond and the dam for the Landfill Collection Runoff Pond and to perform conventional seepage and stability analyses, assessing the performance of the facilities. The potential for liquefaction was to be evaluated according to simplified published methods. Reports from past geotechnical explorations were used to supplement subsurface data.

In response to the Coal Combustion Residual (CCR) rules mandated in the Federal Register on April 17, 2015, AEP contracted Stantec to perform stability analyses for the Boiler Slag Pond Dam and Landfill Runoff Collection Pond to estimate static, seismic, and liquefaction potential factors of safety. According to Section 257.73(e)(1)(i) through (iv), the factor of safety assessment CCR rules are:

- (i) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.
- (ii) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.
- (iii) The calculated seismic factor of safety must equal or exceed 1.00
- (iv) For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

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The factors of safety obtained during the analyses for static and seismic load cases were greater than those required for Section 257.73 (e)(1)(i) through (iii). The average factor of safety for each soil horizon that was susceptible to liquefaction was greater than that required in Section 257.74 (e)(1)(iv).

The results of the 2010 analyses can be found in Section 6.1.1 for the Boiler Slag Pond Dam and Section 6.1.2 for the Landfill Runoff Collection Pond. The results of the 2015 CCR review can be found in Section 6.1.2 for the Boiler Slag Pond Dam and Section 6.2.2 for the Landfill Runoff Collection Pond.

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1.0 INTRODUCTION

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Stantec Consulting Services Inc. (Stantec) was contracted to perform a geotechnical exploration, stability analysis, and liquefaction assessment of the dike for these facilities in 2009 (Landfill Runoff Collection Pond) and in 2010 (Boiler Slag Pond Dam). The intent of the explorations was to develop subsurface data at cross-sections along the dike for the Boiler Slag Pond and the dam for the Landfill Collection Runoff Pond and to perform conventional seepage and stability analyses, assessing the performance of the facilities. The potential for liquefaction was to be evaluated according to simplified published methods. Reports from past geotechnical explorations were used to supplement subsurface data.

In response to the Coal Combustion Residual (CCR) rules mandated in the Federal Register on April 17, 2015, AEP contracted Stantec to perform stability analyses for the Boiler Slag Pond Dam and Landfill Runoff Collection Pond to estimate static, seismic, and liquefaction potential factors of safety. According to Section 257.73(e)(1)(i) through (iv) of the CCR rules, the required factors of safety are as follows:

- (i) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.
- (ii) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.
- (iii) The calculated seismic factor of safety must equal or exceed 1.00
- (iv) For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

Table 1 summarizes the geometric characteristics of the embankments.



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Table 1 Clifty Creek Facility Geometry

Facility Section	Height (feet)	Crest Width (feet)	Downstream Slope Grade	Upstream Slope Grade
Boiler Slag Pond Section A-A'	41	22	2.5H:1V*	1.75H:1V*
Boiler Slag Pond Section B-B'	31	30	2.5H:1V*	1.5H:1V*
Boiler Slag Pond Section C-C'	35	30	2H:1V*	2H:1V*
Landfill Runoff Collection Pond Section D-D'	61	20	2.5H:1V*	3H:1V*
Landfill Runoff Collection Pond Section E-E'	51	20	2.5H:1V*	4.5H:1V*

*Denotes horizontal to vertical ratio

2.0 GEOLOGY OF THE SITE

The site lies within the Muscatatuck Regional Slope Physiographic Region of Indiana. This gently sloping plain is made of bedrock that is mostly Devonian in age that has been dissected by streams. Along the Ohio River the uplands immediately to the north are rugged and stand in bold relief to the flood plain. The reaches of each drainageway typically contain accumulations of silt, clay, and sand that make up the flat-lying flood plains. The site topography is steep to moderately sloping toward natural drainage channels. Topographic relief between Clifty Creek Power Plant and the uplands to the north is on the order of 350 feet.

Published soils information for the site was obtained from the Soil Survey of Jefferson County, Indiana, (US Department of Agriculture [USDA], Natural Resources Conservation Service [NRCS], 1985). The soil survey indicated the side slopes of Devil's Backbone and the ridge flanks to the north of the site belong to the Eden-Caneyville complex (EgG). These soils are found on steep to very steep slopes ranging from 25 to 60 percent. The Eden-Caneyville complex consists of moderately deep and well-drained soils that formed on slopes facing the Ohio River and on back slopes facing adjacent to tributaries near the river.

Mapping of unconsolidated sediments obtained from Regional Geologic Map, Louisville Sheet, Part B (Indiana Department of Natural Resources [IDNR], 1972) indicates the lowland areas adjacent to the Ohio River are predominantly underlain by clay, silt, sand, and gravel deposited as alluvium, lacustrine and outwash deposits. The glacial deposits in the area are of the Illinoian and Wisconsinan Quaternary age and belong to the Atherton Formation. The overlying more recent alluvial deposits belong to the Martinsville Formation.



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The Atherton Formation consists of coarse- to fine-grained, well-sorted sediments that were deposited by glacial outwash (sand and gravel deposited by glacial meltwater streams), lake sediments and loess. The Martinsville Formation consists of alluvial sediments of non-glacial origin that have been deposited in modern flood plains along the major drainage ways. This formation varies in thickness from a few inches up to 30 feet near rivers.

Available geologic mapping from Bedrock Geology of Indiana (Indiana Geological Survey [IGS] Miscellaneous Map 48, IGS, 1987) shows the site to be underlain by bedrock of the Maquoketa Group. The Maquoketa Group in Indiana is a westward-thinning wedge, 1,000 feet thick in southeastern Indiana and 200 feet thick in northwestern Indiana. Overall, the group consists principally of shale (about 80 percent) and limestone (about 20 percent), although limestone is dominant in some areas. The lower part of the group is almost entirely shale, and the lower part of the shale is dark brown to nearly black. These rocks were deposited during the Upper Ordovician Period.

3.0 FIELD EXPLORATIONS AND SITE RECONNAISSANCE

The borings for the 2009 and 2010 geotechnical exploration were advanced using 3¼-inch inside-diameter hollow-stem augers powered by a truck-mounted drill rig. Standard penetration tests (SPTs) were performed at 2.5-foot intervals in accordance with ASTM D 1586. Undisturbed Shelby tube samples were performed at selected intervals to obtain samples for consolidated-undrained (CU) triaxial compression (ASTM D 4767) and permeability testing (ASTM D 5084-90). Sample depths and recovery amounts are presented on the boring logs. Additionally, disturbed bag samples were collected from auger cuttings obtained from the boreholes.

A Stantec geotechnical engineer directed the drill crews, logged the subsurface materials encountered during the exploration and collected soil samples. During field logging, particular attention was given to each material's color, texture, moisture content, and consistency or relative density.

Following the field explorations, the Shelby tubes and bag samples were transported to Stantec's (or certified vendor's) laboratory for testing. Natural moisture content and unit weight testing were performed on samples extruded from the tubes. Testing consisting of sieve and hydrometer analyses (ASTM D 422) and Atterberg limits (ASTM D 4318) was performed on representative samples in order to classify the soil according to the Unified Soil Classification System (USCS). Consolidated undrained triaxial compression tests (ASTM D 4767) and falling head permeability tests (ASTM D 5084) were also performed on Shelby tube samples. Standard Proctor moisture-density testing (ASTM D 698) was performed on disturbed soil bag samples collected from the auger cuttings.



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3.1 BOILER SLAG POND DAM

3.1.1 2010 Geotechnical Exploration

Stantec advanced six borings at the dike of the Boiler Slag Pond Dam near the locations requested by AEP. The boring locations are shown in Appendix A. Borings B-1, B-3, and B-5 were positioned along the crest of the dike and Borings B-2, B-4, and B-6 were located along the downstream toe.

Upon completion of drilling, one-inch diameter standpipe piezometers were installed in four of the borings (Borings B-1, B-3, B-4, and B-5). In these, ten-foot long sections of polyvinyl chloride (PVC) well screen were placed in the borehole with the bottoms at approximate depths ranging from 30 to 40 feet. PVC riser tubing extended to the tops of the piezometers. Flush-mount well covers were installed along the crest of the dike (Borings B-1, B-3, and B-5) and an above-ground steel tube cover was used at the toe of the downstream slope (Boring B-4). Refer to Appendix C for piezometer installation details.

3.1.2 2015 CCR Mandate Site Reconnaissance

Representatives from Stantec visited the Boiler Slag Pond Dam for a site reconnaissance on August 25, 2015. The purpose of this visit was to confirm that physical conditions at the pond, such as geometry of the embankment, pool elevations, etc. had not changed since the completion of the analysis in 2010. The crest and exterior slopes of the pond were walked by Stantec personnel, while the interior slopes were observed from the crest. Evidence of alterations to the pond since 2010 were not observed during the reconnaissance.

3.2 LANDFILL RUNOFF COLLECTION POND DAM

3.2.1 Previous Explorations

Two historical exploration reports were used to develop subsurface profiles and engineering parameters for the onsite material. The Fly Ash Dam Raising Feasibility Report (AEP, 1985) was implemented to obtain geotechnical properties of the dams, dikes, and foundation material to perform a feasibility assessment of raising the dams by 30 feet. Approximately 22 borings with SPT sampling and 11 Cone Penetrometer Test (CPT) borings were performed for this study. This report was used to develop a subsurface profile of the dam and estimate soil properties and shear strength parameters.

The Hydrogeologic Study Report (Applied Geology and Environmental Science, Inc., 2006) summarized the piezometers and field permeability testing performed by various firms. This report was used to develop initial phreatic surfaces for the stability analyses, and the field



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permeability testing data were reviewed to assist in selecting hydraulic conductivity values for soil horizons in the seepage analysis.

A review of the existing data by Stantec revealed a lack of laboratory testing necessary to develop drained (long-term) shear strength parameters. Standard Proctor moisture-density testing was recommended to compare with in-situ total unit weights to estimate the apparent degree of compaction used during construction. The review of the existing data resulted in the additional exploration explained in Section 3.2.2.

3.2.2 2009 Geotechnical Exploration

Stantec advanced four additional borings along the southern dam on November 11 and 19, 2009 to collect undisturbed Shelby tube and disturbed bag samples for laboratory testing. The boring locations are shown in Appendix A. Borings B-7 and B-9 were positioned along the crest of the dam, and Borings B-8 and B-10 were located along the downstream toe of the dam embankment. The borings were numbered in sequence with the six borings drilled at the Boiler Slag Pond Dam, also advanced late in 2009.

3.2.3 2015 Geotechnical Exploration

An additional boring (B-12) was advanced on July 6-7, 2015 to confirm subsurface conditions. This boring was placed on the crest of the dam, between the two cross-sections. The location of the boring can be seen on the site plan in Appendix A. Standard Penetration Test samples were collected at five-foot intervals. These samples were taken to a Stantec laboratory for natural moisture content, hydrometer analyses, and Atterberg limits testing.

3.2.4 2015 CCR Mandate Site Reconnaissance

Representatives from Stantec visited the Landfill Runoff Collection Pond for a site reconnaissance on August 25, 2015. The purpose of this visit was to confirm that physical conditions at the pond, such as geometry of the embankment, pool elevations, etc. had not changed since the completion of the analysis in 2010. The crest and exterior slopes of the pond were walked by Stantec personnel, while the interior slopes were observed from the crest. Evidence of alterations to the pond since 2010 were not observed during the reconnaissance.

4.0 RESULTS OF EXPLORATIONS

Logs of borings are provided in Appendix B and shown graphically on stability analysis cross sections in Appendix I for the 2009 and 2010 explorations. Results of natural moisture content tests and SPTs are provided on the logs adjacent to the appropriate sample. Summaries of engineering classification tests are provided in Appendix D.



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4.1 BOILER SLAG POND DAM

4.1.1 2010 Geotechnical Exploration

4.1.1.1 Boring B-1

Boring B-1 was on the crest along cross-section A-A' of the Boiler Slag Pond Dam. The surface elevation of this boring was 473.4 feet.

Lean clay with sand was observed from the surface of the boring to a depth of 67.5 feet (Elevation 405.9 feet). From the surface of the boring to a depth of 37.5 feet (Elevation 435.9 feet), this material was described as light yellowish brown with light gray, damp to moist, and medium stiff to stiff. Natural moisture contents ranged from 15 to 23 percent and SPT N-values varied from 7 to 15 blows per foot (bpf). A liquid limit of 32 percent and a plasticity index of 13 percent were determined for a sample from this horizon. This sample was classified as CL, lean clay with sand, according to the Unified Soil Classification System (USCS) and A-6 (10) according to the Association of American State and Highway Transportation Officials (AASHTO) system. The average total unit weight of undisturbed samples was 131 pounds per cubic foot (pcf).

From a depth of 37.5 to 67.5 feet (Elevation 435.9 to 405.9 feet), the lean clay with sand was described as light yellowish brown with light gray, moist to wet, and very soft to medium stiff. Natural moisture contents ranged from 20 to 37 percent and SPT N-values varied from 2 to 7 blows per foot. A liquid limit of 28 percent and a plasticity index of 12 percent were determined for this soil. A Shelby tube sample yielded a total unit weight of 129 pounds per cubic foot. A representative sample from this layer classified as CL, lean clay with sand, according to the USCS and A-6 (8) according to the AASHTO system.

Bedrock, described as weathered gray shale, was encountered at a depth of 67.5 feet (Elevation 405.9 feet) and was augered to a boring termination depth of 71.5 feet (Elevation 401.9 feet). Groundwater was observed during the drilling at a depth of 40.0 feet (Elevation 433.4 feet) during drilling.

4.1.1.2 Boring B-2

Boring B-2 was advanced at the downstream toe along the same cross-section as Boring B-1 at a surface elevation of 444.0 feet.

From the surface of the boring to a depth of 51.5 feet (Elevation 392.5 feet), lean clay with sand was observed. The top 30 feet of this deposit was described as light yellowish brown with gray, moist to wet, and soft to very stiff. Moisture contents ranged from 17 to 32 percent and SPT N-values varied from 2 to 19 bpf, with an average of 7 blows per foot. The average total unit weight of the soil was 124 pounds per cubic foot.



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The lower 21.5 feet of the lean clay with sand was described as gray, moist to wet, and soft to medium stiff. Natural moisture contents ranged from 25 to 35 percent and SPT N-values varied from 2 to 6 blows per foot. A liquid limit of 33 percent and plasticity index of 18 percent was determined for this material. A representative sample of this soil classified as CL, lean clay with sand according to the USCS and A-6 (13) according to the AASHTO system. Total unit weights of 117 and 121 pcf were determined for Shelby tube samples.

From a depth of 51.5 to 55.5 feet (Elevation 392.5 to 388.5 feet), well-graded gravel with silt and sand was observed. Bedrock was encountered below this material, described as shale, gray, hard, and medium bedded. Groundwater was observed at a depth of 22.5 feet (Elevation 421.5 feet) during drilling.

4.1.1.3 Boring B-3

Boring B-3 was positioned on the crest of the dike along cross-section B-B'. The surface elevation of the boring was 471.6 feet.

Lean clay with sand, described as light yellowish brown with light gray, was observed from the boring surface to a depth of 37.5 feet (Elevation 434.1 feet). The soil was further described as damp to moist and medium-stiff to very stiff. Moisture contents ranged from 15 to 22 percent and SPT N-values varied from 8 to 17 blows per foot. The average total unit weight was 131 pounds per cubic foot.

Gray lean clay with sand was observed below the upper soil horizon to the termination depth of 71.5 feet (Elevation 400.1 feet). This soil was described as moist and soft to very stiff. Moisture contents ranged from 20 to 40 percent and SPT N-values varied from 2 to 18 bpf, with an average of 6 blows per foot. The average total unit weight was 126 pounds per cubic foot.

Groundwater was observed at a depth of 40.0 feet (Elevation 431.6 feet) during drilling. Bedrock was not encountered.

4.1.1.4 Boring B-4

Boring B-4 was located along the downstream toe of the dike, downhill from Boring B-3, at a surface elevation of 444.0 feet.

Brown to dark gray lean clay with sand was observed from the surface of the boring to a depth of 15.0 feet (Elevation 429.0 feet). The soil was described as damp to moist and medium stiff to very stiff. Natural moisture contents ranged from 14 to 22 percent and SPT N-values varied from 7 to 16 blows per foot.

Gray lean clay with sand was encountered below the upper soil horizon to a depth of 57.5 feet (Elevation 386.5 feet) and was described as moist to wet and soft to stiff. Moisture contents



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varied from 21 to 35 percent and SPT N-values varied from 3 to 9 blows per foot. A representative sample yielded a liquid limit of 25 percent and a plasticity index of 8 percent. This material classified as CL, lean clay with sand, according to the USCS and A-4 (4) according to the AASHTO system.

Underlying the lean clay with sand, well-graded gravel with silt and sand was observed to a termination depth of 71.5 feet (Elevation 372.5 feet). This material was described as gray, wet, and dense to very dense. Moisture contents ranged from 9 to 13 percent and SPT N-values varied from 39 to over 50 blows per foot. A representative sample of this material tested as non-plastic and classified as GW-GM, well-graded gravel with silt and sand, according to the USCS and A-1-a (1) according to the AASHTO system.

Bedrock was not encountered in the boring. Groundwater was observed at a depth of 22.5 feet (Elevation 421.5 feet) during drilling.

4.1.1.5 Boring B-5

Boring B-5 was advanced from the crest of the dike on cross-section C-C'. The surface elevation was 468.7 feet.

Lean clay with sand was observed from the surface of Boring B-5 to a depth of 40.0 feet (Elevation 428.7 feet). The soil was described as light yellowish brown with light gray, damp to moist, and medium stiff to very stiff. Natural moisture contents ranged from 15 to 25 percent and SPT N-values varied from 6 to 19 blows per foot. The average total unit weight of the soil was 128 pounds per cubic foot.

Additional lean clay with sand was encountered below the uppermost layer to a depth of 47.5 feet (Elevation 421.2 feet). This material was described as gray, moist to wet, and soft. Natural moisture contents ranged from 23 to 25 percent and SPT N-values varied between 3 and 4 blows per foot. The total unit weight was 119 pounds per cubic foot.

Below the lean clay with sand, sandy silt was observed to the termination depth of 71.5 feet (397.2 feet). The sandy silt was described as light yellowish brown to gray, wet, and soft to stiff. Moisture contents ranged from 22 to 30 and SPT N-values varied from 2 to 13 bpf, with an average of 7 blows per foot. A representative sample from this horizon tested as non-plastic and classified as ML, sandy silt, according to the USCS and A-4 (0) according to the AASHTO system.

Bedrock was not encountered in the boring. Groundwater was encountered at a depth of 45.0 feet (Elevation 423.7 feet) during drilling.

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4.1.1.6 Boring B-6

Boring B-6 was advanced from a surface elevation of 445.5 feet near the southeast toe of slope below Boring B-5.

Lean clay with sand was encountered from the surface to a depth of 27.5 feet (Elevation 418.0 feet). This material was described as brown to gray, damp to moist, and very soft to very stiff. Natural moisture contents ranged from 16 to 32 percent and SPT N-values varied from 0 to 18 bpf, with an average of 6 blows per foot. The average total unit weight was 117 pounds per cubic foot.

Sandy silt was observed below the lean clay with sand to the boring termination depth of 71.5 feet (Elevation 374.0 feet). This soil was described as gray, moist to wet, and very soft to stiff. Moisture contents ranged from 27 to 40 percent and SPT N-values varied from 1 to 11 bpf, with an average of 5 blows per foot. The total unit weight was 117 pounds per cubic foot.

Bedrock was not encountered in the boring. Groundwater was observed at a depth of 30.0 feet (Elevation 415.5 feet) during drilling.

4.1.1.7 Piezometers

Piezometers were installed on the crest in Borings B-1, B-3, and B-5, and at the downstream toe in Boring B-4. Details of piezometers installations are shown in Appendix C. Ten-foot long piezometers screens were installed with the tips at approximate depths of 40 feet along the crest and 30 feet at the downstream toe of slope. Table 2 summarizes the installations and first two readings performed on the piezometers.

Table 2 Summary of Piezometer Elevations for the Boiler Slag Pond Dam

Boring No.	Top of Piezometer (feet)	Tip of Piezometer (feet)	Piezometric Reading on 11/13/09 (feet)	Piezometric Reading on 02/01/10 (feet)
B-1	473.4	433.4	434.2	434.1
B-3	471.8	431.6	440.6	434.6
B-4	446.7	414.0	430.7	428.5
B-5	469.0	428.7	434.9	430.4

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4.2 LANDFILL RUNOFF COLLECTION POND

4.2.1 2009 Geotechnical Exploration

4.2.1.1 Boring B-7

Boring B-7 was advanced from the crest of the dam along cross-section D-D'. The surface elevation of the boring was 503.4 feet. Approximately 0.5 feet of asphalt pavement and gravel base was observed at the surface of the boring.

Below the pavement and gravel base, lean clay was observed to a boring termination depth of 29.0 feet (Elevation 474.4 feet). The lean clay was described as yellow and light gray, moist, and stiff. Three undisturbed Shelby tube samples were obtained from a depth of 23.0 to 29.0 feet (Elevation 480.4 to 474.4 feet). Natural moisture contents of those samples ranged from 18 to 24 percent, and total unit weights varied from 128 to 133 pounds per cubic foot. A representative sample yielded a liquid limit of 28 percent and a plasticity index of 8. This sample classified as CL, lean clay, according to the USCS and A-4 (7) according to the AASHTO system.

Neither bedrock nor groundwater was encountered during drilling.

4.2.1.2 Boring B-8

Boring B-8 was located at the toe of slope downstream of Boring B-7. The surface elevation of the boring was 441.5 feet. From the surface of the boring to a depth of 16.0 feet (Elevation 425.5 feet), the soil was visually described as yellow and light gray, damp to moist, silty clay.

Below the silty clay, lean clay was encountered to a depth of 29.0 feet (Elevation 412.5 feet). The lean clay was described as yellowish brown to light gray and moist. Two undisturbed Shelby tube samples were taken from this horizon at depths of between 25.0 and 29.0 feet (Elevation 416.5 to 412.5 feet). Natural moisture contents ranged from 24 to 27 percent, and total unit weights ranged from 124 to 130 pounds per cubic foot. A representative sample of this material yielded a liquid limit of 38 percent and a plasticity index of 17 percent. The sample classified as CL, lean clay according to the USCS and A-6 (15) according to the AASHTO system.

Soil described as lean clay with sand was observed beneath the lean clay to the boring termination depth of 31.0 feet (Elevation 410.5 feet). The lean clay with sand was further described as yellowish brown and light gray and moist. Shelby tube samples yielded moisture contents of 22 and 24 percent and total unit weights of 126 and 129 pounds per cubic foot. This soil had a liquid limit of 45 percent and a plasticity index of 25 percent. The soil classified as CL, lean clay with sand according to the USCS and A-7-6 (20) according to the AASHTO system.

Neither bedrock nor groundwater was encountered during drilling.



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4.2.1.3 Boring B-9

Boring B-9 was advanced along the crest of cross-section E-E' at a surface elevation of 504.3 feet. Asphalt pavement and gravel base was observed at the surface of the boring to a depth of 0.5 feet.

Lean clay was encountered below the pavement to the boring termination depth of 22.0 feet (Elevation 482.3 feet). The lean clay was described as yellow to light gray and damp to moist. Three undisturbed Shelby tube samples were obtained from a depth of 16.0 to 22.0 feet (Elevation 488.3 to 482.3 feet). Natural moisture contents ranged from 17 to 23 percent, and total unit weights varied from 119 to 135 pounds per cubic foot. A sample of this material yielded a liquid limit of 39 percent and a plasticity index of 19 percent. This sample classified as CL, lean clay, according to the USCS and A-6 (17) according to the AASHTO system.

Neither bedrock nor groundwater was encountered during drilling.

4.2.1.4 Boring B-10

Boring B-10 was positioned near the toe below Boring B-9. The surface elevation was 457.3 feet.

Silty clay with sand was observed from the surface of the boring to a depth of 13.2 feet (Elevation 444.1 feet) and from a depth of 16.0 feet to the termination depth of 18.0 feet (Elevation 441.3 to 439.3 feet). This soil was described as yellow to light gray and damp to moist. Two undisturbed Shelby tube samples were taken and natural moisture contents ranged from 21 to 28 percent. Total unit weights of the samples ranged from 116 to 124 pounds per cubic foot. A representative sample of this material yielded a liquid limit of 28 percent and a plasticity index of 7 percent. The sample classified as CL-ML, silty clay with sand according to the USCS and A-4 (5) according to the AASHTO system.

From a depth of 13.2 to 16.0 feet (Elevation 444.1 to 441.3 feet) a layer of silty sand was encountered and describe as gray-brown and damp to moist. One Shelby tube sample was taken from this layer. A representative sample of this soil classified as non-plastic SM, silty sand, according to the USCS and A-2-4 (0) according to the AASHTO system.

4.2.2 2015 Geotechnical Exploration

Boring B-12 was advanced on the crest of the dam between the analysis cross-sections. The ground surface elevation of the boring was estimated to be 503.9 feet. A layer of asphalt with gravel base was encountered at the surface of the boring to a depth of 0.4 feet (Elevation 503.5 feet).

Beneath the asphalt and gravel base, lean clay with sand was encountered to a depth of 40.0 feet (Elevation 463.9 feet). This material was described as gray, damp, and medium stiff to stiff.



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The natural moisture contents ranged from 18 to 28 percent and the SPT N-values varied from 7 to 15 blows per foot. The liquid limit of this material ranged from 31 to 43 percent and the plasticity index varied from 13 to 22 percent. The material classified as CL, lean clay with sand, according to the USCS and A-6 (7) or A-7-6 (15) according to the AASHTO system.

Silty clay with sand was observed beneath the lean clay with sand to a depth of 50.0 feet (Elevation 453.9 feet). This material was described as brown, moist, and medium stiff to very stiff. The natural moisture contents ranged from 16 to 19 percent and the SPT N-values varied from 8 to 16 blows per foot. A representative sample of this material yielded a liquid limit of 26 percent and a plasticity index of 7 percent. The material classified as CL-ML, silty clay with sand, according to the USCS and A-4 (4) according to the AASHTO system.

Cohesionless material was encountered beneath the silty clay with sand to the depth of 90.0 feet (Elevation 413.9 feet). This material was silt, silt with sand, silty sand, or sand; and was described as brown or gray, damp to wet, and loose to medium dense. The natural moisture contents ranged from 15 to 28 percent and the SPT N-values varied from 6 to 28 blows per foot. Samples from these materials tested as non-plastic. The material classified as ML (sandy silt, silt, or silt with sand) or SM (silty sand) according to the USCS and A-4 (0) according to the AASHTO system.

Beneath the cohesionless material, lean clay was encountered to the boring termination depth of 101.5 feet (402.4 feet). This material was described as gray, moist, and medium stiff to very stiff. The natural moisture content ranged from 23 to 27 percent and the SPT N-values varied from 8 to 19 blows per foot. A representative sample from this material yielded a liquid limit of 42 percent and a plasticity index of 23 percent. The sample classified as CL, lean clay, according to the USCS and A-7-6 (20) according to the AASHTO system.

5.0 LABORATORY TESTING

Laboratory tests in addition to the natural moisture content, classification tests, and unit weight tests mentioned in Section 4 were conducted on samples taken from the Boiler Slag Pond Dam (2010 Geotechnical Exploration) and Landfill Runoff Collection Pond (2009 Geotechnical Exploration). The results from the additional testing are summarized in the following sections.

5.1 BOILER SLAG POND DAM

5.1.1 Consolidated-Undrained Triaxial Compression Testing

Three consolidated-undrained (CU) triaxial compression tests were performed on undisturbed samples collected from the borings. These tests were performed in accordance with ASTM D



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4767, and detailed results of the tests are provided in Appendix E. The samples were described as lean clay with sand. Table 3 shows a summary of the CU triaxial tests performed.

Table 3 Summary of CU Triaxial Compression Testing for the Boiler Slag Pond Dam

Boring Nos.	Depth (feet)	Soil Description	Material	Effective Cohesion, c' (psf)	Effective Angle of Internal Friction, ϕ' (deg.)
B-3, B-5	8.1 – 11.2	Lean Clay with Sand	Embankment	330	33.2
B-2, B-4	18.2 – 24.3	Lean Clay with Sand	Foundation	320	27.2
B-1, B-3	43.1 – 48.7	Lean Clay with Sand	Foundation	170	30.2

5.1.2 Permeability Testing

Four permeability tests (ASTM D 5084, Falling-Head, Method C, Rising Tailwater) were performed on undisturbed samples. Detailed data sheets showing the results of the tests are provided in Appendix F. Vertical hydraulic conductivities ranged from 8.7×10^{-9} to 1.6×10^{-6} centimeters per second. The samples were described as lean clay with sand. Table 4 summarizes the results of the permeability tests.

Table 4 Summary of Permeability Testing for the Boiler Slag Pond Dam

Boring No.	Depth, feet	Soil Description	Material	Vertical Hydraulic Conductivity, cm/second
B-1	16.1 – 16.6	Lean Clay with Sand	Embankment	1.44×10^{-7}
B-2	42.6 – 43.1	Lean Clay with Sand	Foundation	8.70×10^{-9}
B-4	7.6 – 8.1	Lean Clay with Sand	Embankment	1.58×10^{-6}
B-6	17.6 – 18.1	Lean Clay with Sand	Foundation	2.01×10^{-7}

5.1.3 Moisture-Density Testing

Three standard Proctor moisture-density tests (ASTM D 698) were performed on bag samples taken from auger cuttings. The data sheets for these tests are provided in Appendix G.



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Maximum dry densities ranged from 113.0 to 117.4 pcf and optimum moisture contents varied from 13.4 to 15.8 percent. The samples were described as lean clay with sand. Table 5 summarizes the results of the tests.

Table 5 Summary of Moisture-Density Testing for the Boiler Slag Pond Dam

Boring No.	Depth, feet	Material	Soil Description	Maximum Dry Density, pcf	Optimum Moisture Content, %
B-1	5.0 +/- 2.0	Embankment	Lean Clay with Sand	117.4	13.4
B-5	7.5 +/- 2.0	Embankment	Lean Clay with Sand	113.0	15.8

These moisture-density tests were performed to compare with natural moisture contents and unit weights of the soils. Within the embankment soils, natural moisture contents ranged from 15 to 25 percent with an average of 19 percent. Dry densities of the embankment soil ranged from 106 to 115 pcf, with an average of 110 pounds per cubic foot. The results of these tests indicate that the average natural moisture content of the embankment soil is 3 to 5 percent above optimum moisture and that the average percent compaction of the embankment soil is on the order of 94 to 97 percent of the standard Proctor maximum density.

5.2 LANDFILL RUNOFF COLLECTION POND

5.2.1 Consolidated-Undrained Triaxial Testing

Four CU triaxial compression tests were performed on undisturbed samples collected from the borings. These tests were performed in accordance with ASTM D 4767, and detailed results of the tests are provided in Appendix E. The samples were described as lean clay, lean clay with sand, or sandy clay. Table 6 shows a summary of the CU triaxial tests performed.

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Table 6 Summary of CU Triaxial Compression Testing for the Landfill Runoff Collection Pond

Boring No.	Depth (feet)	Soil Description	Material	Effective Cohesion, c' (psf)	Effective Angle of Internal Friction, ϕ' (deg.)
B-7	25.8 – 29.0	Lean Clay	Embankment	430	29.3
B-8	25.8 – 30.9	Lean Clay with Sand	Foundation	410	28.0
B-9	17.4 – 21.4	Lean Clay	Embankment	360	25.7
B-10	13.4 – 18.0	Sandy Clay	Foundation	300	35.1

5.2.2 Permeability Testing

Four permeability tests (ASTM D 5084, Falling-Head, Method C, Rising Tailwater) were performed on undisturbed samples. Detailed data sheets showing the results of the tests are provided in Appendix F. Vertical hydraulic conductivities ranged from 3.4×10^{-8} to 1.4×10^{-7} centimeters per second. The samples were described as lean clay, lean clay with sand, or silt. Table 7 summarizes the results of the permeability tests.

Table 7 Summary of Permeability Testing for the Landfill Runoff Collection Pond

Boring No.	Depth, feet	Material	Soil Description	Vertical Hydraulic Conductivity, cm/second
B-7	27.4 – 27.7	Embankment	Lean Clay	8.4×10^{-8}
B-8	29.7 – 30.9	Foundation	Silt	3.4×10^{-8}
B-9	18.3 – 18.9	Embankment	Lean Clay	6.2×10^{-8}
B-10	16.4 – 16.7	Foundation	Lean Clay with Sand	1.4×10^{-7}

5.2.3 Moisture-Density Testing

One standard Proctor moisture-density test (ASTM D 698) was performed on a bag sample of embankment soil taken from auger cuttings. The data sheet for this test is provided in Appendix



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G. The maximum dry density was 110.6 pcf and the optimum moisture content was 16.9 percent. The sample was described as lean clay. Table 8 summarizes the results of the tests.

Table 8 Summary of Moisture-Density Testing for the Landfill Runoff Collection Pond

Boring No.	Depth, feet	Material	Soil Description	Maximum Dry Density, pcf	Optimum Moisture Content, %
B-7	7.0 +/- 2.0	Embankment	Lean Clay	110.6	16.9

The moisture-density test was performed to compare with in-situ natural moisture contents and unit weights of the soils. Within the embankment soils, natural moisture contents varied from 17 to 24 percent with an average of 20 percent. Dry densities of the embankment soil ranged from 99 to 114 pounds per cubic foot, with an average of 108 pounds per cubic foot. The results of these tests indicate that the average natural moisture content of the embankment soil is about 3 percent above optimum moisture and that the average percent compaction of the embankment soil is approximately 98 percent of the standard Proctor maximum density.

6.0 ENGINEERING ANALYSIS

6.1 BOILER SLAG POND DAM

Based on the review of available information, results of the geotechnical exploration and results of laboratory testing, Stantec performed engineering analyses of the Boiler Slag Pond Dam in 2010. This included liquefaction, seepage, and slope stability analysis of three cross sections. The procedures used and the results of the analyses are presented in the following paragraphs. The results of the liquefaction analysis are shown in Appendix H, and the cross section drawings showing the results of the seepage and stability analyses are provided in Appendix I. Appendix J provides an explanation of derivations of shear strength, seepage, and liquefaction analysis parameters.

6.1.1 Engineering Analyses Performed in 2015 as Part of CCR Mandate

6.1.1.1 Liquefaction Analysis

The liquefaction analysis conducted in 2010 was revisited as part of the CCR Mandate. The details for this analysis are contained in Appendix H. Similar to the analysis performed in 2010, a screening process was used to determine if the cohesive material encountered in the borings has the potential for liquefaction. The screening process was conducted for four samples which had liquid limits below 37 percent. According to the Seed et al and Bray and Sancio plots



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supplied in Appendix H, one sample could be labeled as susceptible to liquefaction and another could be labeled as moderately susceptible to liquefaction.

The remaining cohesionless material encountered in the critical cross-sections was tested for liquefaction as a coarse-grained analysis similar to the one conducted in 2010. According to the CCR Mandate, for dikes constructed of soils that have a susceptibility to liquefaction, the calculated factor of safety must equal or exceed 1.20. Test data from Borings B-1 and B-2, representative of cross-section A-A', Boring Nos. B-3 and B-4, representative of cross-section B-B', and B-5 and B-6, representative of cross-section C-C' was used. Soil characteristics (grain size, plasticity, etc.) from SPT and Shelby tube samples were summarized to assess liquefaction potential. The copies of the spreadsheets used for the calculations appear in Appendix H and provide the soil, test data, and calculations used in the assessment.

It was assumed during the screening process for potential liquefaction that the steady-state water elevation consistent with that developed during the stability analysis would be used as the groundwater elevation. Unsaturated soils above this elevation were considered not liquefiable. Also the dike embankment materials, consisting of engineered fill, were not considered liquefiable.

Factors of safety against liquefaction were estimated for soil layers predicted to be potentially liquefiable during the screening process. As a result of recent industry publications that attempted to update certain correlations that had larger uncertainty that are used in the calculations for the factor of safety, slight differences in the factors of safety were obtained than those reported in 2010. Inputs such as depth, material properties, seismic accelerations, etc. have not been altered. Ranges and averages of these factors of safety for the potentially liquefiable soil layers are summarized in Table 9.

Table 9 Liquefaction Factor of Safety for the Boiler Slag Pond Dam, CCR Mandate

Boring No.	Depth (feet)	Elevation (feet)	Unified Soil Classification	Liquefaction FS, Range	Liquefaction FS, Average
B-2	51.5 – 56.0	392.5 – 388.0	GW-GM	10.00	10.00
B-4	57.5 – 71.5	386.5 – 372.5	GW-GM	10.00	10.00
B-5	47.5 – 71.5	421.2 – 397.2	ML	1.60 – 3.52	2.41
B-6	27.5 – 71.5	418.0 – 374.0	ML	1.08 – 2.64	1.73

The range of factors of safety for each soil horizon represents factors of safety calculated from each individual corrected N-value at that specific depth and overburden pressure. Due to the variable and somewhat unreliable nature associated with the SPT, it is recommended that the



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liquefaction factors of safety be evaluated according to the average values shown in Table 9. The average liquefaction factors of safety against liquefaction ranged from 1.73 to 10.00 and are considered acceptable.

6.1.1.2 Seepage Analysis

The seepage analysis conducted in 2010 was reviewed as part of the CCR Mandate. The seepage models used in the SEEP/W product were calibrated to recent piezometric data and visual field operations. Changes to the material properties developed in Appendix J of this report were not deemed necessary.

The 2010 analysis used a normal pool elevation of 442 feet to establish the piezometric line. During the 2015 site reconnaissance with AEP personnel, it was learned that the normal pool elevation is currently 448 feet and is not expected to change. As a result, a piezometric line has been adjusted for the current normal pool elevation of 448 feet, and has been used during the CCR Mandate review. The seepage analysis conducted at the critical cross-sections of A-A', B-B', and C-C' were reviewed.

The results of the seepage analysis were used to revise the stability cross-sections.

6.1.1.3 Stability Analysis

The stability analysis conducted in 2010 was reviewed as part of the CCR Mandate, using the results of the seepage analysis review in Section 6.1.1.2. Similar to 2010, SLOPE/W was the software used during the analysis. The drained shear strength parameters developed in 2010, located in Appendix J, were maintained for the updated analysis. Undrained shear strength parameters were not derived in 2010. These parameters were determined by CU test data for the Embankment Fill and Lean Clay with Sand. Undrained shear strength parameters for cohesionless materials were taken to be identical to the drained shear strength parameters.

Table 10 summarizes the drained and undrained shear strength parameters used in the analysis.

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Table 10 Shear Strength Parameters for CCR Mandate Review

Material	Unit Weight (pcf)	Drained Shear Strengths		Undrained Shear Strengths	
		ϕ' (deg.)	Effective Cohesion (psf)	ϕ (deg.)	Cohesion (psf)
Embankment	130	33.2	165	13	600
Lean Clay with Sand	119	27.2	160	5	1,200
Gravel with Silt and Sand	130	35	0	35	0
Bottom Ash	115	28	0	28	0
Silty Sand	130	30	0	30	0

The upstream and downstream slopes of each cross-section were analyzed, incorporating the auto locate and entry/exit search routines to locate the critical slip surface. Once the potential failure surface with the lowest factor of safety was identified, the optimization routine was run.

When the surface slope is composed of a material with low effective cohesion, an infinite slope failure (shallow sliding parallel to the surface) will be critical. A minimum failure depth of ten feet was specified for each section, to eliminate the evaluation of surficial sloughing and erosional types of instability.

For this review, SLOPE/W was used to investigate one normal pool elevation, considered the maximum steady-state pool, and one PMF pool elevation:

- Current normal pool level of 448 feet.
- 50 Percent PMF pool level of 468.4 feet, applied as a steady-state load condition within SLOPE/W.

Using the drained and undrained strength parameters listed in Table 10, the existing dam was analyzed at the three critical cross sections selected for the CCR review. The undrained materials strengths were used in the seismic analyses.

A summary of the factors of safety are presented in Table 13 at the end of this section and printouts of the GeoStudio runs are presented in Appendix I.

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6.2 LANDFILL RUNOFF COLLECTION POND

Based on the review of available information, results of geotechnical exploration and results of laboratory testing, Stantec performed engineering analyses of the Landfill Runoff Collection Pond in 2009. This included liquefaction, seepage, and slope stability analysis of two cross sections. The procedures used and the results of the analyses are presented in the following paragraphs. The results of the liquefaction analysis are shown in Appendix H, and the cross section drawings showing the results of the seepage and stability analyses are provided in Appendix I. Appendix J provides an explanation of derivations of shear strength, seepage, and liquefaction analysis parameters.

6.2.1 Engineering Analyses Performed in 2015 as Part of CCR Mandate

6.2.1.1 Liquefaction Analysis

The liquefaction analysis conducted in 2010 as part of the 2009 geotechnical exploration was revisited as part of the CCR Mandate. The details for this analysis are contained in Appendix H. Similar to the analysis performed in 2010, a screening process was used to determine if the cohesive material encountered in the borings has the potential for liquefaction. The screening process was conducted for nine samples, four of which had liquid limits below 37 percent. According to the Seed et al and Bray and Sancio plots supplied in Appendix H, none of the samples are considered susceptible to liquefaction.

The remaining cohesionless material encountered in the critical cross-sections was tested for liquefaction as a coarse-grained analysis similar to the one conducted in 2010. According to the CCR Mandate, for dikes constructed of soils that have a susceptibility to liquefaction, the calculated factor of safety must equal or exceed 1.20. Test data from historic Borings SS2-1 and SS2-4, representative of cross-section D-D' and historic Borings SI-1, SS3-1, and SS3-4, representative of cross-section E-E', were used. Soil characteristics (grain size, plasticity, etc.) from SPT and Shelby tube samples were summarized to assess liquefaction potential. The copies of the spreadsheets used for the calculations appear in Appendix H and provide the soil, test data, and calculations used in the assessment.

It was assumed during the screening process for potential liquefaction that the steady-state water elevation consistent with that developed during the stability analysis would be used as the groundwater elevation. Unsaturated soils above this elevation were considered not liquefiable. Also the dike embankment materials, consisting of engineered fill, were not considered liquefiable.

Factors of safety against liquefaction were estimated for soil layers predicted to be potentially liquefiable during the screening process. As a result of recent industry publications that attempted to update certain correlations that had larger uncertainty that are used in the



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calculations for the factor of safety, slight differences in the factors of safety were obtained than those reported in 2010. Inputs such as depth, material properties, seismic accelerations, etc. have not been altered. Ranges and averages of these factors of safety for the potentially liquefiable soil layers are summarized in Table 11.

Table 11 Liquefaction Factor of Safety for the Boiler Slag Pond Dam, CCR Mandate

Boring No.	Depth (feet)	Elevation (feet)	Unified Soil Classification	Liquefaction FS, Range	Liquefaction FS, Average
SI-1	14.0 – 26.0	442.6 – 430.6	ML	2.06 – 2.40	2.23
SI-1	26.0 – 36.0	430.6 – 420.6	SC	10.00	10.00
SI-1	36.0 – 41.0	420.6 – 415.6	SM	5.02	5.02
SI-1	41.0 – 79.5	415.6 – 377.1	ML	2.08 – 10.00*	4.87
SS2-1	61.0 – 66.0	443.5 – 438.5	ML	6.22	6.22
SS2-1	71.0 – 86.0	443.5 – 418.5	SM	2.41 – 10.00	6.31
SS2-4	16.0 – 21.0	423.8 – 418.8	SM	3.29	3.29
SS2-4	61.0 – 64.0	388.8 – 385.8	GC	3.50	3.50
SS3-1	36.0 – 46.0	468.5 – 458.5	ML	3.36 – 4.92	4.14
SS3-1	46.0 – 51.0	458.5 – 453.5	SP	5.34	5.34
SS3-1	51.0 – 56.0	453.5 – 448.5	SC	10.00	10.00
SS3-1	56.0 – 66.0	448.5 – 438.5	SP	3.28 – 3.84	3.56
SS3-1	66.0 – 71.0	438.5 – 433.5	SM	5.03	5.03
SS3-1	71.0 – 86.0	433.5 – 418.5	SP	2.93 – 10.00	6.25
SS3-1	86.0 – 96.0	418.5 – 408.5	SM	5.53 – 6.09	5.81
SS4-1	41.0 – 46.0	464.6 – 459.6	ML	3.28	3.28
SS4-1	46.0 – 66.0	459.6 – 439.6	SM	2.32 – 4.51	3.60
SS4-1	71.0 – 76.0	434.6 – 429.6	SC	1.83	1.83
SS4-1	76.0 – 94.0	429.6 – 411.6	ML	4.01 – 6.30	5.62

*Typical range is 2.08 – 2.93, typical average is 3.16



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6.2.1.2 Seepage Analysis

The seepage analysis conducted in 2010 as a part of the 2009 geotechnical exploration was reviewed as part of the CCR Mandate. The seepage models used in the SEEP/W product were calibrated to recent piezometric data and visual field operations. Changes to the material properties developed in Appendix J of this report and the piezometric lines developed were not deemed necessary. The seepage analysis conducted at the critical cross-sections of D-D' and E-E' were reviewed.

The results of the seepage analysis were used to revise the stability cross-sections.

6.2.1.3 Stability Analysis

The stability analysis conducted in 2010 was reviewed as part of the CCR Mandate, using the results of the seepage analysis review in Section 6.2.1.2. Similar to 2010, SLOPE/W was the software used during the analysis. The drained shear strength parameters developed in 2010, located in Appendix J, were maintained for the updated analysis. Undrained shear strength parameters were not derived in 2010. These parameters were determined by CU test data for the Embankment and Lean Clay with Sand. The undrained shear strength parameters for the silty clay with sand layer were taken from established typical value tables. Undrained shear strength parameters for cohesionless materials were taken to be identical to the drained shear strength parameters.

Table 12 summarizes the drained and undrained shear strength parameters used in the analysis.

Table 12 Shear Strength Parameters for CCR Mandate Review

Material	Unit Weight (pcf)	Drained Shear Strengths		Undrained Shear Strengths	
		ϕ' (deg.)	Effective Cohesion (psf)	ϕ (deg.)	Cohesion (psf)
Embankment	129	27.5	198	21	1,400
Lean Clay with Sand	127	28	206	17	1,200
Sandy Silt	125	30	0	30	0
Silty Sand	94	30	0	30	0
Clayey Gravel with Sand	130	35	0	35	0
Fly Ash	115	25	0	25	0
Silty Clay with Sand	118	34	152	20	1,000



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The upstream and downstream slopes of each cross-section were analyzed, incorporating the auto locate and entry/exit search routines to locate the critical slip surface. Once the potential failure surface with the lowest factor of safety was identified, the optimization routine was run.

When the surface slope is composed of a material with low effective cohesion, an infinite slope failure (shallow sliding parallel to the surface) will be critical. Failure was defined as any slip surface that begins in the crest with a reasonable depth of failure. A minimum failure depth was specified for each section, to eliminate the evaluation of surficial sloughing and erosional types of instability.

For this review, SLOPE/W was used to investigate one normal pool elevation and one PMF pool elevation:

- Current normal pool level of 485 feet.
- PMF pool level of 501.4 feet, applied as a surcharge load within SLOPE/W.

Using the drained and undrained strength parameters listed in Table 12, the existing dam was analyzed at the three critical cross sections selected for the CCR review. The undrained shear strength parameters were used in the seismic analyses.

A summary of the factors of safety are presented in Table 14 at the end of this section and printouts of the GeoStudio runs are presented in Appendix I.

**REPORT OF CCR RULE STABILITY ANALYSES
AEP CLIFTY CREEK POWER PLANT
BOILER SLAG POND DAM AND LANDFILL RUNOFF COLLECTION POND**

ENGINEERING ANALYSIS
February 16, 2016

Table 13 Summary of Computed Factors of Safety for the West Boiler Slag Pond Dam, 2015 CCR Mandate

Headwater Pool	Drainage	Incipient Motion	Seismic Load Case	Acceptance Criteria	Factor of Safety		
					A-A'	B-B'	C-C'
Normal Pool Elevation (448 feet)	Drained	Downstream	No	1.50	2.30	2.44	2.30
Normal Pool Elevation (448 feet)		Upstream		1.50	1.88	1.63	2.73
50% PMF Elevation (462.8 feet)		Downstream		1.40	2.30	2.44	2.18
50% PMF Elevation (462.8 feet)		Upstream		1.40	2.13	1.95	3.88
Normal Pool Elevation (448 feet)	Undrained	Downstream	Yes	1.00	1.35	1.30	1.53
Normal Pool Elevation (448 feet)		Upstream		1.00	1.34	1.30	2.25

Table 14 Summary of Computed Factors of Safety for the Landfill Runoff Collection Pond Dam, 2015 CCR Mandate

Headwater Pool	Drainage	Incipient Motion	Seismic Load Case	Acceptance Criteria	Factor of Safety	
					D-D'	E-E'
Normal Pool Elevation (485 feet)	Drained	Downstream	No	1.50	1.85	1.99
Normal Pool Elevation (485 feet)		Upstream		1.50	2.73	3.51
PMF Elevation Surcharge (501.4 feet)		Downstream		1.40	1.81	1.99
PMF Elevation Surcharge (501.4 feet)		Upstream		1.40	3.47	4.51
Normal Pool Elevation (485 feet)	Undrained	Downstream	Yes	1.00	1.42	1.64
Normal Pool Elevation (485 feet)		Upstream		1.00	1.94	2.28

**REPORT OF CCR RULE STABILITY ANALYSES
AEP CLIFTY CREEK POWER PLANT
BOILER SLAG POND DAM AND LANDFILL RUNOFF COLLECTION POND**

February 16, 2016

7.0 CONCLUSIONS

7.1 PE CERTIFICATION

I, Stan Harris, being a Professional Engineer in good standing in the State of Indiana, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this certification is prepared in accordance with the accepted practice of engineering. I certify that pursuant to 40 CFR 257.73(e)(2), the safety factor assessment for the AEP Clifty Creek Power Plant's Boiler Slag Pond Dam and Landfill Runoff Collection Pond demonstrates compliance with the factors of safety specified in 40 CFR 257.73(e)(1)(i) through (iv).

SIGNATURE



DATE

2/16/16

ADDRESS:

Stantec Consulting Services Inc.
11687 Lebanon Road
Cincinnati, Ohio 45241-2012

TELEPHONE:

(513) 842-8200



7.2 GENERAL

The analyses presented herein are based on information gathered (from various sources) using that degree of care and skill ordinarily exercised under similar circumstances by competent members of the engineering profession. Subsurface profiles are generally based on straight-line interpolation between borings and no warranties can be made regarding the continuity of subsurface conditions between the borings.

The boring logs and related information presented in this report depict approximate subsurface conditions only at the specific boring locations noted and at the time of drilling. Conditions at other locations may differ from those occurring at the boring locations. This report may not be applicable if the facility is modified from what is described in this report or if the site conditions are altered. This report may require updating to reflect the different, modified facility specifics and/or the altered site conditions.



**REPORT OF CCR RULE STABILITY ANALYSES
AEP CLIFTY CREEK POWER PLANT
BOILER SLAG POND DAM AND LANDFILL RUNOFF COLLECTION POND**

REFERENCES

February 16, 2016

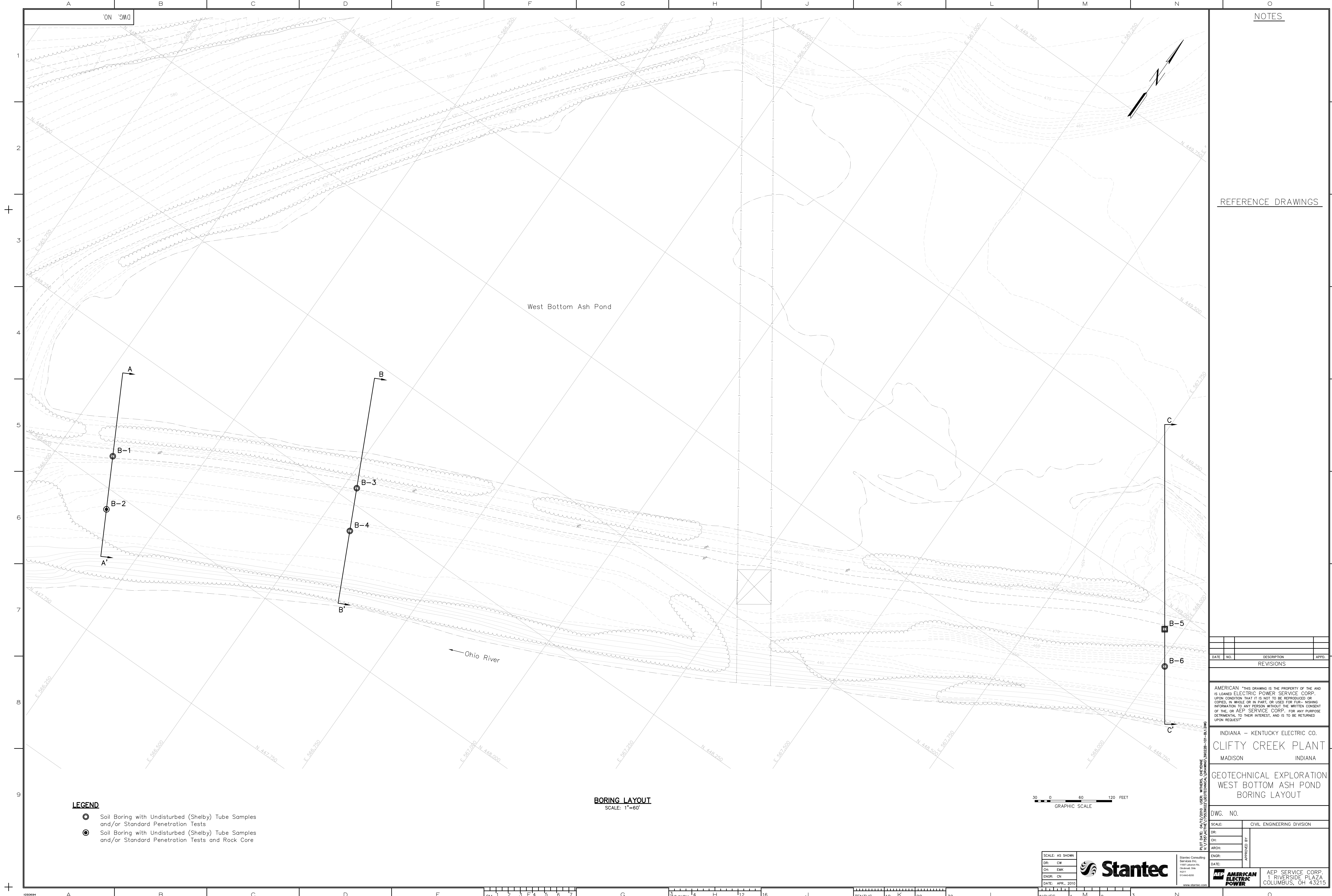
8.0 REFERENCES

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APPENDIX A

SITE PLANS

BOILER SLAG POND DAM



NOTES

REFERENCE DRAWINGS

DATE	NO.	DESCRIPTION	APPR.
REVISIONS			

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INDIANA - KENTUCKY ELECTRIC CO.
CLIFTY CREEK PLANT
 MADISON INDIANA

GEOTECHNICAL EXPLORATION
 WEST BOTTOM ASH POND
 BORING LAYOUT

DWG. NO. _____
 SCALE: _____
 CIVIL ENGINEERING DIVISION

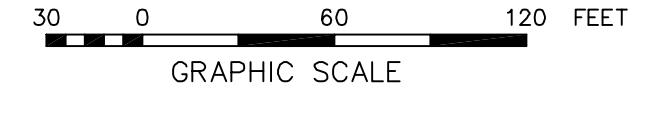
APPROVED BY: _____
 DATE: _____

AMERICAN ELECTRIC POWER
 AEP SERVICE CORP.
 1 RIVERSIDE PLAZA
 COLUMBUS, OH 43215

LEGEND

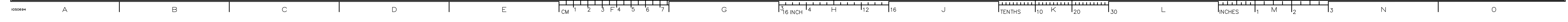
- Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests
- Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests and Rock Core

BORING LAYOUT
 SCALE: 1"=60'

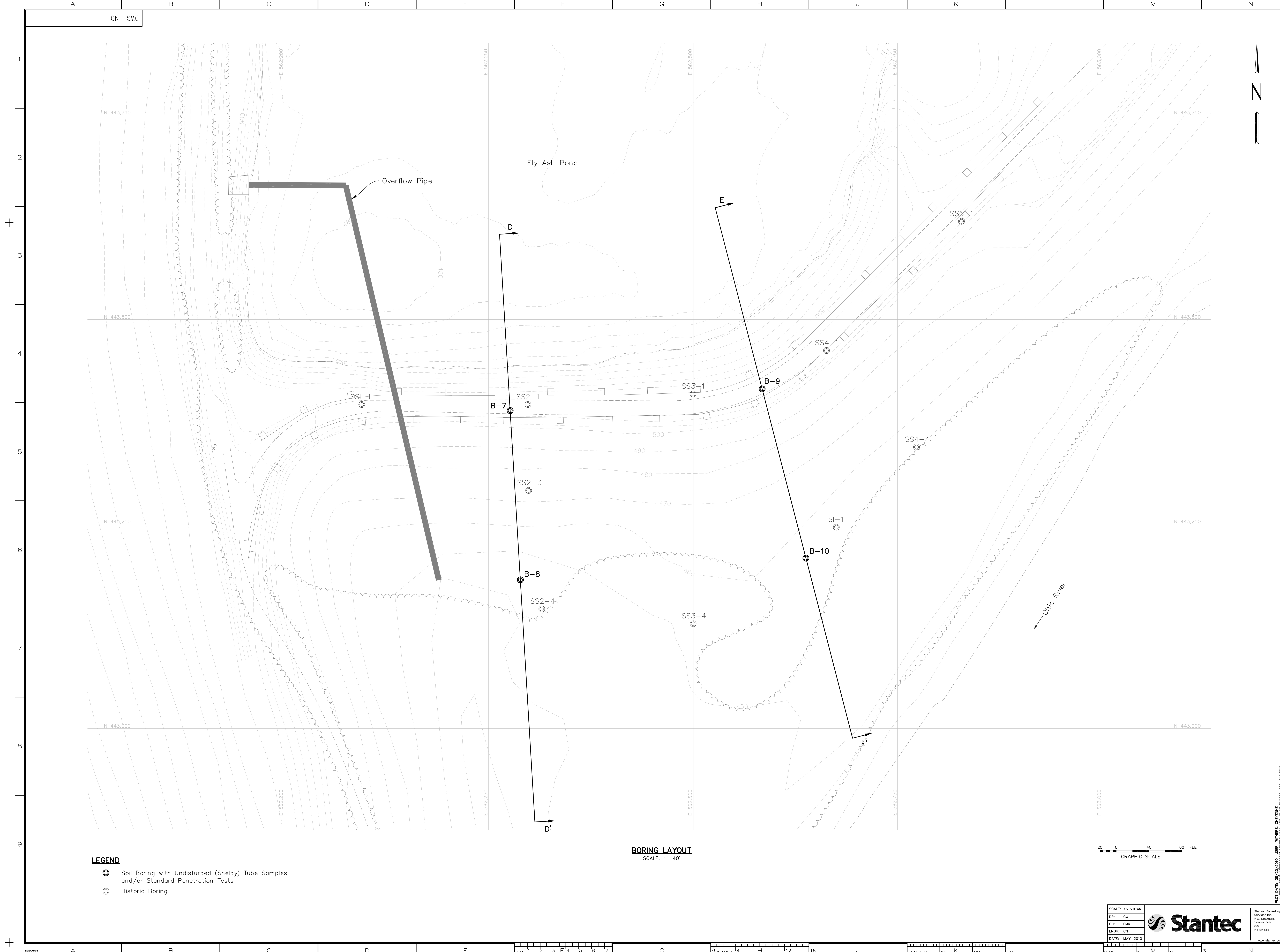


SCALE: AS SHOWN
 DR: CW
 CH: EMK
 ENGR: CN
 DATE: APR., 2010

Stantec Consulting Services Inc.
 10815 Lorain Rd.
 Dayton, Ohio 45424
 918-462-8200
 www.stantec.com



LANDFILL RUNOFF COLLECTION POND



BORING LAYOUT
SCALE: 1"=40'

- LEGEND**
- Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests
 - Historic Boring

NOTES

REFERENCE DRAWINGS

DATE	NO.	DESCRIPTION	APPR.
REVISIONS			

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INDIANA - KENTUCKY ELECTRIC CO.
CLIFTY CREEK PLANT
MADISON INDIANA
GEOTECHNICAL EXPLORATION
LANDFILL RUNOFF
COLLECTION POND DAM
BORING LAYOUT

DWG. NO. CIVIL ENGINEERING DIVISION

SCALE: AS SHOWN
DR: CW
CH: EMK
ENGR: CN
DATE: MAY, 2010

SCALE: AS SHOWN
DR: CW
CH: EMK
ENGR: CN
DATE: MAY, 2010



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AMERICAN ELECTRIC POWER
AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

DATE: MAY, 2010
 DRAWN BY: CW
 CHECKED BY: EMK
 APPROVED BY: CN
 PROJECT NO.: 002208-102-012.000

APPENDIX B

BORING LOGS

BOILER SLAG POND DAM

Project Number <u>175539022</u>		Location <u>West Crest: West Pond Dam</u>	
Project Name <u>AEP Clifty Creek / Ash Ponds</u>		Boring No. <u>B-1</u>	Total Depth <u>71.5 ft</u>
County <u>Jefferson, IN</u>		Surface Elevation <u>473.4 ft</u>	
Project Type <u>Geotechnical Exploration</u>		Date Started <u>11/3/09</u>	Completed <u>11/4/09</u>
Supervisor <u>C. Nisingizwe</u> Driller <u>M. Wethington</u>		Depth to Water <u>40.0 ft</u>	Date/Time <u>11/4/09</u>
Logged By <u>C. Nisingizwe</u>		Depth to Water <u>39.2 ft</u>	Date/Time <u>11/13/09</u>

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core							RQD	Run	Rec. Ft.	Rec. %	Run Depth
473.4'	0.0'	Top of Hole							
		Lean Clay With Sand, light yellowish brown with light gray, damp to moist, medium stiff to very stiff, Fill		SPT-1	2.5 - 4.0	1.2	6-5-6	17	N = 11
				SPT-2	5.0 - 6.5	1.3	5-5-5	15	N = 10
				ST-3	7.5 - 9.5	2.0		23	
				SPT-4	10.0 - 11.5	0.4	1-5-5	21	N = 10
				SPT-5	12.5 - 14.0	1.3	2-2-5	17	N = 7
				ST-6	15.0 - 17.0	2.0		20	
				SPT-7	17.5 - 19.0	1.5	5-6-9	19	N = 15
				SPT-8	20.0 - 21.5	1.5	3-5-10	15	N = 15
				SPT-9	22.5 - 24.0	1.5	3-7-7	17	N = 14
				SPT-10	25.0 - 26.5	1.2	3-3-5	17	N = 8
				SPT-11	27.5 - 29.0	1.3	3-4-8	20	N = 12
				SPT-12	30.0 - 31.5	1.4	4-4-7	19	N = 11
				SPT-13	32.5 - 34.0	1.3	2-4-5	18	N = 9
				SPT-14	35.0 - 36.5	1.1	2-5-5	17	N = 10
435.9'	37.5'				SPT-15	37.5 - 39.0	1.2	1-2-4	20	N = 6

STANTEC/FNSM_LEGACY_175539022 CLIFTY CREEK.GPJ FNSM-GRAPHIC LOG.GDT 5/20/10

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	
		Lean Clay With Sand, light yellowish brown with light gray, moist to wet, very soft to medium stiff <i>(Continued)</i>		SPT-16	40.0 - 41.5	1.3	1-2-3	24	N = 5
				ST-17	42.5 - 44.5	2.0		22	
				SPT-18	45.0 - 46.5	1.5	1-1-1	30	N = 2
				SPT-19	47.5 - 49.0	1.5	1-1-2	23	N = 3
				SPT-20	50.0 - 51.5	1.1	1-1-3	28	N = 4
				SPT-21	52.5 - 54.0	1.5	1-1-1	27	N = 2
				SPT-22	55.0 - 56.5	1.5	1-2-2	25	N = 4
				SPT-23	57.5 - 59.0	1.1	1-1-3	28	N = 4
				SPT-24	60.0 - 61.5	1.4	1-2-3	28	N = 5
				SPT-25	62.5 - 64.0	1.3	1-2-4	37	N = 6
				SPT-26	65.0 - 66.5	1.2	2-2-5	34	N = 7
405.9'	67.5'								
		Gray, Weathered Shale, Augered		SPT-27	67.5 - 69.0	0.4	50+	14	50+
401.9'	71.5'			SPT-28	70.0 - 71.5	0.3	50+	5	50+
No Refusal / Bottom of Hole									

STANTEC/FISM_LEGACY 175539022 CLIFTY CREEK.GPJ FISM-GRAPHIC LOG.GDT 5/20/10

Project Number	175539022	Location	West Toe: West Pond Dam	
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	B-2	Total Depth 61.0 ft
County	Jefferson, IN	Surface Elevation	444.0 ft	
Project Type	Geotechnical Exploration	Date Started	11/12/09	Completed 11/12/09
Supervisor	C. Nisingizwe Driller M. Wethington	Depth to Water	22.5 ft	Date/Time 11/12/09
Logged By	C. Nisingizwe	Depth to Water	N/A	Date/Time N/A

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core							RQD	Run	Rec. Ft.	Rec. %	Run Depth
444.0'	0.0'	Top of Hole							
		Lean Clay With Sand, light yellowish brown with gray, moist to wet, soft to very stiff		SPT-1	2.5 - 4.0	1.2	7-8-11	17	N = 19
				SPT-2	5.0 - 6.5	0.6	4-3-4	19	N = 7
				SPT-3	7.5 - 9.0	0.6	3-3-4	24	N = 7
				ST-4	10.0 - 12.0	1.6		22	
				SPT-5	12.5 - 14.0	1.2	2-2-3	25	N = 5
				SPT-6	15.0 - 16.5	1.2	2-2-2	28	N = 4
				SPT-7	17.5 - 19.0	1.5	1-1-1	30	N = 2
				SPT-8	20.0 - 21.5	1.5	1-2-2	32	N = 4
				ST-9	22.5 - 24.5	2.0		29	
				SPT-10	25.0 - 26.5	1.5	2-2-2	29	N = 4
				SPT-11	27.5 - 29.0	0.7	1-4-5	30	N = 9
414.0'	30.0'	Lean Clay With Sand, gray, moist to wet, soft to medium stiff		SPT-12	30.0 - 31.5	1.5	3-3-3	25	N = 6
	SPT-13		32.5 - 34.0	1.5	3-3-3	32	N = 6		
	SPT-14		35.0 - 36.5	1.5	1-2-3	33	N = 5		
	SPT-15		37.5 - 39.0	1.5	1-2-2	31	N = 4		

STANTEC/FNSM_LEGACY 175539022 CLIFTY CREEK.GPJ FNSM-GRAPHIC LOG.GDT 5/20/10

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	
		Lean Clay With Sand, gray, moist to wet, soft to medium stiff <i>(Continued)</i>		SPT-16	40.0 - 41.5	1.5	3-3-3	30	N = 6
				ST-17	42.5 - 44.5	1.5		33	
				SPT-18	45.0 - 46.5	1.5	1-1-1	35	N = 2
392.5'	51.5'			SPT-19	50.0 - 51.5	1.5	4-3-3	33	N = 6
		Gravel With Silt And Sand, gray, wet, very dense							
388.5'	55.5'		SPT-20	55.0 - 55.5	0.4	11-50+	10		Began Core N = 50+
		Shale, gray, hard, medium bedded							
383.0'	61.0'			45	5.5	5.5	100	61.0	
Bottom of Hole Top of Rock = 56.0' Elevation (388.0')									

STANTEC/FMSM_LEGACY 175539022 CLIFTY CREEK GRP FMSM-GRAPHIC LOG.GDT 5/20/10

Project Number <u>175539022</u>		Location <u>Middle Crest: West Pond Dam</u>	
Project Name <u>AEP Clifty Creek / Ash Ponds</u>		Boring No. <u>B-3</u>	Total Depth <u>71.5 ft</u>
County <u>Jefferson, IN</u>		Surface Elevation <u>471.6 ft</u>	
Project Type <u>Geotechnical Exploration</u>		Date Started <u>11/4/09</u>	Completed <u>11/5/09</u>
Supervisor <u>C. Nisingizwe</u> Driller <u>M. Wethington</u>		Depth to Water <u>40.0 ft</u>	Date/Time <u>11/4/09</u>
Logged By <u>C. Nisingizwe</u>		Depth to Water <u>31.0 ft</u>	Date/Time <u>11/13/09</u>

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core							RQD	Run	Rec. Ft.	Rec. %	Run Depth
471.6'	0.0'	Top of Hole							
		Lean Clay With Sand, light yellowish brown with light gray, damp to moist, stiff to very stiff, Fill		SPT-1	2.5 - 4.0	0.7	4-5-6	15	N = 11
				SPT-2	5.0 - 6.5	1.1	3-4-4	17	N = 8
				SPT-3	7.5 - 9.0	1.1	3-3-7	16	N = 10
				ST-4	10.0 - 12.0	2.0		16	
				SPT-5	12.5 - 14.0	1.5	4-4-5	22	N = 9
				SPT-6	15.0 - 16.5	1.0	3-4-6	17	N = 10
				SPT-7	17.5 - 19.0	1.3	3-5-7	18	N = 12
				ST-8	20.0 - 22.0	2.0		18	
				SPT-9	22.5 - 24.0	1.5	3-5-7	17	N = 12
				SPT-10	25.0 - 26.5	1.3	3-4-5	18	N = 9
				SPT-11	27.5 - 29.0	1.5	6-7-8	16	N = 15
				SPT-12	30.0 - 31.5	1.5	5-5-5	18	N = 10
				SPT-13	32.5 - 34.0	1.5	4-7-10	17	N = 17
				SPT-14	35.0 - 36.5	1.5	5-7-9	22	N = 16
434.1'	37.5'				SPT-15	37.5 - 39.0	1.5	5-7-11	20	N = 18

STANTEC/FISM_LEGACY_175539022 CLIFTY CREEK.GPJ FISM-GRAPHIC LOG.GDT 5/20/10

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	
400.1'	71.5'	Lean Clay With Sand, gray to light brown, moist to wet, very stiff to very stiff <i>(Continued)</i>		SPT-16	40.0 - 41.5	1.5	1-2-2	24	N = 4
				SPT-17	42.5 - 44.0	1.5	1-2-2	23	N = 4
				SPT-18	45.0 - 46.5	1.3	2-3-3	25	N = 6
				ST-19	47.5 - 49.5	2.0		23	
				SPT-20	50.0 - 51.5	1.5	1-2-2	25	N = 4
				SPT-21	52.5 - 54.0	1.5	1-1-1	25	N = 2
				SPT-22	55.0 - 56.5	1.5	1-2-3	24	N = 5
				SPT-23	57.5 - 59.0	1.5	1-1-1	40	N = 2
				SPT-24	60.0 - 61.5	1.5	3-4-4	28	N = 8
				SPT-25	62.5 - 64.0	1.5	1-2-4	33	N = 6
				SPT-26	65.0 - 66.5	1.5	1-3-4	34	N = 7
				SPT-27	67.5 - 69.0	1.5	2-4-5	29	N = 9
				SPT-28	70.0 - 71.5	1.5	3-3-5	31	N = 8
No Refusal / Bottom of Hole									

STANTEC/FISM_LEGACY 175539022 CLIFTY CREEK GPR FISM-GRAPHIC LOG.GDT 5/20/10

Project Number		175539022		Location		Middle Toe: West Pond Dam				
Project Name		AEP Clifty Creek / Ash Ponds		Boring No.		B-4		Total Depth		71.5 ft
County		Jefferson, IN		Surface Elevation		444.0 ft				
Project Type		Geotechnical Exploration		Date Started		11/10/09		Completed		11/11/09
Supervisor		C. Nisingizwe Driller M. Wethington		Depth to Water		22.5 ft		Date/Time		11/10/09
Logged By		C. Nisingizwe		Depth to Water		16.0 ft		Date/Time		11/13/09
Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks	
Elevation	Depth		Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth		
444.0'	0.0'	Top of Hole								
		Lean Clay With Sand, brown to dark gray, damp to moist, medium stiff to very stiff		SPT-1	2.5 - 4.0	1.3	8-8-8	14	N = 16	
				SPT-2	5.0 - 6.5	1.4	6-7-8	16	N = 15	
				ST-3	7.5 - 9.5	2.0		--		
				SPT-4	10.0 - 11.5	1.3	3-5-6	19	N = 11	
				SPT-5	12.5 - 14.0	1.0	2-3-4	22	N = 7	
429.0'	15.0'	Lean Clay With Sand, gray, moist to wet, soft to stiff		SPT-6	15.0 - 16.5	1.2	2-2-3	26	N = 5	
				ST-7	17.5 - 19.5	2.0		--		
				SPT-8	20.0 - 21.5	1.5	2-2-2	26	N = 4	
				SPT-9	22.5 - 24.0	1.5	1-2-3	27	N = 5	
				SPT-10	25.0 - 26.5	1.5	2-2-4	26	N = 6	
				SPT-11	27.5 - 29.0	1.5	1-2-3	27	N = 5	
				SPT-12	30.0 - 31.5	1.5	1-1-2	28	N = 3	
				SPT-13	32.5 - 34.0	1.5	1-2-2	35	N = 4	
				SPT-14	35.0 - 36.5	1.5	2-4-5	31	N = 9	
				ST-15	37.5 - 39.5	2.0		--		

STANTEC/FNSM_LEGACY 175539022 CLIFTY CREEK.GPJ FNSM-GRAPHIC LOG.GDT 5/20/10

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	
386.5'	57.5'	Lean Clay With Sand, gray, moist to wet, soft to stiff (Continued)		SPT-16	40.0 - 41.5	1.5	2-2-2	24	N = 4
				SPT-17	42.5 - 44.0	1.2	1-2-3	33	N = 5
				SPT-18	45.0 - 46.5	1.5	2-4-4	35	N = 8
				SPT-19	47.5 - 49.0	1.2	1-2-4	31	N = 6
				SPT-20	50.0 - 51.5	1.5	2-3-4	31	N = 7
				SPT-21	52.5 - 54.0	1.5	1-2-3	30	N = 5
				SPT-22	55.0 - 56.5	1.5	2-3-4	21	N = 7
372.5'	71.5'	Gravel With Silt And Sand, gray, moist, dense to very dense		SPT-23	57.5 - 59.0	1.5	10-17-22	13	N = 39
				SPT-24	60.0 - 61.5	1.5	16-28-18	9	N = 46
				SPT-25	65.0 - 66.5	0.7	26-50+	12	N = 50+
				SPT-26	70.0 - 71.5	0.7	20-22-30	9	N = 52
No Refusal / Bottom of Hole									

STANTEC/FISM_LEGACY 175539022 CLIFTY CREEK GPR FISM-GRAPHIC LOG.GDT 5/20/10

Project Number		175539022		Location		East Crest: West Pond Dam				
Project Name		AEP Clifty Creek / Ash Ponds		Boring No.		B-5		Total Depth		71.5 ft
County		Jefferson, IN		Surface Elevation		468.7 ft				
Project Type		Geotechnical Exploration		Date Started		11/10/09		Completed		11/10/09
Supervisor		C. Nisingizwe Driller M. Wethington		Depth to Water		45.0 ft		Date/Time		11/10/09
Logged By		C. Nisingizwe		Depth to Water		33.8 ft		Date/Time		11/13/09
Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks	
Elevation	Depth		Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth		
468.7'	0.0'	Top of Hole								
		Lean Clay With Sand, light yellowish brown with light gray, damp to moist, medium stiff to very stiff, Fill		SPT-1	2.5 - 4.0	1.5	6-9-10	15	N = 19	
				SPT-2	5.0 - 6.5	1.5	4-4-5	17	N = 9	
				ST-3	7.5 - 9.5	1.6		17		
				SPT-4	10.0 - 11.5	1.3	6-7-8	23	N = 15	
				SPT-5	12.5 - 14.0	0.0	3-4-6	--	N = 10	
				SPT-6	15.0 - 16.5	1.3	1-3-4	16	N = 7	
				SPT-7	17.5 - 19.0	1.0	5-7-9	16	N = 16	
				SPT-8	20.0 - 21.5	0.6	1-2-5	18	N = 7	
				ST-9	22.5 - 24.5	1.8		19		
				SPT-10	25.0 - 26.5	1.2	2-3-5	22	N = 8	
				SPT-11	27.5 - 29.0	1.4	1-2-5	25	N = 7	
				SPT-12	30.0 - 31.5	1.3	4-5-7	23	N = 12	
				SPT-13	32.5 - 34.0	1.5	2-3-5	19	N = 8	
432.2'	36.5'			SPT-14	35.0 - 36.5	1.5	4-6-10	18	N = 16	
		Lean Clay With Sand, gray, moist, soft		SPT-15	37.5 - 39.0	1.5	2-3-3	21	N = 6	

STANTEC/FISM_LEGACY 175539022 CLIFTY CREEK.GPJ FISM-GRAPHIC LOG.GDT 5/20/10

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	
421.2'	47.5'	Lean Clay With Sand, gray, moist, soft (Continued)		SPT-16	40.0 - 41.5	1.3	1-1-2	25	N = 3
				ST-17	42.5 - 44.5	2.0		23	
				SPT-18	45.0 - 46.5	1.5	1-1-3	25	N = 4
397.2'	71.5'	Sandy Silt, light yellowish brown to gray, wet, soft to stiff		SPT-19	47.5 - 49.0	1.5	1-1-3	28	N = 4
				SPT-20	50.0 - 51.5	1.5	1-1-5	24	N = 6
				SPT-21	52.5 - 54.0	1.0	1-1-1	22	N = 2
				SPT-22	55.0 - 56.5	1.3	1-2-2	23	N = 4
				SPT-23	57.5 - 59.0	1.5	1-2-3	26	N = 5
				SPT-24	60.0 - 61.5	1.5	2-3-4	22	N = 7
				SPT-25	62.5 - 64.0	1.5	2-3-6	27	N = 9
				SPT-26	65.0 - 66.5	1.5	2-5-6	28	N = 11
				SPT-27	67.5 - 69.0	1.5	2-4-5	28	N = 9
				SPT-28	70.0 - 71.5	1.5	3-5-8	30	N = 13
No Refusal / Bottom of Hole									

STANTEC/FISM_LEGACY 175539022 CLIFTY CREEK.GPJ FISM-GRAPHIC LOG.GDT 5/20/10

Project Number		175539022		Location		East Toe: West Pond Dam				
Project Name		AEP Clifty Creek / Ash Ponds		Boring No.		B-6		Total Depth		71.5 ft
County		Jefferson, IN		Surface Elevation		445.5 ft				
Project Type		Geotechnical Exploration		Date Started		11/19/09		Completed		11/19/09
Supervisor		C. Nisingizwe Driller Danny Jessie		Depth to Water		30.0 ft		Date/Time		11/19/09
Logged By		C. Nisingizwe		Depth to Water		N/A		Date/Time		N/A

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core							RQD	Run	Rec. Ft.	Rec. %	Run Depth
445.5'	0.0'	Top of Hole							
		Lean Clay With Sand, brown to gray, damp to moist, stiff to very stiff		SPT-1	2.5 - 4.0	1.0	2-4-4	19	N = 8
				SPT-2	5.0 - 6.5	1.0	4-4-6	18	N = 10
				ST-3	7.5 - 9.5	2.0		25	
				SPT-4	10.0 - 11.5	1.2	5-7-11	16	N = 18
				SPT-5	12.5 - 14.0	1.1	2-2-2	21	N = 4
				SPT-6	15.0 - 16.5	1.3	1-1-2	31	N = 3
				ST-7	17.5 - 19.5	1.2		32	
				SPT-8	20.0 - 21.5	1.5	0-1-0	32	N = 1
				SPT-9	22.5 - 24.0	1.5	0-0-2	29	N = 2
				SPT-10	25.0 - 26.5	1.5	2-1-3	29	N = 4
418.0'	27.5'	Sandy Silt, gray, moist to wet, very soft to stiff		SPT-11	27.5 - 29.0	1.5	0-3-2	32	N = 5
				SPT-12	30.0 - 31.5	1.5	0-0-3	32	N = 3
				SPT-13	32.5 - 34.0	1.5	0-1-2	33	N = 3
				SPT-14	35.0 - 36.5	1.5	0-0-1	35	N = 1
				SPT-15	37.5 - 39.0	1.5	0-0-1	30	N = 1

STANTEC/FNSM_LEGACY_175539022 CLIFTY CREEK.GPJ FNSM-GRAPHIC LOG.GDT 5/20/10

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	
		Sandy Silt, gray, moist to wet, very soft to stiff <i>(Continued)</i>		ST-16	40.0 - 42.0	1.1		31	
				SPT-17	42.5 - 44.0	1.5	0-1-1	35	N = 2
				SPT-18	45.0 - 46.5	1.5	0-0-1	40	N = 1
				SPT-19	47.5 - 49.0	1.5	0-0-1	40	N = 1
				SPT-20	50.0 - 51.5	1.5	0-2-3	39	N = 5
				SPT-21	52.5 - 54.0	1.5	0-5-6	27	N = 11
				SPT-22	55.0 - 56.5	1.5	4-3-4	31	N = 7
				SPT-23	57.5 - 59.0	1.5	4-4-5	35	N = 9
				SPT-24	60.0 - 61.5	1.5	5-5-6	28	N = 11
				SPT-25	65.0 - 66.5	1.5	4-5-4	28	N = 9
374.0'	71.5'			SPT-26	70.0 - 71.5	0.0	5-5-5	--	N = 10
No Refusal / Bottom of Hole									

STANTEC/FISM_LEGACY_175539022 CLIFTY CREEK GPR / FISM-GRAPHIC LOG.GDT 5/20/10

LANDFILL RUNOFF COLLECTION POND:
2009 GEOTECHNICAL EXPLORATION

Project Number	175539022	Location	Crest: LRCP Dam	
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	B-7	Total Depth 29.0 ft
County	Jefferson, IN	Surface Elevation	503.4 ft	
Project Type	Geotechnical Exploration	Date Started	11/12/09	Completed 11/12/09
Supervisor	C. Nisingizwe Driller M. Wethington	Depth to Water	Dry	Date/Time 11/12/09
Logged By	C. Nisingizwe	Depth to Water	N/A	Date/Time N/A

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	
503.4'	0.0'	Top of Hole							
502.9'	0.5'	Asphalt pavement and gravel base							
		Lean Clay, yellow and light gray, moist, stiff							
				ST-1	23.0 - 25.0	2.0		--	
				ST-2	25.0 - 27.0	2.0		20	
				ST-3	27.0 - 29.0	2.0		20	
474.4'	29.0'	No Refusal / Bottom of Hole							

STANTEC/FNSM_LEGACY 175539022 CLIFTY CREEK.GPJ FNSM-GRAPHIC.LOG.GDT 4/16/10

Project Number	<u>175539022</u>	Location	<u>Toe: LRCP Dam</u>	
Project Name	<u>AEP Clifty Creek / Ash Ponds</u>	Boring No.	B-8	Total Depth <u>31.0 ft</u>
County	<u>Jefferson, IN</u>	Surface Elevation	<u>441.5 ft</u>	
Project Type	<u>Geotechnical Exploration</u>	Date Started	<u>11/19/09</u>	Completed <u>11/19/09</u>
Supervisor	<u>C. Nisingizwe</u> Driller <u>Danny Jessie</u>	Depth to Water	<u>Dry</u>	Date/Time <u>11/19/09</u>
Logged By	<u>C. Nisingizwe</u>	Depth to Water	<u>N/A</u>	Date/Time <u>N/A</u>

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	
441.5'	0.0'	Top of Hole							
		Silty Clay, yellow and light gray, damp to moist							
425.5'	16.0'	Lean Clay, yellowish brown and light gray, moist							
				ST-1	25.0 - 27.0	2.0		25	
				ST-2	27.0 - 29.0	2.0		26	
412.5'	29.0'			ST-3	29.0 - 31.0	2.0		23	
410.5'	31.0'	Lean Clay With Sand, yellowish brown and light gray, moist							
		No Refusal / Bottom of Hole							

STANTEC/FNSM_LEGACY 175539022 CLIFTY CREEK.GPJ FNSM-GRAPHIC.LOG.GDT 4/16/10

Project Number	<u>175539022</u>	Location	<u>Crest: LRCP Dam</u>	
Project Name	<u>AEP Clifty Creek / Ash Ponds</u>	Boring No.	B-9	Total Depth <u>22.0 ft</u>
County	<u>Jefferson, IN</u>	Surface Elevation	<u>504.3 ft</u>	
Project Type	<u>Geotechnical Exploration</u>	Date Started	<u>11/12/09</u>	Completed <u>11/12/09</u>
Supervisor	<u>C. Nisingizwe</u> Driller <u>M. Wethington</u>	Depth to Water	<u>Dry</u>	Date/Time <u>11/12/09</u>
Logged By	<u>C. Nisingizwe</u>	Depth to Water	<u>N/A</u>	Date/Time <u>N/A</u>

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core							RQD	Run	Rec. Ft.	Rec. %	Run Depth
504.3'	0.0'	Top of Hole							
503.8'	0.5'	Asphalt pavement and gravel base							
		Lean Clay, yellowish brown and light gray, damp to moist							
				ST-1	16.0 - 18.0	2.0		22	
				ST-2	18.0 - 20.0	2.0		19	
				ST-3	20.0 - 22.0	2.0		20	
482.3'	22.0'								

No Refusal /
Bottom of Hole

STANTEC/FNSM_LEGACY 175539022 CLIFTY CREEK.GPJ FNSM-GRAPHIC.LOG.GDT 4/16/10

Project Number	175539022	Location	Toe: LRCP Dam	
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	B-10	Total Depth 18.0 ft
County	Jefferson, IN	Surface Elevation	457.3 ft	
Project Type	Geotechnical Exploration	Date Started	11/19/09	Completed 11/19/07
Supervisor	C. Nisingizwe Driller Danny Jessie	Depth to Water	Dry	Date/Time 11/19/07
Logged By	C. Nisingizwe	Depth to Water	N/A	Date/Time N/A

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core							RQD	Run	Rec. Ft.	Rec. %	Run Depth
457.3'	0.0'	Top of Hole							
		Silty Clay With Sand, yellow and light gray, damp to moist							
444.1'	13.2'			ST-1	12.0 - 14.0	1.5		17	
441.3'	16.0'	Silty Sand, gray to brown, damp to moist		ST-2	14.0 - 16.0	2.0		10	
439.3'	18.0'	Silty Clay With Sand, yellow and light gray, damp to moist		ST-3	16.0 - 18.0	2.0		25	

No Refusal /
Bottom of Hole

STANTEC\FMSM_LEGACY 175539022 CLIFTY CREEK.GPJ FMSM-GRAPHIC LOG.GDT 4/16/10

LANDFILL RUNOFF COLLECTION POND:
2015 GEOTECHNICAL EXPLORATION

Project Number	175553022	Location	Landfill Runoff Collection Pond Dam		
Project Name	CCR Rule - AEP Clifty Creek	Boring No.	B-12	Total Depth	101.5 ft
County	Jefferson, IN	Surface Elevation	503.9 (estimated)		
Project Type	Geotechnical Exploration	Date Started	7/6/15	Completed	7/7/15
Supervisor	C. Nisingizwe	Driller	E. Caudill	Depth to Water	60.0 ft
Logged By	C. Nisingizwe	Depth to Water	N/A	Date/Time	7/7/15
		Depth to Water	N/A	Date/Time	N/A

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois. Cont. %	Remarks
Elevation	Depth		Rock Core							RQD	Run	Rec. Ft.	Rec. %	Run Depth
503.9	0.0	Top of Hole							
(estimated)	0.4	Asphalt and base							
		Lean Clay With Sand, gray, damp, medium stiff to stiff		SPT-1	1.0 - 2.5	1.5	1-2-5	21	Pocket Penetrometer (PP) = 2.50 tsf
				SPT-2	5.0 - 6.5	1.5	3-3-4	20	PP = 2.50 tsf
				SPT-3	10.0 - 11.5	1.2	3-4-5	23	PP = 3.50 tsf
				SPT-4	15.0 - 16.5	1.0	3-3-5	19	PP = 2.50 tsf
				SPT-5	20.0 - 21.5	0.9	4-6-9	18	PP = 2.50 tsf
				SPT-6	25.0 - 26.5	1.1	3-5-7	18	PP = 4.25 tsf
				SPT-7	30.0 - 31.5	1.3	2-5-8	19	PP = 4.50 tsf
				SPT-8	35.0 - 36.5	0.9	WOH-3-4	18	PP = 4.00 tsf

STANTEC\FISM_LEGACY_GINT.LOG.GPJ FISM-GRAPHIC.LOG.GDT 8/6/15

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core			RQD	Run	Rec. Ft.		Rec. %	Run Depth
	40.0	Lean Clay With Sand, gray, damp, medium stiff to stiff <i>(Continued)</i>							
	50.0	Silty Clay With Sand, brown, moist, medium stiff to very stiff		SPT-9	40.0 - 41.5	1.5	6-8-8	16	
			SPT-10	45.0 - 46.5	1.5	1-3-5	19		
	58.0	Silt With Sand, grayish light brown, moist, medium stiff to stiff		SPT-11	50.0 - 51.5	1.5	2-3-3	22	
			SPT-12	55.0 - 56.5	1.0	2-5-8	20		
	63.5	Silty Sand, grayish light brown, damp, very stiff		SPT-13	60.0 - 61.5	1.4	3-11-17	15	
	70.0	Silt With Sand, grayish light brown, wet, stiff		SPT-14	65.0 - 66.5	1.5	2-3-8	28	
	78.0	Sand, mottled gray and brown, moist to wet, medium stiff to stiff		SPT-15	70.0 - 71.5	1.5	3-5-5	22	
			SPT-16	75.0 - 76.5	1.3	2-3-5	28		

STANTECFRSM_LEGACY_GINT.LOG.GPJ_FNSM-GRAPHIC.LOG.GDT_8/6/15

Project Number <u>175553022</u>	Location <u>Landfill Runoff Collection Pond Dam</u>
Project Name <u>CCR Rule - AEP Clifty Creek</u>	Boring No. B-12 Total Depth <u>101.5 ft</u>

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	
		Silt, gray, moist to wet, medium stiff to stiff		SPT-17	80.0 - 81.5	1.5	6-9-6	26	
				SPT-18	85.0 - 86.5	1.5	2-3-5	28	
	90.0			SPT-19	90.0 - 91.5	1.5	2-4-4	25	PP = 2.25 tsf
		Lean Clay, gray, moist, medium stiff to very stiff		SPT-20	95.0 - 96.5	1.5	5-8-11	23	PP = 3.75 tsf
				SPT-21	100.0 - 101.5	1.5	4-6-8	27	PP = 3.50 tsf
	101.5								

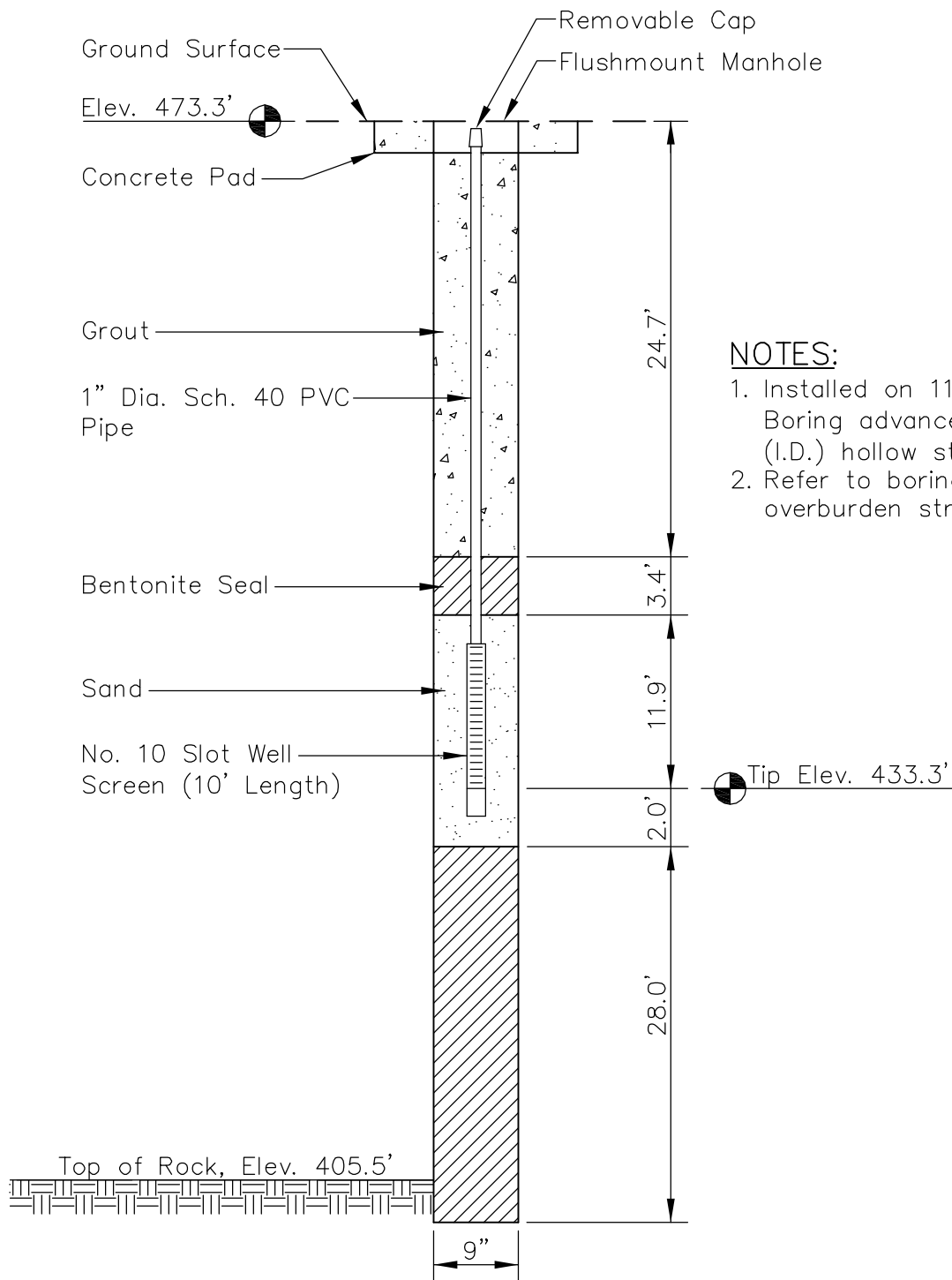
No Refusal /
Bottom of Hole

STANTEC\FM\LEGACY_GINT\LOG.GPJ_FMSM\GRAPHIC\LOG.GDT_8/6/15

APPENDIX C

PIEZOMETER DETAILS

BOILER SLAG POND DAM



NOTES:

1. Installed on 11/04/2009. Boring advanced with 4.25" (I.D.) hollow stem augers.
2. Refer to boring log for overburden stratigraphy.

PLOT DATE: 02/18/2010 USER: JENNINGS, MATTHEW V: \\1755\ACTIVE\175539022\GEO\TECHNICAL\DRAWING\INSTRUMENTS\PZB1.DWG

**PIEZOMETER B-1
WEST BOTTOM ASH DAM
CLIFTY CREEK PLANT**

LOCATION:

Northing: 448,055.94
 Easting: 566,098.09
 Ground Elevation: 473.3'

Horizontal Datum: NAD 27
 Vertical Datum: NGVD88

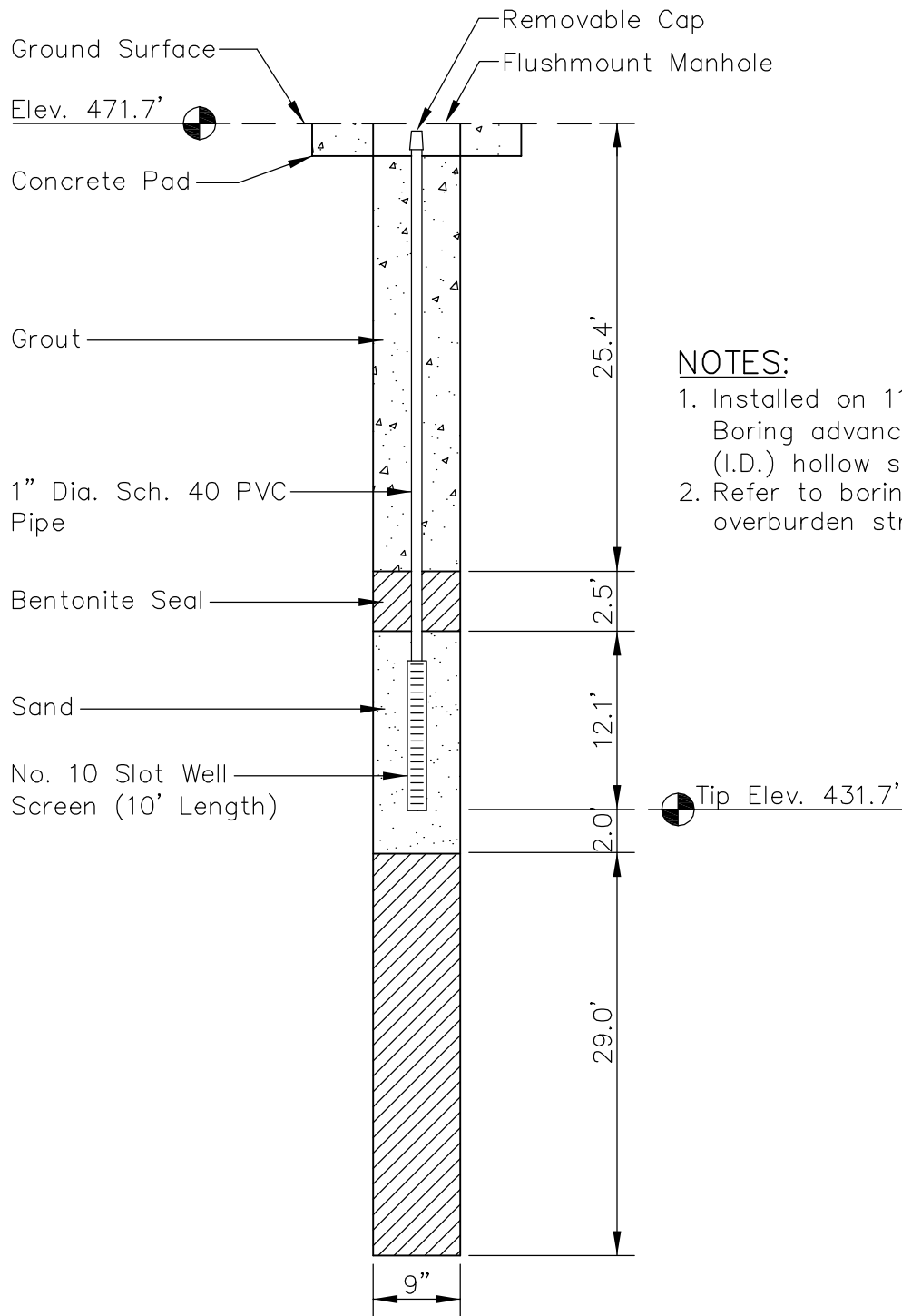


Stantec

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 11687 Lebanon Rd.
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 45241-2012
 513-842-8200

www.stantec.com

DRAWN BY	MJ	DATE	FEB., 2010	REVISED		SHEET
CHECKED BY	CN	PROJ. NO.	175539022	1.	3.	1 OF 1
CHECKED BY	EMK	SCALE	NTS	2.	4.	



NOTES:

1. Installed on 11/05/2009. Boring advanced with 4.25" (I.D.) hollow stem augers.
2. Refer to boring log for overburden stratigraphy.

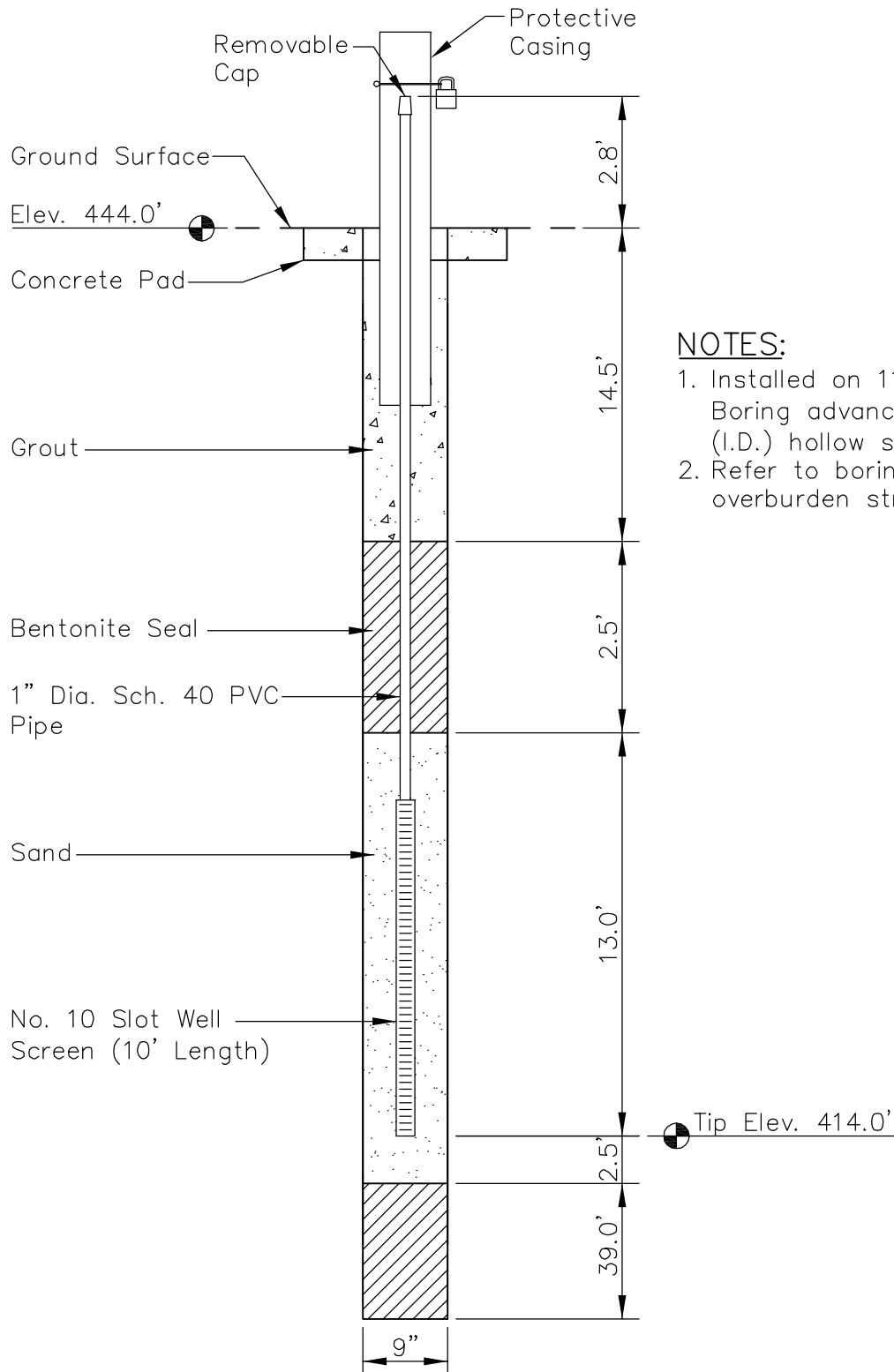
PLOT DATE: 02/18/2010 USER: JENNINGS, MATTHEW V: 1755\ACTIVE\175539022\GEO\TECHNICAL\DRAWING\INSTRUMENTS\PZB3.DWG

LOCATION:

Northing: 448,278.25
 Easting: 566,522.86
 Ground Elevation: 471.7'

Horizontal Datum: NAD 27
 Vertical Datum: NGVD88

PIEZOMETER B-3 WEST BOTTOM ASH DAM CLIFTY CREEK PLANT			
Stantec		Stantec Consulting Services Inc. 11687 Lebanon Rd. Cincinnati, Ohio 45241-2012 513-842-8200 www.stantec.com	
DRAWN BY	MJ	DATE	FEB., 2010
CHECKED BY	CN	PROJ. NO.	175539022
CHECKED BY	EMK	SCALE	NTS
		REVISED	
		1.	3.
		2.	4.
			SHEET
			1 OF 1



NOTES:

1. Installed on 11/11/2009. Boring advanced with 4.25" (I.D.) hollow stem augers.
2. Refer to boring log for overburden stratigraphy.

PLOT DATE: 02/18/2010 USER: JENNINGS, MATTHEW V: 1755\ACTIVE\175539022\GEO\TECHNICAL\DRAWING\INSTRUMENTS\PZB4.DWG

**PIEZOMETER B-4
WEST BOTTOM ASH DAM
CLIFTY CREEK PLANT**

LOCATION:

Northing: 448,202.42
 Easting: 566,559.67
 Ground Elevation: 444.0'

Horizontal Datum: NAD 27
 Vertical Datum: NGVD88

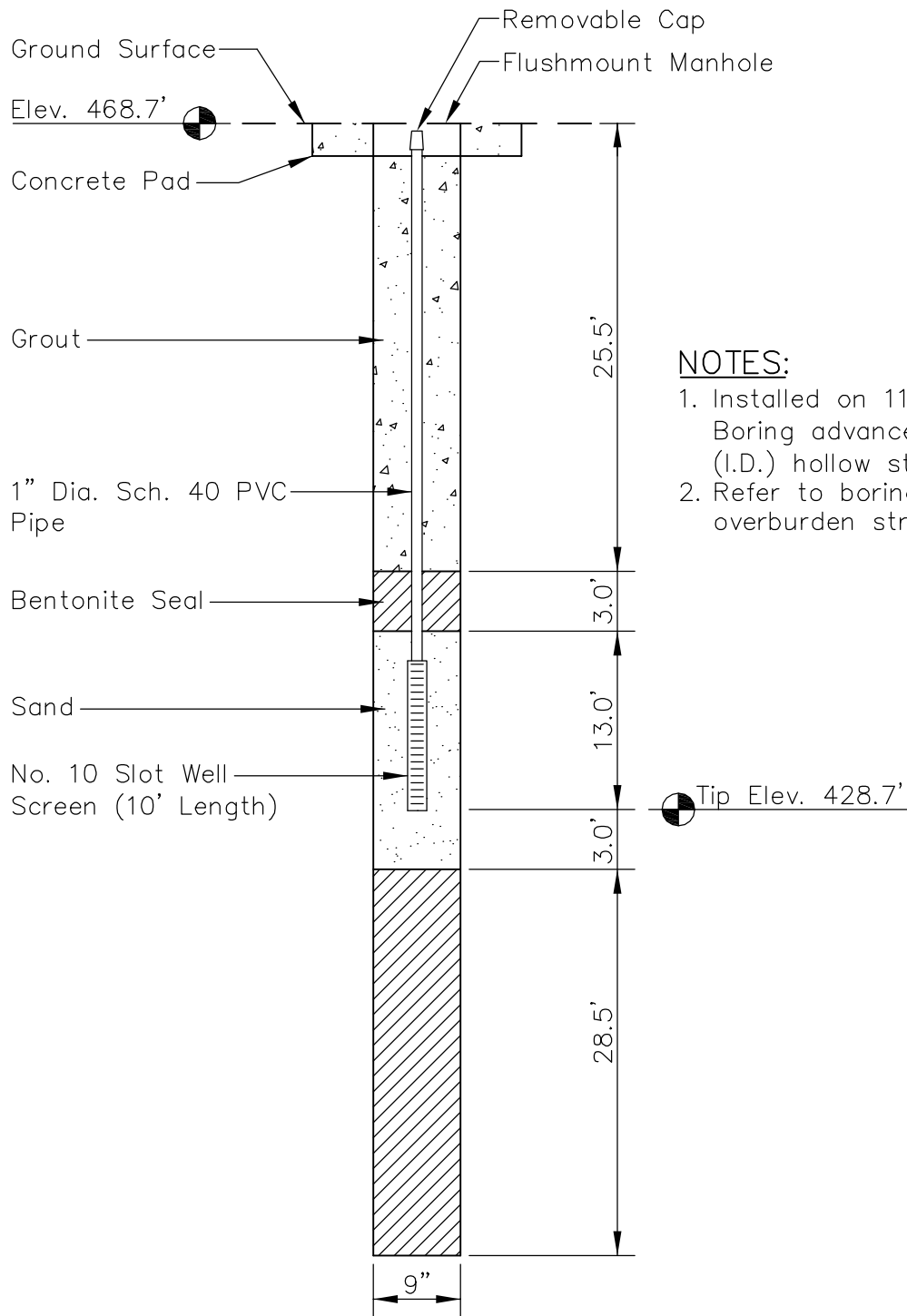


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 513-842-8200

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DRAWN BY	CW	DATE	FEB., 2010	REVISED		SHEET 1 OF 1
CHECKED BY	CN	PROJ. NO.	175539022	1.	3.	
CHECKED BY	EMK	SCALE	NTS	2.	4.	



NOTES:

1. Installed on 11/10/2009. Boring advanced with 4.25" (I.D.) hollow stem augers.
2. Refer to boring log for overburden stratigraphy.

PLOT DATE: 02/18/2010 USER: JENNINGS, MATTHEW V: 1755\ACTIVE\175539022\GEO\TECHNICAL\DRAWING\INSTRUMENTS\PZB5.DWG

PIEZOMETER B-5 WEST BOTTOM ASH DAM CLIFTY CREEK PLANT			
Stantec		Stantec Consulting Services Inc. 11687 Lebanon Rd. Cincinnati, Ohio 45241-2012 513-842-8200 www.stantec.com	
DRAWN BY	MJ	DATE	FEB., 2010
CHECKED BY	CN	PROJ. NO.	175539022
CHECKED BY	EMK	SCALE	NTS
		REVISED	SHEET
		1.	3.
		2.	4.
			1 OF 1

LOCATION:

Northing: 448,958.53
 Easting: 567,968.94
 Ground Elevation: 468.7'

Horizontal Datum: NAD 27
 Vertical Datum: NGVD88

APPENDIX D

SOIL CLASSIFICATION SUMMARIES

BOILER SLAG POND DAM



Summary of Soil Tests

Project Name AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds Project Number 175539022
 Source B-1, 10.0'-11.5', 12.5'-14.0' Lab ID 4
 County Jefferson, IN Date Received 11-16-09
 Sample Type SPT Comp Date Reported 11-30-09

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
 Moisture Content (%): 19.1

Atterberg Limits

Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: 32
 Plastic Limit: 19
 Plasticity Index: 13
 Activity Index: 0.54

Particle Size Analysis

Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	
3/4"	19	
3/8"	9.5	
No. 4	4.75	100.0
No. 10	2	99.8
No. 40	0.425	98.4
No. 200	0.075	84.0
	0.02	49.1
	0.005	31.1
	0.002	23.7
estimated	0.001	22.1

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.2
Coarse Sand	0.2	1.4
Medium Sand	1.4	---
Fine Sand	14.4	14.4
Silt	52.9	60.3
Clay	31.1	23.7

Moisture-Density Relationship

Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
 Prepared: Dry
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: CL
 Group Name: Lean clay with sand
 AASHTO Classification: A-6 (10)

Comments: _____

Project Name AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface Project Number 175539022
 Source B-1, 10.0'-11.5', 12.5'-14.0' Lab ID 4

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
 Prepared using: ASTM D 421

Particle Shape: Angular
 Particle Hardness: Hard and Durable

Tested By: KR
 Test Date: 11-20-2009
 Date Received: 11-16-2009

Maximum Particle size: No. 4 Sieve

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	
No. 4	100.0
No. 10	99.8

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

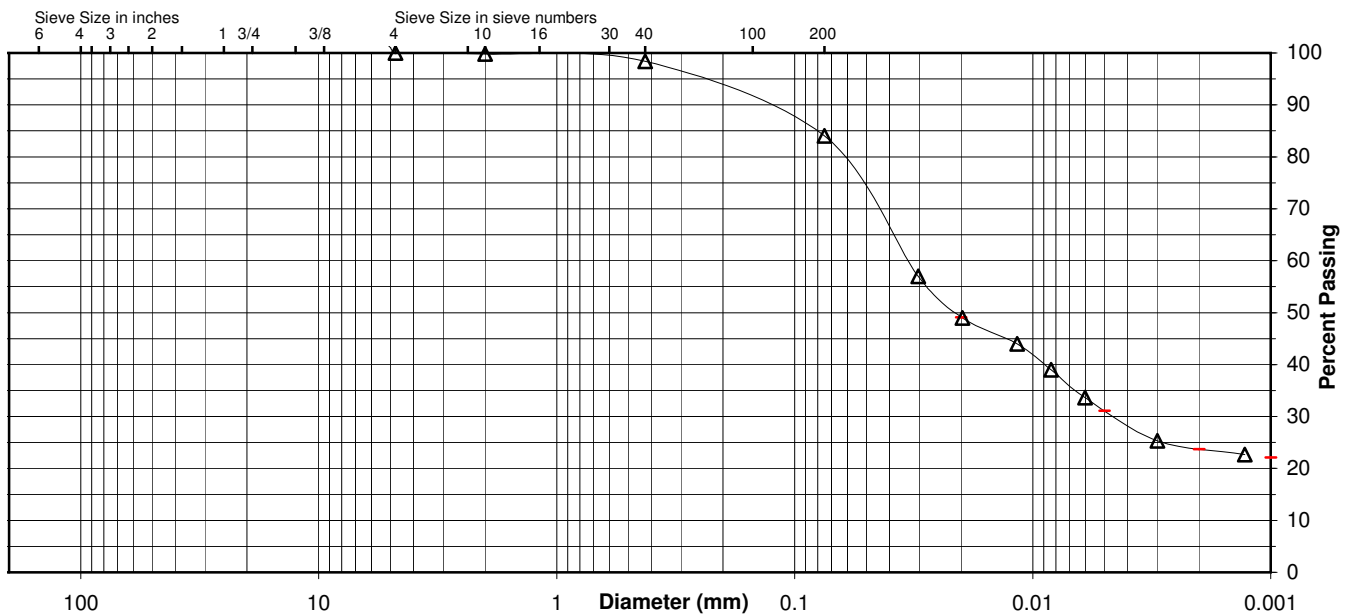
 Specific Gravity 2.7

Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	98.4
No. 200	84.0
0.02 mm	49.1
0.005 mm	31.1
0.002 mm	23.7
0.001 mm	22.1

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.2	1.4	14.4	52.9	31.1
AASHTO	Gravel		Coarse Sand	Fine Sand	Silt		Clay
	0.2		1.4	14.4	60.3		23.7



Comments _____

Reviewed By _____

Project AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface e:
 Source B-1, 10.0'-11.5', 12.5'-14.0'

Project No. 175539022

Lab ID 4

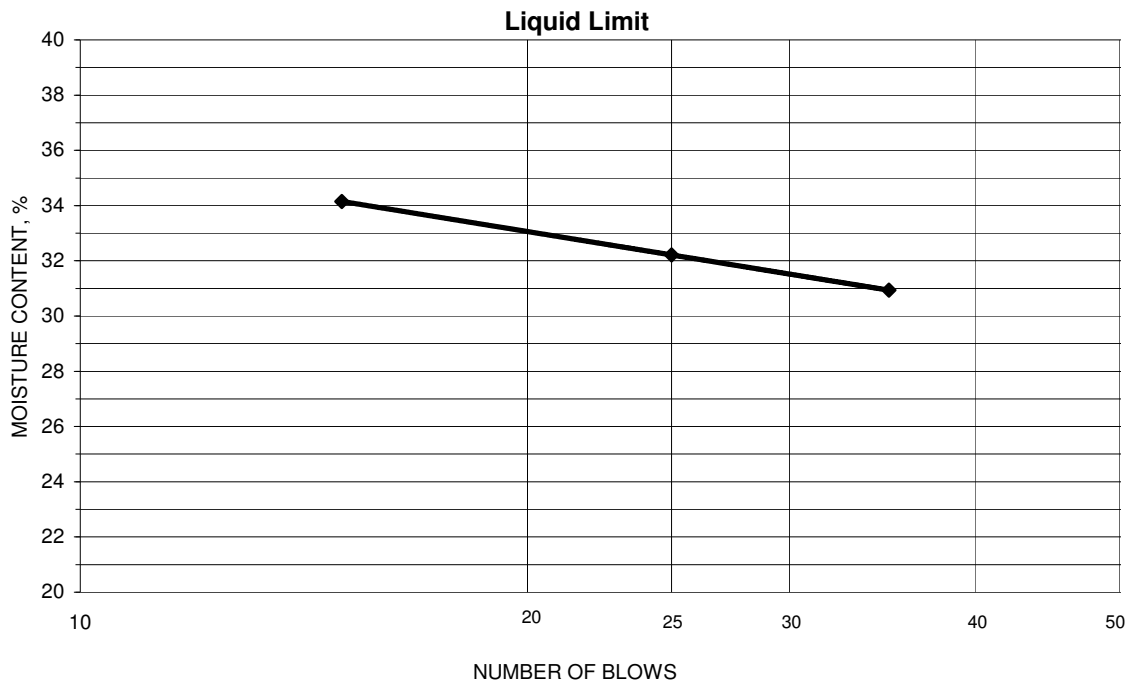
% + No. 40 2

Tested By RG Test Method ASTM D 4318 Method A

Date Received 11-16-2009

Test Date 11-23-2009 Prepared Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
22.20	19.41	11.24	15	34.1	32
20.53	18.13	10.68	25	32.2	
22.58	19.87	11.11	35	30.9	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
24.73	22.56	11.06	18.9	19	13
24.53	22.36	11.08	19.2		

Remarks: _____
 _____ Reviewed By _____



Summary of Soil Tests

Project Name AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds Project Number 175539022
 Source B-1, 47.5'-49.0', 50.0'-51.5' Lab ID 20
 County Jefferson, IN Date Received 11-16-09
 Sample Type SPT Comp Date Reported 11-30-09

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
 Moisture Content (%): 25.3

Atterberg Limits

Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: 28
 Plastic Limit: 16
 Plasticity Index: 12
 Activity Index: 0.60

Particle Size Analysis

Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	
3/4"	19	
3/8"	9.5	100.0
No. 4	4.75	100.0
No. 10	2	99.9
No. 40	0.425	99.7
No. 200	0.075	84.1
	0.02	54.5
	0.005	28.2
	0.002	20.4
estimated	0.001	17.1

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.1
Coarse Sand	0.1	0.2
Medium Sand	0.2	---
Fine Sand	15.6	15.6
Silt	55.9	63.7
Clay	28.2	20.4

Moisture-Density Relationship

Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
 Prepared: Dry
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.77

Classification

Unified Group Symbol: CL
 Group Name: Lean clay with sand
 AASHTO Classification: A-6 (8)

Comments: _____

Project Name AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface Project Number 175539022
 Source B-1, 47.5'-49.0', 50.0'-51.5' Lab ID 20

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
 Prepared using: ASTM D 421

Particle Shape: Angular
 Particle Hardness: Hard and Durable

Tested By: KR
 Test Date: 11-20-2009
 Date Received 11-16-2009

Maximum Particle size: 3/8" Sieve

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	100.0
No. 4	100.0
No. 10	99.9

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

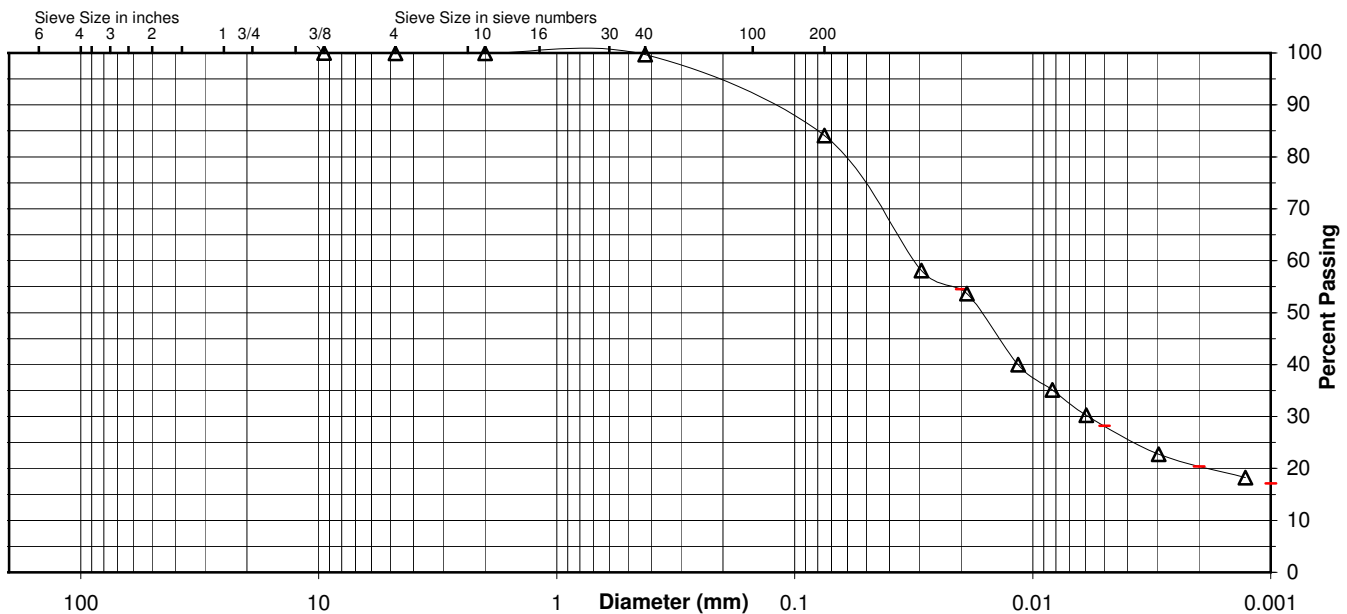
 Specific Gravity 2.77

Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	99.7
No. 200	84.1
0.02 mm	54.5
0.005 mm	28.2
0.002 mm	20.4
0.001 mm	17.1

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.1	0.2	15.6	55.9	28.2
AASHTO	Gravel		Coarse Sand	Fine Sand	Silt		Clay
	0.1		0.2	15.6	63.7		20.4



Comments _____

Reviewed By _____

Project AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface e:
 Source B-1, 47.5'-49.0', 50.0'-51.5'

Project No. 175539022

Lab ID 20

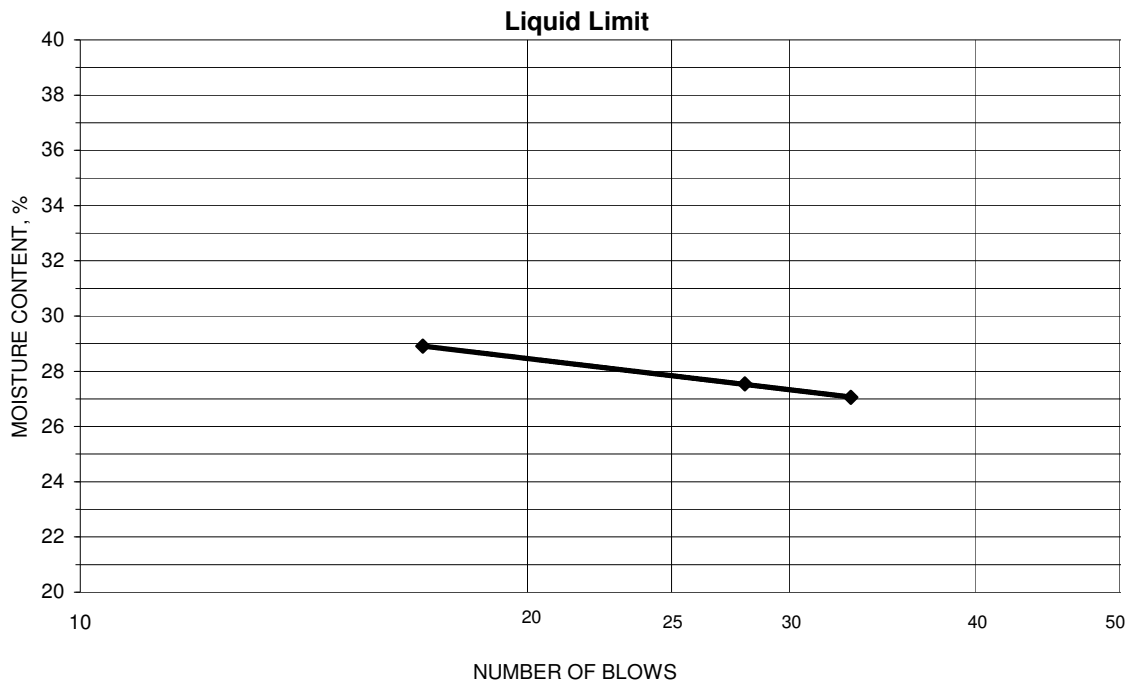
% + No. 40 0

Tested By RG Test Method ASTM D 4318 Method A

Date Received 11-16-2009

Test Date 11-23-2009 Prepared Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
23.68	21.01	11.14	33	27.1	28
23.20	20.50	11.16	17	28.9	
23.78	21.05	11.14	28	27.5	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
25.05	23.09	10.96	16.2	16	12
22.52	20.86	10.61	16.2		

Remarks: _____
 _____ Reviewed By _____



Summary of Soil Tests

Project Name AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds Project Number 175539022
 Source B-2, 32.5'-34.0', 35.0'-36.5' Lab ID 43
 County Jefferson, IN Date Received 11-16-09
 Sample Type SPT Comp Date Reported 11-30-09

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
 Moisture Content (%): 32.1

Atterberg Limits

Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: 33
 Plastic Limit: 15
 Plasticity Index: 18
 Activity Index: 0.90

Particle Size Analysis

Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	
3/4"	19	
3/8"	9.5	100.0
No. 4	4.75	99.7
No. 10	2	99.7
No. 40	0.425	98.7
No. 200	0.075	79.7
	0.02	50.6
	0.005	28.1
	0.002	19.7
estimated	0.001	16.0

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.3	0.3
Coarse Sand	0.0	1.0
Medium Sand	1.0	---
Fine Sand	19.0	19.0
Silt	51.6	60.0
Clay	28.1	19.7

Moisture-Density Relationship

Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
 Prepared: Dry
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.72

Classification

Unified Group Symbol: CL
 Group Name: Lean clay with sand
 AASHTO Classification: A-6 (13)

Comments: _____



Particle-Size Analysis of Soils

ASTM D 422

Project Name AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface Project Number 175539022
 Source B-2, 32.5'-34.0', 35.0'-36.5' Lab ID 43

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
 Prepared using: ASTM D 421
 Particle Shape: Angular
 Particle Hardness: Hard and Durable
 Tested By: KR
 Test Date: 11-20-2009
 Date Received: 11-16-2009

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	100.0
No. 4	99.7
No. 10	99.7

Maximum Particle size: 3/8" Sieve

Analysis for the portion Finer than the No. 10 Sieve

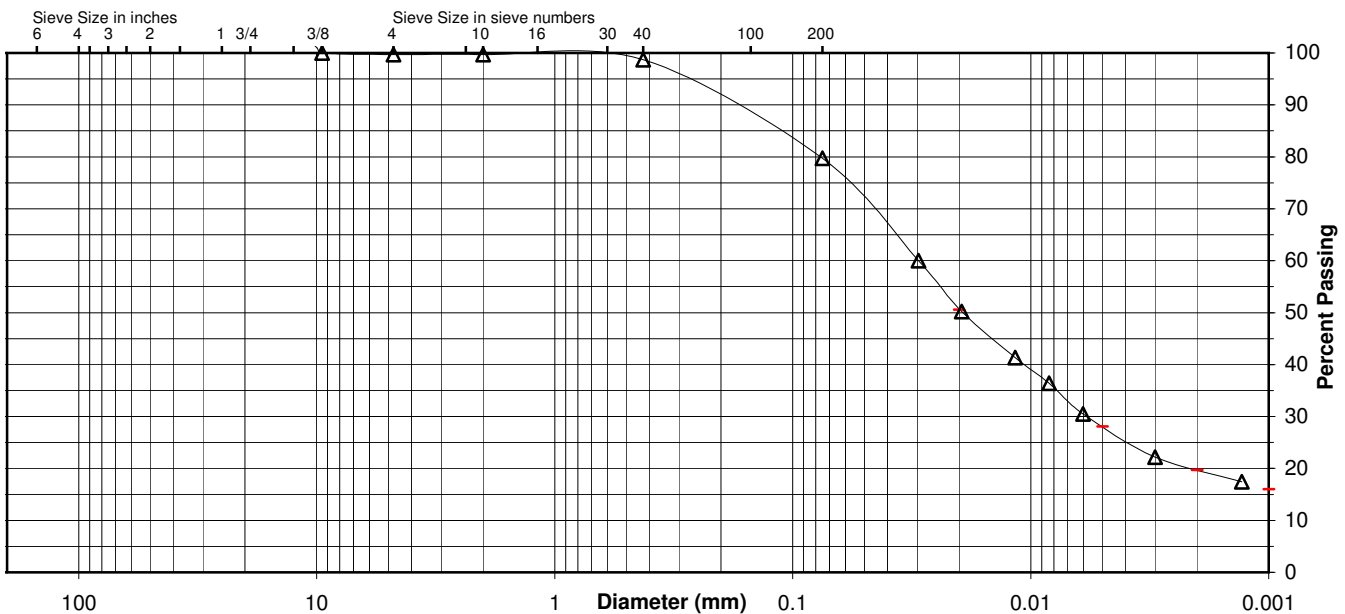
Analysis Based on: Total Sample
 Specific Gravity 2.72

No. 40	98.7
No. 200	79.7
0.02 mm	50.6
0.005 mm	28.1
0.002 mm	19.7
0.001 mm	16.0

Dispersed using: Apparatus A - Mechanical, for 1 minute

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.3	0.0	1.0	19.0	51.6	28.1
AASHTO	Gravel		Coarse Sand	Fine Sand	Silt		Clay
	0.3		1.0	19.0	60.0		19.7



Comments _____

Reviewed By _____

Project AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface e:
 Source B-2, 32.5'-34.0', 35.0'-36.5'

Project No. 175539022

Lab ID 43

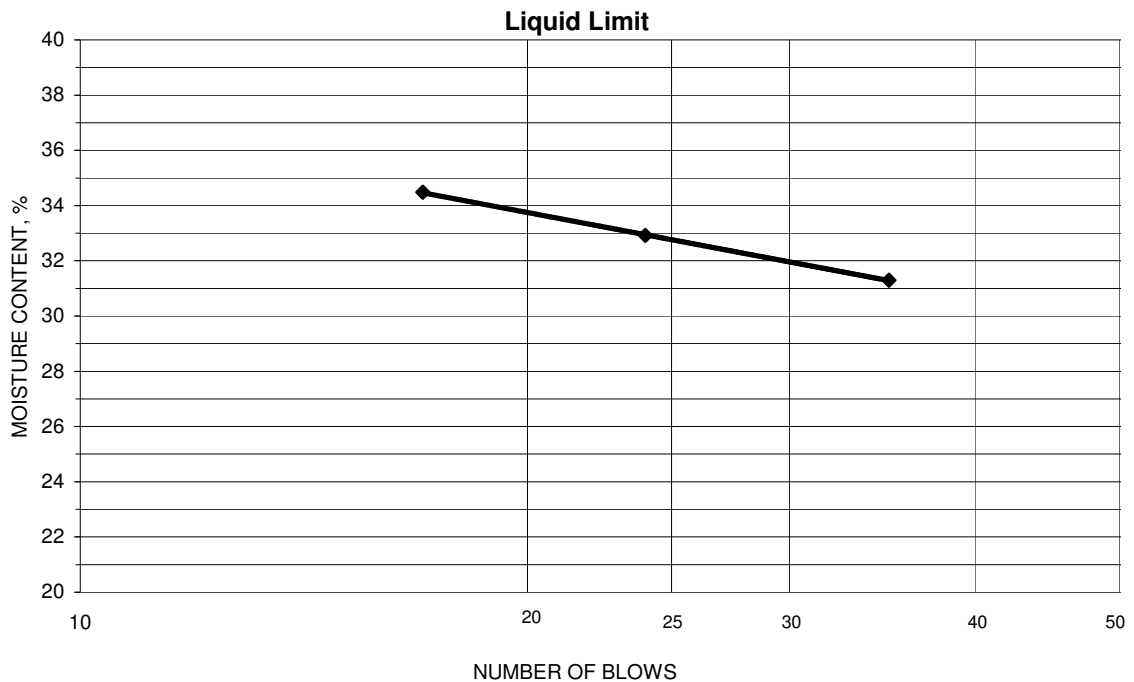
% + No. 40 1

Tested By KR Test Method ASTM D 4318 Method A

Date Received 11-16-2009

Test Date 11-23-2009 Prepared Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
23.26	20.15	11.13	17	34.5	33
23.44	20.29	10.72	24	32.9	
24.86	21.58	11.10	35	31.3	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
21.11	19.78	10.98	15.1	15	18
21.07	19.72	10.97	15.4		

Remarks: _____
 _____ Reviewed By _____



Summary of Soil Tests

Project Name AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds Project Number 175539022
 Source B-4, 20.0'-21.5', 22.5'-24.0' Lab ID 87
 County Jefferson, IN Date Received 11-16-09
 Sample Type SPT Comp Date Reported 11-30-09

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
 Moisture Content (%): 26.6

Atterberg Limits

Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: 25
 Plastic Limit: 17
 Plasticity Index: 8
 Activity Index: 0.40

Particle Size Analysis

Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	
3/4"	19	
3/8"	9.5	
No. 4	4.75	100.0
No. 10	2	100.0
No. 40	0.425	99.7
No. 200	0.075	80.7
	0.02	52.0
	0.005	27.7
	0.002	19.5
estimated	0.001	15.1

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.0
Coarse Sand	0.0	0.3
Medium Sand	0.3	---
Fine Sand	19.0	19.0
Silt	53.0	61.2
Clay	27.7	19.5

Moisture-Density Relationship

Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
 Prepared: Dry
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.60

Classification

Unified Group Symbol: CL
 Group Name: Lean clay with sand
 AASHTO Classification: A-4 (4)

Comments: _____

Project Name AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface Project Number 175539022
 Source B-4, 20.0'-21.5', 22.5'-24.0' Lab ID 87

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
 Prepared using: ASTM D 421

Particle Shape: Angular
 Particle Hardness: Hard and Durable

Tested By: KR
 Test Date: 11-20-2009
 Date Received: 11-16-2009

Maximum Particle size: No. 4 Sieve

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	
No. 4	100.0
No. 10	100.0

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

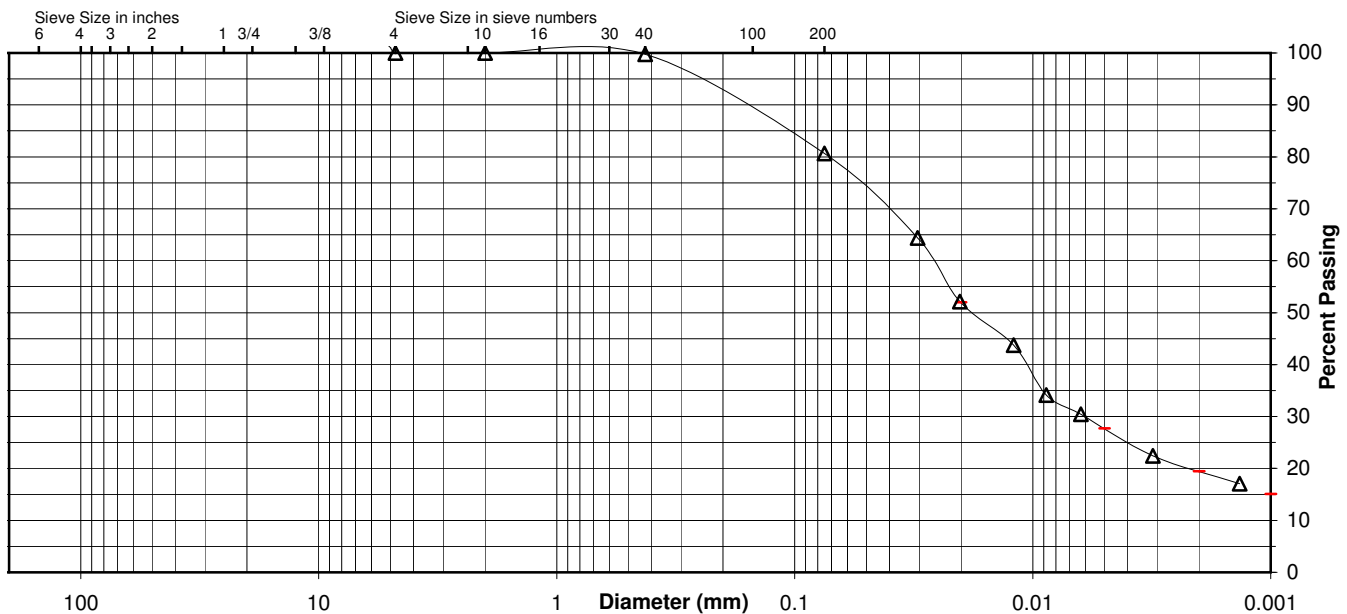
Specific Gravity 2.6

Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	99.7
No. 200	80.7
0.02 mm	52.0
0.005 mm	27.7
0.002 mm	19.5
0.001 mm	15.1

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.0	0.3	19.0	53.0	27.7
AASHTO	Gravel		Coarse Sand	Fine Sand	Silt		Clay
	0.0		0.3	19.0	61.2		19.5



Comments _____

Reviewed By _____

Project AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface e:
 Source B-4, 20.0'-21.5', 22.5'-24.0'

Project No. 175539022

Lab ID 87

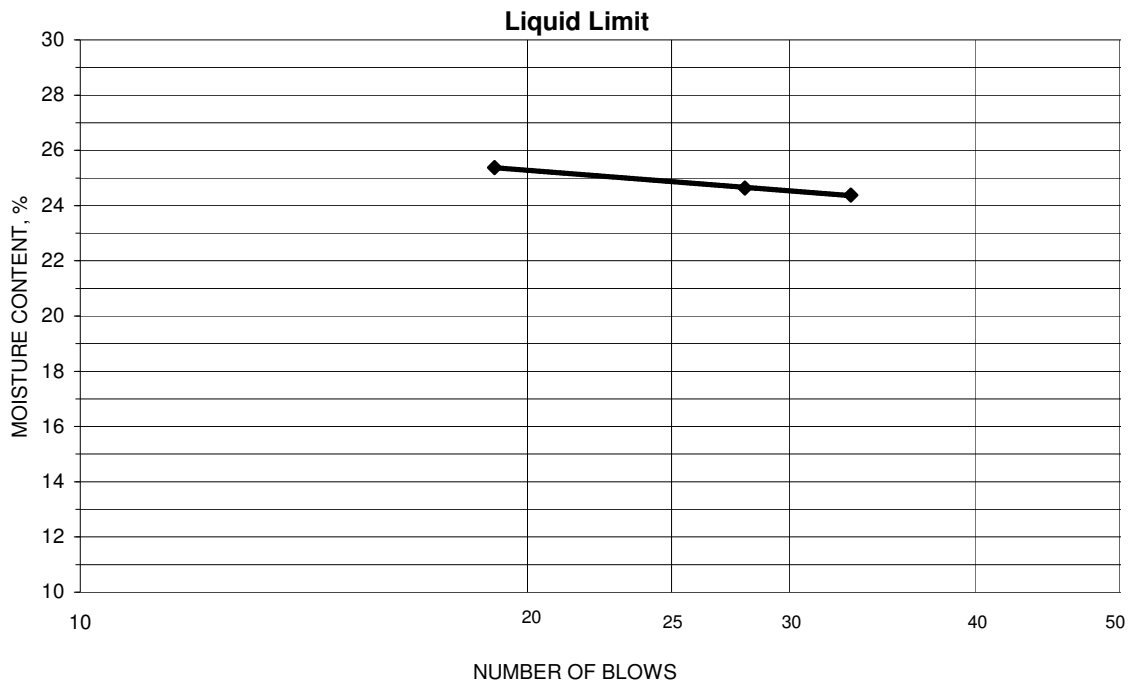
% + No. 40 0

Tested By RG Test Method ASTM D 4318 Method A

Date Received 11-16-2009

Test Date 11-23-2009 Prepared Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
24.04	21.40	10.57	33	24.4	25
23.55	21.04	11.15	19	25.4	
23.10	20.72	11.06	28	24.6	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
24.08	22.17	11.08	17.2	17	8
25.29	23.10	10.68	17.6		

Remarks: _____
 _____ Reviewed By _____



Summary of Soil Tests

Project Name AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds Project Number 175539022
 Source B-4, 57.5'-59.0', 60.0'-61.5' Lab ID 103
 County Jefferson, IN Date Received 11-16-09
 Sample Type SPT Comp Date Reported 11-30-09

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
 Moisture Content (%): 10.9

Atterberg Limits

Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: ---
 Plastic Limit: Non Plastic
 Plasticity Index: ---
 Activity Index: N/A

Particle Size Analysis

Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
3"	75	
2"	50	
1 1/2"	37.5	100.0
1"	25	97.1
3/4"	19	92.5
3/8"	9.5	72.7
No. 4	4.75	46.1
No. 10	2	32.6
No. 40	0.425	13.6
No. 200	0.075	5.7
	0.02	2.9
	0.005	1.5
	0.002	1.1
estimated	0.001	0.9

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	53.9	67.4
Coarse Sand	13.5	19.0
Medium Sand	19.0	---
Fine Sand	7.9	7.9
Silt	4.2	4.6
Clay	1.5	1.1

Moisture-Density Relationship

Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
 Prepared: Dry
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.72

Classification

Unified Group Symbol: GW-GM
 Group Name: Well-graded gravel with silt and sand
 AASHTO Classification: A-1-a (1)

Comments: _____



Particle-Size Analysis of Soils

ASTM D 422

Project Name AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface Project Number 175539022
 Source B-4, 57.5'-59.0', 60.0'-61.5' Lab ID 103

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
 Prepared using: ASTM D 421
 Particle Shape: Angular
 Particle Hardness: Hard and Durable
 Tested By: KR
 Test Date: 11-20-2009
 Date Received: 11-16-2009

Sieve Size	% Passing
3"	
2"	
1 1/2"	100.0
1"	97.1
3/4"	92.5
3/8"	72.7
No. 4	46.1
No. 10	32.6

Maximum Particle size: 1 1/2" Sieve

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

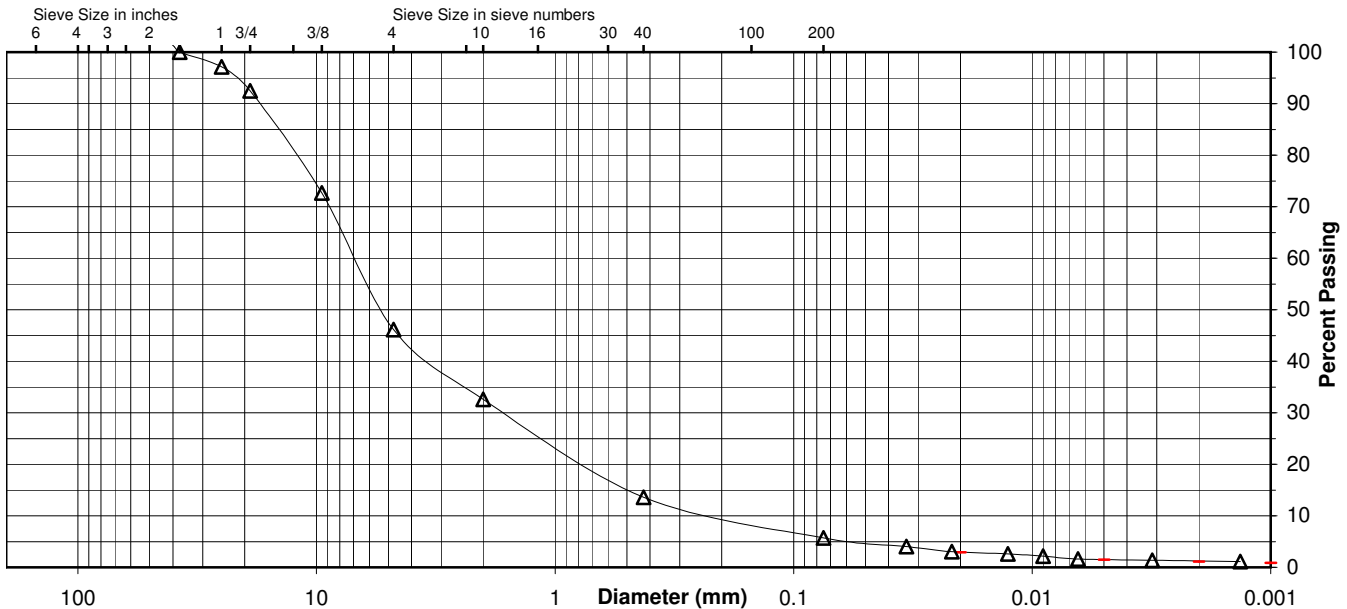
Specific Gravity 2.72

Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	13.6
No. 200	5.7
0.02 mm	2.9
0.005 mm	1.5
0.002 mm	1.1
0.001 mm	0.9

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
		7.5	46.4	13.5	19.0	7.9	4.2	1.5
AASHTO	Gravel			Coarse Sand	Fine Sand	Silt	Clay
	67.4			19.0	7.9	4.6	1.1



Comments _____

Reviewed By _____

Project AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface e:
 Source B-4, 57.5'-59.0', 60.0'-61.5'

 Project No. 175539022

 Lab ID 103

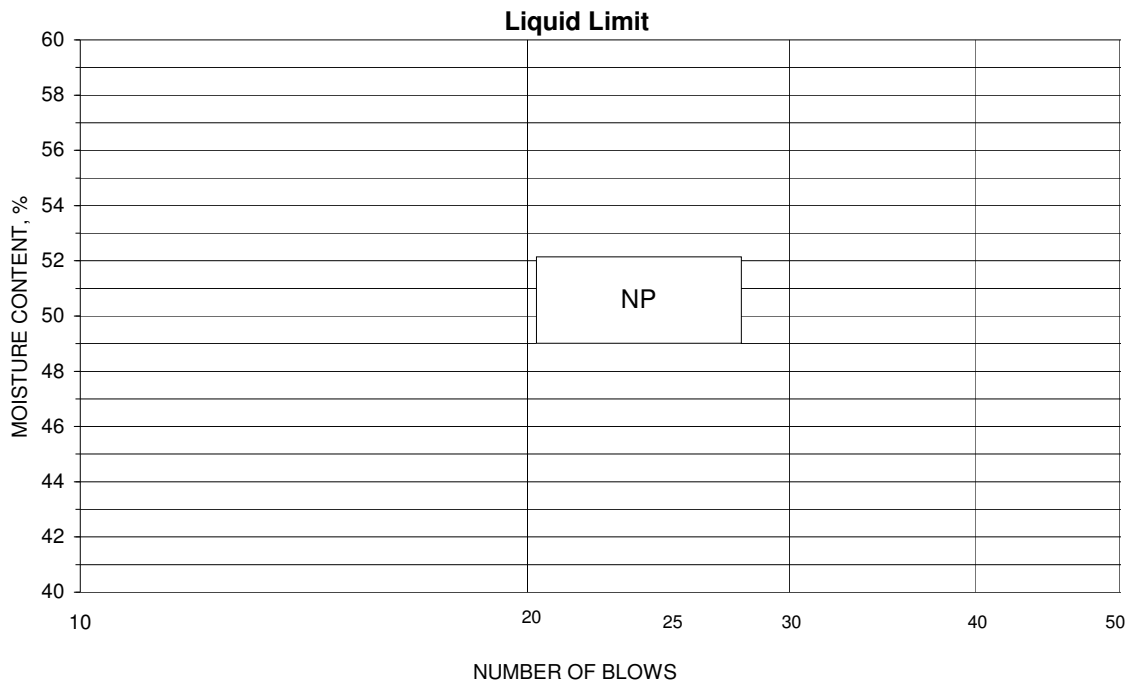
 % + No. 40 86

 Tested By RG Test Method ASTM D 4318 Method A

 Date Received 11-16-2009

 Test Date 11-23-2009 Prepared Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
					#VALUE!



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
					#VALUE!

 Remarks: _____
 _____ Reviewed By _____



Summary of Soil Tests

Project Name AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds Project Number 175539022
 Source B-5, 55.0'-56.5', 57.5'-59.0' Lab ID 129
 County Jefferson, IN Date Received 11-16-09
 Sample Type SPT Comp Date Reported 11-30-09

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
 Moisture Content (%): 24.9

Atterberg Limits

Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: ---
 Plastic Limit: Non Plastic
 Plasticity Index: ---
 Activity Index: N/A

Particle Size Analysis

Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	
3/4"	19	
3/8"	9.5	100.0
No. 4	4.75	100.0
No. 10	2	100.0
No. 40	0.425	99.9
No. 200	0.075	54.0
	0.02	26.2
	0.005	16.7
	0.002	13.0
estimated	0.001	10.5

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.0
Coarse Sand	0.0	0.1
Medium Sand	0.1	---
Fine Sand	45.9	45.9
Silt	37.3	41.0
Clay	16.7	13.0

Moisture-Density Relationship

Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
 Prepared: Dry
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.74

Classification

Unified Group Symbol: ML
 Group Name: Sandy silt
 AASHTO Classification: A-4 (0)

Comments: _____

Project Name AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface Project Number 175539022
 Source B-5, 55.0'-56.5', 57.5'-59.0' Lab ID 129

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
 Prepared using: ASTM D 421

Particle Shape: Angular
 Particle Hardness: Hard and Durable

Tested By: KR
 Test Date: 11-20-2009
 Date Received: 11-16-2009

Maximum Particle size: 3/8" Sieve

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	100.0
No. 4	100.0
No. 10	100.0

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

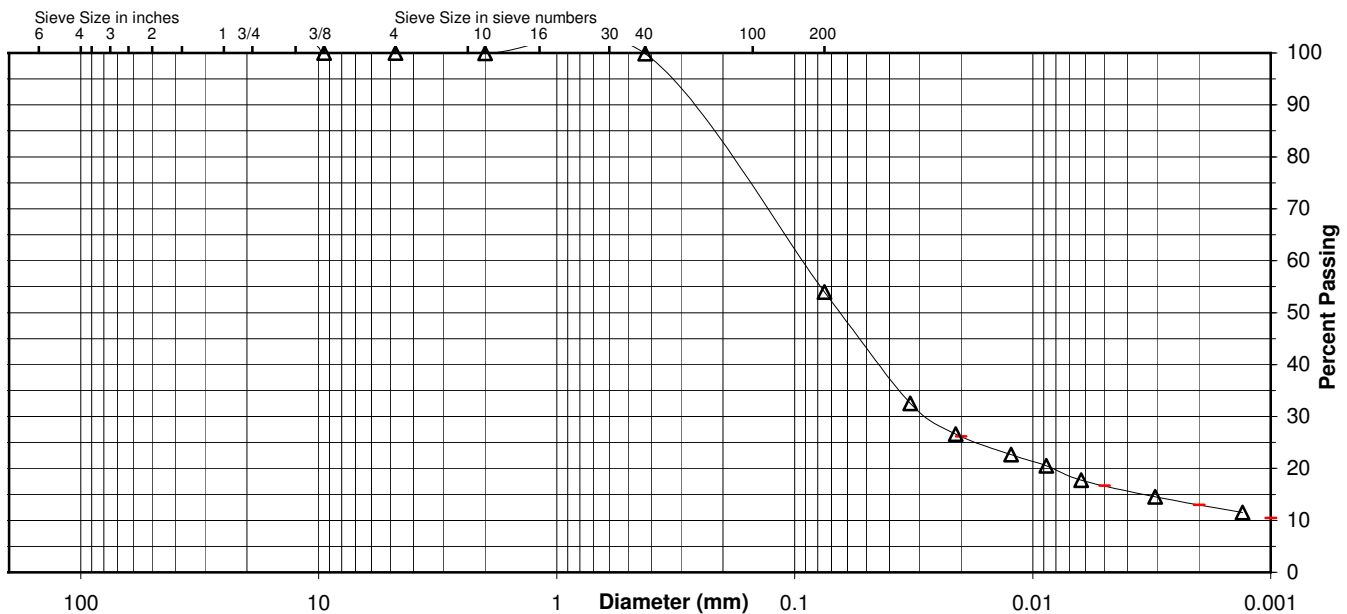
Specific Gravity 2.74

Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	99.9
No. 200	54.0
0.02 mm	26.2
0.005 mm	16.7
0.002 mm	13.0
0.001 mm	10.5

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.0	0.1	45.9	37.3	16.7
AASHTO	Gravel		Coarse Sand	Fine Sand	Silt		Clay
	0.0		0.1	45.9	41.0		13.0



Comments _____

Reviewed By _____

Project AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface e:
 Source B-5, 55.0'-56.5', 57.5'-59.0'

Project No. 175539022

Lab ID 129

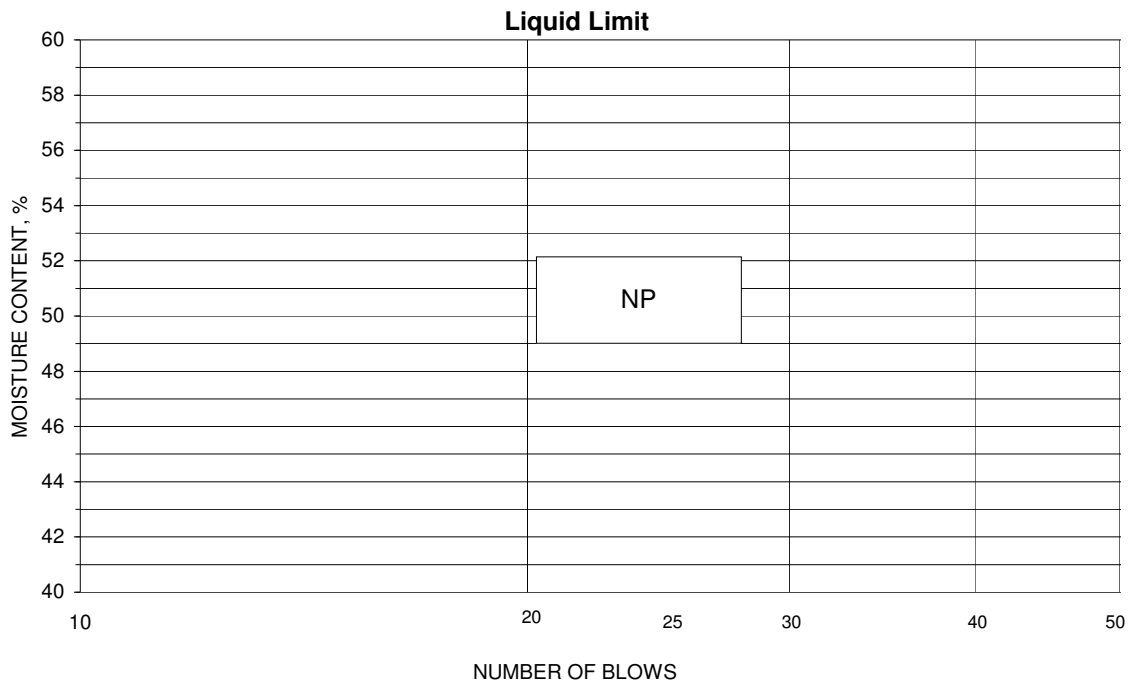
% + No. 40 0

Tested By RG Test Method ASTM D 4318 Method A

Date Received 11-16-2009

Test Date 11-23-2009 Prepared Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
					#VALUE!



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
					#VALUE!

Remarks: _____
 _____ Reviewed By _____

LANDFILL RUNOFF COLLECTION POND:
2009 GEOTECHNICAL EXPLORATION



GeoTesting Express

SPECIFIC GRAVITY TEST

(ASTM D854)

Project No. GTX-1516
 Project Name Clifty Creek

Tested By JM
 Test Date 12/8/2009

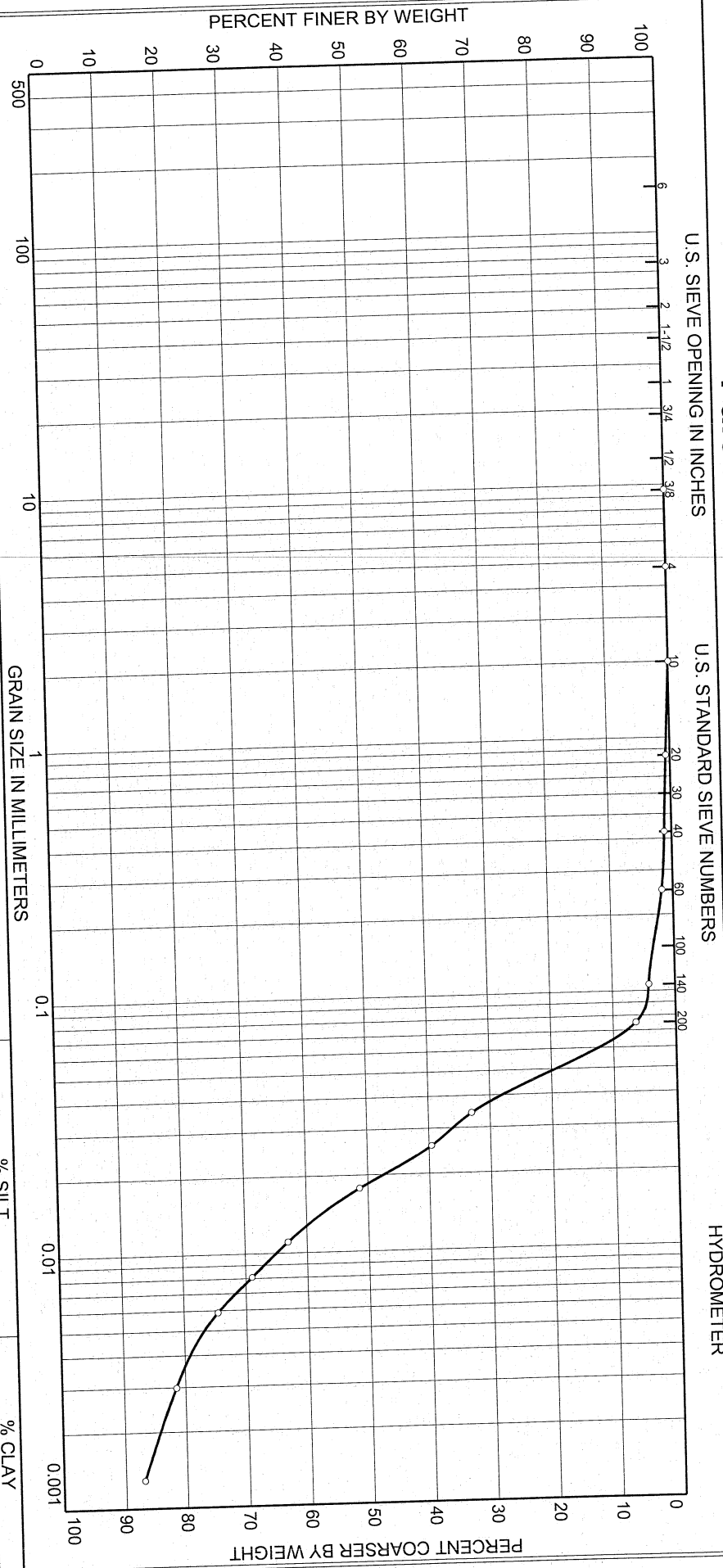
Reviewed By MM
 Review Date 12/13/2009

(1) Boring No.	(2) Depth (ft)	(3) Sample No.	(4) Lab No.	(5) Flask No.	(6) Temperature (°C)	(7) Weight, WF (grams)	(8) Weight, WFS (grams)	(9) Weight of Soil (grams) (8)-(7)	(10) Weight, CWF (grams)	(11) Weight, DS (grams)	(12) Specific Gravity <small>(9)/[(10)-(11)+(9)]</small>	(13) Specific Gravity at 20° C
B-7	27.2-27.8	-	--	41	17	304.60	358.10	53.50	433.68	466.86	2.633	2.634
B-8	25.5-25.8	-	--	33	17	286.35	316.64	30.29	408.76	427.56	2.636	2.638
B-8	29.7-30.3	-	--	34	18	273.88	322.48	48.60	407.64	437.9	2.650	2.651
B-9	30.2-20.8	-	--	40	18	303.59	336.38	32.79	437.43	457.84	2.649	2.650
B-10	14.2-14.8	-	--	29	17	265.69	319.25	53.56	405.05	438.63	2.681	2.682
B-10	16.2-16.8	-	--	29	21	273.96	325.28	51.32	404.86	436.87	2.658	2.657

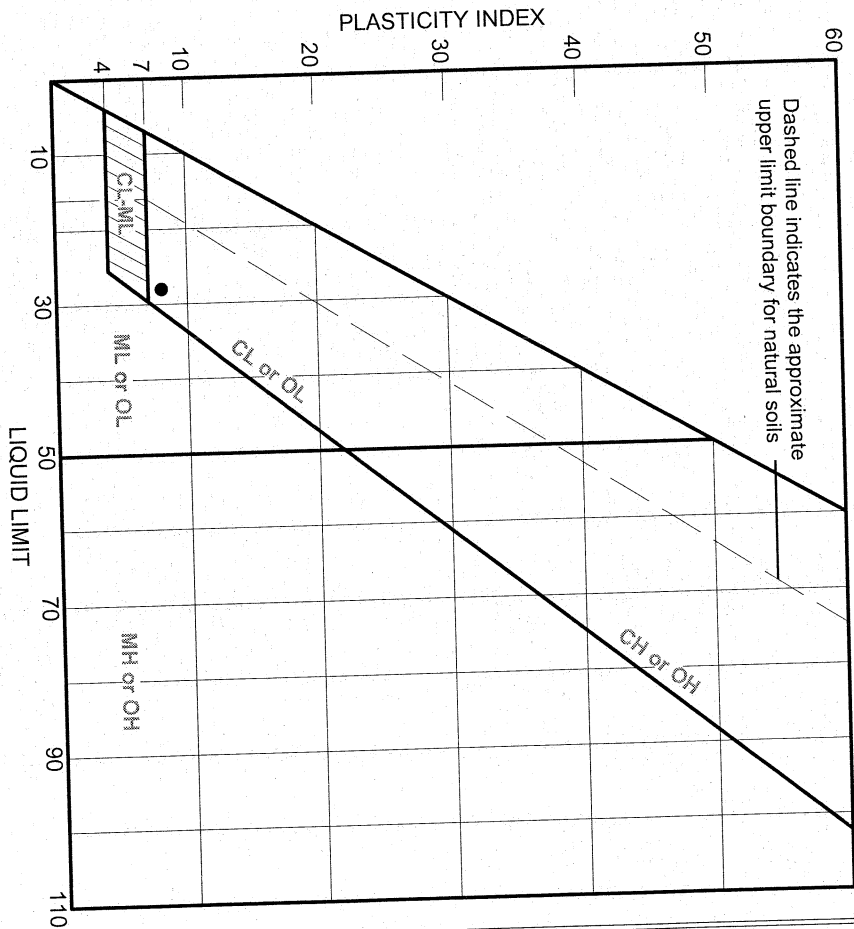
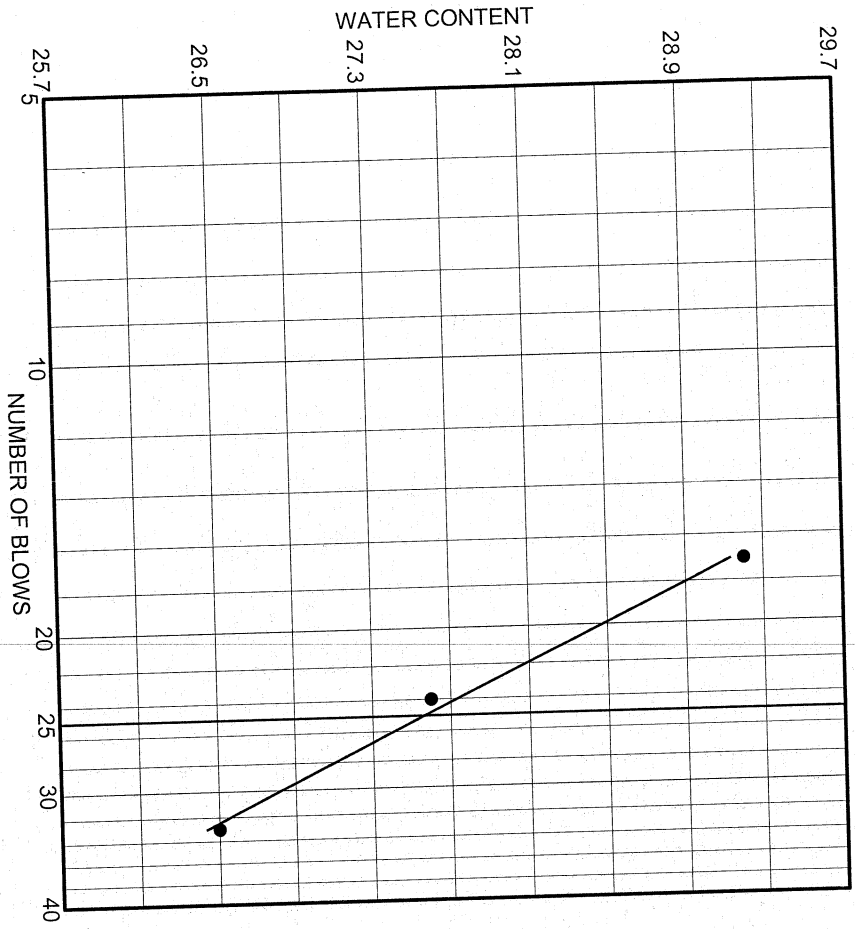
WF - Water and Flask
 WFS - Water, Flask and Soil
 CWF - Calibration Water and Flask
 DS - Deaired Sample

Particle Size Distribution Report ASTM D422

HYDROMETER



LIQUID AND PLASTIC LIMITS TEST REPORT



SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
	B-7	27.2-27.8 ft	12/10/09	CL	Lean clay		28	8

Client Stantec
Project Clifty Creek

Project No. GTX-1516 Lab no.

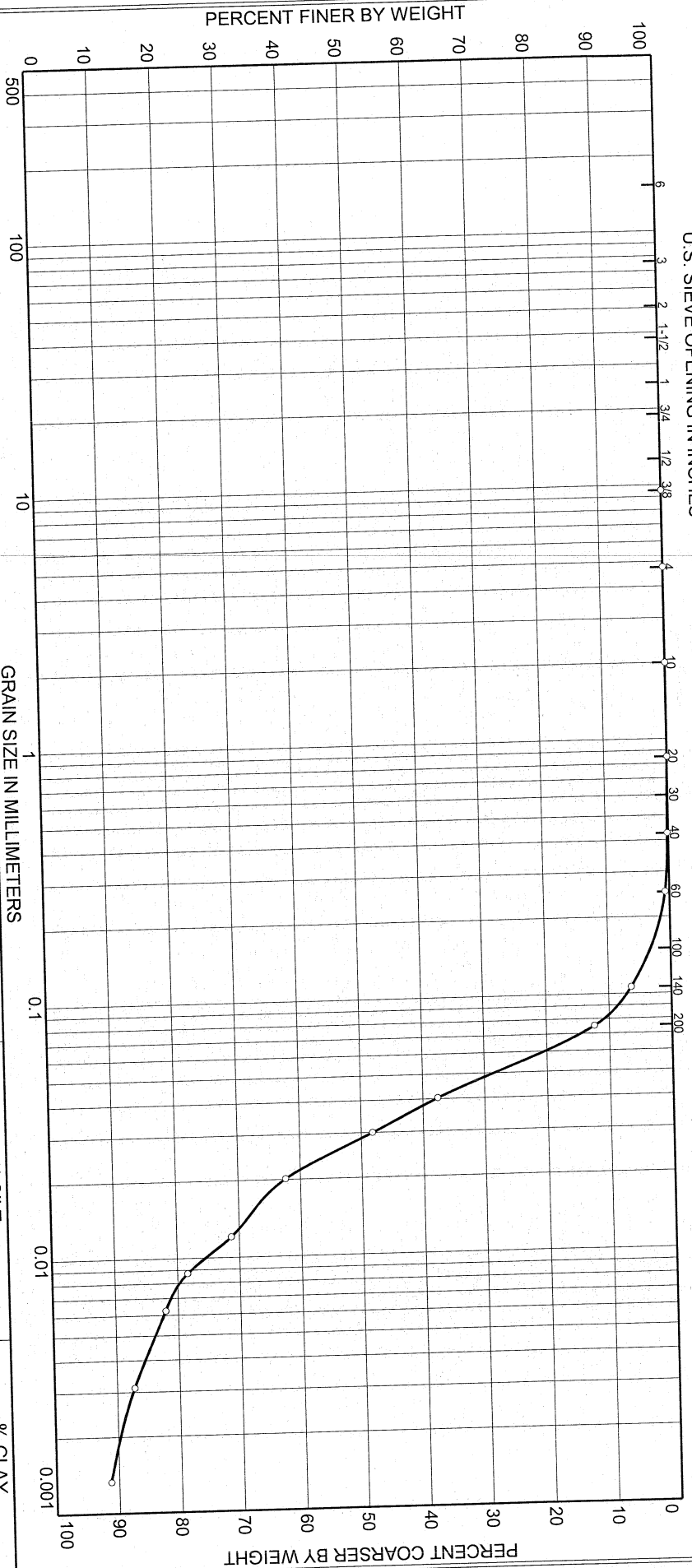
GeoTesting Express Inc.

Particle Size Distribution Report ASTM D422

U.S. SIEVE OPENING IN INCHES

U.S. STANDARD SIEVE NUMBERS

HYDROMETER



% COBBLES

% GRAVEL

% SAND

% SILT

% CLAY

0.0

0.0

12.4

71.3

16.3

SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
	B-8	25.5-25.8 ft	12/10/09	CL	Lean clay		38	21

Client Stantec

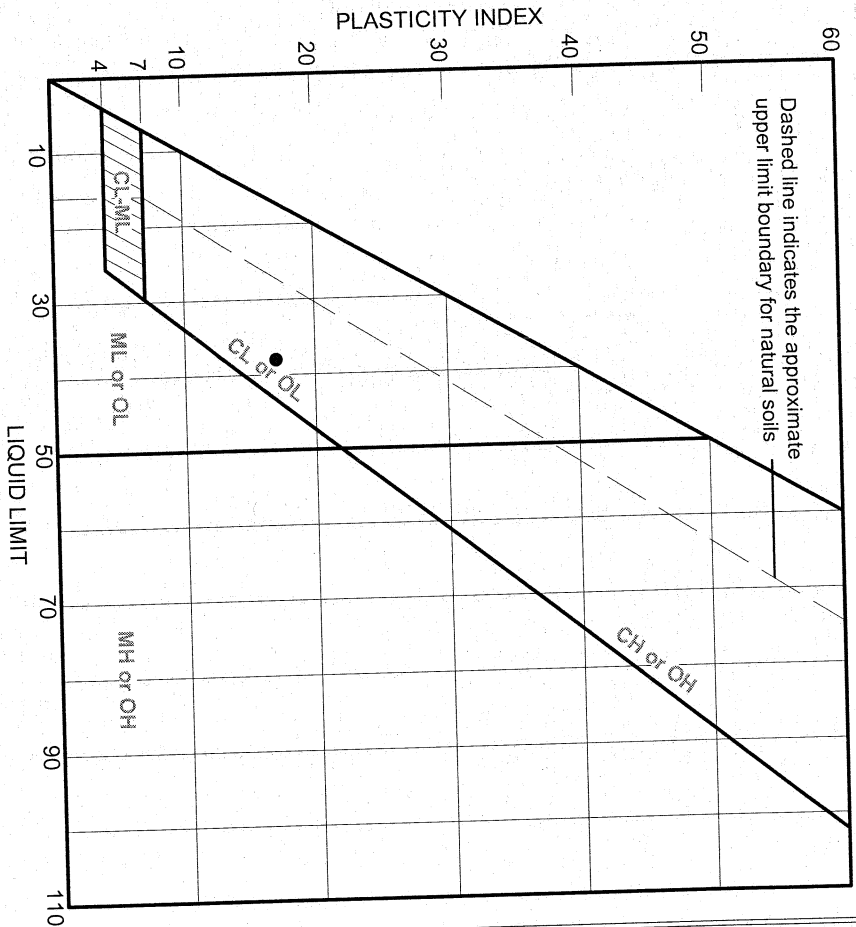
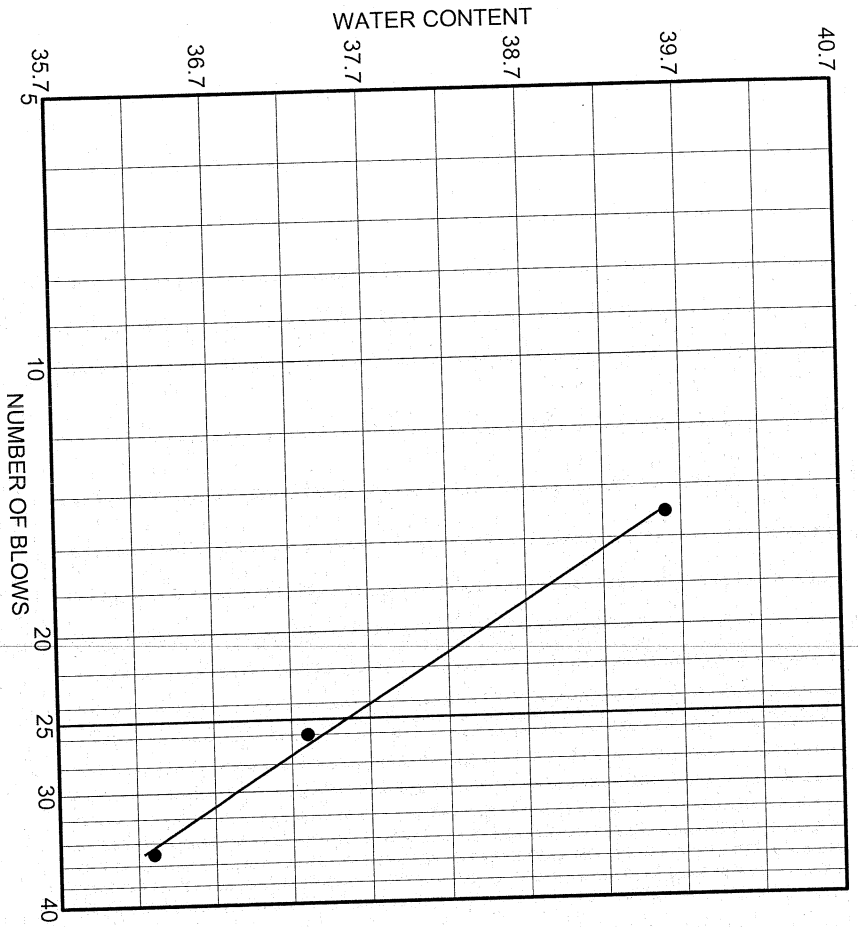
Project Clifty Creek

Project No. GTX-1516

Lab no.

GeoTesting
Express Inc.

LIQUID AND PLASTIC LIMITS TEST REPORT



SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
	B-8	25.5-25.8 ft	12/10/09	CL	Lean clay		38	17

Client Stantec
Project Clifty Creek

Project No. GTX-1516 Lab no.

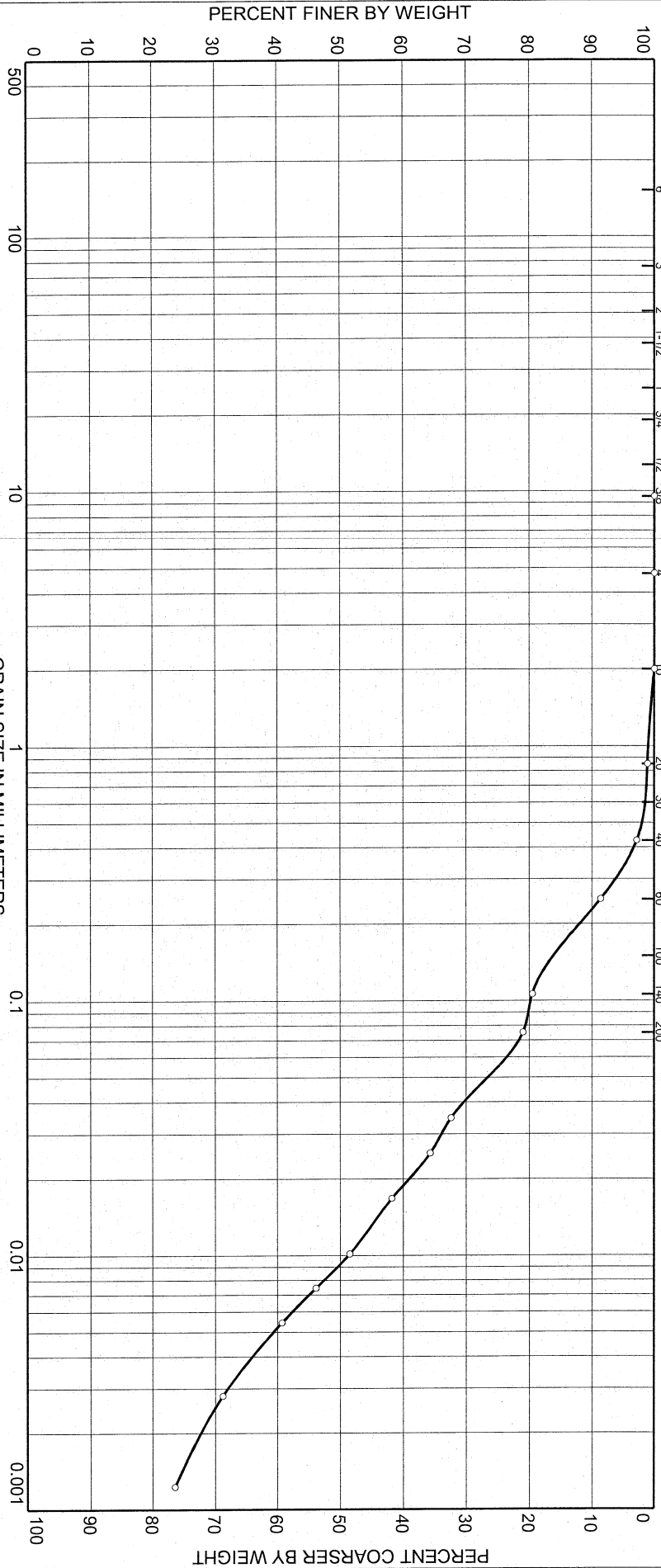
GeoTesting Express Inc.

Particle Size Distribution Report ASTM D422

U.S. SIEVE OPENING IN INCHES

U.S. STANDARD SIEVE NUMBERS

HYDROMETER



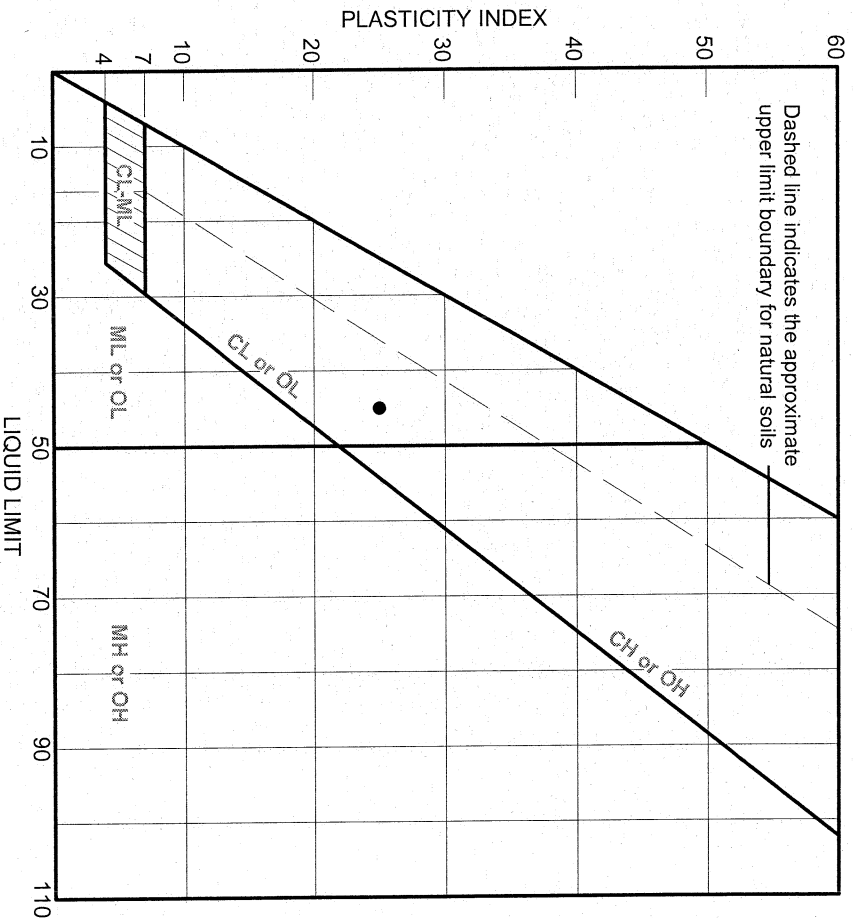
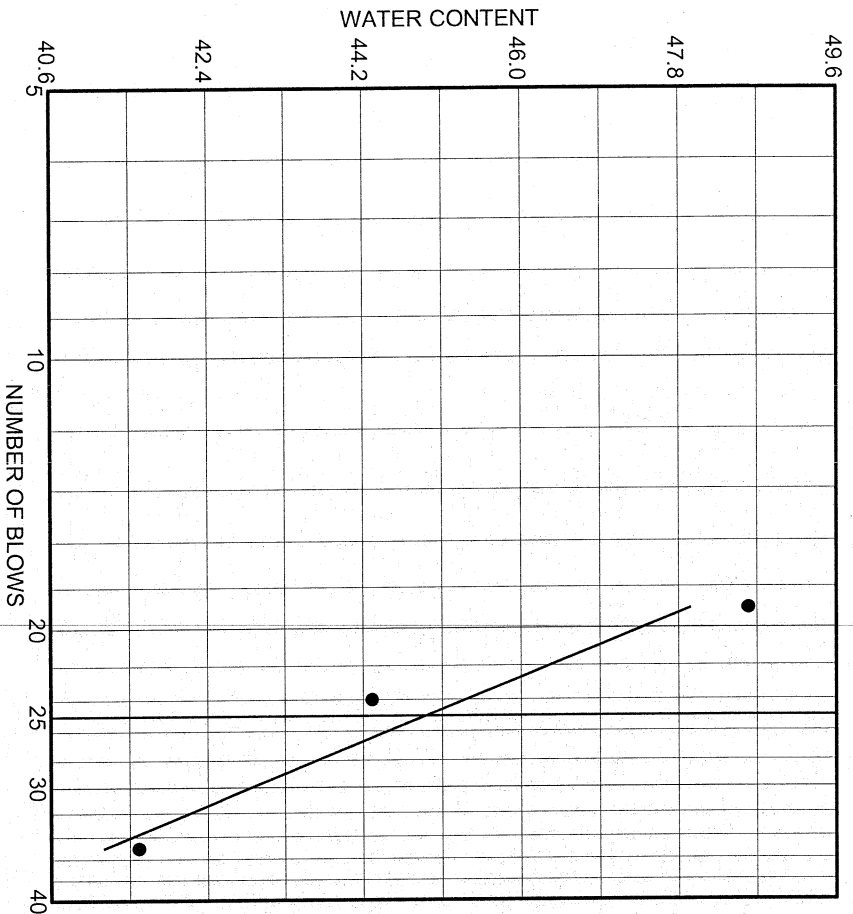
% COBBLES	0.0	% GRAVEL	0.0	% SAND	21.0	% SILT	39.6	% CLAY	39.4
-----------	-----	----------	-----	--------	------	--------	------	--------	------

SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
	B-8	29.7-30.3 ft	12/10/09	CL	Lean clay with sand		45	20

Client Stantec
 Project Clifty Creek

Project No. GTX-1516 Lab no. **Geo Testing Express Inc.**

LIQUID AND PLASTIC LIMITS TEST REPORT



SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
	B-8	29.7-30.3 ft	12/10/09	CL	Lean clay with sand		45	25

Client Stantec
Project Clifty Creek

Project No. GTX-1516

Lab no.

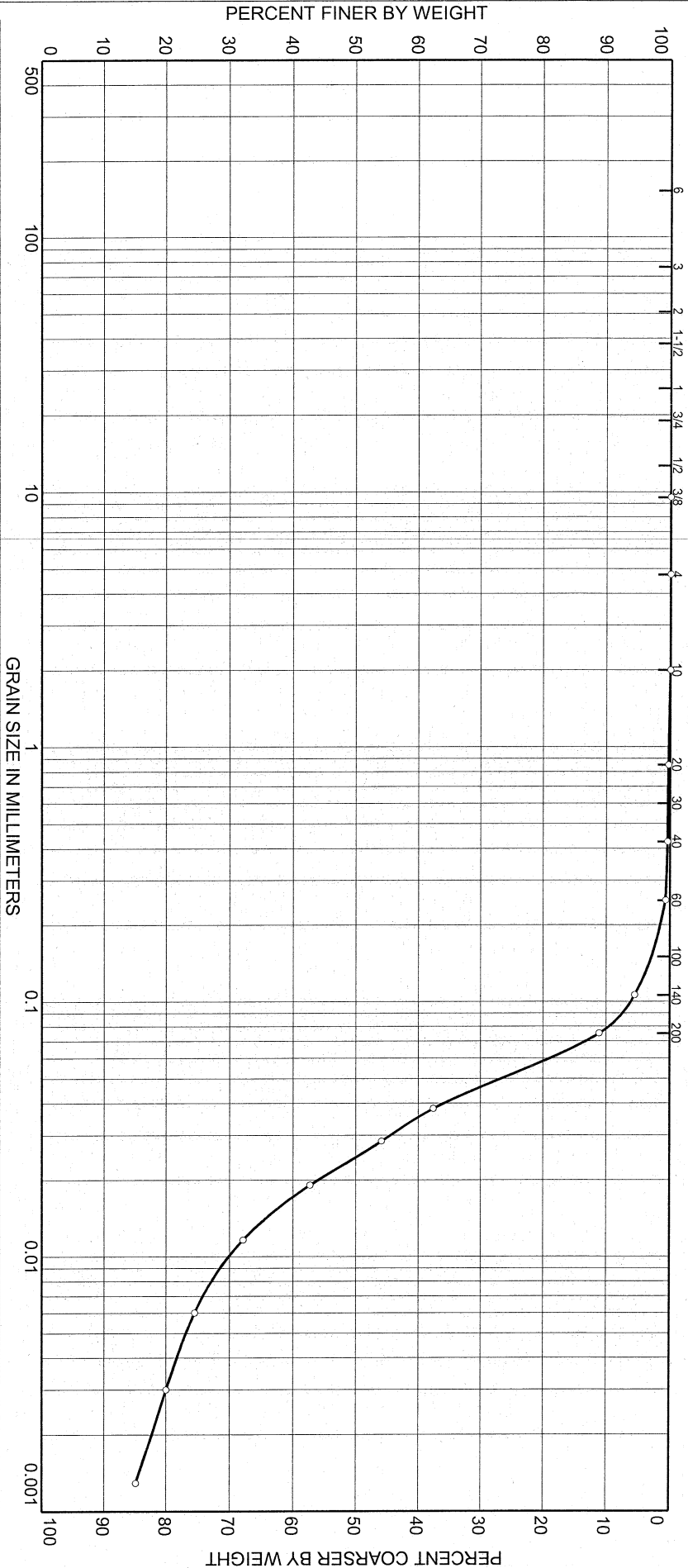
Geo Testing
Express Inc.

Particle Size Distribution Report ASTM D422

U.S. SIEVE OPENING IN INCHES

U.S. STANDARD SIEVE NUMBERS

HYDROMETER



% COBBLES	0.0	% GRAVEL	0.0	% SAND	11.1	% SILT	65.8	% CLAY	23.1
-----------	-----	----------	-----	--------	------	--------	------	--------	------

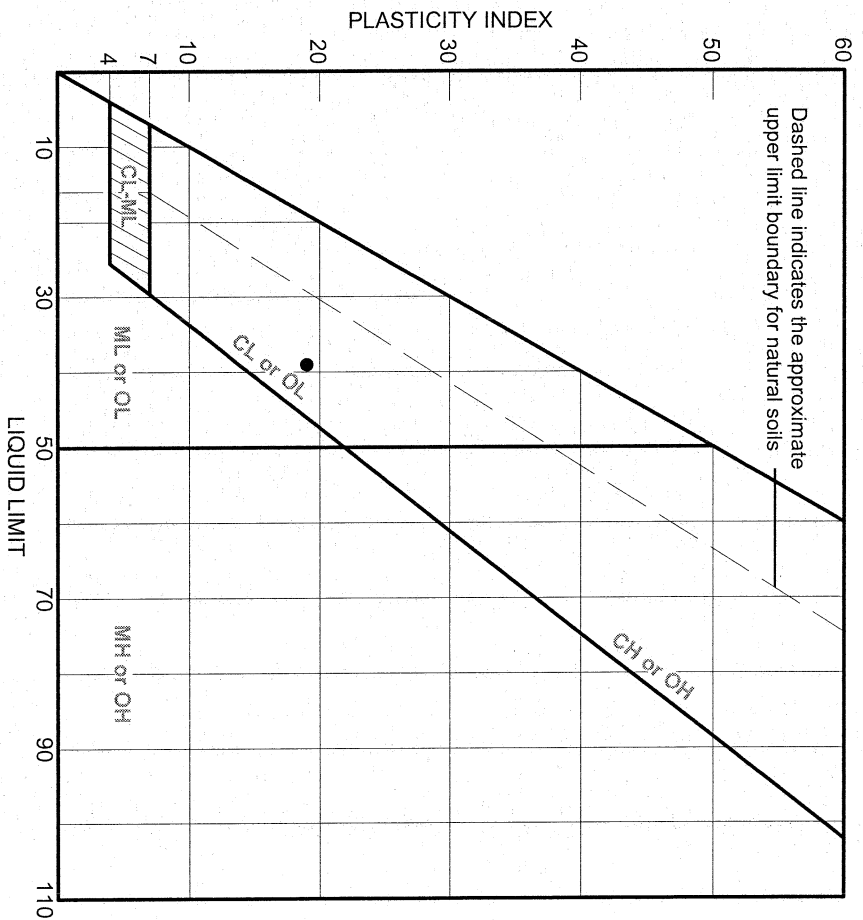
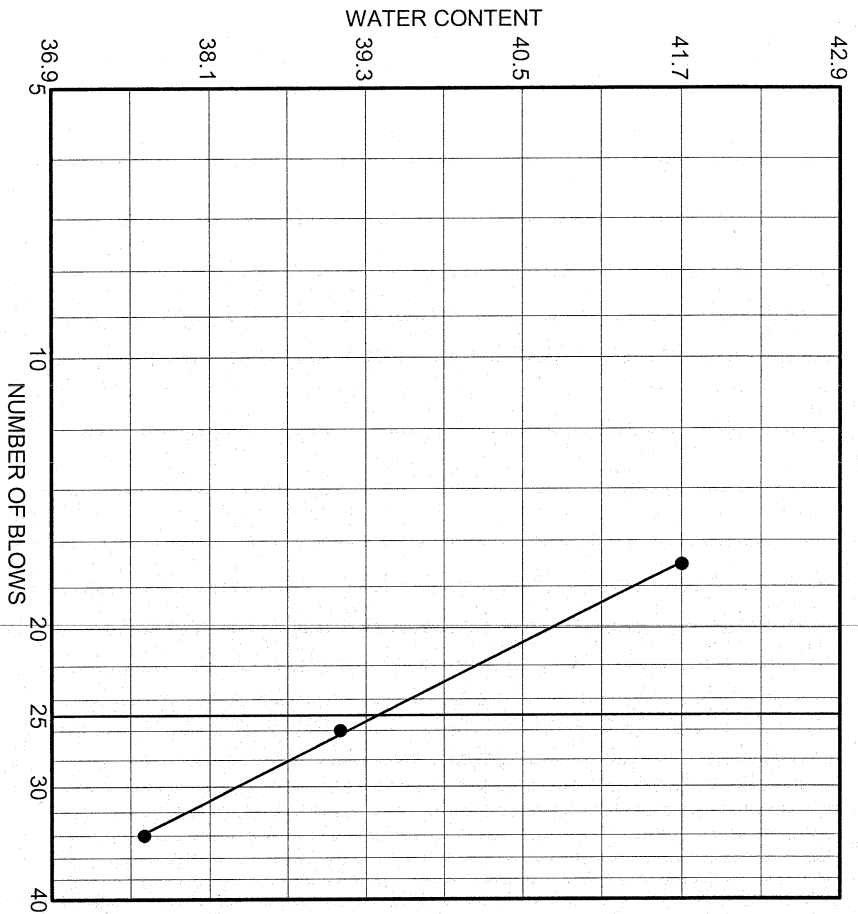
SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
	B-9	20.2-20.8 ft	12/10/09	CL	Lean clay		39	20

Client Stattec
Project Clifty Creek

Project No. GTX-1516
Lab no.

**Geo Testing
Express Inc.**

LIQUID AND PLASTIC LIMITS TEST REPORT



SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
	B-9	20.2-20.8 ft	12/10/09	CL	Lean clay		39	19

Client Stantec
 Project Clifty Creek
 Project No. GTX-1516 Lab no.

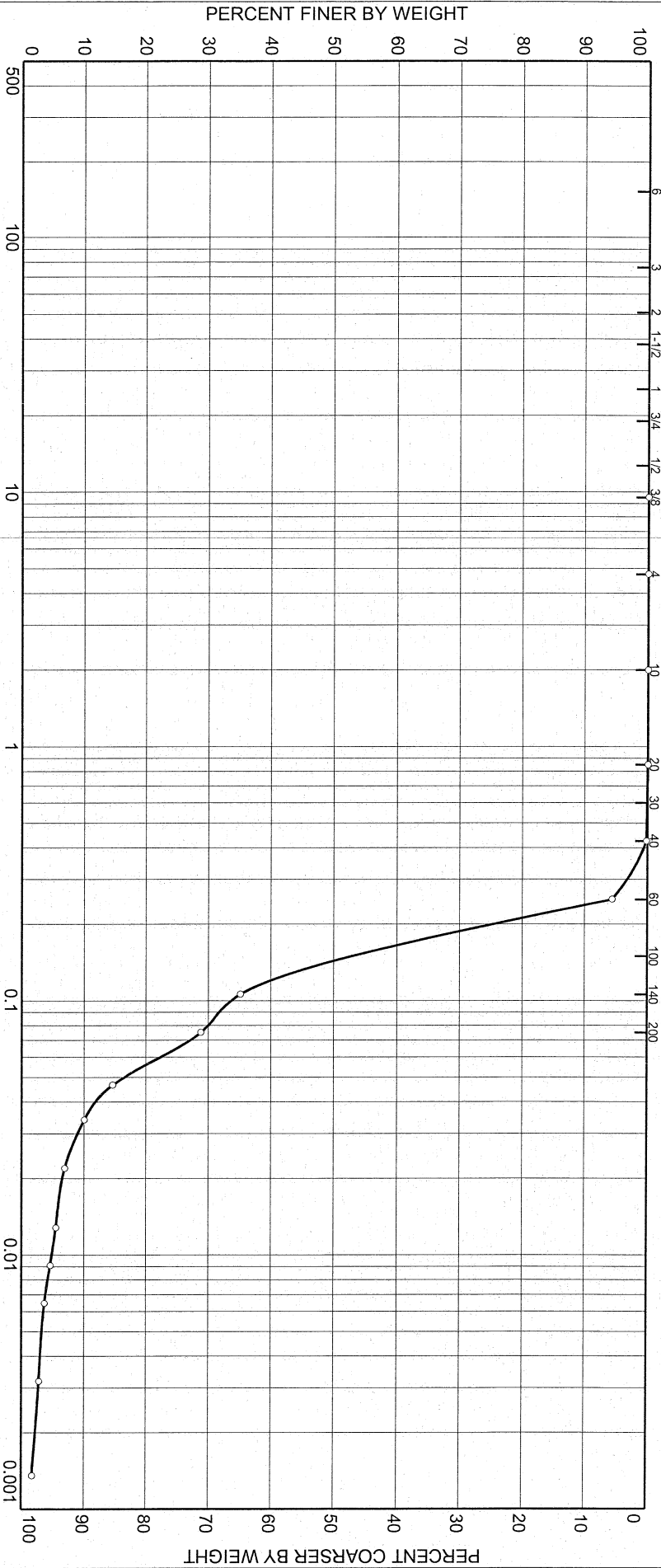
Geo Testing
Express Inc.

Particle Size Distribution Report ASTM D422

U.S. SIEVE OPENING IN INCHES

U.S. STANDARD SIEVE NUMBERS

HYDROMETER



% COBBLES	0.0	% GRAVEL	0.0
% SAND	71.2	% SILT	25.5
% CLAY	3.3		

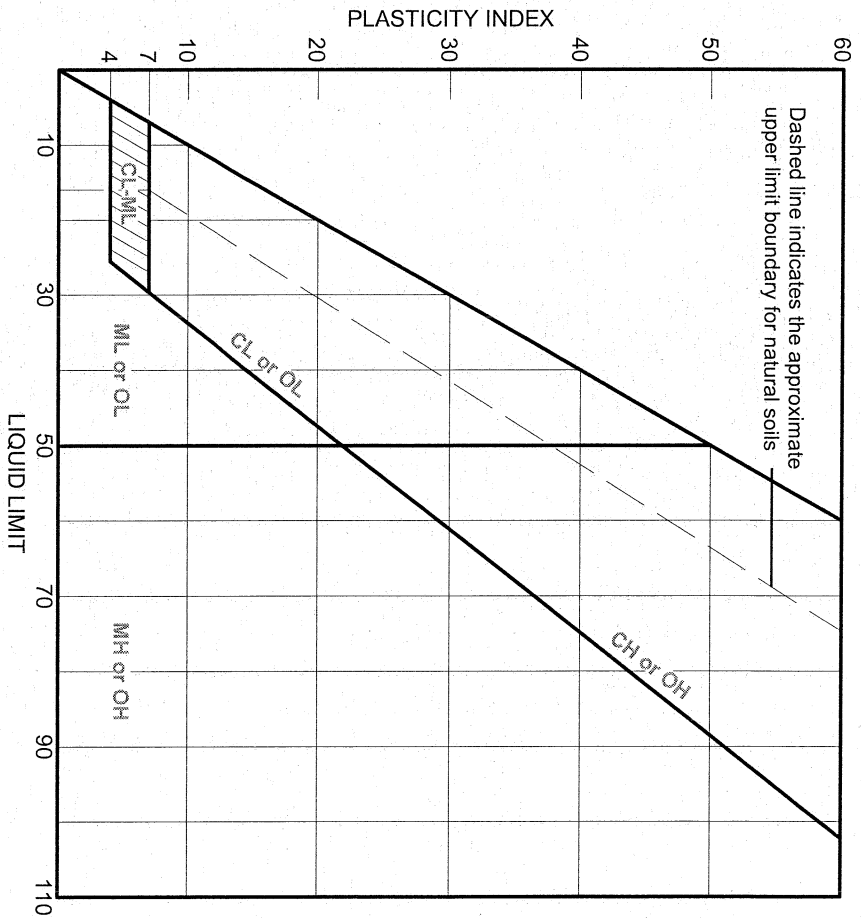
SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
	B-10	14.2-14.8 ft	12/10/09	SM	Silty sand			

Client Stantec
Project Clifty Creek

Project No. GTX-1516 Lab no.

Geo Testing Express Inc.

LIQUID AND PLASTIC LIMITS TEST REPORT



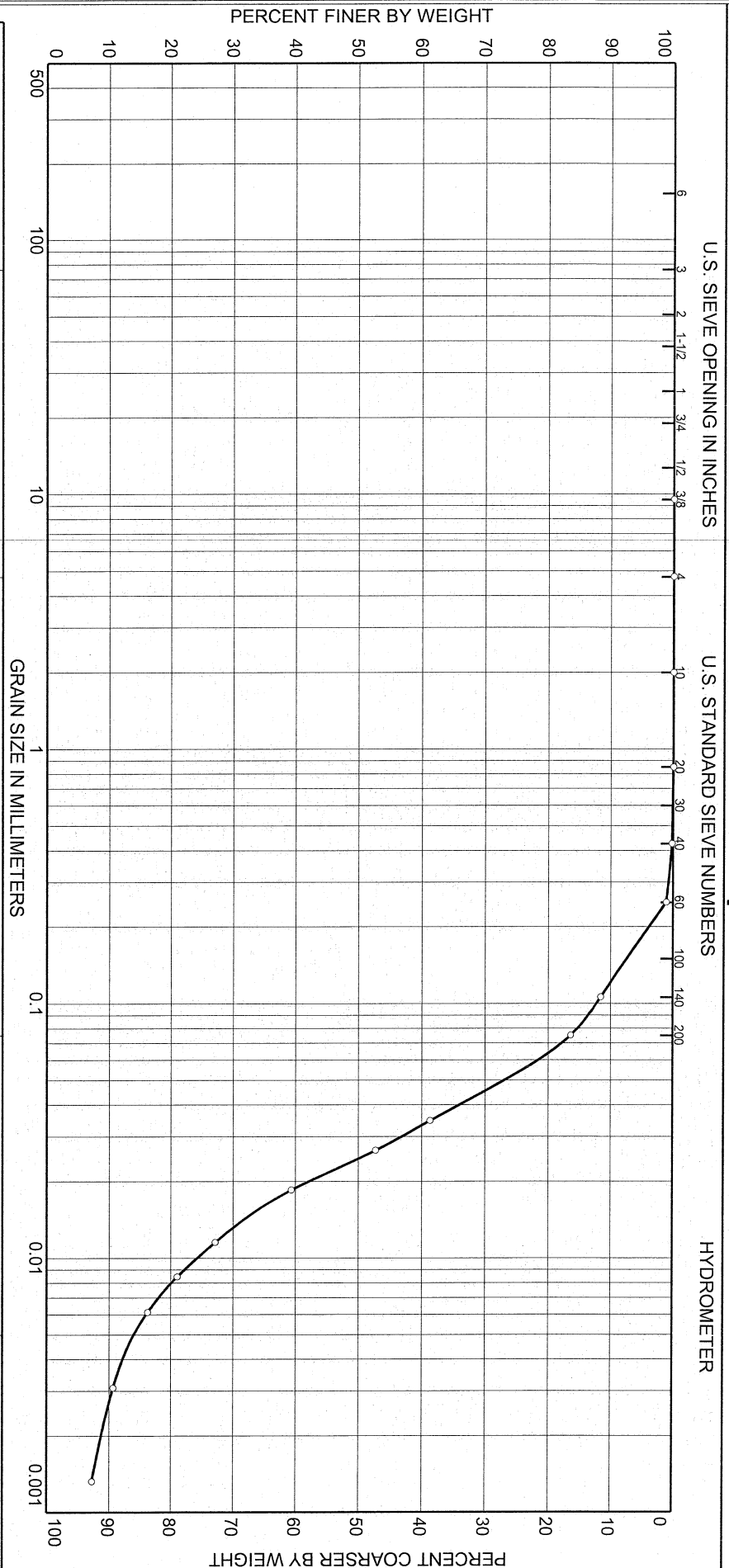
SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	NP
	B-10	14.2-14.8 ft	12/10/09	SM	Silty sand		NV	NP

Client Stattec
 Project Clifty Creek

Project No. GTX-1516 Lab no. _____

**Geo Testing
Express Inc.**

Particle Size Distribution Report ASTM D422

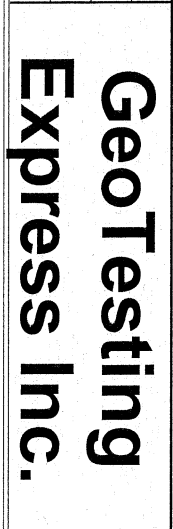


% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	16.4	69.7	13.9

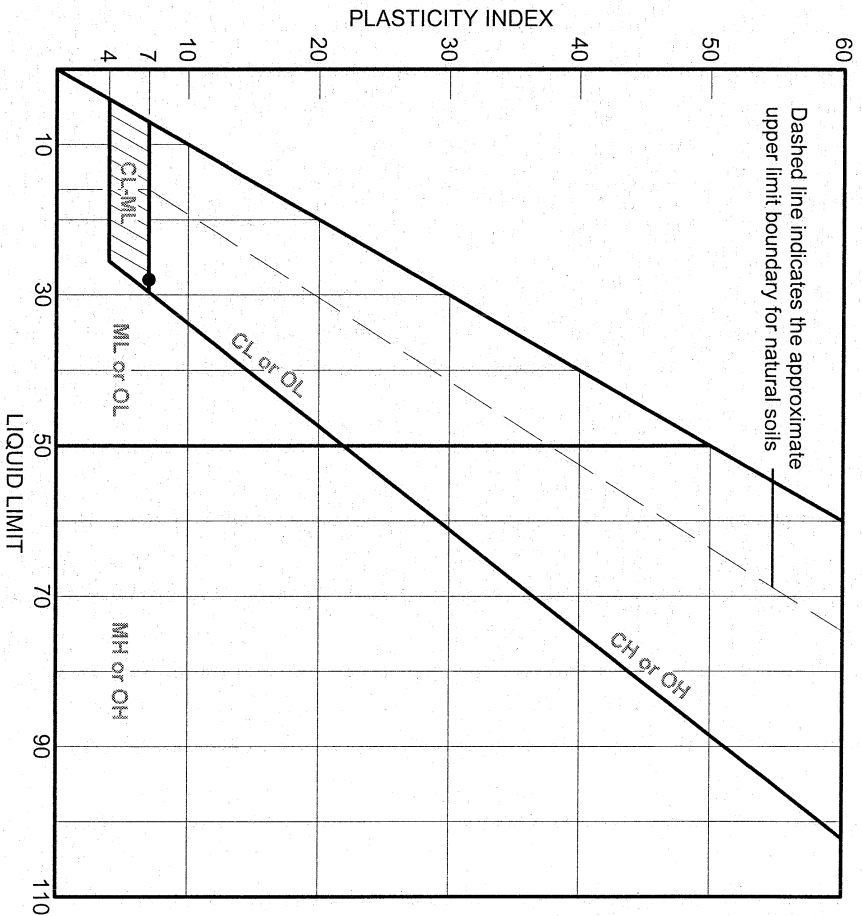
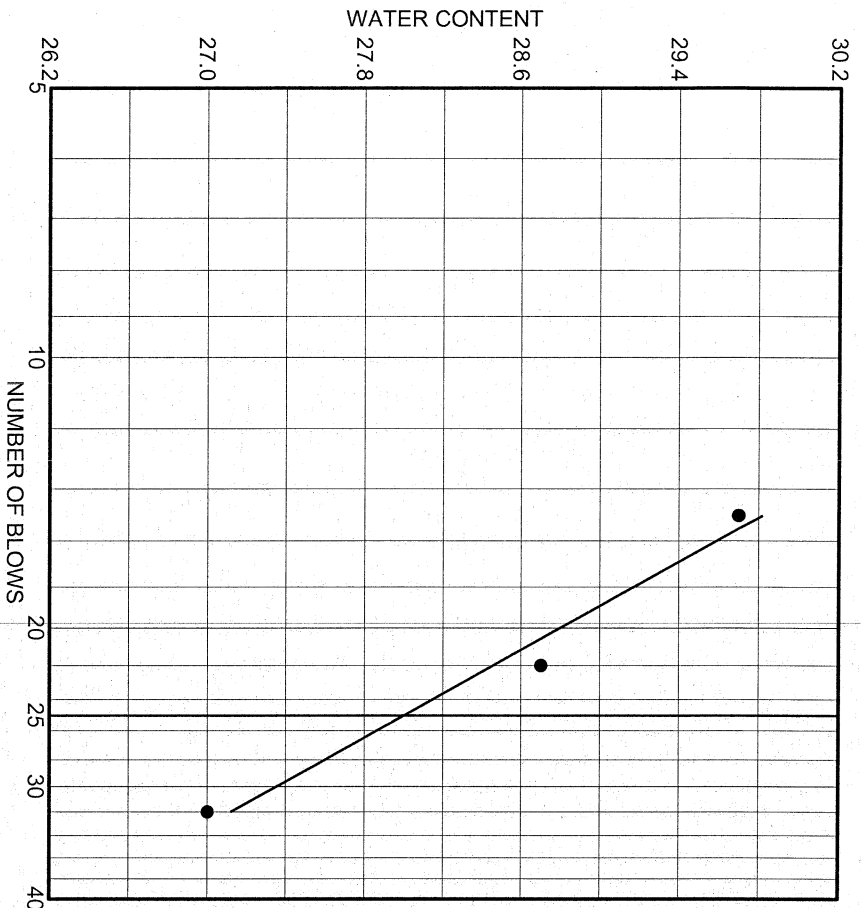
SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
	B-10	16.2-16.8 ft	12/10/09	CL-ML	Silty clay with sand		28	21

Client Stantec
Project Clifty Creek

Project No. GTX-1516 Lab no.



LIQUID AND PLASTIC LIMITS TEST REPORT



SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
	B-10	16.2-16.8 ft	12/10/09	CL-ML	Silty clay with sand		28	7

Client Stattec

Project Clifty Creek

Project No. GTX-1516

Lab no.

**Geo Testing
Express Inc.**

LANDFILL RUNOFF COLLECTION POND:
2015 GEOTECHNICAL EXPLORATION



Summary of Soil Tests

Project Name CCR Rule - AEP Clifty Creek Project Number 17553022
 Source B-12, 10.0'-11.5' Lab ID 3
 Sample Type SPT Date Received 7-21-15
 Date Reported 8-3-15

Test Results

Natural Moisture Content
 Test Method: ASTM D 2216
 Moisture Content (%): 23.1

Atterberg Limits
 Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: 43
 Plastic Limit: 21
 Plasticity Index: 22
 Activity Index: 1.05

Particle Size Analysis
 Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		% Passing
Sieve Size	(mm)	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 4	4.75	100.0
No. 10	2	74.7
No. 40	0.425	74.1
No. 200	0.075	71.7
	0.02	54.4
	0.005	30.3
	0.002	21.1
estimated	0.001	17.0

Moisture-Density Relationship
 Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	25.3
Coarse Sand	25.3	0.6
Medium Sand	0.6	---
Fine Sand	2.4	2.4
Silt	41.4	50.6
Clay	30.3	21.1

California Bearing Ratio
 Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity
 Test Method: ASTM D 854
 Prepared: Dry
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.70

Classification
 Unified Group Symbol: CL
 Group Name: Lean clay with sand
 AASHTO Classification: A-7-6 (15)

Comments: _____

Reviewed By RJ

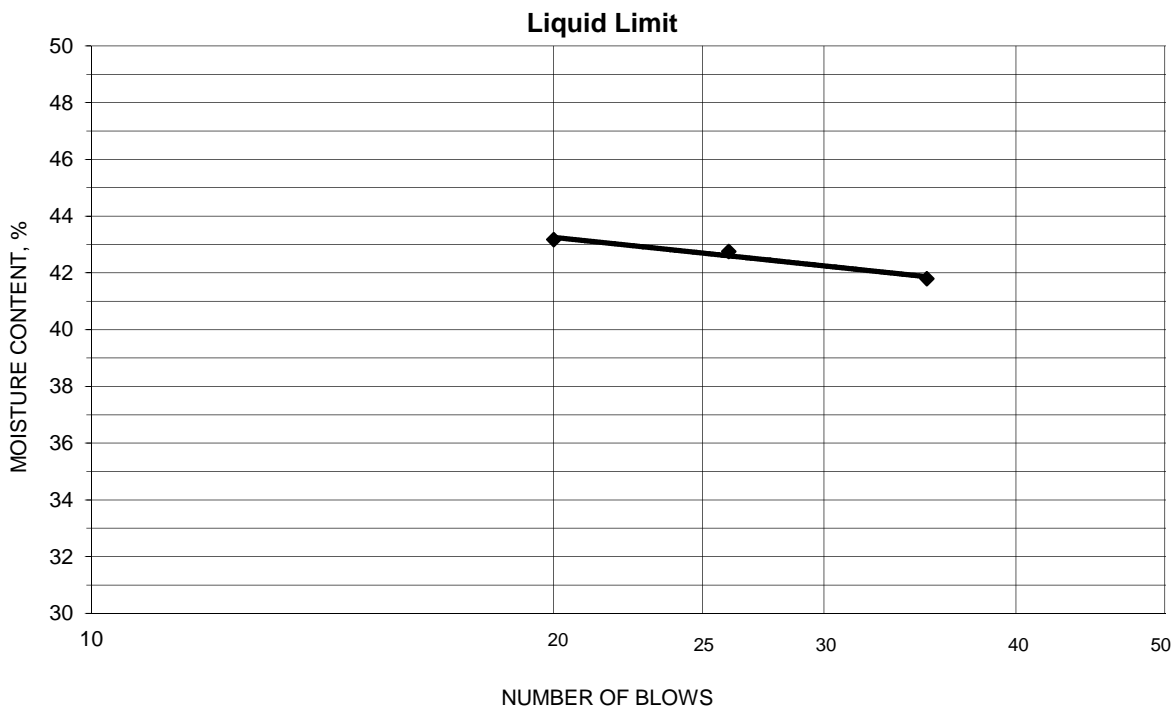


ATTERBERG LIMITS

Project CCR Rule - AEP Clifty Creek
 Source B-12, 10.0'-11.5'
 Tested By kws Test Method ASTM D 4318 Method A
 Test Date 07-27-2015 Prepared Dry

Project No. 175553022
 Lab ID 3
 % + No. 40 26
 Date Received 07-21-2015

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
19.52	17.10	11.31	35	41.8	43
18.33	16.09	10.85	26	42.7	
19.57	17.04	11.18	20	43.2	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
18.01	16.88	11.47	20.9	21	22
17.57	16.44	11.11	21.2		

Remarks: _____

Reviewed By RJ



Summary of Soil Tests

Project Name CCR Rule - AEP Clifty Creek Project Number 17553022
 Source B-12, 30.0'-31.5' Lab ID 7
 Sample Type SPT Date Received 7-21-15
 Date Reported 8-3-15

Test Results

Natural Moisture Content
 Test Method: ASTM D 2216
 Moisture Content (%): 19.0

Atterberg Limits
 Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: 31
 Plastic Limit: 18
 Plasticity Index: 13
 Activity Index: 0.87

Particle Size Analysis
 Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	
	N/A	Passing
	N/A	
	N/A	
	N/A	
	N/A	
3/4"	19	100.0
3/8"	9.5	99.8
No. 4	4.75	89.2
No. 10	2	77.8
No. 40	0.425	77.3
No. 200	0.075	71.4
	0.02	42.9
	0.005	21.6
	0.002	15.2
estimated	0.001	12.0

Moisture-Density Relationship
 Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	10.8	22.2
Coarse Sand	11.4	0.5
Medium Sand	0.5	---
Fine Sand	5.9	5.9
Silt	49.8	56.2
Clay	21.6	15.2

California Bearing Ratio
 Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity
 Test Method: ASTM D 854
 Prepared: Dry
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.68

Classification
 Unified Group Symbol: CL
 Group Name: Lean clay with sand
 AASHTO Classification: A-6 (7)

Comments: _____

Reviewed By RJ

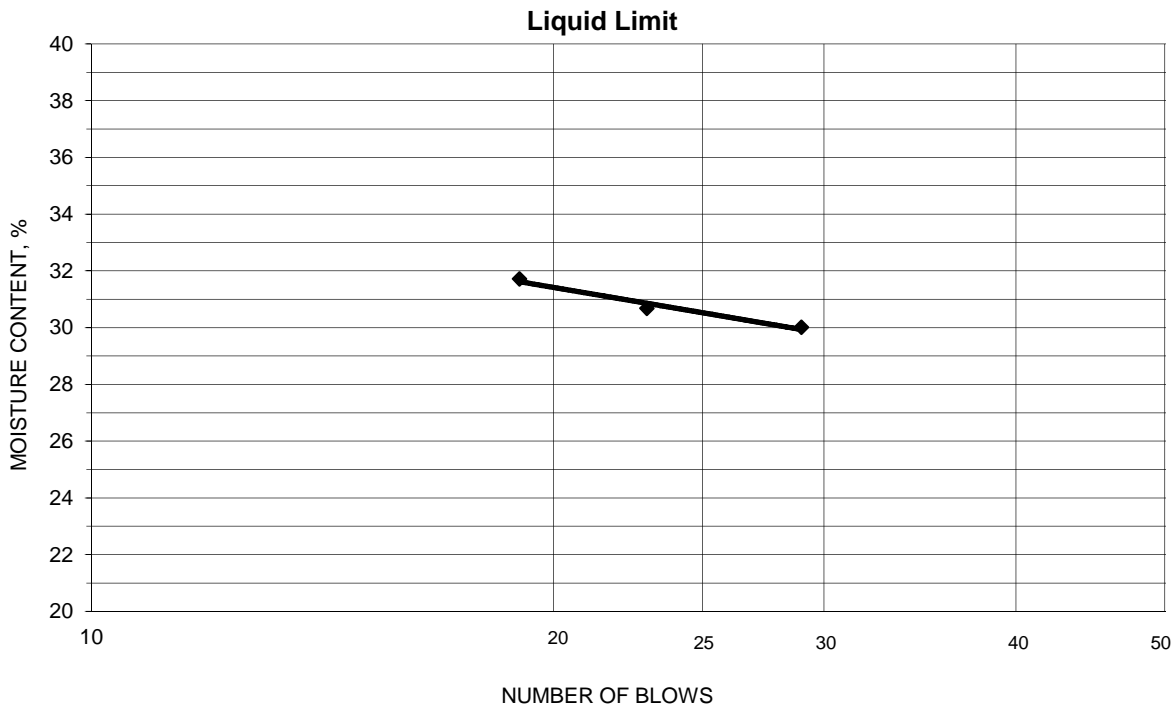


ATTERBERG LIMITS

Project CCR Rule - AEP Clifty Creek
 Source B-12, 30.0'-31.5'
 Tested By KG Test Method ASTM D 4318 Method A
 Test Date 07-31-2015 Prepared Dry

Project No. 175553022
 Lab ID 7
 % + No. 40 23
 Date Received 07-21-2015

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
19.80	17.75	10.92	29	30.0	31
19.72	17.68	11.03	23	30.7	
20.84	18.48	11.04	19	31.7	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
19.95	18.61	11.11	17.9	18	13
20.10	18.75	11.18	17.8		

Remarks: _____

Reviewed By RJ



Summary of Soil Tests

Project Name CCR Rule - AEP Clifty Creek Project Number 17553022
 Source B-12, 45.0'-46.5' Lab ID 10
 Sample Type SPT Date Received 7-21-15
 Date Reported 8-3-15

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
 Moisture Content (%): 18.7

Atterberg Limits

Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: 26
 Plastic Limit: 19
 Plasticity Index: 7
 Activity Index: 0.64

Particle Size Analysis

Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		% Passing
Sieve Size	(mm)	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 4	4.75	100.0
No. 10	2	99.3
No. 40	0.425	99.2
No. 200	0.075	82.2
	0.02	34.0
	0.005	14.0
	0.002	10.7
estimated	0.001	10.0

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.7
Coarse Sand	0.7	0.1
Medium Sand	0.1	---
Fine Sand	17.0	17.0
Silt	68.2	71.5
Clay	14.0	10.7

Moisture-Density Relationship

Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
 Prepared: Dry
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.72

Classification

Unified Group Symbol: CL-ML
 Group Name: Silty clay with sand
 AASHTO Classification: A-4 (4)

Comments: _____

Reviewed By RJ



Particle-Size Analysis of Soils
ASTM D 422

Project Name CCR Rule - AEP Clifty Creek
Source B-12, 45.0'-46.5'

Project Number 175553022
Lab ID 10

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method ASTM D 422
Prepared using ASTM D 421

Particle Shape Angular
Particle Hardness: Hard and Durable

Tested By JS
Test Date 07-24-2015
Date Received 07-21-2015

Sieve Size	% Passing
No. 4	100.0
No. 10	99.3

Maximum Particle size: No. 4 Sieve

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

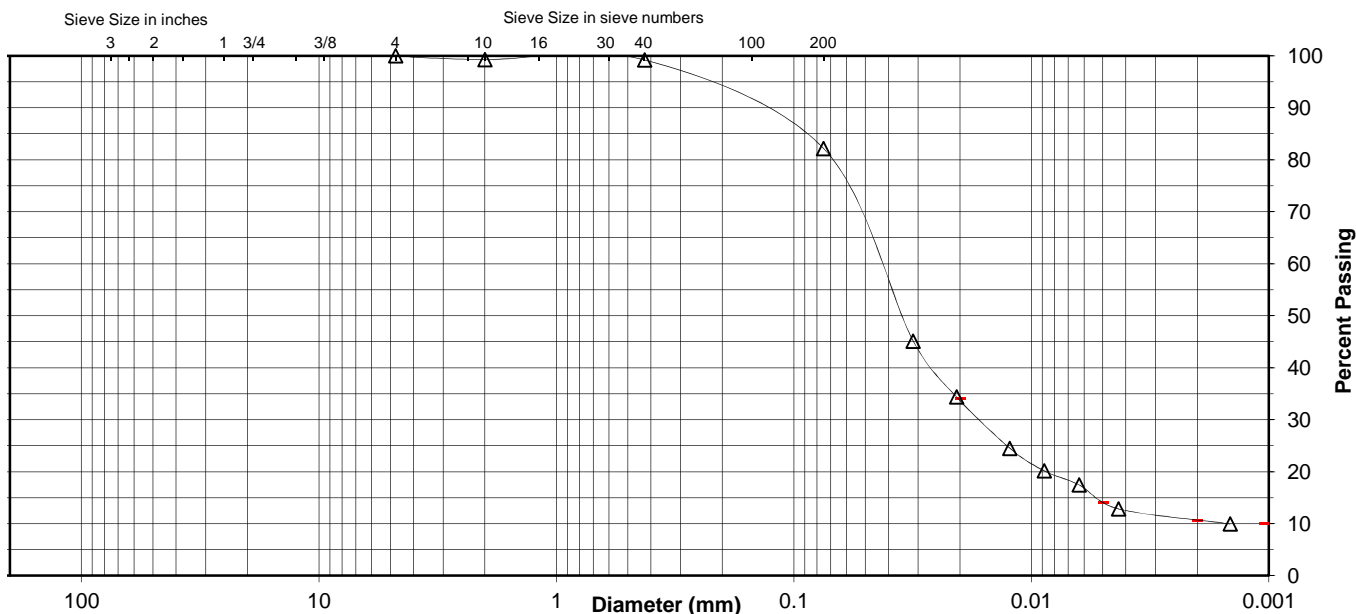
Specific Gravity 2.72

Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	99.2
No. 200	82.2
0.02 mm	34.0
0.005 mm	14.0
0.002 mm	10.7
0.001 mm	10.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.7	0.1	17.0	68.2	14.0
AASHTO	Gravel		Coarse Sand	Fine Sand	Silt	Clay	
	0.7		0.1	17.0	71.5	10.7	



Comments _____

Reviewed By RJ

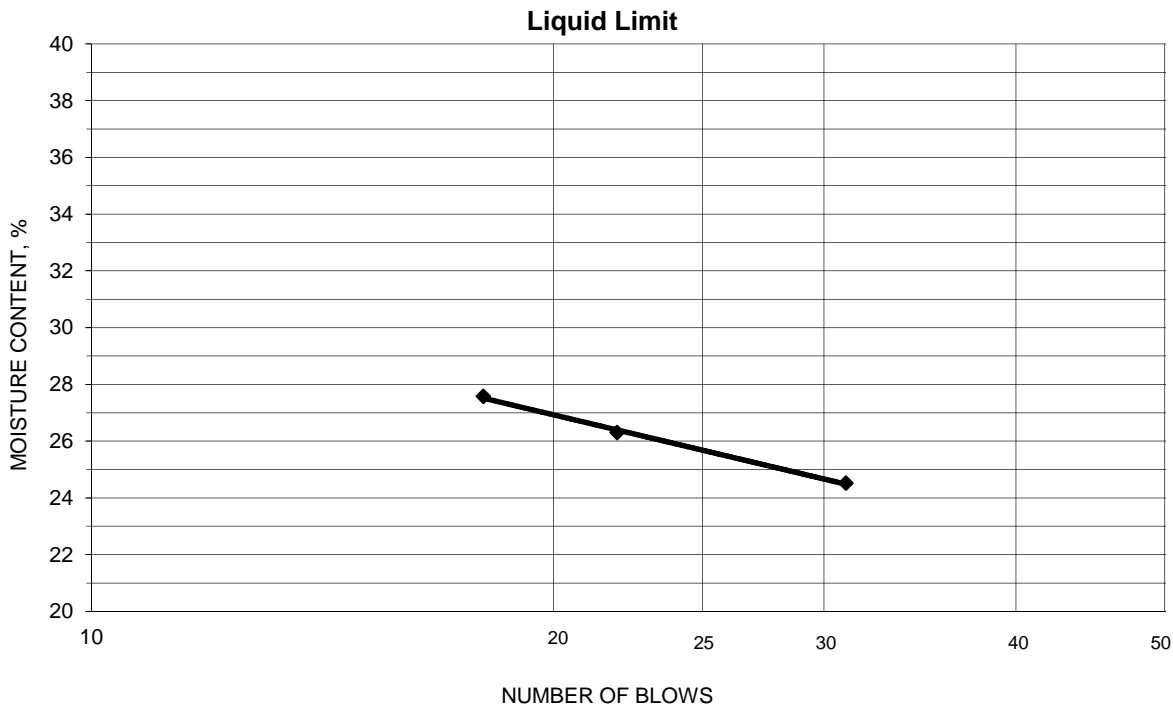


ATTERBERG LIMITS

Project CCR Rule - AEP Clifty Creek
 Source B-12, 45.0'-46.5'
 Tested By TA Test Method ASTM D 4318 Method A
 Test Date 07-30-2015 Prepared Dry

Project No. 175553022
 Lab ID 10
 % + No. 40 1
 Date Received 07-21-2015

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
19.13	17.46	11.11	22	26.3	26
21.65	19.32	10.87	18	27.6	
22.47	20.32	11.55	31	24.5	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
17.45	16.47	11.42	19.4	19	7
17.70	16.74	11.60	18.7		

Remarks: _____

Reviewed By RJ



Summary of Soil Tests

Project Name CCR Rule - AEP Clifty Creek Project Number 17553022
 Source B-12, 50.0'-51.5' Lab ID 11
 Sample Type SPT Date Received 7-21-15
 Date Reported 8-3-15

Test Results

Natural Moisture Content
 Test Method: ASTM D 2216
 Moisture Content (%): 21.9

Atterberg Limits
 Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: NP
 Plastic Limit: NP
 Plasticity Index: NP
 Activity Index: N/A

Particle Size Analysis
 Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	
	N/A	Passing
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 10	2	100.0
No. 40	0.425	99.8
No. 200	0.075	81.3
	0.02	29.1
	0.005	6.3
	0.002	3.2
estimated	0.001	1.0

Moisture-Density Relationship
 Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.0
Coarse Sand	0.0	0.2
Medium Sand	0.2	---
Fine Sand	18.5	18.5
Silt	75.0	78.1
Clay	6.3	3.2

California Bearing Ratio
 Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity
 Test Method: ASTM D 854
 Prepared: Dry
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.68

Classification
 Unified Group Symbol: ML
 Group Name: Silt with sand
 AASHTO Classification: A-4 (0)

Comments: _____

Reviewed By RJ

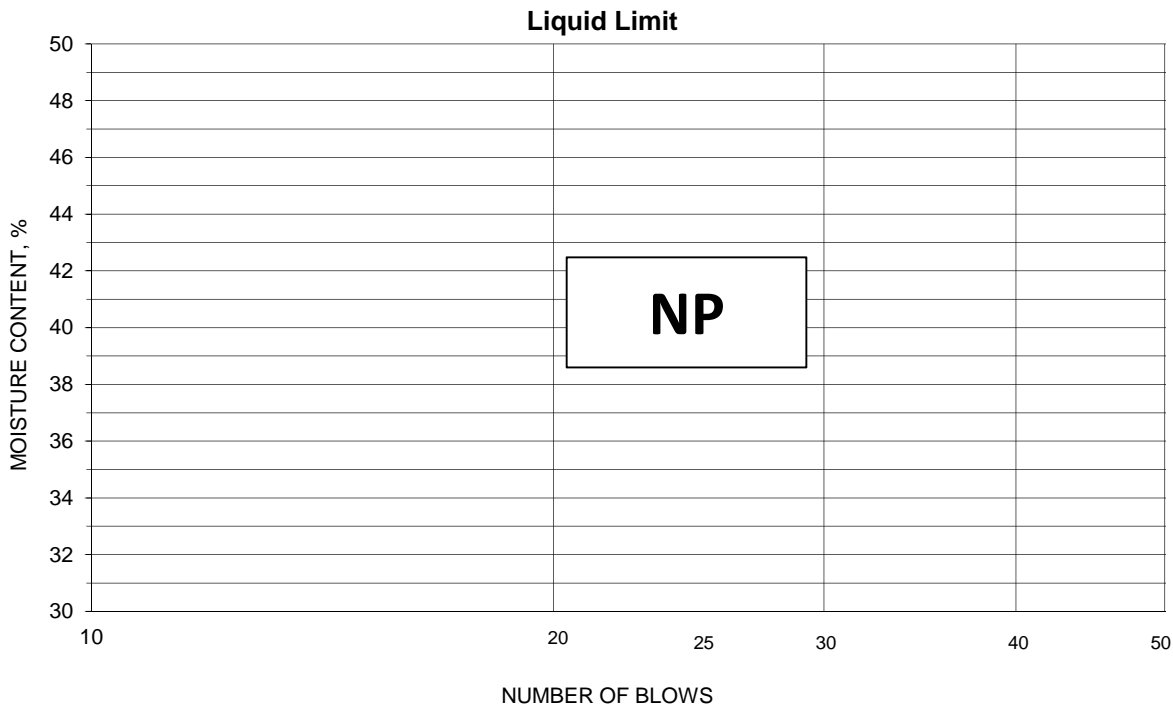


ATTERBERG LIMITS

Project CCR Rule - AEP Clifty Creek
 Source B-12, 50.0'-51.5'
 Tested By TA Test Method ASTM D 4318 Method A
 Test Date 07-30-2015 Prepared Dry

Project No. 175553022
 Lab ID 11
 % + No. 40 0
 Date Received 07-21-2015

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index

Remarks: _____

Reviewed By RJ



Summary of Soil Tests

Project Name CCR Rule - AEP Clifty Creek Project Number 17553022
 Source B-12, 60.0'-61.5' Lab ID 13
 Sample Type SPT Date Received 7-21-15
 Date Reported 8-3-15

Test Results

Natural Moisture Content
 Test Method: ASTM D 2216
 Moisture Content (%): 14.8

Atterberg Limits
 Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: NP
 Plastic Limit: NP
 Plasticity Index: NP
 Activity Index: N/A

Particle Size Analysis
 Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		% Passing
Sieve Size	(mm)	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 4	4.75	100.0
No. 10	2	98.5
No. 40	0.425	95.7
No. 200	0.075	36.1
	0.02	12.4
	0.005	5.1
	0.002	2.8
estimated	0.001	1.0

Moisture-Density Relationship
 Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	1.5
Coarse Sand	1.5	2.8
Medium Sand	2.8	---
Fine Sand	59.6	59.6
Silt	31.0	33.3
Clay	5.1	2.8

California Bearing Ratio
 Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity
 Test Method: ASTM D 854
 Prepared: Dry
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.75

Classification
 Unified Group Symbol: SM
 Group Name: Silty sand
 AASHTO Classification: A-4 (0)

Comments: _____

Reviewed By RJ



Particle-Size Analysis of Soils
ASTM D 422

Project Name CCR Rule - AEP Clifty Creek
Source B-12, 60.0'-61.5'

Project Number 175553022
Lab ID 13

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method ASTM D 422
Prepared using ASTM D 421

Particle Shape Angular
Particle Hardness: Hard and Durable

Tested By JS
Test Date 07-24-2015
Date Received 07-21-2015

Sieve Size	% Passing
No. 4	100.0
No. 10	98.5

Maximum Particle size: No. 4 Sieve

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

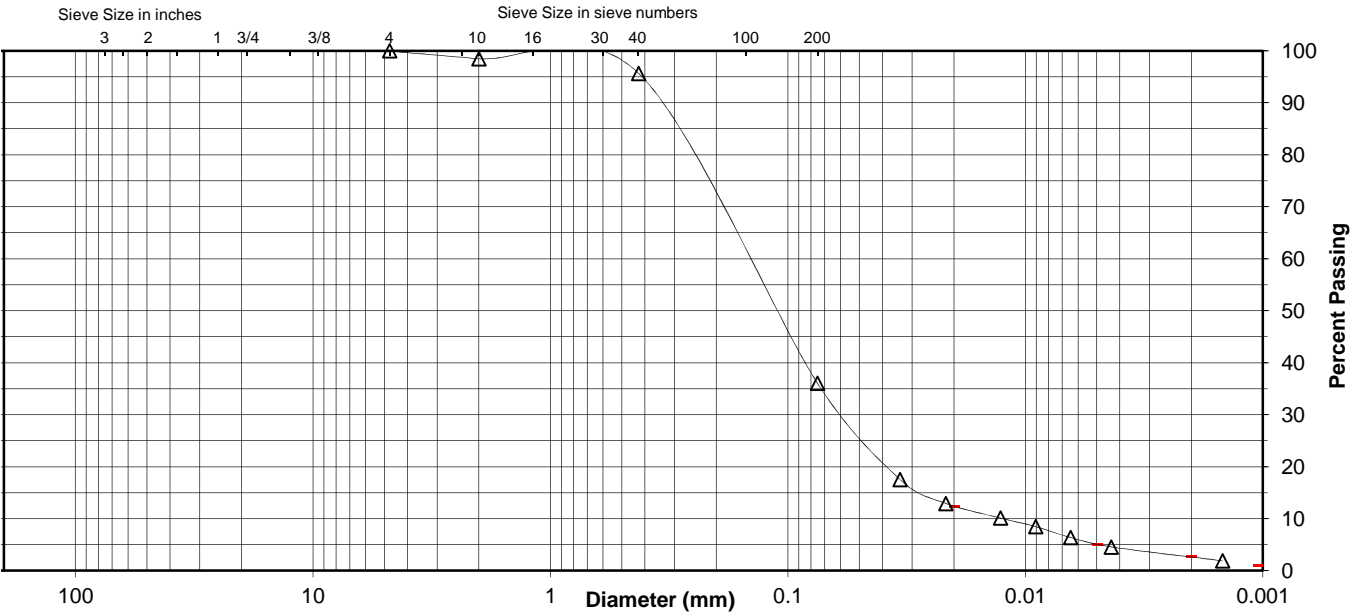
Specific Gravity 2.75

Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	95.7
No. 200	36.1
0.02 mm	12.4
0.005 mm	5.1
0.002 mm	2.8
0.001 mm	1.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	1.5	2.8	59.6	31.0	5.1
AASHTO	Gravel		Coarse Sand		Fine Sand	Silt	Clay
	1.5		2.8		59.6	33.3	2.8



Comments _____

Reviewed By RJ

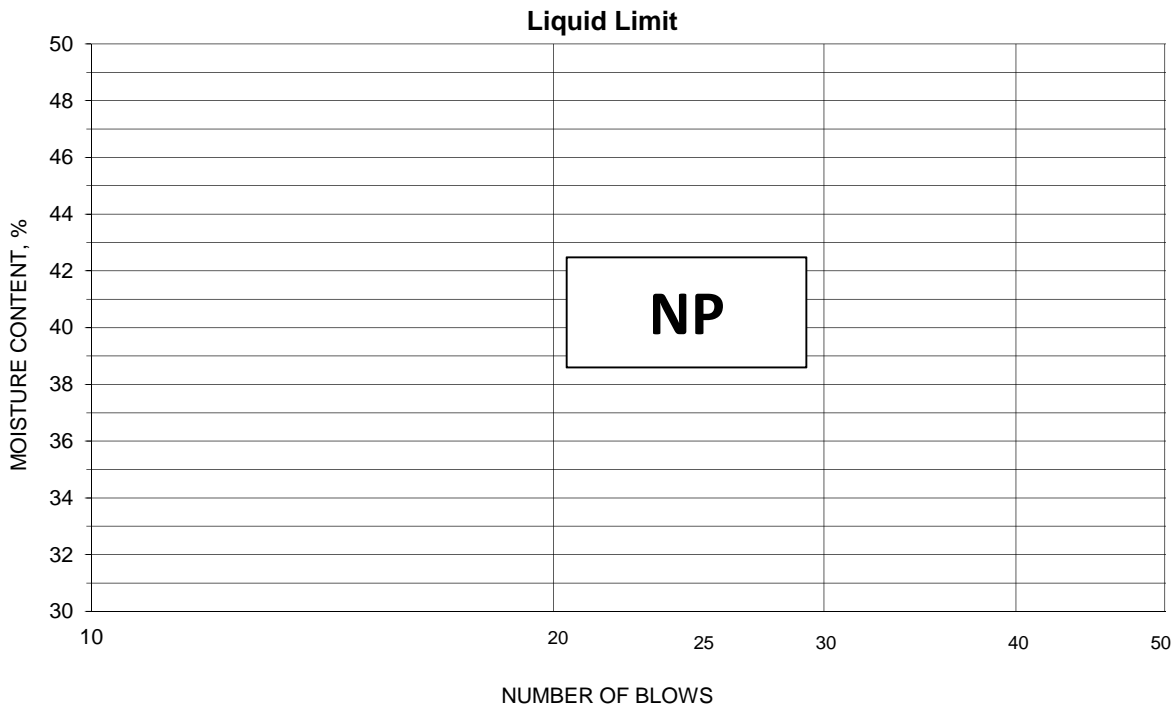


ATTERBERG LIMITS

Project CCR Rule - AEP Clifty Creek
 Source B-12, 60.0'-61.5'
 Tested By DB Test Method ASTM D 4318 Method A
 Test Date 07-24-2015 Prepared Dry

Project No. 175553022
 Lab ID 13
 % + No. 40 4
 Date Received 07-21-2015

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index

Remarks: _____

Reviewed By RJ



Summary of Soil Tests

Project Name CCR Rule - AEP Clifty Creek Project Number 17553022
 Source B-12, 70.0'-71.5' Lab ID 15
 Sample Type SPT Date Received 7-21-15
 Date Reported 8-3-15

Test Results

Natural Moisture Content
 Test Method: ASTM D 2216
 Moisture Content (%): 21.6

Atterberg Limits
 Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: NP
 Plastic Limit: NP
 Plasticity Index: NP
 Activity Index: N/A

Particle Size Analysis
 Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		% Passing
Sieve Size	(mm)	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 10	2	100.0
No. 40	0.425	98.6
No. 200	0.075	56.5
	0.02	21.7
	0.005	3.7
	0.002	1.5
estimated	0.001	1.0

Moisture-Density Relationship
 Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.0
Coarse Sand	0.0	1.4
Medium Sand	1.4	---
Fine Sand	42.1	42.1
Silt	52.8	55.0
Clay	3.7	1.5

California Bearing Ratio
 Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity
 Test Method: ASTM D 854
 Prepared: Dry
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.71

Classification
 Unified Group Symbol: ML
 Group Name: Sandy silt
 AASHTO Classification: A-4 (0)

Comments: _____

Reviewed By RJ



Particle-Size Analysis of Soils

ASTM D 422

Project Name CCR Rule - AEP Clifty Creek
 Source B-12, 70.0'-71.5'

Project Number 175553022
 Lab ID 15

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method ASTM D 422
 Prepared using ASTM D 421

Particle Shape N/A
 Particle Hardness: N/A

Tested By JS
 Test Date 07-24-2015
 Date Received 07-21-2015

Sieve Size	% Passing
No. 10	100.0

Maximum Particle size: No. 10 Sieve

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

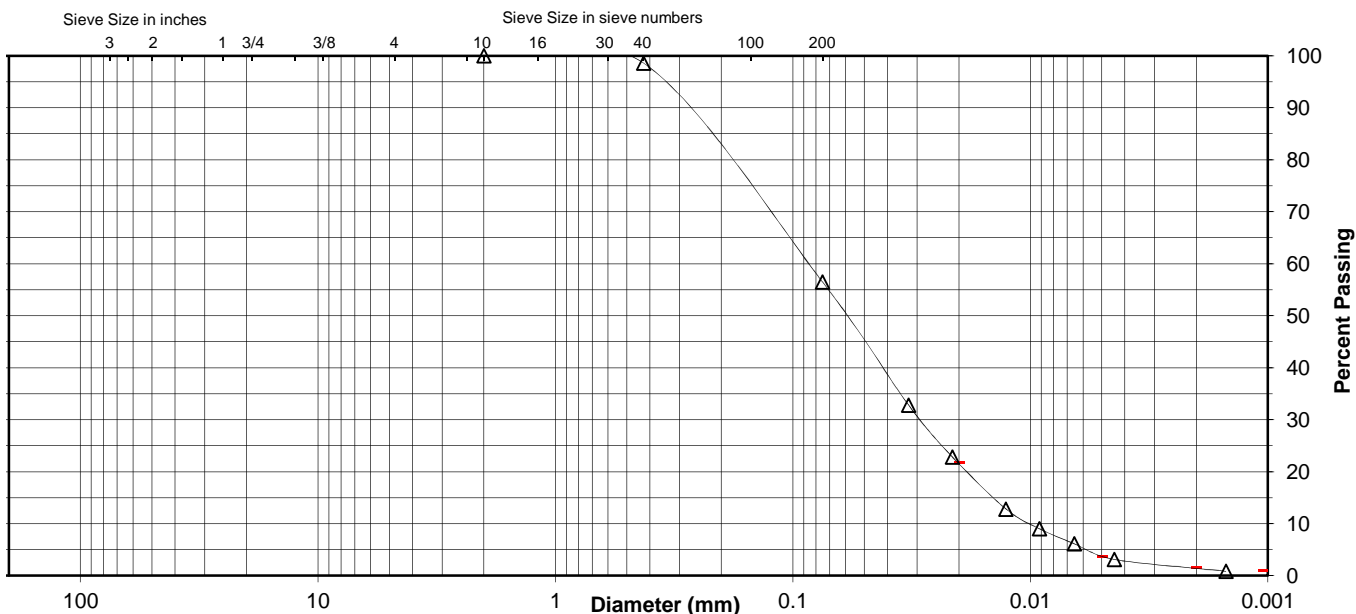
Specific Gravity 2.71

Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	98.6
No. 200	56.5
0.02 mm	21.7
0.005 mm	3.7
0.002 mm	1.5
0.001 mm	1.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay	
	0.0	0.0	0.0	1.4	42.1	52.8	3.7	
AASHTO	Gravel		Coarse Sand		Fine Sand		Silt	Clay
	0.0		1.4		42.1		55.0	1.5



Comments _____

Reviewed By RJ

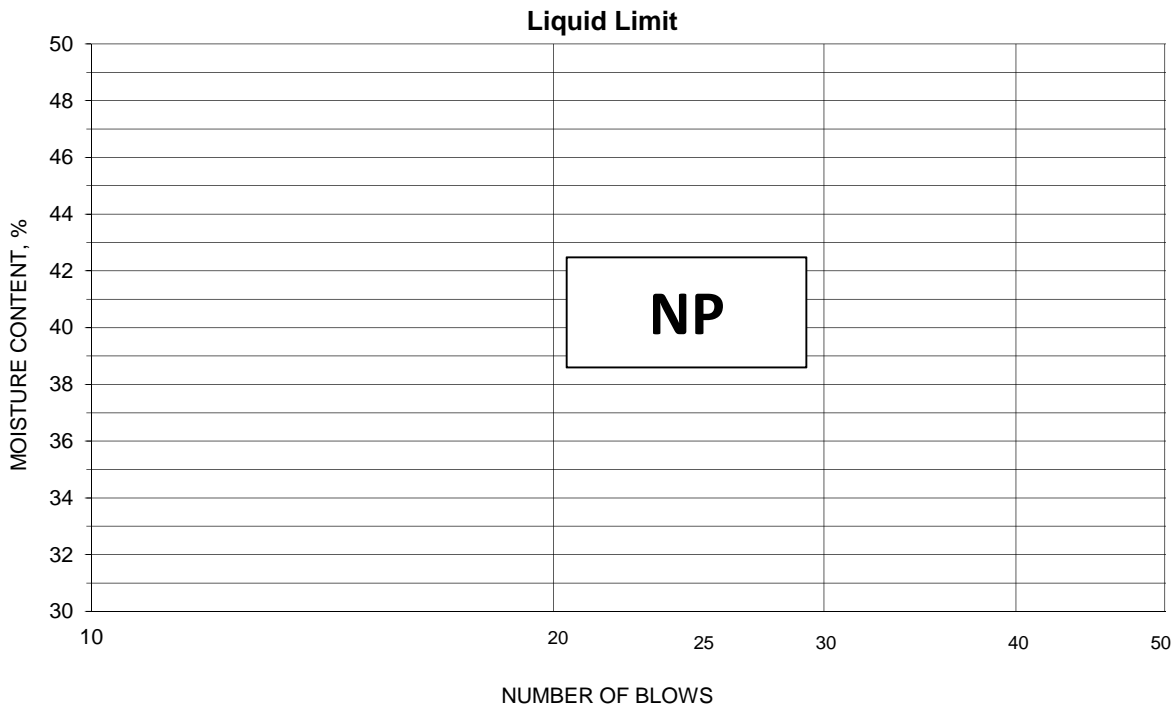


ATTERBERG LIMITS

Project CCR Rule - AEP Clifty Creek
 Source B-12, 70.0'-71.5'
 Tested By KDG Test Method ASTM D 4318 Method A
 Test Date 07-31-2015 Prepared Dry

Project No. 175553022
 Lab ID 15
 % + No. 40 1
 Date Received 07-21-2015

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index

Remarks: _____

Reviewed By RJ



Summary of Soil Tests

Project Name CCR Rule - AEP Clifty Creek Project Number 175553022
 Source B-12, 80.0'-81.5' Lab ID 17
 Sample Type SPT Date Received 7-21-15
 Date Reported 8-3-15

Test Results

Natural Moisture Content
 Test Method: ASTM D 2216
 Moisture Content (%): 25.7

Atterberg Limits
 Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: NP
 Plastic Limit: NP
 Plasticity Index: NP
 Activity Index: N/A

Particle Size Analysis
 Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	
	N/A	Passing
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 4	4.75	100.0
No. 10	2	98.9
No. 40	0.425	98.9
No. 200	0.075	90.2
	0.02	28.8
	0.005	5.6
	0.002	1.4
estimated	0.001	0.0

Moisture-Density Relationship
 Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	1.1
Coarse Sand	1.1	0.0
Medium Sand	0.0	---
Fine Sand	8.7	8.7
Silt	84.6	88.8
Clay	5.6	1.4

California Bearing Ratio
 Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity
 Test Method: ASTM D 854
 Prepared: Dry
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.73

Classification
 Unified Group Symbol: ML
 Group Name: Silt
 AASHTO Classification: A-4 (0)

Comments: _____

Reviewed By RJ



Particle-Size Analysis of Soils
ASTM D 422

Project Name CCR Rule - AEP Clifty Creek
Source B-12, 80.0'-81.5'

Project Number 175553022
Lab ID 17

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method ASTM D 422
Prepared using ASTM D 421

Particle Shape Angular
Particle Hardness: Hard and Durable

Tested By JS
Test Date 07-24-2015
Date Received 07-21-2015

Sieve Size	% Passing
No. 4	100.0
No. 10	98.9

Maximum Particle size: No. 4 Sieve

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

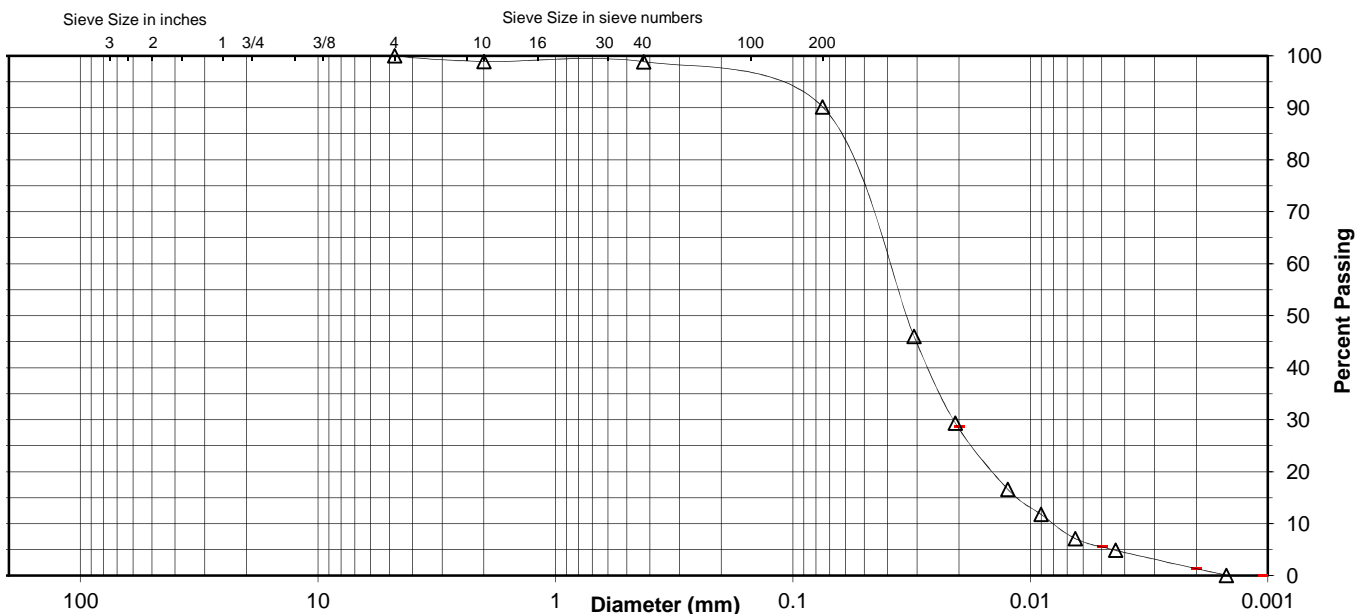
Specific Gravity 2.73

Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	98.9
No. 200	90.2
0.02 mm	28.8
0.005 mm	5.6
0.002 mm	1.4
0.001 mm	0.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	1.1	0.0	8.7	84.6	5.6
AASHTO	Gravel		Coarse Sand		Fine Sand	Silt	Clay
	1.1		0.0		8.7	88.8	1.4



Comments _____

Reviewed By RJ

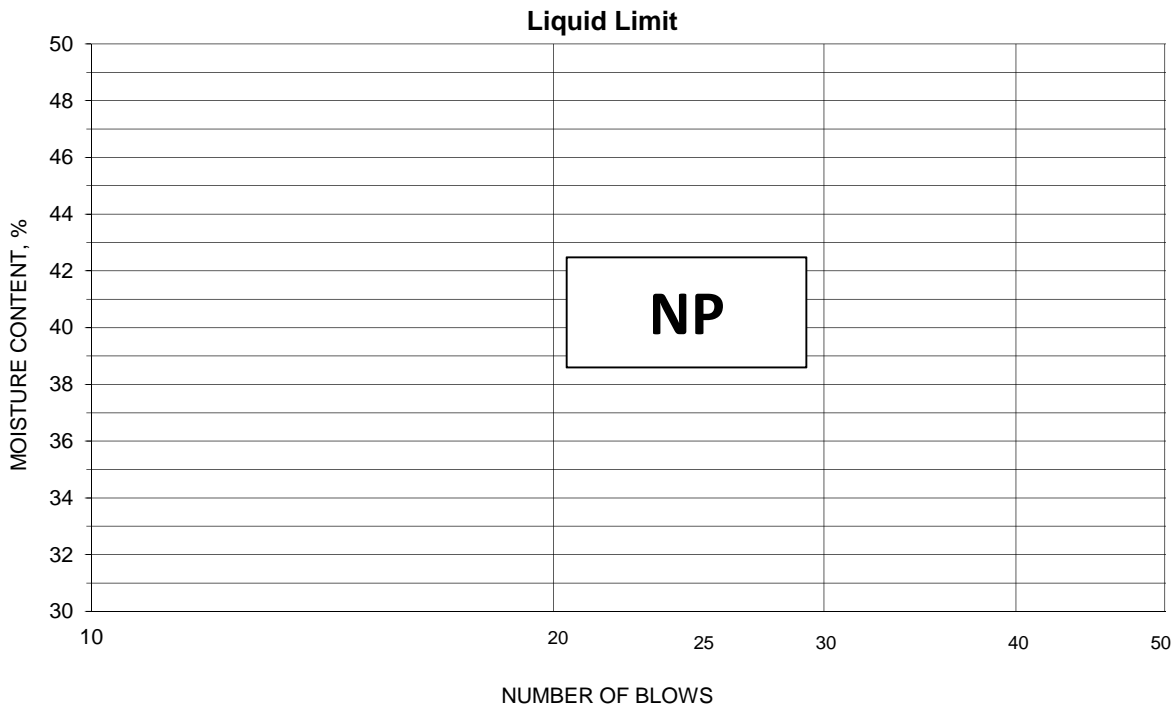


ATTERBERG LIMITS

Project CCR Rule - AEP Clifty Creek
 Source B-12, 80.0'-81.5'
 Tested By KG Test Method ASTM D 4318 Method A
 Test Date 07-24-2015 Prepared Dry

Project No. 175553022
 Lab ID 17
 % + No. 40 1
 Date Received 07-21-2015

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index

Remarks: _____

Reviewed By RJ



Summary of Soil Tests

Project Name CCR Rule - AEP Clifty Creek Project Number 17553022
 Source B-12, 95.0'-96.5' Lab ID 20
 Sample Type SPT Date Received 7-21-15
 Date Reported 8-3-15

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
 Moisture Content (%): 23.4

Atterberg Limits

Test Method: ASTM D 4318 Method A
 Prepared: Dry
 Liquid Limit: 42
 Plastic Limit: 19
 Plasticity Index: 23
 Activity Index: 0.74

Particle Size Analysis

Preparation Method: ASTM D 421
 Gradation Method: ASTM D 422
 Hydrometer Method: ASTM D 422

Particle Size		% Passing
Sieve Size	(mm)	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 4	4.75	100.0
No. 10	2	92.9
No. 40	0.425	92.4
No. 200	0.075	86.2
	0.02	71.6
	0.005	43.0
	0.002	30.6
estimated	0.001	26.0

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	7.1
Coarse Sand	7.1	0.5
Medium Sand	0.5	---
Fine Sand	6.2	6.2
Silt	43.2	55.6
Clay	43.0	30.6

Moisture-Density Relationship

Test Not Performed
 Maximum Dry Density (lb/ft³): N/A
 Maximum Dry Density (kg/m³): N/A
 Optimum Moisture Content (%): N/A
 Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed
 Bearing Ratio (%): N/A
 Compacted Dry Density (lb/ft³): N/A
 Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
 Prepared: Dry
 Particle Size: No. 10
 Specific Gravity at 20° Celsius: 2.68

Classification

Unified Group Symbol: CL
 Group Name: Lean clay
 AASHTO Classification: A-7-6 (20)

Comments: _____

Reviewed By RJ



Particle-Size Analysis of Soils
ASTM D 422

Project Name CCR Rule - AEP Clifty Creek
Source B-12, 95.0'-96.5'

Project Number 175553022
Lab ID 20

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method ASTM D 422
Prepared using ASTM D 421

Particle Shape Angular
Particle Hardness: Hard and Durable

Tested By JS
Test Date 07-24-2015
Date Received 07-21-2015

Sieve Size	% Passing
No. 4	100.0
No. 10	92.9

Maximum Particle size: No. 4 Sieve

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

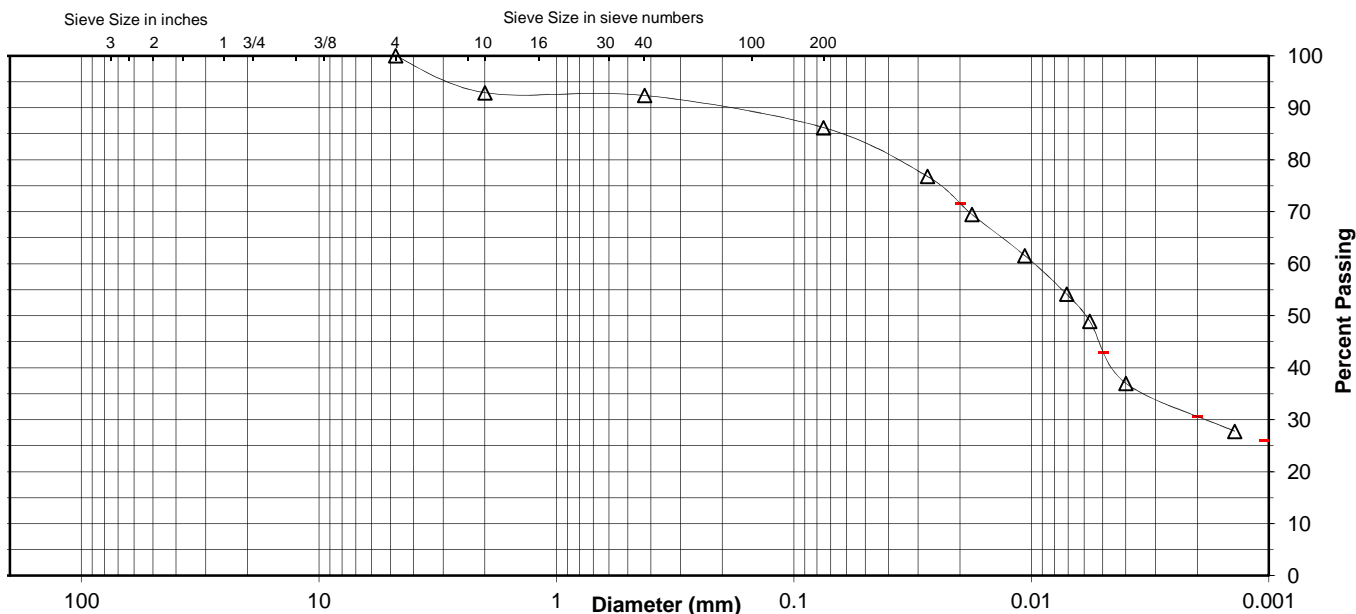
Specific Gravity 2.68

Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	92.4
No. 200	86.2
0.02 mm	71.6
0.005 mm	43.0
0.002 mm	30.6
0.001 mm	26.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	7.1	0.5	6.2	43.2	43.0
AASHTO	Gravel		Coarse Sand		Fine Sand	Silt	Clay
	7.1		0.5		6.2	55.6	30.6



Comments _____

Reviewed By RJ

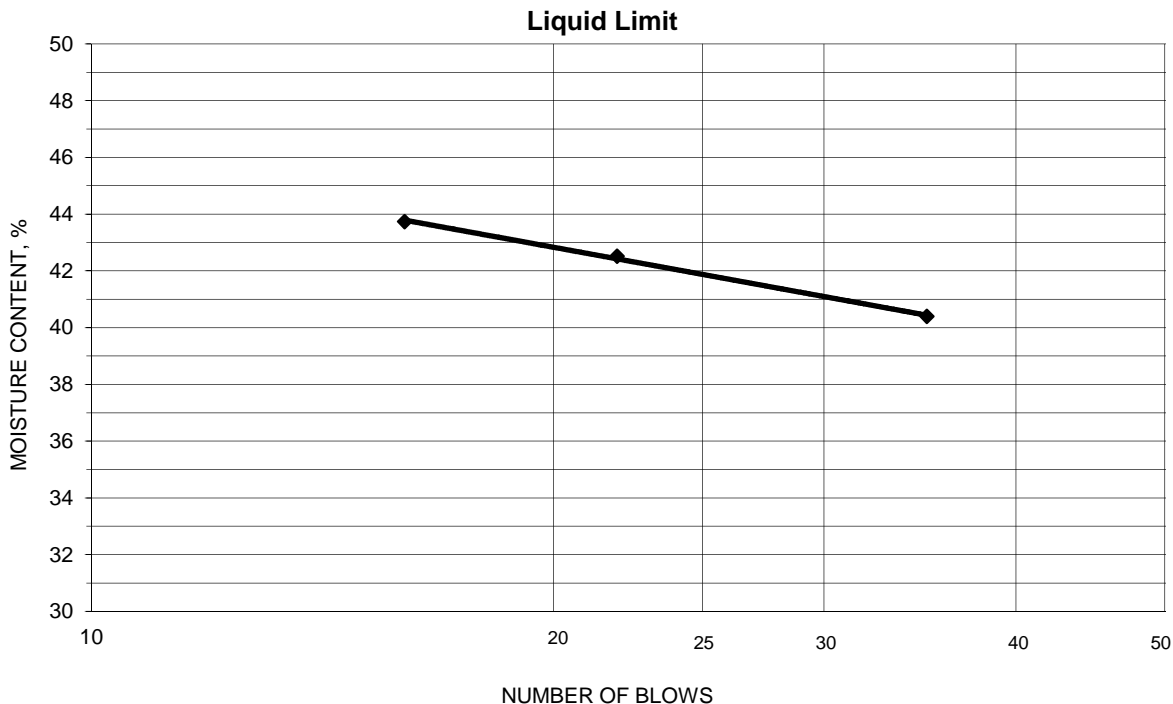


ATTERBERG LIMITS

Project CCR Rule - AEP Clifty Creek
 Source B-12, 95.0'-96.5'
 Tested By KDG Test Method ASTM D 4318 Method A
 Test Date 07-31-2015 Prepared Dry

Project No. 175553022
 Lab ID 20
 % + No. 40 8
 Date Received 07-21-2015

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
23.24	19.63	11.14	22	42.5	42
20.15	17.36	10.98	16	43.7	
21.03	18.17	11.09	35	40.4	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
17.59	16.51	10.80	18.9	19	23
17.15	16.14	10.89	19.2		

Remarks: _____

Reviewed By RJ

APPENDIX E

CONSOLIDATED-UNDRAINED TRIAXIAL TESTS

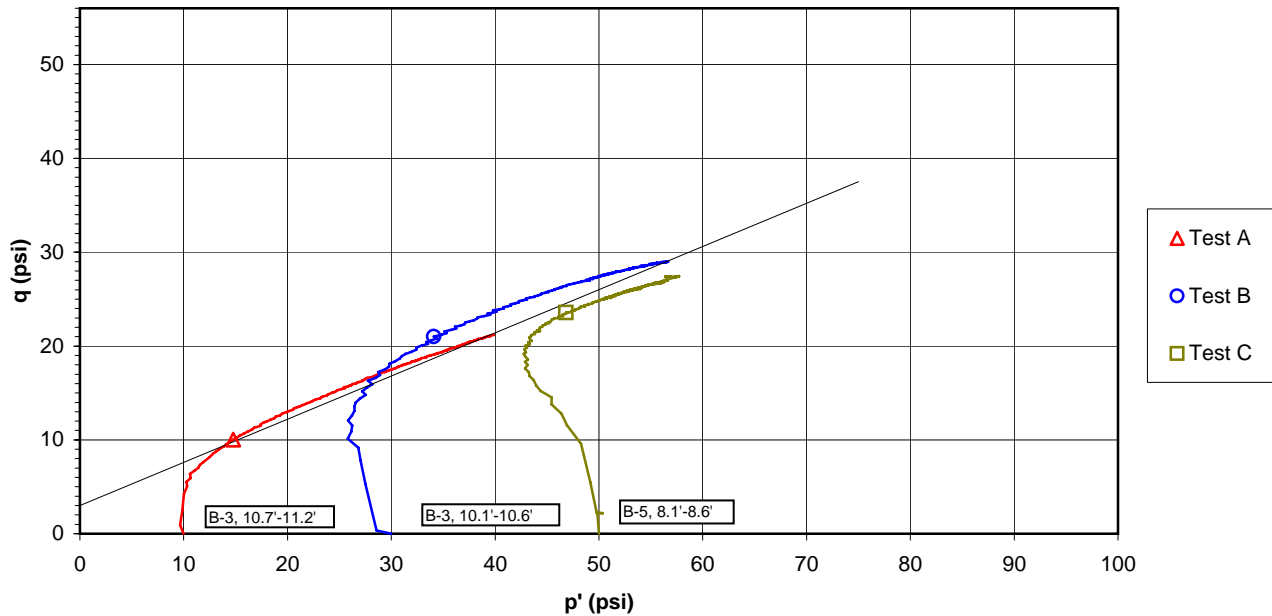
BOILER SLAG POND DAM

Project AEP-Clifty Creek-West Bottom and Fly Ash Ponds subsurface exploration
 Sample ID B-3, 10.7'-11.2' & B-3, 10.1'-10.6' & B-5, 8.1'-8.6'

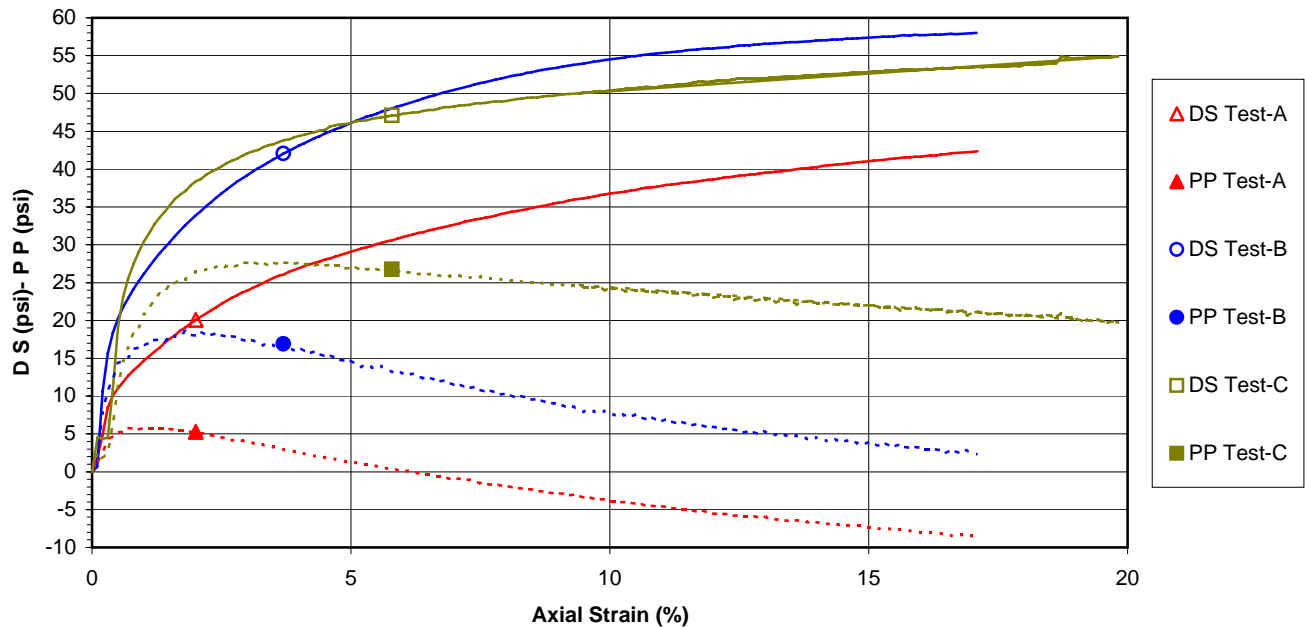
Project No. 175539022
 Test Number 1

Failure Criterion: $\phi' = 27.4 \text{ deg.}$ $c' = 490 \text{ psf}$
 Maximum Effective Principal Stress Ratio

p' vs. q Plot



Deviator Stress and Induced Pore Pressure vs. Axial Strain

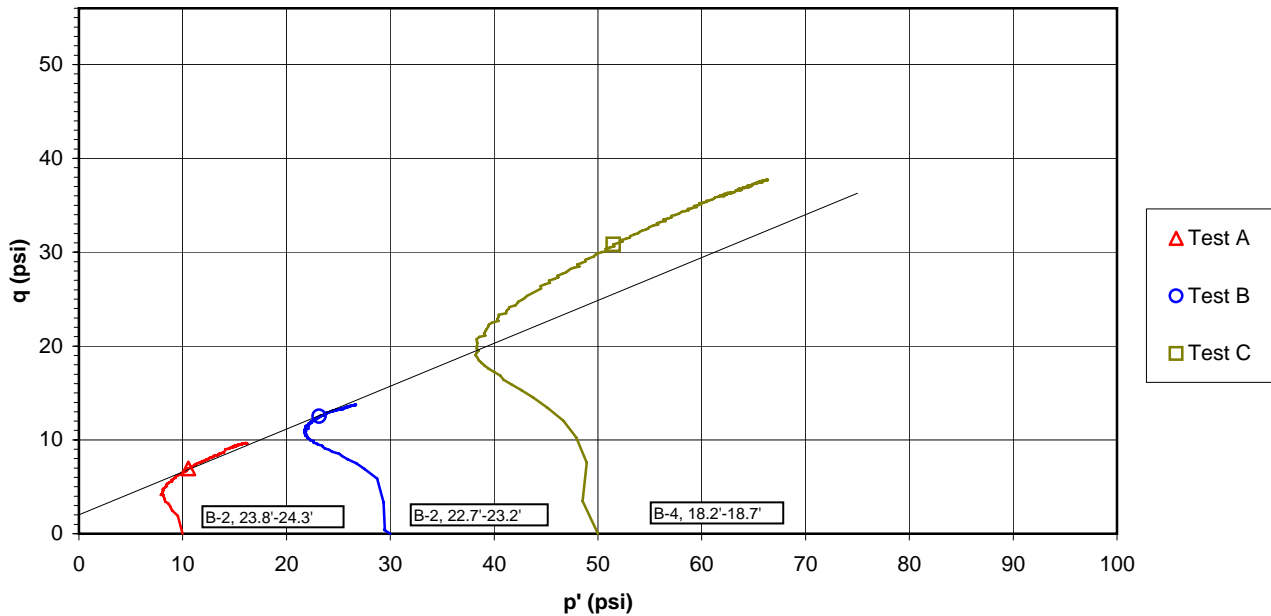


Project AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration
 Sample ID B-2, 23.8'-24.3' & B-2, 22.7'-23.2' & B-4, 18.2'-18.7'

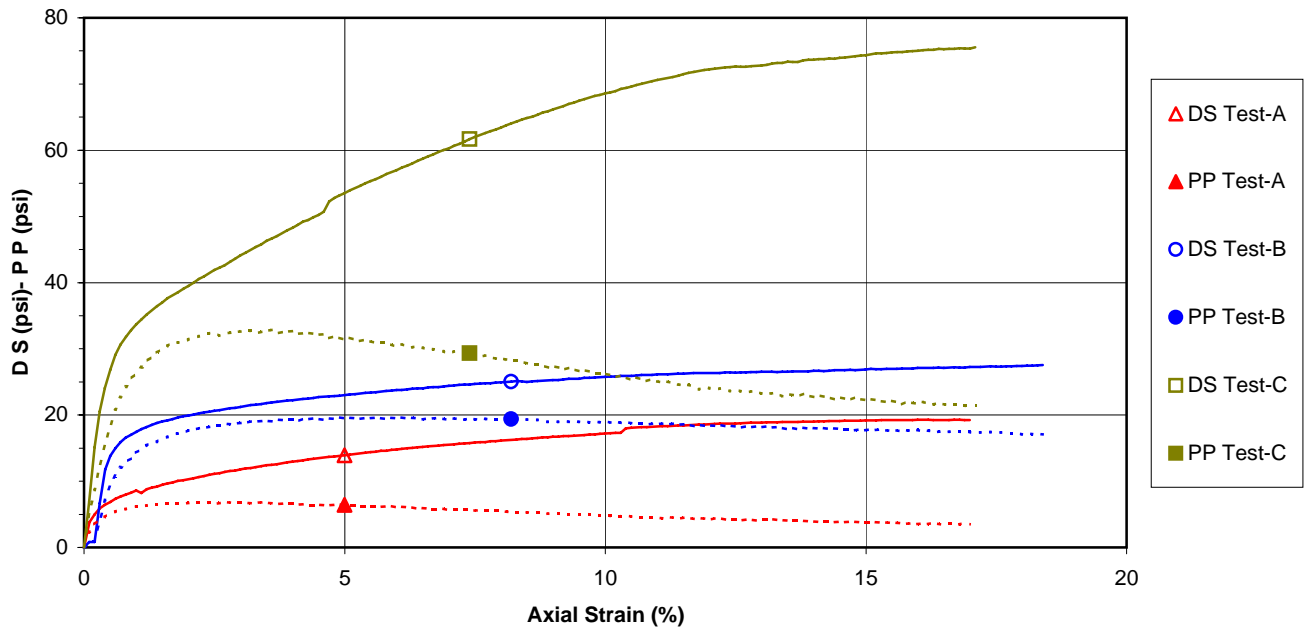
Project No. 175539022
 Test Number 2

Failure Criterion: $\phi' = 27.2 \text{ deg.}$ $c' = 320 \text{ psf}$
 Maximum Effective Principal Stress Ratio

p' vs. q Plot



Deviator Stress and Induced Pore Pressure vs. Axial Strain

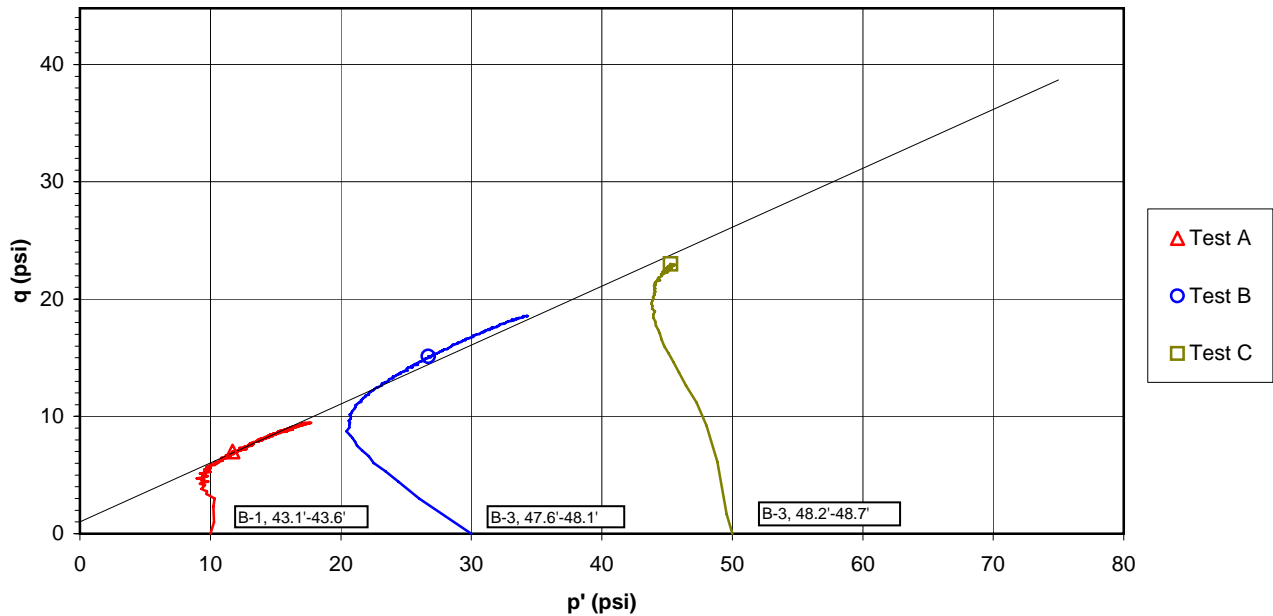


Project AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration
 Sample ID B-1, 43.1'-43.6' & B-3, 47.6'-48.1' & B-3, 48.2'-48.7'

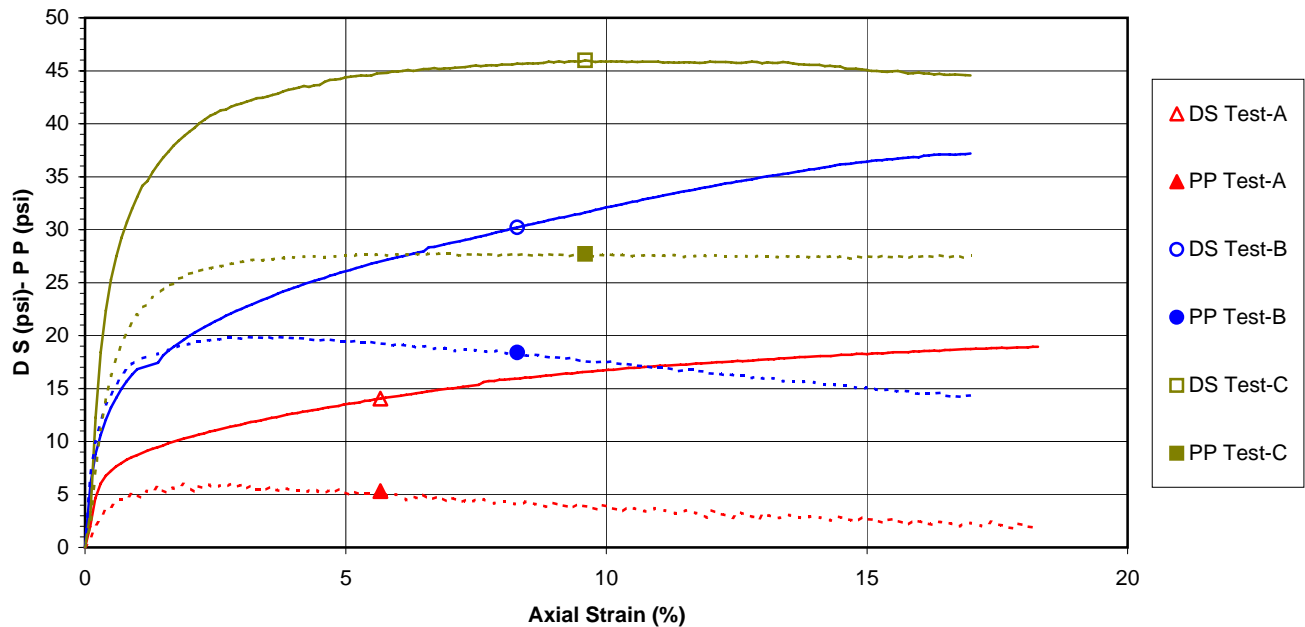
Project No. 175539022
 Test Number 3

Failure Criterion: $\phi' = 30.2 \text{ deg.}$ $c' = 170 \text{ psf}$
 Maximum Effective Principal Stress Ratio

p' vs. q Plot

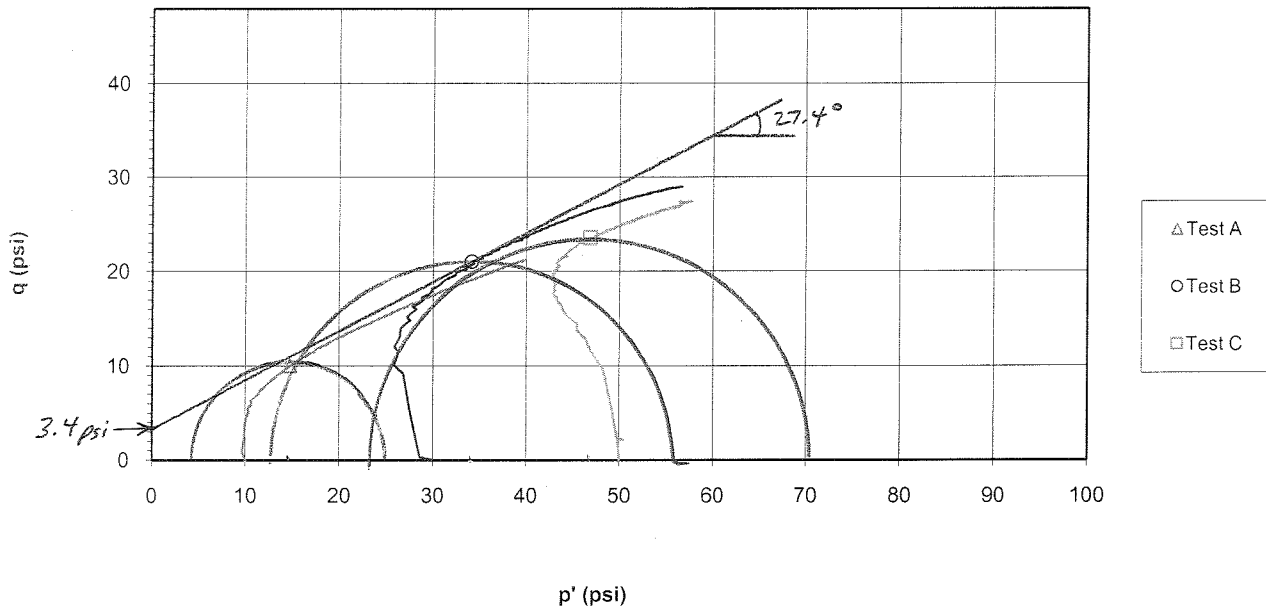
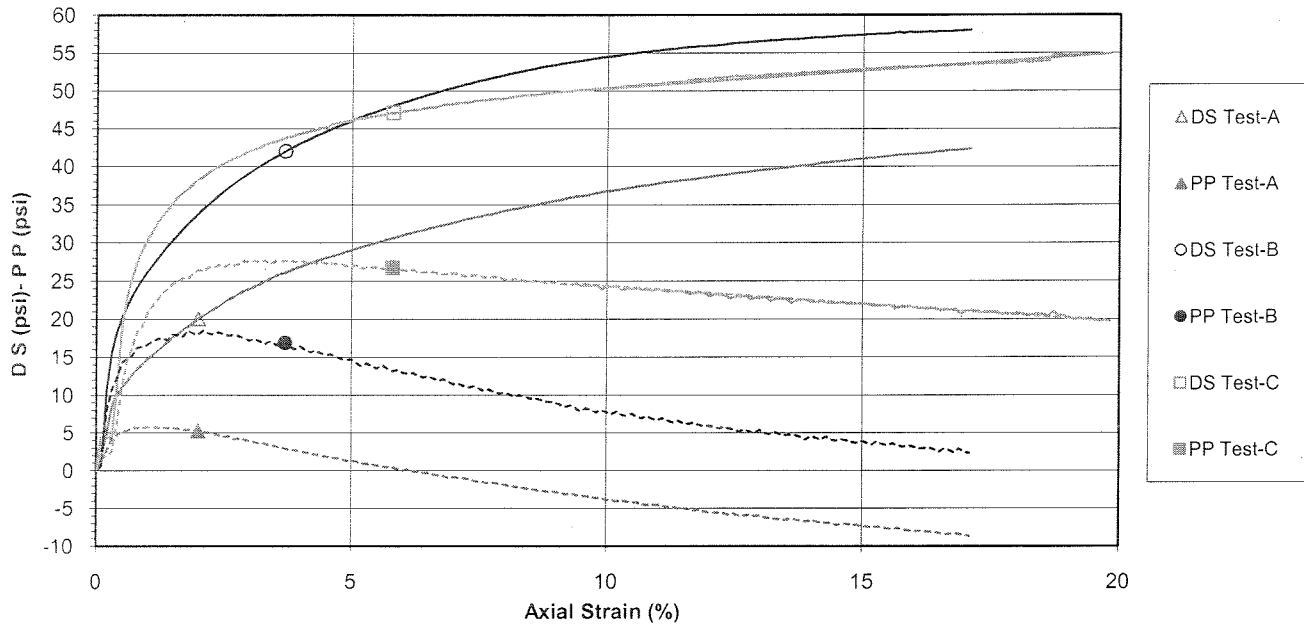


Deviator Stress and Induced Pore Pressure vs. Axial Strain



Project AEP-Clifty Creek-West Bottom and Fly Ash Ponds subsurface exploration
 Sample ID B-3, 10.7'-11.2' & B-3, 10.1'-10.6' & B-5, 8.1'-8.6'

 Project No. 175539022
 Test Number 1
 $\phi' = 27.4 \text{ deg.}$
 $c' = 490 \text{ psf}$
 Failure Criterion: Maximum Effective Principal Stress Ratio

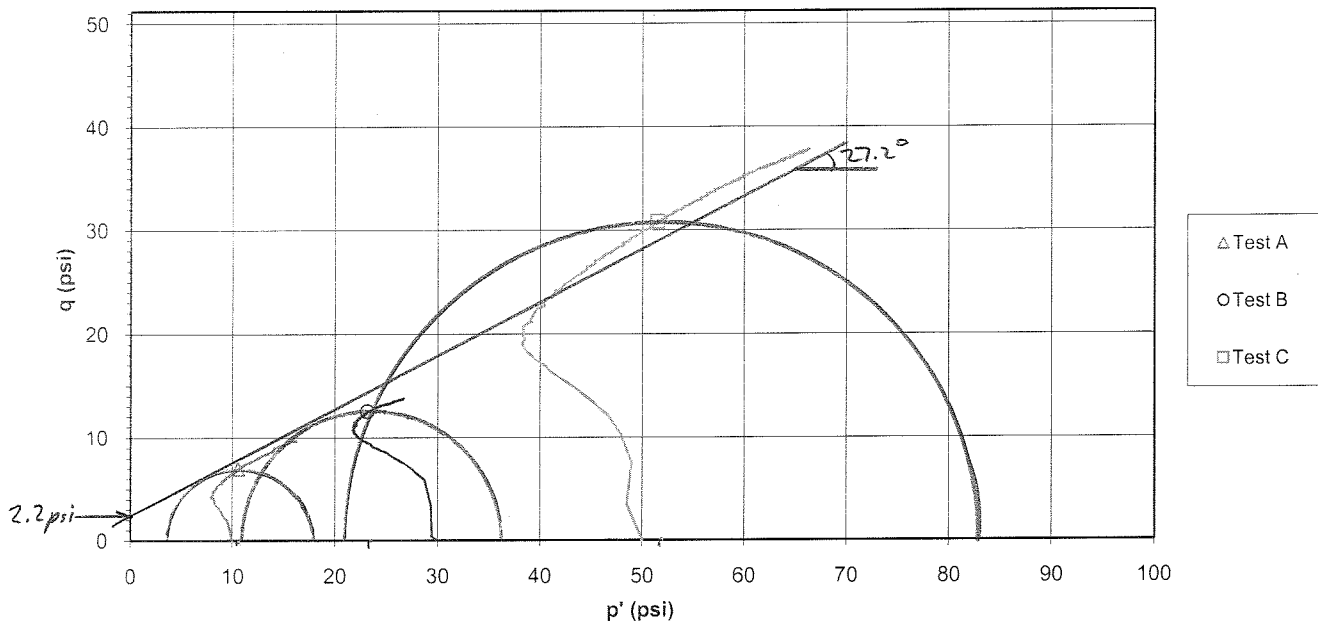
p' vs. q Plot

Deviator Stress and Induced Pore Pressure vs. Axial Strain


Project AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration
 Sample ID B-2, 23.8'-24.3' & B-2, 22.7'-23.2' & B-4, 18.2'-18.7'

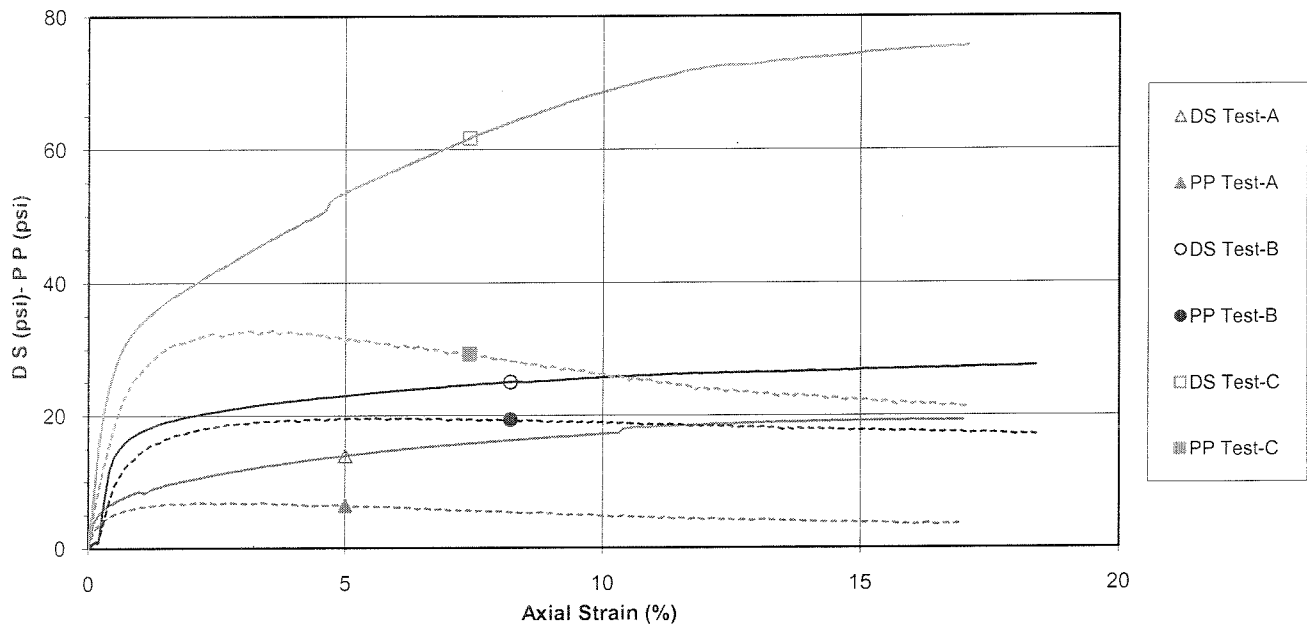
Project No. 175539022
 Test Number 2

Failure Criterion: $\phi' = 27.2 \text{ deg.}$ $c' = 320 \text{ psf}$
 Maximum Effective Principal Stress Ratio

p' vs. q Plot



Deviator Stress and Induced Pore Pressure vs. Axial Strain

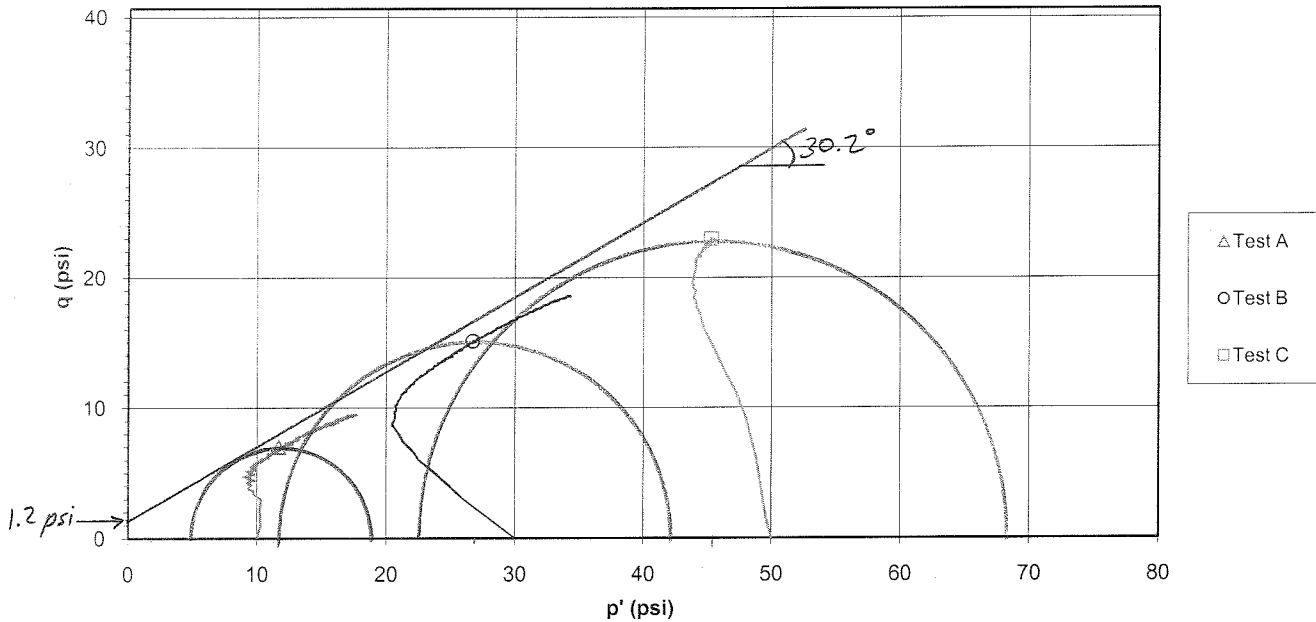


Project AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration
 Sample ID B-1, 43.1'-43.6' & B-3, 47.6'-48.1' & B-3, 48.2'-48.7'

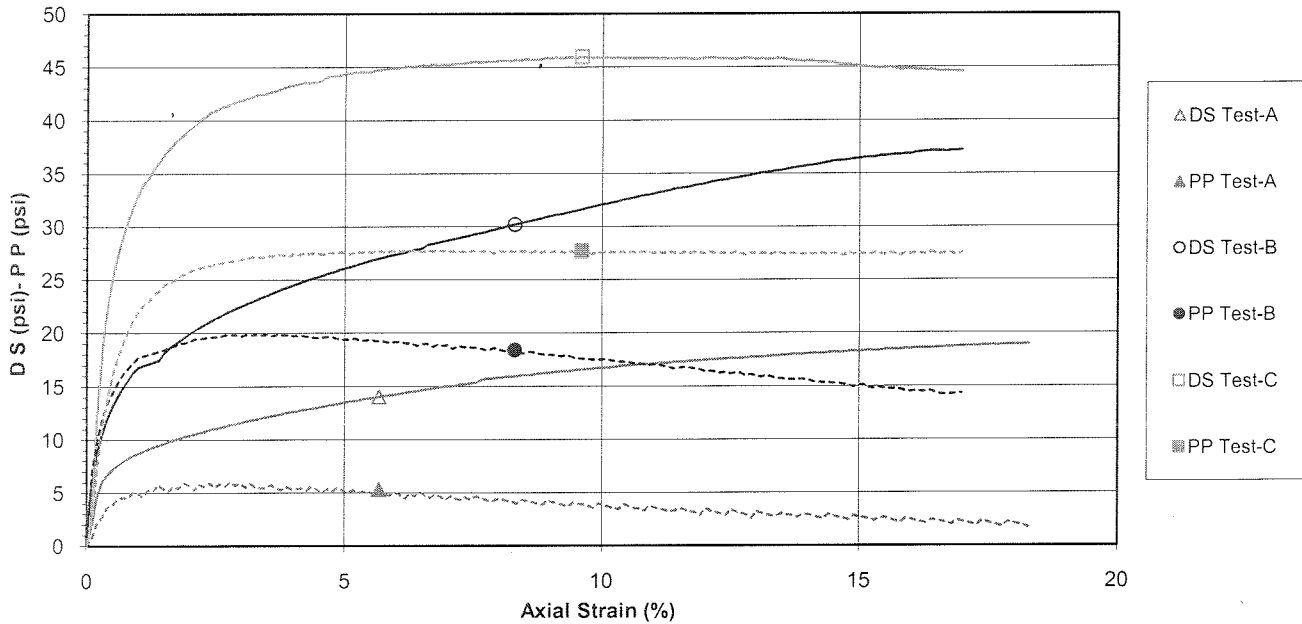
Project No. 175539022
 Test Number 3

Failure Criterion: $\phi' = 30.2 \text{ deg.}$ $c' = 170 \text{ psf}$
 Maximum Effective Principal Stress Ratio

p' vs. q Plot

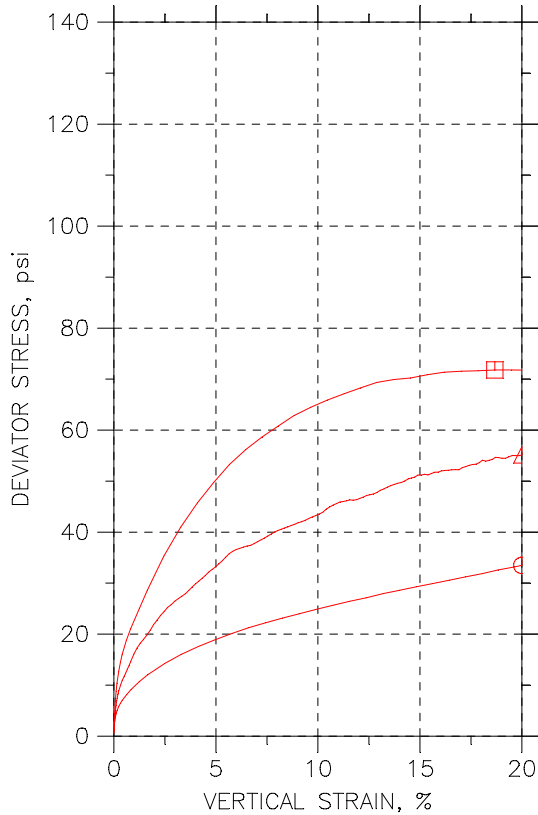
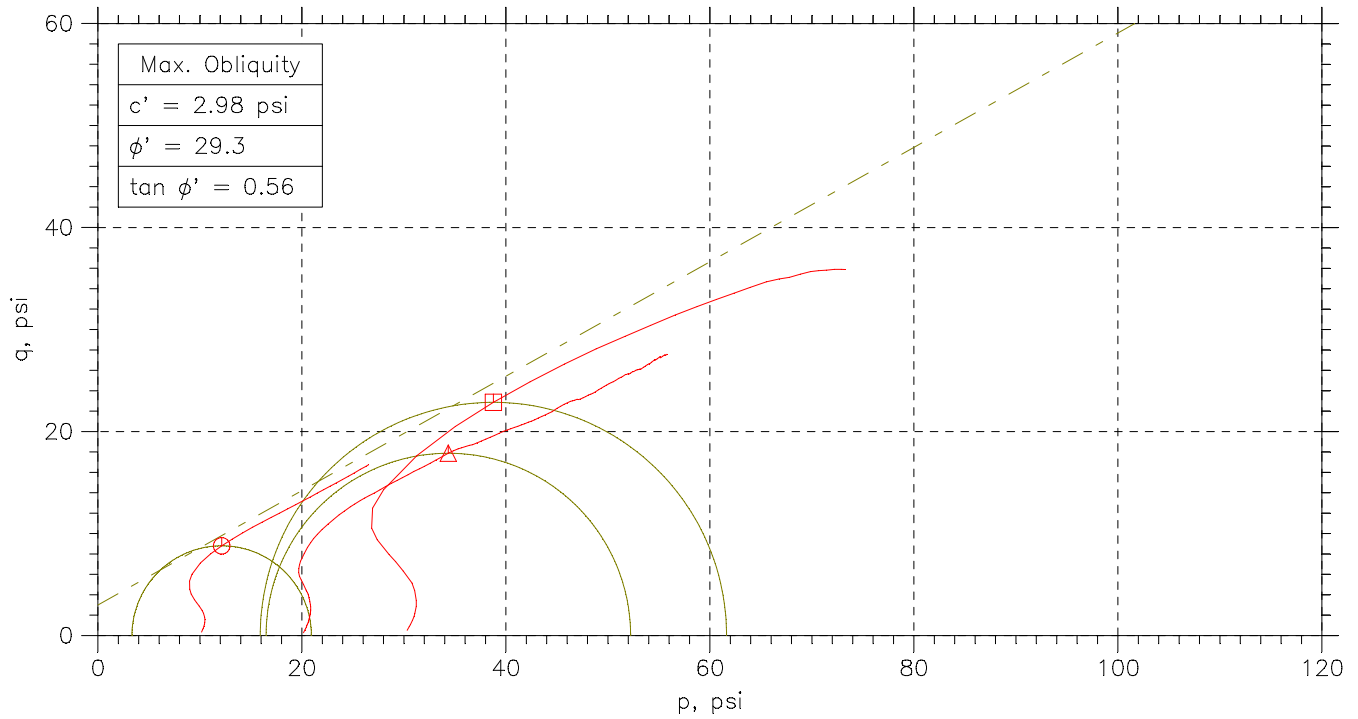


Deviator Stress and Induced Pore Pressure vs. Axial Strain



LANDFILL RUNOFF COLLECTION POND

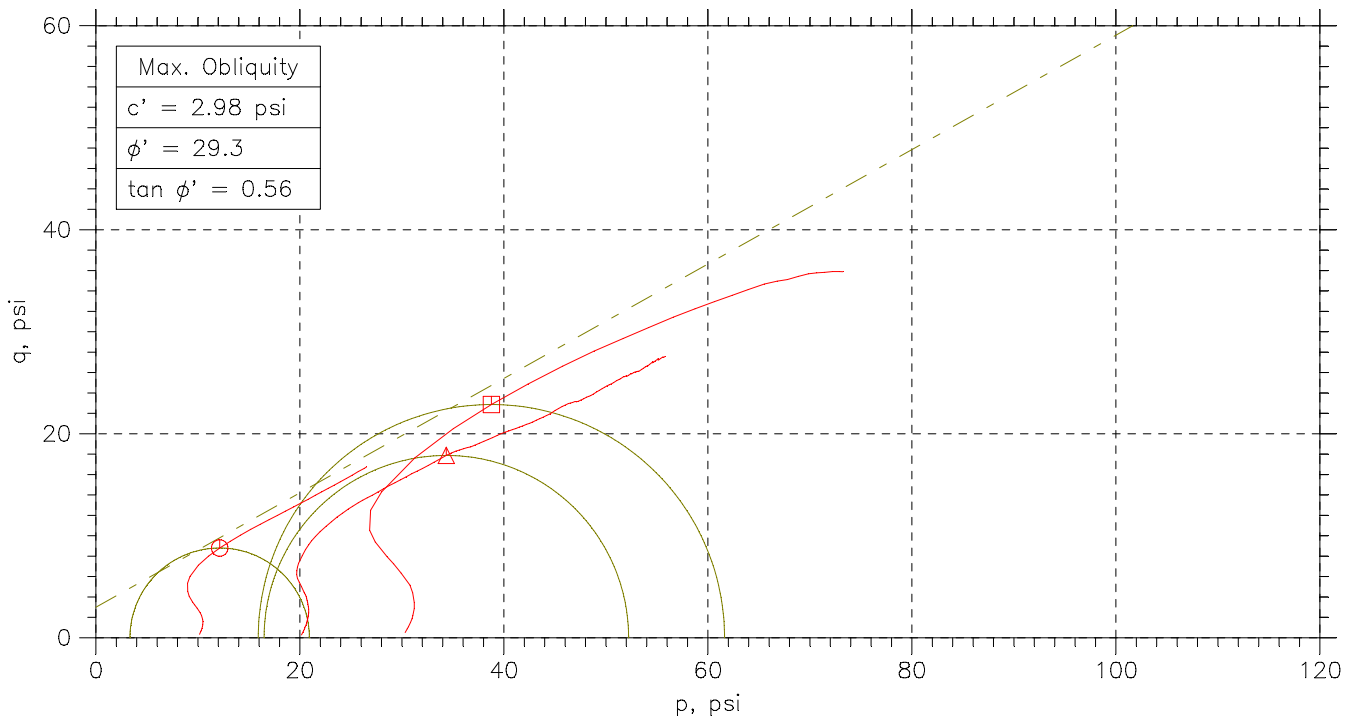
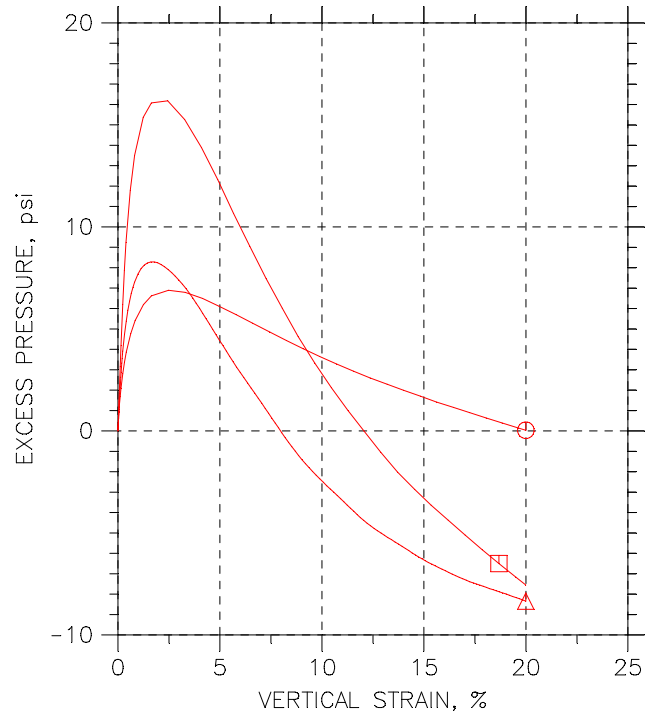
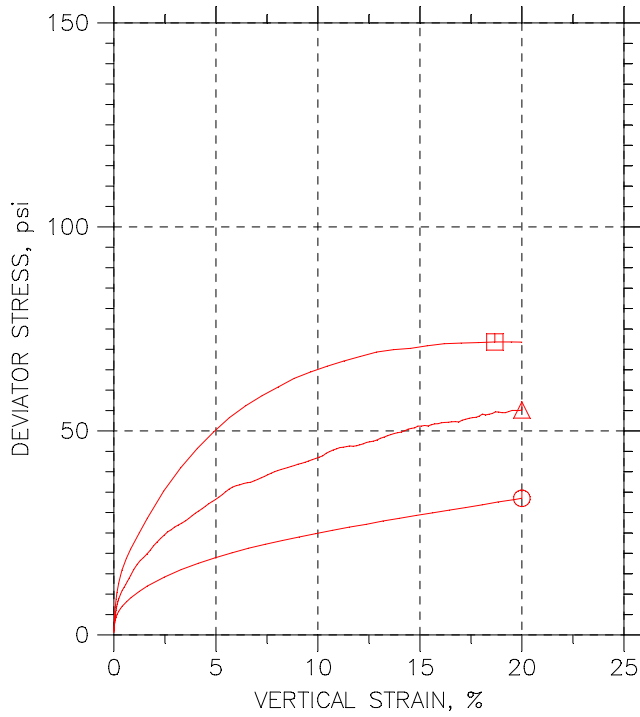
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



Symbol	⊙	△	□	
Sample No.	---	---	---	
Test No.	1.1	1.2	1.3	
Depth	25.8-26.0	26.4-27.0	28.4-29.0	
Initial	Diameter, in	2.835	2.834	2.832
	Height, in	6.314	5.928	5.929
	Water Content, %	20.2	21.0	19.0
	Dry Density, pcf	109.	107.5	111.3
	Saturation, %	99.8	99.6	99.7
Before Shear	Void Ratio	0.546	0.568	0.515
	Water Content, %	21.0	21.6	19.1
	Dry Density, pcf	107.7	106.5	111.2
	Saturation*, %	100.0	100.0	100.0
	Void Ratio	0.566	0.583	0.515
	Back Press., psi	137.2	125.1	116.2
	Ver. Eff. Cons. Stress, psi	9.834	19.88	29.8
	Shear Strength, psi	16.74	27.57	35.9
	Strain at Failure, %	20	20	18.7
	Strain Rate, %/min	0.08	0.08	0.08
	B-Value	0.96	0.95	0.95
	Estimated Specific Gravity	2.7	2.7	2.7
	Liquid Limit	---	---	---
	Plastic Limit	---	---	---

 <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek				
	Location: Jefferson, IN				
	Project No.: GTX-1516				
	Boring No.: B-7				
	Sample Type: UD				
	Description: Light Brown				
Remarks: System 1062					

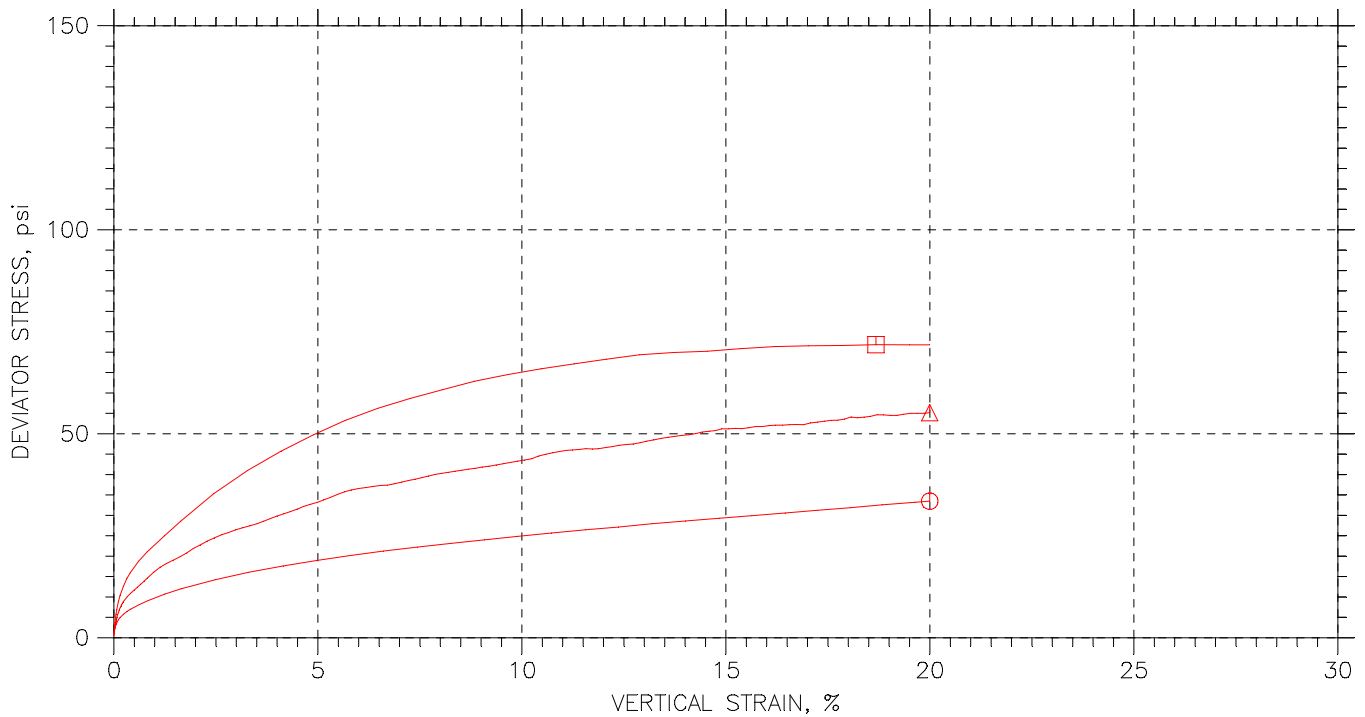
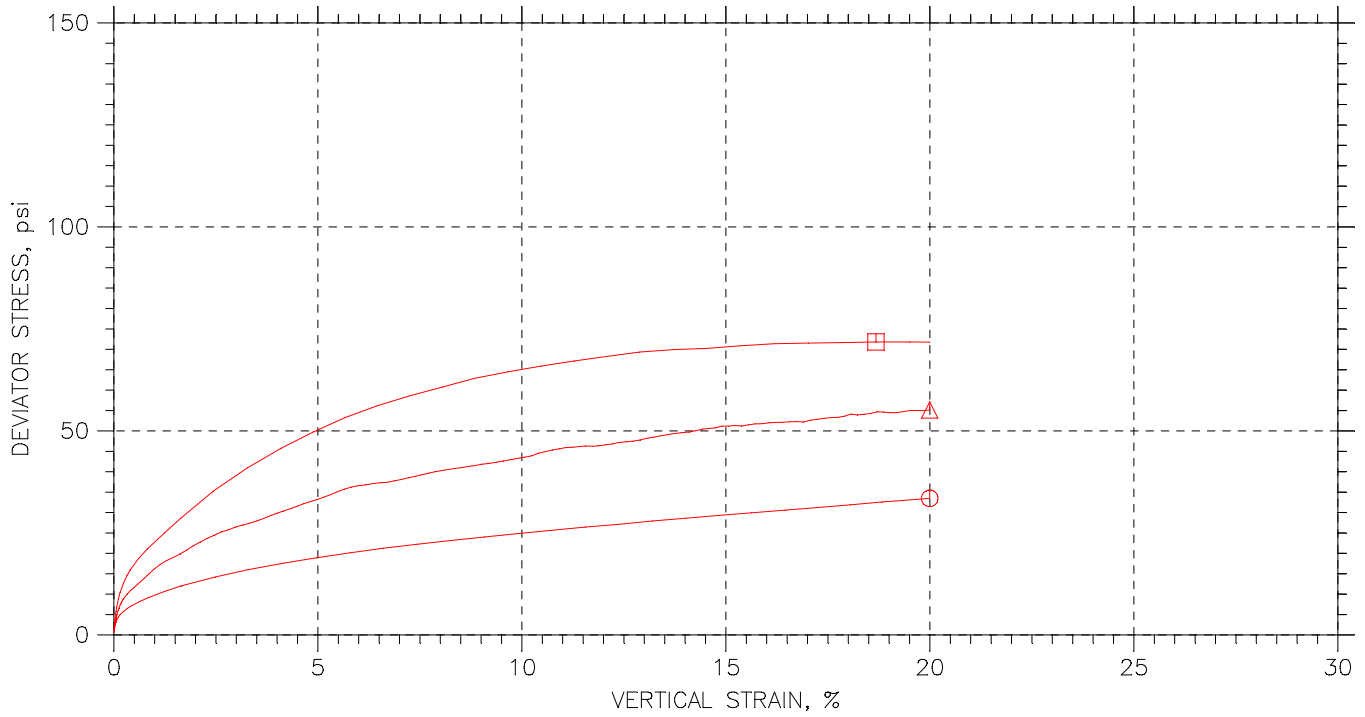
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767




	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	1.1	25.8-26.0	jm	12/10/09	mm		1516-1.1.dat
△	---	1.2	26.4-27.0	jm	12/10/09	mm		1516-1.2.dat
□	---	1.3	28.4-29.0	jm	12/9/09	mm		1516-1.3.dat

<p style="font-size: small;">a subsidiary of Geocomp Corporation</p>	Project: Clifty Creek		Location: Jefferson, IN		Project No.: GTX-1516	
	Boring No.: B-7		Sample Type: UD			
	Description: Light Brown					
	Remarks: System 1062					

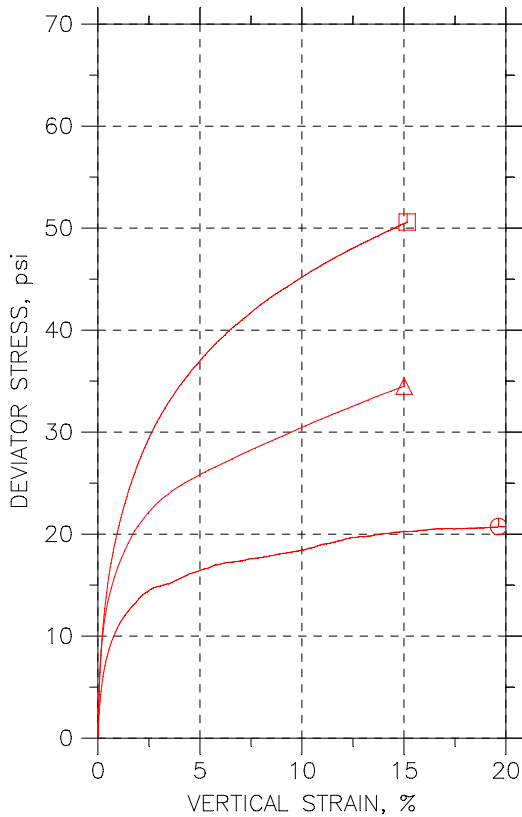
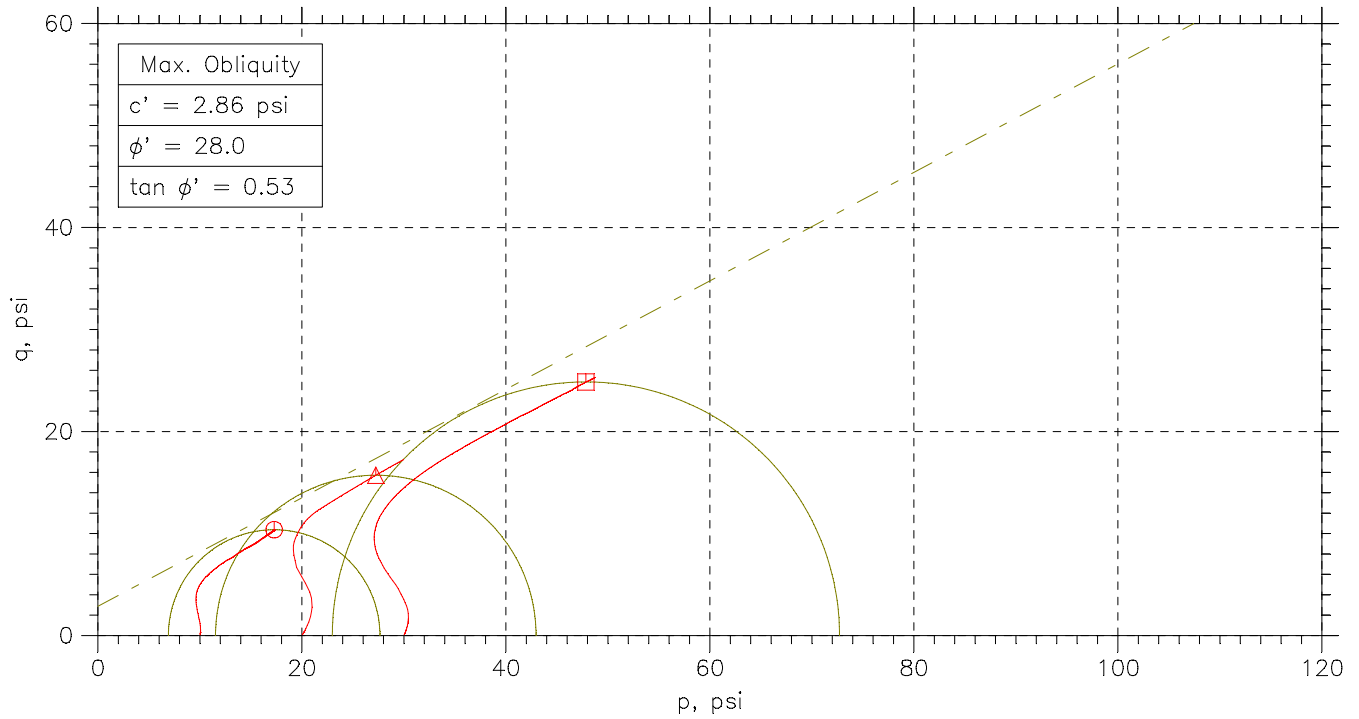
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	1.1	25.8-26.0	jm	12/10/09	mm		1516-1.1.dat
△	---	1.2	26.4-27.0	jm	12/10/09	mm		1516-1.2.dat
□	---	1.3	28.4-29.0	jm	12/9/09	mm		1516-1.3.dat

 <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek		Location: Jefferson, IN		Project No.: GTX-1516	
	Boring No.: B-7		Sample Type: UD			
	Description: Light Brown					
	Remarks: System 1062					

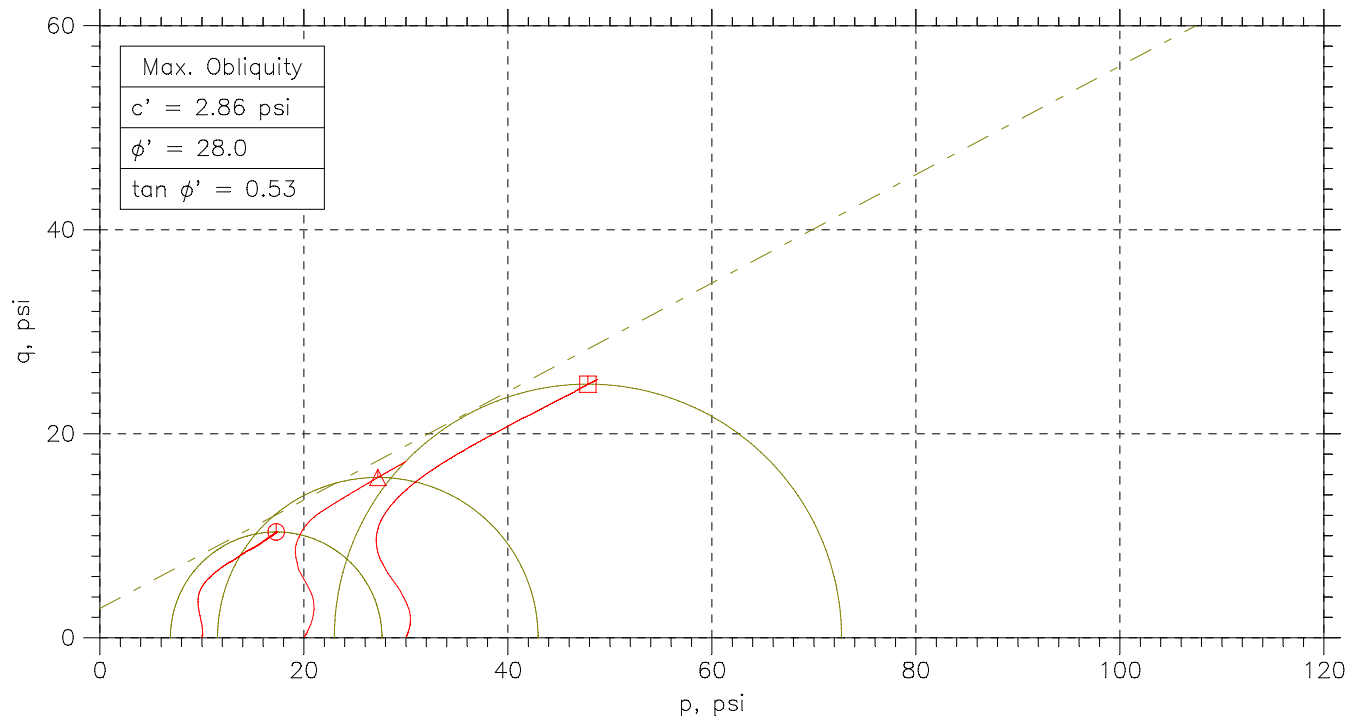
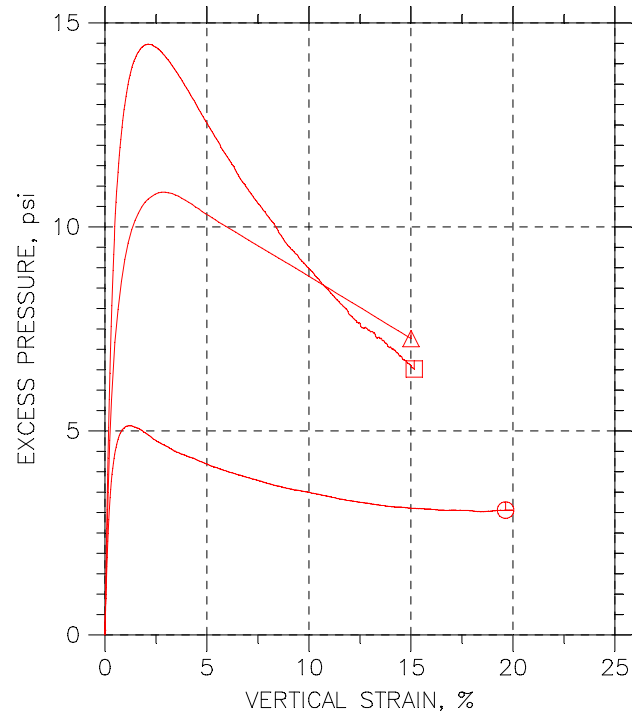
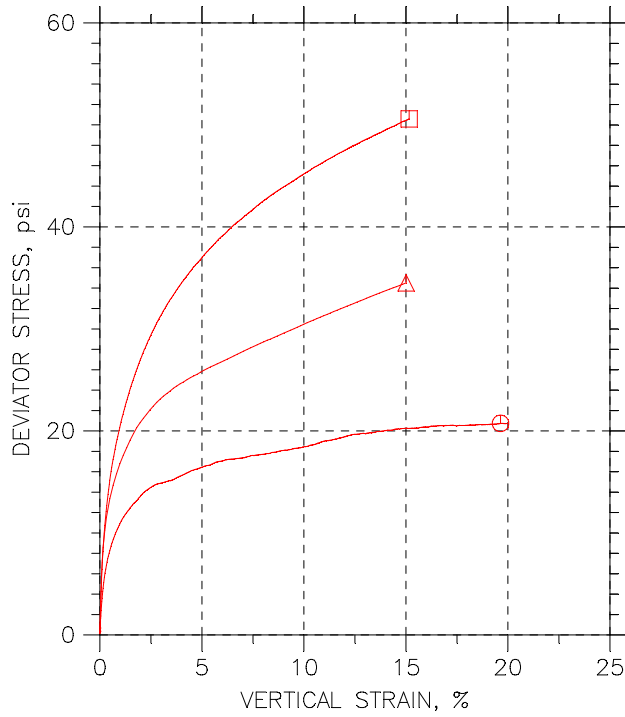
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767




Symbol	⊙	△	□	
Sample No.	---	---	---	
Test No.	2.1	2.2	2.3	
Depth	25.8-26.4'	28.4-29.0'	30.3-30.9'	
Initial	Diameter, in	2.82	2.824	2.838
	Height, in	5.82	6.027	6.001
	Water Content, %	21.0	20.7	20.9
	Dry Density, pcf	107.2	107.6	107.6
	Saturation, %	99.2	98.7	99.6
Before Shear	Void Ratio	0.572	0.567	0.567
	Water Content, %	20.5	19.8	19.0
	Dry Density, pcf	108.5	109.8	111.4
	Saturation*, %	100.0	100.0	100.0
	Void Ratio	0.554	0.535	0.513
	Back Press., psi	59.25	124.8	56.31
	Ver. Eff. Cons. Stress, psi	9.968	19.98	29.96
	Shear Strength, psi	10.37	17.25	25.3
	Strain at Failure, %	19.6	15	15.2
	Strain Rate, %/min	0.016	0.016	0.016
	B-Value	0.95	0.96	0.95
	Estimated Specific Gravity	2.7	2.7	2.7
	Liquid Limit	---	---	---
	Plastic Limit	---	---	---

 <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek			
	Location: Jefferson, IN.			
	Project No.: GTX-1516			
	Boring No.: B-8			
	Sample Type: UD			
	Description: Greenish brown lean clay with sand			
Remarks: 2054				

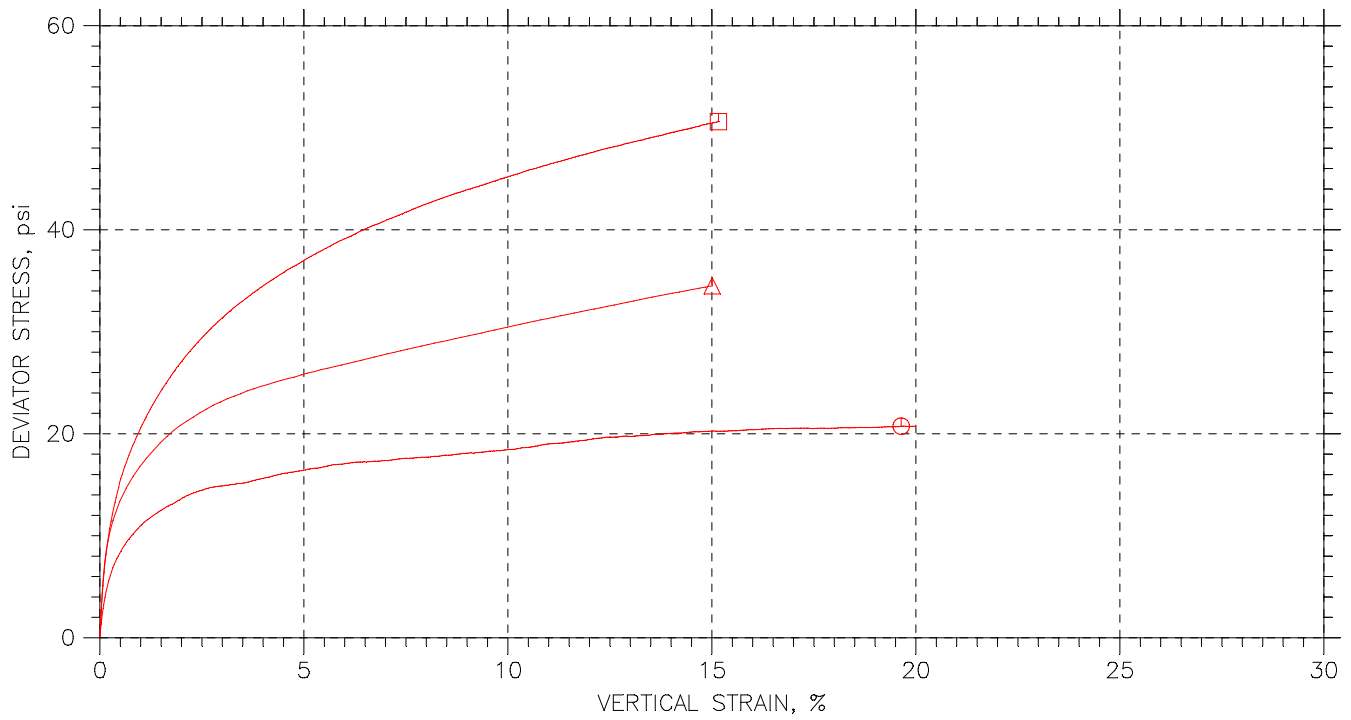
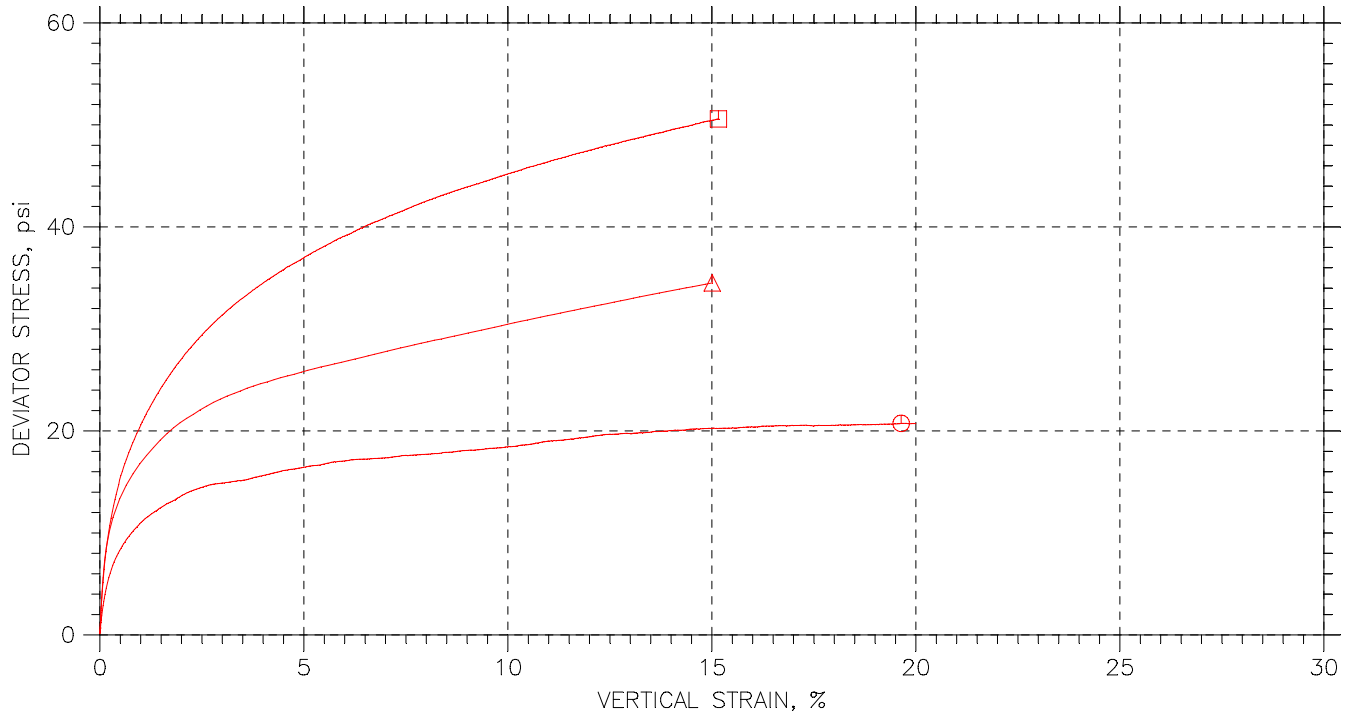
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767




	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	2.1	25.8-26.4	jm	12/11/09	mm		1516-2.1.dat
△	---	2.2	28.4-29.0	jm	12/11/09	mm		1516-2.2A.dat
□	---	2.3	30.3-30.9'	jm	12/09/09	mm		1516-2.3.dat

 <p style="font-size: small;">a subsidiary of Geocomp Corporation</p>	Project: Clifty Creek		Location: Jefferson, IN.		Project No.: GTX-1516	
	Boring No.: B-8		Sample Type: UD			
	Description: Greenish brown lean clay with sand					
	Remarks: 2054					

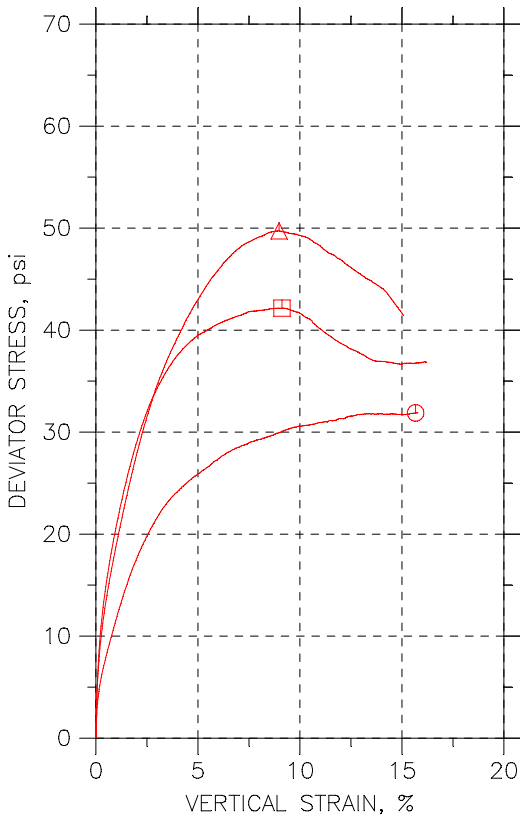
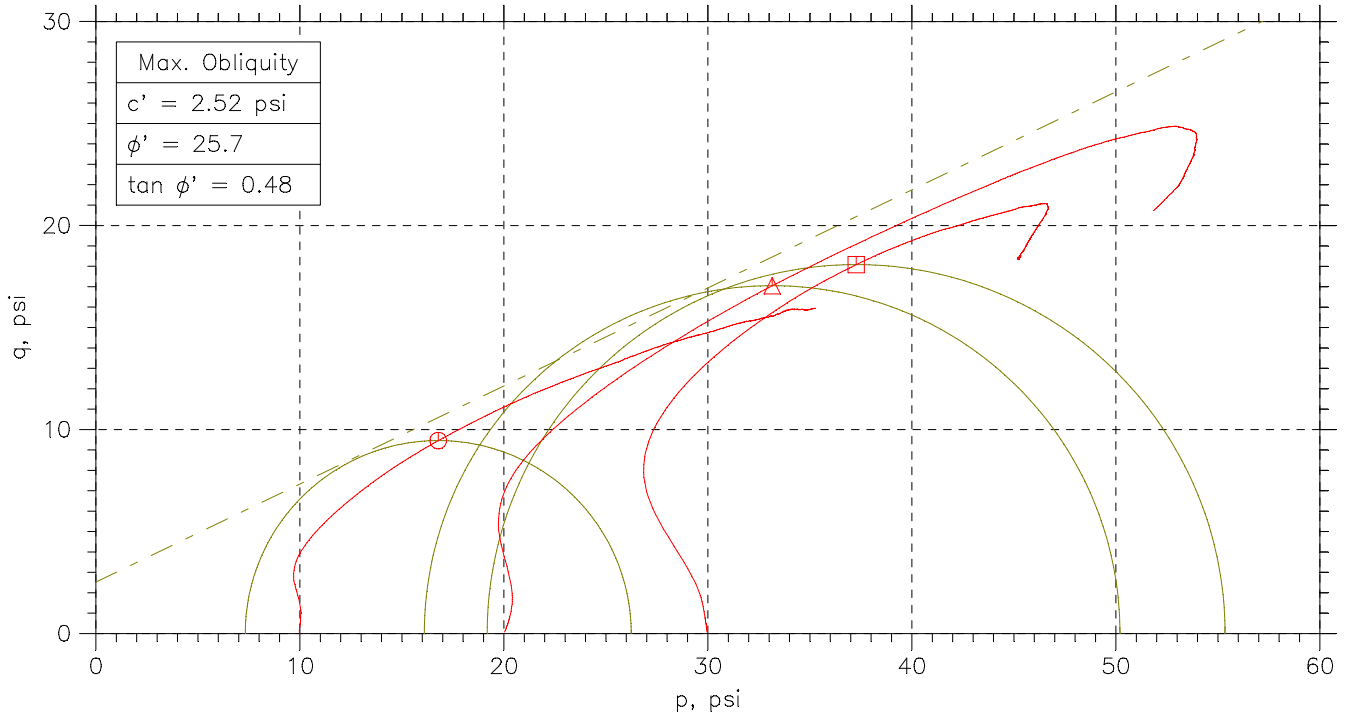
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767




	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	2.1	25.8-26.4	jm	12/11/09	mm		1516-2.1.dat
△	---	2.2	28.4-29.0	jm	12/11/09	mm		1516-2.2A.dat
□	---	2.3	30.3-30.9'	jm	12/09/09	mm		1516-2.3.dat

 <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek		Location: Jefferson, IN.		Project No.: GTX-1516	
	Boring No.: B-8		Sample Type: UD			
	Description: Greenish brown lean clay with sand					
	Remarks: 2054					

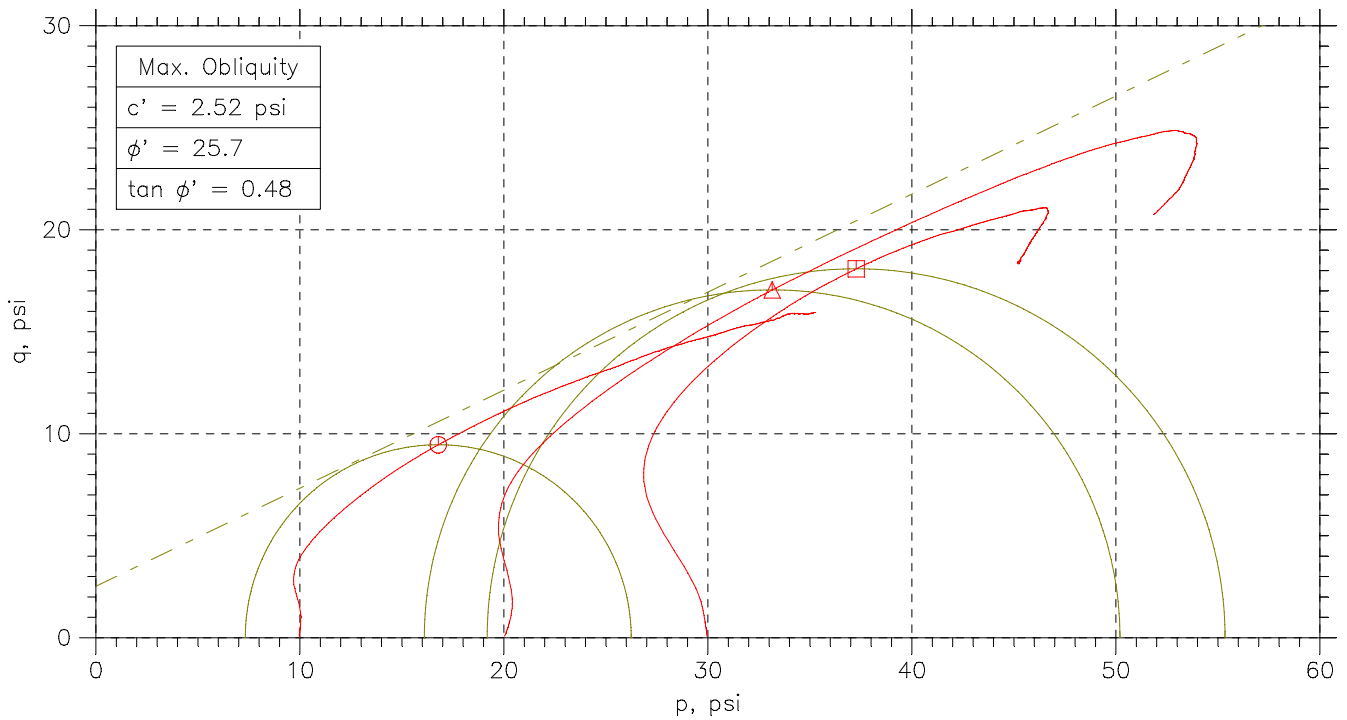
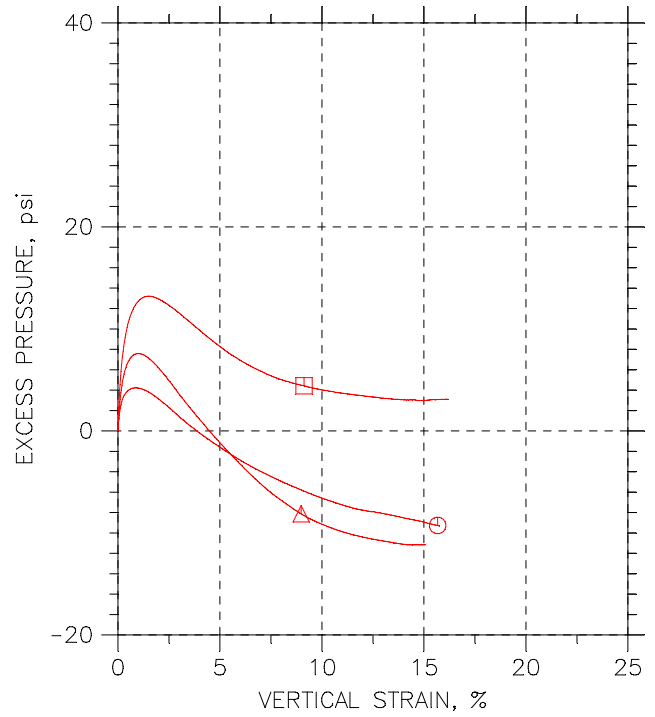
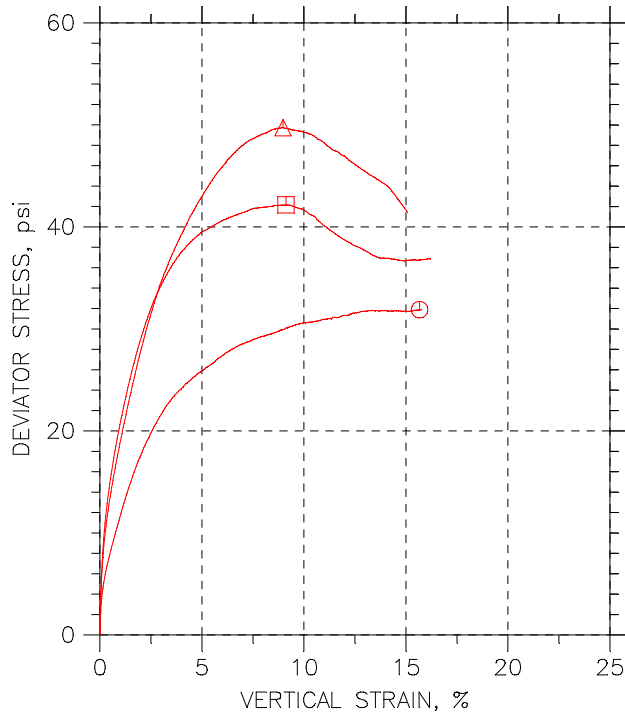
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767




Symbol	⊕	△	□	
Sample No.	---	---	---	
Test No.	3.1	3.2	3.3	
Depth	17.4-18.0	19.4-20.0	20.8--21.4	
Initial	Diameter, in	2.835	2.835	2.837
	Height, in	6.319	6.281	6.177
	Water Content, %	19.4	18.4	20.8
	Dry Density, pcf	109.7	111.4	107.3
	Saturation, %	97.8	96.9	98.6
Before Shear	Void Ratio	0.536	0.514	0.571
	Water Content, %	19.2	18.9	22.7
	Dry Density, pcf	111.	111.7	104.5
	Saturation*, %	100.0	100.0	100.0
	Void Ratio	0.518	0.509	0.613
	Back Press., psi	136.8	122	116.2
	Ver. Eff. Cons. Stress, psi	9.997	19.96	29.88
	Shear Strength, psi	15.94	24.86	21.08
	Strain at Failure, %	15.7	8.98	9.12
	Strain Rate, %/min	0.016	0.016	0.016
	B-Value	0.95	0.96	0.95
	Estimated Specific Gravity	2.7	2.7	2.7
	Liquid Limit	---	---	---
	Plastic Limit	---	---	---

 <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek				
	Location: Jefferson, IN				
	Project No.: GTX-1516				
	Boring No.: B-9				
	Sample Type: UD				
	Description: Brown lean clay with sand				
Remarks: System 1057					

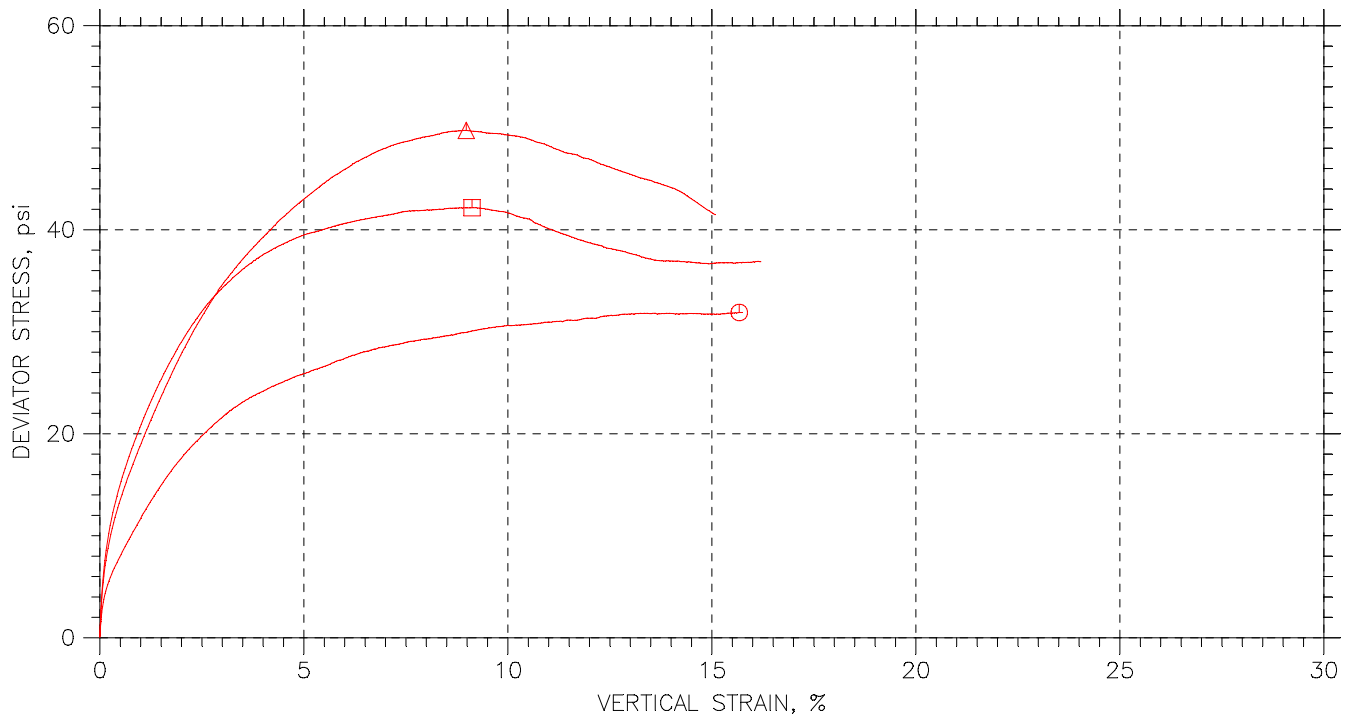
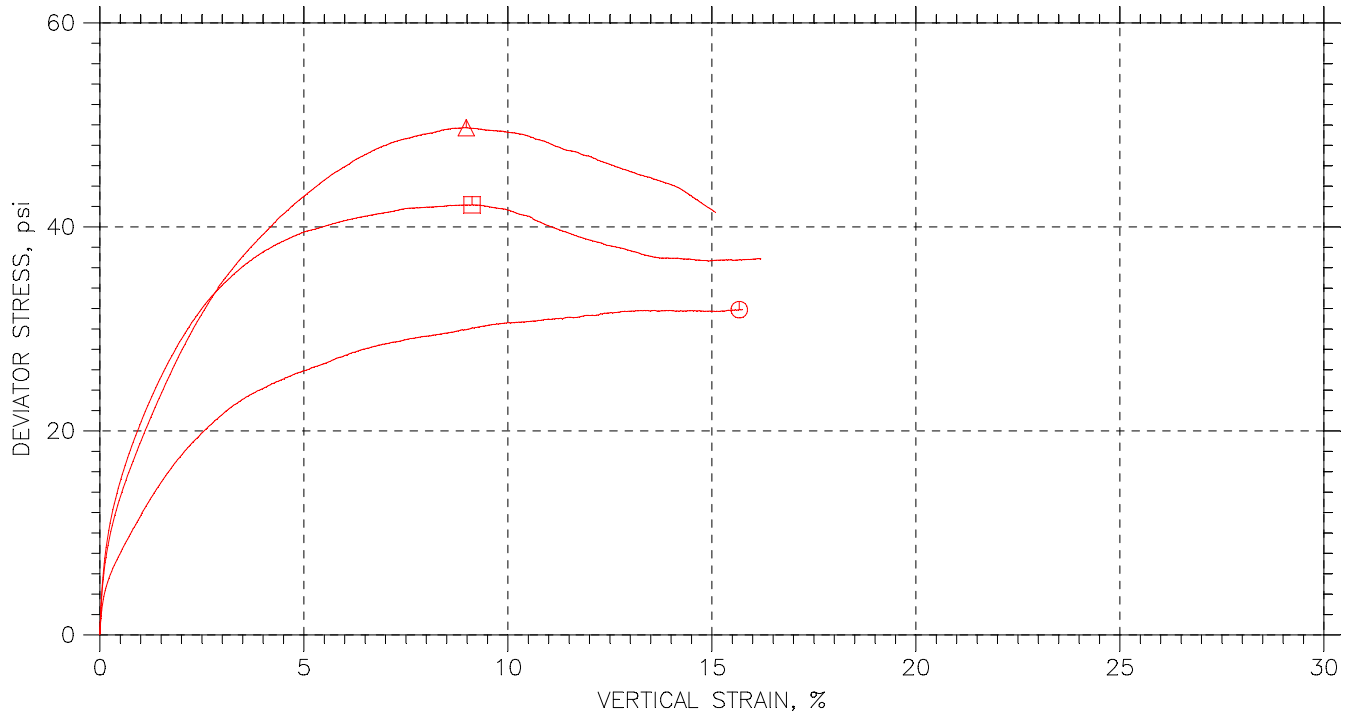
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767




	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	3.1	17.4-18.0	jm	12/15/09	mm		1516-3.1.dat
△	---	3.2	19.4-20.0	jm	12/16/09	mm		1516-3.2Adat.dat
□	---	3.3	20.8--21.4	jm	12/10/09	mm		1516-3.3.dat

 <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek		Location: Jefferson, IN		Project No.: GTX-1516	
	Boring No.: B-9		Sample Type: UD			
	Description: Brown lean clay with sand					
	Remarks: System 1057					

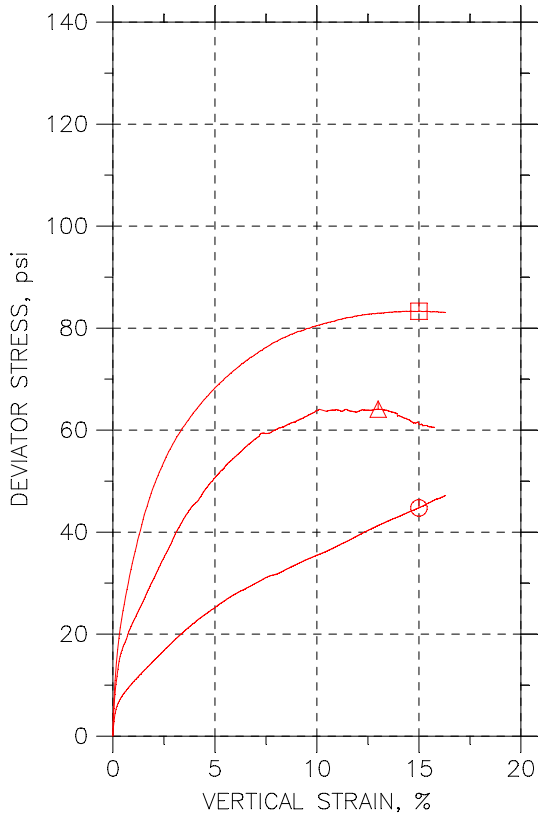
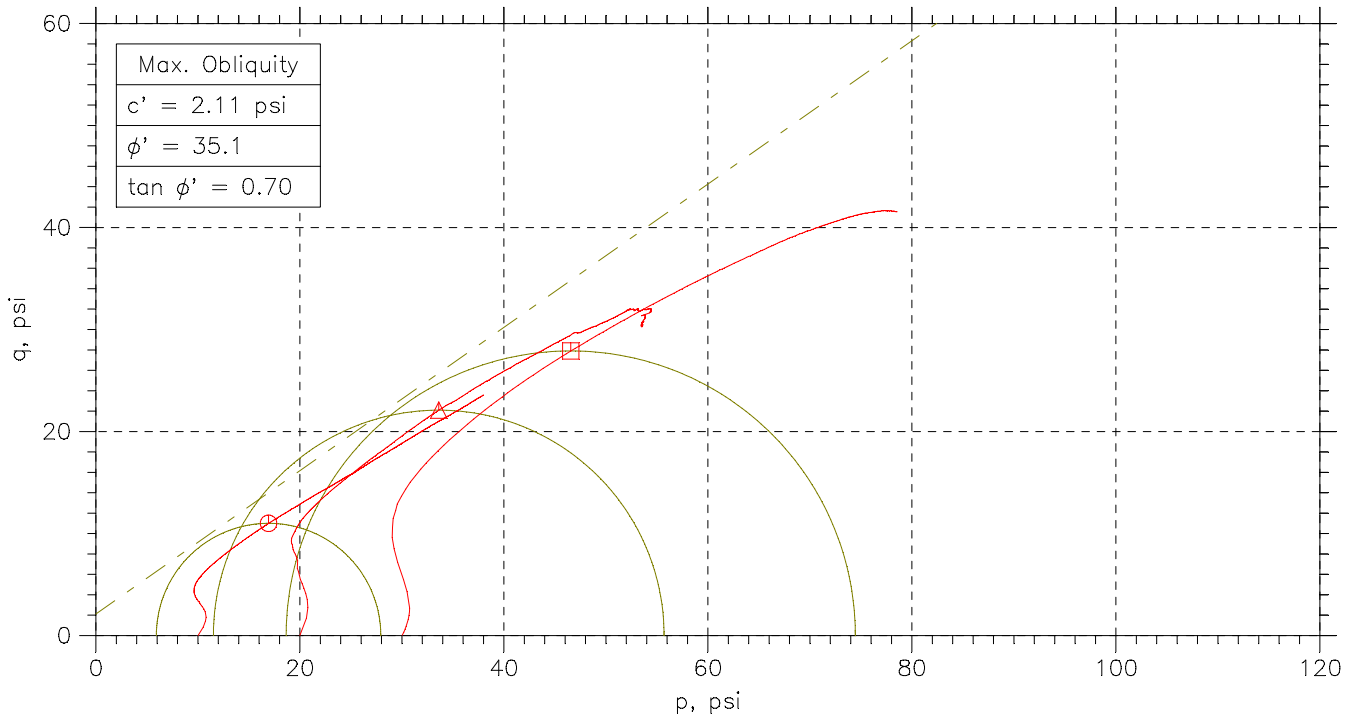
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊕	---	3.1	17.4-18.0	jm	12/15/09	mm		1516-3.1.dat
△	---	3.2	19.4-20.0	jm	12/16/09	mm		1516-3.2Adat.dat
□	---	3.3	20.8--21.4	jm	12/10/09	mm		1516-3.3.dat

 <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek		Location: Jefferson, IN		Project No.: GTX-1516	
	Boring No.: B-9		Sample Type: UD			
	Description: Brown lean clay with sand					
	Remarks: System 1057					

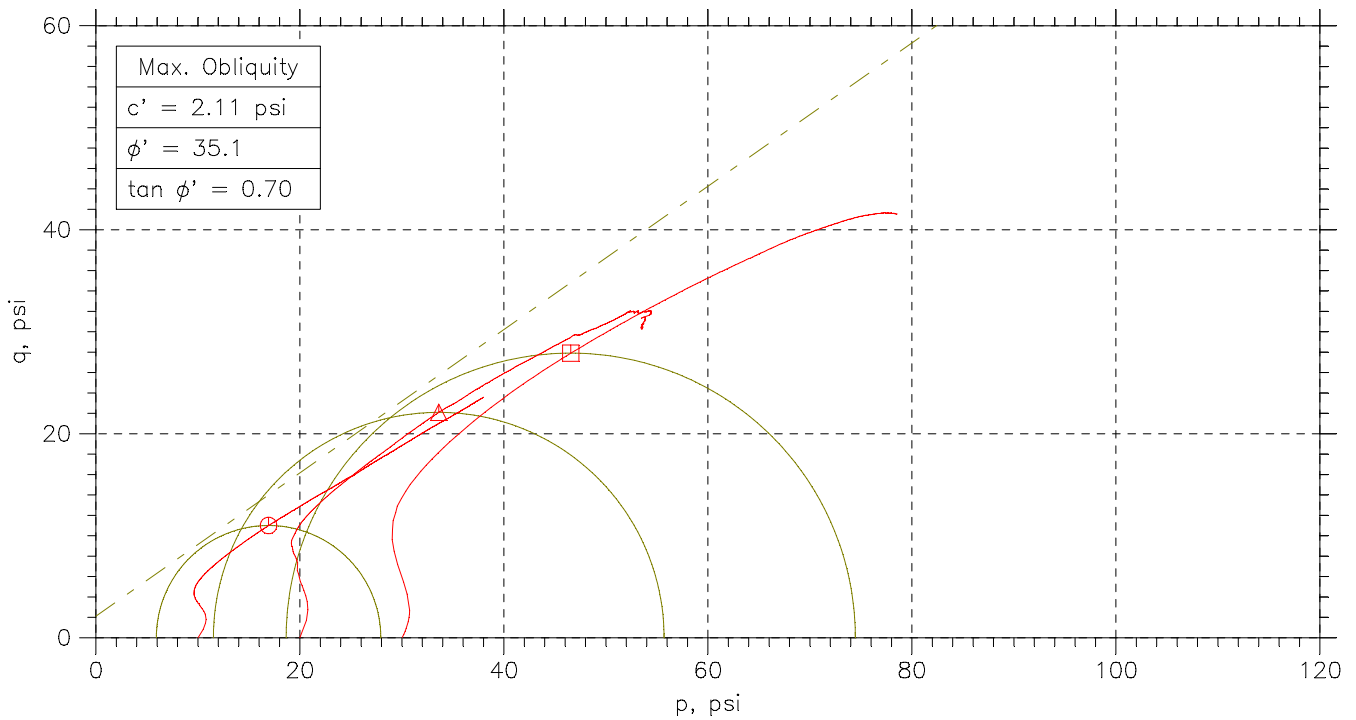
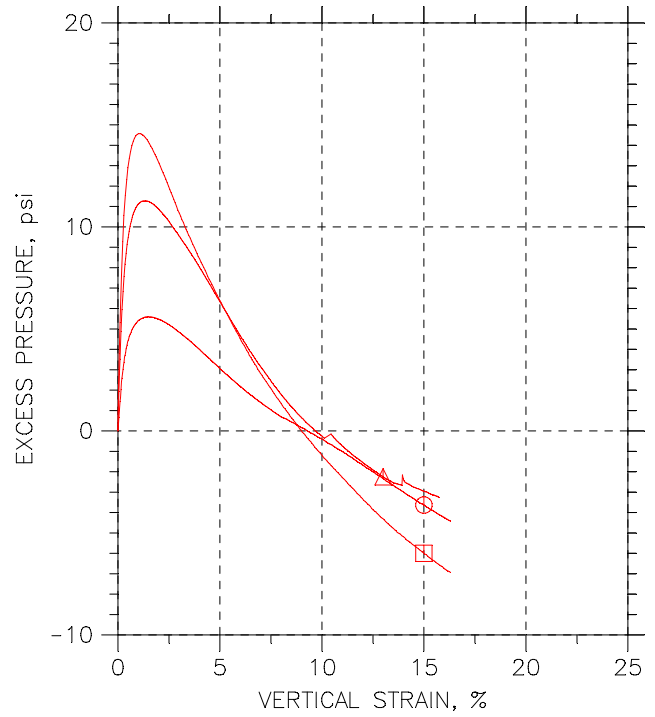
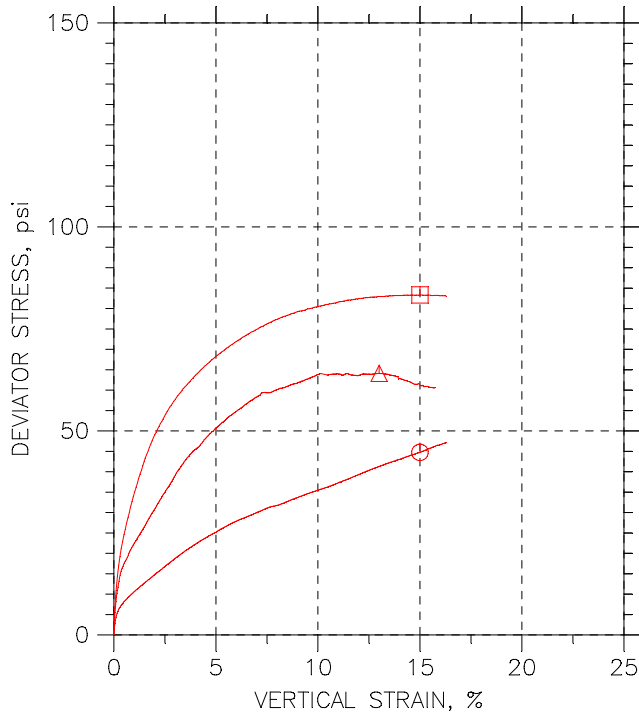
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767




Symbol	⊙	△	□	
Sample No.	---	----	----	
Test No.	CU-4.1	CU-4.2	CU-4.3	
Depth	13.4-14.0'	16.8-17.4'	17.4-18.'	
Initial	Diameter, in	2.83	2.71	2.72
	Height, in	5.78	5.52	5.51
	Water Content, %	14.2	27.4	26.6
	Dry Density, pcf	102.9	93.8	93.72
	Saturation, %	59.9	93.0	89.9
Before Shear	Void Ratio	0.638	0.797	0.798
	Water Content, %	23.2	18.5	19.2
	Dry Density, pcf	103.7	112.4	111.
	Saturation*, %	100.0	100.0	100.0
	Void Ratio	0.625	0.5	0.519
	Back Press., psi	27.99	73	84.99
	Ver. Eff. Cons. Stress, psi	10	19.99	30
	Shear Strength, psi	22.37	32.06	41.66
	Strain at Failure, %	15	13	15
	Strain Rate, %/min	0.032	0.032	0.032
	B-Value	0.95	0.95	0.96
	Estimated Specific Gravity	2.7	2.7	2.7
	Liquid Limit	---	---	---
	Plastic Limit	---	---	---

 <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek				
	Location: ----				
	Project No.: GTX-1516				
	Boring No.: B-10				
	Sample Type: UD				
	Description:				
Remarks: 2054					

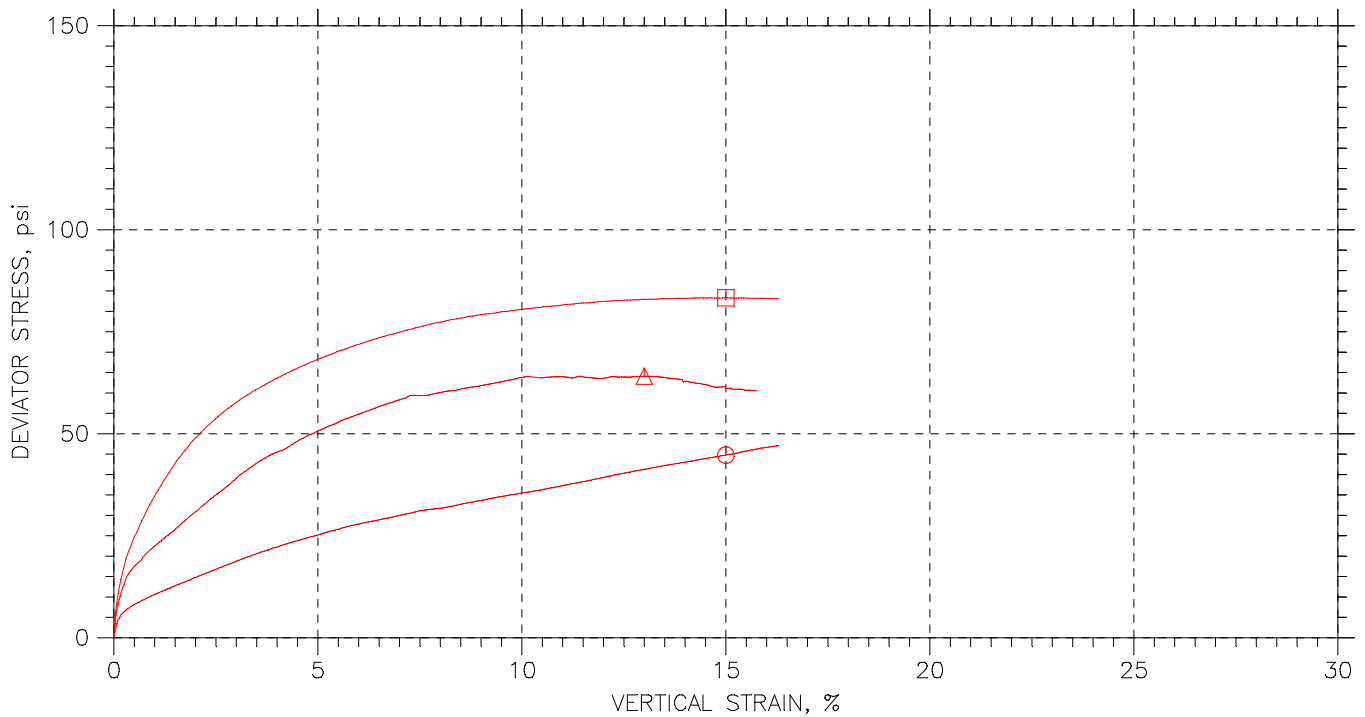
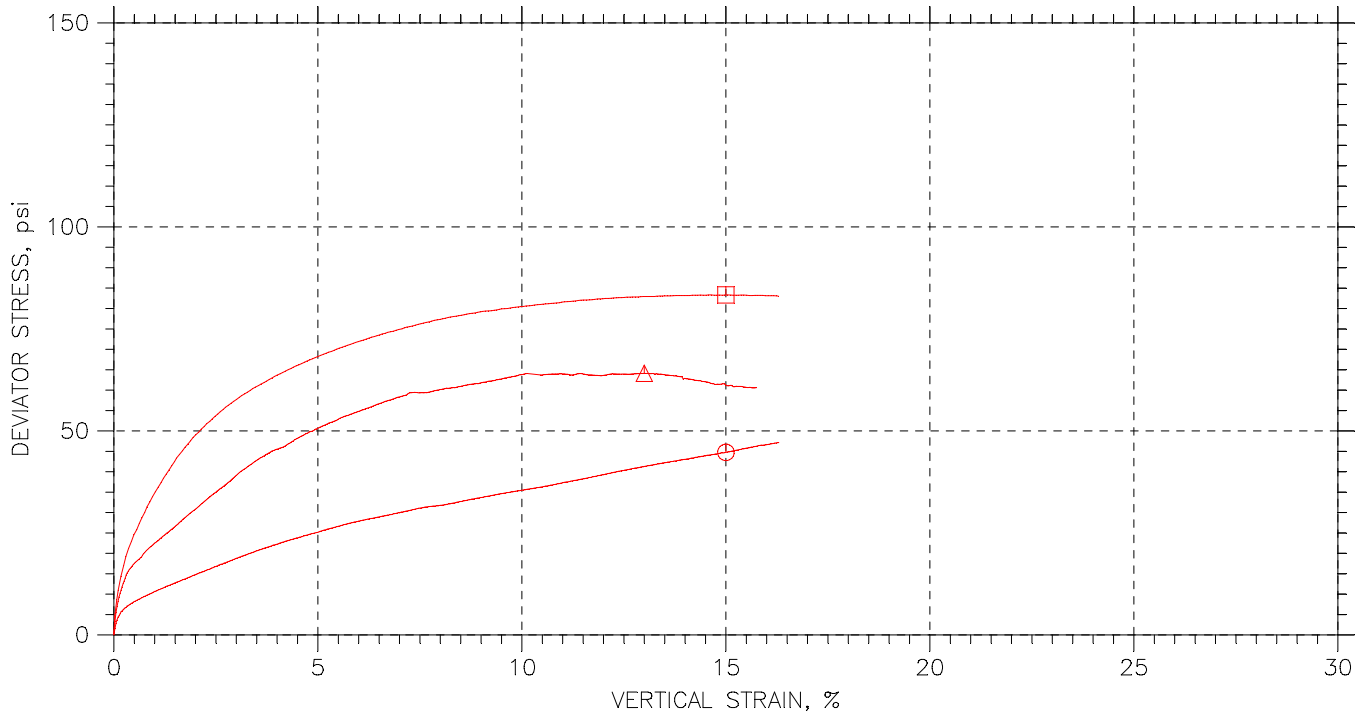
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767




	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	CU-4.1	13.4-14.0'	JM	12/12/09	MM		1516-4.1.dat
△	----	CU-4.2	16.8-17.4'	JM	12/13/09	MM		1516-4.2.dat
□	----	CU-4.3	17.4-18.'	JM	12/12/09	MM		1516-4.3.dat

 <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek		Location: ----		Project No.: GTX-1516	
	Boring No.: B-10		Sample Type: UD			
	Description:					
	Remarks: 2054					

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	CU-4.1	13.4-14.0'	JM	12/12/09	MM		1516-4.1.dat
△	----	CU-4.2	16.8-17.4'	JM	12/13/09	MM		1516-4.2.dat
□	----	CU-4.3	17.4-18.'	JM	12/12/09	MM		1516-4.3.dat

 <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek		Location: ----		Project No.: GTX-1516	
	Boring No.: B-10		Sample Type: UD			
	Description:					
	Remarks: 2054					

APPENDIX F

PERMEABILITY TESTS

BOILER SLAB POND DAM



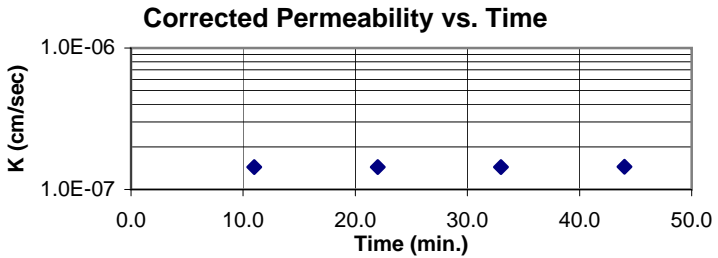
Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter ASTM D 5084-03

Project Name AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration Project No. 175539022
 Source B-1, 15.0'-17.0', T1 16.1'-16.6' Test ID 7A
 Visual Classification Lean Clay (CL), brown, moist, firm Prepared By CSM
 Undisturbed XX Specific Gravity 2.72 ASTM D854-A Date 12-9-09
 Maximum Dry Density (pcf) _____ Percent of Maximum _____
 Permeant: De-aired tap water
 Selection and Preparation Comments: _____

Specimens (if compacted) were compacted in a Proctor Mold as follows: The Maximum Dry Density was converted to Wet Density, this mass was divided by 4 (layers) and 3 of the 4 layers were compacted into the mold using a Proctor Hammer using 19 blows per layer. The density was varied by reducing the height of the drop by the amount listed beside "Compacted". The specimen was trimmed from the bottom two layers.

	Initial Specimen Data	After Consolidation Data	After Test Data	Final Pressures (psi)
Height (in.)	1.4783	1.4675	1.4676	Chamber <u>75</u>
Diameter (in.)	2.8043		2.8179	Influent <u>70</u>
Moisture Content (%)	19.7		20.8	Effluent <u>65</u>
Dry Unit Weight (pcf)	109.5		109.2	Applied Head Difference (psi) <u>5</u>
Void Ratio	0.551		0.555	Back Pressure Saturated to (psi) <u>65</u>
Degree of Saturation (%)	97.3		101.9	Maximum Effective Consolidation Stress (psi) <u>10</u>
Trimmings MC (%)	19.6			Minimum Effective Consolidation Stress (psi) <u>5</u>

Date	Clock (24H:M)	Temp. °F	Bottom Head	Top Head	Test Time (sec)	Hydraulic Conductivity			
						k (m/s)	k (cm/s)	k @ 20° C (m/s)	k @ 20° C (cm/s)
12-21-09	10:24	73.0	15.02	8.57	0	---	---	---	---
12-21-09	10:35	73.0	14.90	8.69	6.60E+02	1.5E-09	1.5E-07	1.4E-09	1.4E-07
12-21-09	10:46	73.0	14.78	8.81	6.60E+02	1.5E-09	1.5E-07	1.4E-09	1.4E-07
12-21-09	10:57	73.0	14.66	8.93	6.60E+02	1.5E-09	1.5E-07	1.4E-09	1.4E-07
12-21-09	11:08	73.0	14.54	9.05	6.60E+02	1.5E-09	1.5E-07	1.4E-09	1.4E-07



A gradient of approximately 93.4 was used for this test. This gradient exceeds ASTM guidelines for maximum gradient, but was used to achieve the requestors desired test duration. Examination of the sample shows no signs of material loss or clogging that may affect test results.

Average Hydraulic Conductivity @ 20° C (last 4 determinations) m/s 1.44E-09 cm/s 1.44E-07
 Average Hydraulic Conductivity @ 20° C (last run) m/s 1.44E-09 cm/s 1.44E-07

Reviewed by: _____



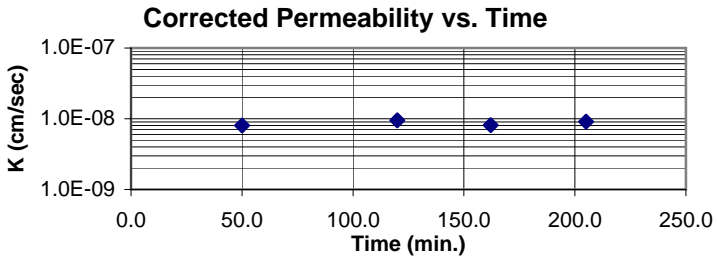
Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter ASTM D 5084-03

Project Name AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration Project No. 175539022
 Source B-2, 42.5'-44.5', T1 42.6'-43.1' Test ID 48A
 Visual Classification Lean Clay (CL), gray, wet, soft Prepared By CSM
 Undisturbed XX Specific Gravity 2.69 ASTM D854-A Date 11-30-09
 Maximum Dry Density (pcf) _____ Percent of Maximum _____
 Permeant: De-aired tap water
 Selection and Preparation Comments: _____

Specimens (if compacted) were compacted in a Proctor Mold as follows: The Maximum Dry Density was converted to Wet Density, this mass was divided by 4 (layers) and 3 of the 4 layers were compacted into the mold using a Proctor Hammer using 19 blows per layer. The density was varied by reducing the height of the drop by the amount listed beside "Compacted". The specimen was trimmed from the bottom two layers.

	Initial Specimen Data	After Consolidation Data	After Test Data	Final Pressures (psi)
Height (in.)	1.4906	1.3473	1.3472	Chamber <u>75</u>
Diameter (in.)	2.8023		2.8480	Influent <u>70</u>
Moisture Content (%)	31.6		26.0	Effluent <u>65</u>
Dry Unit Weight (pcf)	91.6		98.1	Applied Head Difference (psi) <u>5</u>
Void Ratio	0.834		0.712	Back Pressure Saturated to (psi) <u>65</u>
Degree of Saturation (%)	101.8		98.1	Maximum Effective Consolidation Stress (psi) <u>10</u>
Trimmings MC (%)	30.9			Minimum Effective Consolidation Stress (psi) <u>5</u>

Date	Clock (24H:M)	Temp. °F	Bottom Head	Top Head	Test Time (sec)	Hydraulic Conductivity			
						k (m/s)	k (cm/s)	k @ 20° C (m/s)	k @ 20° C (cm/s)
12-22-09	8:20	70.0	22.26	3.46	0	---	---	---	---
12-22-09	9:10	70.0	22.13	3.59	3.00E+03	8.3E-11	8.3E-09	8.1E-11	8.1E-09
12-22-09	10:20	70.0	21.92	3.81	4.20E+03	9.8E-11	9.8E-09	9.5E-11	9.5E-09
12-22-09	11:02	70.0	21.81	3.92	2.52E+03	8.4E-11	8.4E-09	8.1E-11	8.1E-09
12-22-09	11:45	70.0	21.68	4.04	2.58E+03	9.3E-11	9.3E-09	9.1E-11	9.1E-09



A gradient of approximately 92.6 was used for this test. This gradient exceeds ASTM guidelines for maximum gradient, but was used to achieve the requestors desired test duration. Examination of the sample shows no signs of material loss or clogging that may affect test results.

Average Hydraulic Conductivity @ 20° C (last 4 determinations) m/s 8.70E-11 cm/s 8.70E-09
 Average Hydraulic Conductivity @ 20° C (last run) m/s 8.70E-11 cm/s 8.70E-09

Reviewed by: _____



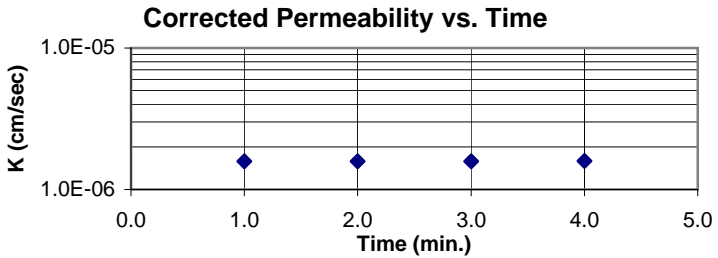
Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter ASTM D 5084-03

Project Name AEP-Clifty Creek- West Bottom Ash and Fly Ash Ponds subsurface exploration Project No. 175539022
 Source B-4, 7.5'-9.5', TI 7.6'-8.1' Test ID 82A
 Visual Classification Lean Clay (CL), brown, moist, firm, organic odor Prepared By CSM
 Undisturbed XX Specific Gravity 2.7 ASTM D854-A Date 12-9-09
 Maximum Dry Density (pcf) _____ Percent of Maximum _____
 Permeant: De-aired tap water
 Selection and Preparation Comments: _____

Specimens (if compacted) were compacted in a Proctor Mold as follows: The Maximum Dry Density was converted to Wet Density, this mass was divided by 4 (layers) and 3 of the 4 layers were compacted into the mold using a Proctor Hammer using 19 blows per layer. The density was varied by reducing the height of the drop by the amount listed beside "Compacted". The specimen was trimmed from the bottom two layers.

	Initial Specimen Data	After Consolidation Data	After Test Data	Final Pressures (psi)	
Height (in.)	1.4754	1.4631	1.4654	Chamber	75
Diameter (in.)	2.8057		2.8200	Influent	70
Moisture Content (%)	18.8		20.1	Effluent	65
Dry Unit Weight (pcf)	110.0		109.6	Applied Head Difference (psi)	5
Void Ratio	0.532		0.537	Back Pressure Saturated to (psi)	65
Degree of Saturation (%)	95.6		100.8	Maximum Effective Consolidation Stress (psi)	10
Trimmings MC (%)	19.1			Minimum Effective Consolidation Stress (psi)	5

Date	Clock (24H:M)	Temp. °F	Bottom Head	Top Head	Test Time (sec)	Hydraulic Conductivity			
						k (m/s)	k (cm/s)	k @ 20° C (m/s)	k @ 20° C (cm/s)
12-21-09	11:25	73.0	15.06	10.34	0	---	---	---	---
12-21-09	11:26	73.0	14.94	10.46	6.00E+01	1.7E-08	1.7E-06	1.6E-08	1.6E-06
12-21-09	11:27	73.0	14.82	10.58	6.00E+01	1.7E-08	1.7E-06	1.6E-08	1.6E-06
12-21-09	11:28	73.0	14.70	10.70	6.00E+01	1.7E-08	1.7E-06	1.6E-08	1.6E-06
12-21-09	11:29	73.0	14.58	10.82	6.00E+01	1.7E-08	1.7E-06	1.6E-08	1.6E-06



A gradient of approximately 93.5 was used for this test. This gradient exceeds ASTM guidelines for maximum gradient, but was used to achieve the requestors desired test duration. Examination of the sample shows no signs of material loss or clogging that may affect test results.

Average Hydraulic Conductivity @ 20° C (last 4 determinations) m/s 1.58E-08 cm/s 1.58E-06
 Average Hydraulic Conductivity @ 20° C (last run) m/s 1.58E-08 cm/s 1.58E-06

Reviewed by: _____



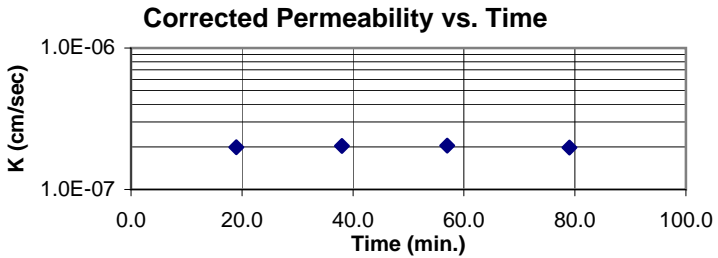
Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter ASTM D 5084-03

Project Name AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration Project No. 175539022
 Source B-6, 17.5'-19.0', T1 17.6'-18.1' Test ID 291
 Visual Classification Lean Clay (CL), brown, moist, firm Prepared By CSM
 Undisturbed XX Specific Gravity 2.68 ASTM D854-A Date 12-9-09
 Maximum Dry Density (pcf) _____ Percent of Maximum _____
 Permeant: De-aired tap water
 Selection and Preparation Comments: _____

Specimens (if compacted) were compacted in a Proctor Mold as follows: The Maximum Dry Density was converted to Wet Density, this mass was divided by 4 (layers) and 3 of the 4 layers were compacted into the mold using a Proctor Hammer using 19 blows per layer. The density was varied by reducing the height of the drop by the amount listed beside "Compacted". The specimen was trimmed from the bottom two layers.

	Initial Specimen Data	After Consolidation Data	After Test Data	Final Pressures (psi)	
Height (in.)	1.4778	1.4443	1.4478	Chamber	75
Diameter (in.)	2.8030		2.7955	Influent	70
Moisture Content (%)	32.0		33.2	Effluent	65
Dry Unit Weight (pcf)	87.1		89.4	Applied Head Difference (psi)	5
Void Ratio	0.921		0.872	Back Pressure Saturated to (psi)	65
Degree of Saturation (%)	93.1		102.1	Maximum Effective Consolidation Stress (psi)	10
Trimmings MC (%)	33.1			Minimum Effective Consolidation Stress (psi)	5

Date	Clock (24H:M)	Temp. °F	Bottom Head	Top Head	Test Time (sec)	Hydraulic Conductivity			
						k (m/s)	k (cm/s)	k @ 20° C (m/s)	k @ 20° C (cm/s)
12-21-09	13:10	73.0	19.94	4.28	0	---	---	---	---
12-21-09	13:29	73.0	19.65	4.56	1.14E+03	2.1E-09	2.1E-07	2.0E-09	2.0E-07
12-21-09	13:48	73.0	19.36	4.85	1.14E+03	2.2E-09	2.2E-07	2.0E-09	2.0E-07
12-21-09	14:07	73.0	19.07	5.14	1.14E+03	2.2E-09	2.2E-07	2.0E-09	2.0E-07
12-21-09	14:29	73.0	18.71	5.43	1.32E+03	2.1E-09	2.1E-07	2.0E-09	2.0E-07



A gradient of approximately 93.4 was used for this test. This gradient exceeds ASTM guidelines for maximum gradient, but was used to achieve the requestors desired test duration. Examination of the sample shows no signs of material loss or clogging that may affect test results.

Average Hydraulic Conductivity @ 20° C (last 4 determinations) m/s 2.01E-09 cm/s 2.01E-07
 Average Hydraulic Conductivity @ 20° C (last run) m/s 2.01E-09 cm/s 2.01E-07

Reviewed by: _____

LANDFILL RUNOFF COLLECTION POND

PERMEABILITY TEST (ASTM D5084 - 90) (Method C, Increasing Tailwater Level)

Project Number GTX-1516 Tested By JM
 Project Name Clifty Creek Test Date 12/12/10
 Boring No. B-7 Reviewed By MM
 Sample No. --- Review Date 12/15/10
 Sample Depth 27.4-27.7 ft Lab No. 5
 Sample Description Lean clay



Sample Data

Length, in		Diameter, in		Pan No.	CS-1
Location 1	2.831	Location 1	2.825	Dry Soil+Pan, grams	484.22
Location 2	2.830	Location 2	2.825	Pan Weight, grams	8.17
Location 3	2.829	Location 3	2.825		
Average	2.830	Average	2.825	Moisture Content, %	24.6
		Wet Soil + Tare, grams	593.33	Wet Unit Weight, pcf	127.4
		Tare Weight, grams	0.00	Dry Unit Weight, pcf	102.2

Remarks: _____

Chamber Pressure, psi 65
 Back Pressure, psi 60
 Confining Pressure, psi 5

Date Start	Date Finish	Time Start	Time Finish	Time (sec)	H _a (cm)	H ₁ (cm)	H _b (cm)	H ₂ (cm)	k cm/sec	Temp (°C)	k cm/sec at 20 °C
				2820	9.9	100.3	10.60	99.5	8.4E-08	22	8.1E-08
				6300	9.9	100.3	11.80	98.4	9.7E-08	24	8.8E-08
				9000	9.9	100.3	12.50	97.7	9.4E-08	24	8.5E-08
				14400	9.9	100.3	14.00	96.1	9.5E-08	24	8.6E-08
				27000	9.9	100.3	17.00	93	9.1E-08	24	8.3E-08

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	UD	102.2	N/A	Vertical

Avg. k at 20 °C 8.4E-08 cm/sec

a = area of burette in cm² H_a = initial inlet head in cm H_b = final inlet head in cm a = 0.16 cm²
 L = length of sample in cm H₁ = initial outlet head in cm H₂ = final outlet head in cm A = 40.44 cm²
 A = area of sample in cm² t = time in seconds L = 7.19 cm



HYDRAULIC CONDUCTIVITY

Project No. **GTX-1516** Tested By **JM**
Project Name **Clifty Creek** Test Date **12/12/2010**
Boring No. **B-7** Reviewed By **MM**
Sample No. **---** Review Date **12/15/2010**
Sample Depth **27.4-27.7 ft** Lab No. **5**
Sample Description **Lean clay**

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	<i>UD</i>
Sample Orientation:	<i>Vertical</i>
Initial Water Content, %:	<i>24.6</i>
Wet Unit Weight, pcf:	<i>127.4</i>
Dry Unit Weight, pcf:	<i>102.2</i>
Compaction, %:	<i>N/A</i>
Hydraulic Conductivity, cm/sec. @20 °C	<i>8.4E-08</i>

Remarks: _____

PERMEABILITY TEST (ASTM D5084 - 90) (Method C, Increasing Tailwater Level)

Project Number GTX-1516 Tested By JM
 Project Name Clifty Creek Test Date 12/12/10
 Boring No. B-8 Reviewed By MM
 Sample No. --- Review Date 12/15/10
 Sample Depth 29.7-30.3 ft Lab No. 7
 Sample Description Lean clay with sand



Sample Data

Length, in		Diameter, in		Pan No.	A44
Location 1	2.841	Location 1	2.775	Dry Soil+Pan, grams	487.70
Location 2	2.843	Location 2	2.784	Pan Weight, grams	8.99
Location 3	2.844	Location 3	2.788		
Average	2.843	Average	2.782	Moisture Content, %	23.5
		Wet Soil + Tare, grams	591.11	Wet Unit Weight, pcf	130.3
		Tare Weight, grams	0.00	Dry Unit Weight, pcf	105.5

Remarks: _____

Chamber Pressure, psi 65
 Back Pressure, psi 60
 Confining Pressure, psi 5

Date Start	Date Finish	Time Start	Time Finish	Time (sec)	H _a (cm)	H ₁ (cm)	H _b (cm)	H ₂ (cm)	k cm/sec	Temp (°C)	k cm/sec at 20 °C
				3200	6.5	107.2	6.90	106.9	3.2E-08	22	3.1E-08
				6600	6.5	107.2	7.40	106.4	3.8E-08	24	3.4E-08
				11400	6.5	107.2	8.10	105.7	4.0E-08	24	3.7E-08
				18000	6.5	107.2	9.00	104.8	4.1E-08	24	3.7E-08
				30000	6.5	107.2	10.20	103.6	3.7E-08	24	3.3E-08

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	UD	105.5	N/A	Vertical

Avg. k at 20 °C 3.4E-08 cm/sec

a = area of burette in cm² H_a = initial inlet head in cm H_b = final inlet head in cm a = 0.16 cm²
 L = length of sample in cm H₁ = initial outlet head in cm H₂ = final outlet head in cm A = 39.23 cm²
 A = area of sample in cm² t = time in seconds L = 7.22 cm



HYDRAULIC CONDUCTIVITY

Project No. **GTX-1516** Tested By **JM**
Project Name **Clifty Creek** Test Date **12/12/2010**
Boring No. **B-8** Reviewed By **MM**
Sample No. **---** Review Date **12/15/2010**
Sample Depth **29.7-30.3 ft** Lab No. **7**
Sample Description **Lean clay with sand**

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	<i>UD</i>
Sample Orientation:	<i>Vertical</i>
Initial Water Content, %:	<i>23.5</i>
Wet Unit Weight, pcf:	<i>130.3</i>
Dry Unit Weight, pcf:	<i>105.5</i>
Compaction, %:	<i>N/A</i>
Hydraulic Conductivity, cm/sec. @20 °C	<i>3.4E-08</i>

Remarks: _____

PERMEABILITY TEST (ASTM D5084 - 90) (Method C, Increasing Tailwater Level)

Project Number GTX-1516 Tested By JM
 Project Name Clifty Creek Test Date 12/12/10
 Boring No. B-9 Reviewed By MM
 Sample No. --- Review Date 12/15/10
 Sample Depth 18.3-18.6 Lab No. 8
 Sample Description Lean clay



Sample Data

Length, in		Diameter, in		Pan No.	a-18
Location 1	2.899	Location 1	2.872	Dry Soil+Pan, grams	541.33
Location 2	2.901	Location 2	2.877	Pan Weight, grams	9.11
Location 3	2.905	Location 3	2.877		
Average	2.902	Average	2.875	Moisture Content, %	21.0
		Wet Soil + Tare, grams	644.22	Wet Unit Weight, pcf	130.3
		Tare Weight, grams	0.00	Dry Unit Weight, pcf	107.6

Remarks: _____

Chamber Pressure, psi 65
 Back Pressure, psi 60
 Confining Pressure, psi 5

Date Start	Date Finish	Time Start	Time Finish	Time (sec)	H _a (cm)	H ₁ (cm)	H _b (cm)	H ₂ (cm)	k cm/sec	Temp (°C)	k cm/sec at 20 °C
				1800	5.3	100.4	5.70	100	6.6E-08	22	6.3E-08
				4800	5.3	100.4	6.40	99.3	6.9E-08	24	6.2E-08
				8400	5.3	100.4	7.20	98.5	6.8E-08	24	6.2E-08
				16200	5.3	100.4	8.80	96.9	6.6E-08	24	6.0E-08
				27000	5.3	100.4	11.00	94.7	6.7E-08	24	6.0E-08

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	UD	107.6	N/A	Vertical

Avg. k at 20 °C 6.2E-08 cm/sec

a = area of burette in cm² H_a = initial inlet head in cm H_b = final inlet head in cm a = 0.16 cm²
 L = length of sample in cm H₁ = initial outlet head in cm H₂ = final outlet head in cm A = 41.89 cm²
 A = area of sample in cm² t = time in seconds L = 7.37 cm



HYDRAULIC CONDUCTIVITY

Project No.	<i>GTX-1516</i>	Tested By	<i>JM</i>
Project Name	<i>Clifty Creek</i>	Test Date	<i>12/12/2010</i>
Boring No.	<i>B-9</i>	Reviewed By	<i>MM</i>
Sample No.	<i>---</i>	Review Date	<i>12/15/2010</i>
Sample Depth	<i>18.3-18.6</i>	Lab No.	<i>8</i>
Sample Description	<i>Lean clay</i>		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	<i>UD</i>
Sample Orientation:	<i>Vertical</i>
Initial Water Content, %:	<i>21.0</i>
Wet Unit Weight, pcf:	<i>130.3</i>
Dry Unit Weight, pcf:	<i>107.6</i>
Compaction, %:	<i>N/A</i>
Hydraulic Conductivity, cm/sec. @20 °C	<i>6.2E-08</i>

Remarks: _____

PERMEABILITY TEST (ASTM D5084 - 90) (Method C, Increasing Tailwater Level)

Project Number GTX-1516 Tested By JM
 Project Name Clifty Creek Test Date 12/12/10
 Boring No. B-10 Reviewed By MM
 Sample No. --- Review Date 12/15/10
 Sample Depth 16.4-16.7 ft Lab No. 11
 Sample Description Lean clay



Sample Data

Length, in		Diameter, in		Pan No.	a-22
Location 1	3.121	Location 1	2.876	Dry Soil+Pan, grams	539.99
Location 2	3.203	Location 2	2.877	Pan Weight, grams	9.13
Location 3	3.126	Location 3	2.877		
Average	3.150	Average	2.877	Moisture Content, %	21.1
		Wet Soil + Tare, grams	642.99	Wet Unit Weight, pcf	119.6
		Tare Weight, grams	0.00	Dry Unit Weight, pcf	98.8

Remarks: _____

Chamber Pressure, psi 65
 Back Pressure, psi 60
 Confining Pressure, psi 5

Date Start	Date Finish	Time Start	Time Finish	Time (sec)	H _a (cm)	H ₁ (cm)	H _b (cm)	H ₂ (cm)	k cm/sec	Temp (°C)	k cm/sec at 20 °C
				1800	7.7	99.3	8.50	98.5	1.5E-07	22	1.4E-07
				4800	7.7	99.3	9.90	97.1	1.6E-07	22	1.5E-07
				8400	7.7	99.3	11.20	94.7	1.7E-07	22	1.6E-07
				16200	7.7	99.3	13.00	92.9	1.3E-07	22	1.2E-07
				24000	7.7	99.3	15.00	90.9	1.2E-07	22	1.1E-07

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	UD	107.6	N/A	Vertical

Avg. k at 20 °C 1.4E-07 cm/sec

a = area of burette in cm² H_a = initial inlet head in cm H_b = final inlet head in cm a = 0.16 cm²
 L = length of sample in cm H₁ = initial outlet head in cm H₂ = final outlet head in cm A = 41.93 cm²
 A = area of sample in cm² t = time in seconds L = 8.00 cm



HYDRAULIC CONDUCTIVITY

Project No. **GTX-1516** Tested By **JM**
Project Name **Clifty Creek** Test Date **12/12/2010**
Boring No. **B-10** Reviewed By **MM**
Sample No. **---** Review Date **12/15/2010**
Sample Depth **16.4-16.7 ft** Lab No. **11**
Sample Description **Lean clay**

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	<i>UD</i>
Sample Orientation:	<i>Vertical</i>
Initial Water Content, %:	<i>21.1</i>
Wet Unit Weight, pcf:	<i>119.6</i>
Dry Unit Weight, pcf:	<i>98.8</i>
Compaction, %:	<i>N/A</i>
Hydraulic Conductivity, cm/sec. @20 °C	<i>1.4E-07</i>

Remarks: _____

APPENDIX G

STANDARD PROCTOR MOISTURE-DENSITY TESTS

BOILER SLAG POND DAM



Moisture-Density Data Sheet

Project: AEP - Clifty Creek - West Bottom Ash Pond

Project No.: 175539022

Source: B-1, 5.0'

Sample No.: 319

Sample Description: Brown lean clay with gravel, moist

Nmc: 15.6 %

Visual Notes: N/A

Test Method: ASTM D 698 - Method A

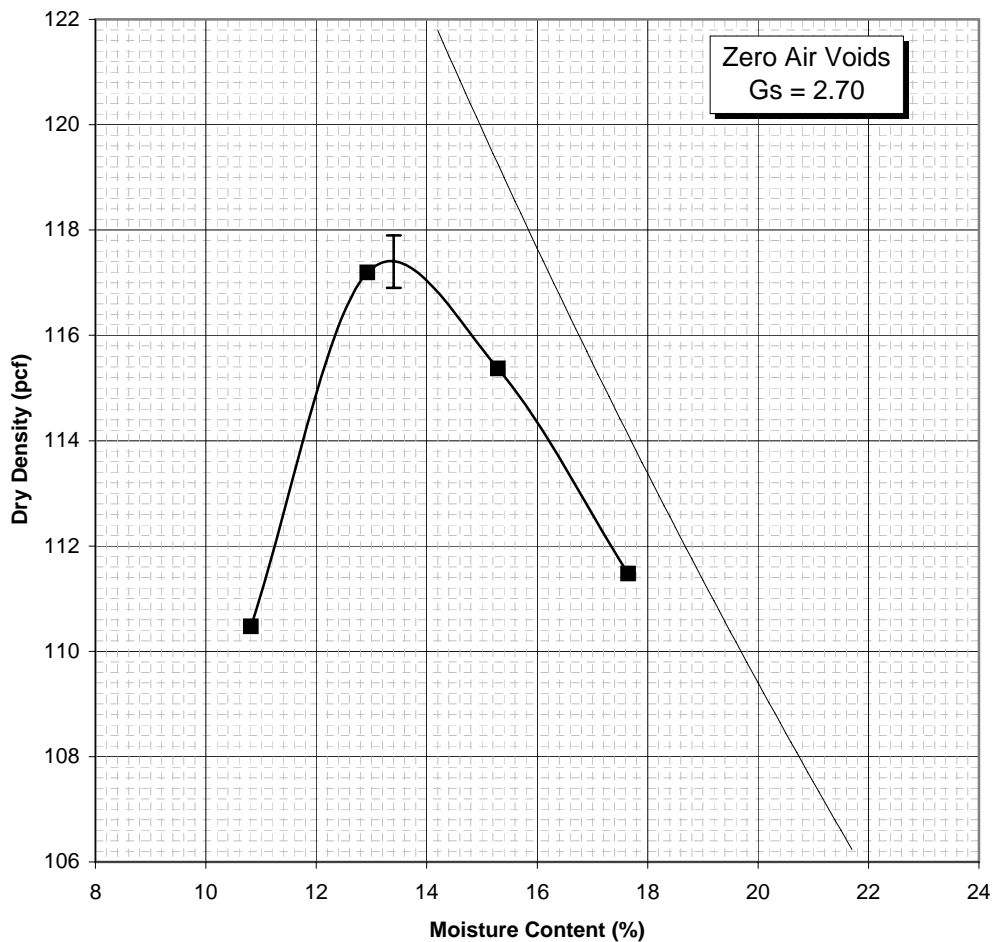
Prepared: Dry

Oversized Fraction: < 5 %

Rammer: Mechanical

Gs - Fines: Assumed

Mold Weight 2041 grams		Moisture Determination				
Wet Weight plus Mold (grams)	Wet Weight minus Mold (grams)	Wet Soil and Can Weight (grams)	Dry Soil and Can Weight (grams)	Can Weight (grams)	Water Content (%)	Dry Density (pcf)
3879	1838	432.75	397.39	70.52	10.8	110.5
4028	1987	462.87	418.39	74.30	12.9	117.2
4038	1997	405.73	362.08	76.62	15.3	115.4
4010	1969	368.39	324.37	74.94	17.6	111.5



Maximum Dry Density 117.4 PCF
Optimum Moisture Content 13.4 %



Moisture-Density Data Sheet

Project: AEP - Clifty Creek - West Bottom Ash Pond

Project No.: 175539022

Source: B-5, 7.5'

Sample No.: 320

Sample Description: brown lean clay, moist

Nmc: 18.2 %

Visual Notes: N/A

Test Method: ASTM D 698 - Method A

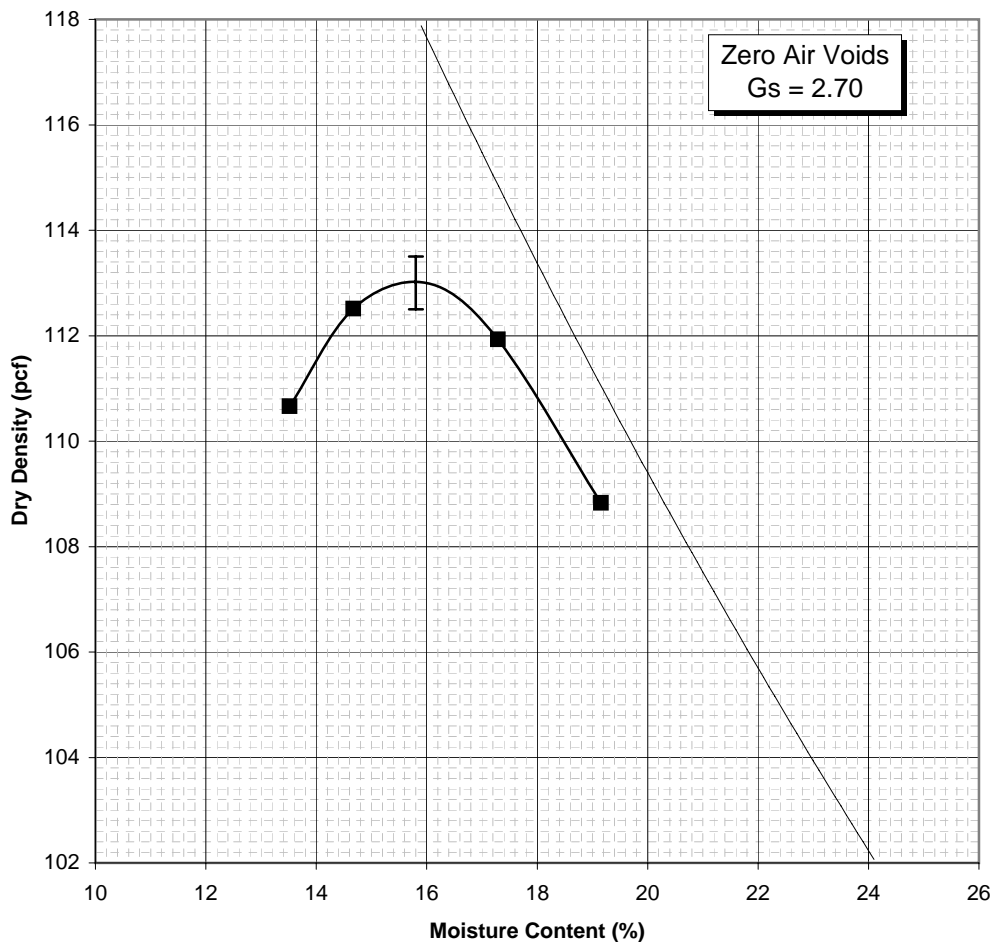
Prepared: Dry

Oversized Fraction: < 5 %

Rammer: Mechanical

Gs - Fines: Assumed

Mold Weight 2041 grams		Moisture Determination				
Wet Weight plus Mold (grams)	Wet Weight minus Mold (grams)	Wet Soil and Can Weight (grams)	Dry Soil and Can Weight (grams)	Can Weight (grams)	Water Content (%)	Dry Density (pcf)
3927	1886	422.84	381.18	72.94	13.5	110.7
3978	1937	388.97	348.78	74.79	14.7	112.5
4012	1971	392.34	345.43	74.11	17.3	111.9
3988	1947	409.73	355.79	74.24	19.2	108.8



Maximum Dry Density 113.0 PCF
Optimum Moisture Content 15.8 %

LANDFILL RUNOFF COLLECTION POND



Moisture-Density Data Sheet

Project: AEP - Clifty Creek - South Fly Ash Pond

Project No.: 175539022

Source: B-7, 7.0'

Sample No.: 321

Sample Description: brown lean clay, moist

Nmc: 20.5 %

Visual Notes: N/A

Test Method: ASTM D 698 - Method A

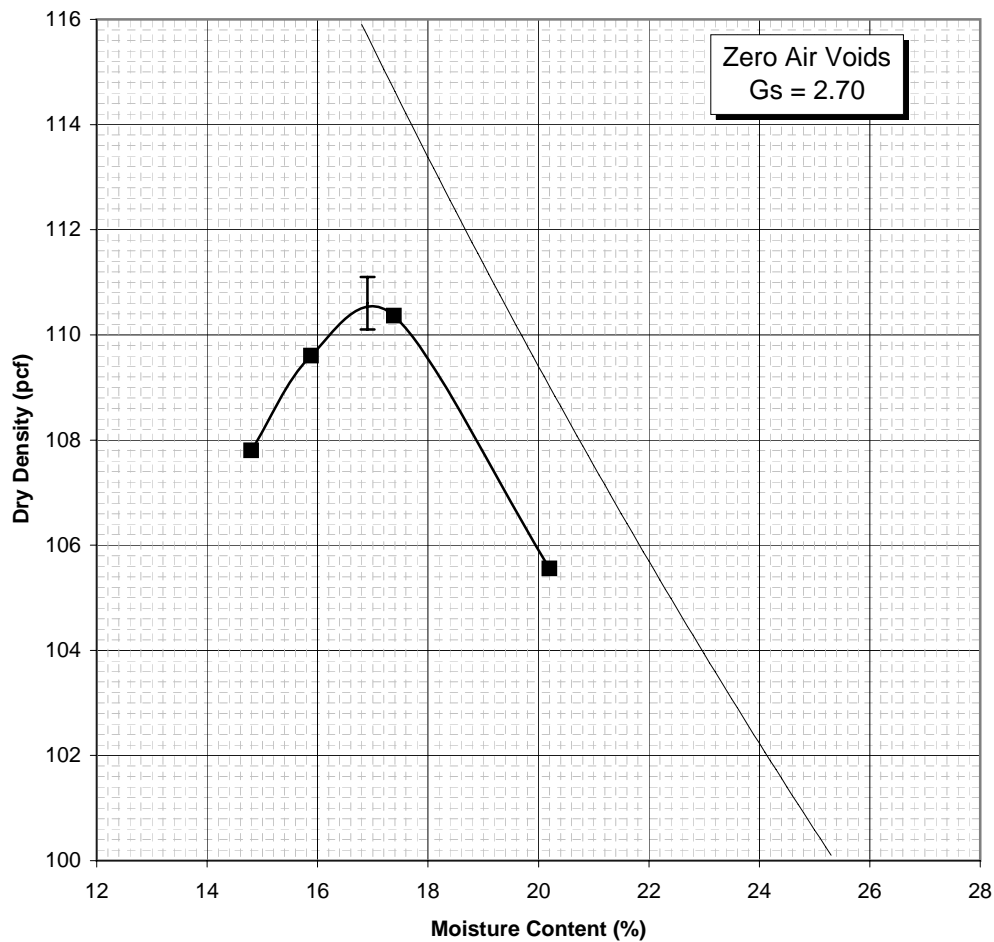
Prepared: Dry

Oversized Fraction: < 5 %

Rammer: Mechanical

Gs - Fines: Assumed

Mold Weight 2041 grams		Moisture Determination				
Wet Weight plus Mold (grams)	Wet Weight minus Mold (grams)	Wet Soil and Can Weight (grams)	Dry Soil and Can Weight (grams)	Can Weight (grams)	Water Content (%)	Dry Density (pcf)
3899	1858	421.72	374.30	53.84	14.8	107.8
3948	1907	420.48	370.25	54.04	15.9	109.6
3986	1945	425.03	373.25	75.37	17.4	110.4
3946	1905	465.82	400.33	76.15	20.2	105.6



Maximum Dry Density 110.6 PCF
Optimum Moisture Content 16.9 %

APPENDIX H

LIQUEFACTION ANALYSIS

BOILER SLAG POND DAM: 2015 CCR
MANDATE

FINE-GRAINED ANALYSIS

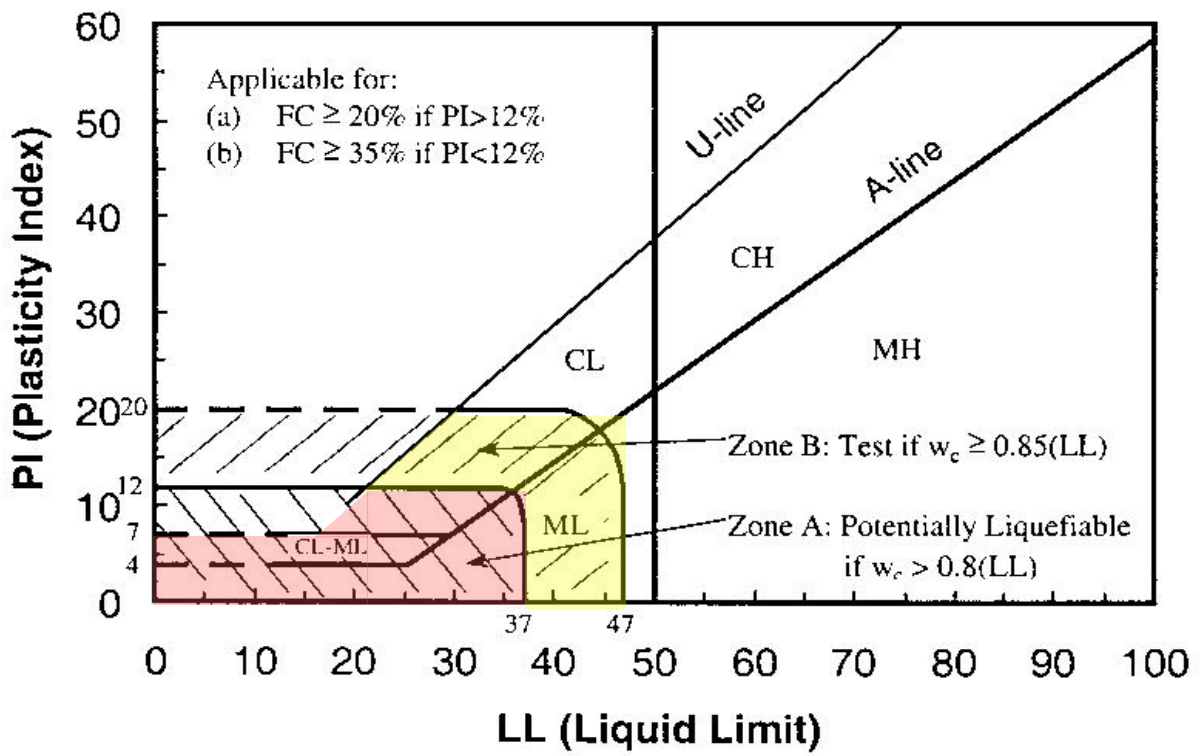
Liquefaction Susceptibility of Fine-Grained Soils

Stantec Project Number:	175553022
Project Name:	AEP Clifty Creek
Site/Structure Name:	West Bottom Ash Dam

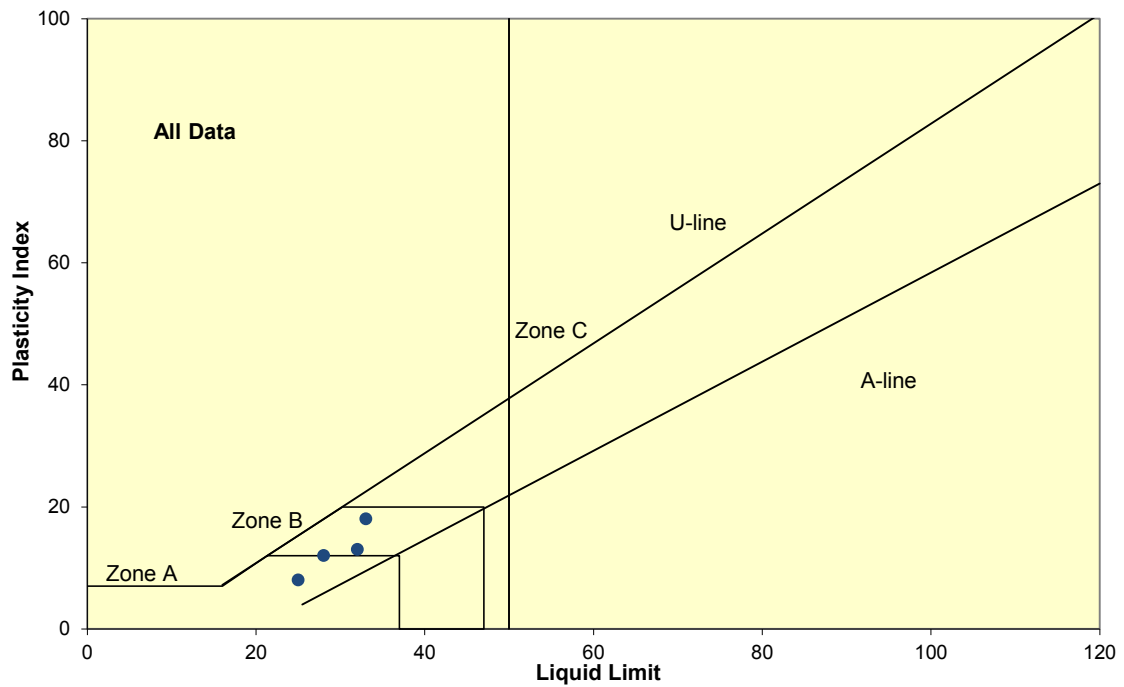
Note: NP = Non-Plastic

Lab ID	Boring	Depth(s)	Soil Classification	NMC (w _c) (%)	% Passing #200	% Passing #40	LL	PI
4	B-1	10.0-11.5, 12.5-14.0	CL	19.1	84	98.4	32	13
20	B-1	47.5-49.0, 50.0-51.5	CL	25.3	84.1	99.7	28	12
43	B-2	32.5-34.0, 35.0-36.5	CL	32.1	79.7	98.7	33	18
87	B-4	20.0-21.5, 22.5-24.0	CL	26.6	80.7	99.7	25	8
103	B-4	57.5-59.0, 60.0-61.5	GW-GM	10.9	5.7	13.6	NP	NP
129	B-5	55.0-56.5, 57.5-59.0	ML	24.9	54	99.9	NP	NP

Sand-like versus Clay-like Behavior (-1 indicates result does not meet criteria, green shading indicates result does meet criteria, no results shown for non-plastic material)												Overall Judgement based on 3 methods (sand-like or clay-like)
Using Criteria published by Seed et al (2003)						Using Criteria published by Idriss and Boulanger (2008)		Using criteria published by MSHA (2010)				
Meets criteria for sand-like behavior		Meets criteria for clay-like behavior				Meets criteria for sand-like behavior	Meets criteria for clay-like behavior	Meets criteria for sand-like behavior	Meets criteria for clay-like behavior	Borderline soils (treat as sand-like)		
LL in Zone A (see plot)	PI in Zone A (see plot)	LL in Zone B (see plot)	PI in Zone B (see plot)	LL in Zone C (see plot)	PI in Zone C (see plot)	PI < 7	PI >= 7	PI <= 7	P40>=35%, P200>=20%, and PI>=10	7 < PI < 10, or does not meet P40 or P200		
-1	-1	32	13	-1	-1	-1	13	-1	13	-1	Clay-like	
28	12	-1	-1	-1	-1	-1	12	-1	12	-1	Clay-like	
-1	-1	33	18	-1	-1	-1	18	-1	18	-1	Clay-like	
25	8	-1	-1	-1	-1	-1	8	-1	-1	8	Sand-like	
											Sand-like	
											Sand-like	

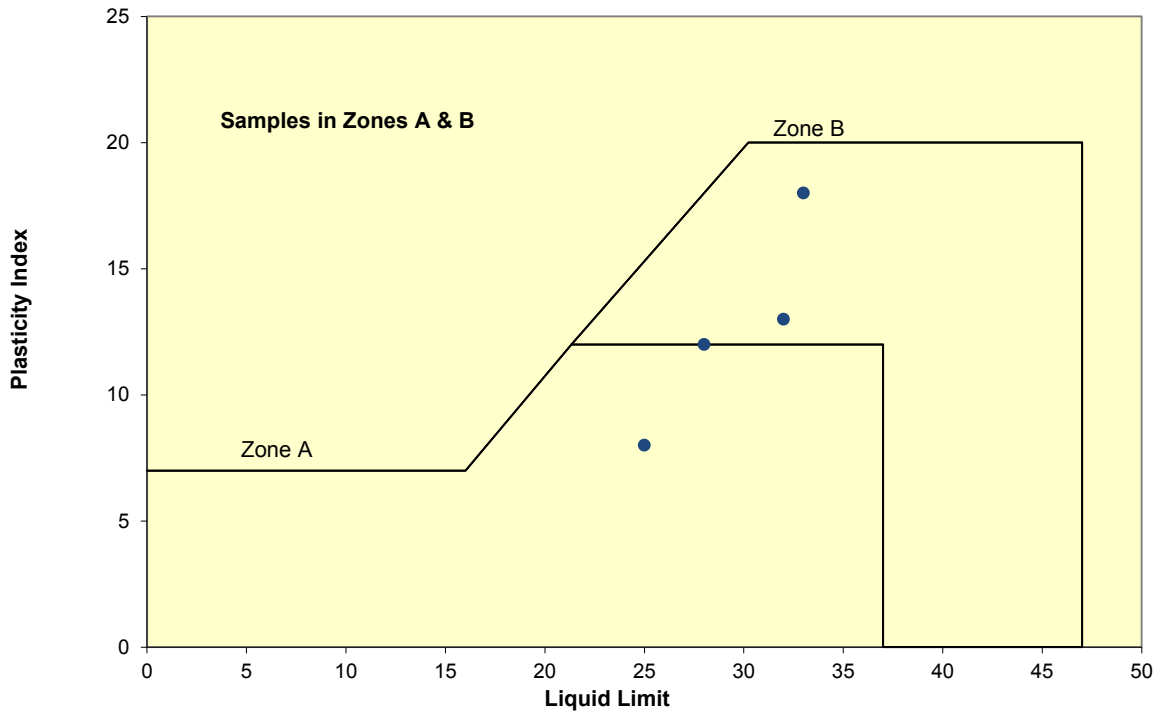


(a)

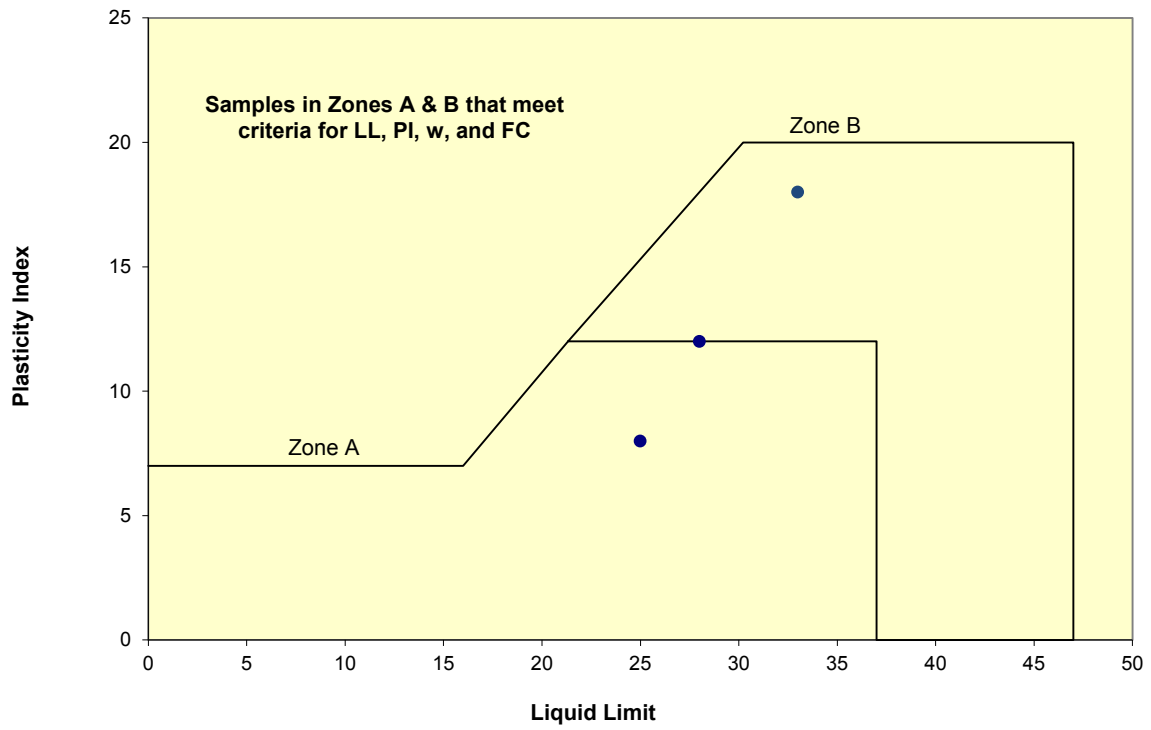


(b)

Screening Criteria for Liquefiable Fine-Grained Soils (Seed et al. 2003)

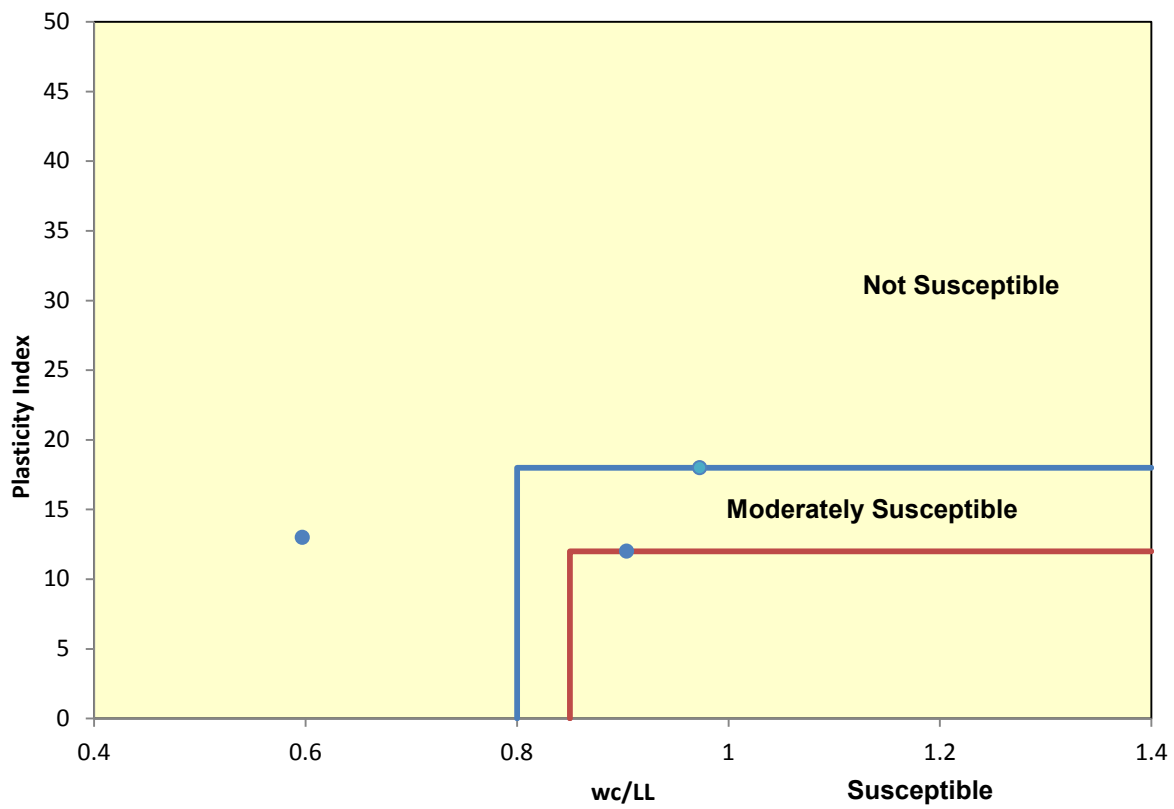
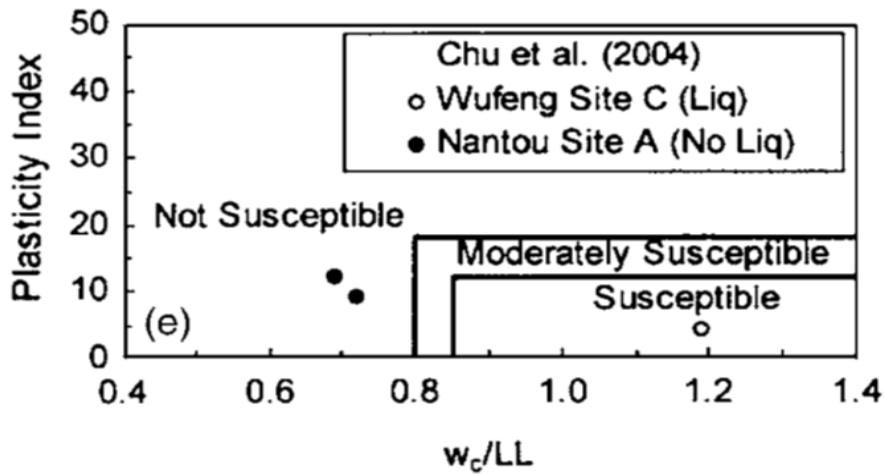


(c)



(d)

Screening Criteria for Liquefiable Fine-Grained Soils (Seed et al. 2003)

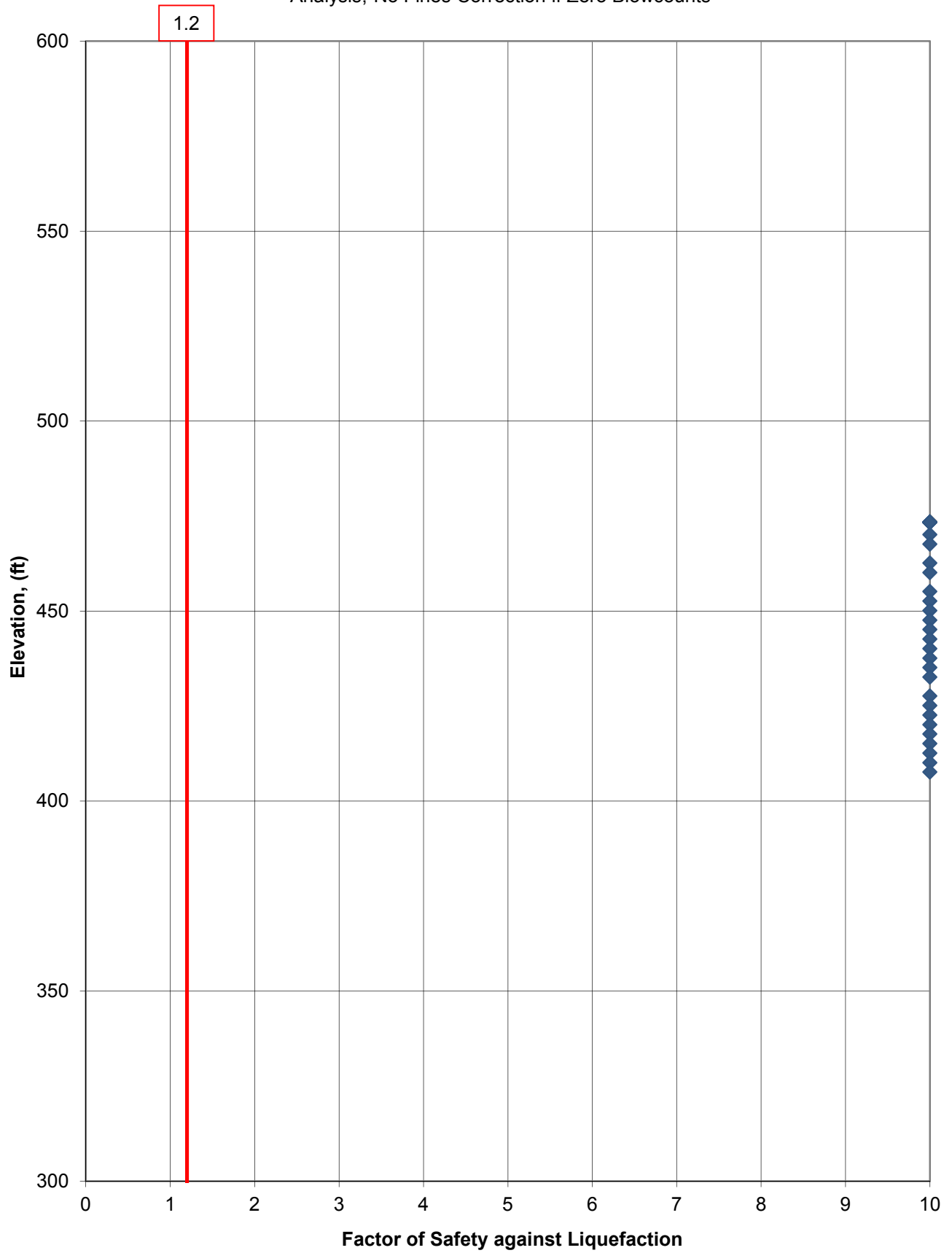


Screening Criteria for Assessing Liquefaction in Fine Grained Soils (Bray and Sancio 2006)

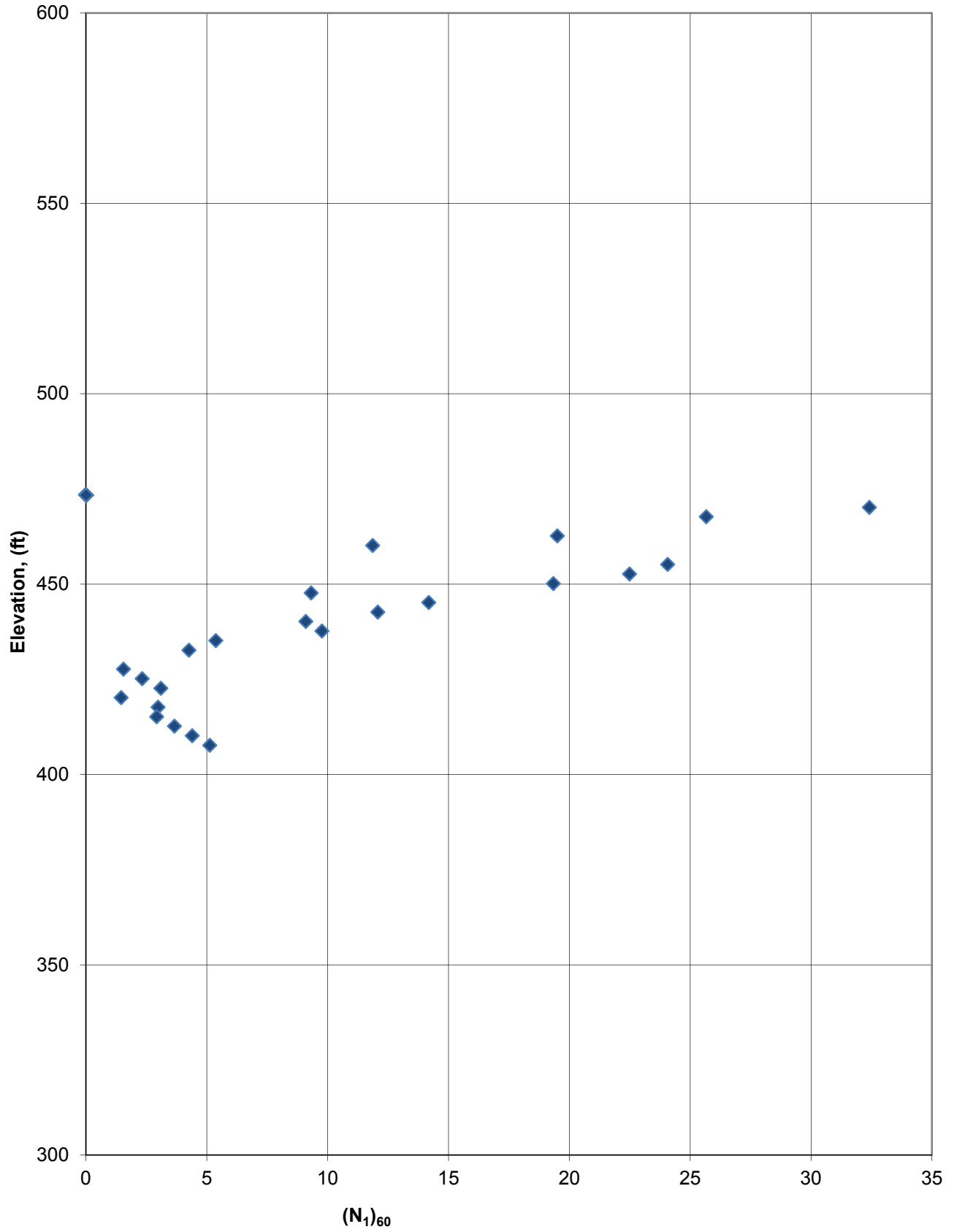
COARSE-GRAINED ANALYSIS

Depth of Mid. Pt. of Sample (ft.)	Vert. Total Stress during EQ (tsf)	Vert. Total Stress during EQ w/ Fill (tsf)	Static Pore Pressure during EQ (tsf)	Vert. Eff. Stress during EQ (tsf)	Vert. Eff. Stress during EQ w/ Fill (tsf)	Alpha I	Beta I	Equivalent Clean Sand N-Value (N) _{60cs}	CRR7.5	Ksigma	Kalpha	EQ Source		Event (MCE, OBE, etc.)	Shake Stress Curve Fit Parameters			Using SHAKE Data					
												a max (g)	EQ Mag (Mw)		m4:	m3:	m2:	m1:	CSR eq	FS liq	FS liq	FS liq	FS liq
z	σ_v	$\sigma_{v,with fill}$	u	σ'_v	$\sigma'_{v,with fill}$							Mag. Scaling	CRR	EQ Motion File	Max. Shake Stress (psf)	Avg. Shake Stress (psf)	Design EQ	Design EQ	Design EQ	Design EQ	for plot	Design EQ	for plot
Boring ID: B-1						<p>Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.</p>																	
Top of Fill Elevation: 473.4																							
Fill Height: 0.0																							
Fill Total Unit Weight: 125																							
Fill Total Stress: 0.00																							
	totstr-top		u-top	effstr-top																			
	0.16		0.00	0.16																			
3.3	0.20	0.20	0.00	0.20	0.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.00	
5.8	0.36	0.36	0.00	0.36	0.36	NA	NA	NA	NA	NA	NA	0.95	NA	0.989	0.055	0	0	0.000	NA	10.0	NA	10.00	
10.8	0.67	0.67	0.00	0.67	0.67	NA	NA	NA	NA	NA	NA	0.95	NA	0.978	0.054	0	0	0.000	NA	10.0	NA	10.00	
13.3	0.83	0.83	0.00	0.83	0.83	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	10.00	
18.3	1.14	1.14	0.00	1.14	1.14	NA	NA	NA	NA	NA	NA	0.95	NA	0.961	0.053	0	0	0.000	NA	10.0	NA	10.00	
20.8	1.30	1.30	0.00	1.30	1.30	NA	NA	NA	NA	NA	NA	0.95	NA	0.955	0.053	0	0	0.000	NA	10.0	NA	10.00	
23.3	1.45	1.45	0.00	1.45	1.45	NA	NA	NA	NA	NA	NA	0.95	NA	0.948	0.052	0	0	0.000	NA	10.0	NA	10.00	
25.8	1.61	1.61	0.00	1.61	1.61	NA	NA	NA	NA	NA	NA	0.95	NA	0.939	0.052	0	0	0.000	NA	10.0	NA	10.00	
28.3	1.77	1.77	0.00	1.77	1.77	NA	NA	NA	NA	NA	NA	0.95	NA	0.929	0.051	0	0	0.000	NA	10.0	NA	10.00	
30.8	1.92	1.92	0.00	1.92	1.92	NA	NA	NA	NA	NA	NA	0.95	NA	0.917	0.051	0	0	0.000	NA	10.0	NA	10.00	
33.3	2.08	2.08	0.00	2.08	2.08	NA	NA	NA	NA	NA	NA	0.95	NA	0.902	0.050	0	0	0.000	NA	10.0	NA	10.00	
35.8	2.23	2.23	0.00	2.23	2.23	NA	NA	NA	NA	NA	NA	0.95	NA	0.885	0.049	0	0	0.000	NA	10.0	NA	10.00	
38.3	2.39	2.39	0.04	2.35	2.35	NA	NA	NA	NA	NA	NA	0.95	NA	0.866	0.049	0	0	0.000	NA	10.0	NA	10.00	
40.8	2.55	2.55	0.12	2.43	2.43	NA	NA	NA	NA	NA	NA	0.95	NA	0.844	0.049	0	0	0.000	NA	10.0	NA	10.00	
45.8	2.86	2.86	0.27	2.59	2.59	NA	NA	NA	NA	NA	NA	0.95	NA	0.796	0.049	0	0	0.000	NA	10.0	NA	10.00	
48.3	3.02	3.02	0.35	2.66	2.66	NA	NA	NA	NA	NA	NA	0.95	NA	0.771	0.048	0	0	0.000	NA	10.0	NA	10.00	
50.8	3.17	3.17	0.43	2.74	2.74	NA	NA	NA	NA	NA	NA	0.95	NA	0.745	0.048	0	0	0.000	NA	10.0	NA	10.00	
53.3	3.33	3.33	0.51	2.82	2.82	NA	NA	NA	NA	NA	NA	0.95	NA	0.720	0.047	0	0	0.000	NA	10.0	NA	10.00	
55.8	3.48	3.48	0.59	2.90	2.90	NA	NA	NA	NA	NA	NA	0.95	NA	0.696	0.046	0	0	0.000	NA	10.0	NA	10.00	
58.3	3.64	3.64	0.66	2.98	2.98	NA	NA	NA	NA	NA	NA	0.95	NA	0.674	0.046	0	0	0.000	NA	10.0	NA	10.00	
60.8	3.80	3.80	0.74	3.06	3.06	NA	NA	NA	NA	NA	NA	0.95	NA	0.653	0.045	0	0	0.000	NA	10.0	NA	10.00	
63.3	3.95	3.95	0.82	3.13	3.13	NA	NA	NA	NA	NA	NA	0.95	NA	0.634	0.044	0	0	0.000	NA	10.0	NA	10.00	
65.8	4.11	4.11	0.90	3.21	3.21	NA	NA	NA	NA	NA	NA	0.95	NA	0.617	0.044	0	0	0.000	NA	10.0	NA	10.00	

Clifty Creek AEP, Boring = B-1, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts



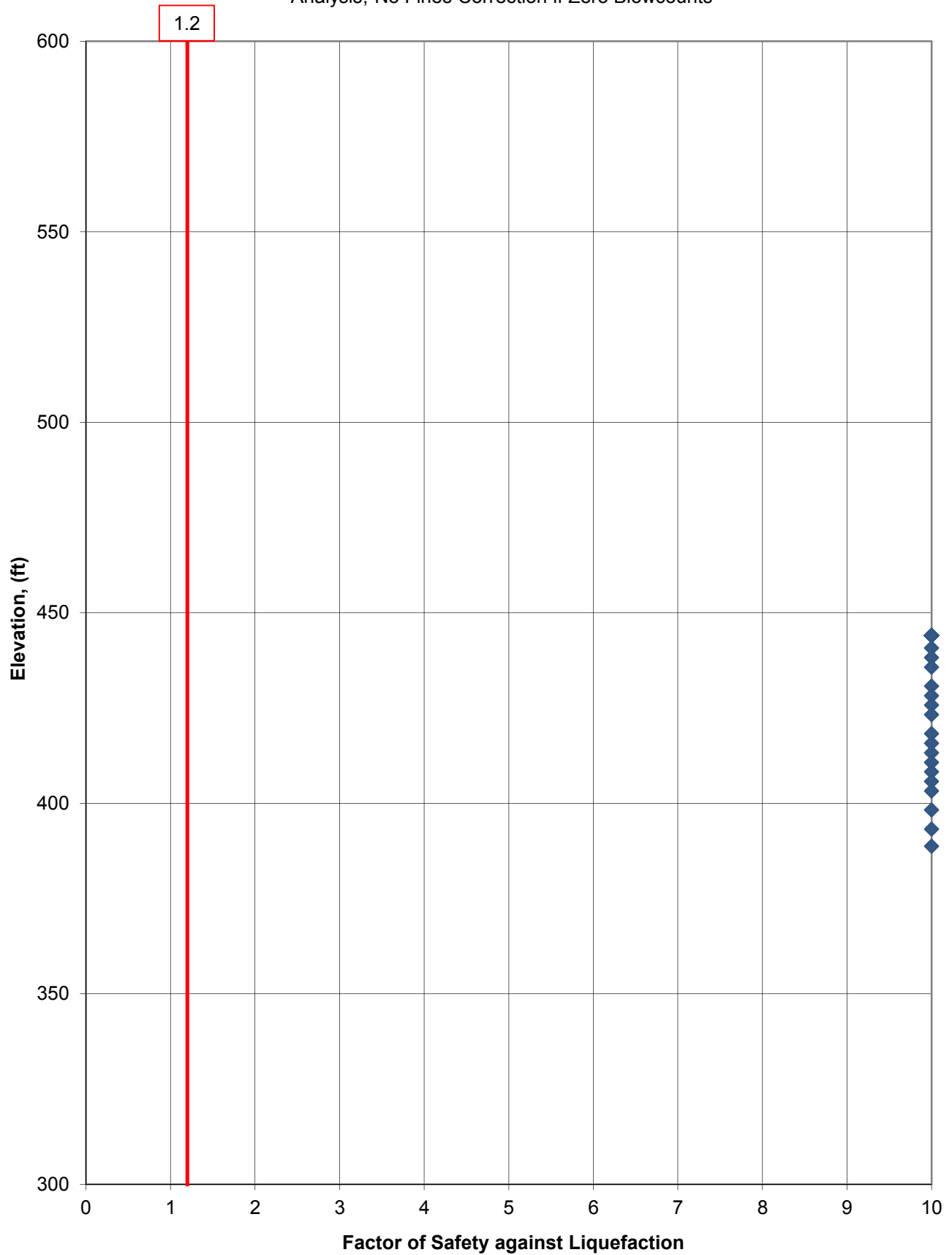
Clifty Creek AEP, Boring = B-1, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts



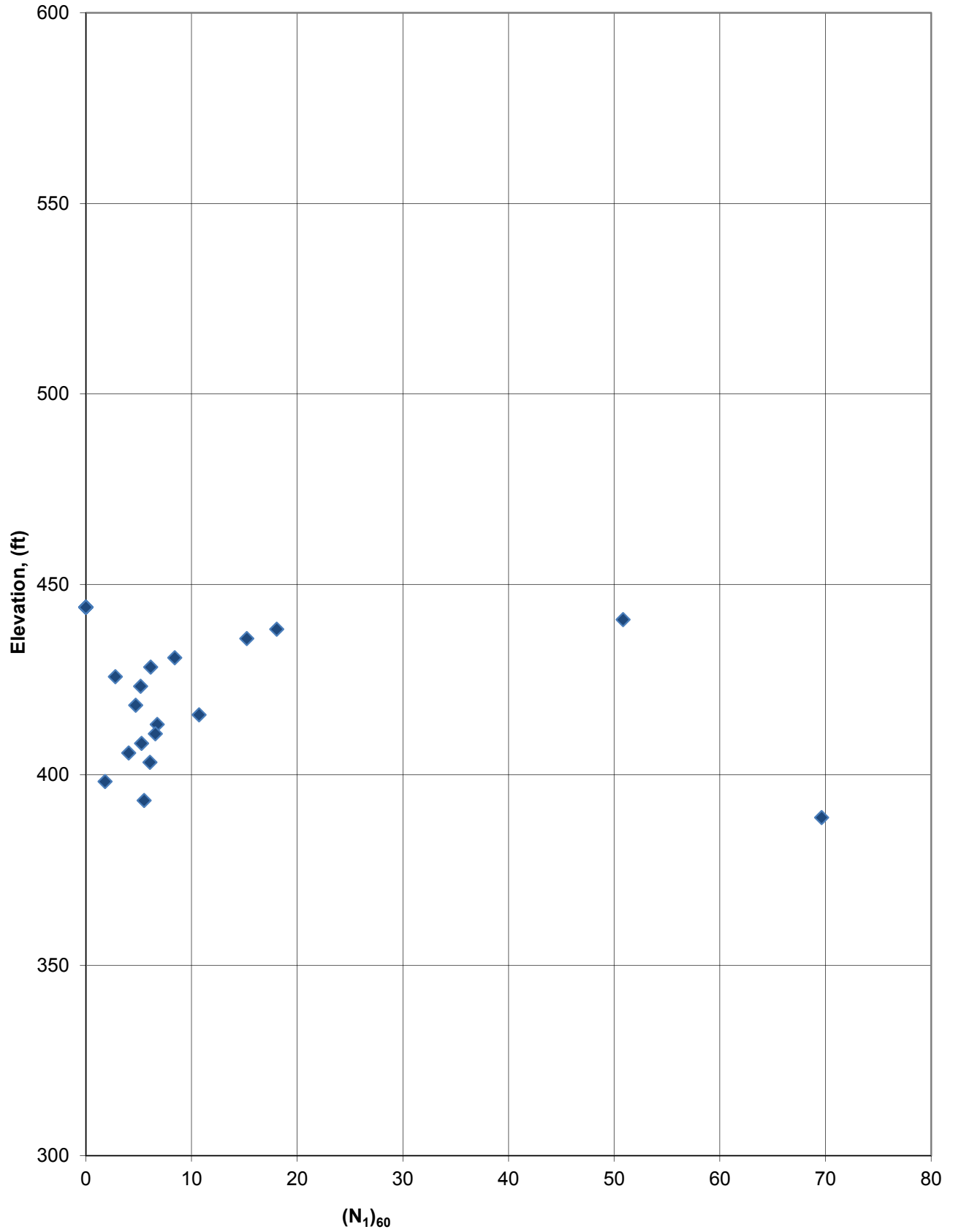
Depth of Mid. Pt. of Sample (ft.)	Vert. Total Stress during EQ (tsf)	Vert. Total Stress during EQ w/ Fill (tsf)	Static Pore Pressure during EQ (tsf)	Vert. Eff. Stress during EQ (tsf)	Vert. Eff. Stress during EQ w/ Fill (tsf)	Alpha I	Beta I	Equivalent Clean Sand N-Value (N ₁) ^{60cs}	CRR7.5	Ksigma	Kalpha	EQ Source		CRR	Event (MCE, OBE, etc.)		Avg. Shake Stress (psf) Design EQ	Using SHAKE Data			Shake Stress Curve Fit Parameters										
												a max (g)	EQ Mag (Mw)		EQ Motion File	Max. Shake Stress (psf) Design EQ		CSR eq	FS liq	FS liq	m4:	m3:	m2:	m1:							
z	σ _v	σ _v with fill	u	σ' _v	σ' _v with fill							Mag. Scaling	Factor (Cm)	Design EQ	Simplified Stress Reduction Coeff., r _d	Simplified CSR eq Design EQ															
						Boring ID: B-2																									
						Top of Fill Elevation: 444.0																									
						Fill Height: 0.0																									
						Fill Total Unit Weight: 125																									
						Fill Total Stress: 0.00																									
						<table border="1"> <tr> <td>totstr-top</td> <td>0.16</td> </tr> <tr> <td>u-top</td> <td>0.00</td> </tr> <tr> <td>effstr-top</td> <td>0.16</td> </tr> </table>		totstr-top	0.16	u-top	0.00	effstr-top	0.16																		
totstr-top	0.16																														
u-top	0.00																														
effstr-top	0.16																														
3.3	0.20	0.20	0.00	0.20	0.20	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.0								
5.8	0.36	0.36	0.00	0.36	0.36	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.989	0.055	0	0	0.000	NA	10.0	NA	10.0								
8.3	0.52	0.52	0.00	0.52	0.52	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.983	0.054	0	0	0.000	NA	10.0	NA	10.0								
13.3	0.83	0.83	0.00	0.83	0.83	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	10.0								
15.8	0.98	0.98	0.02	0.96	0.96	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.967	0.055	0	0	0.000	NA	10.0	NA	10.0								
18.3	1.14	1.14	0.10	1.04	1.04	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.961	0.058	0	0	0.000	NA	10.0	NA	10.0								
20.8	1.30	1.30	0.18	1.12	1.12	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.955	0.061	0	0	0.000	NA	10.0	NA	10.0								
25.8	1.61	1.61	0.34	1.27	1.27	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.939	0.066	0	0	0.000	NA	10.0	NA	10.0								
28.3	1.77	1.77	0.41	1.35	1.35	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.929	0.067	0	0	0.000	NA	10.0	NA	10.0								
30.8	1.92	1.92	0.49	1.43	1.43	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.917	0.068	0	0	0.000	NA	10.0	NA	10.0								
33.3	2.08	2.08	0.57	1.51	1.51	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.902	0.069	0	0	0.000	NA	10.0	NA	10.0								
35.8	2.23	2.23	0.65	1.59	1.59	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.885	0.069	0	0	0.000	NA	10.0	NA	10.0								
38.3	2.39	2.39	0.73	1.67	1.67	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.866	0.069	0	0	0.000	NA	10.0	NA	10.0								
40.8	2.55	2.55	0.80	1.74	1.74	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.844	0.068	0	0	0.000	NA	10.0	NA	10.0								
45.8	2.86	2.86	0.96	1.90	1.90	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.796	0.066	0	0	0.000	NA	10.0	NA	10.0								
50.8	3.17	3.17	1.12	2.06	2.06	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.745	0.063	0	0	0.000	NA	10.0	NA	10.0								
55.3	3.45	3.45	1.26	2.20	2.20	0.02	1.00	70	NA	0.781	1.000	0.95	NA	NA	0.701	0.061	0	0	0.000	NA	10.0	NA	10.0								

Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.

Clifty Creek AEP, Boring = B-2, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts

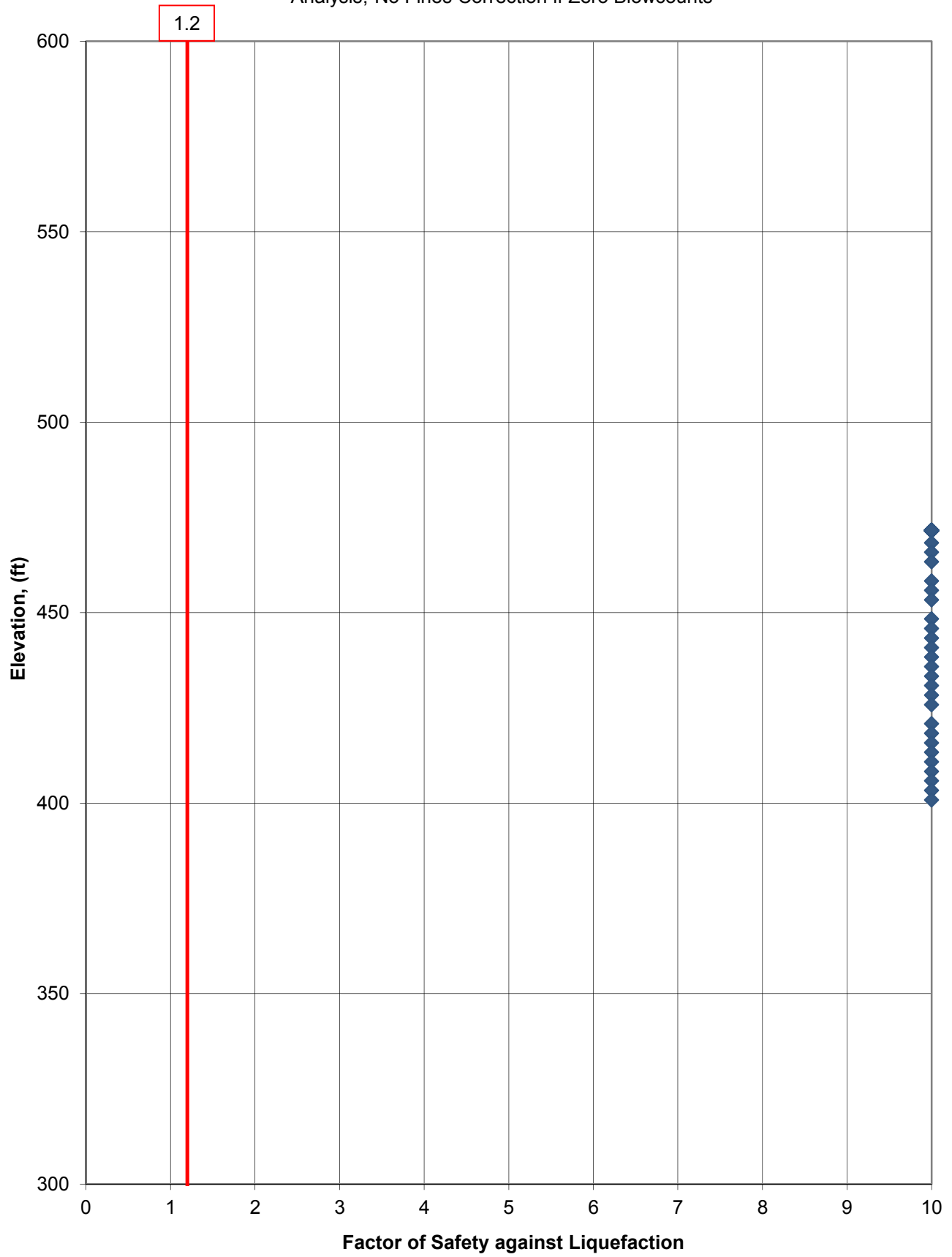


Clifty Creek AEP, Boring = B-2, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts

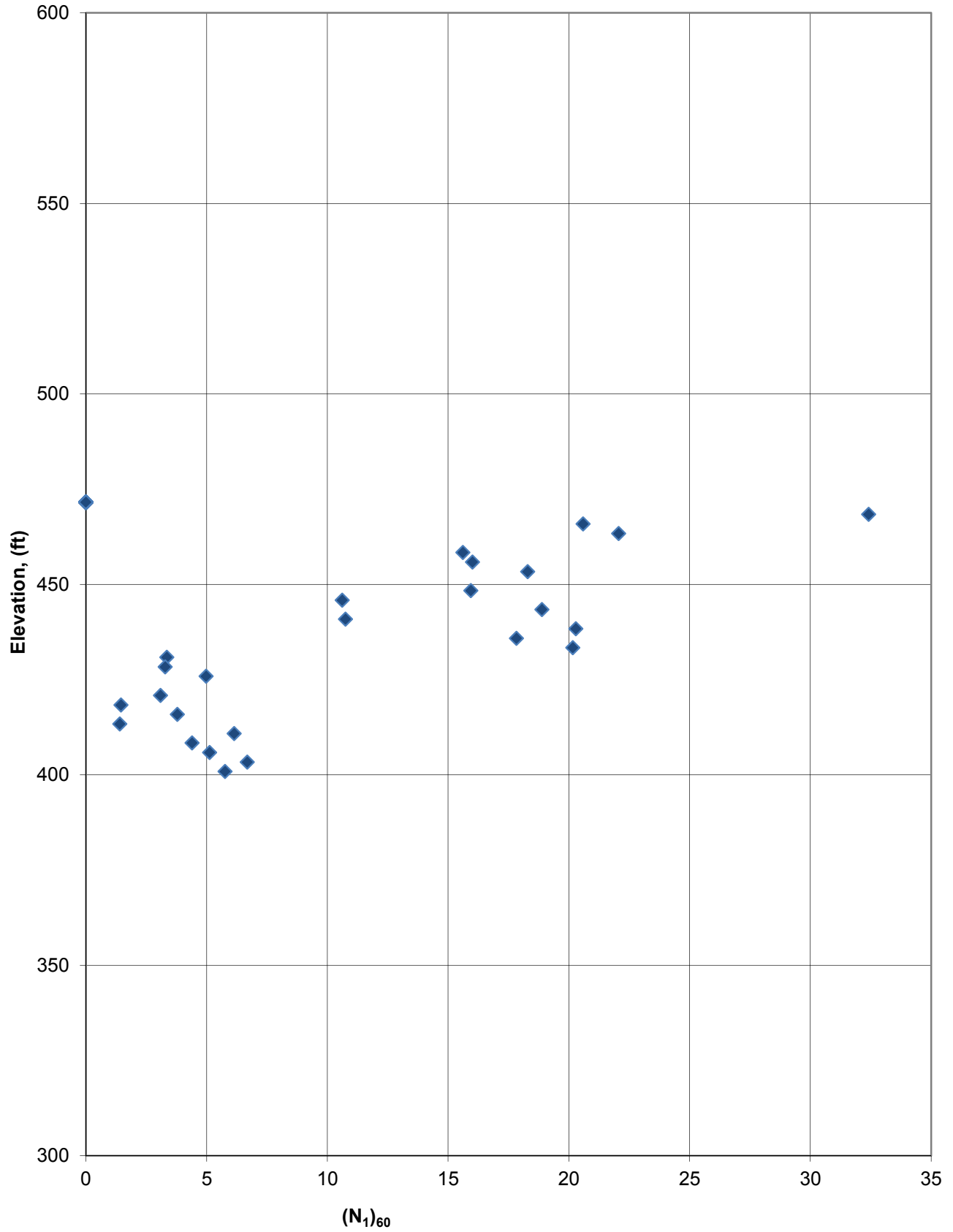


Depth of Mid. Pt. of Sample (ft.)	Vert. Total Stress during EQ (tsf)	Vert. Total Stress during EQ w/ Fill (tsf)	Static Pore Pressure during EQ (tsf)	Vert. Eff. Stress during EQ (tsf)	Vert. Eff. Stress during EQ w/ Fill (tsf)	Alpha I	Beta I	(N ₁) ^{60cs}	CRR7.5	Ksigma	Kalpha	EQ Source		CRR	Event (MCE, OBE, etc.)		Avg. Shake Stress (psf)	Using SHAKE Data			Shake Stress Curve Fit Parameters		
												EQ Mag (Mw)	a max (g)		EQ Motion File	Max. Shake Stress (psf)		Simplified Stress Reduction	Simplified CSR eq	CSR eq	FS liq	FS liq	m4:	m3:	m2:	m1:
z	σ _v	σ _v with fill	u	σ' _v	σ' _v with fill			N-Value				Mag. Scaling	Factor (Cm)	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ
Boring ID: B-3 Top of Fill Elevation: 471.6 Fill Height: 0.0 Fill Total Unit Weight: 125 Fill Total Stress: 0.00						<i>Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.</i>																	
	totstr-top		u-top	effstr-top																			
	0.16		0.00	0.16																			
3.3	0.20	0.20	0.00	0.20	0.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.00	
5.8	0.36	0.36	0.00	0.36	0.36	NA	NA	NA	NA	NA	NA	0.95	NA	0.989	0.055	0	0	0.000	NA	10.0	NA	10.00	
8.3	0.52	0.52	0.00	0.52	0.52	NA	NA	NA	NA	NA	NA	0.95	NA	0.983	0.054	0	0	0.000	NA	10.0	NA	10.00	
13.3	0.83	0.83	0.00	0.83	0.83	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	10.00	
15.8	0.98	0.98	0.00	0.98	0.98	NA	NA	NA	NA	NA	NA	0.95	NA	0.967	0.053	0	0	0.000	NA	10.0	NA	10.00	
18.3	1.14	1.14	0.00	1.14	1.14	NA	NA	NA	NA	NA	NA	0.95	NA	0.961	0.053	0	0	0.000	NA	10.0	NA	10.00	
23.3	1.45	1.45	0.00	1.45	1.45	NA	NA	NA	NA	NA	NA	0.95	NA	0.948	0.052	0	0	0.000	NA	10.0	NA	10.00	
25.8	1.61	1.61	0.00	1.61	1.61	NA	NA	NA	NA	NA	NA	0.95	NA	0.939	0.052	0	0	0.000	NA	10.0	NA	10.00	
28.3	1.77	1.77	0.00	1.77	1.77	NA	NA	NA	NA	NA	NA	0.95	NA	0.929	0.051	0	0	0.000	NA	10.0	NA	10.00	
30.8	1.92	1.92	0.00	1.92	1.92	NA	NA	NA	NA	NA	NA	0.95	NA	0.917	0.051	0	0	0.000	NA	10.0	NA	10.00	
33.3	2.08	2.08	0.00	2.08	2.08	NA	NA	NA	NA	NA	NA	0.95	NA	0.902	0.050	0	0	0.000	NA	10.0	NA	10.00	
35.8	2.23	2.23	0.00	2.23	2.23	NA	NA	NA	NA	NA	NA	0.95	NA	0.885	0.049	0	0	0.000	NA	10.0	NA	10.00	
38.3	2.39	2.39	0.07	2.32	2.32	NA	NA	NA	NA	NA	NA	0.95	NA	0.866	0.049	0	0	0.000	NA	10.0	NA	10.00	
40.8	2.55	2.55	0.15	2.40	2.40	NA	NA	NA	NA	NA	NA	0.95	NA	0.844	0.050	0	0	0.000	NA	10.0	NA	10.00	
43.3	2.70	2.70	0.23	2.48	2.48	NA	NA	NA	NA	NA	NA	0.95	NA	0.821	0.049	0	0	0.000	NA	10.0	NA	10.00	
45.8	2.86	2.86	0.30	2.56	2.56	NA	NA	NA	NA	NA	NA	0.95	NA	0.796	0.049	0	0	0.000	NA	10.0	NA	10.00	
50.8	3.17	3.17	0.46	2.71	2.71	NA	NA	NA	NA	NA	NA	0.95	NA	0.745	0.048	0	0	0.000	NA	10.0	NA	10.00	
53.3	3.33	3.33	0.54	2.79	2.79	NA	NA	NA	NA	NA	NA	0.95	NA	0.720	0.047	0	0	0.000	NA	10.0	NA	10.00	
55.8	3.48	3.48	0.62	2.87	2.87	NA	NA	NA	NA	NA	NA	0.95	NA	0.696	0.047	0	0	0.000	NA	10.0	NA	10.00	
58.3	3.64	3.64	0.69	2.95	2.95	NA	NA	NA	NA	NA	NA	0.95	NA	0.674	0.046	0	0	0.000	NA	10.0	NA	10.00	
60.8	3.80	3.80	0.77	3.02	3.02	NA	NA	NA	NA	NA	NA	0.95	NA	0.653	0.045	0	0	0.000	NA	10.0	NA	10.00	
63.3	3.95	3.95	0.85	3.10	3.10	NA	NA	NA	NA	NA	NA	0.95	NA	0.634	0.045	0	0	0.000	NA	10.0	NA	10.00	
65.8	4.11	4.11	0.93	3.18	3.18	NA	NA	NA	NA	NA	NA	0.95	NA	0.617	0.044	0	0	0.000	NA	10.0	NA	10.00	
68.3	4.27	4.27	1.01	3.26	3.26	NA	NA	NA	NA	NA	NA	0.95	NA	0.602	0.044	0	0	0.000	NA	10.0	NA	10.00	
70.8	4.42	4.42	1.08	3.34	3.34	NA	NA	NA	NA	NA	NA	0.95	NA	0.588	0.043	0	0	0.000	NA	10.0	NA	10.00	

Clifty Creek AEP, Boring = B-3, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts

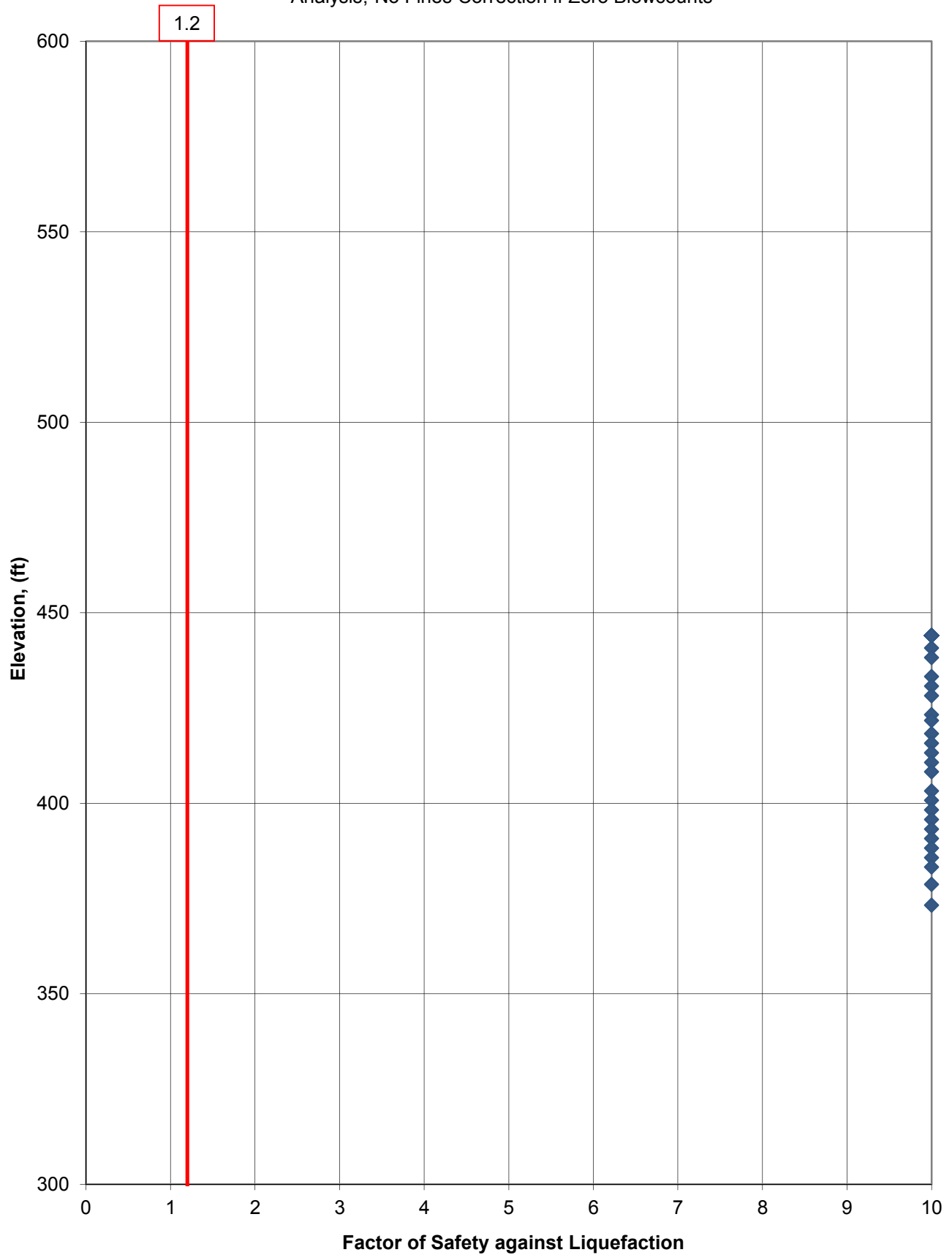


Clifty Creek AEP, Boring = B-3, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts

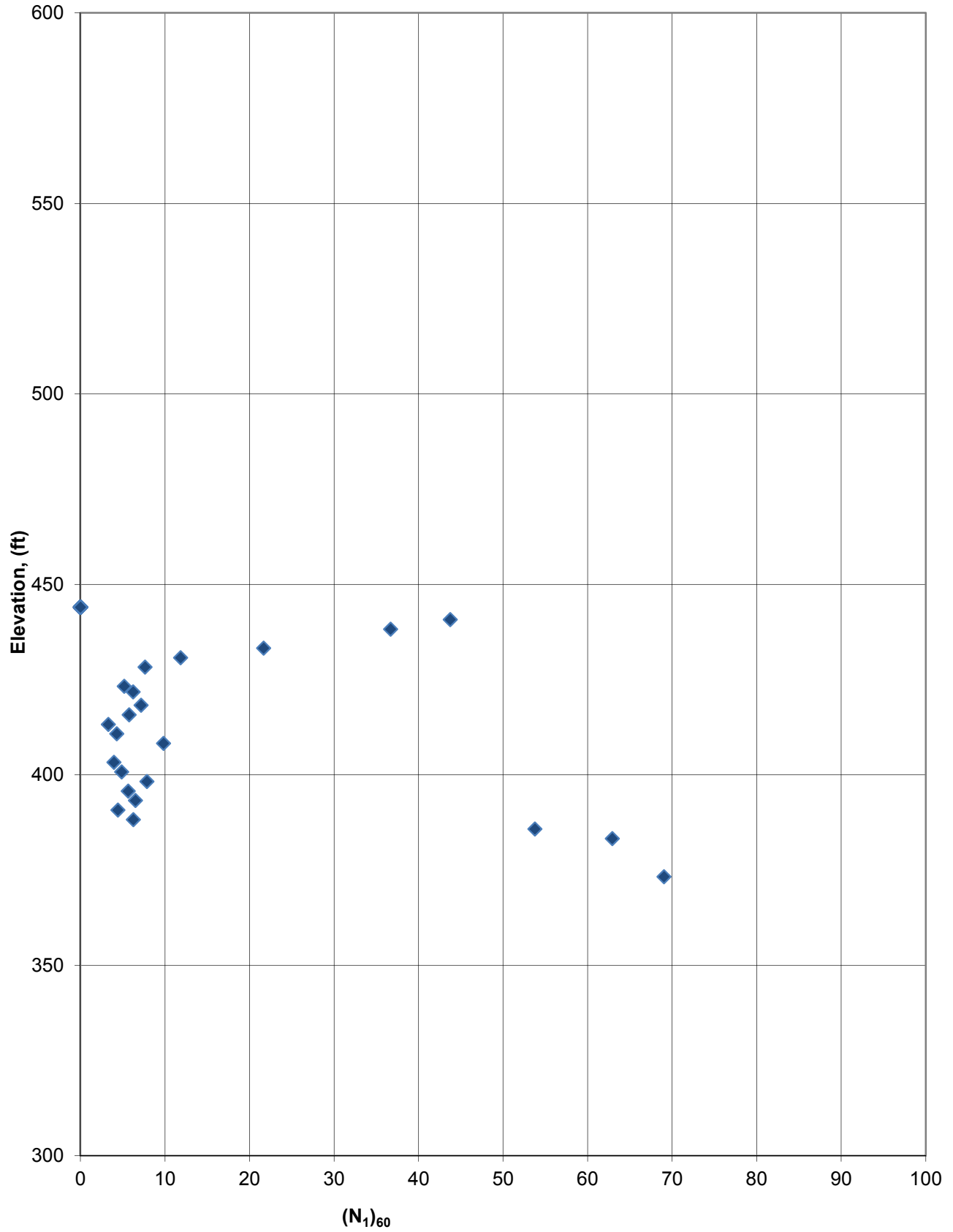


Depth of Mid. Pt. of Sample (ft.)	Vert. Total Stress during EQ (tsf)	Vert. Total Stress during EQ w/ Fill (tsf)	Static Pore Pressure during EQ (tsf)	Vert. Eff. Stress during EQ (tsf)	Vert. Eff. Stress during EQ w/ Fill (tsf)	Alpha I	Beta I	Equivalent Clean Sand N-Value (N ₁) ^{60cs}	CRR7.5	Ksigma	Kalpha	EQ Source		CRR	Event (MCE, OBE, etc.)		Avg. Shake Stress (psf) Design EQ	Using SHAKE Data			Shake Stress Curve Fit Parameters		
												a max (g)	EQ Mag (Mw)		EQ Motion File	Max. Shake Stress (psf) Design EQ		CSR eq	FS liq	FS liq	m4:	m3:	m2:	m1:
z	σ _v	σ _{v with fill}	u	σ' _v	σ' _{v with fill}							Mag. Scaling Factor (Cm)	Simplified Stress Reduction Coeff., r _d	Simplified CSR eq Design EQ	0	0	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ
Boring ID: B-4 Top of Fill Elevation: 444.0 Fill Height: 0.0 Fill Total Unit Weight: 125 Fill Total Stress: 0.00						<i>Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.</i>																	
	totstr-top		u-top	effstr-top																			
	0.16		0.00	0.16																			
3.3	0.20	0.20	0.00	0.20	0.20	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.00
5.8	0.36	0.36	0.00	0.36	0.36	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.989	0.055	0	0	0.000	NA	10.0	NA	10.00
10.8	0.67	0.67	0.00	0.67	0.67	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.978	0.054	0	0	0.000	NA	10.0	NA	10.00
13.3	0.83	0.83	0.00	0.83	0.83	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	10.00
15.8	0.98	0.98	0.00	0.98	0.98	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.967	0.053	0	0	0.000	NA	10.0	NA	10.00
20.8	1.30	1.30	0.15	1.15	1.15	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.955	0.060	0	0	0.000	NA	10.0	NA	10.00
22.3	1.39	1.39	0.20	1.20	1.20	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.951	0.061	0	0	0.000	NA	10.0	NA	10.00
25.8	1.61	1.61	0.30	1.31	1.31	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.939	0.064	0	0	0.000	NA	10.0	NA	10.00
28.3	1.77	1.77	0.38	1.38	1.38	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.929	0.066	0	0	0.000	NA	10.0	NA	10.00
30.8	1.92	1.92	0.46	1.46	1.46	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.917	0.067	0	0	0.000	NA	10.0	NA	10.00
33.3	2.08	2.08	0.54	1.54	1.54	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.902	0.067	0	0	0.000	NA	10.0	NA	10.00
35.8	2.23	2.23	0.62	1.62	1.62	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.885	0.068	0	0	0.000	NA	10.0	NA	10.00
40.8	2.55	2.55	0.77	1.77	1.77	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.844	0.067	0	0	0.000	NA	10.0	NA	10.00
43.3	2.70	2.70	0.85	1.85	1.85	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.821	0.066	0	0	0.000	NA	10.0	NA	10.00
45.8	2.86	2.86	0.93	1.93	1.93	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.796	0.065	0	0	0.000	NA	10.0	NA	10.00
48.3	3.02	3.02	1.01	2.01	2.01	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.771	0.064	0	0	0.000	NA	10.0	NA	10.00
50.8	3.17	3.17	1.08	2.09	2.09	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.745	0.063	0	0	0.000	NA	10.0	NA	10.00
53.3	3.33	3.33	1.16	2.17	2.17	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.720	0.061	0	0	0.000	NA	10.0	NA	10.00
55.8	3.48	3.48	1.24	2.24	2.24	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.696	0.060	0	0	0.000	NA	10.0	NA	10.00
58.3	3.64	3.64	1.32	2.32	2.32	0.02	1.00	54	NA	0.764	1.000147	0.95	NA	0.674	0.058	0	0	0.000	NA	10.0	NA	10.00	
60.8	3.80	3.80	1.40	2.40	2.40	0.02	1.00	63	NA	0.754	1.000147	0.95	NA	0.653	0.057	0	0	0.000	NA	10.0	NA	10.00	
65.3	4.08	4.08	1.54	2.54	2.54	0.02	1.00	1354	NA	0.737	1.000147	0.95	NA	0.620	0.055	0	0	0.000	NA	10.0	NA	10.00	
70.8	4.42	4.42	1.71	2.71	2.71	0.02	1.00	69	NA	0.717	1.000147	0.95	NA	0.588	0.053	0	0	0.000	NA	10.0	NA	10.00	

Clifty Creek AEP, Boring = B-4, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts

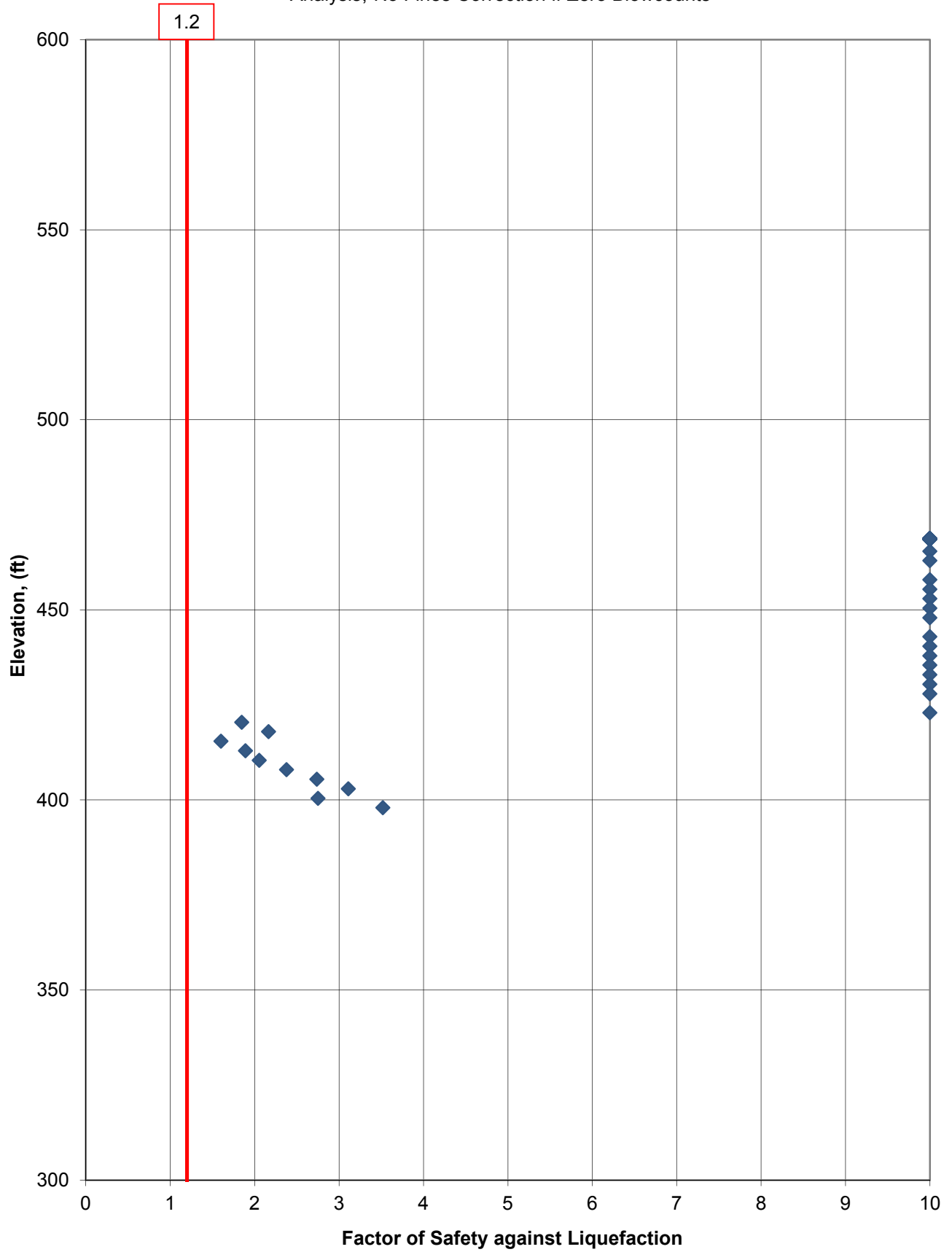


Clifty Creek AEP, Boring = B-4, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts

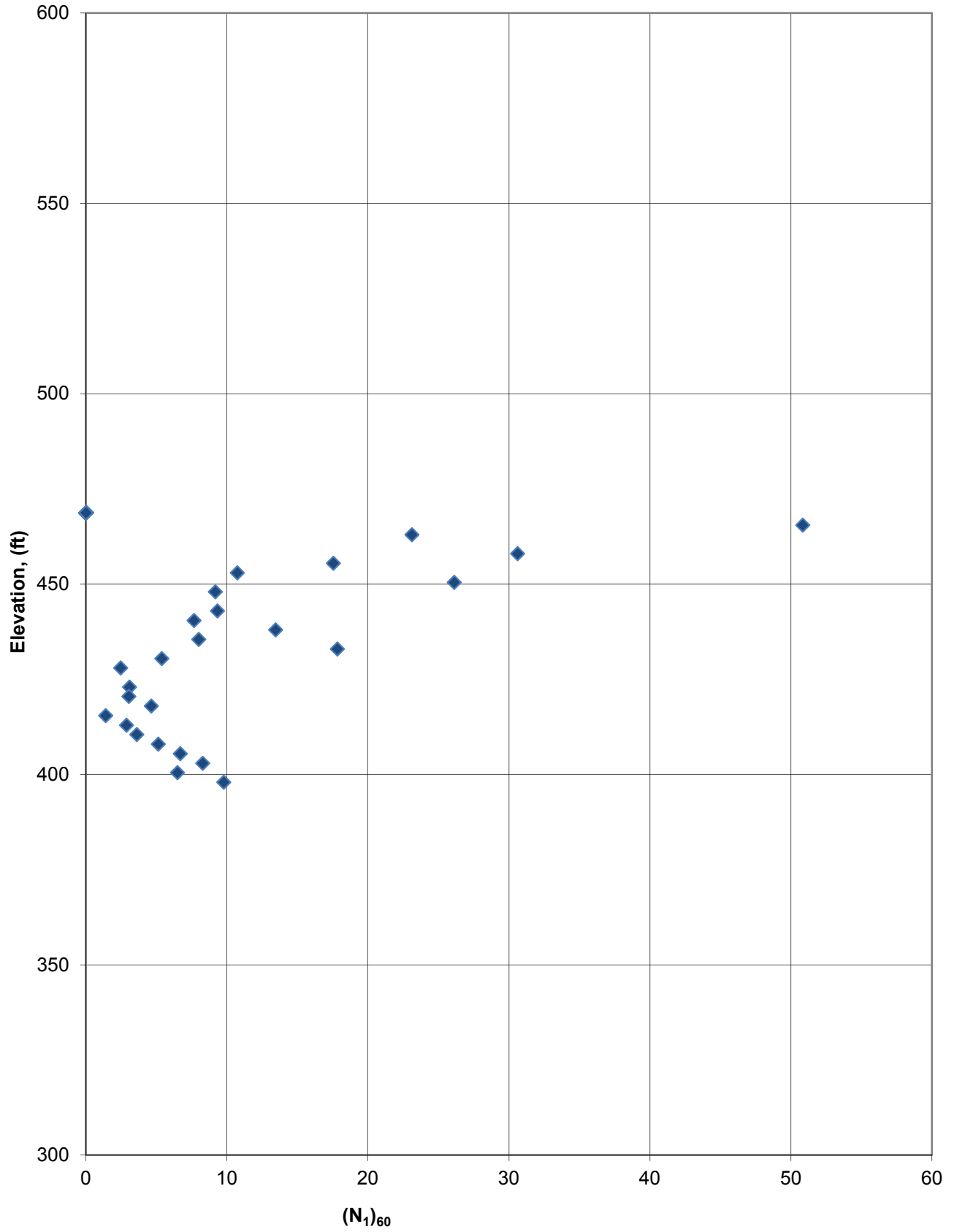


Depth of Mid. Pt. of Sample (ft.)	Vert. Total Stress during EQ (tsf)	Vert. Total Stress during EQ w/ Fill (tsf)	Static Pore Pressure during EQ (tsf)	Vert. Eff. Stress during EQ (tsf)	Vert. Eff. Stress during EQ w/ Fill (tsf)	Alpha I	Beta I	Equivalent Clean Sand N-Value (N) ^{60CS}	CRR7.5	Ksigma	Kalpha	EQ Source 0 a max (g) 0.085 EQ Mag (Mw) 7.7 Mag. Scaling	CRR	Simplified Stress Reduction		Max. Shake Stress (psf)	Avg. Shake Stress (psf)	Using SHAKE Data			Simplified	
														EQ Motion File 0	Event (MCE, OBE, etc.) 0			CSR eq	FS liq	FS liq	FS liq	FS liq
z	σ _v	σ _v with fill	u	σ' _v	σ' _v with fill							Factor (Cm)	Design EQ	Coef. r ₁₅	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ
Boring ID: B-5						Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.																
Top of Fill Elevation: 468.7																						
Fill Height: 0.0																						
Fill Total Unit Weight: 125																						
Fill Total Stress: 0.00																						
	tolstr-top 0.16		u-top 0.00	effstr-top 0.16																		
3.3	0.20	0.20	0.00	0.20	0.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.0
5.8	0.36	0.36	0.00	0.36	0.36	NA	NA	NA	NA	NA	NA	0.95	NA	0.989	0.055	0	0	0.000	NA	10.0	NA	10.0
10.8	0.67	0.67	0.00	0.67	0.67	NA	NA	NA	NA	NA	NA	0.95	NA	0.978	0.054	0	0	0.000	NA	10.0	NA	10.0
13.3	0.83	0.83	0.00	0.83	0.83	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	10.0
15.8	0.98	0.98	0.00	0.98	0.98	NA	NA	NA	NA	NA	NA	0.95	NA	0.967	0.053	0	0	0.000	NA	10.0	NA	10.0
18.3	1.14	1.14	0.00	1.14	1.14	NA	NA	NA	NA	NA	NA	0.95	NA	0.961	0.053	0	0	0.000	NA	10.0	NA	10.0
20.8	1.30	1.30	0.00	1.30	1.30	NA	NA	NA	NA	NA	NA	0.95	NA	0.955	0.053	0	0	0.000	NA	10.0	NA	10.0
25.8	1.61	1.61	0.00	1.61	1.61	NA	NA	NA	NA	NA	NA	0.95	NA	0.939	0.052	0	0	0.000	NA	10.0	NA	10.0
28.3	1.77	1.77	0.00	1.77	1.77	NA	NA	NA	NA	NA	NA	0.95	NA	0.929	0.051	0	0	0.000	NA	10.0	NA	10.0
30.8	1.92	1.92	0.00	1.92	1.92	NA	NA	NA	NA	NA	NA	0.95	NA	0.917	0.051	0	0	0.000	NA	10.0	NA	10.0
33.3	2.08	2.08	0.00	2.08	2.08	NA	NA	NA	NA	NA	NA	0.95	NA	0.902	0.050	0	0	0.000	NA	10.0	NA	10.0
35.8	2.23	2.23	0.00	2.23	2.23	NA	NA	NA	NA	NA	NA	0.95	NA	0.885	0.049	0	0	0.000	NA	10.0	NA	10.0
38.3	2.39	2.39	0.07	2.32	2.32	NA	NA	NA	NA	NA	NA	0.95	NA	0.866	0.049	0	0	0.000	NA	10.0	NA	10.0
40.8	2.55	2.55	0.15	2.40	2.40	NA	NA	NA	NA	NA	NA	0.95	NA	0.844	0.050	0	0	0.000	NA	10.0	NA	10.0
45.8	2.86	2.86	0.30	2.56	2.56	NA	NA	NA	NA	NA	NA	0.95	NA	0.796	0.049	0	0	0.000	NA	10.0	NA	10.0
48.3	3.02	3.02	0.38	2.63	2.63	5.00	1.20	9	0.101	0.937	1.000	0.95	0.090	0.771	0.049	0	0	0.000	#DIV/0!	#DIV/0!	1.8	1.85
50.8	3.17	3.17	0.46	2.71	2.71	5.00	1.20	11	0.118	0.932	1.000	0.95	0.104	0.745	0.048	0	0	0.000	#DIV/0!	#DIV/0!	2.2	2.17
53.3	3.33	3.33	0.54	2.79	2.79	5.00	1.20	7	0.085	0.941	1.000	0.95	0.076	0.720	0.047	0	0	0.000	#DIV/0!	#DIV/0!	1.6	1.60
55.8	3.48	3.48	0.62	2.87	2.87	5.00	1.20	8	0.100	0.935	1.000	0.95	0.088	0.696	0.047	0	0	0.000	#DIV/0!	#DIV/0!	1.9	1.89
58.3	3.64	3.64	0.69	2.95	2.95	5.00	1.20	9	0.107	0.929	1.000003	0.95	0.094	0.674	0.046	0	0	0.000	#DIV/0!	#DIV/0!	2.1	2.05
60.8	3.80	3.80	0.77	3.02	3.02	5.00	1.20	11	0.123	0.920	1.000004	0.95	0.108	0.653	0.045	0	0	0.000	#DIV/0!	#DIV/0!	2.4	2.38
63.3	3.95	3.95	0.85	3.10	3.10	5.00	1.20	13	0.141	0.915	1.000006	0.95	0.122	0.634	0.045	0	0	0.000	#DIV/0!	#DIV/0!	2.7	2.74
65.8	4.11	4.11	0.93	3.18	3.18	5.00	1.20	15	0.159	0.906	1.000008	0.95	0.137	0.617	0.044	0	0	0.000	#DIV/0!	#DIV/0!	3.1	3.11
68.3	4.27	4.27	1.01	3.26	3.26	5.00	1.20	13	0.138	0.911	1.000006	0.95	0.120	0.602	0.044	0	0	0.000	#DIV/0!	#DIV/0!	2.8	2.75
70.8	4.42	4.42	1.08	3.34	3.34	5.00	1.20	17	0.178	0.898	1.00001	0.95	0.151	0.588	0.043	0	0	0.000	#DIV/0!	#DIV/0!	3.5	3.52

Clifty Creek AEP, Boring = B-5, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts

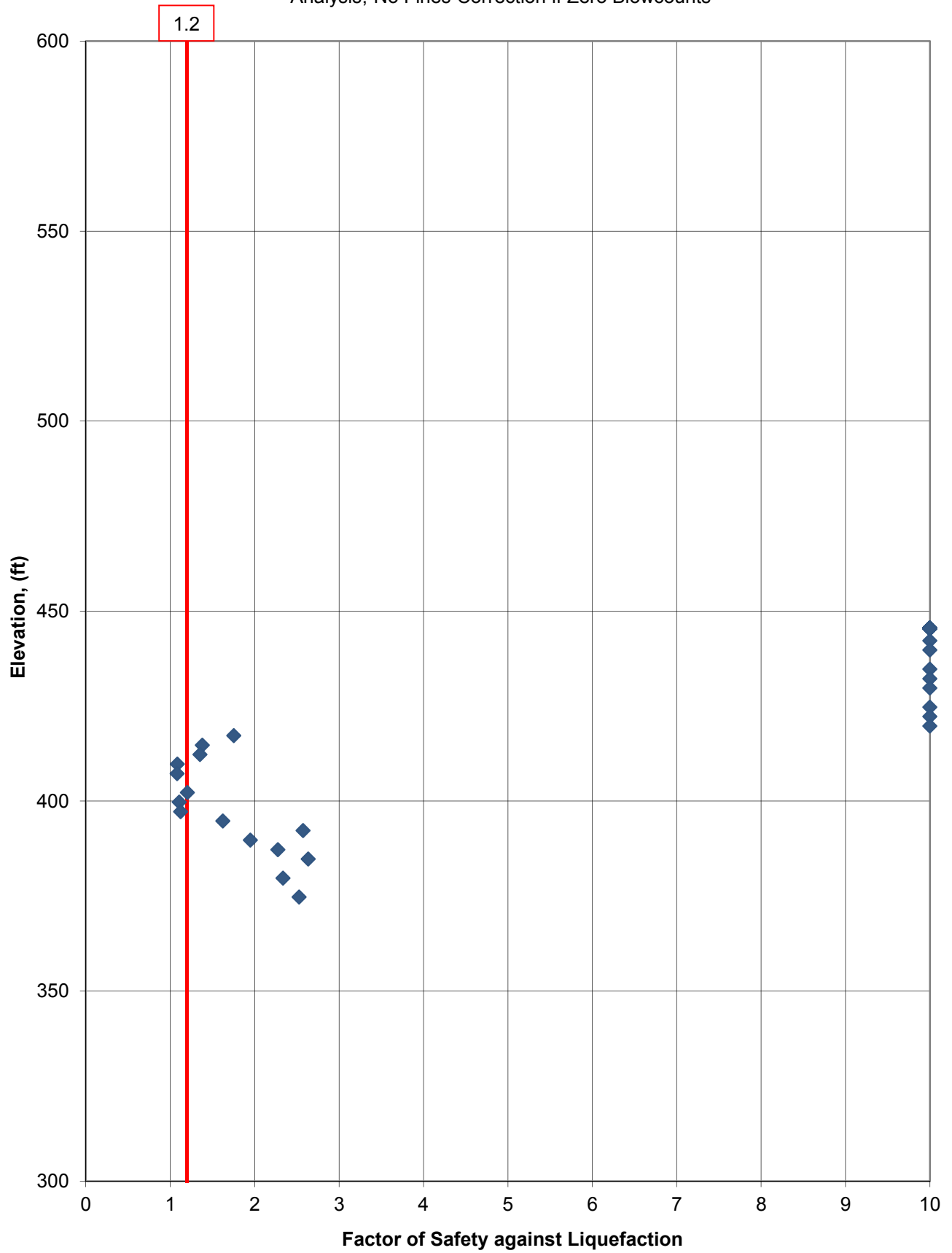


Clifty Creek AEP, Boring = B-5, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts

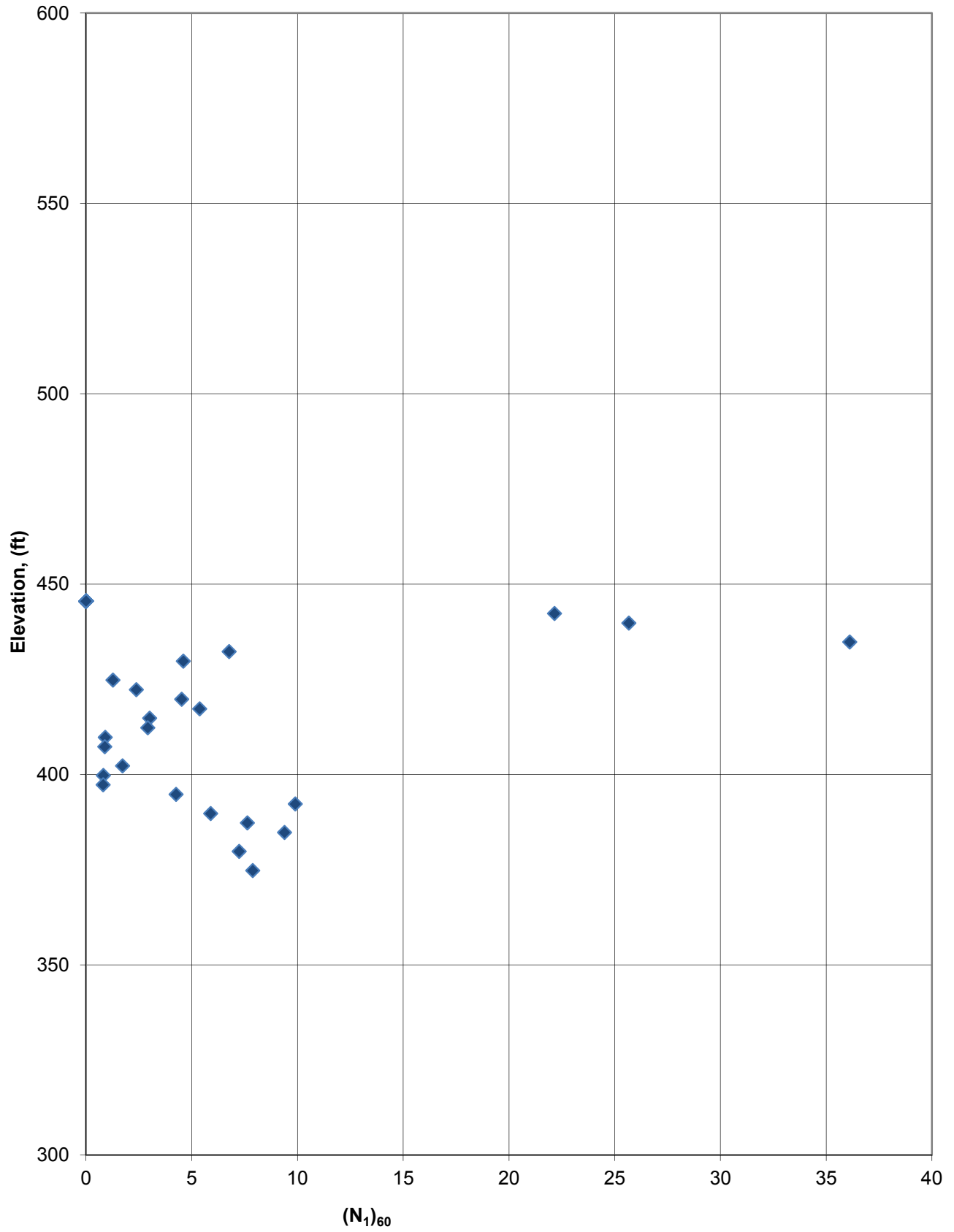


Depth of Mid. Pt. of Sample (ft.)	Vert. Total Stress during EQ (tsf)	Vert. Total Stress during EQ w/ Fill (tsf)	Static Pore Pressure during EQ (tsf)	Vert. Eff. Stress during EQ (tsf)	Vert. Eff. Stress during EQ w/ Fill (tsf)	Alpha I	Beta I	Equivalent Clean Sand N-Value (N ₁) ^{60cs}	CRR7.5	Ksigma	Kalpha	EQ Source		Event (MCE, OBE, etc.)		Shake Stress Curve Fit Parameters											
												EQ Mag (Mw)	Mag. Scaling	0	0	m4:	m3:	m2:	m1:								
z	σ _v	σ _v with fill	u	σ' _v	σ' _v with fill							EQ Mag (Mw)	Factor (Cm)	Design EQ	Simplified Stress Reduction	Simplified CSR eq	Max. Shake Stress (psf)	Avg. Shake Stress (psf)	Using SHAKE Data			Simplified					
												7.7			Coeff., r _d	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ	FS liq	FS liq	FS liq	FS liq			
						Boring ID: B-6		<p>Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.</p>																			
						Top of Fill Elevation: 445.5																					
						Fill Height: 0.0																					
						Fill Total Unit Weight: 125																					
						Fill Total Stress: 0.00																					
	totstr-top		u-top	effstr-top																							
	0.16		0.00	0.16																							
3.3	0.20	0.20	0.00	0.20	0.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	NA	10.0	10.0			
5.8	0.36	0.36	0.00	0.36	0.36	NA	NA	NA	NA	NA	NA	0.95	NA	0.989	0.055	0	0	0.000	NA	10.0	NA	NA	10.0	10.0			
10.8	0.67	0.67	0.00	0.67	0.67	NA	NA	NA	NA	NA	NA	0.95	NA	0.978	0.054	0	0	0.000	NA	10.0	NA	NA	10.0	10.0			
13.3	0.83	0.83	0.00	0.83	0.83	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	NA	10.0	10.0			
15.8	0.98	0.98	0.02	0.96	0.96	NA	NA	NA	NA	NA	NA	0.95	NA	0.967	0.055	0	0	0.000	NA	10.0	NA	NA	10.0	10.0			
20.8	1.30	1.30	0.18	1.12	1.12	NA	NA	NA	NA	NA	NA	0.95	NA	0.955	0.061	0	0	0.000	NA	10.0	NA	NA	10.0	10.0			
23.3	1.45	1.45	0.26	1.20	1.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.948	0.064	0	0	0.000	NA	10.0	NA	NA	10.0	10.0			
25.8	1.61	1.61	0.34	1.27	1.27	NA	NA	NA	NA	NA	NA	0.95	NA	0.939	0.066	0	0	0.000	NA	10.0	NA	NA	10.0	10.0			
28.3	1.77	1.77	0.41	1.35	1.35	5.00	1.20	11	0.126	0.981	1.000	0.95	0.117	0.929	0.067	0	0	0.000	#DIV/0!	#DIV/0!	1.8	1.8	1.75	1.75			
30.8	1.92	1.92	0.49	1.43	1.43	5.00	1.20	9	0.101	0.979	1.000	0.95	0.094	0.917	0.068	0	0	0.000	#DIV/0!	#DIV/0!	1.4	1.4	1.38	1.38			
33.3	2.08	2.08	0.57	1.51	1.51	5.00	1.20	9	0.100	0.977	1.000	0.95	0.093	0.902	0.069	0	0	0.000	#DIV/0!	#DIV/0!	1.4	1.4	1.35	1.35			
35.8	2.23	2.23	0.65	1.59	1.59	5.00	1.20	6	0.080	0.978	1.000	0.95	0.075	0.885	0.069	0	0	0.000	#DIV/0!	#DIV/0!	1.1	1.1	1.08	1.08			
38.3	2.39	2.39	0.73	1.67	1.67	5.00	1.20	6	0.080	0.976	1.000	0.95	0.074	0.866	0.069	0	0	0.000	#DIV/0!	#DIV/0!	1.1	1.1	1.08	1.08			
43.3	2.70	2.70	0.88	1.82	1.82	5.00	1.20	7	0.088	0.967	1.000	0.95	0.081	0.821	0.067	0	0	0.000	#DIV/0!	#DIV/0!	1.2	1.2	1.20	1.20			
45.8	2.86	2.86	0.96	1.90	1.90	5.00	1.20	6	0.080	0.969	1.000	0.95	0.073	0.796	0.066	0	0	0.000	#DIV/0!	#DIV/0!	1.1	1.1	1.11	1.11			
48.3	3.02	3.02	1.04	1.98	1.98	5.00	1.20	6	0.079	0.967	1.000	0.95	0.073	0.771	0.065	0	0	0.000	#DIV/0!	#DIV/0!	1.1	1.1	1.12	1.12			
50.8	3.17	3.17	1.12	2.06	2.06	5.00	1.20	10	0.114	0.952	1.000	0.95	0.103	0.745	0.063	0	0	0.000	#DIV/0!	#DIV/0!	1.6	1.6	1.62	1.62			
53.3	3.33	3.33	1.19	2.13	2.13	5.00	1.20	17	0.180	0.938	1.000	0.95	0.160	0.720	0.062	0	0	0.000	#DIV/0!	#DIV/0!	2.6	2.6	2.57	2.57			
55.8	3.48	3.48	1.27	2.21	2.21	5.00	1.20	12	0.132	0.944	1.000	0.95	0.118	0.696	0.061	0	0	0.000	#DIV/0!	#DIV/0!	1.9	1.9	1.95	1.95			
58.3	3.64	3.64	1.35	2.29	2.29	5.00	1.20	14	0.152	0.935	1.000008	0.95	0.135	0.674	0.059	0	0	0.000	#DIV/0!	#DIV/0!	2.3	2.3	2.27	2.27			
60.8	3.80	3.80	1.43	2.37	2.37	5.00	1.20	16	0.173	0.928	1.000011	0.95	0.152	0.653	0.058	0	0	0.000	#DIV/0!	#DIV/0!	2.6	2.6	2.64	2.64			
65.8	4.11	4.11	1.58	2.53	2.53	5.00	1.20	14	0.147	0.928	1.000007	0.95	0.130	0.617	0.055	0	0	0.000	#DIV/0!	#DIV/0!	2.3	2.3	2.34	2.34			
70.8	4.42	4.42	1.74	2.68	2.68	5.00	1.20	14	0.155	0.922	1.000008	0.95	0.135	0.588	0.054	0	0	0.000	#DIV/0!	#DIV/0!	2.5	2.5	2.53	2.53			

Clifty Creek AEP, Boring = B-6, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts



Clifty Creek AEP, Boring = B-6, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts



LANDFILL RUNOFF COLLECTION POND:
2015 CCR MANDATE

FINE-GRAINED ANALYSIS

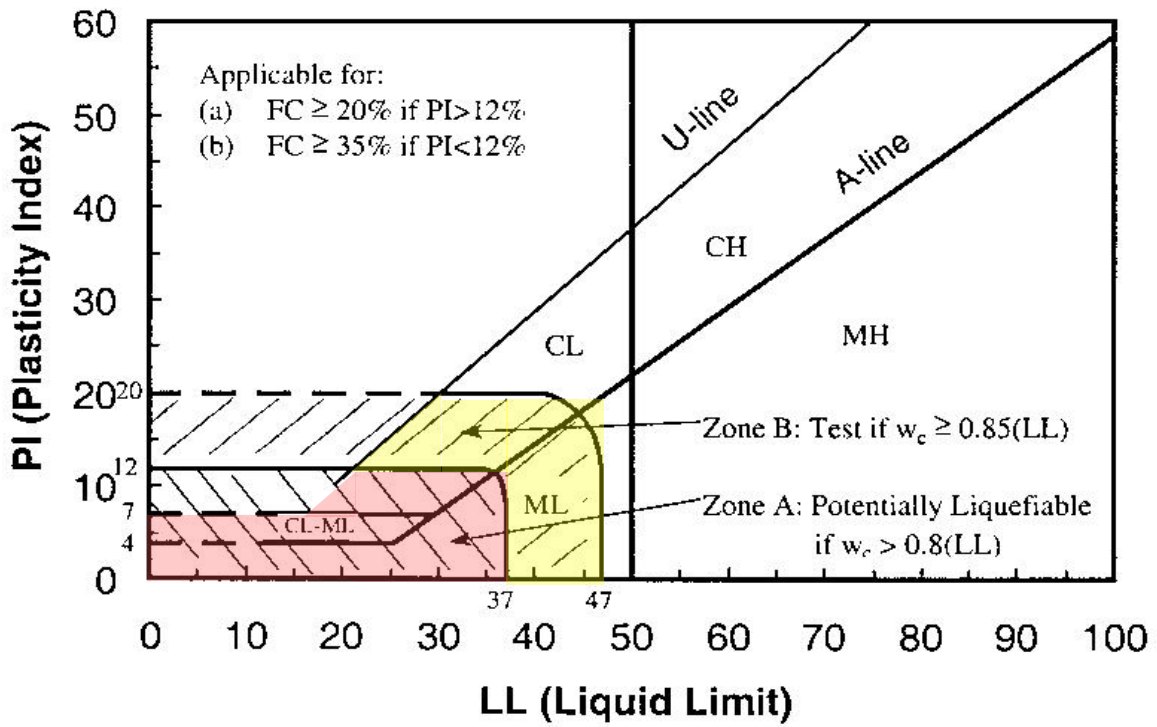
Liquefaction Susceptibility of Fine-Grained Soils

Stateco Project Number:	175553022
Project Name:	AEP City Creek
Site/Structure Name:	Landfill Runoff Collection Pond Dam

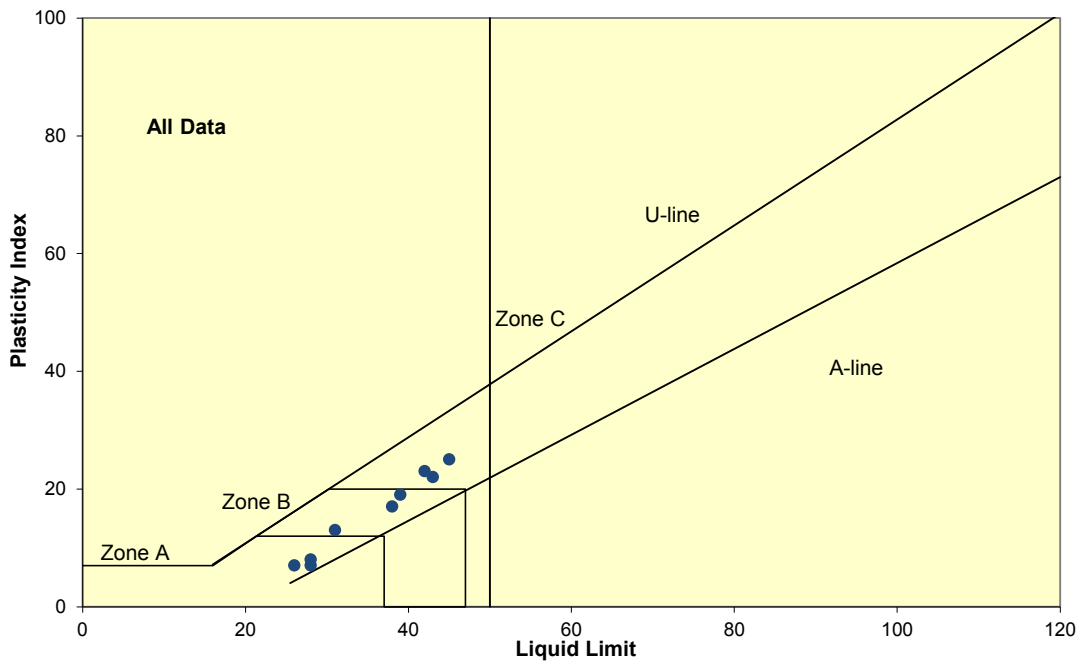
Note: NP = Non-Plastic

Lab ID	Boring	Depth(s)	Soil Classification	NMC (w _c) (%)	% Passing #200	% Passing #40	LL	PI
	B-7	27.2-27.8	CL	23.6	93.5	98	28	8
	B-8	25.5-25.8	CL	26.8	93.5	99.5	38	17
	B-8	29.7-30.3	CL	23.5	79	99	45	25
	B-9	20.2-20.8	CL	20.2	89	99.9	39	19
	B-10	14.2-14.8	SM	20.0	100	29	NP	NP
	B-10	16.2-16.8	CL-ML	20.6	100	84	28	7
3	B-12	10.0-11.5	CL	23.1	71.7	74.1	43	22
7	B-12	30.0-31.5	CL	19.0	71.4	77.3	31	13
10	B-12	45.0-46.5	CL-ML	18.7	82.2	99.2	26	7
11	B-12	50.0-51.5	ML	21.9	81.3	99.8	NP	NP
13	B-12	60.0-61.5	SM	14.8	36.1	95.7	NP	NP
15	B-12	70.0-71.5	ML	21.6	56.5	98.6	NP	NP
17	B-12	80.0-81.5	ML	25.7	50.2	98.9	NP	NP
20	B-12	95.0-96.5	CL	23.4	86.2	92.4	42	23

Sand-like versus Clay-like Behavior (-1 indicates result does not meet criteria, green shading indicates result does meet criteria, no results shown for non-plastic material)											Susceptibility of Clay-like Soils to Cyclic Softening (-1 indicates result does not meet criteria, green shading indicates result does meet criteria, no results shown for Sand-like materials)																	
Using Criteria published by Seed et al (2003)						Using Criteria published by Irfraz and Boulanger (2008)					Using criteria published by MSHA (2010)					Overall Judgement based on 3 methods (sand-like or clay-like)			Using Criteria published by Seed et al (2003)				Using Criteria published by Bray and Sancio (2006)				Overall Judgement based on 2 methods (susceptibility)	
Meets criteria for sand-like behavior		Meets criteria for clay-like behavior				Meets criteria for sand-like behavior	Meets criteria for clay-like behavior	Meets criteria for sand-like behavior	Meets criteria for clay-like behavior	Meets criteria for sand-like behavior	Meets criteria for clay-like behavior	Borderline soils (treat as sand-like)	Overall Judgement based on 3 methods (sand-like or clay-like)	Meets all criteria for B (clay-like and potentially liquefiable, -2 indicates zone A but susceptible, -3 indicates not applicable due to fines content)		Clay-like soil is susceptible (must meet both)		Clay-like soil is not susceptible (must meet one or both)		Clay-like soil is moderately susceptible		Overall Judgement based on 2 methods (susceptibility)						
LL in Zone A (see plot)	PI in Zone A (see plot)	LL in Zone B (see plot)	PI in Zone B (see plot)	LL in Zone C (see plot)	PI in Zone C (see plot)	PI < 7	PI >= 7	PI <= 7	P40>=35%, P200>=20% and PI>=10	7 < PI < 10, or does not meet P40 or P200	LL	PI		w _c /LL >= 0.85	PI <= 12	w _c /LL < 0.80	PI > 18	Intermediate w _c /LL (see plot)	Intermediate PI (see plot)									
	28	8	-1	-1	-1	-1	-1	8	-1	-1	8	Sand-like																
	-1	-1	38	17	-1	-1	-1	17	-1	17	-1	Clay-like	-1	-1	-1.00	-1	0.71	17	-1.00	-1	Not Susceptible							
	-1	-1	-1	-1	45	25	-1	25	-1	25	-1	Clay-like	-1	-1	-1.00	-1	0.52	25	-1.00	-1	Not Susceptible							
	-1	-1	39	19	-1	-1	-1	19	-1	19	-1	Clay-like	-1	-1	-1.00	-1	0.52	19	-1.00	-1	Not Susceptible							
												Sand-like																
	28	7	-1	-1	-1	-1	-1	7	7	-1	-1	Sand-like																
	-1	-1	-1	-1	43	22	-1	22	-1	22	-1	Clay-like	-1	-1	-1.00	-1	0.54	22	-1.00	-1	Not Susceptible							
	-1	-1	31	13	-1	-1	-1	13	-1	13	-1	Clay-like	-1	-1	-1.00	-1	0.61	13	-1.00	-1	Not Susceptible							
	26	7	-1	-1	-1	-1	-1	7	7	-1	-1	Sand-like																
												Sand-like																
												Sand-like																
												Sand-like																
	-1	-1	-1	-1	42	23	-1	23	-1	23	-1	Clay-like	-1	-1	-1.00	-1	0.56	23	-1.00	-1	Not Susceptible							

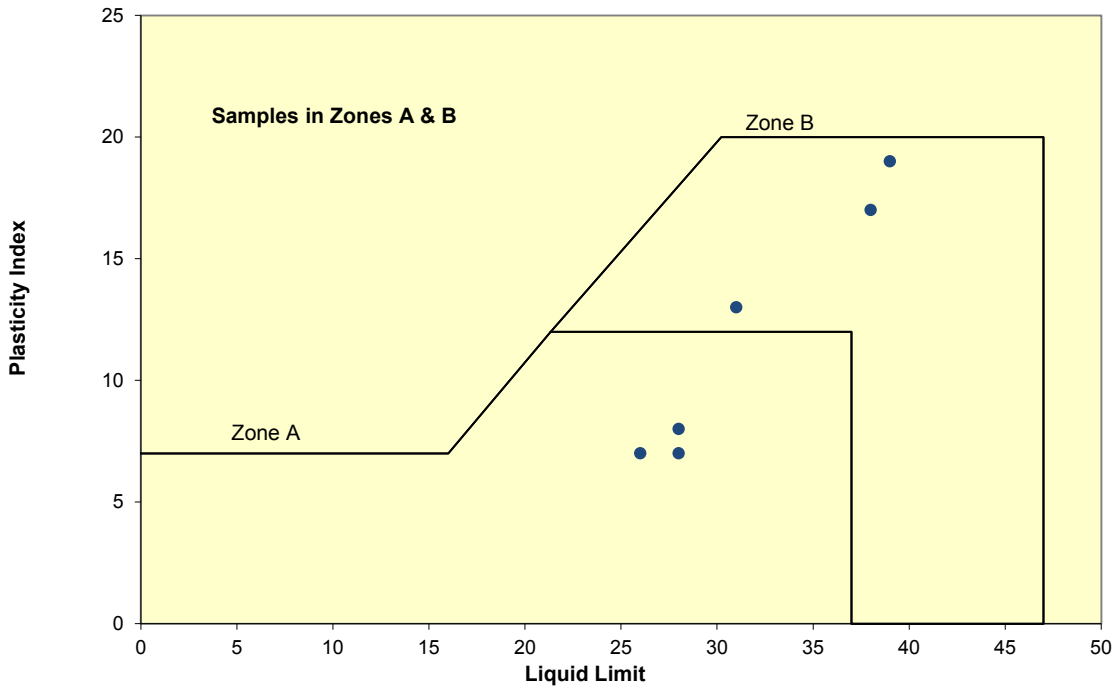


(a)

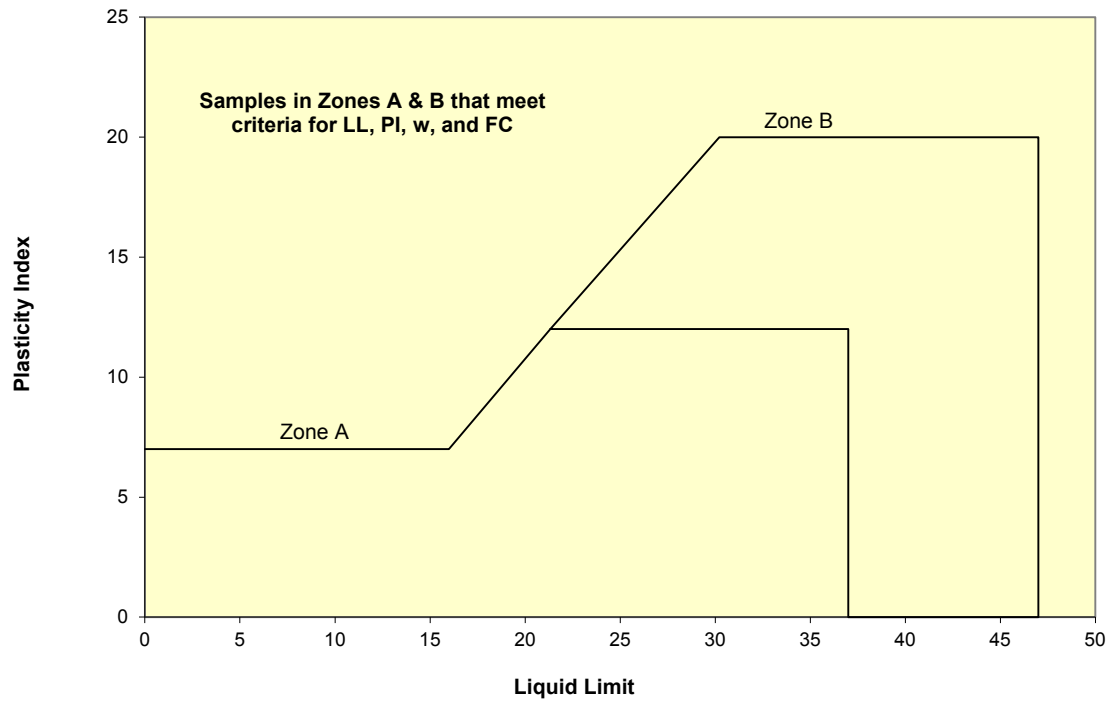


(b)

Screening Criteria for Liquefiable Fine-Grained Soils (Seed et al. 2003)

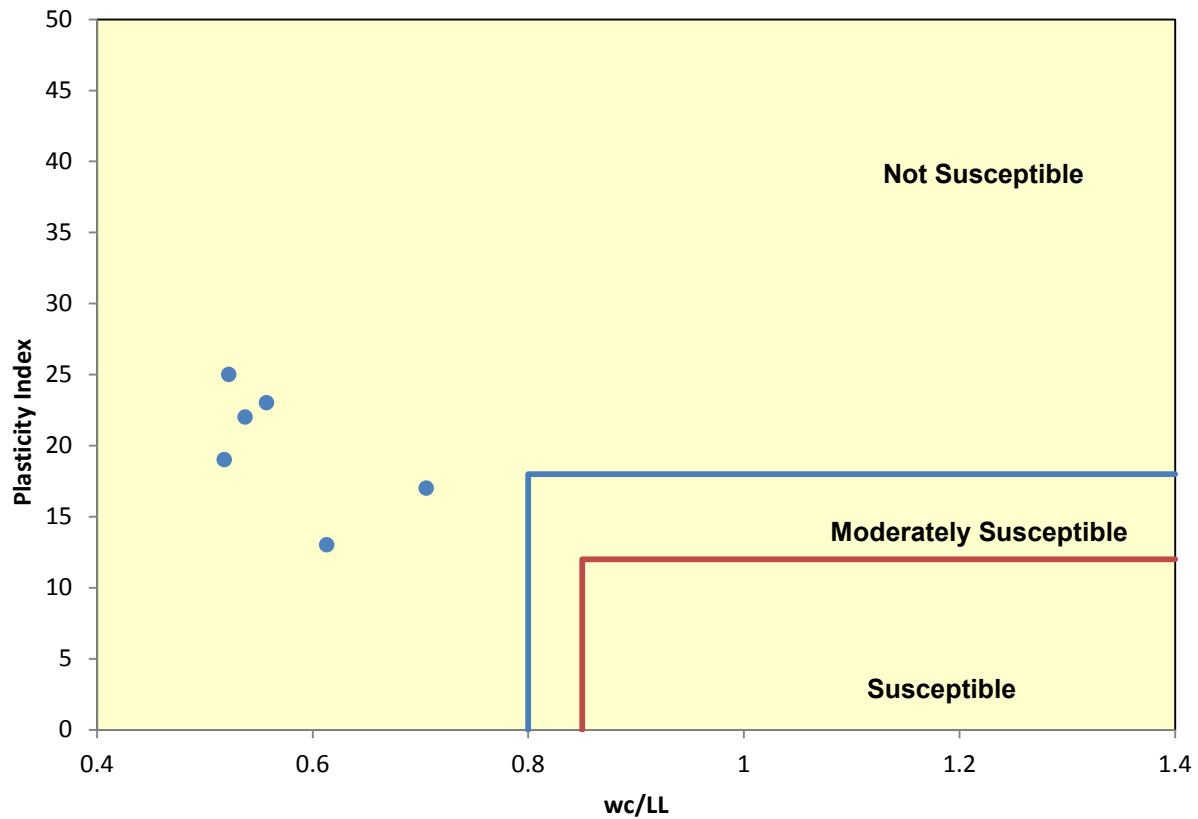
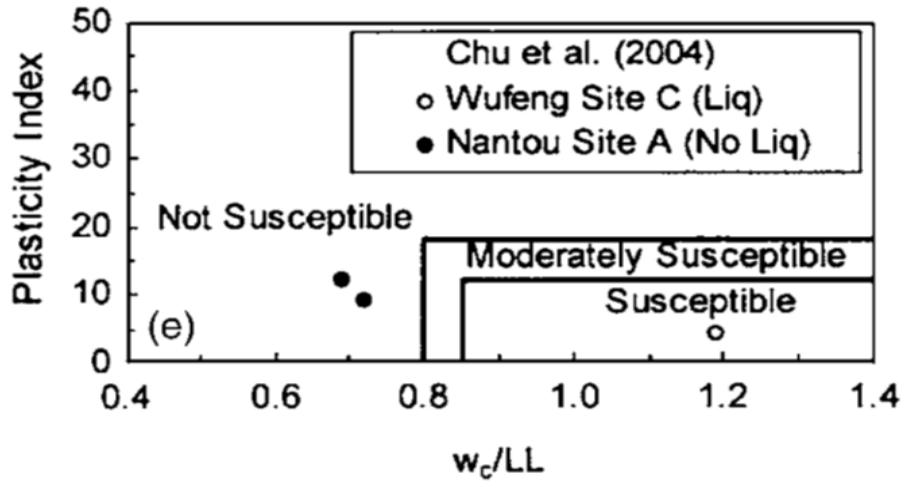


(c)



(d)

Screening Criteria for Liquefiable Fine-Grained Soils (Seed et al. 2003)

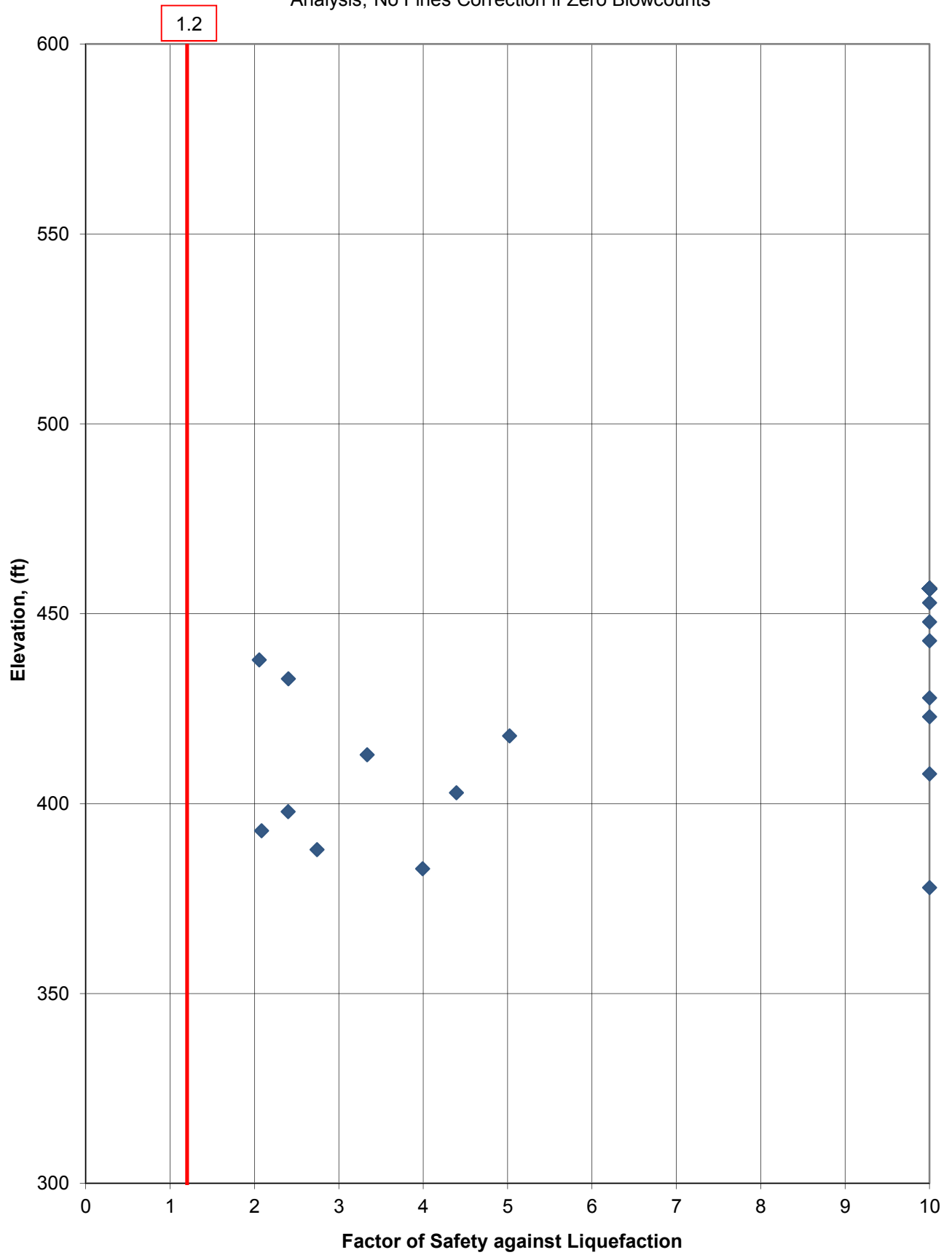


Screening Criteria for Assessing Liquefaction in Fine Grained Soils (Bray and Sancio 2006)

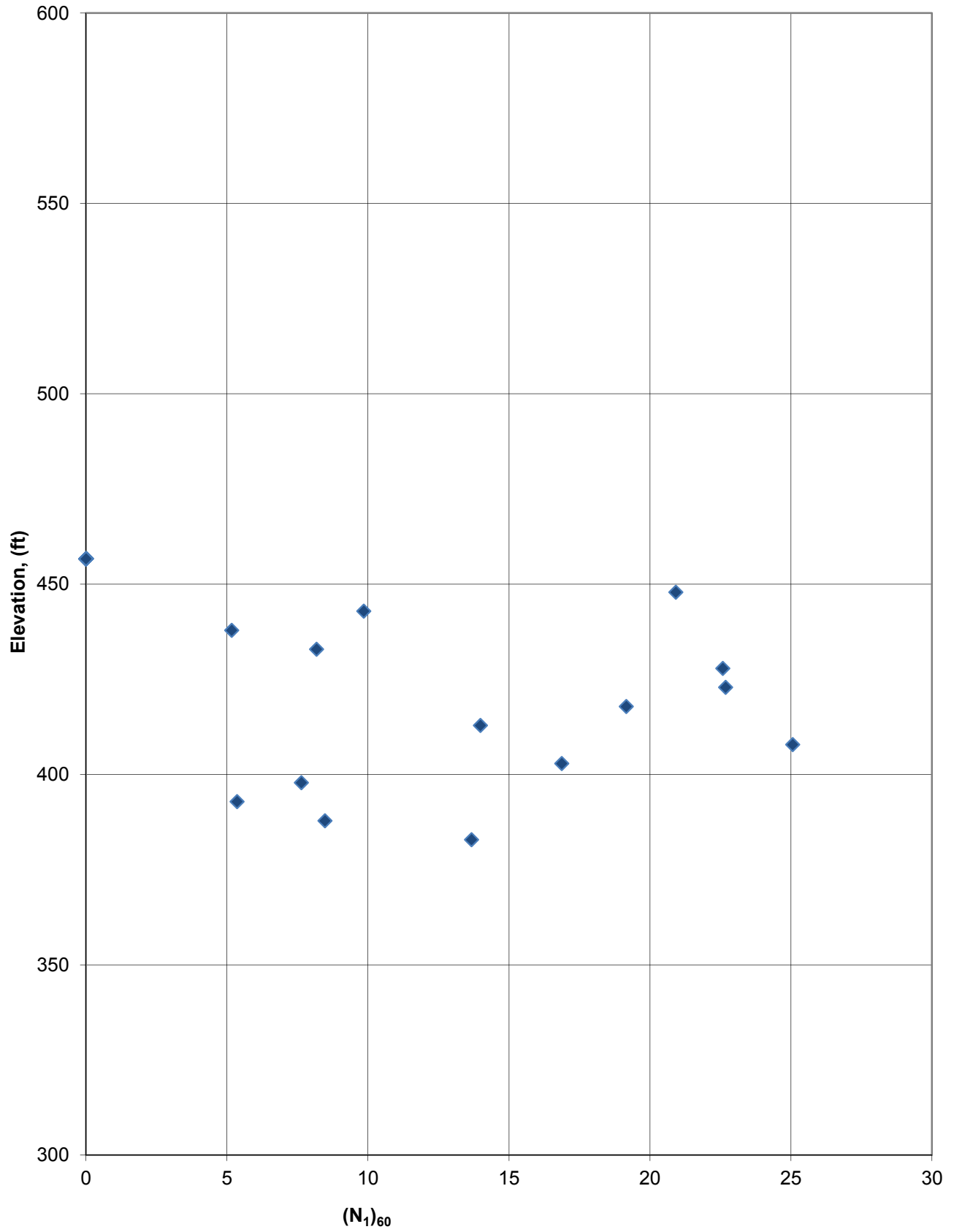
COARSE-GRAINED ANALYSIS

Depth of Mid. Pt. of Sample (ft.)	Vert. Total Stress during EQ (tsf)	Vert. Total Stress during EQ w/ Fill (tsf)	Static Pore Pressure during EQ (tsf)	Vert. Eff. Stress during EQ (tsf)	Vert. Eff. Stress during EQ w/ Fill (tsf)	Alpha I	Beta I	Equivalent Clean Sand N-Value (N1) ^{60CS}	CRR7.5	Ksigma	Kalpha	Factor (Cm)	Design EQ	EQ Source		Event (MCE, OBE, etc.)	EQ Motion File	Shake Stress Curve Fit Parameters					
														a max (g)	EQ Mag (Mw)			m4:	m3:	m2:	m1:		
z	σ_v	$\sigma_{v\text{ with fill}}$	u	σ'_v	$\sigma'_{v\text{ with fill}}$									Simplified Stress Reduction	Simplified CSR eq	Max. Shake Stress (psf)	Avg. Shake Stress (psf)	Using SHAKE Data	Using SHAKE Data	Using SHAKE Data	Simplified		
														Coeff., r_d	Design EQ	Design EQ	Design EQ	Design EQ	CSR eq	FS liq	FS liq	FS liq	FS liq
						Boring ID: SI-1		<p>Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.</p>															
						Top of Fill Elevation: 456.6																	
						Fill Height: 0.0																	
						Fill Total Unit Weight: 125																	
						Fill Total Stress: 0.00																	
	tolstr-top		u-top	effstr-top																			
	0.19		0.00	0.19																			
3.8	0.23	0.23	0.00	0.23	0.23	5.00	1.20	46	NA	1.000	1.000	0.95	NA	0.993	0.055	0	0	0.000	NA	10.0	NA	10.0	
8.8	0.55	0.55	0.00	0.55	0.55	5.00	1.20	30	NA	1.000	1.000	0.95	NA	0.982	0.054	0	0	0.000	NA	10.0	NA	10.0	
13.8	0.86	0.86	0.00	0.86	0.86	5.00	1.20	17	NA	1.000	1.000	0.95	NA	0.971	0.054	0	0	0.000	NA	10.0	NA	10.0	
18.8	1.17	1.17	0.15	1.02	1.02	5.00	1.20	11	0.124	1.000	1.000	0.95	0.117	0.960	0.061	0	0	0.000	#DIV/0!	#DIV/0!	2.1	2.06	
23.8	1.48	1.48	0.30	1.18	1.18	5.00	1.20	15	0.158	0.991	1.000	0.95	0.149	0.946	0.066	0	0	0.000	#DIV/0!	#DIV/0!	2.4	2.40	
28.8	1.80	1.80	0.46	1.34	1.34	5.00	1.20	32	NA	0.966	1.000	0.95	NA	0.927	0.069	0	0	0.000	NA	10.0	NA	10.0	
33.8	2.11	2.11	0.62	1.49	1.49	5.00	1.20	32	NA	0.950	1.000	0.95	NA	0.899	0.070	0	0	0.000	NA	10.0	NA	10.0	
38.8	2.42	2.42	0.77	1.65	1.65	5.00	1.20	28	0.369	0.943	1.000	0.95	0.330	0.862	0.070	0	0	0.000	#DIV/0!	#DIV/0!	5.0	5.02	
43.8	2.73	2.73	0.93	1.81	1.81	5.00	1.20	22	0.239	0.945	1.000	0.95	0.214	0.816	0.068	0	0	0.000	#DIV/0!	#DIV/0!	3.3	3.34	
48.8	3.05	3.05	1.08	1.96	1.96	5.00	1.20	35	NA	0.899	1.000	0.95	NA	0.765	0.066	0	0	0.000	NA	10.0	NA	10.0	
53.8	3.36	3.36	1.24	2.12	2.12	5.00	1.20	25	0.297	0.920	1.000	0.95	0.259	0.715	0.063	0	0	0.000	#DIV/0!	#DIV/0!	4.4	4.39	
58.8	3.67	3.67	1.40	2.28	2.28	5.00	1.20	14	0.152	0.936	1.000	0.95	0.135	0.670	0.060	0	0	0.000	#DIV/0!	#DIV/0!	2.4	2.40	
63.8	3.98	3.98	1.55	2.43	2.43	5.00	1.20	11	0.126	0.937	1.000	0.95	0.112	0.631	0.057	0	0	0.000	#DIV/0!	#DIV/0!	2.1	2.08	
68.8	4.30	4.30	1.71	2.59	2.59	5.00	1.20	15	0.162	0.923	1.000	0.95	0.142	0.599	0.055	0	0	0.000	#DIV/0!	#DIV/0!	2.7	2.74	
73.8	4.61	4.61	1.86	2.75	2.75	5.00	1.20	21	0.234	0.902	1.000	0.95	0.200	0.573	0.053	0	0	0.000	#DIV/0!	#DIV/0!	4.0	3.99	
78.8	4.92	4.92	2.02	2.90	2.90	5.00	1.20	62	NA	0.697	1.000	0.95	NA	0.553	0.052	0	0	0.000	NA	10.0	NA	10.0	

Clifty Creek AEP, Boring = SI-1, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts

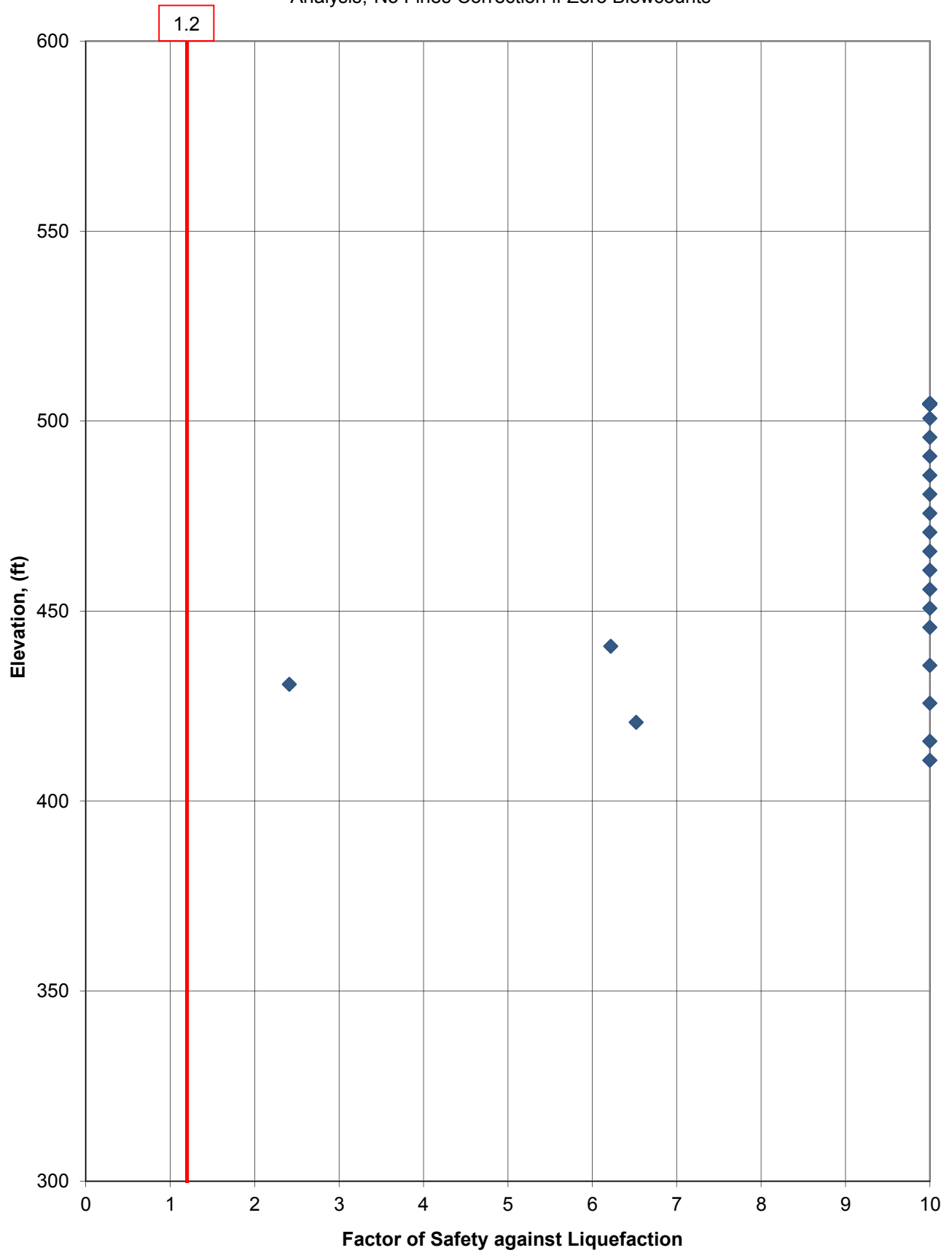


Clifty Creek AEP, Boring = SI-1, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts

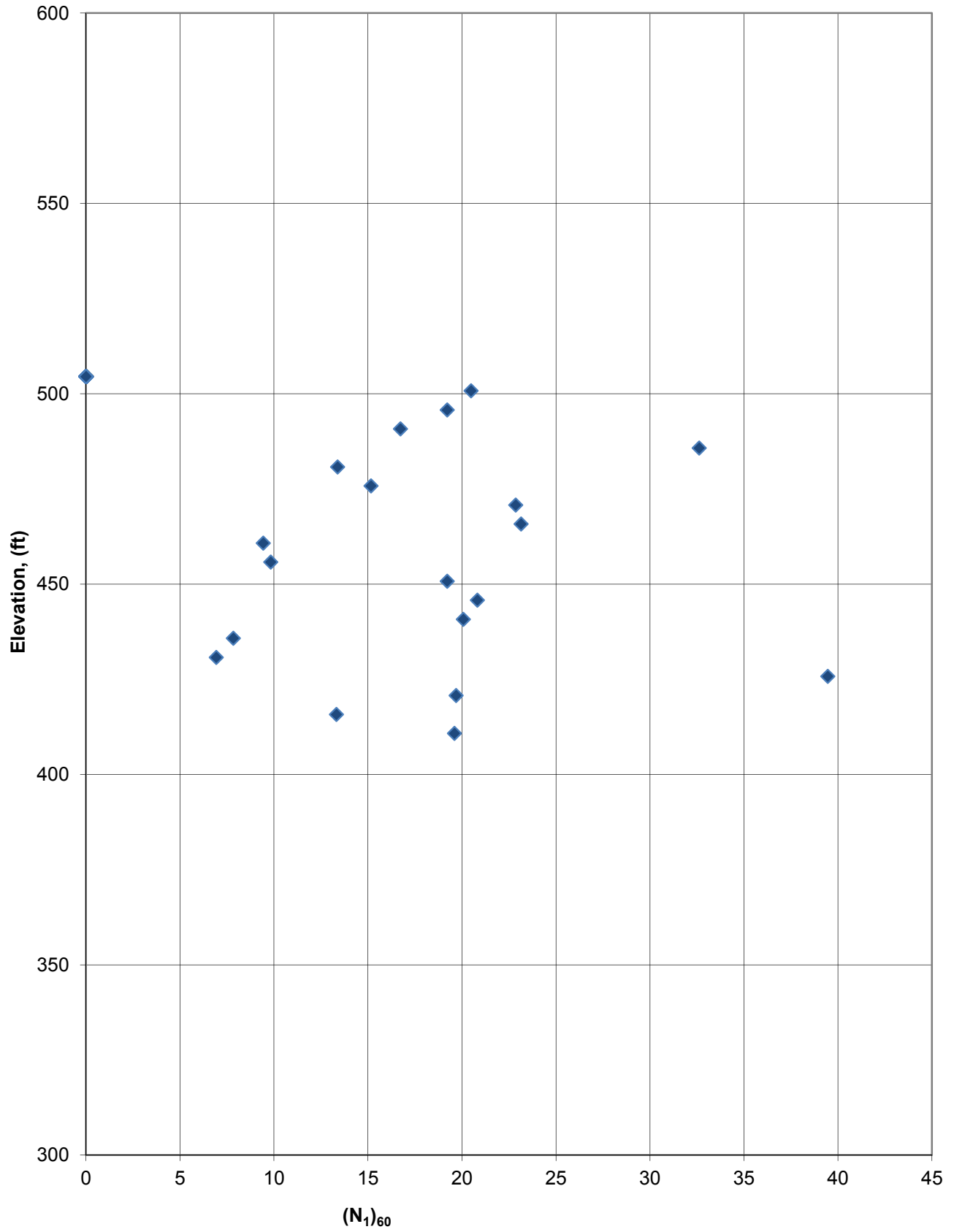


Depth of Mid. Pt. of Sample (ft.)	Vert. Total Stress during EQ (tsf)	Vert. Total Stress during EQ w/ Fill (tsf)	Static Pore Pressure during EQ (tsf)	Vert. Eff. Stress during EQ (tsf)	Vert. Eff. Stress during EQ w/ Fill (tsf)	Effective All-Around Stress during EQ (psf)	Shear Modulus during EQ (ksf)	Equivalent Clean Sand N-Value	Alpha I	Beta I	(N ₁) _{60cs}	CRR7.5	Ksigma	Kalpha	EQ Source		Event (MCE, OBE, etc.)		Shake Stress Curve Fit Parameters						
															0	0	0	0	0	0					
z	σ _v	σ _v with fill	u	σ _v '	σ _v ' with fill	σ _m	G _{max}								Mag. Scaling	CRR	Simplified Stress Reduction Coeff., r _d	Simplified CSR eq Design EQ	Max. Shake Stress (psf) Design EQ	Avg. Shake Stress (psf) Design EQ	Using SHAKE Data		Simplified		
															Factor (Cm)	Design EQ					CSR eq Design EQ	FS liq Design EQ	FS liq for plot	FS liq Design EQ	FS liq for plot
Boring ID: SS2-1						Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.																			
Top of Fill Elevation: 504.5 ft (if no fill, then set this equal to top of SPT hole elev.)																									
Fill Height: 0.0 ft (relative to ground surface during SPT)																									
Fill Total Unit Weight: 125 pcf																									
Fill Total Stress: 0.00 tsf																									
	tsfstr-top 0.19		u-top 0.00	effstr-top 0.19																					
3.8	0.23	0.23	0.00	0.23	0.23	312.50	#NUM!	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.993	0.055	0	0	0.000	NA	10.0	NA	10.00
8.8	0.55	0.55	0.00	0.55	0.55	729.17	#NUM!	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.982	0.054	0	0	0.000	NA	10.0	NA	10.00
13.8	0.86	0.86	0.12	0.74	0.74	989.83	#NUM!	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.971	0.062	0	0	0.000	NA	10.0	NA	10.00
18.8	1.17	1.17	0.27	0.90	0.90	1198.50	#NUM!	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.960	0.069	0	0	0.000	NA	10.0	NA	10.00
23.8	1.48	1.48	0.43	1.06	1.06	1407.17	#NUM!	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.946	0.074	0	0	0.000	NA	10.0	NA	10.00
28.8	1.80	1.80	0.59	1.21	1.21	1615.83	#NUM!	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.927	0.076	0	0	0.000	NA	10.0	NA	10.00
33.8	2.11	2.11	0.74	1.37	1.37	1824.50	#NUM!	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.899	0.077	0	0	0.000	NA	10.0	NA	10.00
38.8	2.42	2.42	0.90	1.52	1.52	2033.17	#NUM!	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.862	0.076	0	0	0.000	NA	10.0	NA	10.00
43.8	2.73	2.73	1.05	1.68	1.68	2241.83	#NUM!	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.816	0.073	0	0	0.000	NA	10.0	NA	10.00
48.8	3.05	3.05	1.21	1.84	1.84	2450.50	#NUM!	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.765	0.070	0	0	0.000	NA	10.0	NA	10.00
53.8	3.36	3.36	1.37	1.99	1.99	2659.17	#NUM!	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.715	0.067	0	0	0.000	NA	10.0	NA	10.00
58.8	3.67	3.67	1.52	2.15	2.15	2867.83	#NUM!	NA	NA	NA	NA	NA	NA	NA	0.95	NA	0.670	0.063	0	0	0.000	NA	10.0	NA	10.00
63.8	3.98	3.98	1.68	2.31	2.31	3076.50	#NUM!	5.00	1.20	29	0.414	0.896	1.000	0.95	0.352	0.631	0.060	0	0	0.000	#DIV/0!	#DIV/0!	6.2	6.22	
68.8	4.30	4.30	1.83	2.46	2.46	3285.17	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.599	0.058	0	0	0.000	NA	10.0	NA	10.00	
73.8	4.61	4.61	1.99	2.62	2.62	3493.83	#NUM!	5.00	1.20	13	0.144	0.928	1.000	0.95	0.126	0.573	0.056	0	0	0.000	#DIV/0!	#DIV/0!	2.4	2.41	
78.8	4.92	4.92	2.15	2.78	2.78	3702.50	#NUM!	5.00	1.20	52	NA	0.711	1.000	0.95	NA	0.553	0.054	0	0	0.000	NA	10.0	NA	10.00	
83.8	5.23	5.23	2.30	2.93	2.93	3911.17	#NUM!	5.00	1.20	29	0.393	0.869	1.000	0.95	0.324	0.536	0.053	0	0	0.000	#DIV/0!	#DIV/0!	6.5	6.52	
88.8	5.55	5.55	2.46	3.09	3.09	4119.83	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.522	0.052	0	0	0.000	NA	10.0	NA	10.00	
93.8	5.86	5.86	2.61	3.25	3.25	4328.50	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.511	0.051	0	0	0.000	NA	10.0	NA	10.00	

Clifty Creek AEP, Boring = SS2-1, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts



Clifty Creek AEP, Boring = SS2-1, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts



EQ Source	0
a max (g)	0.085
EQ Mag (Mw)	7.7
Mag. Scaling	

Event (MCE, OBE, etc.)

0

EQ Motion File

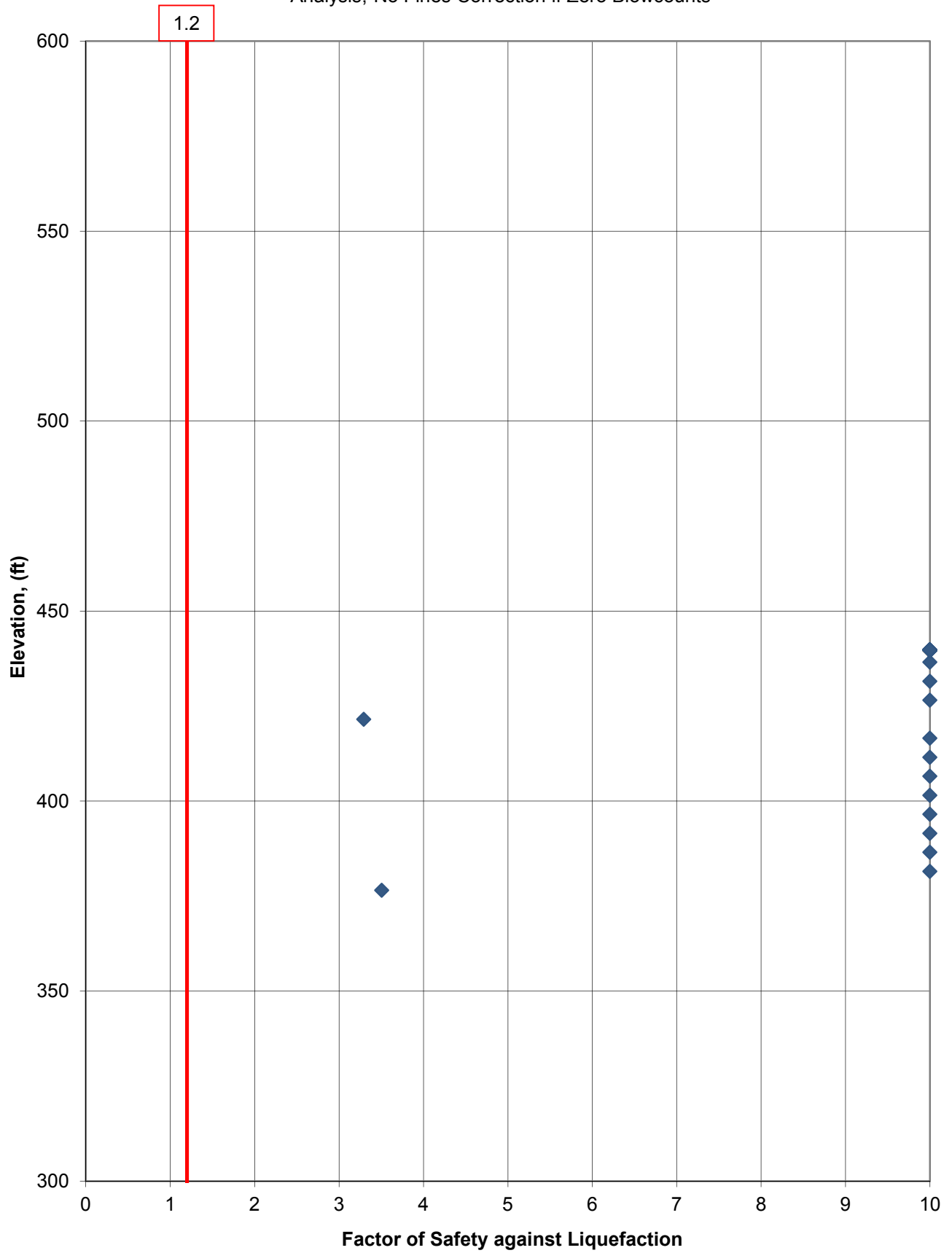
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Shake Stress Curve Fit Parameters

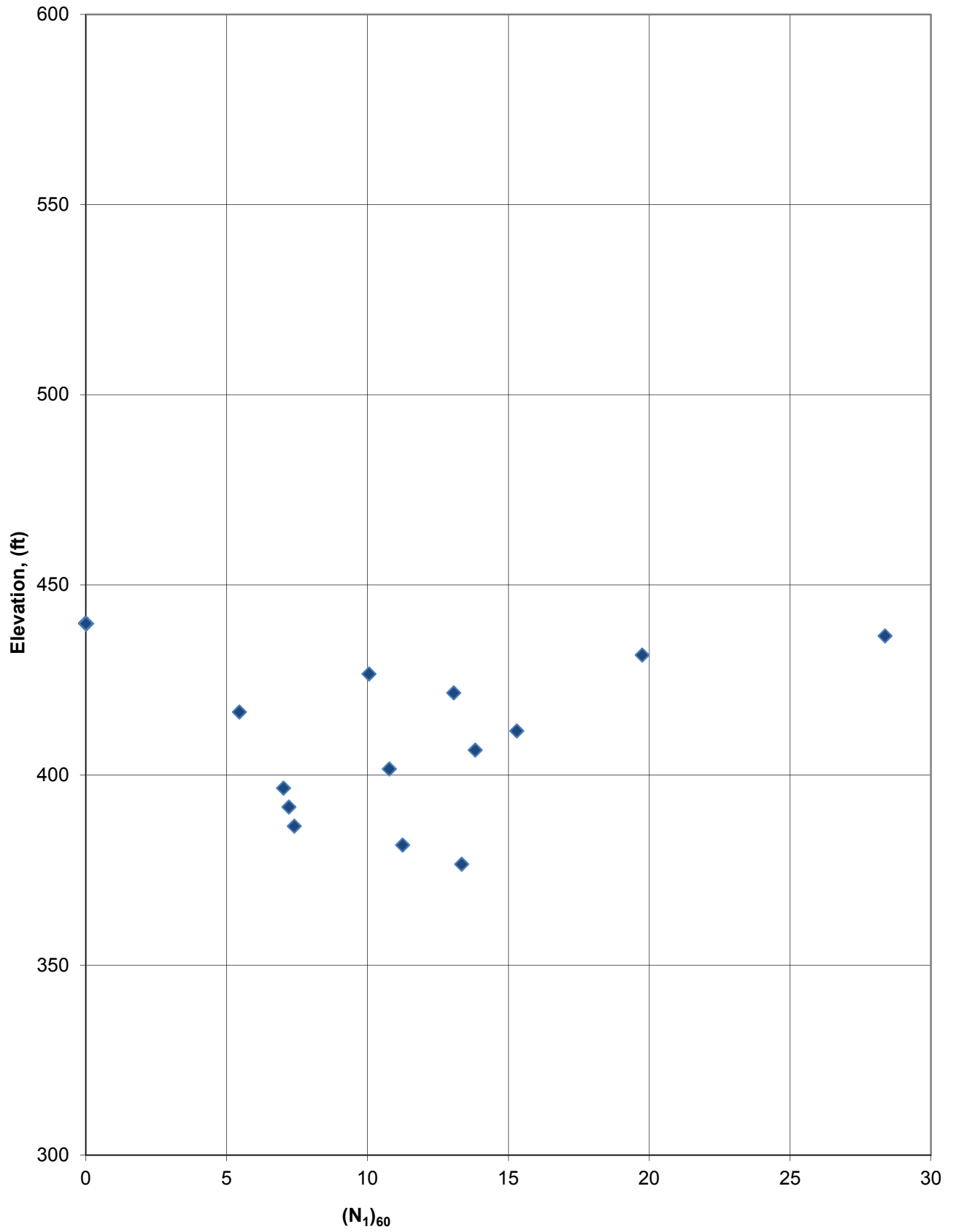
m4:	0
m3:	0
m2:	0
m1:	0

Depth of Mid. Pt. of Sample (ft.)	Vert. Total Stress during EQ (tsf)	Vert. Total Stress during EQ w/ Fill (tsf)	Static Pore Pressure during EQ (tsf)	Vert. Eff. Stress during EQ (tsf)	Vert. Eff. Stress during EQ w/ Fill (tsf)	Alpha I	Beta I	Equivalent Clean Sand N-Value (N1) ^{60CS}	CRR7.5	Ksigma	Kalpha	Factor (Cm)	Design EQ	Simplified Stress Reduction	Simplified CSR eq	Max. Shake Stress (psf)	Avg. Shake Stress (psf)	Using SHAKE Data			Simplified										
														Coeff., r_d	Design EQ			Design EQ	Design EQ	Design EQ	FS liq	FS liq	FS liq	FS liq							
z	σ_v	$\sigma_{v\text{ with fill}}$	u	σ'_v	$\sigma'_{v\text{ with fill}}$													Design EQ	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ								
<table border="1"> <tr><td>Boring ID:</td><td>SS2-4</td></tr> <tr><td>Top of Fill Elevation:</td><td>439.8</td></tr> <tr><td>Fill Height:</td><td>0.0</td></tr> <tr><td>Fill Total Unit Weight:</td><td>125</td></tr> <tr><td>Fill Total Stress:</td><td>0.00</td></tr> </table>						Boring ID:	SS2-4	Top of Fill Elevation:	439.8	Fill Height:	0.0	Fill Total Unit Weight:	125	Fill Total Stress:	0.00	<p>Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.</p>															
Boring ID:	SS2-4																														
Top of Fill Elevation:	439.8																														
Fill Height:	0.0																														
Fill Total Unit Weight:	125																														
Fill Total Stress:	0.00																														
	tolstr-top 0.16		u-top 0.00	effstr-top 0.16																											
3.3	0.20	0.20	0.00	0.20	0.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.00									
8.3	0.52	0.52	0.00	0.52	0.52	NA	NA	NA	NA	NA	NA	0.95	NA	0.983	0.054	0	0	0.000	NA	10.0	NA	10.00									
13.3	0.83	0.83	0.10	0.73	0.73	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.061	0	0	0.000	NA	10.0	NA	10.00									
18.3	1.14	1.14	0.26	0.88	0.88	5.00	1.20	21	0.224	1.000	1.000	0.95	0.212	0.961	0.069	0	0	0.000	#DIV/0!	#DIV/0!	3.3	3.29									
23.3	1.45	1.45	0.41	1.04	1.04	NA	NA	NA	NA	NA	NA	0.95	NA	0.948	0.073	0	0	0.000	NA	10.0	NA	10.00									
28.3	1.77	1.77	0.57	1.20	1.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.929	0.076	0	0	0.000	NA	10.0	NA	10.00									
33.3	2.08	2.08	0.73	1.35	1.35	NA	NA	NA	NA	NA	NA	0.95	NA	0.902	0.077	0	0	0.000	NA	10.0	NA	10.00									
38.3	2.39	2.39	0.88	1.51	1.51	NA	NA	NA	NA	NA	NA	0.95	NA	0.866	0.076	0	0	0.000	NA	10.0	NA	10.00									
43.3	2.70	2.70	1.04	1.67	1.67	NA	NA	NA	NA	NA	NA	0.95	NA	0.821	0.074	0	0	0.000	NA	10.0	NA	10.00									
48.3	3.02	3.02	1.19	1.82	1.82	NA	NA	NA	NA	NA	NA	0.95	NA	0.771	0.070	0	0	0.000	NA	10.0	NA	10.00									
53.3	3.33	3.33	1.35	1.98	1.98	NA	NA	NA	NA	NA	NA	0.95	NA	0.720	0.067	0	0	0.000	NA	10.0	NA	10.00									
58.3	3.64	3.64	1.51	2.14	2.14	NA	NA	NA	NA	NA	NA	0.95	NA	0.674	0.063	0	0	0.000	NA	10.0	NA	10.00									
63.3	3.95	3.95	1.66	2.29	2.29	5.00	1.20	21	0.228	0.920	1.000	0.95	0.199	0.634	0.060	0	0	0.000	#DIV/0!	#DIV/0!	3.5	3.50									

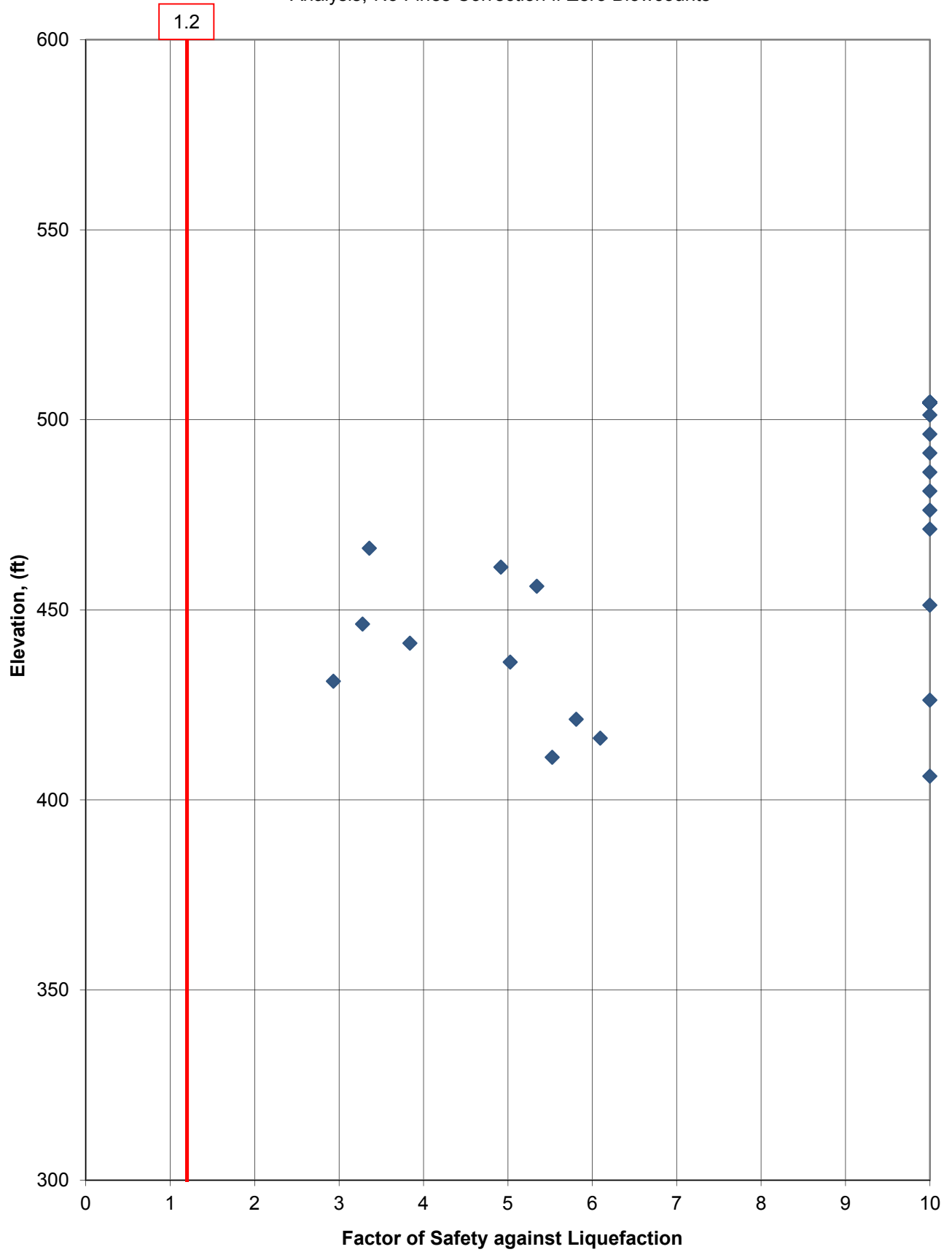
Clifty Creek AEP, Boring = SS2-4, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts



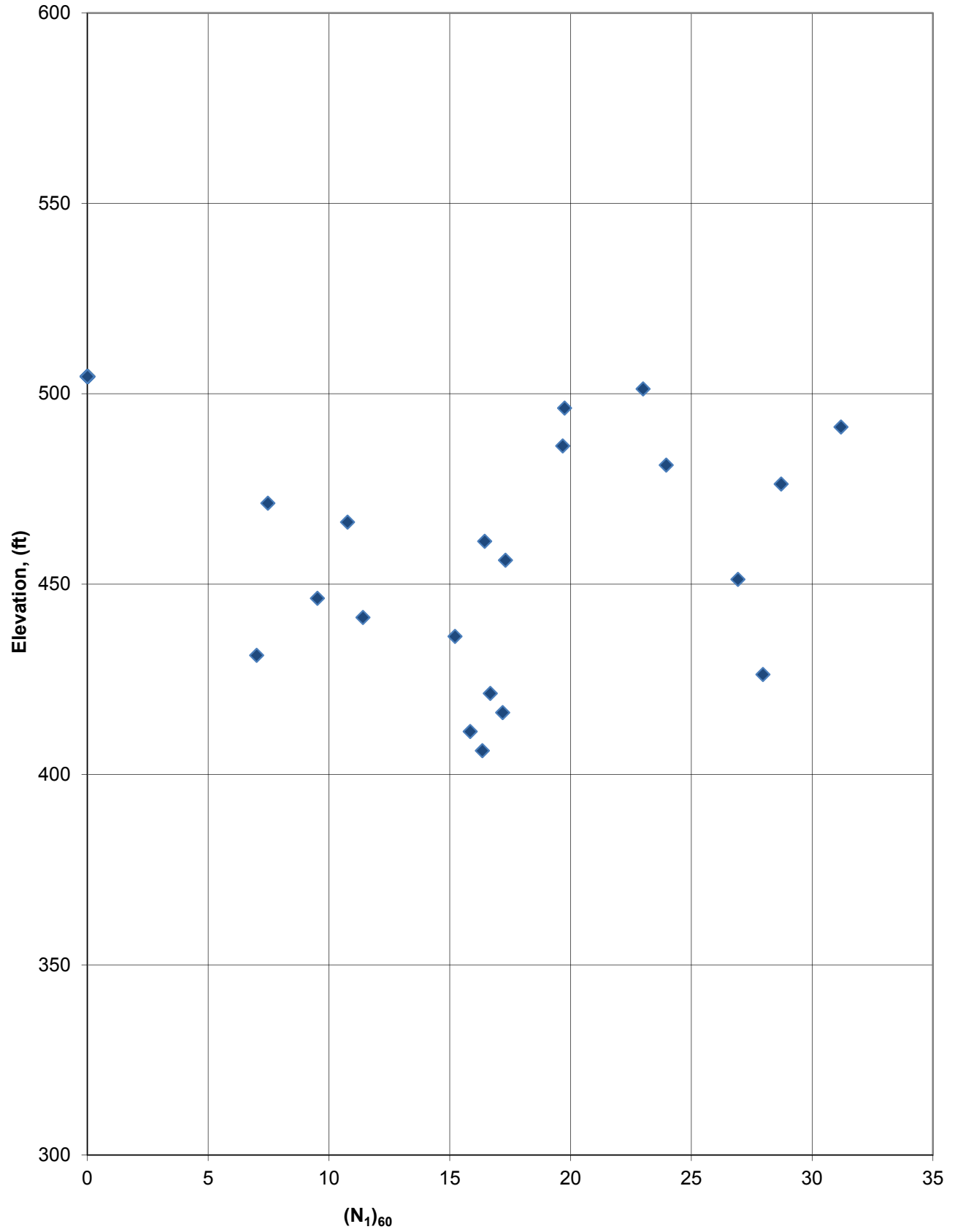
Clifty Creek AEP, Boring = SS2-4, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts



Clifty Creek AEP, Boring = SS3-1, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts

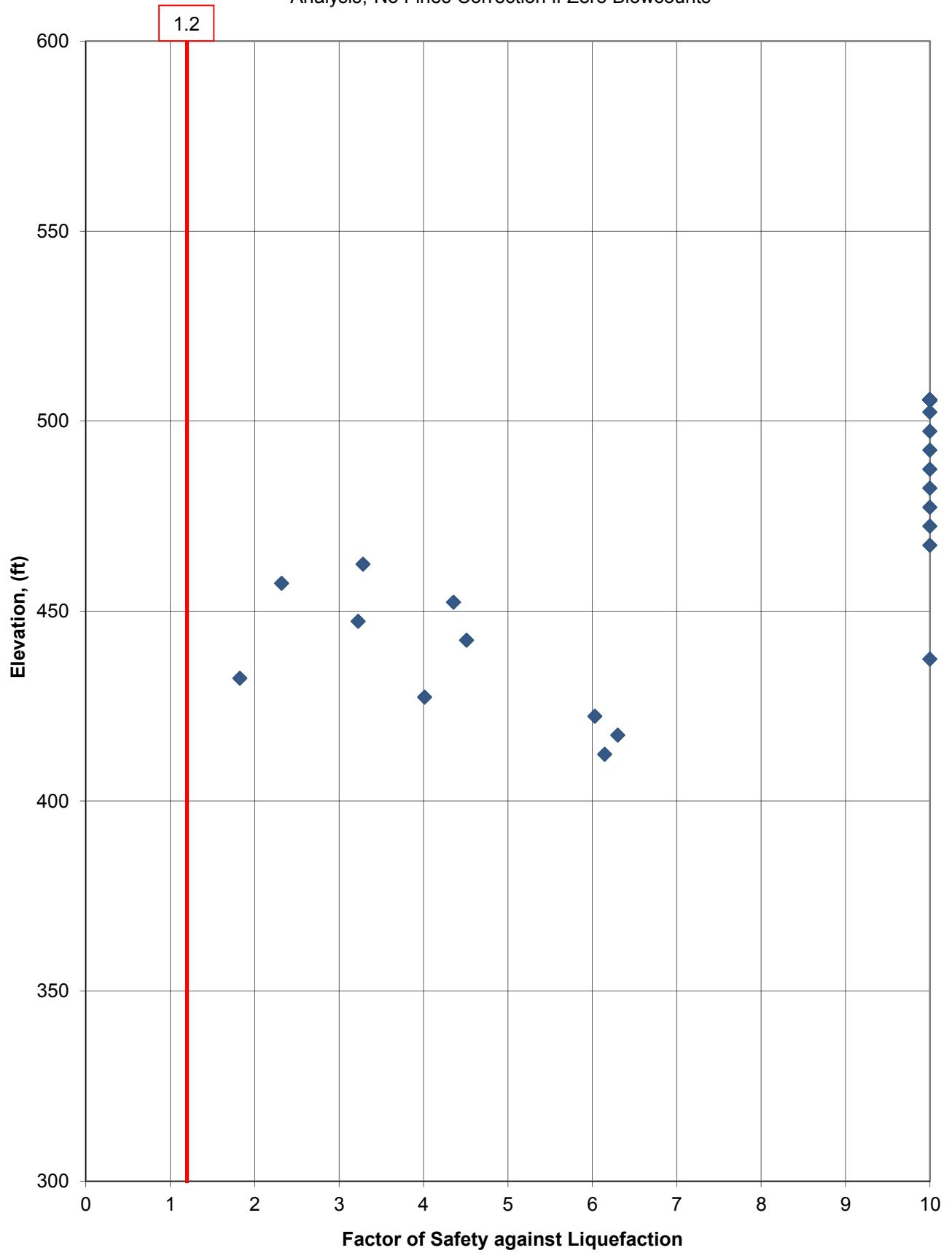


Clifty Creek AEP, Boring = SS3-1, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts

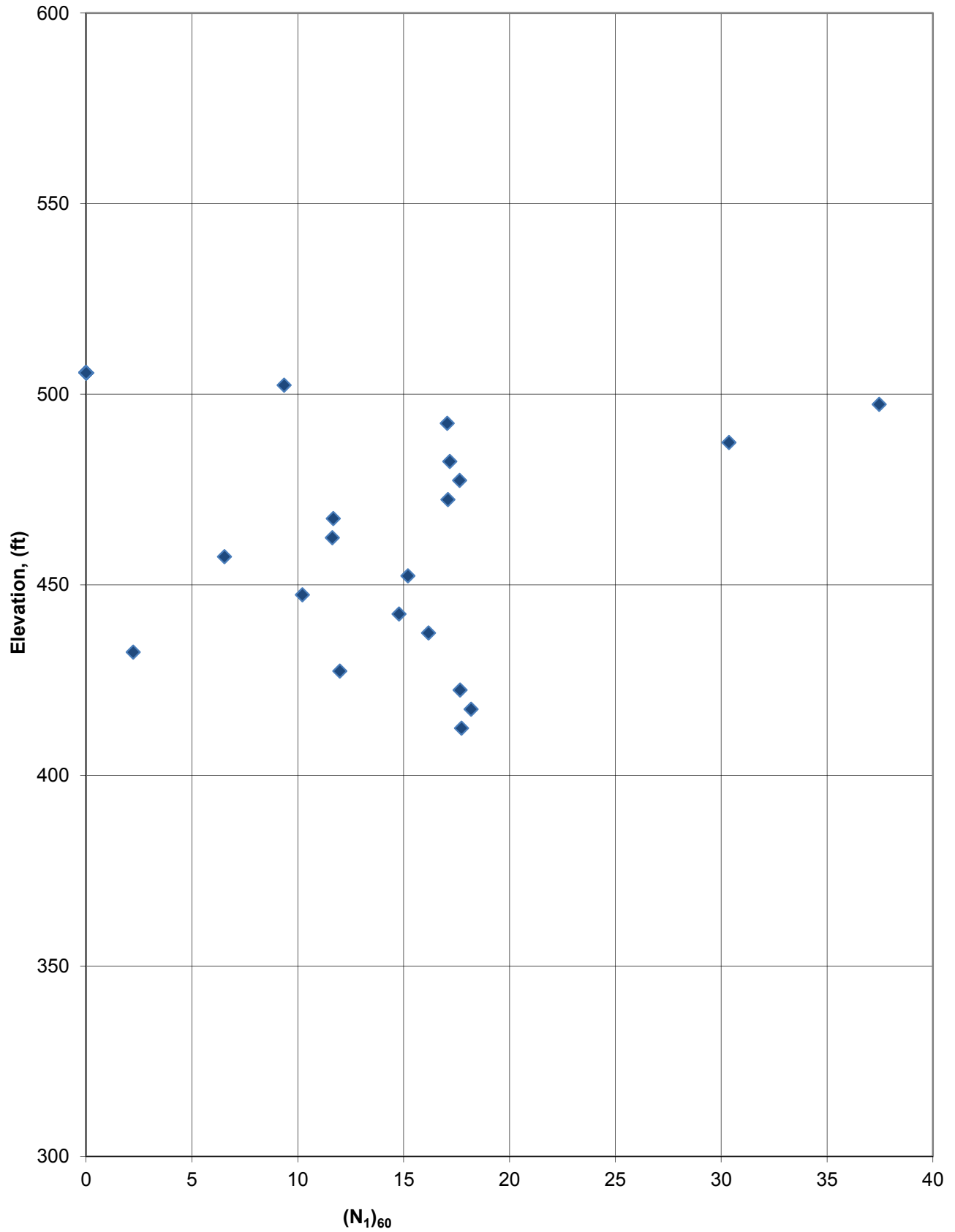


Depth of Mid. Pt. of Sample (ft.)	Vert. Total Stress during EQ (tsf)	Vert. Total Stress during EQ w/ Fill (tsf)	Static Pore Pressure during EQ (tsf)	Vert. Eff. Stress during EQ (tsf)	Vert. Eff. Stress during EQ w/ Fill (tsf)	Effective All-Around Stress during EQ (psf)	Shear Modulus during EQ (ksf)	Equivalent Clean Sand N-Value					EQ Source 0 a max (g) 0.085 EQ Mag (Mw) 7.7	CRR	EQ Motion File 0	Event (MCE, OBE, etc.) 0	Shake Stress Curve Fit Parameters							
								Alpha I	Beta I	(N ₁) _{60cs}	CRR7.5	Ksigma					Kalpha	Factor (Cm)	Design EQ	Simplified Stress Reduction Coeff., r _s	Simplified CSR eq Design EQ	Max. Shake Stress (psf) Design EQ	Avg. Shake Stress (psf) Design EQ	Using SHAKE Data		Simplified
z	σ _v	σ _v with fill	u	σ _v	σ _v with fill	σ _m	C _{max}											CSR eq	FS liq	FS liq	FS liq	FS liq		
Boring ID: SS4-1 Top of Fill Elevation: 505.6 ft (if no fill, then set this equal to top of SPT hole elev.) Fill Height: 0.0 ft (relative to ground surface during SPT) Fill Total Unit Weight: 125 pcf Fill Total Stress: 0.00 tsf						Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.																		
	tsfstr-top 0.16		u-top 0.00	effstr-top 0.16																				
3.3	0.20	0.20	0.00	0.20	0.20	270.83	#NUM!	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.00	
8.3	0.52	0.52	0.00	0.52	0.52	687.50	#NUM!	5.00	1.20	50	NA	1.000	1.000	0.95	NA	0.983	0.054	0	0	0.000	NA	10.0	NA	10.00
13.3	0.83	0.83	0.00	0.83	0.83	1104.17	#NUM!	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	10.00	
18.3	1.14	1.14	0.00	1.14	1.14	1520.83	#NUM!	NA	NA	NA	NA	NA	0.95	NA	0.961	0.053	0	0	0.000	NA	10.0	NA	10.00	
23.3	1.45	1.45	0.00	1.45	1.45	1937.50	#NUM!	NA	NA	NA	NA	NA	0.95	NA	0.948	0.052	0	0	0.000	NA	10.0	NA	10.00	
28.3	1.77	1.77	0.13	1.63	1.63	2177.37	#NUM!	NA	NA	NA	NA	NA	0.95	NA	0.929	0.055	0	0	0.000	NA	10.0	NA	10.00	
33.3	2.08	2.08	0.29	1.79	1.79	2386.03	#NUM!	NA	NA	NA	NA	NA	0.95	NA	0.902	0.058	0	0	0.000	NA	10.0	NA	10.00	
38.3	2.39	2.39	0.44	1.95	1.95	2594.70	#NUM!	NA	NA	NA	NA	NA	0.95	NA	0.866	0.059	0	0	0.000	NA	10.0	NA	10.00	
43.3	2.70	2.70	0.60	2.10	2.10	2803.37	#NUM!	5.00	1.20	19	0.203	0.937	1.000	0.95	0.180	0.821	0.058	0	0	0.000	#DIV/0!	#DIV/0!	3.3	3.28
48.3	3.02	3.02	0.76	2.26	2.26	3012.03	#NUM!	5.00	1.20	13	0.139	0.940	1.000	0.95	0.124	0.771	0.057	0	0	0.000	#DIV/0!	#DIV/0!	2.3	2.32
53.3	3.33	3.33	0.91	2.42	2.42	3220.70	#NUM!	5.00	1.20	23	0.261	0.908	1.000	0.95	0.225	0.720	0.055	0	0	0.000	#DIV/0!	#DIV/0!	4.4	4.36
58.3	3.64	3.64	1.07	2.57	2.57	3429.37	#NUM!	5.00	1.20	17	0.184	0.918	1.000	0.95	0.160	0.674	0.053	0	0	0.000	#DIV/0!	#DIV/0!	3.2	3.22
63.3	3.95	3.95	1.22	2.73	2.73	3638.03	#NUM!	5.00	1.20	23	0.253	0.899	1.000	0.95	0.216	0.634	0.051	0	0	0.000	#DIV/0!	#DIV/0!	4.5	4.51
68.3	4.27	4.27	1.38	2.89	2.89	3846.70	#NUM!	NA	NA	NA	NA	NA	0.95	NA	0.802	0.049	0	0	0.000	NA	10.0	NA	10.00	
73.3	4.58	4.58	1.54	3.04	3.04	4055.37	#NUM!	5.00	1.20	8	0.093	0.931	1.000	0.95	0.082	0.576	0.048	0	0	0.000	#DIV/0!	#DIV/0!	1.8	1.83
78.3	4.89	4.89	1.69	3.20	3.20	4264.03	#NUM!	5.00	1.20	19	0.208	0.898	1.000	0.95	0.177	0.555	0.047	0	0	0.000	#DIV/0!	#DIV/0!	4.0	4.01
83.3	5.20	5.20	1.85	3.35	3.35	4472.70	#NUM!	5.00	1.20	26	0.318	0.867	1.000	0.95	0.261	0.538	0.046	0	0	0.000	#DIV/0!	#DIV/0!	6.0	6.03
88.3	5.52	5.52	2.00	3.51	3.51	4681.37	#NUM!	5.00	1.20	27	0.334	0.852	1.000	0.95	0.270	0.524	0.045	0	0	0.000	#DIV/0!	#DIV/0!	6.3	6.30
93.3	5.83	5.83	2.16	3.67	3.67	4890.03	#NUM!	5.00	1.20	26	0.320	0.857	1.000	0.95	0.260	0.512	0.045	0	0	0.000	#DIV/0!	#DIV/0!	6.1	6.15

Clifty Creek AEP, Boring = SS4-1, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts



Clifty Creek AEP, Boring = SS4-1, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts



APPENDIX I

STABILITY ANALYSIS

BOILER SLAG POND DAM: 2015 CCR
MANDATE

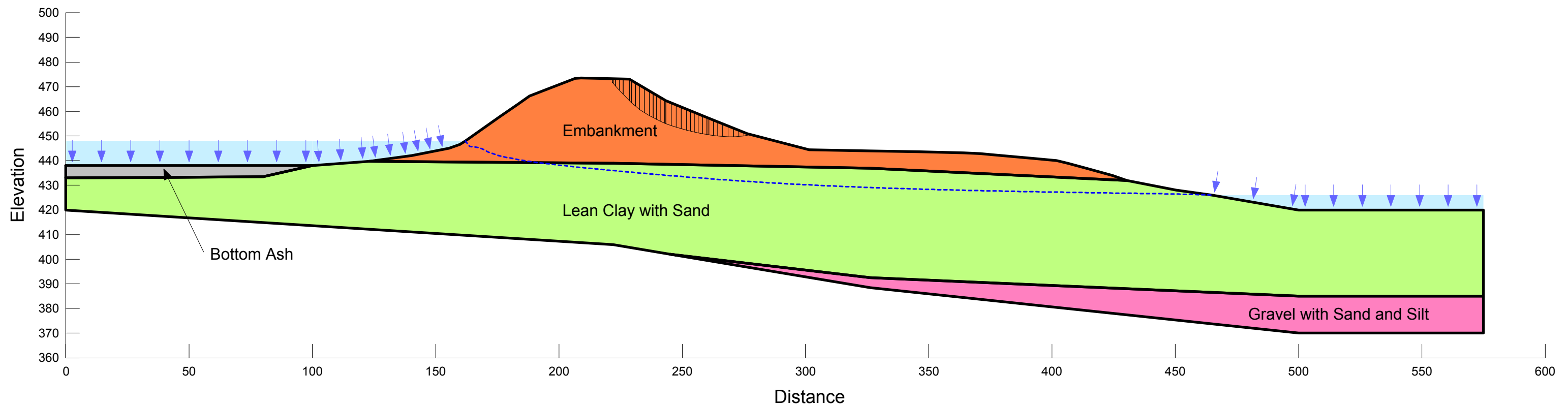
Factor of Safety = 2.30

**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

L01_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section A-A'

Material	Unit Weight (pcf)	Drained Strength Parameters	
		Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Gravel With Silt and Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.



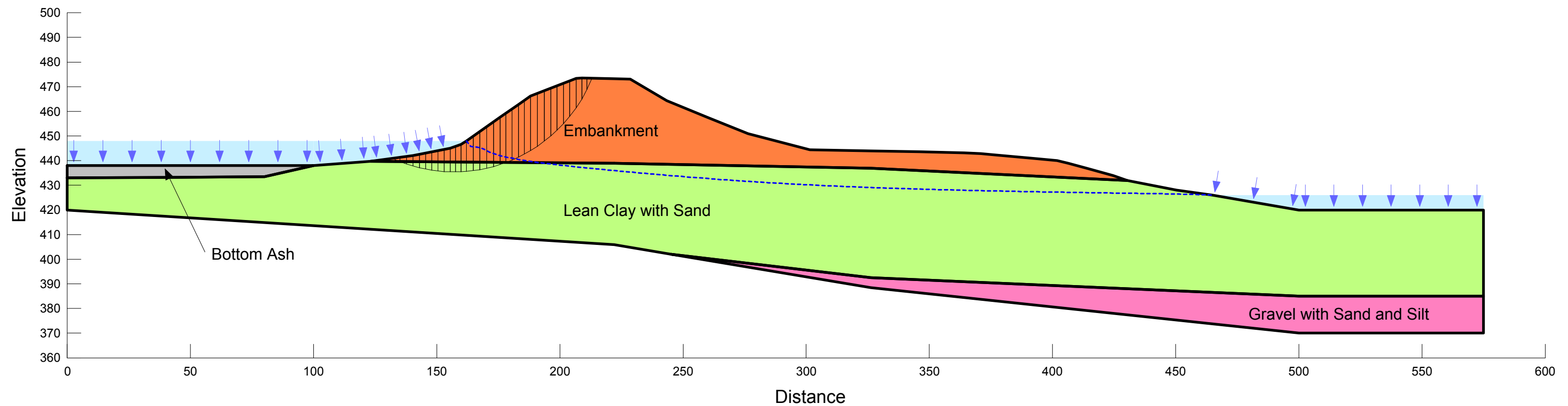
Factor of Safety = 1.88

**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

L02_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section A-A'

Material	Unit Weight (pcf)	Drained Strength Parameters	
		Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Gravel With Silt and Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.



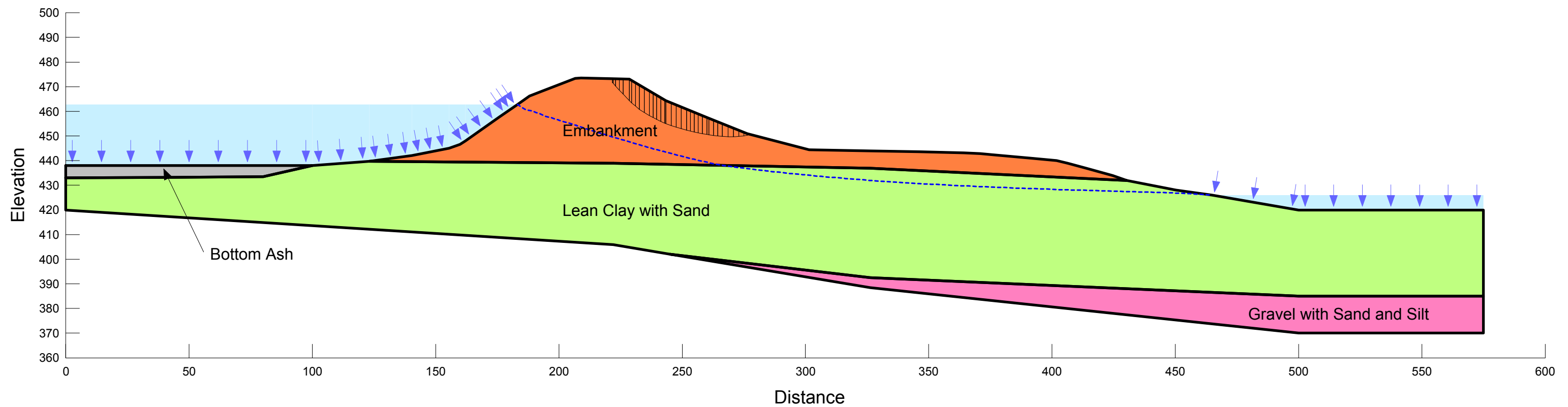
Factor of Safety = 2.30

**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

L03_50% PMF Pool, Downstream Slope Failure
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section A-A'

Material	Unit Weight (pcf)	Drained Strength Parameters	
		Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Gravel With Silt and Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.



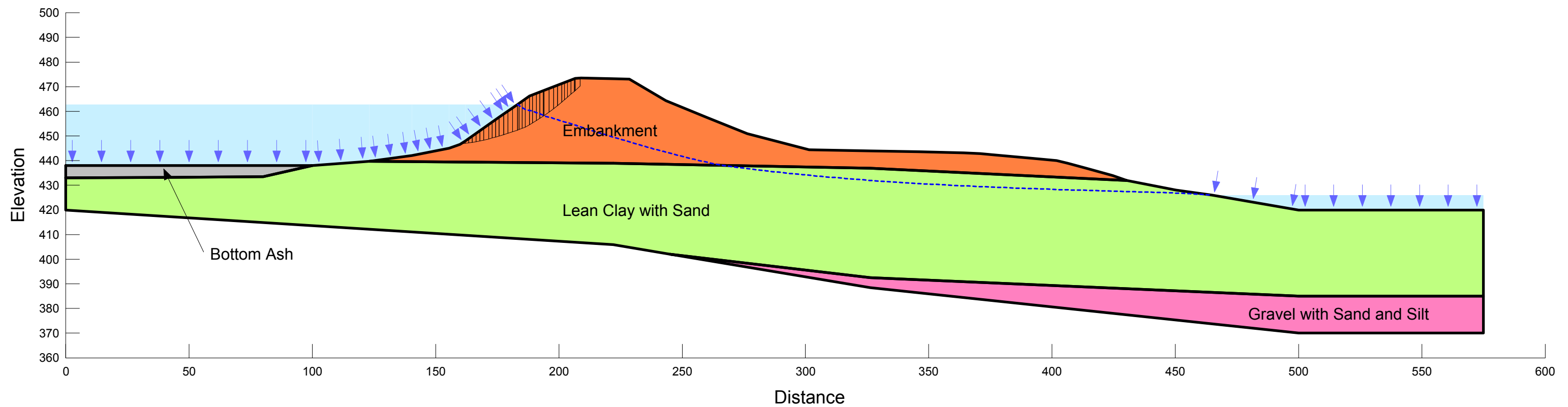
Factor of Safety = 2.13

**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

L04_50% PMF Pool, Upstream Slope Failure
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section A-A'

Material	Unit Weight (pcf)	Drained Strength Parameters	
		Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Gravel With Silt and Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.



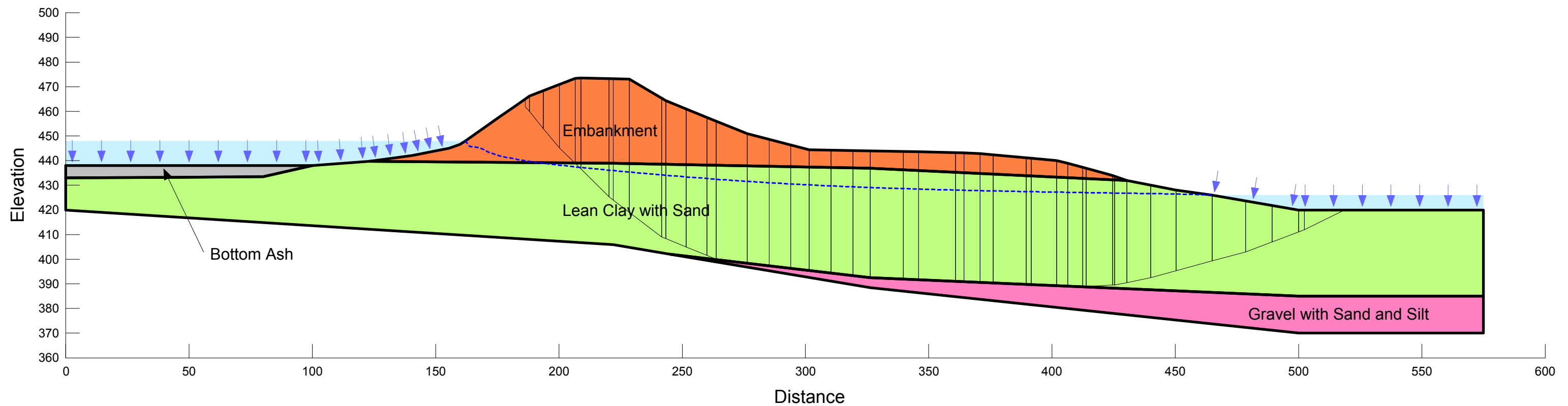
Factor of Safety = 1.35

**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

L05_Seismic_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 448 Feet
Undrained Static Strengths
Incipient Motion in the Downstream Direction
Horizontal Acc: 0.085g
Section A-A'

Material	Unit Weight (pcf)	Drained Strength Parameters		Undrained Strength Parameters	
		Phi (deg.)	Cohesion (psf)	Phi (deg.)	Cohesion (psf)
Embankment (Seismic Undrained)	130	33.2	165	13	600
Lean Clay with Sand (Seismic Undrained)	119	27.2	160	5	1200
Gravel With Silt and Sand (Seismic Undrained)	130	35	0	35	0
Bottom Ash (Seismic Undrained)	115	28	0	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.



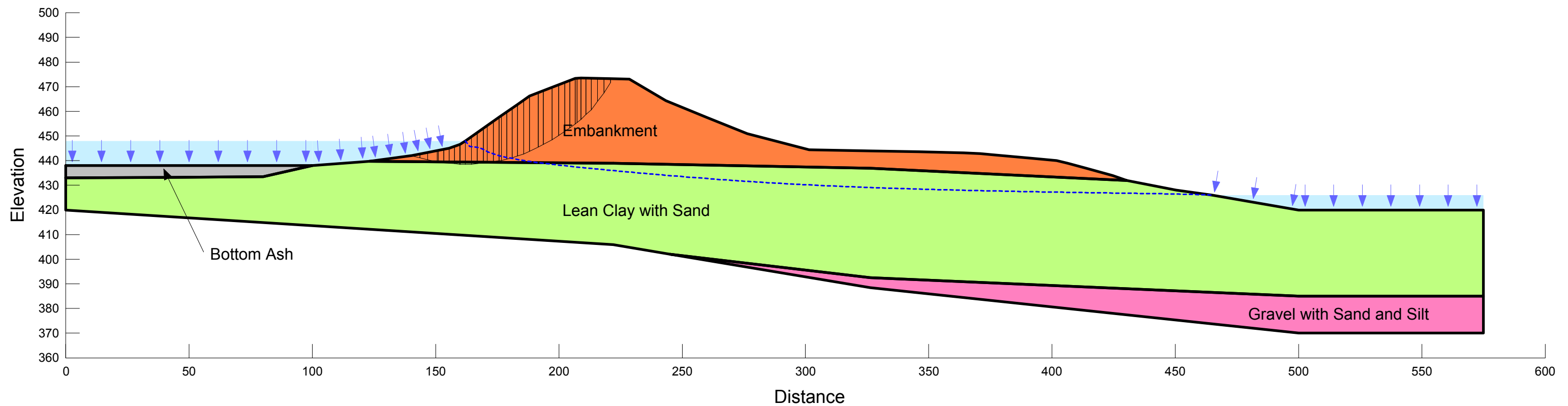
Factor of Safety = 1.34

**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

L06_Seismic_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 448 Feet
Undrained Static Strengths
Incipient Motion in the Upstream Direction
Horizontal Acc: 0.085g
Section A-A'

Material	Unit Weight (pcf)	Drained Strength Parameters		Undrained Strength Parameters	
		Phi (deg.)	Cohesion (psf)	Phi (deg.)	Cohesion (psf)
Embankment (Seismic Undrained)	130	33.2	165	13	600
Lean Clay with Sand (Seismic Undrained)	119	27.2	160	5	1200
Gravel With Silt and Sand (Seismic Undrained)	130	35	0	35	0
Bottom Ash (Seismic Undrained)	115	28	0	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.



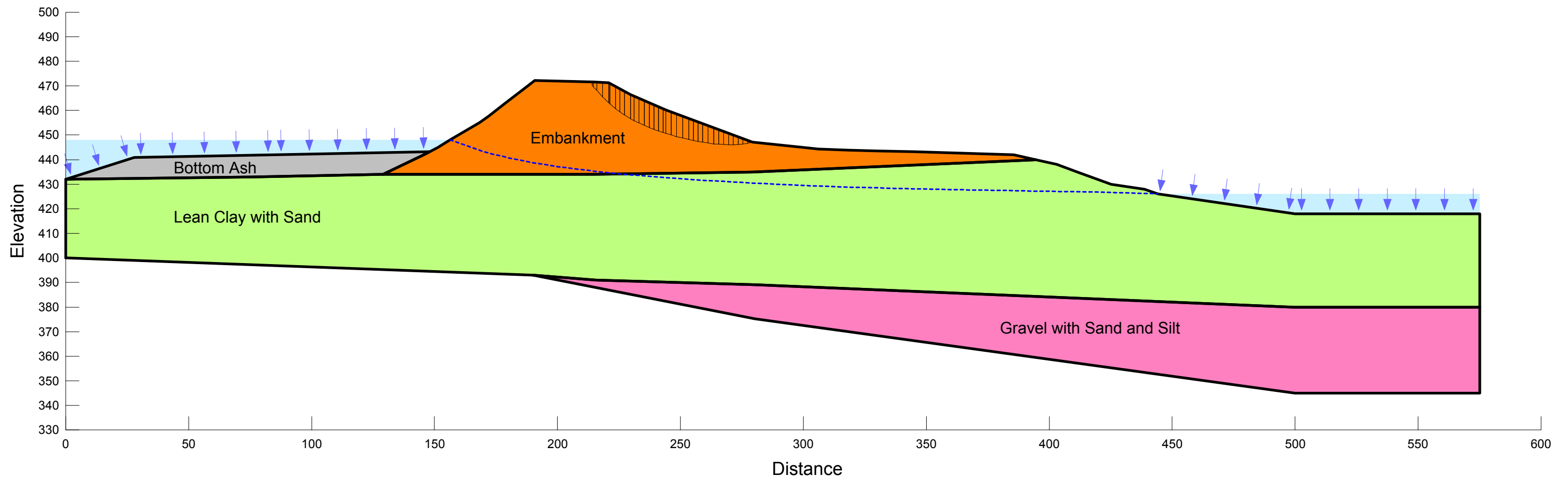
Factor of Safety = 2.44

**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

L01_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section B-B'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters	
		Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay With Sand (Drained)	119	27.2	160
Gravel With Silt And Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0



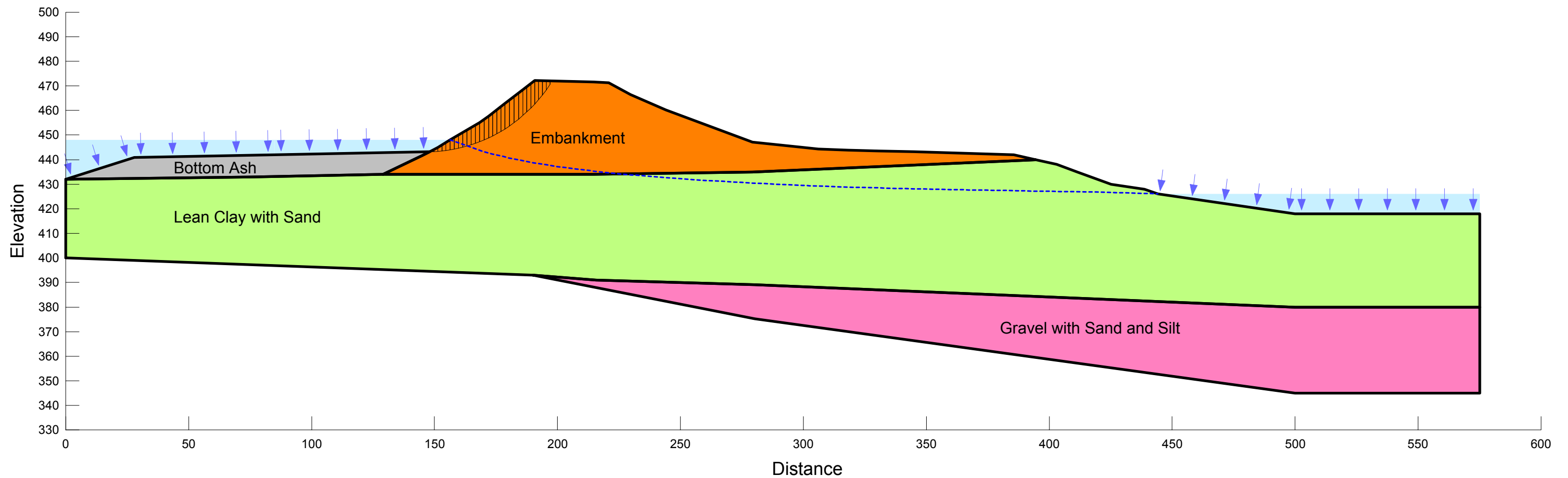
Factor of Safety = 1.63

**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

L02_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section B-B'

Material	Unit Weight (pcf)	Drained Strength Parameters	
		Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay With Sand (Drained)	119	27.2	160
Gravel With Silt And Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.



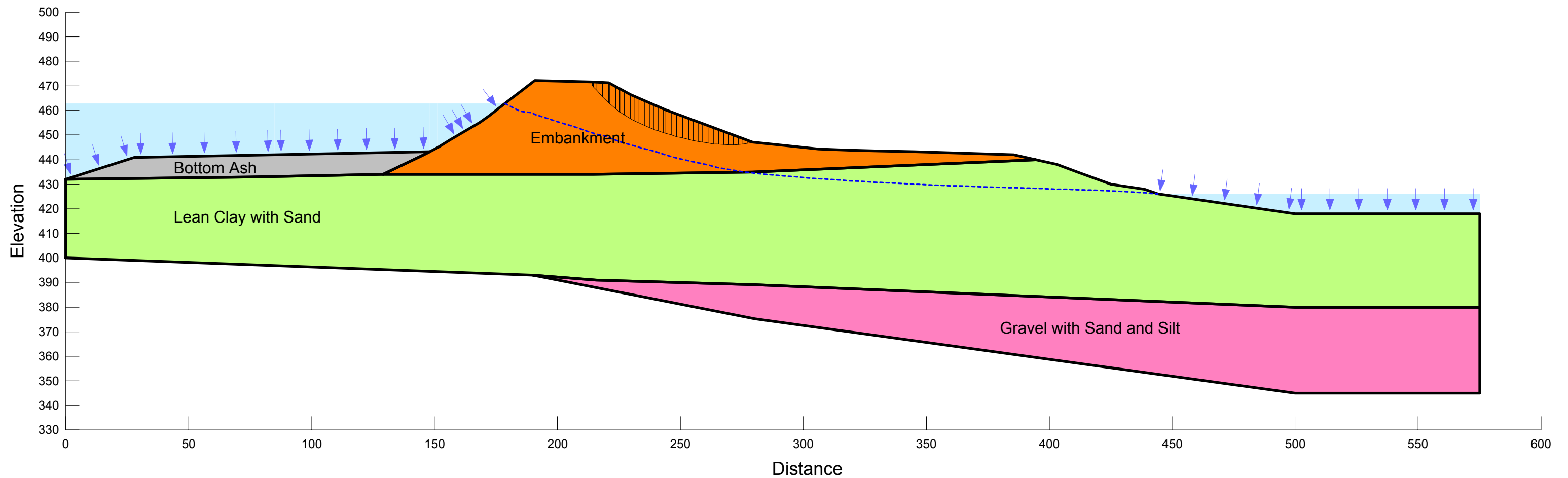
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**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

L03_50% PMF Pool, Downstream Slope Failure
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section B-B'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters	
		Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay With Sand (Drained)	119	27.2	160
Gravel With Silt And Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0



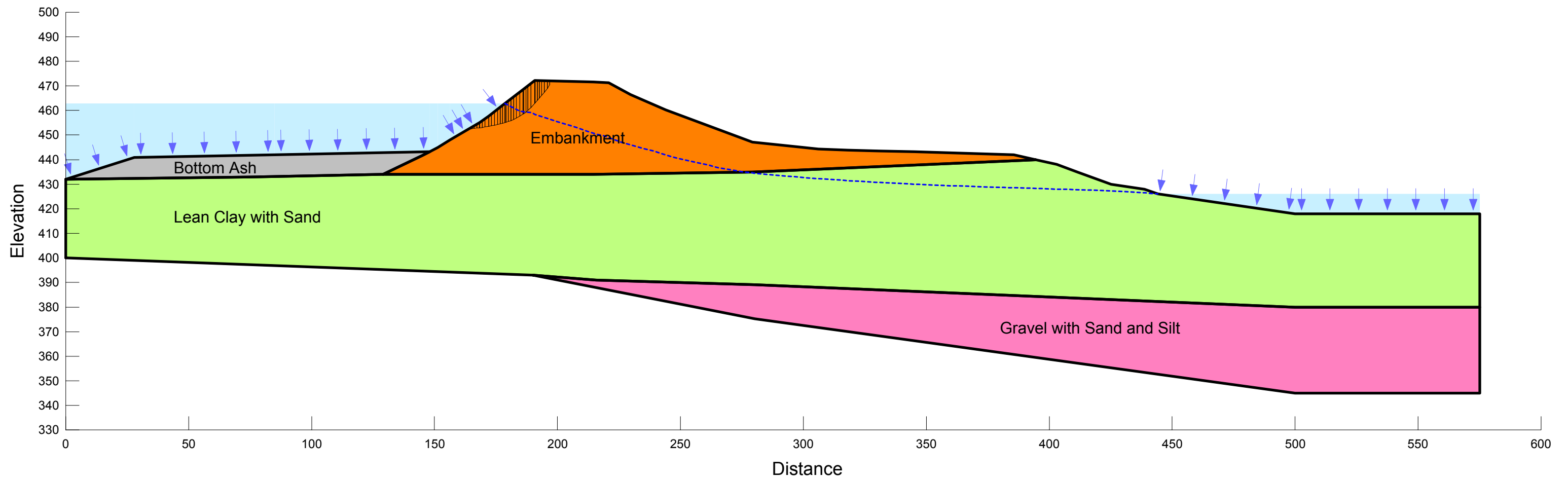
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**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

L04_50% PMF Pool, Upstream Slope Failure
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section B-B'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters	
		Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay With Sand (Drained)	119	27.2	160
Gravel With Silt And Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0



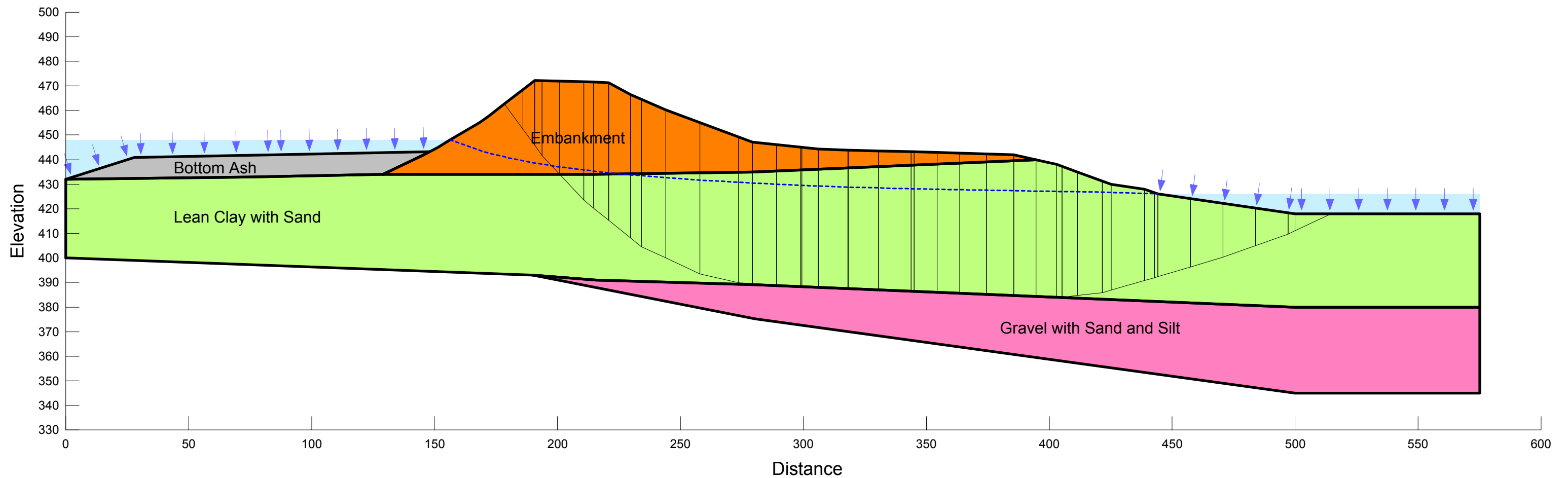
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 1.30

L05_Seismic_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 448 Feet
Undrained Static Strengths
Incipient Motion in the Downstream Direction
Horizontal Acc: 0.085g
Section B-B'

Material	Unit Weight (pcf)	Drained Strength Parameters		Undrained Strength Parameters	
		Phi (deg.)	Cohesion (psf)	Phi (deg.)	Cohesion (psf)
Embankment (Seismic Undrained)	130	33.2	165	13	600
Lean Clay With Sand (Seismic Undrained)	119	27.2	160	5	1200
Gravel With Silt And Sand (Seismic Undrained)	130	35	0	35	0
Bottom Ash (Seismic Undrained)	115	28	0	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.



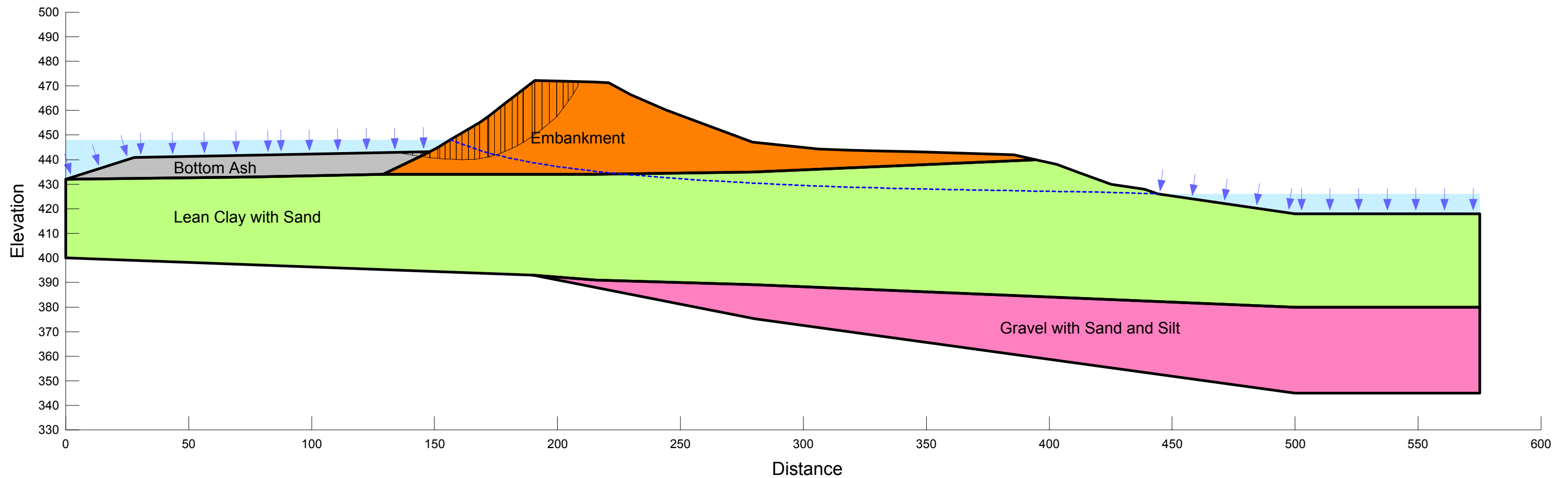
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 1.30

L06_Seismic_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 448 Feet
Undrained Static Strengths
Incipient Motion in the Upstream Direction
Horizontal Acc: 0.085g
Section B-B'

Material	Unit Weight (pcf)	Drained Strength Parameters		Undrained Strength Parameters	
		Phi (deg.)	Cohesion (psf)	Phi (deg.)	Cohesion (psf)
Embankment (Seismic Undrained)	130	33.2	165	13	600
Lean Clay With Sand (Seismic Undrained)	119	27.2	160	5	1200
Gravel With Silt And Sand (Seismic Undrained)	130	35	0	35	0
Bottom Ash (Seismic Undrained)	115	28	0	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.



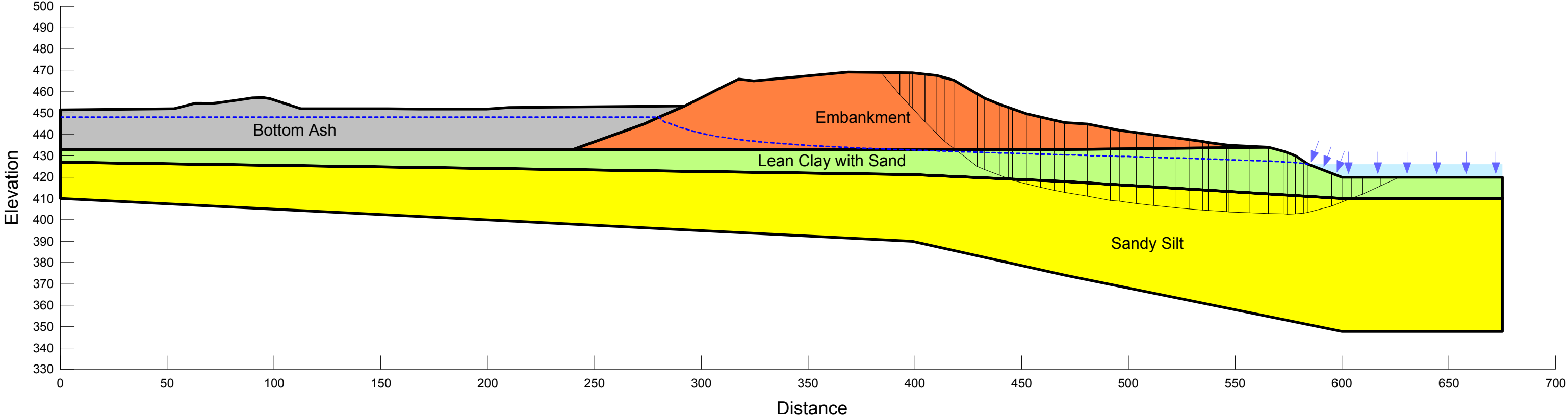
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 2.30

L01_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section C-C'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters	
		Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Sandy Silt (Drained)	130	30	0
Bottom Ash (Drained)	115	28	0



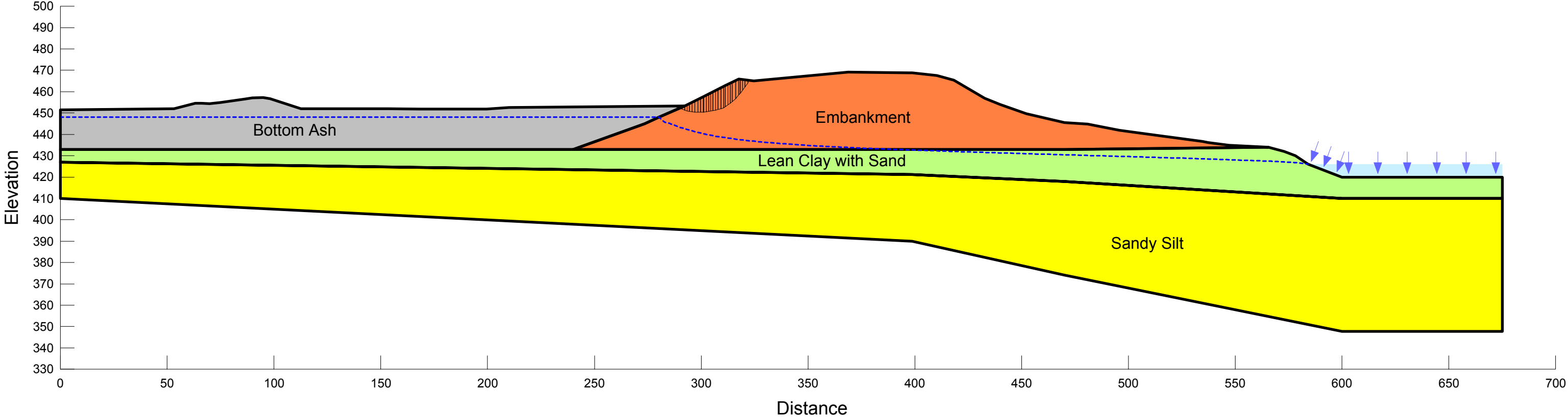
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 2.73

L02_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section C-C'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters	
		Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Sandy Silt (Drained)	130	30	0
Bottom Ash (Drained)	115	28	0



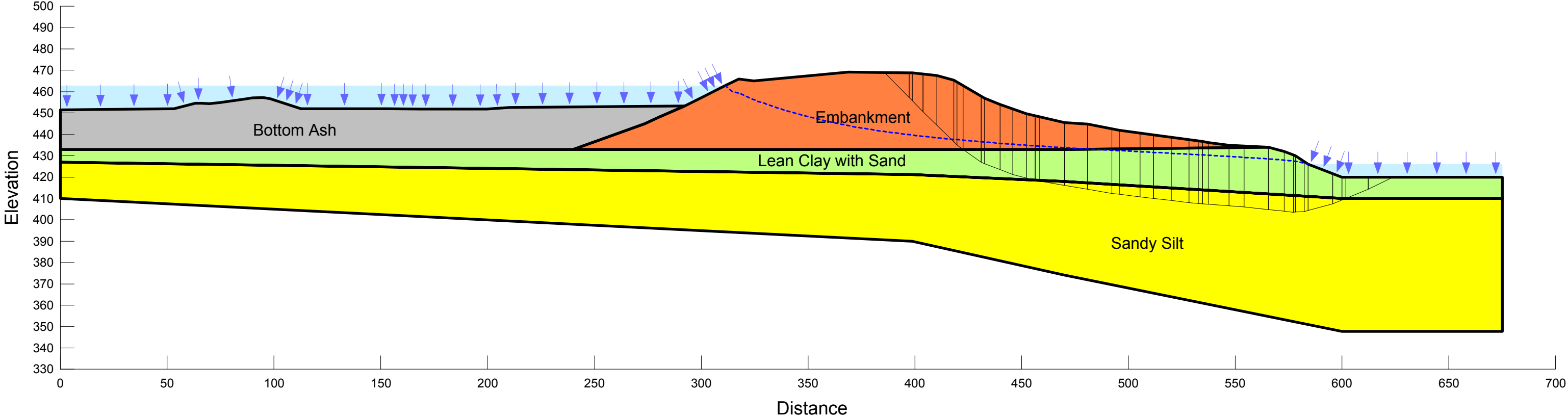
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 2.18

L03_50% PMF Pool, Downstream Slope Failure
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section C-C'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters	
		Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Sandy Silt (Drained)	130	30	0
Bottom Ash (Drained)	115	28	0



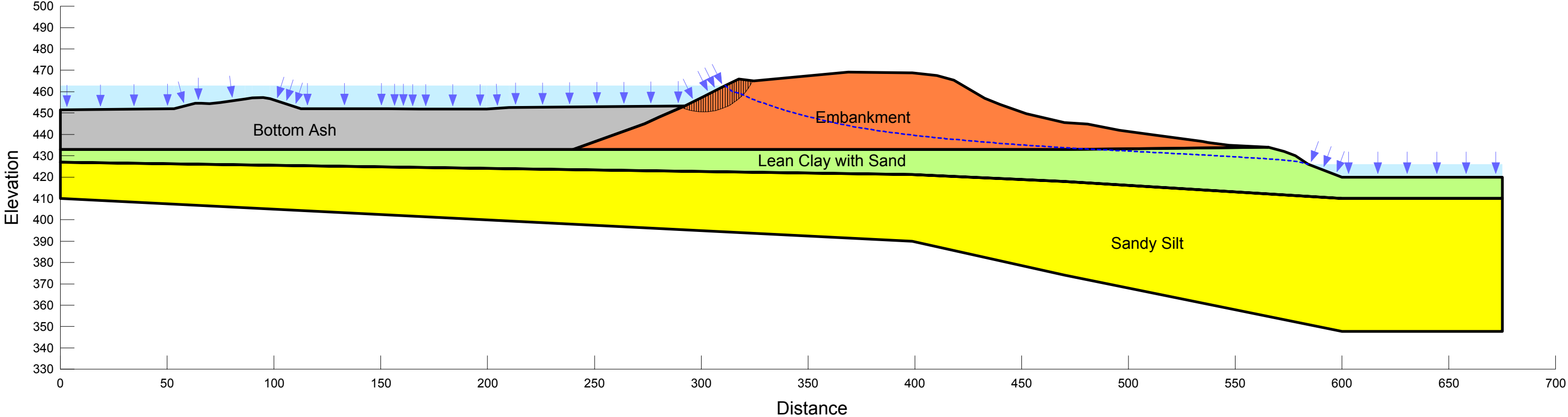
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 3.88

L04_50% PMF Pool, Upstream Slope Failure
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section C-C'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters	
		Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Sandy Silt (Drained)	130	30	0
Bottom Ash (Drained)	115	28	0



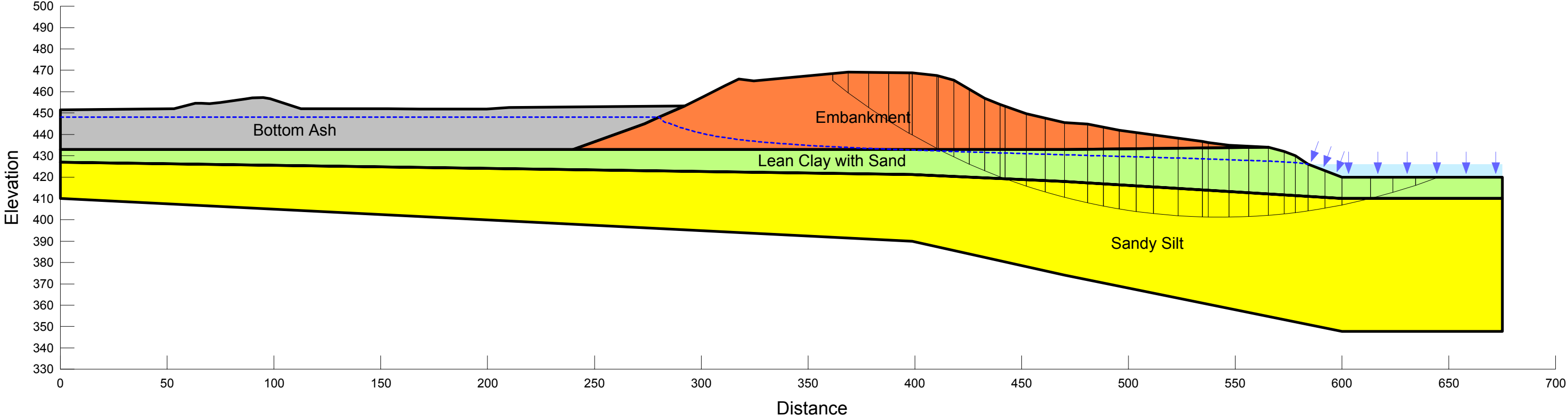
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 1.53

L05_Seismic_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 448 Feet
Undrained Static Strengths
Incipient Motion in the Downstream Direction
Horizontal Acc: 0.085g
Section C-C'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters		Undrained Strength Parameters	
		Phi (deg.)	Cohesion (psf)	Phi (deg.)	Cohesion (psf)
Embankment (Seismic Undrained)	130	33.2	165	13	600
Lean Clay with Sand (Seismic Undrained)	119	27.2	160	5	1200
Sandy Silt (Seismic Undrained)	130	30	0	30	0
Bottom Ash (Seismic Undrained)	115	28	0	28	0



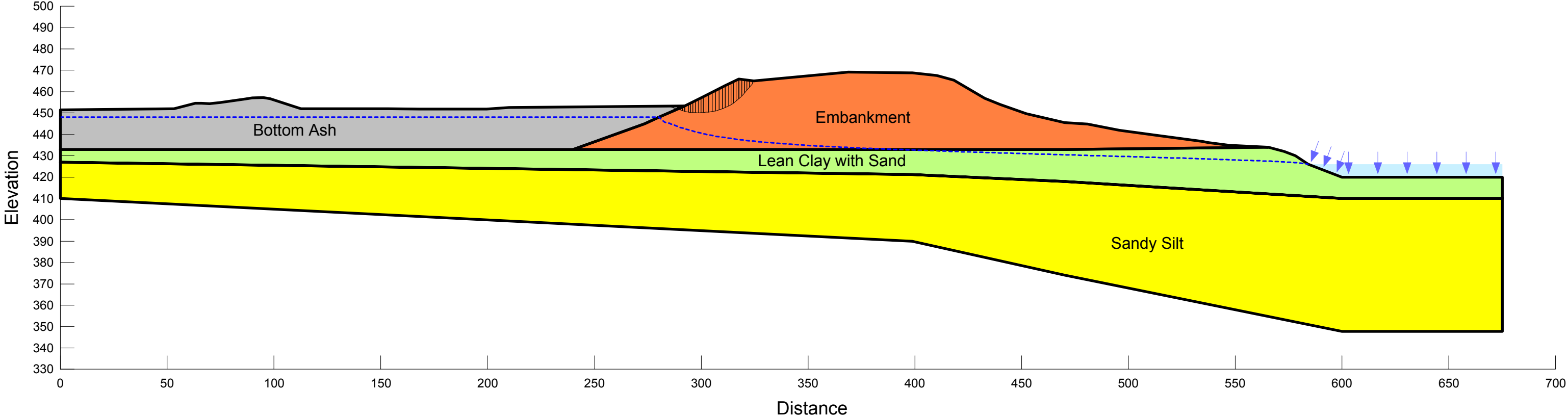
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 2.25

L06_Seismic_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 448 Feet
Undrained Static Strengths
Incipient Motion in the Upstream Direction
Horizontal Acc: 0.085g
Section C-C'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters		Undrained Strength Parameters	
		Phi (deg.)	Cohesion (psf)	Phi (deg.)	Cohesion (psf)
Embankment (Seismic Undrained)	130	33.2	165	13	600
Lean Clay with Sand (Seismic Undrained)	119	27.2	160	5	1200
Sandy Silt (Seismic Undrained)	130	30	0	30	0
Bottom Ash (Seismic Undrained)	115	28	0	28	0



LANDFILL RUNOFF COLLECTION POND:
2015 CCR MANDATE

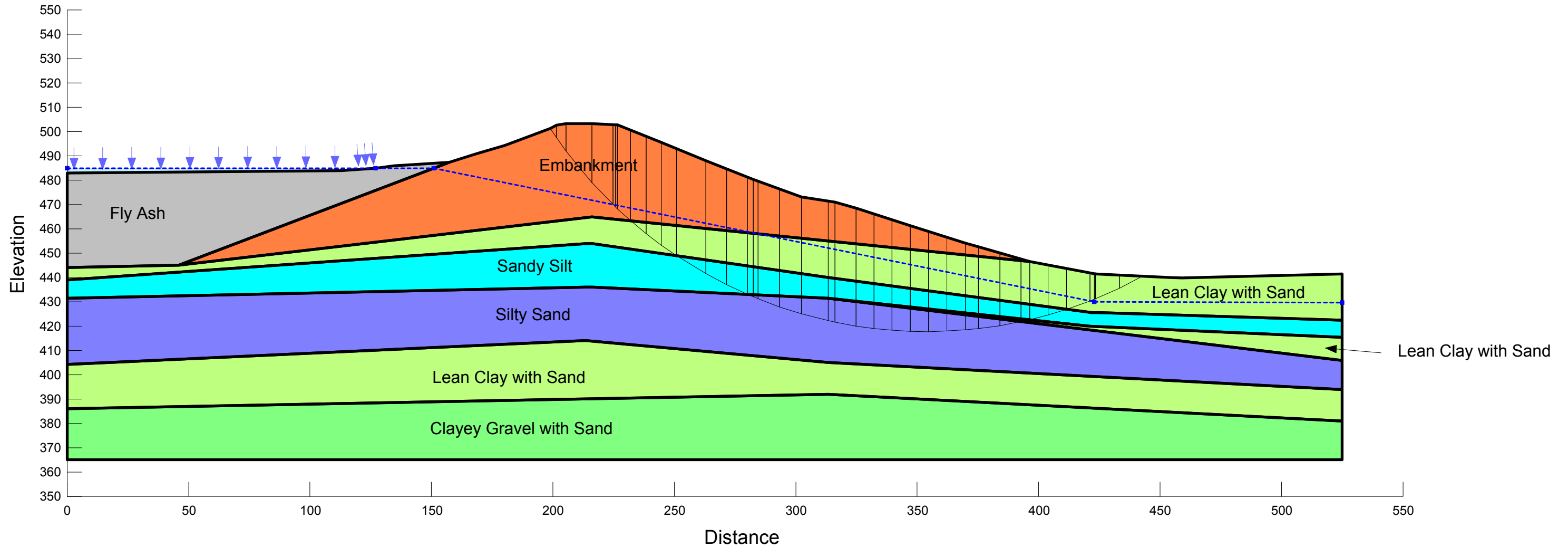
**American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 1.85

L01_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 485 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section D-D'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Drained Strength Parameters			
Material	Unit Weight (pcf)	Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Sandy Silt (Drained)	125	30	0
Silty Sand (Drained)	94	30	0
Clayey Gravel with Sand (Drained)	130	35	0
Fly Ash (Drained)	115	25	0



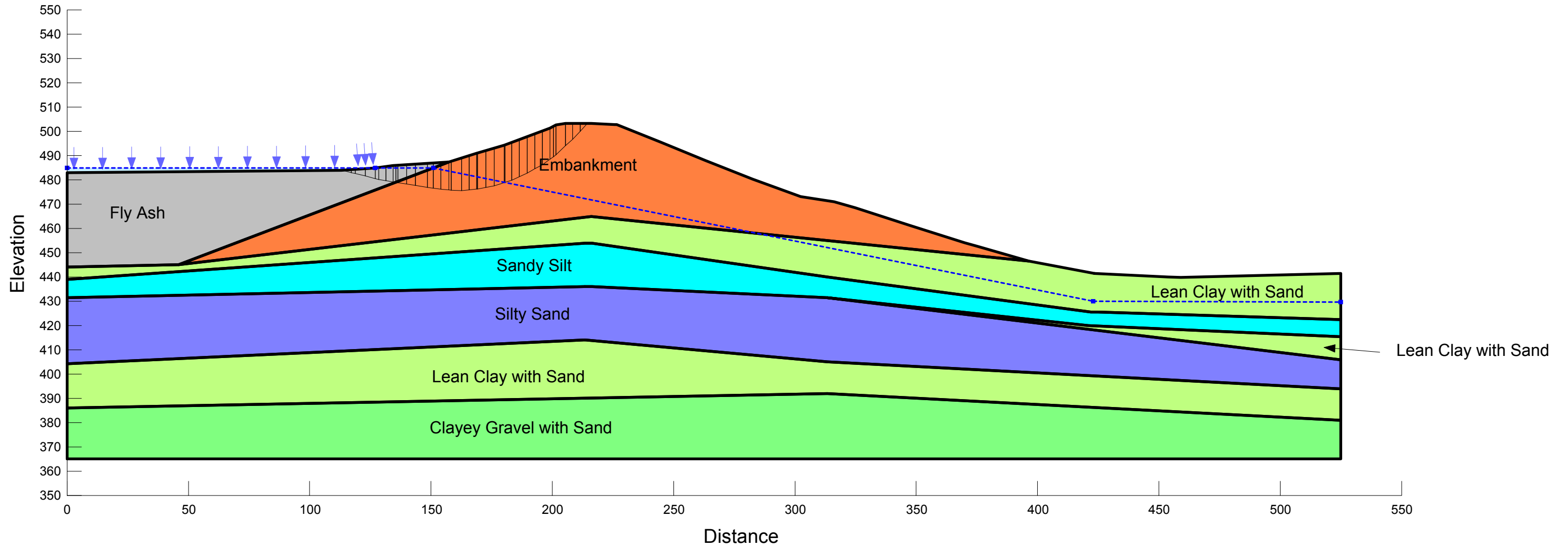
**American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 2.73

L02_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 485 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section D-D'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Drained Strength Parameters			
Material	Unit Weight (pcf)	Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Sandy Silt (Drained)	125	30	0
Silty Sand (Drained)	94	30	0
Clayey Gravel with Sand (Drained)	130	35	0
Fly Ash (Drained)	115	25	0



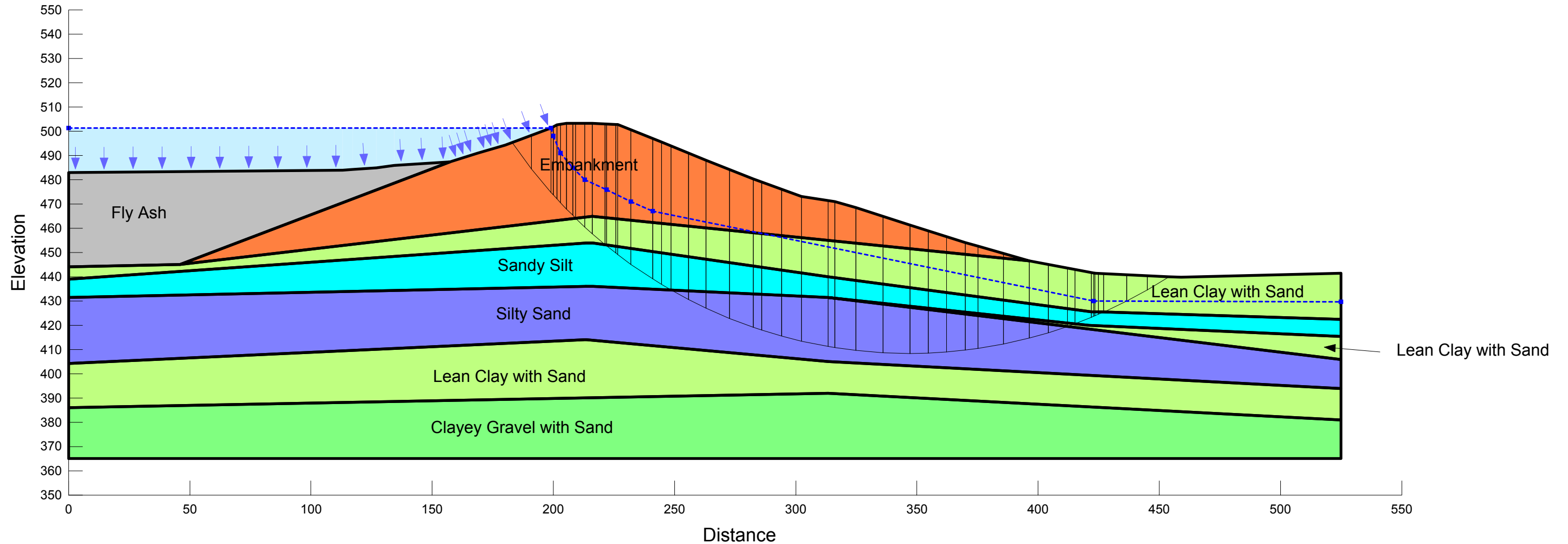
**American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 1.81

L03_PMF Pool, Downstream Slope Failure
PMF Pool Elevation: 501.4 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section D-D'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Drained Strength Parameters			
Material	Unit Weight (pcf)	Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Sandy Silt (Drained)	125	30	0
Silty Sand (Drained)	94	30	0
Clayey Gravel with Sand (Drained)	130	35	0
Fly Ash (Drained)	115	25	0



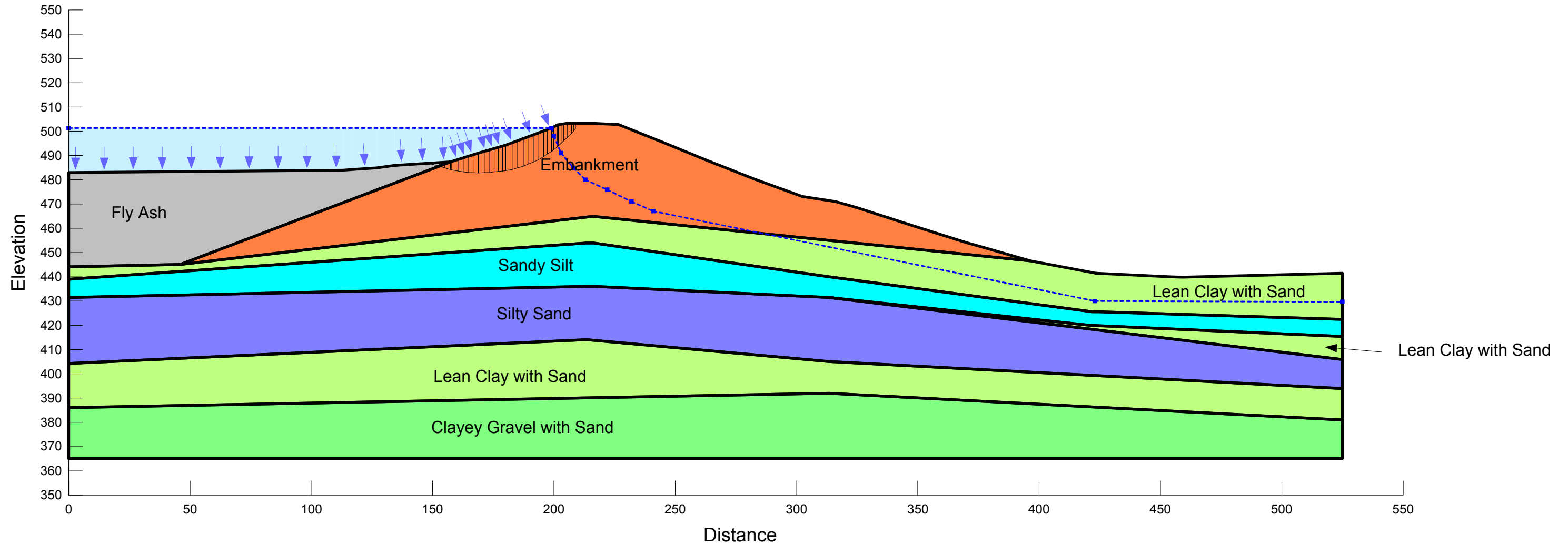
**American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 3.47

L04_PMF Pool, Upstream Slope Failure
PMF Pool Elevation: 501.4 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section D-D'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Drained Strength Parameters			
Material	Unit Weight (pcf)	Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Sandy Silt (Drained)	125	30	0
Silty Sand (Drained)	94	30	0
Clayey Gravel with Sand (Drained)	130	35	0
Fly Ash (Drained)	115	25	0



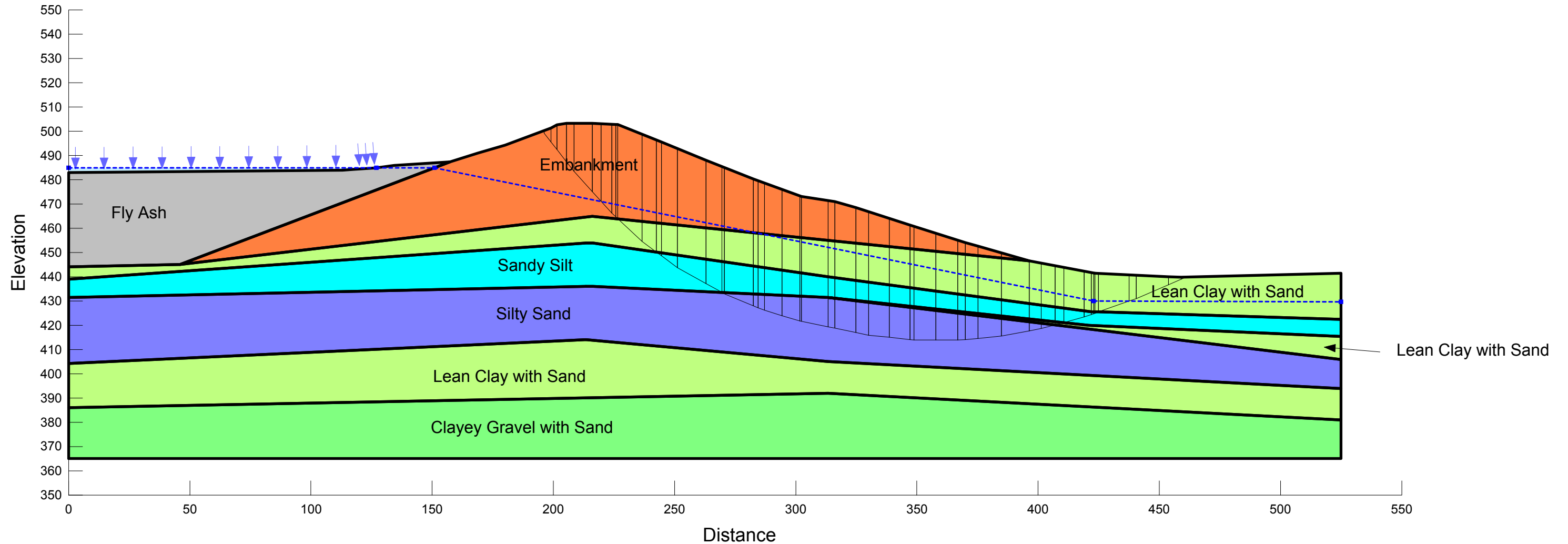
**American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate**

L05_Seismic_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 485 Feet
Undrained Static Strengths
Incipient Motion in the Downstream Direction
Horizontal Acc: 0.085g
Section D-D'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Factor of Safety = 1.42

Material	Unit Weight (pcf)	Drained Strength Parameters		Undrained Strength Parameters	
		Phi (deg.)	Cohesion (psf)	Phi (deg.)	Cohesion (psf)
Embankment (Seismic Undrained)	129	27.5	198	21	1400
Lean Clay with Sand (Seismic Undrained)	127	28	206	17	1200
Sandy Silt (Seismic Undrained)	125	30	0	30	0
Silty Sand (Seismic Undrained)	94	30	0	30	0
Clayey Gravel with Sand (Seismic Undrained)	130	35	0	35	0
Fly Ash (Seismic Undrained)	115	25	0	25	0



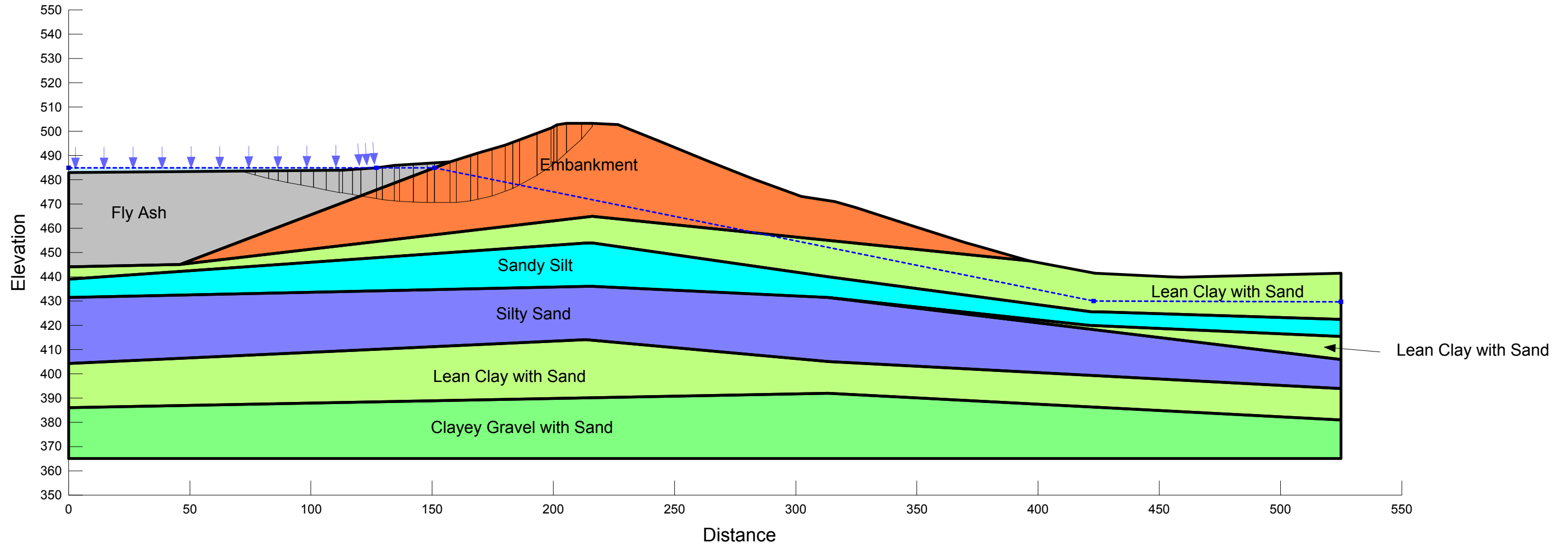
**American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate**

L06_Seismic_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 485 Feet
Undrained Static Strengths
Incipient Motion in the Upstream Direction
Horizontal Acc: 0.085g
Section D-D'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Factor of Safety = 1.94

Material	Unit Weight (pcf)	Drained Strength Parameters		Undrained Strength Parameters	
		Phi (deg.)	Cohesion (psf)	Phi (deg.)	Cohesion (psf)
Embankment (Seismic Undrained)	129	27.5	198	21	1400
Lean Clay with Sand (Seismic Undrained)	127	28	206	17	1200
Sandy Silt (Seismic Undrained)	125	30	0	30	0
Silty Sand (Seismic Undrained)	94	30	0	30	0
Clayey Gravel with Sand (Seismic Undrained)	130	35	0	35	0
Fly Ash (Seismic Undrained)	115	25	0	25	0



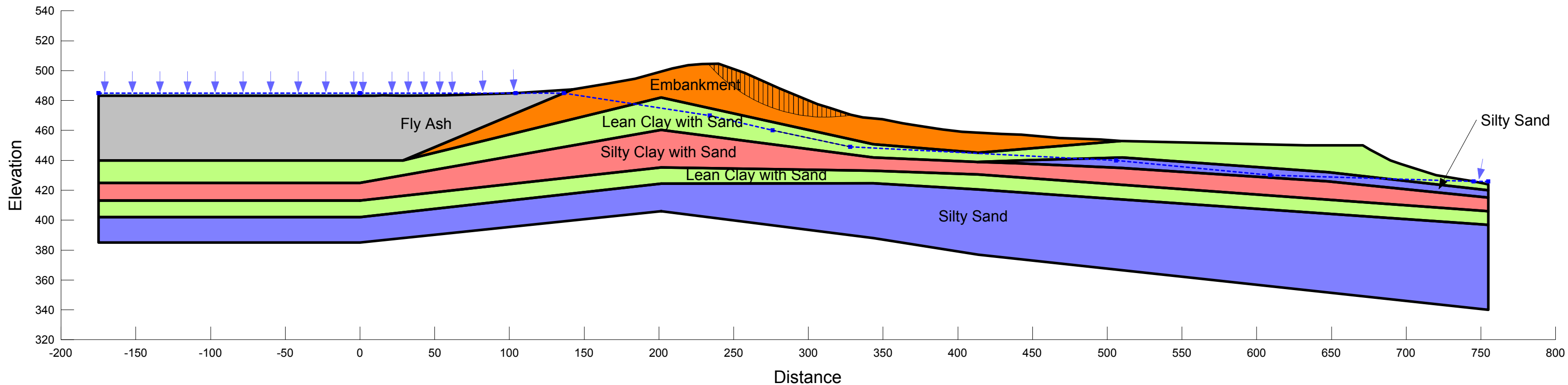
**American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 1.99

L01_Normal Pool, Downstream Crest Loss
Normal Pool Elevation: 485 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section E-E'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Silty Sand (Drained)	94	30	0
Fly Ash (Drained)	115	25	0
Silty Clay with Sand (Drained)	118	34	152



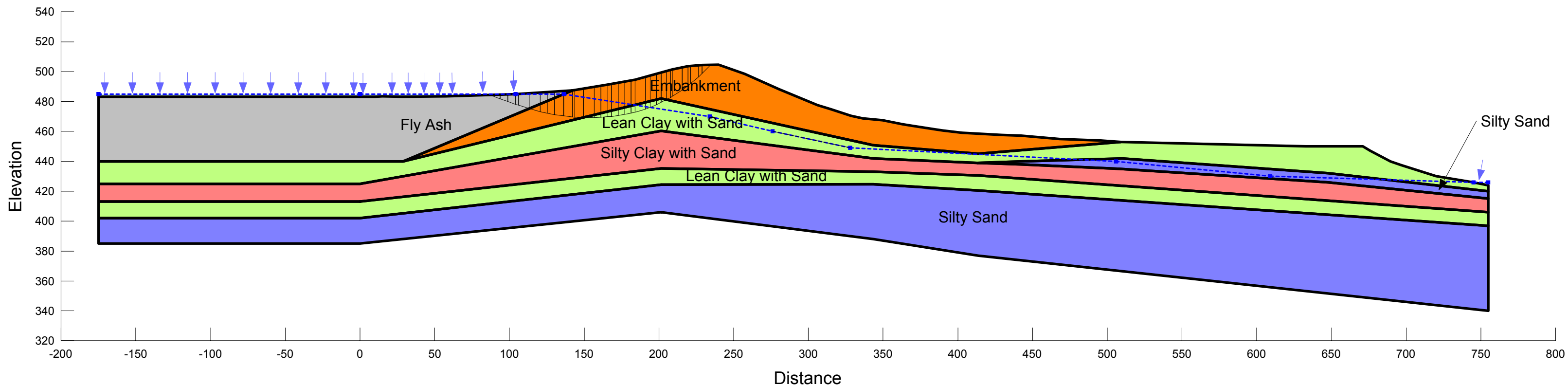
**American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 3.51

L02_Normal Pool, Upstream Crest Loss
Normal Pool Elevation: 485 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section E-E'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Drained Strength Parameters			
Material	Unit Weight (pcf)	Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Silty Sand (Drained)	94	30	0
Fly Ash (Drained)	115	25	0
Silty Clay with Sand (Drained)	118	34	152



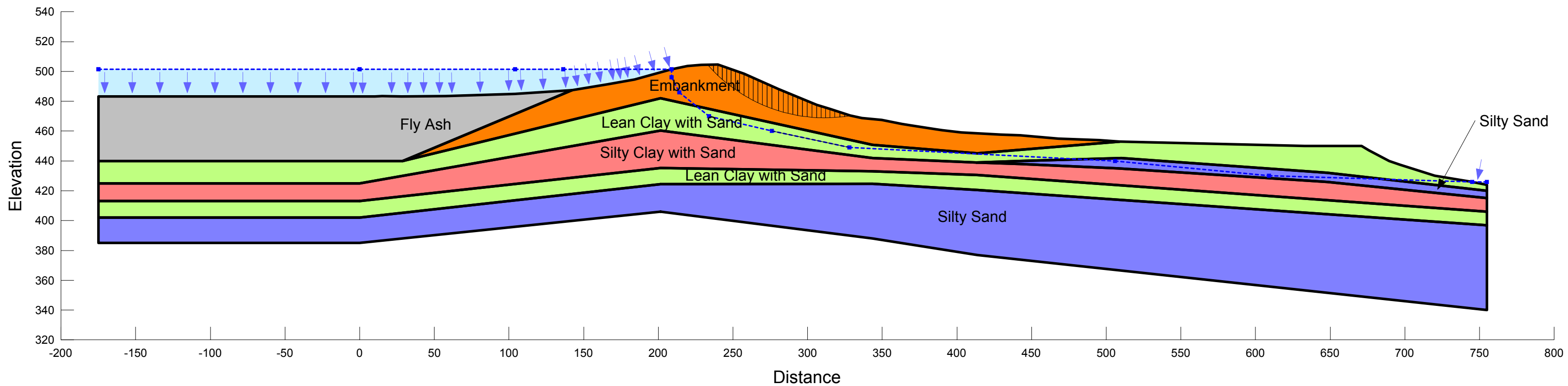
**American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 1.99

L03_PMF Pool, Downstream Crest Loss
PMF Pool Elevation: 501.4 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section E-E'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Silty Sand (Drained)	94	30	0
Fly Ash (Drained)	115	25	0
Silty Clay with Sand (Drained)	118	34	152



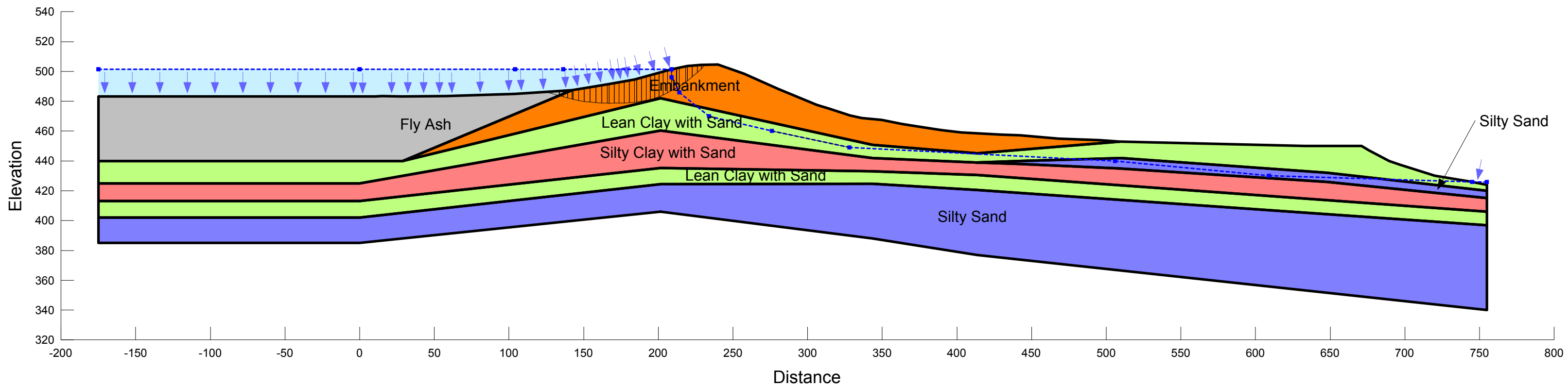
**American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate**

Factor of Safety = 4.51

L04_PMF Pool, Upstream Crest Loss
PMF Pool Elevation: 501.4 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section E-E'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Silty Sand (Drained)	94	30	0
Fly Ash (Drained)	115	25	0
Silty Clay with Sand (Drained)	118	34	152



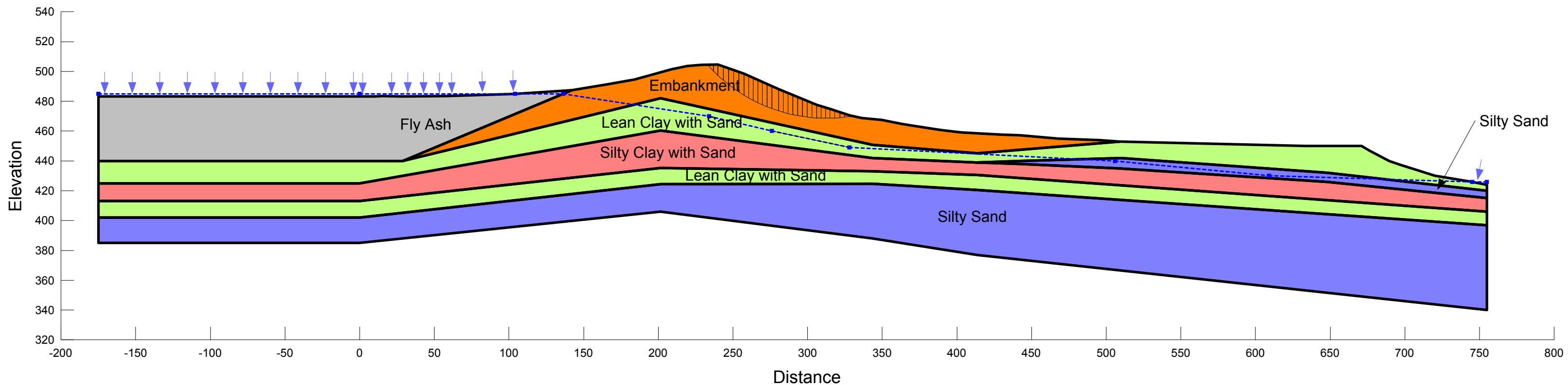
**American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate**

L05_Seismic_Normal Pool, Downstream Crest Loss
Normal Pool Elevation: 485 Feet
Undrained Static Strengths
Incipient Motion in the Downstream Direction
Horizontal Acc: 0.085g
Section E-E'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Factor of Safety = 1.64

Material	Unit Weight (pcf)	Drained Strength Parameters		Undrained Strength Parameters	
		Phi (deg.)	Cohesion (psf)	Phi (deg.)	Cohesion (psf)
Embankment (Seismic Undrained)	129	27.5	198	21	1400
Lean Clay with Sand (Seismic Undrained)	127	28	206	17	1200
Silty Sand (Seismic Undrained)	94	30	0	30	0
Fly Ash (Seismic Undrained)	115	25	0	25	0
Silty Clay with Sand (Seismic Undrained)	118	34	152	20	1000



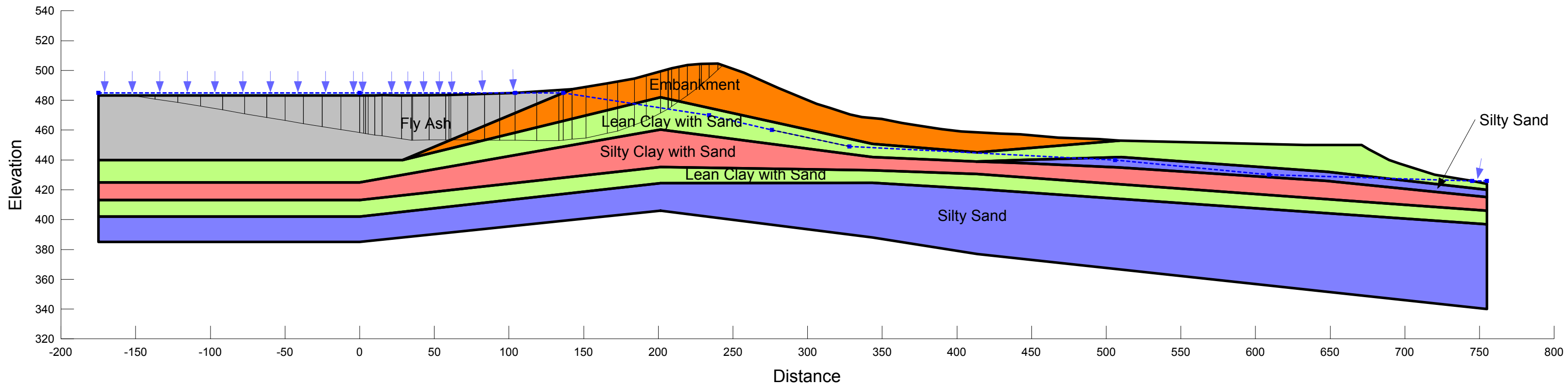
**American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate**

L06_Seismic_Normal Pool, Upstream Crest Loss
Normal Pool Elevation: 485 Feet
Undrained Static Strengths
Incipient Motion in the Upstream Direction
Horizontal Acc: 0.085g
Section E-E'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Factor of Safety = 2.28

Material	Unit Weight (pcf)	Drained Strength Parameters		Undrained Strength Parameters	
		Phi (deg.)	Cohesion (psf)	Phi (deg.)	Cohesion (psf)
Embankment (Seismic Undrained)	129	27.5	198	21	1400
Lean Clay with Sand (Seismic Undrained)	127	28	206	17	1200
Silty Sand (Seismic Undrained)	94	30	0	30	0
Fly Ash (Seismic Undrained)	115	25	0	25	0
Silty Clay with Sand (Seismic Undrained)	118	34	152	20	1000



SEEP MODELS, 2015

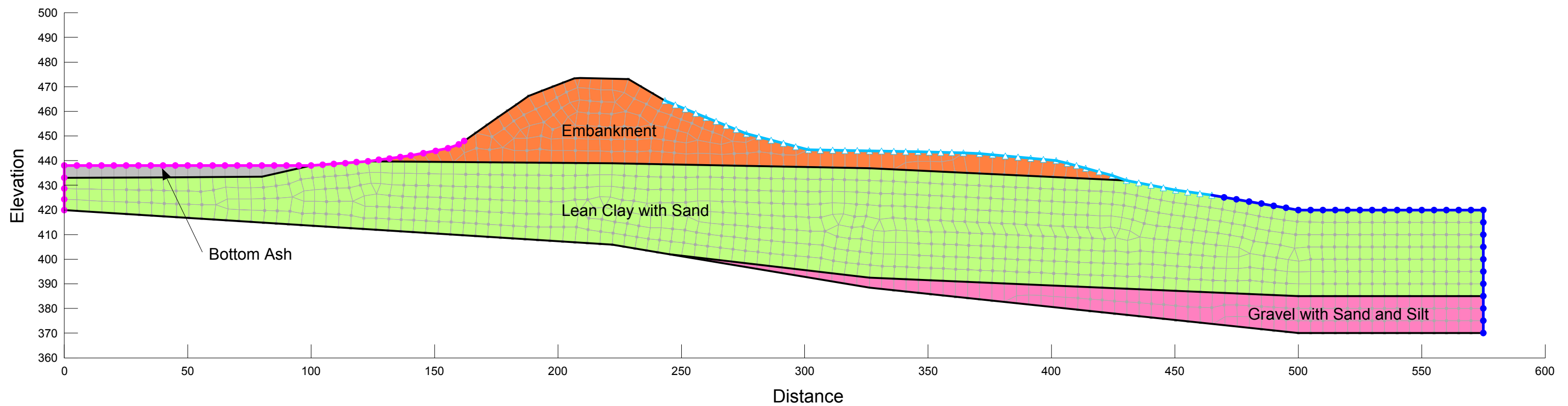
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Boundary Condition and Mesh**

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section A-A'

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft ³ /ft ³	Res. Water Content ft ³ /ft ³
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Gravel With Silt and Sand (Drained)	0.00164	0.2	0.23	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.



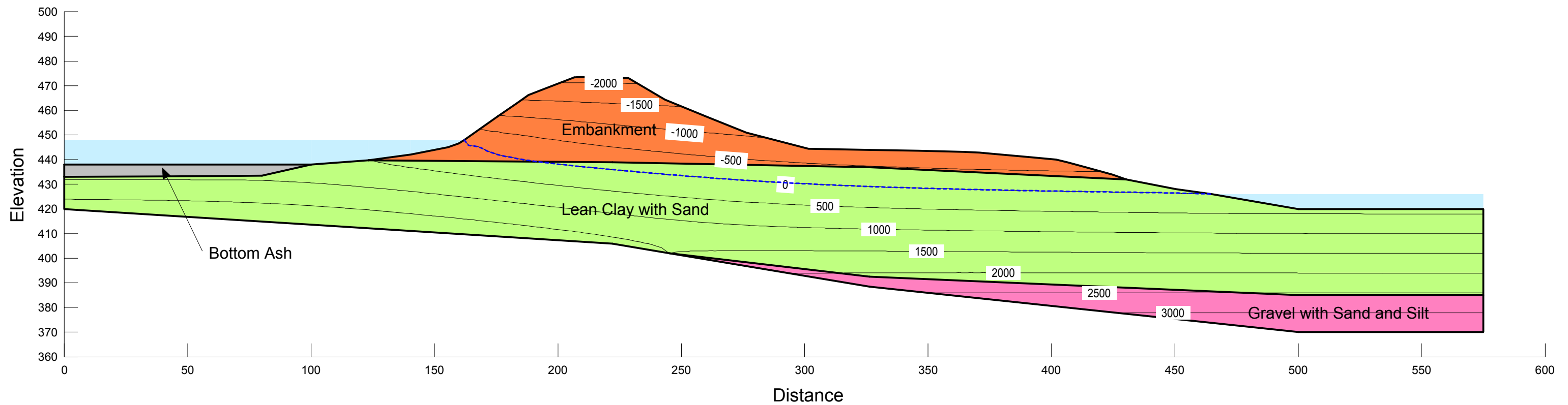
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Pore Water Pressure Contour (psf)**

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section A-A'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft ³ /ft ³	Res. Water Content ft ³ /ft ³
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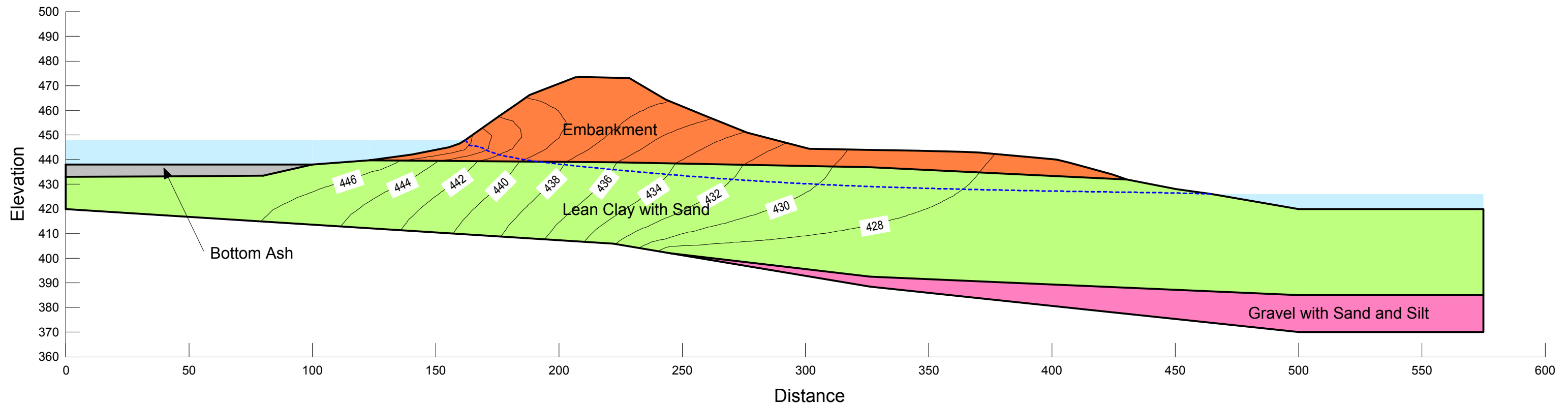
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Total Head Contour (feet)**

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section A-A'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

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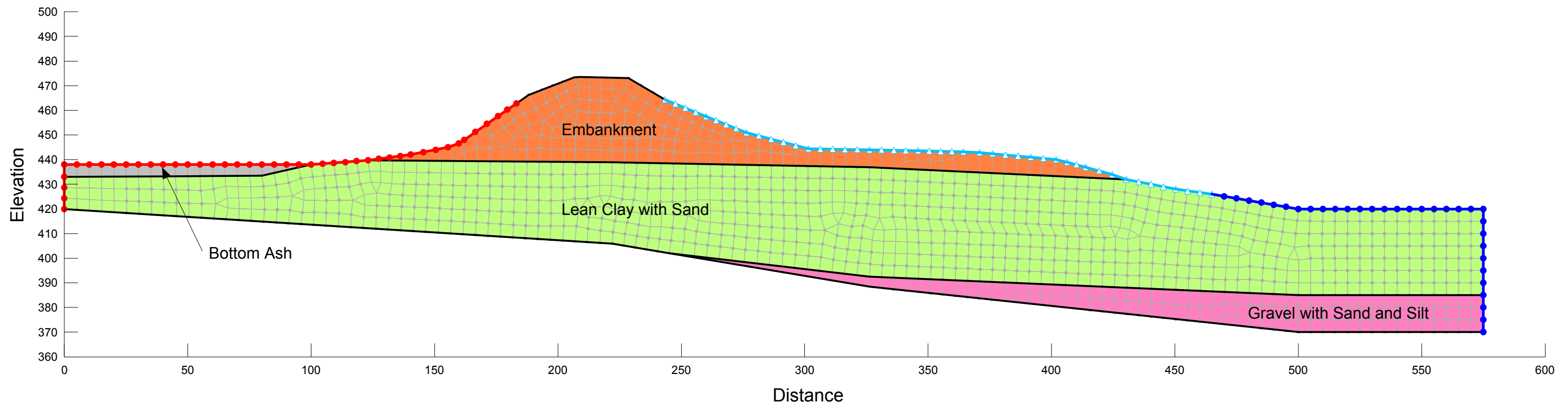
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Boundary Condition and Mesh**

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section A-A'

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft ³ /ft ³	Res. Water Content ft ³ /ft ³
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Gravel With Silt and Sand (Drained)	0.00164	0.2	0.23	0.01
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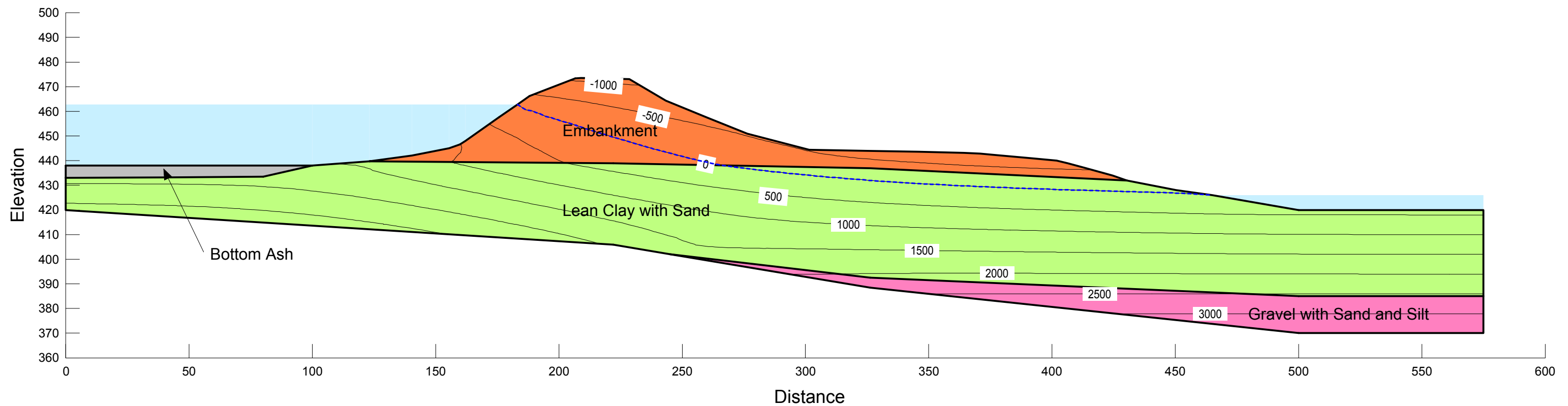
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Pore Water Pressure Contour (psf)**

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section A-A'

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft ³ /ft ³	Res. Water Content ft ³ /ft ³
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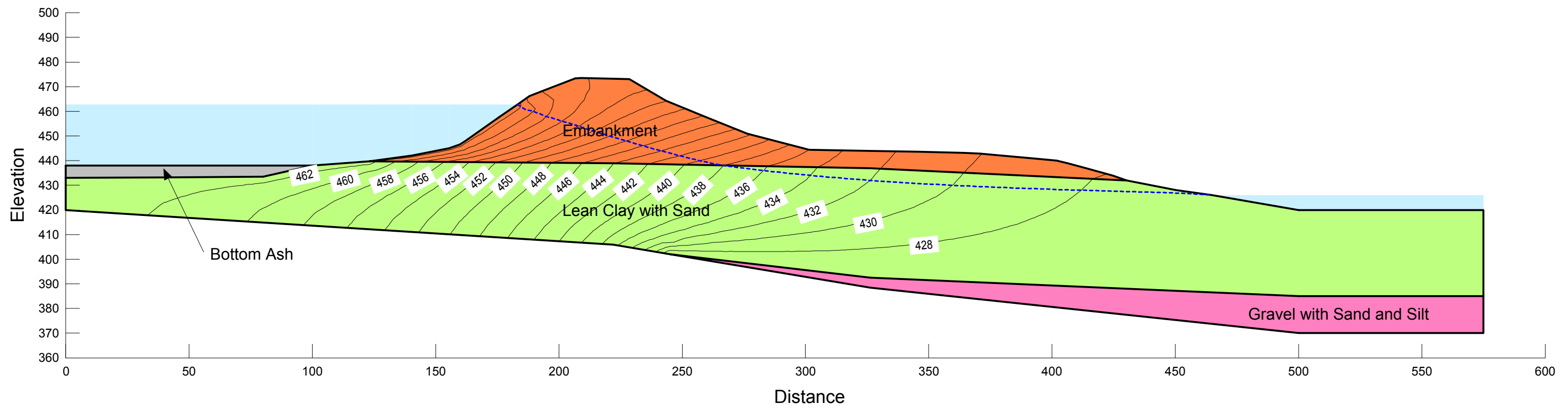
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Total Head Contour (feet)**

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section A-A'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

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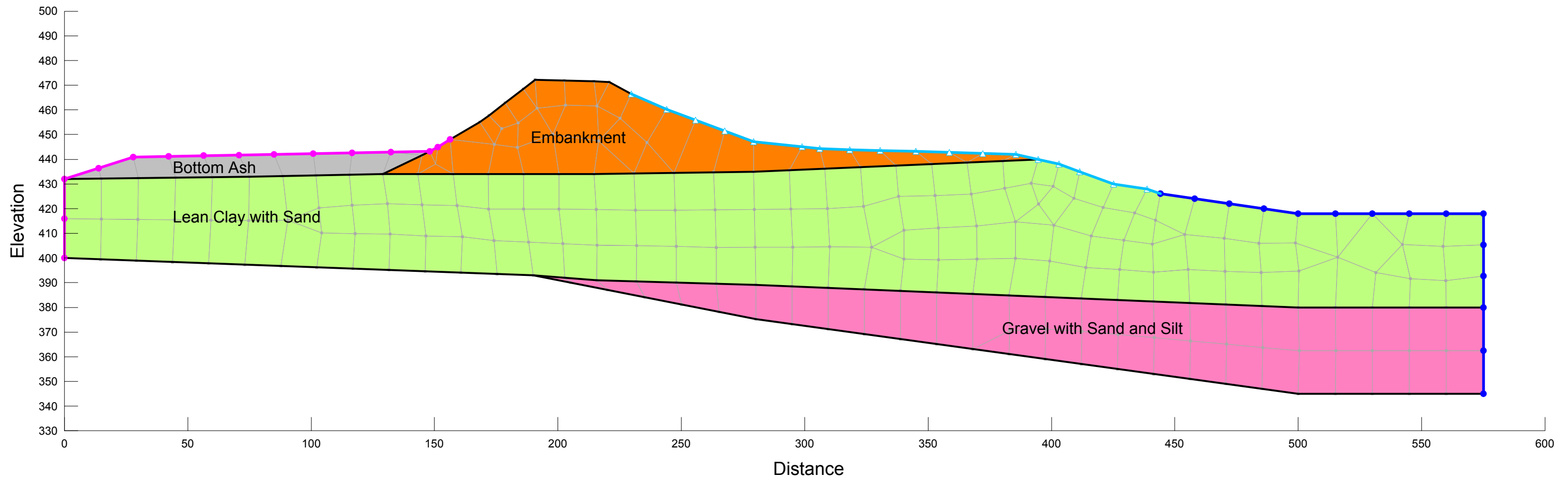
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Boundary Condition and Mesh**

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section B-B'

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft ³ /ft ³	Res. Water Content ft ³ /ft ³
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay With Sand (Drained)	2.83e-007	0.1	0.38	0.09
Gravel With Silt And Sand (Drained)	0.00164	0.2	0.23	0.01
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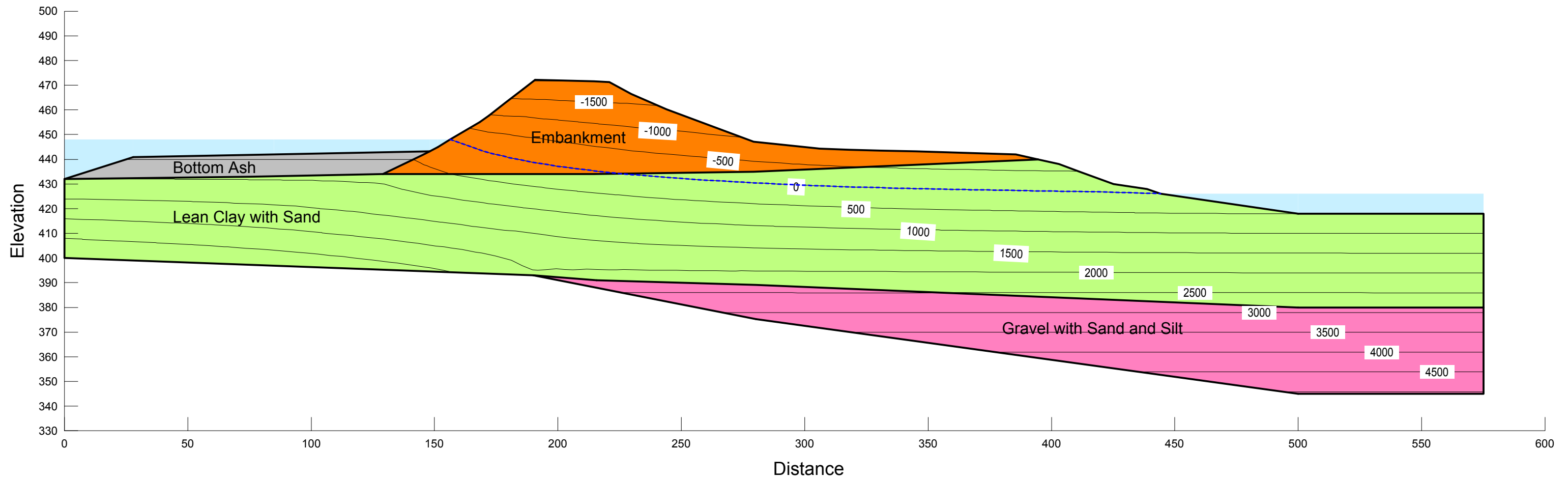
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Pore Water Pressure Contour (psf)**

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section B-B'

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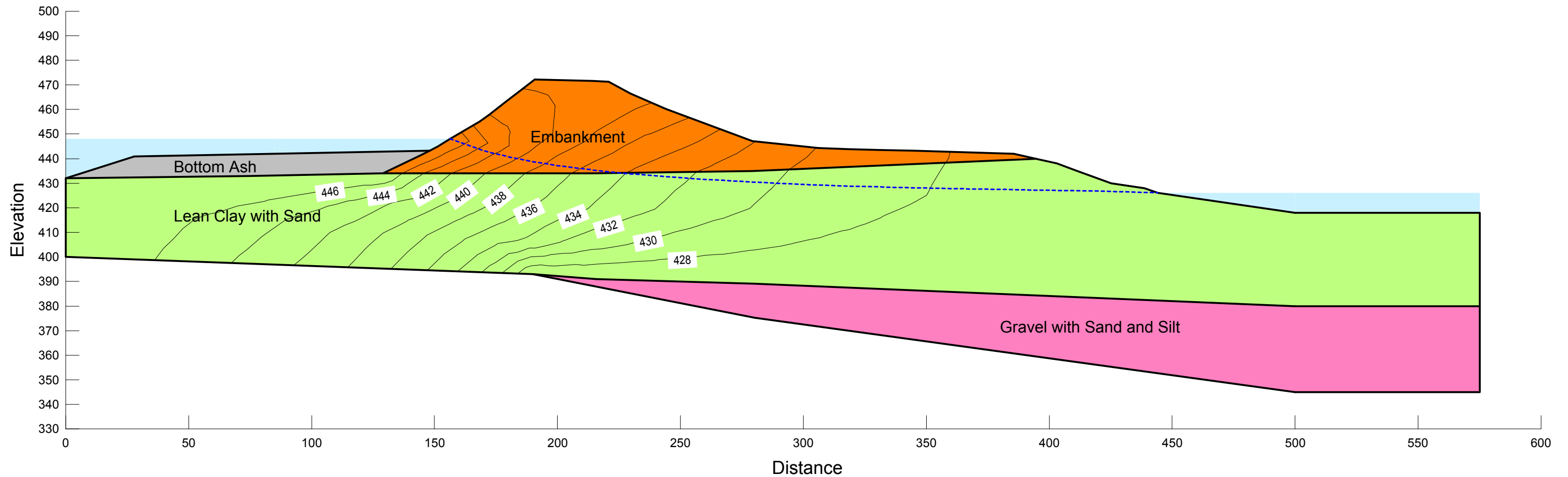
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Total Head Contour (feet)**

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section B-B'

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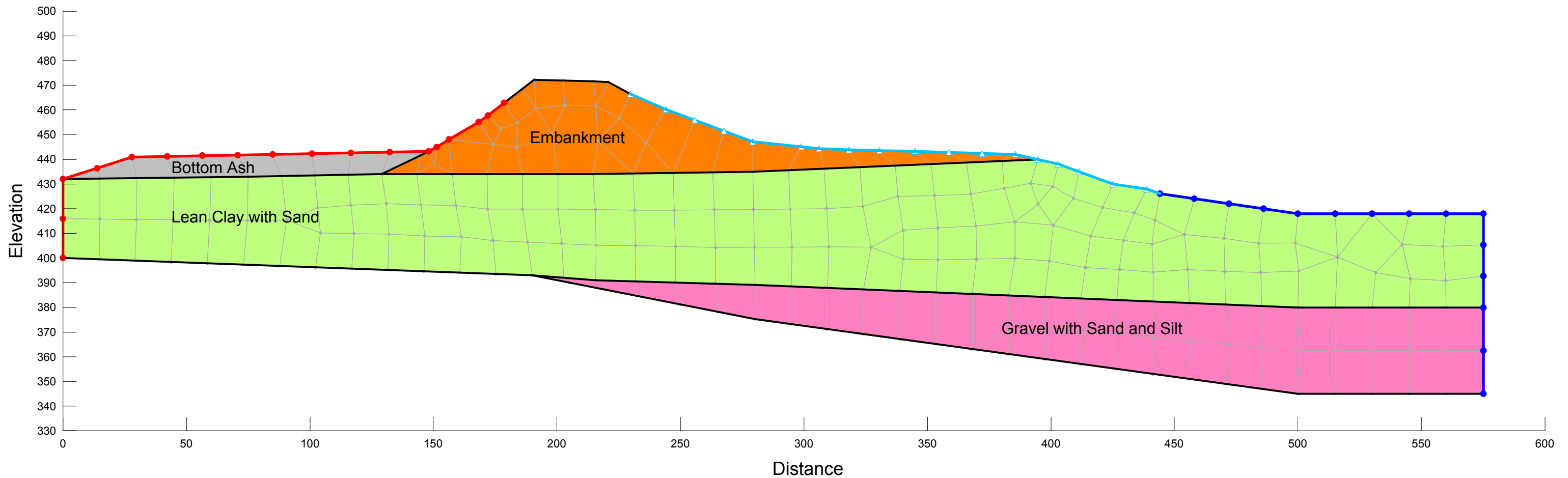
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Boundary Condition and Mesh**

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section B-B'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

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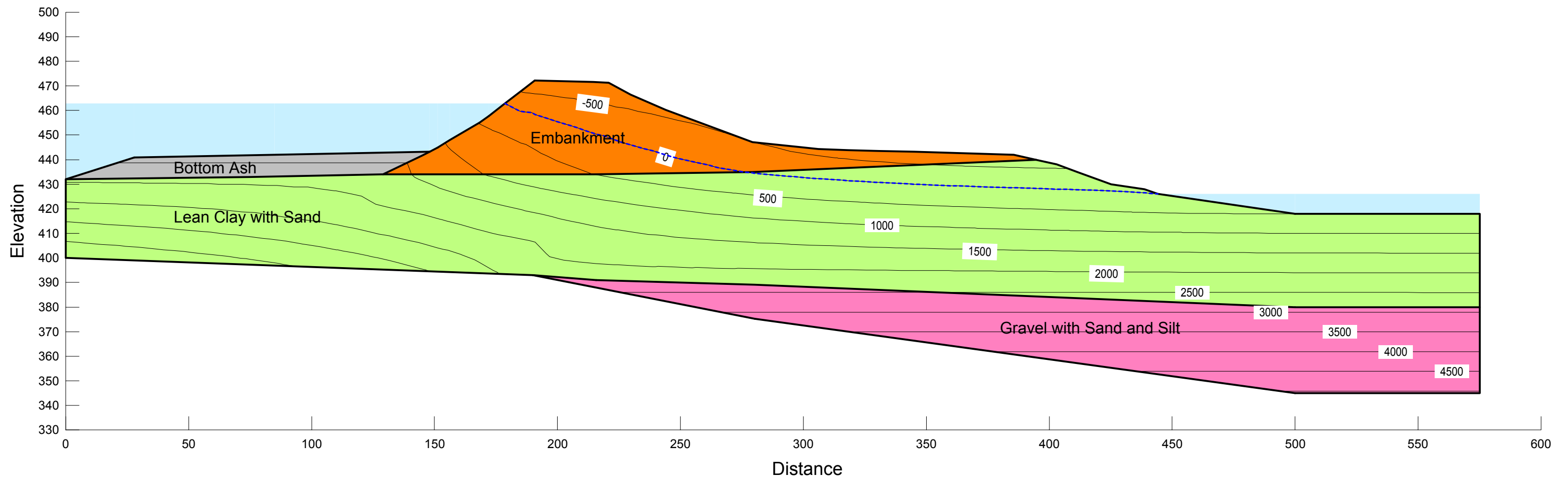
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Pore Water Pressure Contour (psf)**

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section B-B'

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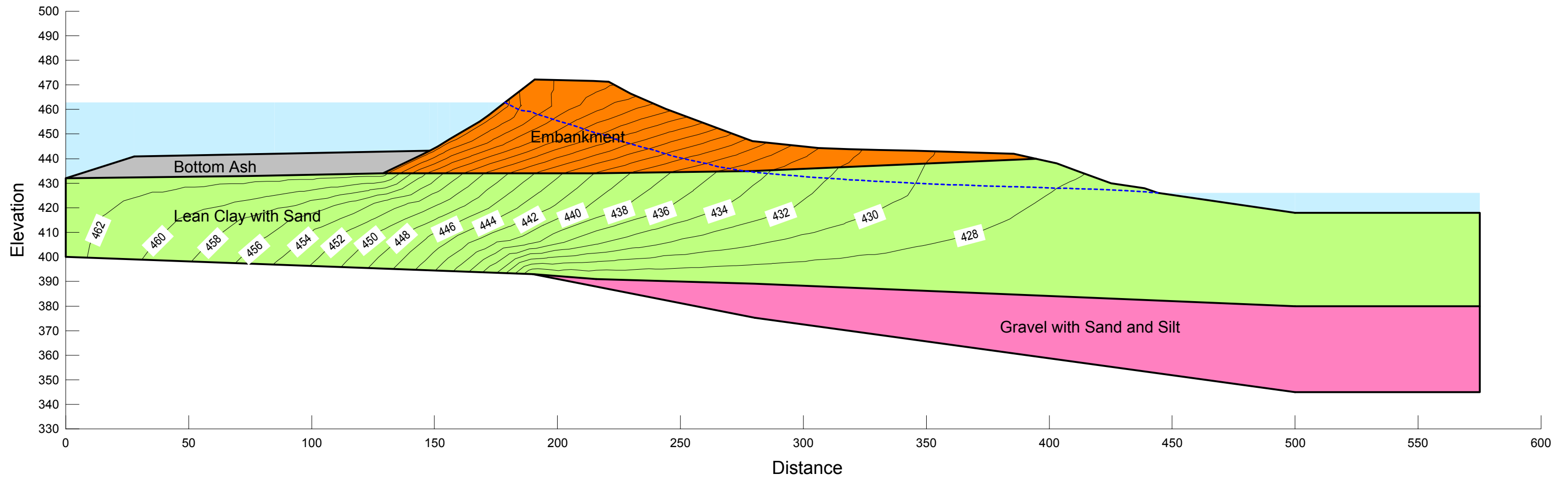
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Total Head Contour (feet)**

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section B-B'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

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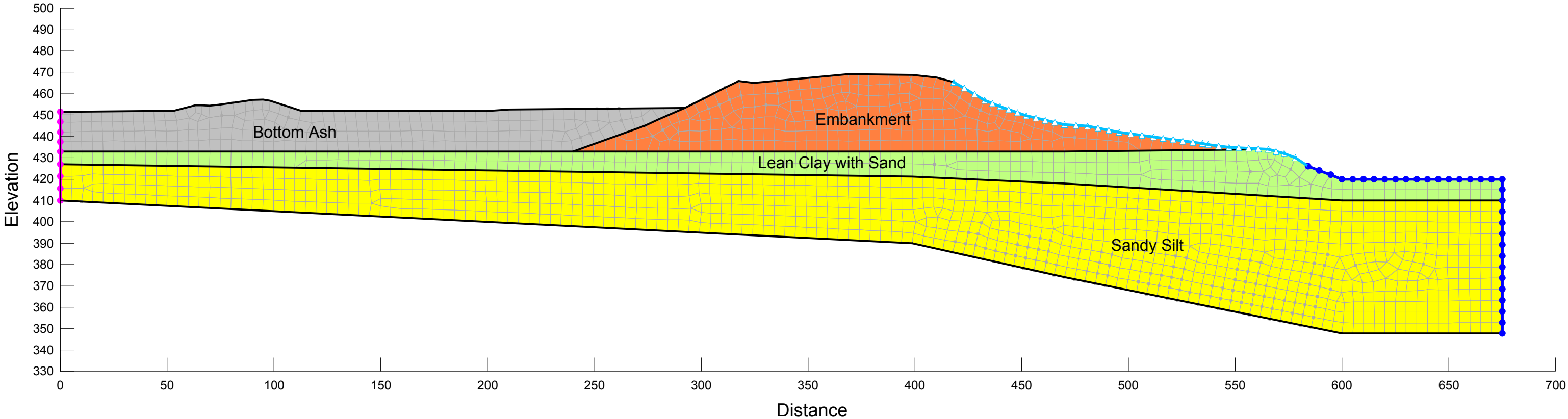
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Boundary Condition and Mesh**

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section C-C'

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft ³ /ft ³	Res. Water Content ft ³ /ft ³
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Sandy Silt (Drained)	1.64e-005	0.2	0.29	0.01
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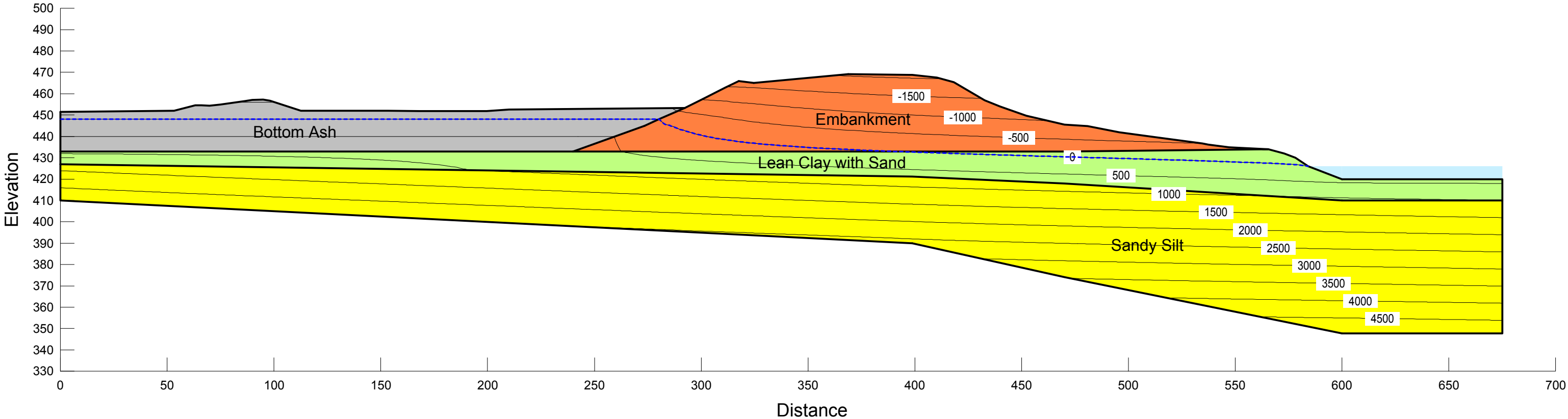
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Pore Water Pressure Contour (psf)**

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section C-C'

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft ³ /ft ³	Res. Water Content ft ³ /ft ³
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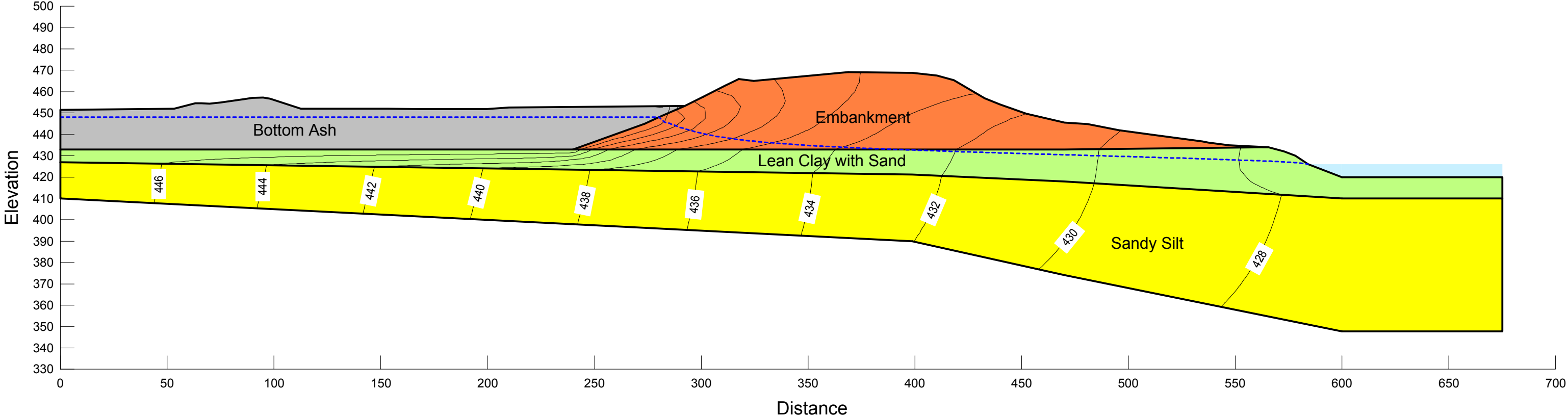
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Total Head Contour (feet)**

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section C-C'

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft ³ /ft ³	Res. Water Content ft ³ /ft ³
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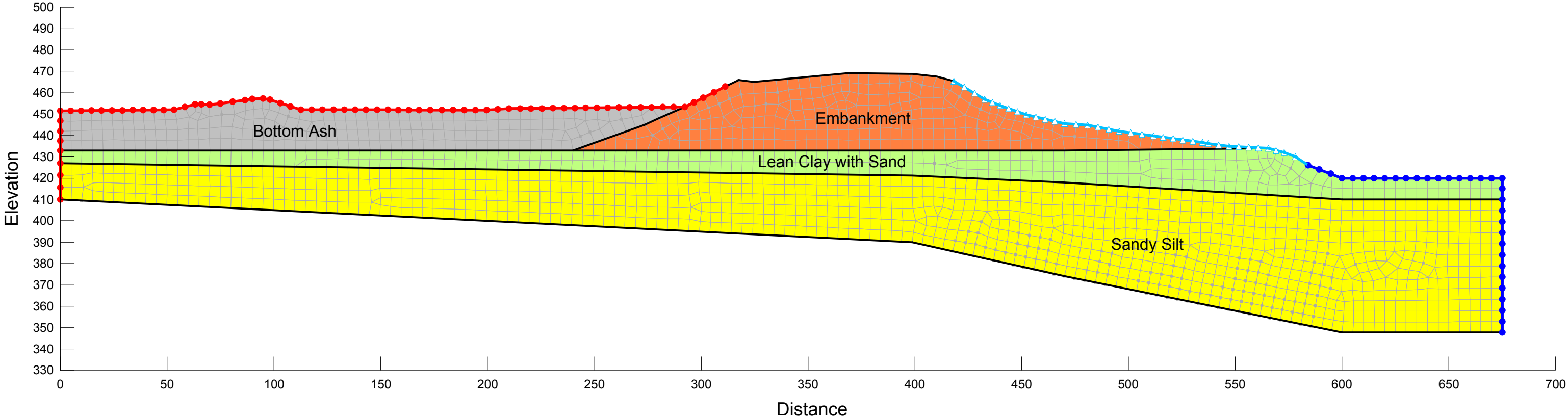
**American Electric Power (AEP)
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Madison, Indiana
CCR Mandate**

**Seepage Analysis
Boundary Condition and Mesh**

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section C-C'

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft ³ /ft ³	Res. Water Content ft ³ /ft ³
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Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
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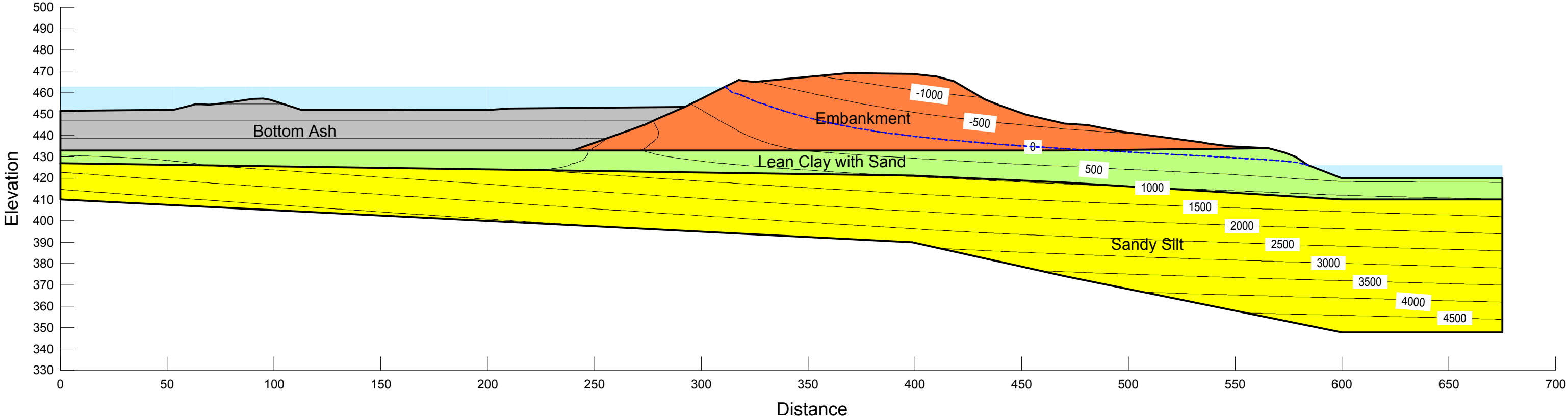
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Pore Water Pressure Contour (psf)**

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section C-C'

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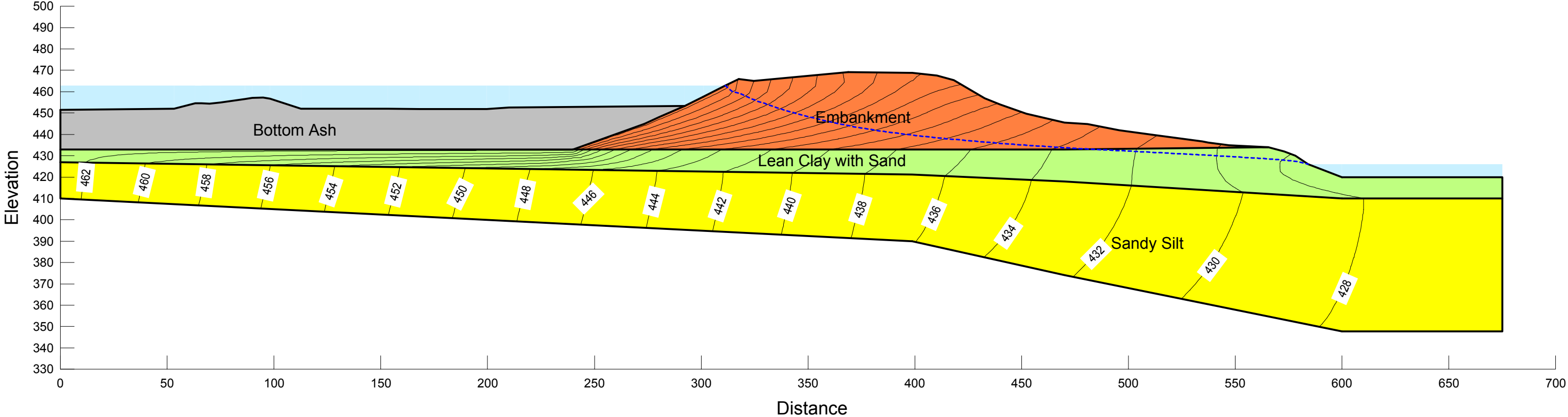
**American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate**

**Seepage Analysis
Total Head Contour (feet)**

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section C-C'

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft ³ /ft ³	Res. Water Content ft ³ /ft ³
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APPENDIX J

PARAMETER DERIVATIONS

BOILER SLAG POND DAM: 2010 PARAMETER DERIVATIONS

WEST BOTTOM ASH DAM GEOTECHNICAL ANALYSIS

CALCULATION SHEET

I. Subsurface Exploration Program Development:

Three cross sections across the dam were analyzed with two borings on each section: On the crest and at the toe.

II. Laboratory Testing Program:

The program was developed based on visual classifications done in the field during subsurface exploration.

- USCS Soil Classification Tests
- CU Triaxial Compression Tests
- Permeability Tests.
- Moisture Density tests.

III. Geotechnical Analysis:

A soil tests summary was developed to select soil parameters to use in the geotechnical analysis. Engineering properties that were not directly tested were determined using typical soil parameter values from NAVFAC DM7-02 Foundations and Earth Structures (Table 1 on Page 39) and the Center For Geotechnical Practice and Research, Performance and Use of the Standard Penetration Test in Geotechnical Engineering Practice report (Figures 34 and 35 on pages 71 and 72 respectively). The two tables are attached at the end of the parameter derivation notes.

Permeability k values that were not tested in the laboratory were selected from typical values provided in the table below and those provided in NAVFAC DM7.02, table 1: Typical Properties of Compacted soils

Soil Type	k_v (cm/s)
Coarse Sand	$>10^{-1}$
Fine Sand	10^{-1} to 10^{-3}
Silty Sand	10^{-3} to 10^{-5}
Silt	10^{-5} to 10^{-7}
Clay	$<10^{-7}$

Soils from the West Bottom Ash Dam were classified into 5 main soil layers.

The following table shows how pertinent parameters were selected and which sections they were applied to.

Soil name	USCS class	Classification Samples	Shear Strength Parameters	Permeability Parameters	Section
Embankment fill	CL	B-1,(10-11.5)(12.5-14)	Triaxial Test No 1	Test ID 7A	A / B / C
Lean Clay with Sand	CL	B-2,(32.5-34)(35-36.5)	Triaxial Test No 2	Average of test ID 48A & 82A	A / B / C
Gravel With Silt and Sand	GW-GM	B-4,(57.5-59)(60-61.5)	Typical values *	Typical values *	A / B
Sand Silt/ Silt with Sand	ML	B-5,(55-56.5)(57.5-59)	Typical values *	Typical values *	C
Bottom Ash		Averaged results from WBAP trench testing.**	Typical values *	Averaged results from WBAP trench testing.	A / B / C

* Typical values as determined from referenced tables.

** Table attached at end of appendix

Soil name	Unit Weight	C	ϕ	K_v (cm/sec)	K_h/K_v	g	e
Embankment fill	130	165	33	1.44 E-07	10	2.72 (ST sample)	0.609 (ST sample)
Lean Clay with Sand	119	160	24	8.62 E-07	10	2.69 (ST sample)	0.700 (ST sample)
Gravel With Silt and Sand	130	0	35	1.00 E-02	5	2.70	0.300
Sand Silt/ Silt with Sand	130	0	30	1.00 E-04	5	2.70	0.400
Bottom Ash	115	0	28	3.5E-01	1		

1. SEEPAGE ANALYSIS.

Geoslope Seep W analysis was used to analyze the model for Seepage. Field piezometer readings were compared to the model's results. The model was calibrated to approximate field water elevations.

Residual and saturated water contents and coefficients of volume compressibility were assumed for all soil layers based on previous experiences and soils' normal values.

Water elevations used were:

- Existing (normal) water elevation in the pond: 442 feet.
- Maximum possible impounded water elevation (spillway highest grate): 457.7 feet
- Ohio River water elevation 426 feet.

Seepage analysis results were used in the slope stability analysis to model pore water pressures.

2. STABILITY ANALYSIS.

Geoslope Slope W was used for the slope stability analysis.

The Spencer Analysis Method was used.

Slip circle method and siding wedge method were modeled by the circular failure plane and the block specified; the circular failure plane produced lower Factors of Safety.

The peak ground acceleration used for the seismic analysis was obtained from US Geological Survey website. The PGA used is 0.08g (USGS indicates 0.07677g). The method selected to do the seismic analysis was the pseudostatic analysis per the project scope.

Loading conditions:

Static Slope Stability Loading Conditions:

- Steady state Seepage normal pool (upstream and downstream slopes): 442 feet
- Steady state seepage maximum pool (upstream and downstream slopes): 457.7 feet
- Rapid drawdown: normal pool steady-state seepage conditions with empty pond and dredged conditions above elevation 433 feet (upstream slope)
- PMF event (upstream and downstream slopes). The flood water was considered as a surcharge and the maximum pool steady state pore pressure line was used, as the water elevation selected for the PMF event is the result of a flood occurring while the dam had the maximum water pool. PMF event water elevation in the pond is: 468.4 feet.

Seismic Slope Stability Loading Conditions:

- Steady state seepage normal pool (upstream and downstream slopes): 442 feet
- Steady state seepage maximum pool (upstream and downstream slopes): 457.7 feet

3. LIQUEFACTION ANALYSIS.

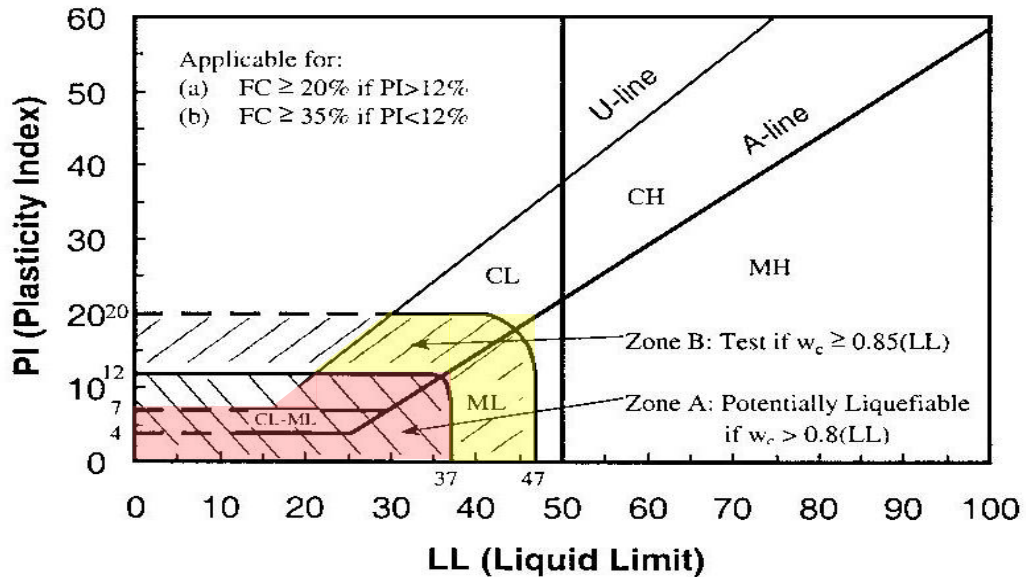
Research and methodology:

- Earthquake intensity: USGS website used to determine the Peak Ground Acceleration and earthquake intensity for an earthquake event of a mean return period of 2,475 years. $PGA = 0.07677g$, the value used in the analysis is $0.08g$ and $M_L = 7.7$.
- Groundwater table: Normal (current) steady state water elevations were considered as the groundwater elevation. Unsaturated soil located above the groundwater table will not liquefy.
- Soil Type:

The dam soil materials, being constructed of engineered fill located above the groundwater table, are not considered liquefiable.

Cohesionless materials are considered liquefiable. The majority of cohesive soils will not liquefy. Cohesive soils susceptible to liquefaction should fall in either zone A or zone B of the following chart.

Screening Criteria for Liquefiable Fine-Grained Soils (Seed et al. 2003)



- Soil relative density (D_r): Soils in a loose relative density state are susceptible to liquefaction. Soils with an SPT-N value of 30 or higher were considered not liquefiable.

Liquefaction Assessment

To assess liquefaction potential for the WBAD, the boring logs from the geotechnical borings and laboratory test data from Shelby tubes and SPT samples were used. The boring logs include the SPT blow counts and soil lithologic descriptions with depth.

Soil characteristics (grain size, plasticity, unit weight, moisture content) from SPT and Shelby tube samples obtained from the geotechnical borings were used in the liquefaction assessment.

Method Used: Simplified Method based on using correlations to blow counts from Standard Penetration Tests (SPTs) as set forth in Youd et al (2001) and discussed in NRC (1985).

The Simplified Method requires estimating the Cyclic Stress Ratio (CSR) and Cyclic Resistance Ratio (CRR) of the soil. The CRR can be estimated using information from SPT tests, corrected to account for various effects. To use the Simplified Method, the SPT N value is normalized to an overburden pressure of approximately 100 kiloPascals (kPa) and a hammer energy ratio of 60% and procedural effects (rod length, sample configuration and borehole diameter).

The $(N_1)_{60}$ may also be corrected for the percent of fines using the relationship:

$$(N_1)_{60cs} = \alpha + \beta(N_1)_{60}$$

It is important to note that the fines correction is an approximation and is only valid for nonplastic fines and with a fines content between 0 and 35%. This correction factor, although widely used, is considered as a rough approximation only.

Once the corrected value for $(N_1)_{60}$ is found, the CRR is calculated as:

$$CRR_{7.5} = \frac{1}{34 - (N_1)_{60}} + \frac{(N_1)_{60}}{135} + \frac{50}{[10 * (N_1)_{60} + 45]^2} - \frac{1}{200}$$

Note that the value calculated is the CRR normalized to a 7.5 magnitude earthquake, hence the $CRR_{7.5}$ notation. When evaluating the liquefaction potential of soil, the $CRR_{7.5}$ must be corrected to the magnitude earthquake of interest.

The CSR is independent of soil properties and may be approximated using the equation:

$$CSR = 0.65 \left(\frac{a_{\max}}{g} \right) \left(\frac{\sigma_v}{\sigma'_v} \right) r_d$$

where:

a_{\max} is the maximum ground acceleration.

g is the acceleration of gravity.

σ_v is the total vertical stress.

σ'_v is the effective vertical stress.

r_d is a stress reduction coefficient.

Liquefaction potential for a soil unit is evaluated by dividing $CRR_{7.5}$ by CSR and then correcting to the magnitude earthquake of interest, as:

$$FS = \frac{CRR_{7.5} * MSF}{CSR}$$

Field experience has shown that the Simplified Method is somewhat conservative; so many designers consider FS values close to unity as an indication of no liquefaction.

B-1

Elevation	Depth	Soil class	N	Remarks
470.2	3.25	CL	11	Not liquefiable. Embankment and located above ground water
467.7	5.75	CL	10	
462.7	10.75	CL	10	
460.2	13.25	CL	7	
455.2	18.25	CL	15	
452.7	20.75	CL	15	
450.2	23.25	CL	14	
447.7	25.75	CL	8	
445.2	28.25	CL	12	
442.7	30.75	CL	11	
440.2	33.25	CL	9	
437.7	35.75	CL	10	
435.2	38.25	CL	6	
432.7	40.75	CL	5	
427.7	45.75	CL	2	Evaluated for liquefaction
425.2	48.25	CL	3	
422.7	50.75	CL	4	
420.2	53.25	CL	2	
417.7	55.75	CL	4	
415.2	58.25	CL	4	
412.7	60.75	CL	5	
410.2	63.25	CL	6	
407.7	65.75	CL	7	

B-2

Elevation	Depth	Soil class	N-field	Remarks
440.8	3.25	CL	19	Not liquefiable as layer is above ground water
438.3	5.75	CL	7	
435.8	8.25	CL	7	
430.8	13.25	CL	5	
428.3	15.75	CL	4	
425.8	18.25	CL	2	Evaluated for liquefaction
423.3	20.75	CL	4	

418.3	25.75	CL	4	
415.8	28.25	CL	9	
413.3	30.75	CL	6	
410.8	33.25	CL	6	
408.3	35.75	CL	5	
405.8	38.25	CL	4	
403.3	40.75	CL	6	
398.3	45.75	CL	2	
393.3	50.75	GW - GM	50	Not liquefiable

B-3

Elevation	Depth	Soil class	N-field	Remarks
468.4	3.25	CL	11	Not liquefiable.
465.9	5.75	CL	8	
463.4	8.25	CL	10	Embankment and located above ground water
458.4	13.25	CL	9	
455.9	15.75	CL	10	
453.4	18.25	CL	12	
448.4	23.25	CL	12	
445.9	25.75	CL	9	
443.4	28.25	CL	15	
440.9	30.75	CL	10	
438.4	33.25	CL	17	
435.9	35.75	CL	16	
433.4	38.25	CL	18	
430.9	40.75	CL	4	Evaluated for liquefaction
428.4	43.25	CL	4	
425.9	45.75	CL	6	
420.9	50.75	CL	4	
418.4	53.25	CL	2	
415.9	55.75	CL	5	
413.4	58.25	CL	2	
410.9	60.75	CL	8	
408.4	63.25	CL	6	
405.9	65.75	CL	7	
403.4	68.25	CL	9	
400.9	70.75	CL	8	

B-4

Elevation	Depth	Soil class	N-field	Remarks
443.5	3.25	CL	16	Not liquefiable as located above ground water
441.0	5.75	CL	15	
436.0	10.75	CL	11	
433.5	13.25	CL	7	
431.0	15.75	CL	5	

426.0	20.75	CL	4	Evaluated for liquefaction
424.5	22.25	CL	5	
421.0	25.75	CL	6	
418.5	28.25	CL	5	
416.0	30.75	CL	3	
413.5	33.25	CL	4	
411.0	35.75	CL	9	
406.0	40.75	CL	4	
403.5	43.25	CL	5	
401.0	45.75	CL	8	
398.5	48.25	CL	6	
396.0	50.75	CL	7	
393.5	53.25	CL	5	
391.0	55.75	CL	7	
388.5	58.25	GW - GM	39		Not liquefiable as layer is very dense
386.0	60.75	GW - GM	46	
381.5	65.25	GW - GM	50	
376.0	70.75	GW - GM	52	

B-5

Elevation	Depth	Soil class	N-field	Remarks	
465.5	3.25	CL	19	Not liquefiable.	
463.0	5.75	CL	9		
458.0	10.75	CL	15		
455.5	13.25	CL	10		
453.0	15.75	CL	7		
450.5	18.25	CL	16		
448.0	20.75	CL	7		
443.0	25.75	CL	8		
440.5	28.25	CL	7		
438.0	30.75	CL	12		
435.5	33.25	CL	8		
433.0	35.75	CL	16		
430.5	38.25	CL	6		
428.0	40.75	CL	3		Evaluated for liquefaction
423.0	45.75	CL	4		
420.5	48.25	ML	4	Evaluated for liquefaction	
418.0	50.75	ML	6		
415.5	53.25	ML	2		
413.0	55.75	ML	4		
410.5	58.25	ML	5		
408.0	60.75	ML	7		
405.5	63.25	ML	9		
403.0	65.75	ML	11		
400.5	68.25	ML	9		
398.0	70.75	ML	13		

B-6

Elevation	Depth	Soil class	N-field	Remarks
442.3	3.25	CL	8	Not liquefiable as layer is above ground water
439.8	5.75	CL	10	
434.8	10.75	CL	18	
432.3	13.25	CL	4	
429.8	15.75	CL	3	
424.8	20.75	CL	1	
422.3	23.25	CL	2	Evaluated for liquefaction
419.8	25.75	CL	4	
417.3	28.25	ML	5	
414.8	30.75	ML	3	Evaluated for liquefaction
412.3	33.25	ML	3	
409.8	35.75	ML	1	
407.3	38.25	ML	1	
402.3	43.25	ML	2	
399.8	45.75	ML	1	
397.3	48.25	ML	1	
394.8	50.75	ML	5	
392.3	53.25	ML	11	
389.8	55.75	ML	4	
387.3	58.25	ML	9	
384.8	60.75	ML	11	
379.8	65.75	ML	9	
374.8	70.75	ML	10	

TABLE 1
Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression		Typical Strength Characteristics				Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
				At 1.4 tsf (20 psf)	At 3.6 tsf (50 psf)	Cohesion (as compacted) paf	Cohesion (saturated) paf	ϕ (Effective Stress Envelope Degree)	Tan ϕ			
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GN	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-4}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	5×10^{-5}	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	2×10^{-6}	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	5×10^{-7}	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	5×10^{-7}	.....
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MI	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	5×10^{-7}	10 or less	50 - 100
CI	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

- All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
- Typical strength characteristics are for effective strength envelopes and are obtained from USSR data.
- Compression values are for vertical loading with complete lateral confinement.
- (>) indicates that typical property is greater than the value shown.
(..) indicates insufficient data available for an estimate.

7.2-39

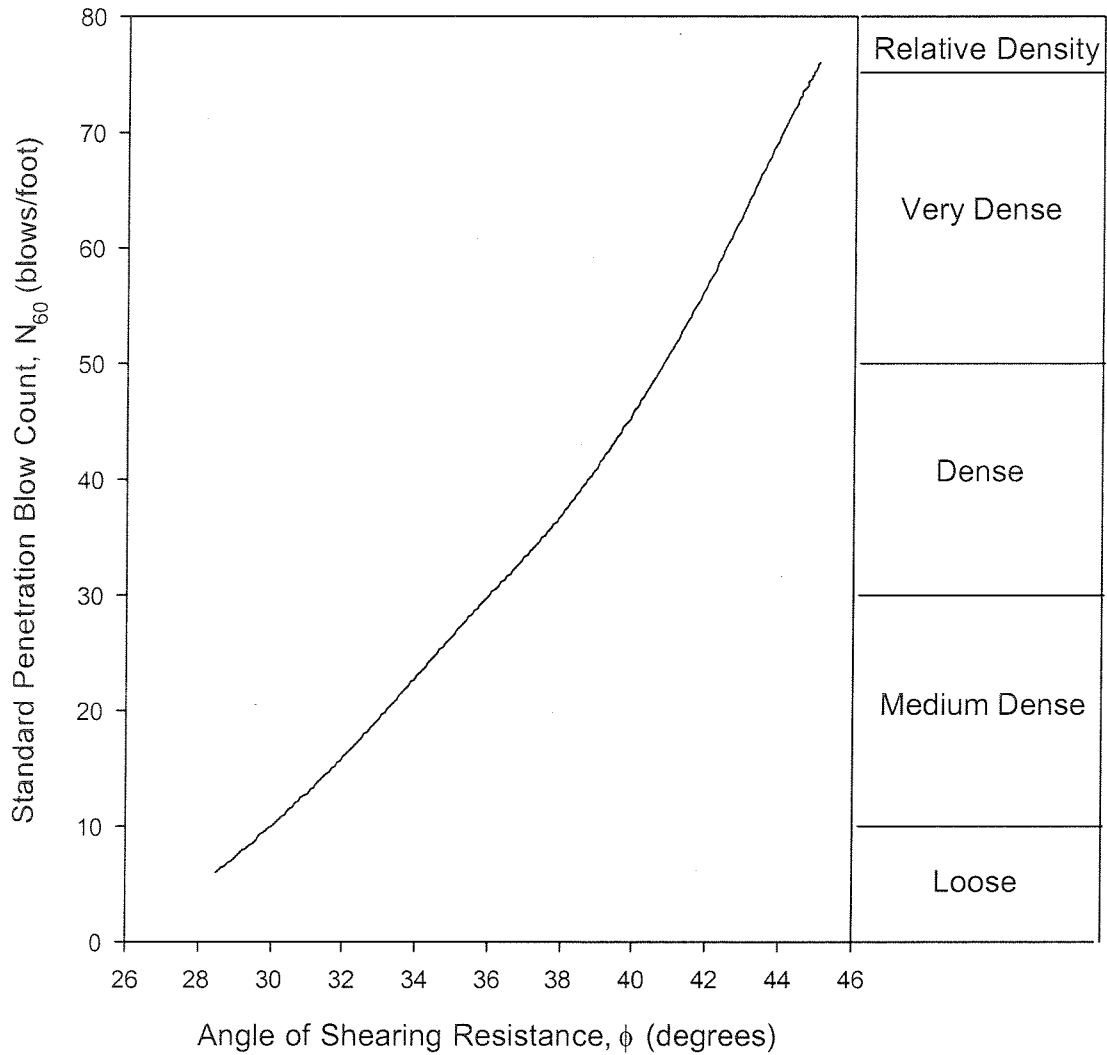


Figure 35. Estimation of the angle of shearing resistance of granular soils from standard penetration test results (Originally from Peck et al., 1974, modified by Carter and Bentley, 1991).

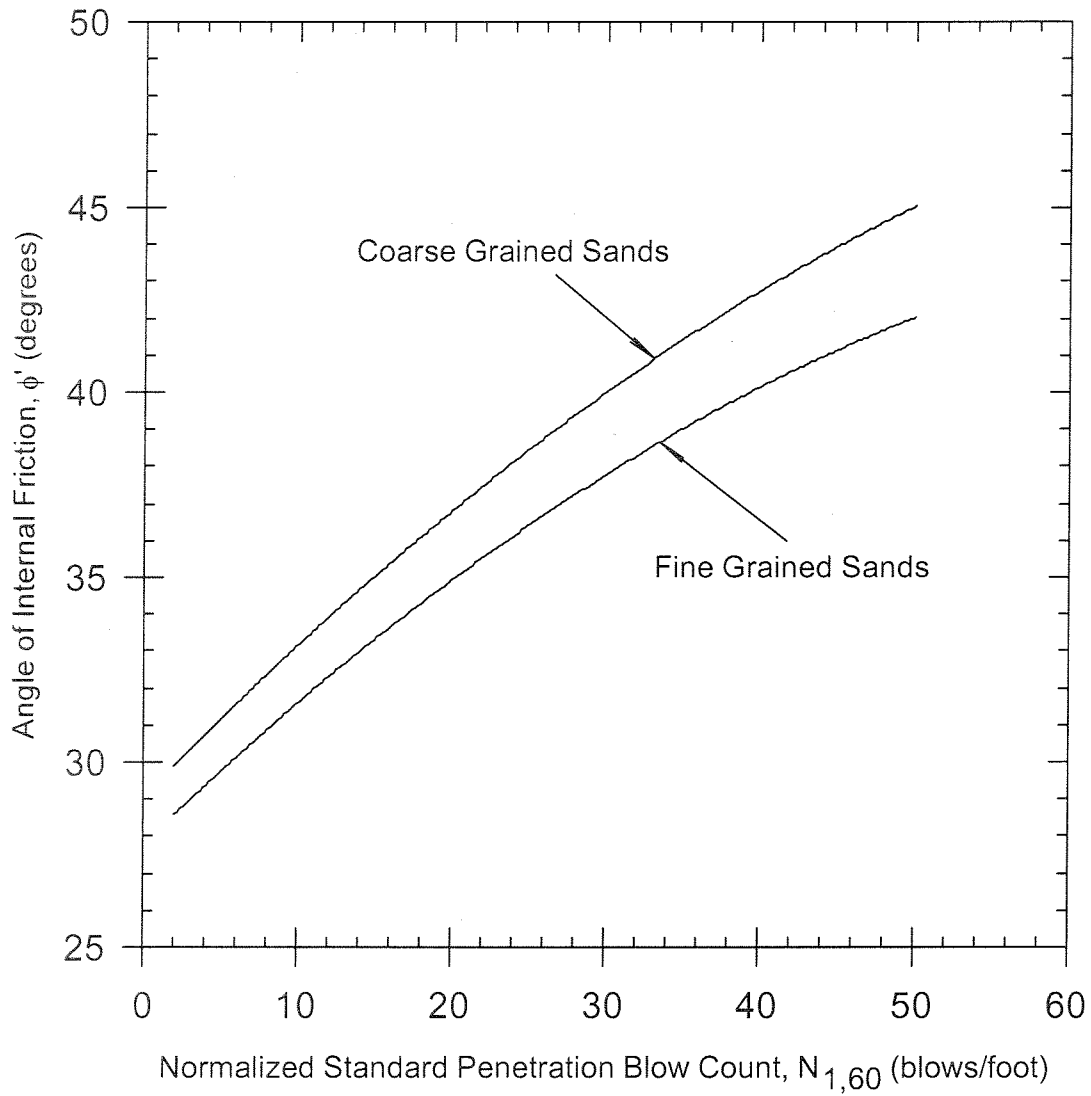


Figure 34. Empirical correlation between friction angle of sands and normalized standard penetration blow count (after Terzaghi et al., 1996)

WBAP Trench Testing (Bottom Ash Testing)

ASTM D 422, C 136

Sample	Classification	ø (%)	D ₁₀ (mm)	D ₃₀ (mm)	D ₆₀ (mm)	Cu	Cc	Sieve Size (% Passing)								Pan	% Gravel	% Sand	% Fines	K(cm/s)	Fines 200 C	Classification
								3" 75	1 1/2" 37.5	1" 25.0	3/4" 19.0	3/8" 9.5	No. 4 4.75	No. 10 2	No. 40 0.425								No. 200 0.075
1	Well Graded Sand (SW) with Gravel	6.2	0.3798	1.1724	3.2161	8.47	1.13	100.0	100.0	96.9	95.0	84.8	74.1	42.9	11.8	1.8	0.0	25.9	72.2	1.7	4.1E-01	
2	Poorly Graded Sand (SP) with Gravel	5.6	0.5766	1.4565	3.4443	5.97	1.07	100.0	100.0	96.1	93.8	85.2	72.9	38.2	5.5	0.8	0.0	27.1	72.1	0.8	1.1E+00	
3	Well Graded Sand (SW)	7.5	0.3386	0.9936	2.6258	7.76	1.11	100.0	100.0	100.0	100.0	95.1	85.9	50.4	12.2	2.2	0.0	14.1	83.8	1.9	3.0E-01	
4	Poorly Graded Sand (SP) with Gravel	5.9	0.5081	1.2732	3.0405	5.98	1.05	100.0	100.0	100.0	95.9	89.7	78.9	42.5	7.3	1.3	0.0	21.1	77.6	1.2	5.9E-01	
5	Poorly Graded Sand (SP) with Gravel	6.0	0.5210	1.2514	2.9512	5.66	1.02	100.0	100.0	100.0	98.7	91.7	80.6	43.7	6.5	1.2	0.0	19.4	79.5	1.1	8.4E-01	
6	Well Graded Sand (SW) with Gravel	7.1	0.3792	1.0490	2.7409	7.23	1.06	100.0	100.0	97.7	94.4	90.1	81.6	47.6	11.0	2.2	0.0	18.4	79.3	2.1	3.6E-01	
7	Poorly Graded Sand (SP-SC) with Clay	23.1	0.0757	0.1599	0.5429	7.17	0.62	100.0	100.0	100.0	100.0	98.4	94.7	80.6	56.1	9.8	0.0	5.3	84.9	10.0	5.6E-02	
8	Well Graded Sand with Gravel (SW), gray	8.7	0.1868	0.8464	2.6959	14.44	1.42	100.0	100.0	100.0	99.5	94.8	84.4	47.1	17.1	2.1	0.0	15.6	82.4	2.1	3.0E-01	
9	Well Graded Sand (SW) with Gravel	5.4	0.3714	1.4341	3.9659	10.68	1.40	100.0	100.0	93.7	89.1	77.9	66.1	36.5	11.3	1.0	0.0	33.9	65.1	1.0	2.9E-01	
10	Well Graded Sand (SW) with Gravel	4.4	0.2954	1.3526	4.3012	14.56	1.44	100.0	100.0	94.8	87.9	76.3	63.1	36.3	12.3	1.4	0.0	36.9	61.7	1.4	1.7E-01	
11	Well Graded Sand (SW) with Gravel	4.4	0.3771	1.1624	3.2364	8.58	1.11	100.0	100.0	100.0	96.3	87.8	75.2	41.0	10.6	1.8	0.0	24.8	73.3	1.8	3.9E-01	
12	Poorly Graded Sand (SP) with Gravel	2.7	0.4552	1.1566	3.1130	6.84	0.94	100.0	100.0	97.9	96.4	86.8	76.9	42.4	8.5	1.4	0.0	23.1	75.5	1.4	4.7E-01	
13	Well Graded Sand (SW) with Gravel	12.5	0.1642	0.7368	2.4777	15.09	1.33	100.0	100.0	100.0	100.0	93.1	84.1	53.4	20.4	3.7	0.0	15.9	80.4	3.7	2.4E-01	
14	Well Graded Sand (SW-SC) with Clay and Gravel	14.0	0.1021	0.9001	3.1464	30.82	2.52	100.0	90.3	90.3	89.1	84.2	75.4	44.5	20.0	7.8	0.0	24.6	67.6	7.8	2.5E-01	CH
15		7.7	0.1110	0.6950	2.4690	22.24	1.76	100.0	100.0	100.0	99.1	93.7	83.3	53.8	21.7	6.6	0.0	16.7	76.7	6.6		
16		8.4	0.0934	0.6601	2.3445	25.10	1.99	100.0	100.0	100.0	100.0	95.3	86.1	54.9	22.4	8.4	0.0	13.9	77.7	8.4		
17		6.8	0.1413	0.7713	2.6062	18.44	1.62	100.0	100.0	100.0	98.3	93.1	81.3	51.6	20.1	6.1	0.0	18.7	75.2	6.1		
18	Silty Sand (SM), with Gravel	8.5						100.0	100.0	94.4	91.5	85.3	76.4	49.5	46.6	33.3	0.0	23.6	43.1	33.3	8.6E-02	
19		8.2	0.1425	0.7675	2.6682	18.72	1.55	100.0	100.0	100.0	98.5	90.6	81.2	50.8	19.8	6.1	0.0	18.8	75.1	6.1		
20	Silty Sand (SM), gray	13.3						100.0	100.0	100.0	100.0	94.3	87.5	61.4	30.9	14.3	0.0	12.5	73.2	14.3	1.9E-02	
21	Silty Sand (SM), gray	16.8						100.0	100.0	100.0	100.0	96.5	89.5	62.2	34.4	17.1	0.0	10.5	72.4	17.1	1.8E-02	
22	Well Graded Sand (SW-SM) with Silt and Gravel	5.8	0.1552	1.0052	2.9060	18.73	2.24	100.0	100.0	100.0	97.1	93.3	84.0	43.5	18.6	5.6	0.0	16.0	78.4	5.6		ML
23	Well Graded Sand (SW-SM) with Silt and Gravel	6.8	0.1053	0.6226	2.6016	24.71	1.42	100.0	100.0	100.0	97.0	89.4	81.0	52.3	23.5	6.7	0.0	19.0	74.3	6.7		ML
24	Well Graded Sand (SW-SM) with Silt	4.5	0.1541	0.8266	2.6141	16.96	1.70	100.0	100.0	100.0	97.7	92.9	86.8	49.2	19.4	5.3	0.0	13.2	81.5	5.3		ML
25	Well Graded Sand (SW-SM) with Silt and Gravel	6.8	0.0972	0.5461	2.4056	24.74	1.28	100.0	100.0	98.4	96.7	90.2	81.0	54.5	26.1	7.2	0.0	19.0	73.8	7.2		ML
		max	0.5766	1.4565	4.3012	30.82	2.52	100.0	100.0	100.0	100.0	98.4	94.7	80.6	56.1	33.3	0.0	36.9	84.9	33.3	1.1E+00	
		min	0.0757	0.1599	0.5429	5.66	0.62	100.0	90.3	90.3	87.9	76.3	63.1	36.3	5.5	0.8	0.0	5.3	43.1	0.8	1.8E-02	
		average	0.2605	0.9472	2.8233	14.50	1.40	100.0	99.6	98.4	96.5	90.0	80.5	49.2	19.8	6.2	0.0	19.5	74.3	6.2	3.5E-01	

LANDFILL RUNOFF COLLECTION POND

FLY ASH DAM GEOTECHNICAL ANALYSIS

PARAMETER DERIVATION

I. Subsurface Exploration Program Development:

The scope determined two sections across the dam. Two borings will be drilled on each section, on the crest and at the toe, only Sheby tube samples were collected that will be used to supplement available historic borings data in the development of the soil profile.

II. Laboratory Testing Program:

The program was developed to provide additional soil data to available historic data.

- USCS Soil Classification Tests.
- Triaxial tests.
- Permeability tests
- Moisture-density tests.

III. Geotechnical Analysis:

A soil tests summary was developed to select soil parameters to use in the geotechnical analysis. Engineering properties that were not directly tested were determined using typical soil parameter values from NAVFAC DM7-02 Foundations and Earth Structures (Table 1 on Page 39) and the Center For Geotechnical Practice and Research, Performance and Use of the Standard Penetration Test in Geotechnical Engineering Practice report (Figures 34 and 35 on pages 72 and 77 respectively). The two tables are attached at the end of the parameter derivation notes.

Permeability k values that were not tested in the laboratory were selected from typical values provided in the table below and those provided in NAVFAC DM7.02, table 1: Typical Properties of Compacted soils

Soil Type	k_v (cm/s)
Coarse Sand	$>10^{-1}$
Fine Sand	10^{-1} to 10^{-3}
Silty Sand	10^{-3} to 10^{-5}
Silt	10^{-5} to 10^{-7}
Clay	$<10^{-7}$

Historic boring and graphic logs were used to develop the dam's soil horizons for soil layers on which soil sampling was not done.

Soils from the Fly Ash Dam were classified into 7 main soil layers.

The following table shows how pertinent parameters were selected and which sections they were applied to.

Soil name	USGS class	Classification Samples	Shear results sample	Permeability k-value sample	Section
Embankment fill	CL	B-9 sample (20.2' – 20.8')	Average Triaxial Test B-7 & B-9	Average K tests B-7 & B-9	D/E
Lean Clay With Sand	CL	B-8 sample (25.5' – 25.8')	Average Triaxial Test B-8 & B-10	Permeability test B-8	D/E
Clayey Sand and Gravel	GC	Fly Ash Dam Raising report logs	Typical values *	Typical values *	D
Sandy Silts	ML	Fly Ash Dam Raising report logs	Typical values *	Typical values *	D
Silty Clay With Sand	CL-ML	B-10 sample (16.2' – 16.8')	Typical values *	Permeability test B-10	E
Silty Sand	SM	B-10 sample (14.2' – 14.8')	Typical values *	Typical values *	D/E
Fly Ash	NA	NA	Typical values *	Hydrogeologic study report	D/E

* Typical values as determined from referenced tables.

Soil name	Unit Weight	C	ϕ	kv (cm/sec)	Typical kh/kv	g	e
Embankment fill	129	198	27.5	7.30E-08	10	2.63 B-7 (27.2-27.8)	0.609 (ST sample)
Lean Clay With Sand	127	205.92	28	3.40E-08	10	2.65 B-8 (29.7-30.3)	0.700 (ST sample)
Clayey Sand and Gravel	130	0	35	1.00E-02	10	2.70	0.5
Sandy Silts	125	0	30	1.00E-04	5	2.65 B-8 (29.7-30.3)	0.4
Silty Clay With Sand	118	151.92	34.1	1.40E-07	10	2.68 B-10 (14.2-14.8)	0.43

Silty Sand	94	0	30	1.00E-04	5	2.66 B-10 (16.2- 16.8)	0.4
Fly Ash	115	0	25	4.75E-04	50	NA	NA

1. SEEPAGE ANALYSIS.

Geoslope Seep W analysis was used to analyze the model for seepage. Historic Field piezometer readings (Hydrogeologic Study Report, Clifty Creek Coal Ash Landfill, AGES. November 2006) were compared to the model's results. The model results were inconsistent with available piezometer readings. This was due to a lack of enough soil property data.

Water elevations used were:

- Existing (normal) water elevation in the pond: 485 feet.
- Ohio River water elevation 426 feet.

Seepage analysis results were not used in slope stability analyses.

2. STABILITY ANALYSIS.

Geoslope Slope W was used for the slope stability analysis.

The Spencer Analysis Method was used.

Slip circle method and siding wedge method were modeled by the circular failure plane and the block specified; the circular failure plane produced lower Factors of Safety.

The peak ground acceleration used for the seismic analysis was obtained from US Geological Survey website. The PGA used is 0.08g. The method selected to do the seismic analysis was the pseudostatic analysis per the project scope.

Loading conditions:

During a period from 2004 to 2006, groundwater readings from different piezometers and wells across the dam and toe area were taken. The results of these readings provide were used for steady state analysis. (Hydrogeologic Study Report, Clifty Creek Coal Ash Landfill, AGES. November 2006)

Static Slope Stability Loading Conditions:

- Steady state Seepage normal pool (upstream and downstream slopes): 485 feet
- PMF event (upstream and downstream slopes). The flood water was considered as a surcharge above the water pool for steady state. PMF event water elevation in the pond: 501.4 feet.

Seismic Slope Stability Loading Conditions:

- Steady state seepage normal pool (upstream and downstream slopes): 485 feet.

3. LIQUEFACTION ANALYSIS.

Research and methodology:

- Earthquake intensity: USGS website used to determine the Peak Ground Acceleration and earthquake intensity for an earthquake event of a mean return period of 2,475 years. $PGA = 0.07677g$ (used $0.08g$) and $M_L = 7.7$.
- Groundwater elevation data from 2004 through 2006 provide a steady state water elevation through the dam and the foundation soil materials. Unsaturated soil located above the groundwater table will not liquefy.
- Soil Type:

The dam soil materials, being constructed of engineered fill are not considered liquefiable.

Cohesionless materials are considered liquefiable. The majority of cohesive soils will not liquefy, cohesive soils susceptible to liquefy should have an liquid limit less than 37 and the water content of the soil must be greater than about 85% of the liquid limit.

Due to the absence of USCS classification laboratory results, cohesive foundation materials were considered potentially liquefiable and Factors of Safety against liquefaction were calculated.

- Soil relative density (D_r): Soils in a loose relative density state are susceptible to liquefaction. Soils with an SPT-N value of 30 or higher were considered not liquefiable.

Liquefaction Assessment

Data from nine historical borings (SI-1, SS1-1, SS2-1, SS2-4, SS3-1, SS3-4, SS4-1, SS4-4, and SS5-1) were used to assess liquefaction potential. These borings were drilled in 1984 as part of the AEP Fly Ash Dam Raising Feasibility Project (1985). Soil characteristics included on the borings include the visually-estimated soil classifications per the USCS and SPT N-values.

In order to analyze the dam and foundation materials against liquefaction, it was necessary to assume the percent fines, or percent silt and clay, for many of the soils due to lack of particle size distribution data for the historic borings. Correlating current laboratory classification results with historic logs was done and where data was not available, typical values were assumed based on the visual USCS classifications on the historical boring logs.

Method Used: Simplified Method based on using correlations to blow counts from Standard Penetration Tests (SPTs) as set forth in Youd et al (2001) and discussed in NRC (1985).

The Simplified Method requires estimating the Cyclic Stress Ratio (CSR) and Cyclic Resistance Ratio (CRR) of the soil. The CRR can be estimated using information from SPT tests, corrected to account for various effects. To use the Simplified Method, the SPT N value is normalized to an overburden pressure of approximately 100 kiloPascals (kPa) and a hammer energy ratio of 60% and procedural effects (rod length, sample configuration and borehole diameter).

The $(N_1)_{60}$ may also be corrected for the percent of fines using the relationship:

$$(N_1)_{60cs} = \alpha + \beta(N_1)_{60}$$

It is important to note that the fines correction is an approximation and is only valid for nonplastic fines and with a fines content between 0 and 35%. This correction factor, although widely used, is considered as a rough approximation only.

Once the corrected value for $(N_1)_{60}$ is found, the CRR is calculated as:

$$CRR_{7.5} = \frac{1}{34 - (N_1)_{60}} + \frac{(N_1)_{60}}{135} + \frac{50}{[10 * (N_1)_{60} + 45]^2} - \frac{1}{200}$$

Note that the value calculated is the CRR normalized to a 7.5 magnitude earthquake, hence the $CRR_{7.5}$ notation. When evaluating the liquefaction potential of soil, the $CRR_{7.5}$ must be corrected to the magnitude earthquake of interest.

The CSR is independent of soil properties and may be approximated using the equation:

$$CSR = 0.65 \left(\frac{a_{max}}{g} \right) \left(\frac{\sigma_v}{\sigma'_v} \right) r_d$$

where:

a_{max} is the maximum ground acceleration.

g is the acceleration of gravity.

σ_v is the total vertical stress.

σ'_v is the effective vertical stress.

r_d is a stress reduction coefficient.

Liquefaction potential for a soil unit is evaluated by dividing $CRR_{7.5}$ by CSR and then correcting to the magnitude earthquake of interest, as:

$$FS = \frac{CRR_{7.5}}{CSR} * MSF$$

Field experience has shown that the Simplified Method is somewhat conservative; so many designers consider FS values close to unity as an indication of no liquefaction.

SI-1

Elevation	Depth	Soil class	N	Remarks
452.8	3.75	SC	16	Not liquefiable, above ground water.
447.8	8.75	SC	13	
442.8	13.75	ML	8	
437.8	18.75	ML	5	Evaluated for liquefaction
432.8	23.75	ML	9	
427.8	28.75	SC	23	
422.8	33.75	SC	24	
417.8	38.75	SM	22	
412.8	43.75	ML	18	
407.8	48.75	ML	28	
402.8	53.75	ML	22	
397.8	58.75	ML	12	
392.8	63.75	ML	9	
387.8	68.75	ML	14	
382.8	73.75	ML	21	
377.8	78.75	ML	50	

SS1-1

Elevation	Depth	Soil class	N-field	Remarks
502.3	3.25	CL	17	Not liquefiable Embankment as layer is above ground water
497.3	8.25	CL	12	
492.3	13.25	CL	17	
487.3	18.25	CL	15	
482.3	23.25	CL-ML	17	
477.3	28.25	CL	15	
472.3	33.25	CL	21	
467.3	38.25	CL	23	
462.3	43.25	ML	30	
457.3	48.25	ML	24	
452.3	53.25	CL	23	Evaluated for liquefaction
447.3	58.25	CL	35	
442.3	63.25	CL	27	
437.3	68.25	SC	8	
432.3	73.25	CL	20	
427.3	78.25	CL	24	
422.3	83.25	CL	30	
417.3	88.25	SC	46	

SS2-1

Elevation	Depth	Soil class	N-field	Remarks
500.7	3.75	CL	10	Not liquefiable. Embankment and located above ground water
495.7	8.75	CL	12	
490.7	13.75	CL	13	
485.7	18.75	CL-ML	26	
480.7	23.75	CL	14	
475.7	28.75	CL	17	
470.7	33.75	CL	24	
465.7	38.75	CL	25	
460.7	43.75	CL	13	
455.7	48.75	CL	14		Evaluated for liquefaction
450.7	53.75	CL	24	
445.7	58.75	CL	26	
440.7	63.75	ML	26	
435.7	68.75	CL	13	
430.7	73.75	SM	12	
425.7	78.75	SM	43	
420.7	83.75	SM	28	
415.7	88.75	CL	22	
410.7	93.75	CL	29	

SS2-4

Elevation	Depth	Soil class	N-field	Remarks
436.6	3.25	CL	13	Evaluated for liquefaction
431.6	8.25	CL	12	
426.6	13.25	CL	8	
421.6	18.25	SM	12	
416.6	23.25	CL	6	
411.6	28.25	CL	17	
406.6	33.25	CL	17	
401.6	38.25	CL	15	
396.6	43.25	CL	11	
391.6	48.25	CL	12	
386.6	53.25	CL	13	
381.6	58.25	CL	19	
376.6	63.25	GC	22	

SS3-1

Elevation	Depth	Soil class	N-field	Remarks
501.2	3.25	CL	11	Not liquefiable.
496.2	8.25	CL-ML	12	
491.2	13.25	CL	22	
486.2	18.25	ML	17	
481.2	23.25	CL	22	Embankment and located above ground water
476.2	28.25	SC	27	
471.2	33.25	CL	10	Evaluated for liquefaction
466.2	38.25	ML	15	
461.2	43.25	ML	22	
456.2	48.25	SP	24	
451.2	53.25	SC	33	
446.2	58.25	SP	17	
441.2	63.25	SP	20	
436.2	68.25	SM	25	
431.2	73.25	SP	14	
426.2	78.25	SP	37	
421.2	83.25	SP	28	
416.2	88.25	SM	29	
411.2	93.25	SM	28	
406.2	98.25	CL	29	

SS3-4

Elevation	Depth	Soil class	N-field	Remarks
448.1	3.75	CL	10	Not liquefiable, above ground water
443.1	8.75	CL	11	
438.1	13.75	SM	5	Evaluated for liquefaction
433.1	18.75	SM	7	
428.1	23.75	SC	2	
423.1	28.75	ML	11	
418.1	33.75	ML	9	
413.1	38.75	CL	2	
408.1	43.75	CL	19	
403.1	48.75	CL	22	
398.1	53.75	CL	15	
393.1	58.75	CL	16	
388.1	63.75	CL	19	
383.1	68.75	CL	21	
378.1	73.75	CL	20	
373.1	78.75	CL	34	

SS4-1

Elevation	Depth	Soil class	N-field	Remarks
502.4	3.25	CL	5	Not liquefiable. Embankment and above ground water
497.4	8.25	ML	23	
492.4	13.25	CL	13	
487.4	18.25	CL	24	
482.4	23.25	CL	17	
477.4	28.25	CL	19	
472.4	33.25	CL	20	
467.4	38.25	CL	16	Evaluated for liquefaction
462.4	43.25	ML	17	
457.4	48.25	SM	11	
452.4	53.25	SM	23	
447.4	58.25	SM	18	
442.4	63.25	SM	24	
437.4	68.25	CL	26	
432.4	73.25	SC	5	
427.4	78.25	ML	22	
422.4	83.25	ML	29	
417.4	88.25	ML	30	
412.4	93.25	ML	30	

SS4-4

Elevation	Depth	Soil class	N-field	Remarks
447.0	3.75	CL	13	Not liquefiable, above ground water
442.0	8.75	CL	7	
437.0	13.75	SM	2	Evaluated for liquefaction
432.0	18.75	CL	4	
427.0	23.75	GC	50	
422.0	28.75	GC	29	

SS5-1

Elevation	Depth	Soil class	N-field	Remarks
501.6	3.25	CL	8	Not liquefiable, Embankment and above ground water
496.6	8.25	CL	20	
491.6	13.25	CL	20	
486.6	18.25	SC	22	
481.6	23.25	SM	25	
476.6	28.25	SM	50	N-values more than 30.
471.6	33.25	SM	50	
466.6	38.25	SM	50	

TABLE 1
Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression		Typical Strength Characteristics				Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
				At 1.4 tsf (20 psf)	At 3.6 tsf (50 psf)	Cohesion (as compacted) paf	Cohesion (saturated) paf	ϕ (Effective Stress Envelope Degree)	Tan ϕ			
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GN	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-4}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$5 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MI	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-7}$	10 or less	50 - 100
CI	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

- All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
- Typical strength characteristics are for effective strength envelopes and are obtained from USSR data.
- Compression values are for vertical loading with complete lateral confinement.
- (>) indicates that typical property is greater than the value shown.
(..) indicates insufficient data available for an estimate.

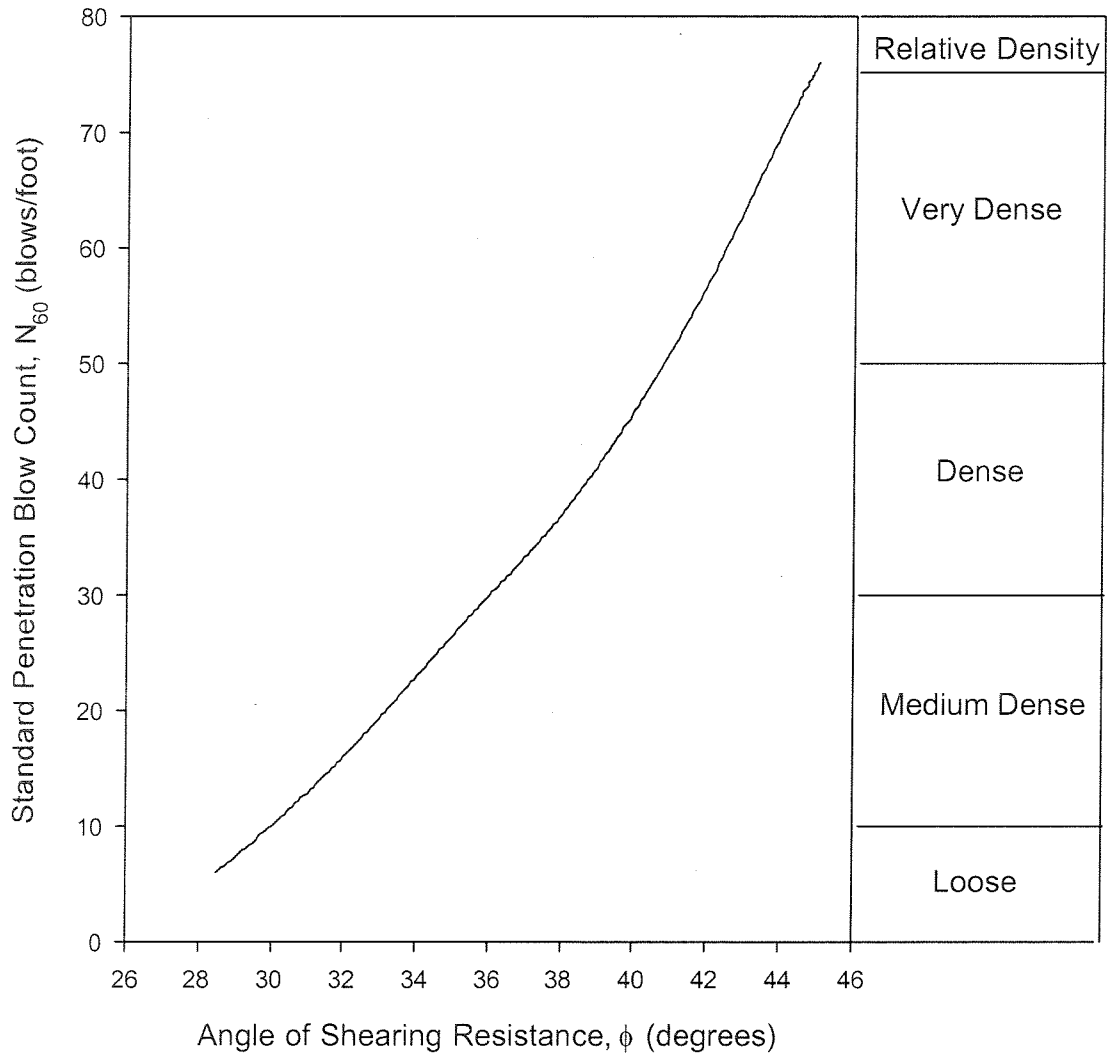


Figure 35. Estimation of the angle of shearing resistance of granular soils from standard penetration test results (Originally from Peck et al., 1974, modified by Carter and Bentley, 1991).

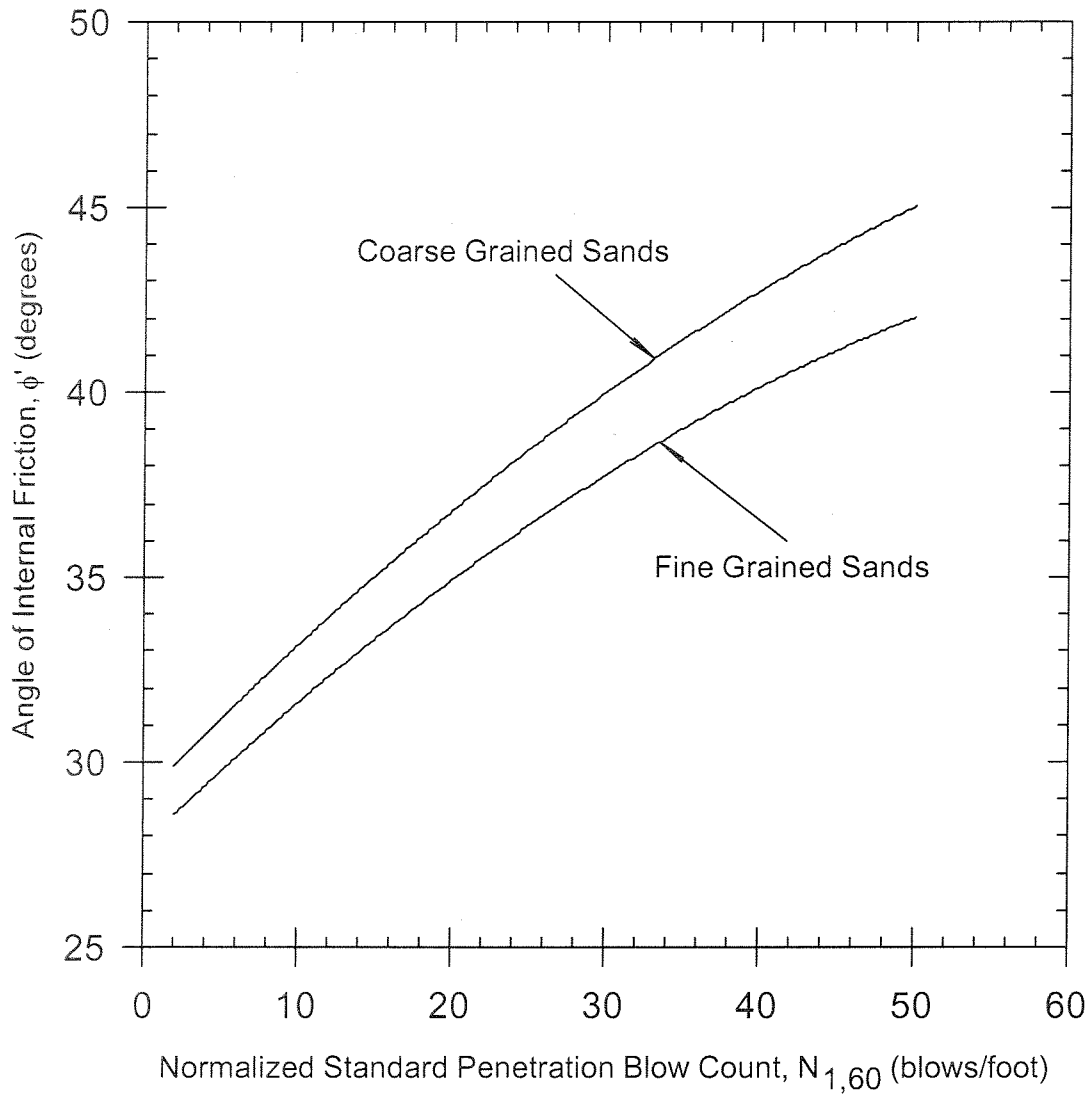
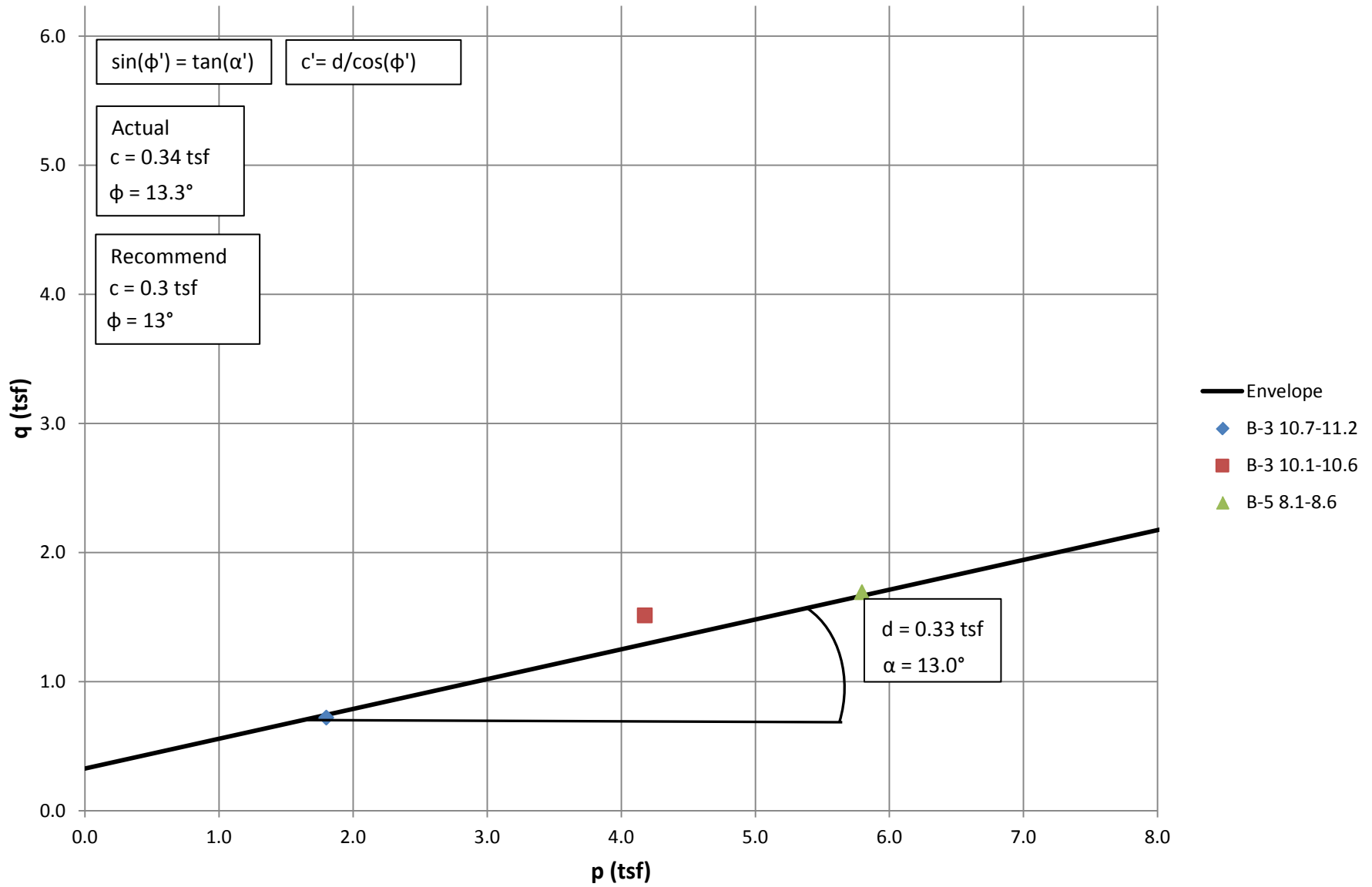


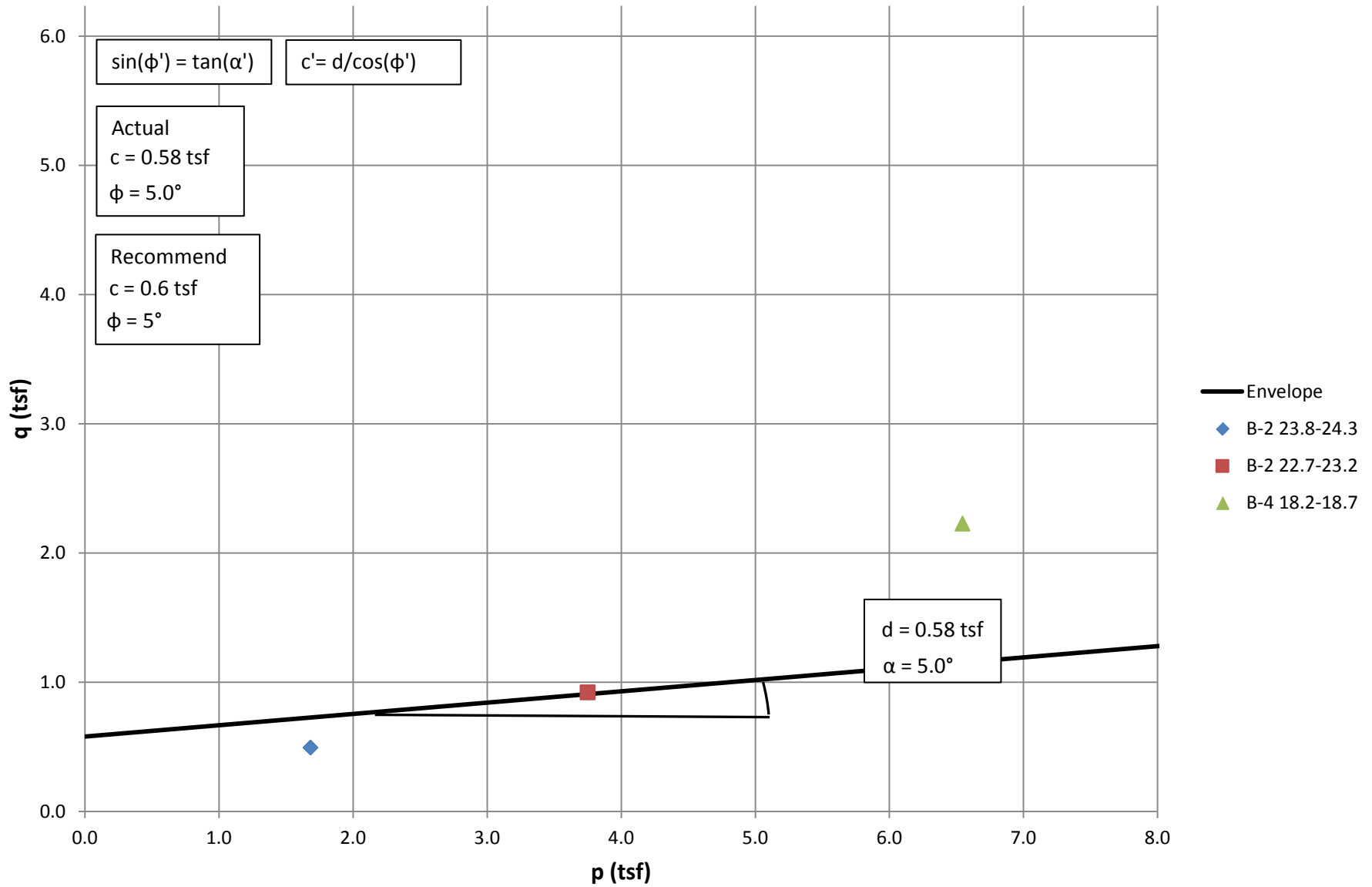
Figure 34. Empirical correlation between friction angle of sands and normalized standard penetration blow count (after Terzaghi et al., 1996)

UNDRAINED CALCULATIONS: BOILER SLAG POND DAM

Embankment Fill (Clifty Creek Boiler Slag Pond Dam) Total Stress Failure Points from CU Triaxial Tests



Lean Clay with Sand (Clifty Creek Boiler Slag Pond Dam) Total Stress Failure Points from CU Triaxial Tests



PLANT: CLIFTY CREEK

FACILITY: BOILER SLAG POND DAM

MATERIAL: EMBANKMENT FILL

$\sigma_1 - \sigma_3$ (plot) (psi)	σ_3' (lab request) (psi)	σ_1' (psi)	u (plot) (psi)	σ_1 (psi)	σ_3 (psi)
20	10	30	5	35	15
42	20	62	17	79	37
47	30	77	27	104	57

MATERIAL: LEAN CLAY w/ SAND

$\sigma_1 - \sigma_3$ (plot) (psi)	σ_3' (lab request) (psi)	σ_1' (psi)	u (plot) (psi)	σ_1 (psi)	σ_3 (psi)
14	10	24	7	31	17
26	20	46	19	65	39
62	30	92	30	122	60

CALCULATED BY: J. SWINGLE



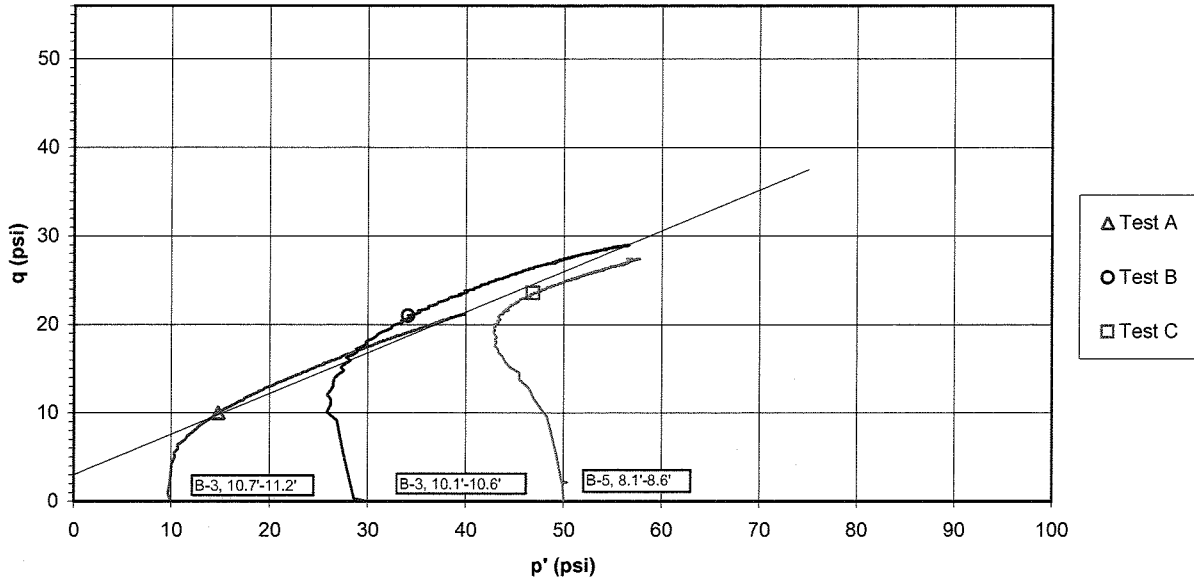
**Consolidated Undrained Triaxial Test
ASTM D4767-04**

Project AEP-Clifty Creek-West Bottom and Fly Ash Ponds subsurface exploration
 Sample ID B-3, 10.7'-11.2' & B-3, 10.1'-10.6' & B-5, 8.1'-8.6'

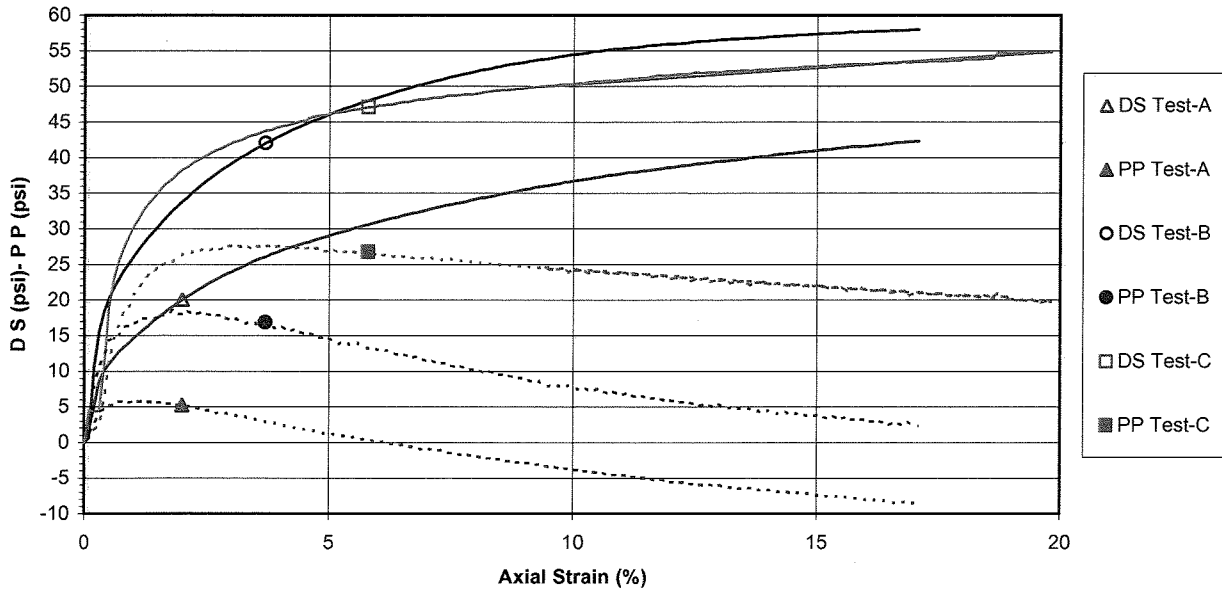
Project No. 175539022
 Test Number 1

$\phi' = 27.4 \text{ deg.}$
 $c' = 490 \text{ psf}$
 Failure Criterion: Maximum Effective Principal Stress Ratio

p' vs. q Plot



Deviator Stress and Induced Pore Pressure vs. Axial Strain





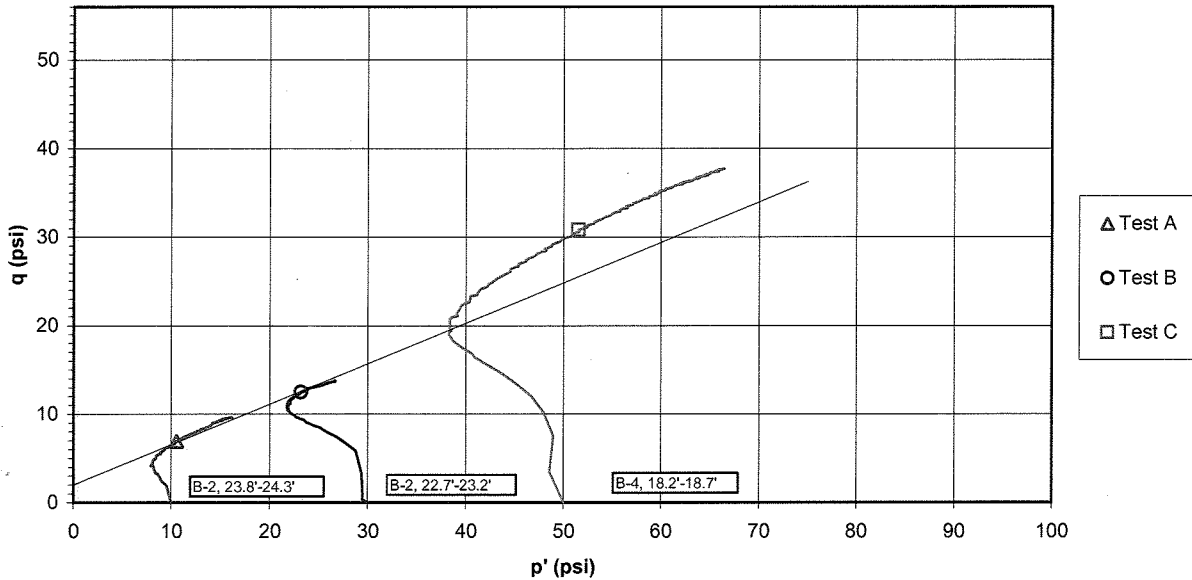
**Consolidated Undrained Triaxial Test
ASTM D4767-04**

Project AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration
 Sample ID B-2, 23.8'-24.3' & B-2, 22.7'-23.2' & B-4, 18.2'-18.7'

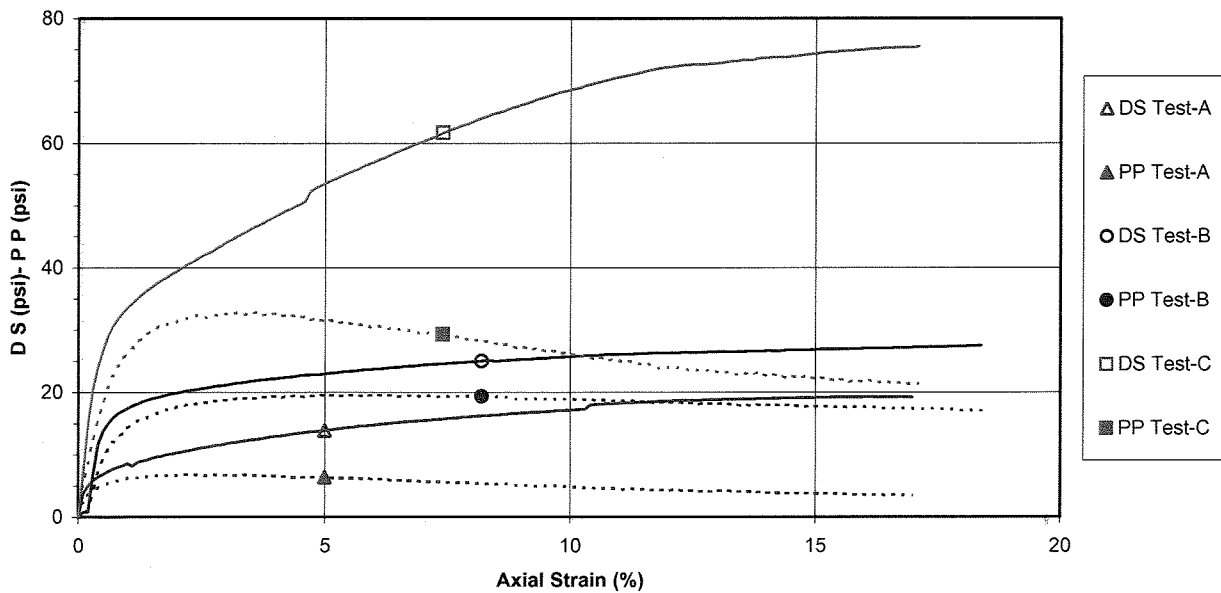
Project No. 175539022
 Test Number 2

$\phi' = 27.2 \text{ deg.}$
 $c' = 320 \text{ psf}$
 Failure Criterion: Maximum Effective Principal Stress Ratio

p' vs. q Plot

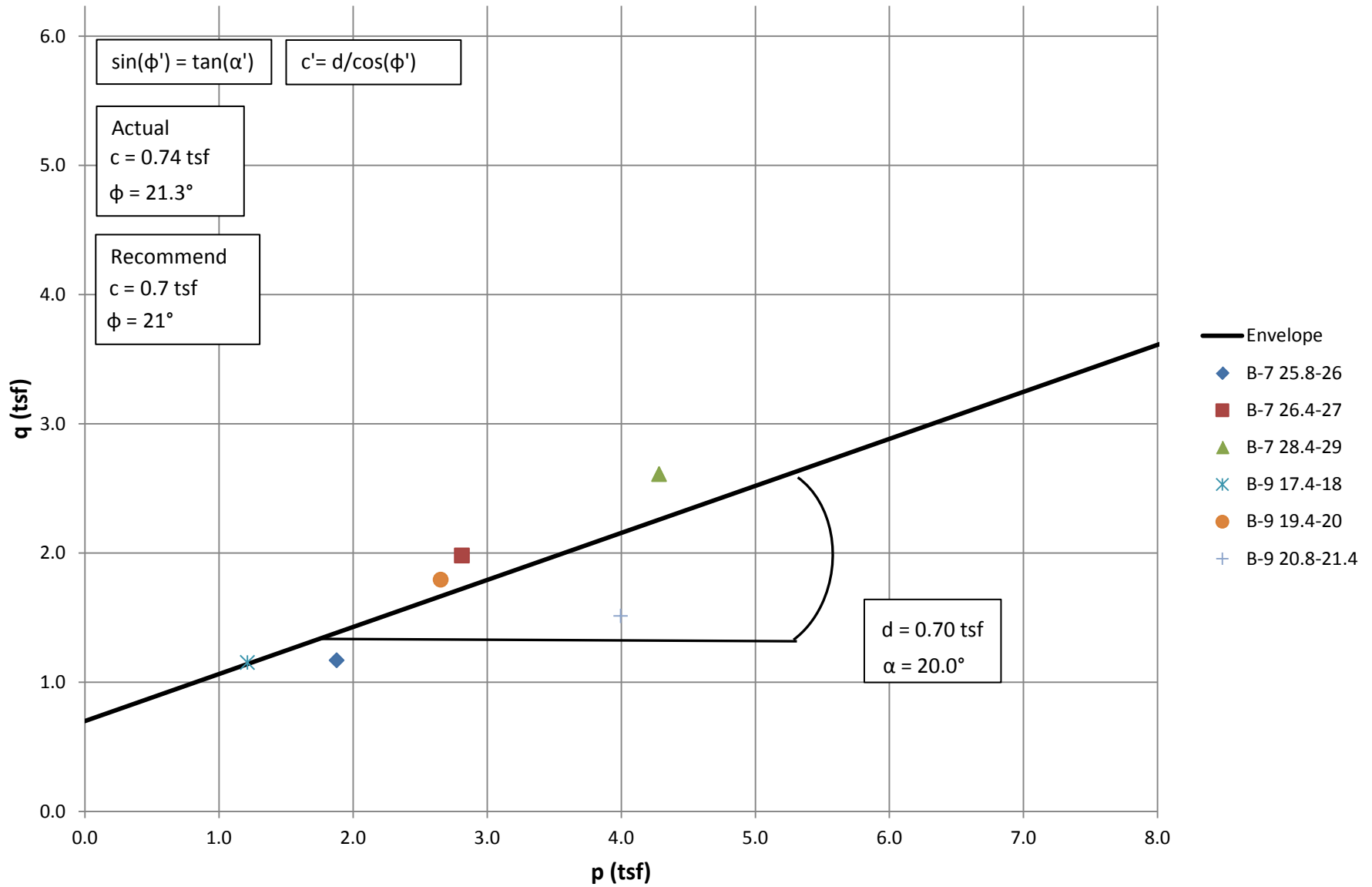


Deviator Stress and Induced Pore Pressure vs. Axial Strain

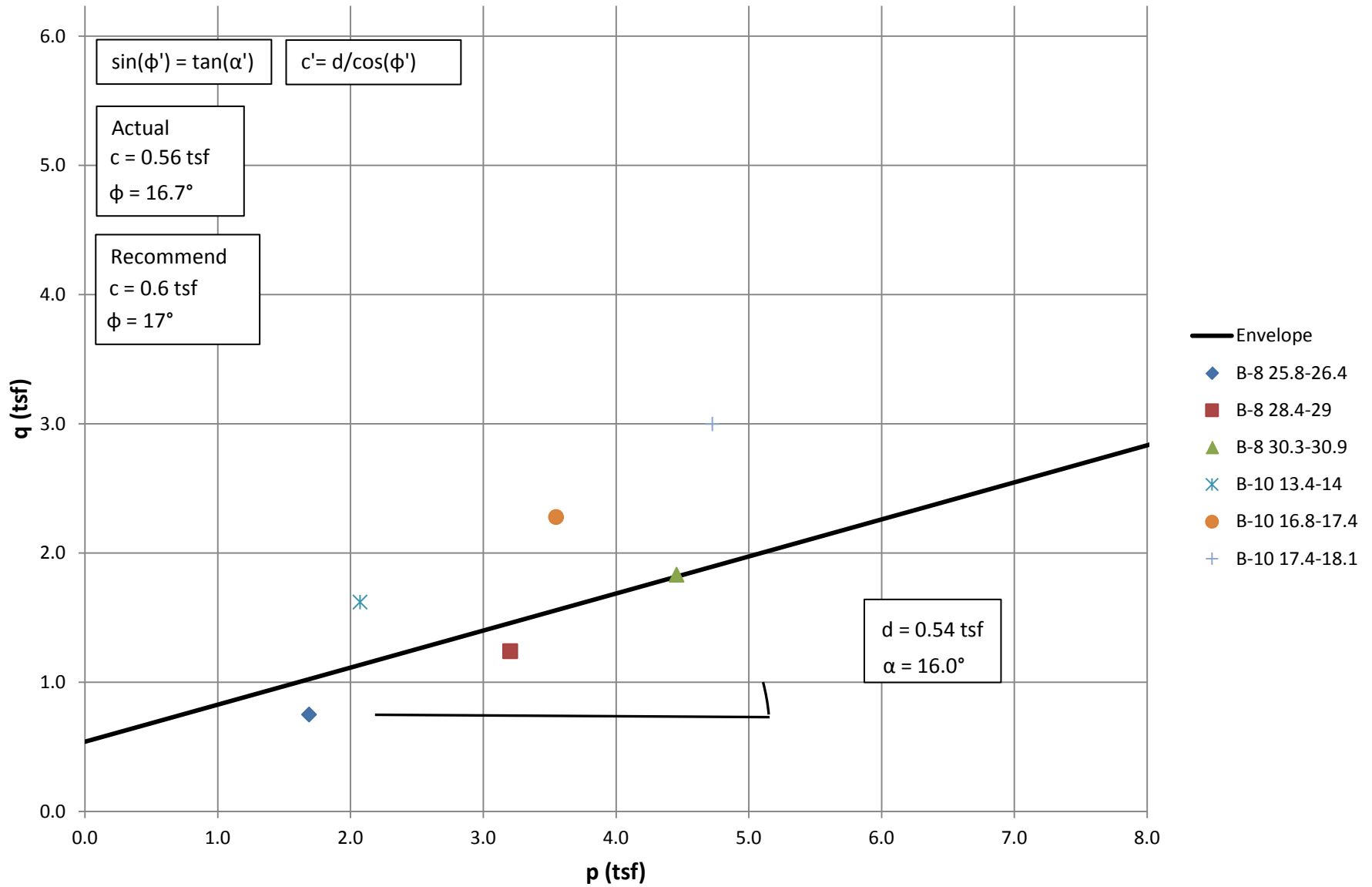


UNDRAINED CALCULATIONS: LANDFILL RUNOFF COLLECTION POND

Embankment Fill (Clifty Creek Fly Ash Pond Dam) Total Stress Failure Points from CU Triaxial Tests



Lean Clay with Sand (Clifty Creek Fly Ash Pond Dam) Total Stress Failure Points from CU Triaxial Tests



PLANT: CLIFTY CREEK

FACILITY: LANDFILL RUNOFF COLLECTION POND

MATERIAL: EMBANKMENT

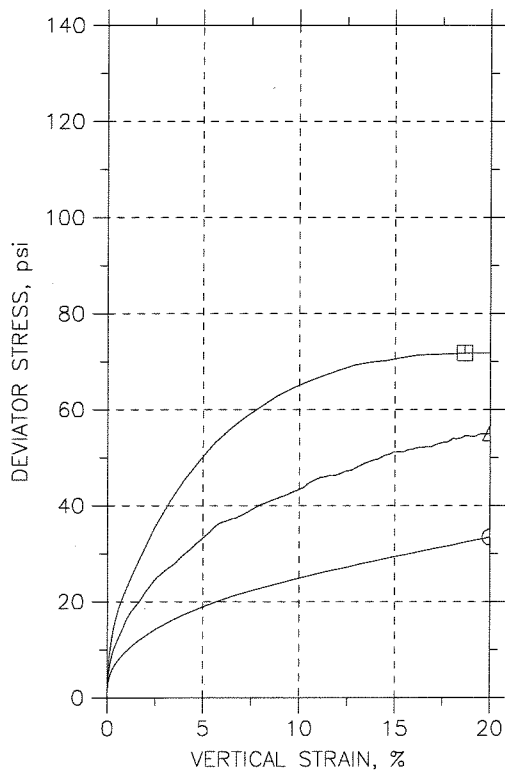
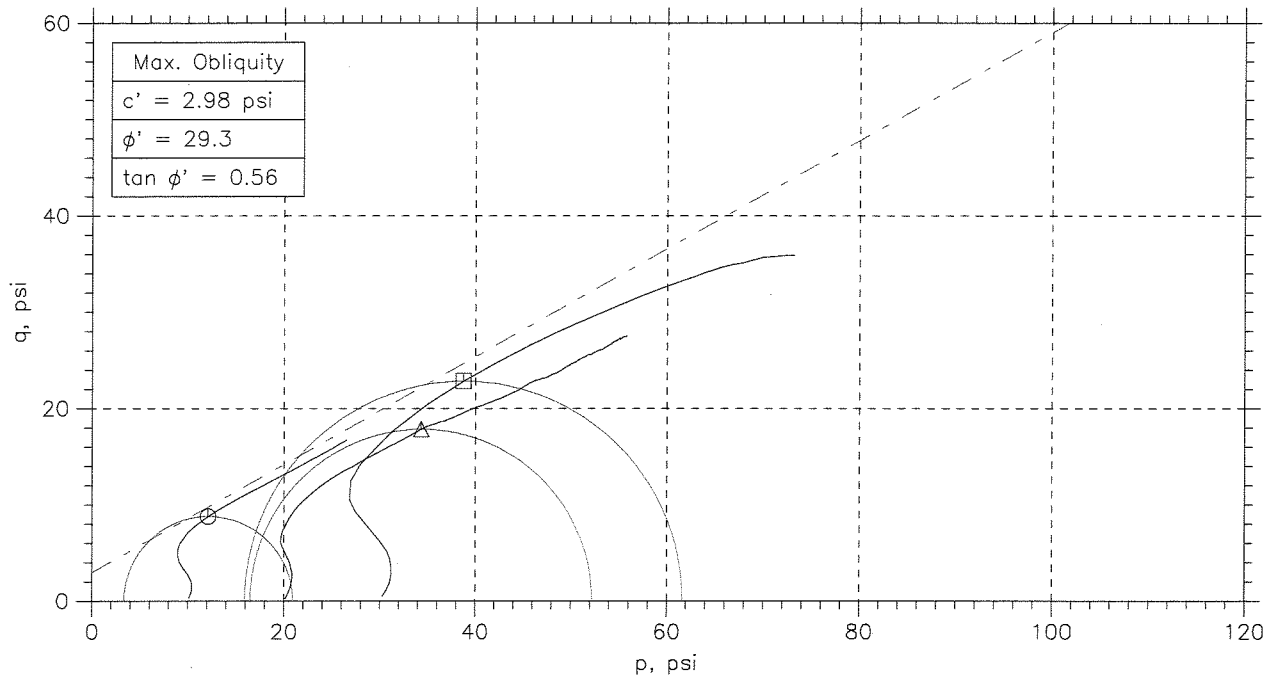
	$\sigma_1' - \sigma_3'$ (plot) (psi)	σ_3' (table) (psi)	σ_1' (psi)	u (plot) (psi)	σ_1 (psi)	σ_3 (psi)
B-7	32.50	9.83	42.33	0.00	42.33	9.83
B-7	55.00	19.88	74.88	-8.33	66.55	11.55
B-7	72.50	29.80	102.30	-6.57	95.73	23.23
B-9	32.00	10.00	42.00	-9.15	32.85	0.85
B-9	49.81	19.96	69.77	-8.00	61.77	11.96
B-9	42.00	29.88	71.88	4.62	76.50	34.50

MATERIAL: LEAN CLAY WITH SAND

	$\sigma_1' - \sigma_3'$ (plot) (psi)	σ_3' (table) (psi)	σ_1' (psi)	u (plot) (psi)	σ_1 (psi)	σ_3 (psi)
B-8	20.84	9.97	30.81	3.05	33.86	13.02
B-8	34.42	19.98	54.42	7.30	61.72	27.28
B-8	50.88	29.96	80.84	6.50	87.34	36.46
B-10	45.00	10.00	55.00	-3.72	51.28	6.28
B-10	63.26	19.99	83.25	-2.33	80.92	17.66
B-10	83.26	30.00	113.26	-6.00	107.26	24.00

CALCULATED BY: J. SWINDLER

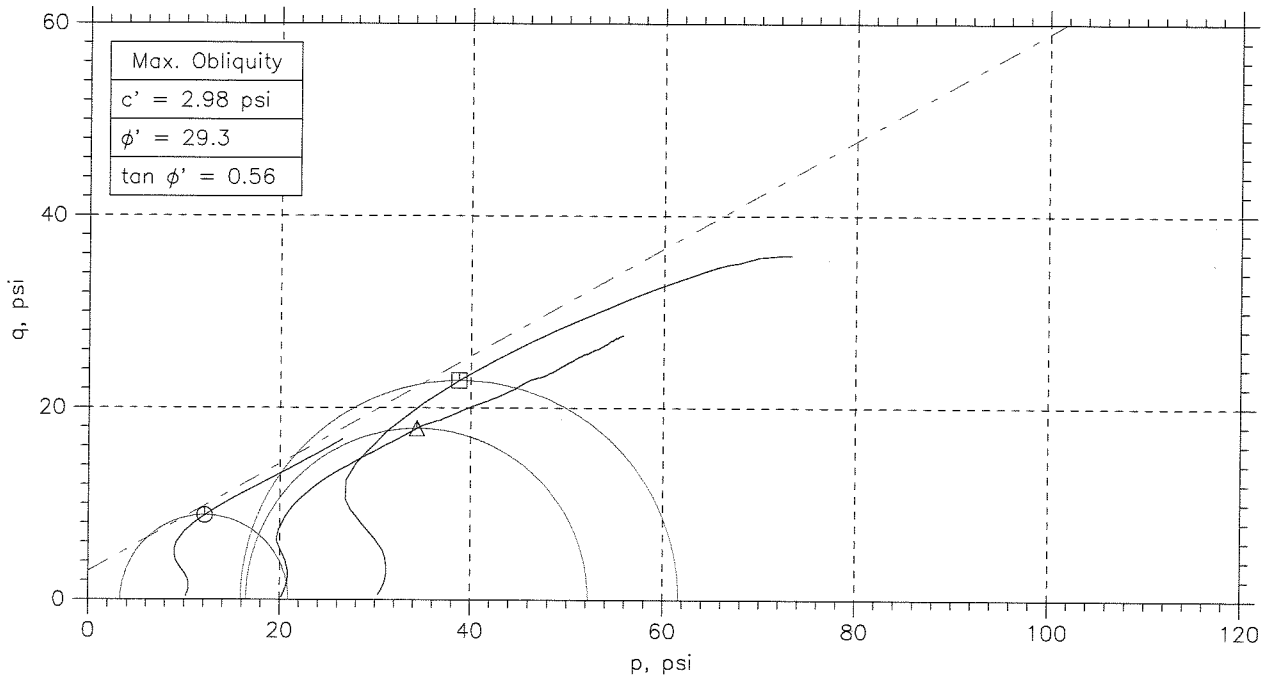
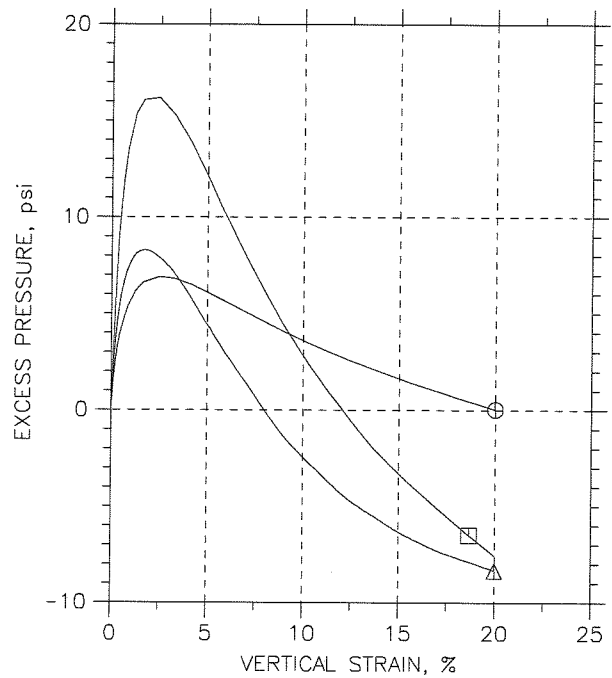
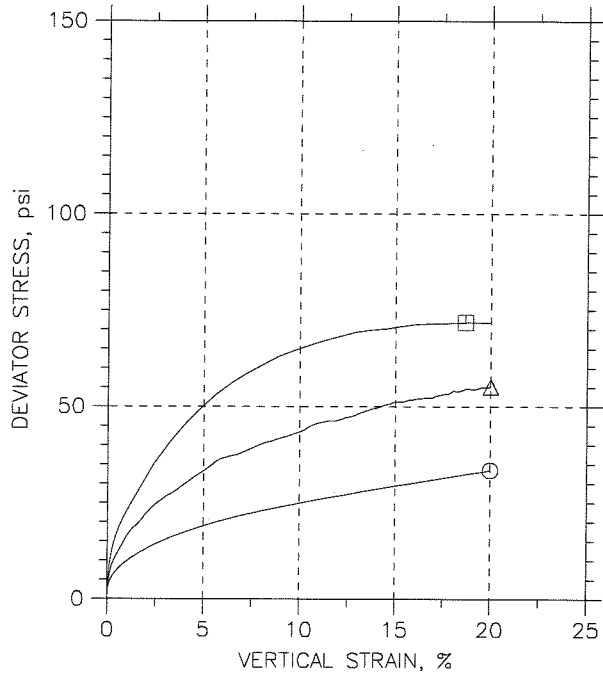
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



Symbol	○	△	□	
Sample No.	---	---	---	
Test No.	1.1	1.2	1.3	
Depth	25.8-26.0	26.4-27.0	28.4-29.0	
Initial	Diameter, in	2.835	2.834	2.832
	Height, in	6.314	5.928	5.929
	Water Content, %	20.2	21.0	19.0
	Dry Density, pcf	109.	107.5	111.3
	Saturation, %	99.8	99.6	99.7
	Void Ratio	0.546	0.568	0.515
Before Shear	Water Content, %	21.0	21.6	19.1
	Dry Density, pcf	107.7	106.5	111.2
	Saturation*, %	100.0	100.0	100.0
	Void Ratio	0.566	0.583	0.515
Back Press., psi	137.2	125.1	116.2	
Ver. Eff. Cons. Stress, psi	9.834	19.88	29.8	
Shear Strength, psi	16.74	27.57	35.9	
Strain at Failure, %	20	20	18.7	
Strain Rate, %/min	0.08	0.08	0.08	
B-Value	0.96	0.95	0.95	
Estimated Specific Gravity	2.7	2.7	2.7	
Liquid Limit	---	---	---	
Plastic Limit	---	---	---	

GeoTesting express <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek				
	Location: Jefferson, IN				
	Project No.: GTX-1516				
	Boring No.: B-7				
	Sample Type: UD				
	Description: Light Brown				
Remarks: System 1062					

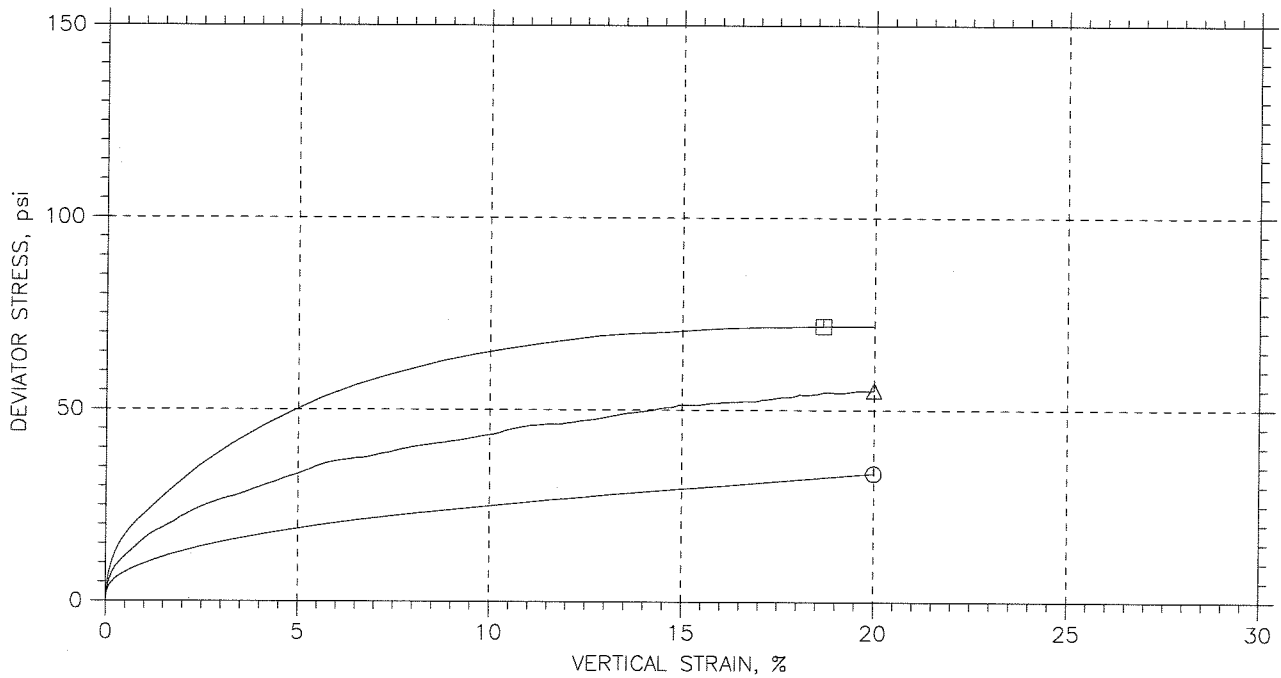
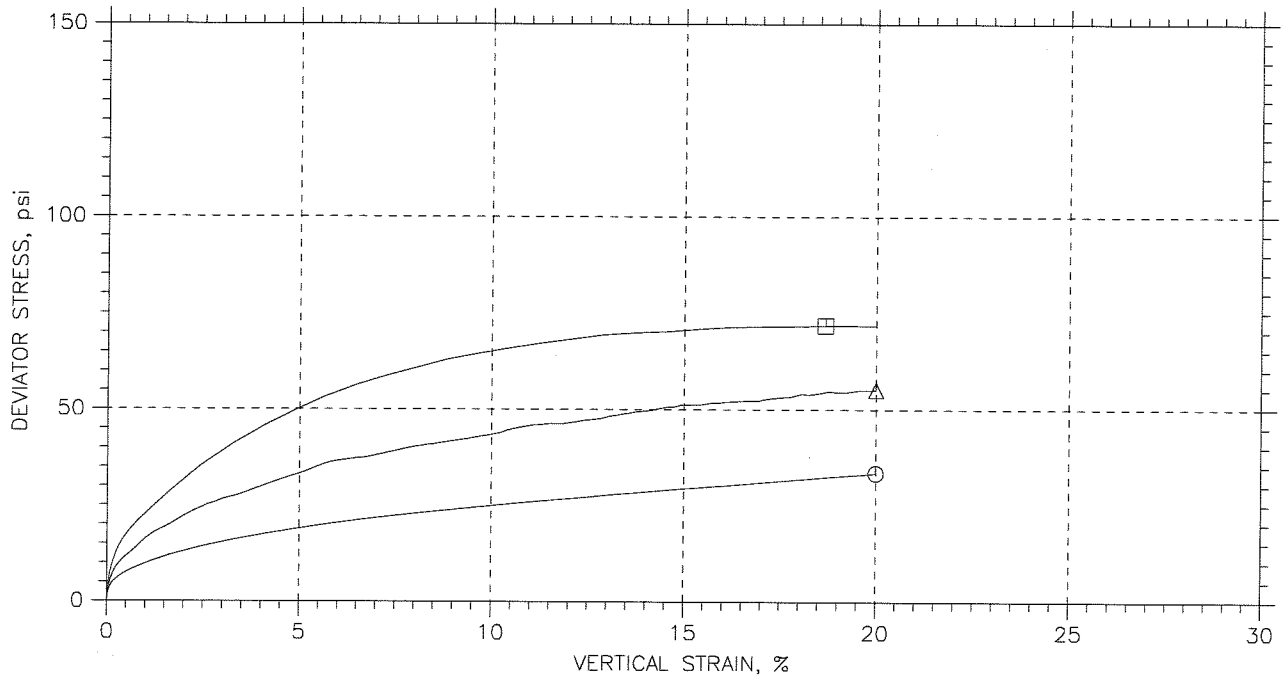
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○ ---	1.1	25.8-26.0	jm	12/10/09	mm		1516-1.1.dat
△ ---	1.2	26.4-27.0	jm	12/10/09	mm		1516-1.2.dat
□ ---	1.3	28.4-29.0	jm	12/9/09	mm		1516-1.3.dat

GeoTesting express <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek		Location: Jefferson, IN		Project No.: GTX-1516	
	Boring No.: B-7		Sample Type: UD			
	Description: Light Brown					
	Remarks: System 1062					

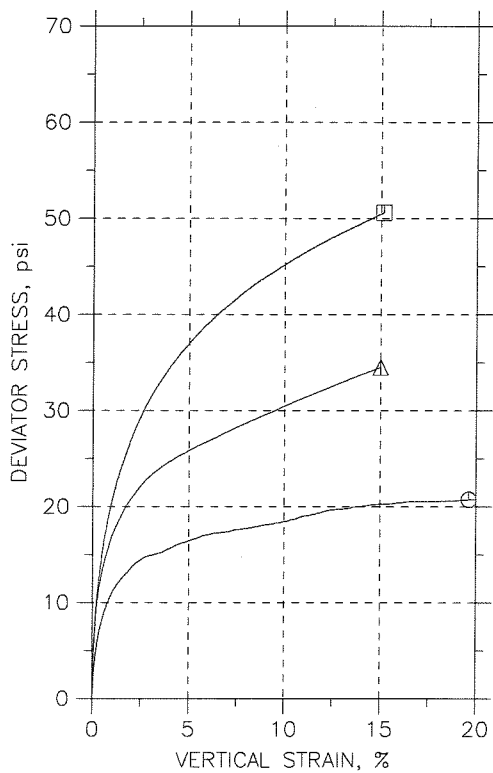
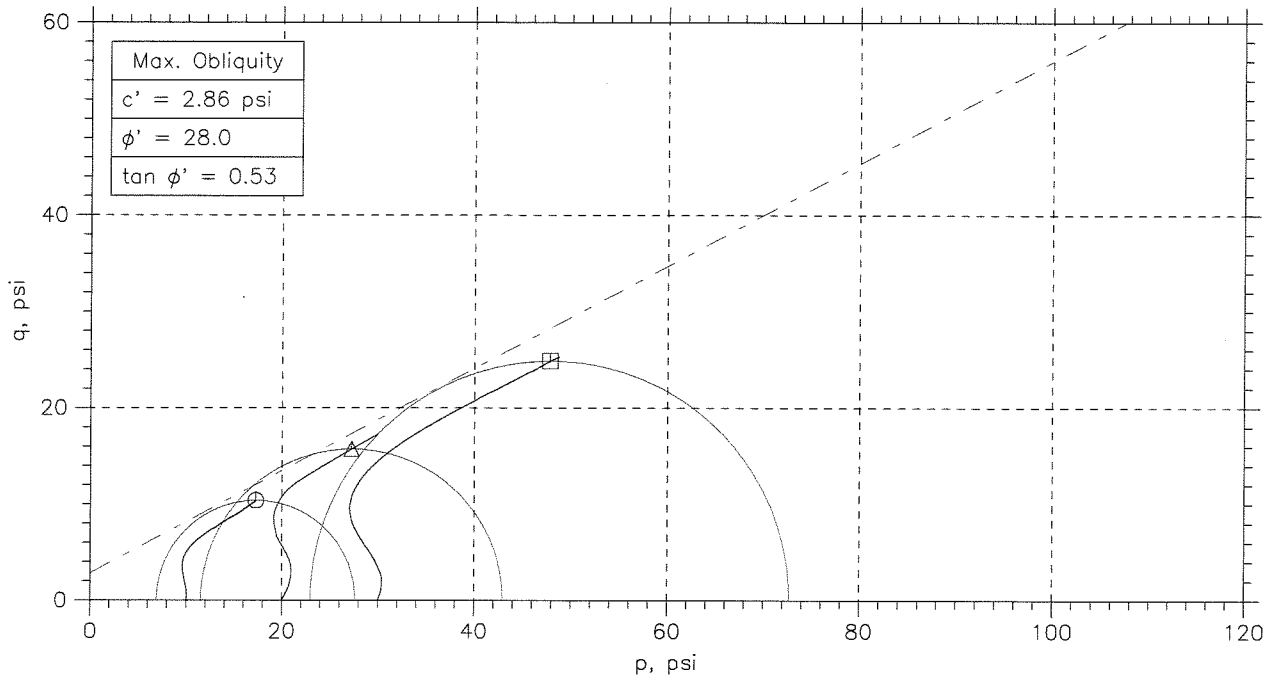
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



Symbol	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	---	1.1	25.8-26.0	jm	12/10/09	mm		1516-1.1.dat
△	---	1.2	26.4-27.0	jm	12/10/09	mm		1516-1.2.dat
□	---	1.3	28.4-29.0	jm	12/9/09	mm		1516-1.3.dat

GeoTesting express <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek		Location: Jefferson, IN		Project No.: GTX-1516	
	Boring No.: B-7		Sample Type: UD			
	Description: Light Brown					
	Remarks: System 1062					

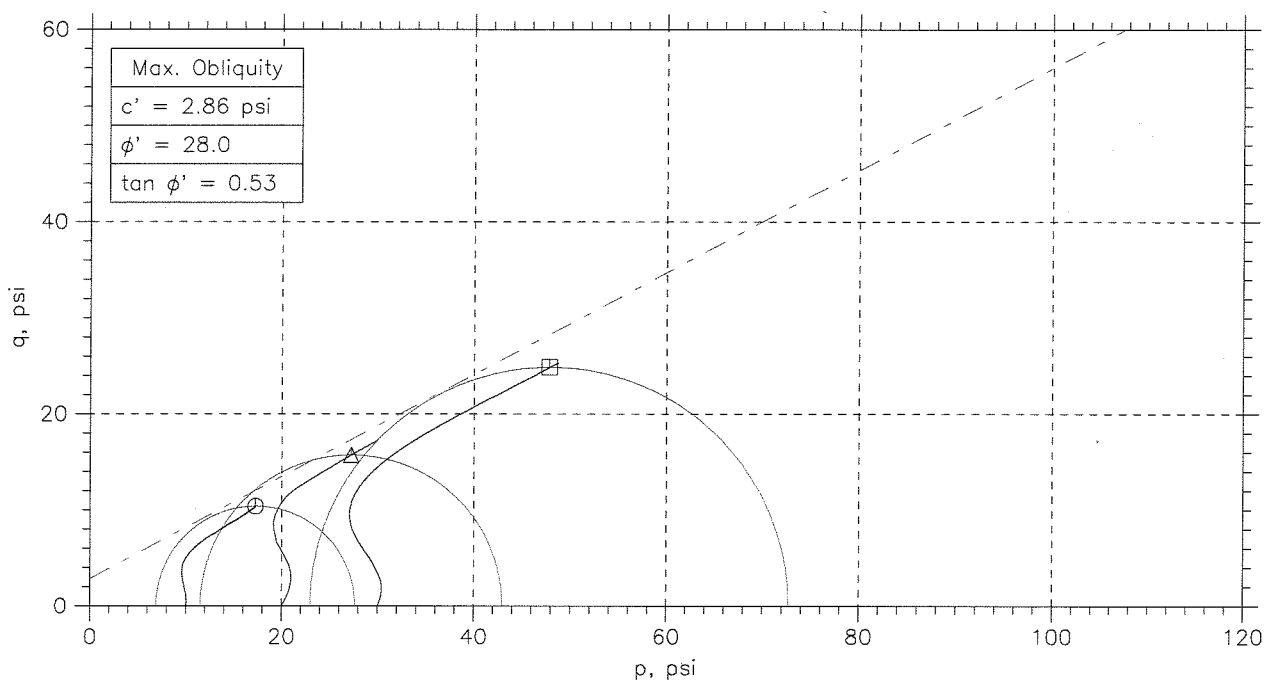
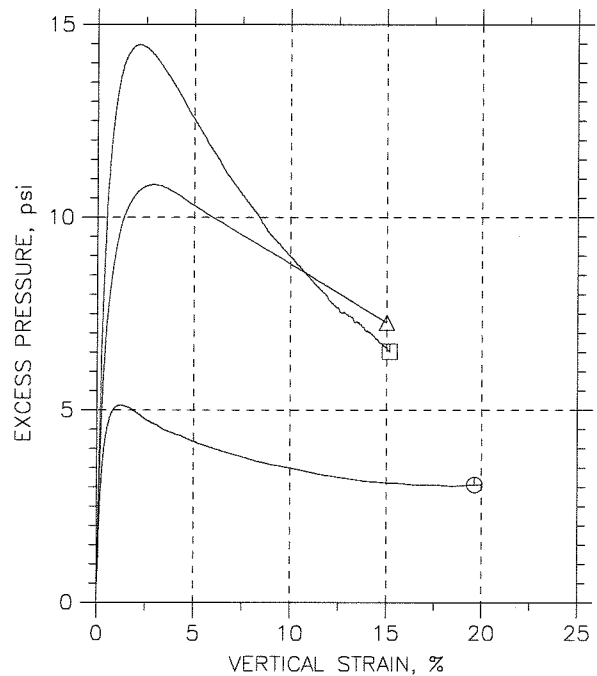
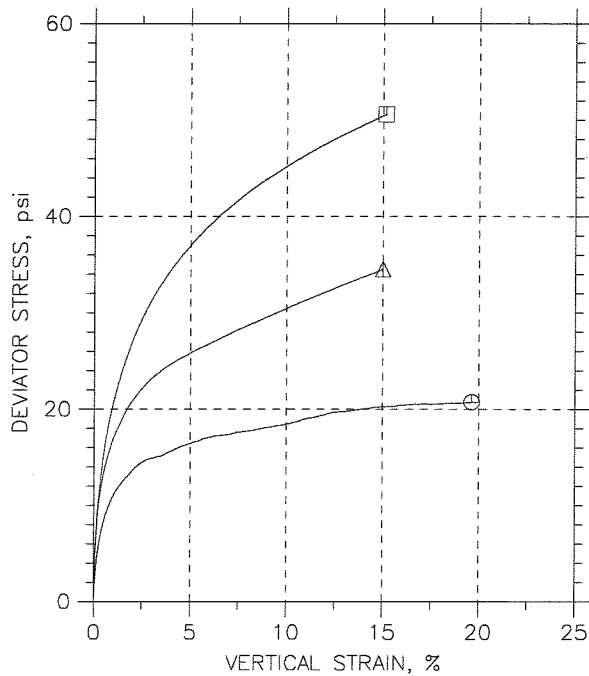
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



Symbol	⊙	△	□	
Sample No.	---	---	---	
Test No.	2.1	2.2	2.3	
Depth	25.8-26.4	28.4-29.0	30.3-30.9	
Initial	Diameter, in	2.82	2.824	2.838
	Height, in	5.82	6.027	6.001
	Water Content, %	21.0	20.7	20.9
	Dry Density, pcf	107.2	107.6	107.6
	Saturation, %	99.2	98.7	99.6
	Void Ratio	0.572	0.567	0.567
Before Shear	Water Content, %	20.5	19.8	19.0
	Dry Density, pcf	108.5	109.8	111.4
	Saturation*, %	100.0	100.0	100.0
	Void Ratio	0.554	0.535	0.513
Back Press., psi	59.25	124.8	56.31	
Ver. Eff. Cons. Stress, psi	9.968	19.98	29.96	
Shear Strength, psi	10.37	17.25	25.3	
Strain at Failure, %	19.6	15	15.2	
Strain Rate, %/min	0.016	0.016	0.016	
B-Value	0.95	0.96	0.95	
Estimated Specific Gravity	2.7	2.7	2.7	
Liquid Limit	---	---	---	
Plastic Limit	---	---	---	

GeoTesting express <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek			
	Location: Jefferson, IN.			
	Project No.: GTX-1516			
	Boring No.: B-8			
	Sample Type: UD			
	Description: Greenish brown lean clay with sand			
Remarks: 2054				

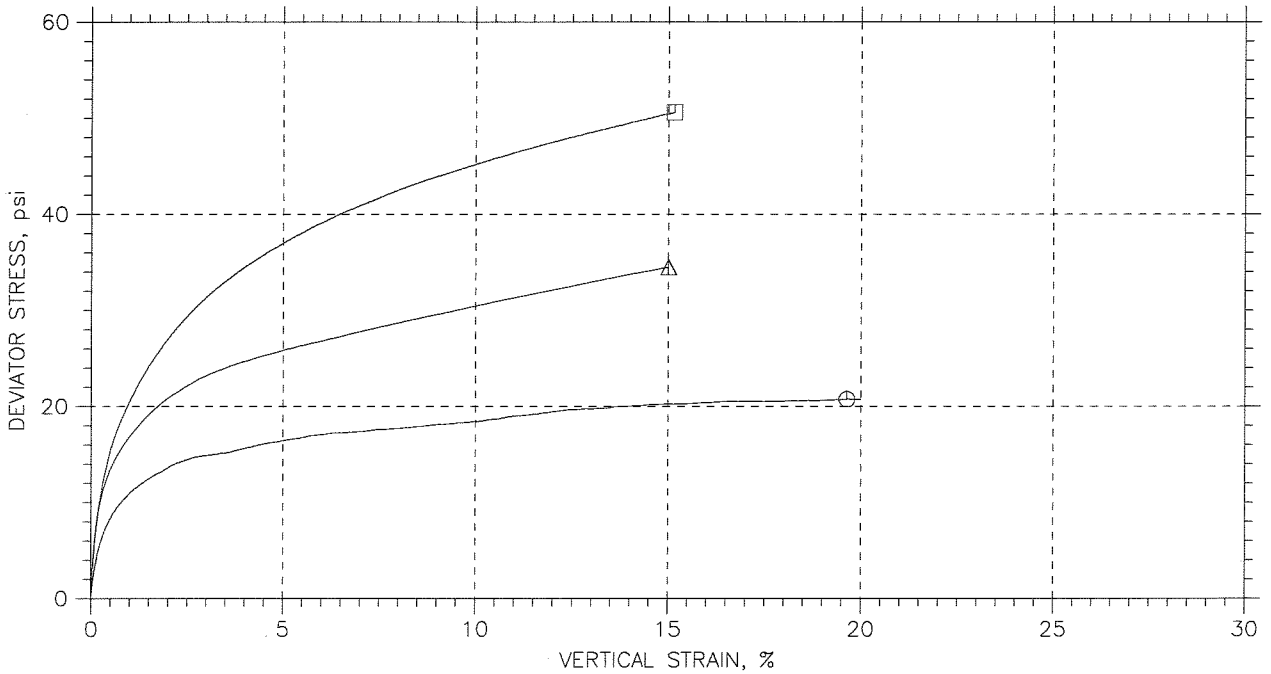
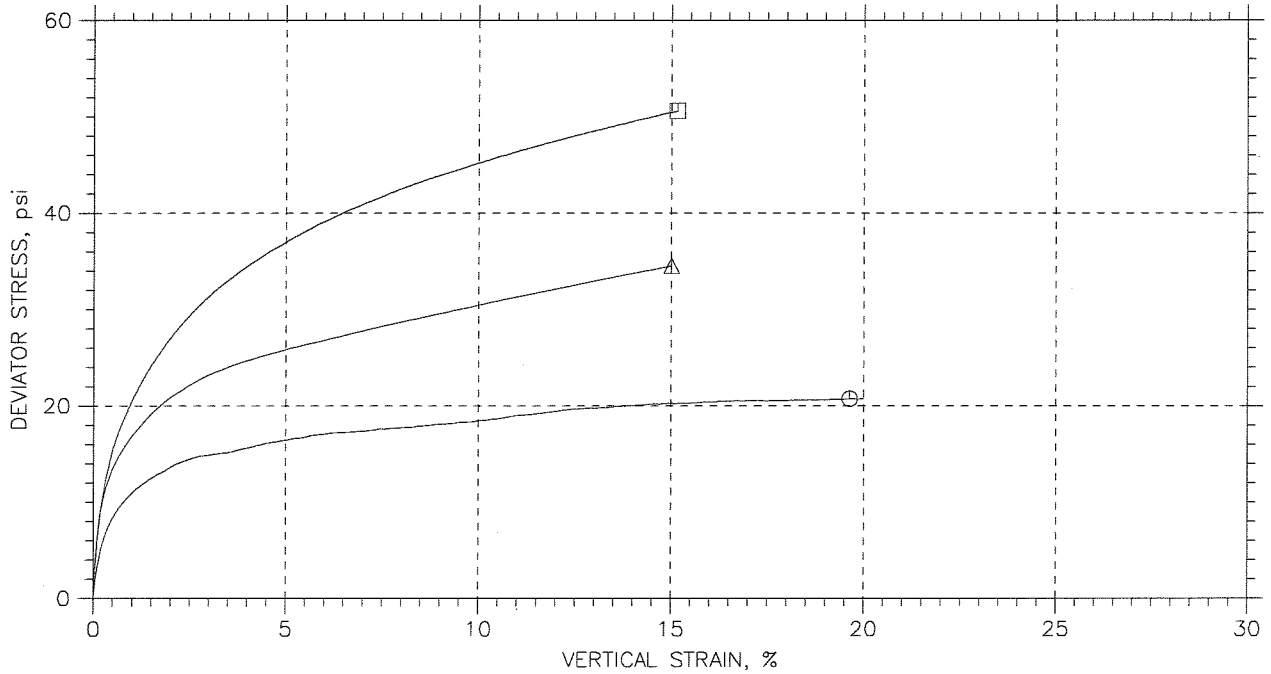
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	2.1	25.8-26.4	jm	12/11/09	mm		1516-2.1.dat
△	---	2.2	28.4-29.0	jm	12/11/09	mm		1516-2.2A.dat
□	---	2.3	30.3-30.9'	jm	12/09/09	mm		1516-2.3.dat

GeoTesting express <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek		Location: Jefferson, IN.		Project No.: GTX-1516	
	Boring No.: B-8		Sample Type: UD			
	Description: Greenish brown lean clay with sand					
	Remarks: 2054					

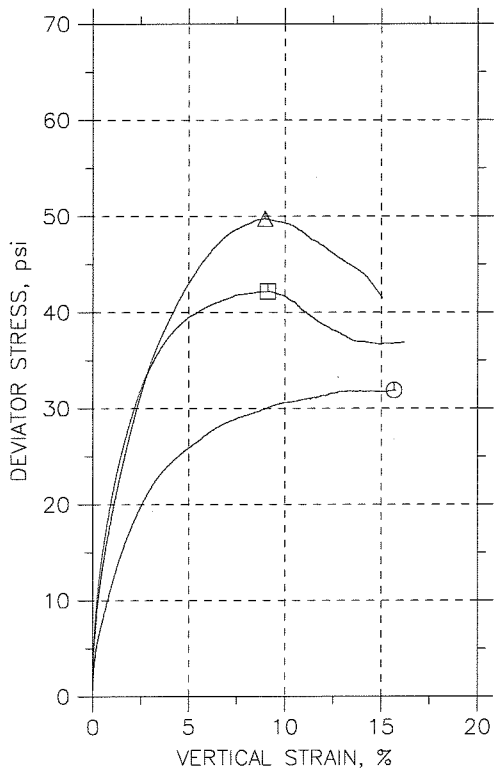
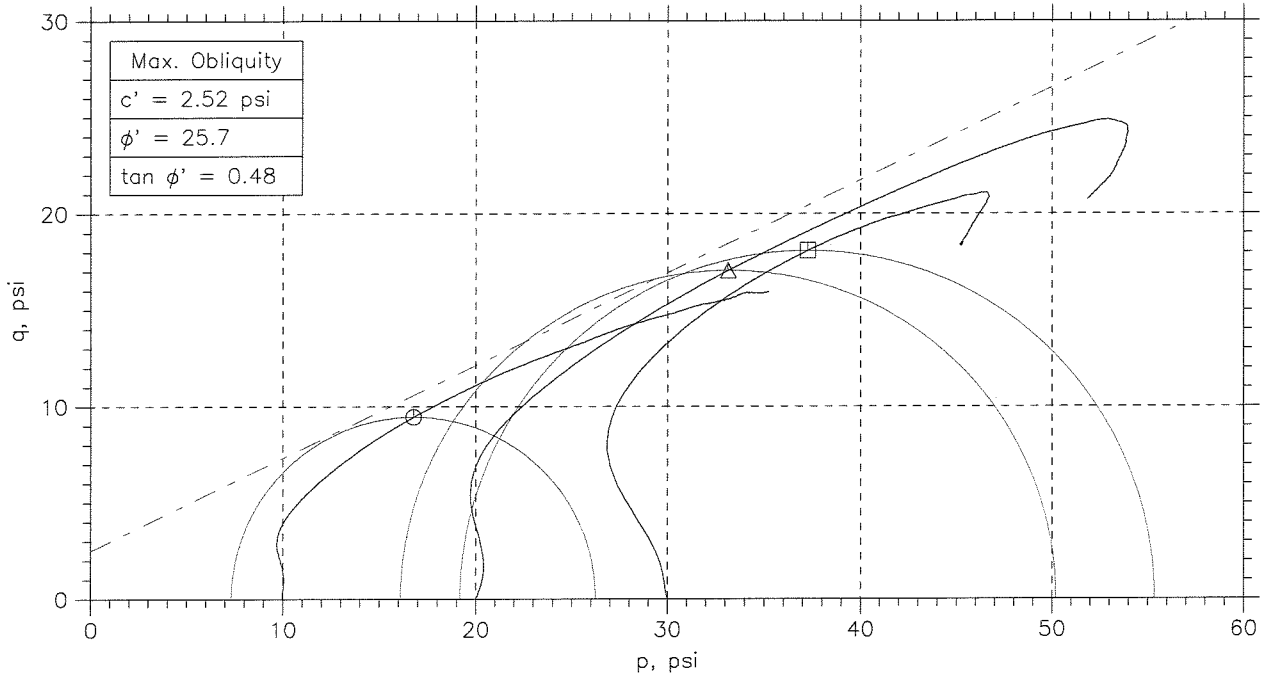
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	2.1	25.8-26.4	jm	12/11/09	mm		1516-2.1.dat
△	---	2.2	28.4-29.0	jm	12/11/09	mm		1516-2.2A.dat
□	---	2.3	30.3-30.9'	jm	12/09/09	mm		1516-2.3.dat

GeoTesting express <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek		Location: Jefferson, IN.		Project No.: GTX-1516	
	Boring No.: B-8		Sample Type: UD			
	Description: Greenish brown lean clay with sand					
	Remarks: 2054					

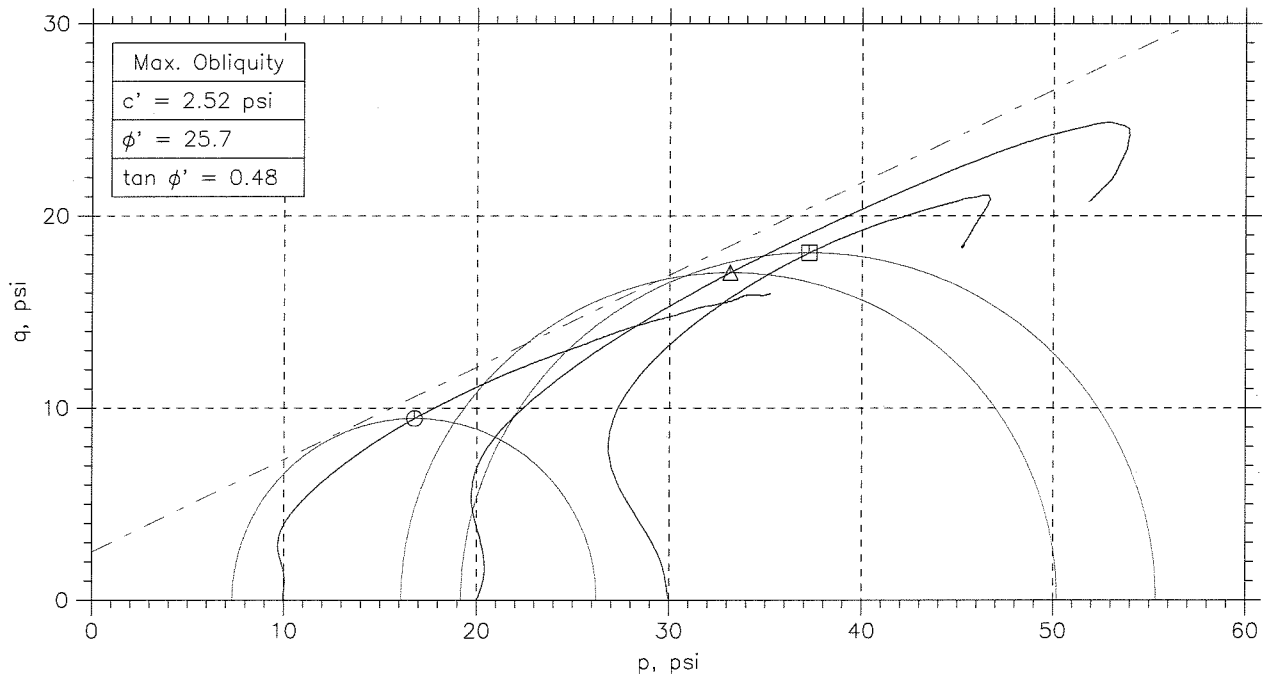
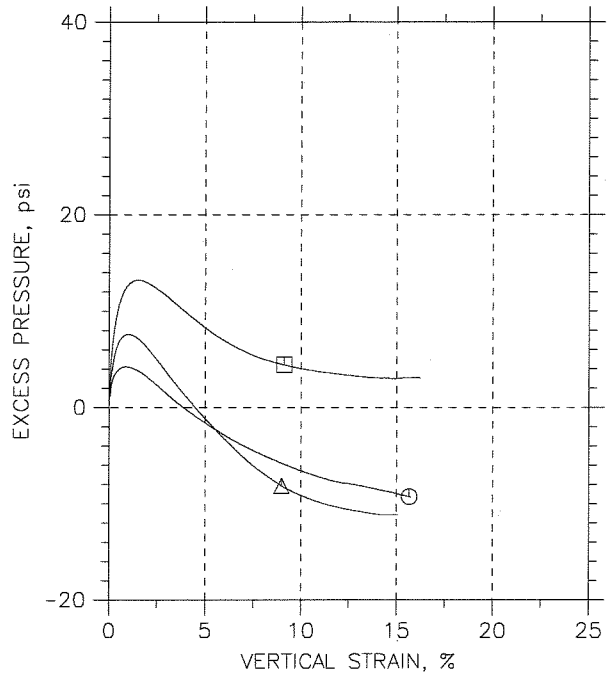
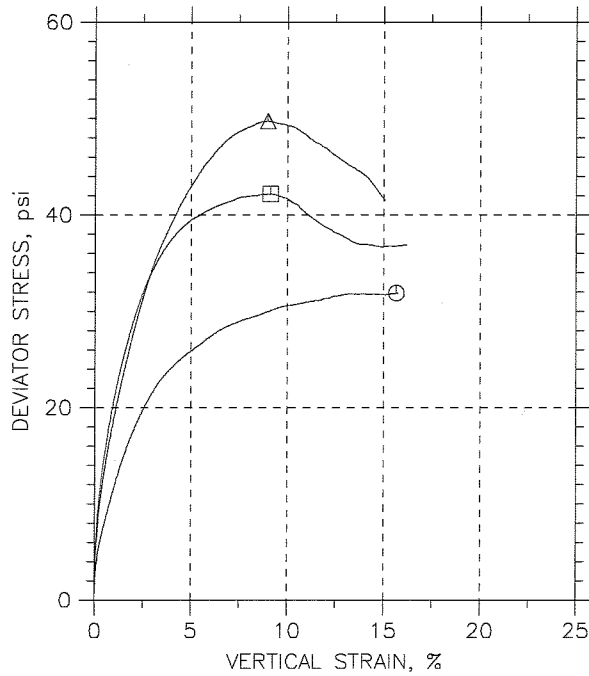
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



Symbol	○	△	□	
Sample No.	---	---	---	
Test No.	3.1	3.2	3.3	
Depth	17.4-18.0	19.4-20.0	20.8--21.4	
Initial	Diameter, in	2.835	2.835	2.837
	Height, in	6.319	6.281	6.177
	Water Content, %	19.4	18.4	20.8
	Dry Density, pcf	109.7	111.4	107.3
	Saturation, %	97.8	96.9	98.6
Before Shear	Void Ratio	0.536	0.514	0.571
	Water Content, %	19.2	18.9	22.7
	Dry Density, pcf	111.	111.7	104.5
	Saturation*, %	100.0	100.0	100.0
Before Shear	Void Ratio	0.518	0.509	0.613
	Back Press., psi	136.8	122	116.2
Ver. Eff. Cons. Stress, psi	9.997	19.96	29.88	
Shear Strength, psi	15.94	24.86	21.08	
Strain at Failure, %	15.7	8.98	9.12	
Strain Rate, %/min	0.016	0.016	0.016	
B-Value	0.95	0.96	0.95	
Estimated Specific Gravity	2.7	2.7	2.7	
Liquid Limit	---	---	---	
Plastic Limit	---	---	---	

GeoTesting express <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek				
	Location: Jefferson, IN				
	Project No.: GTX-1516				
	Boring No.: B-9				
	Sample Type: UD				
	Description: Brown lean clay with sand				
Remarks: System 1057					

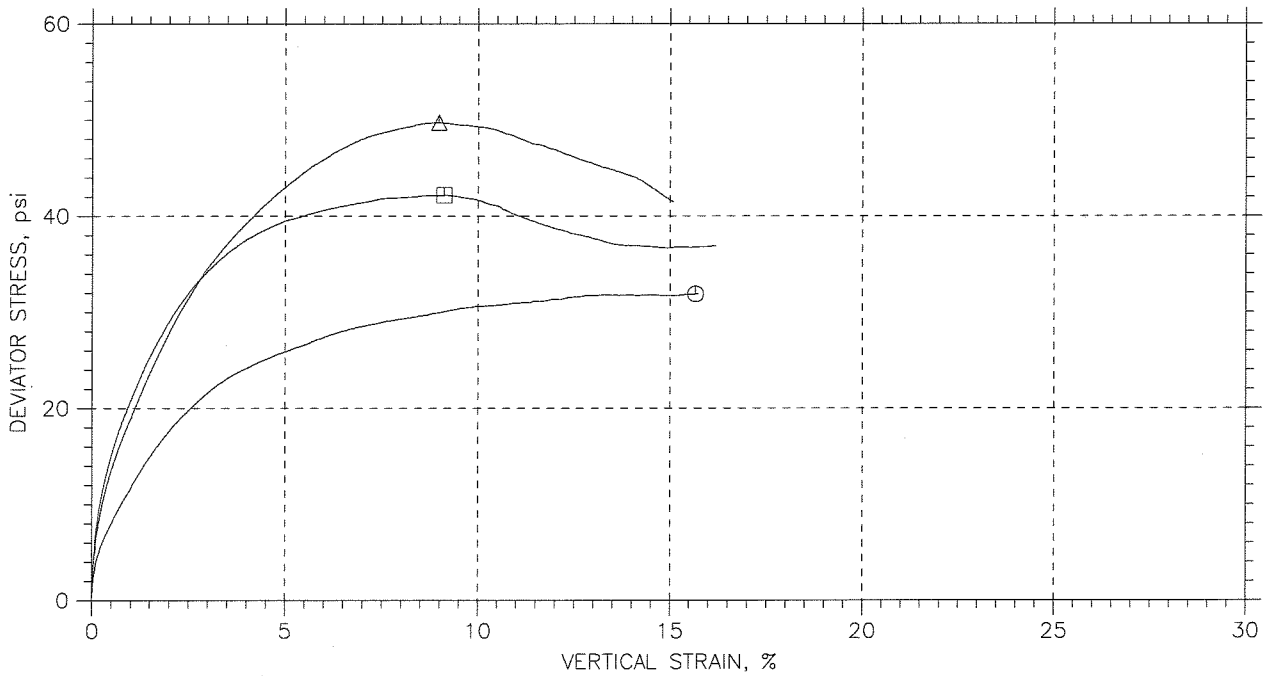
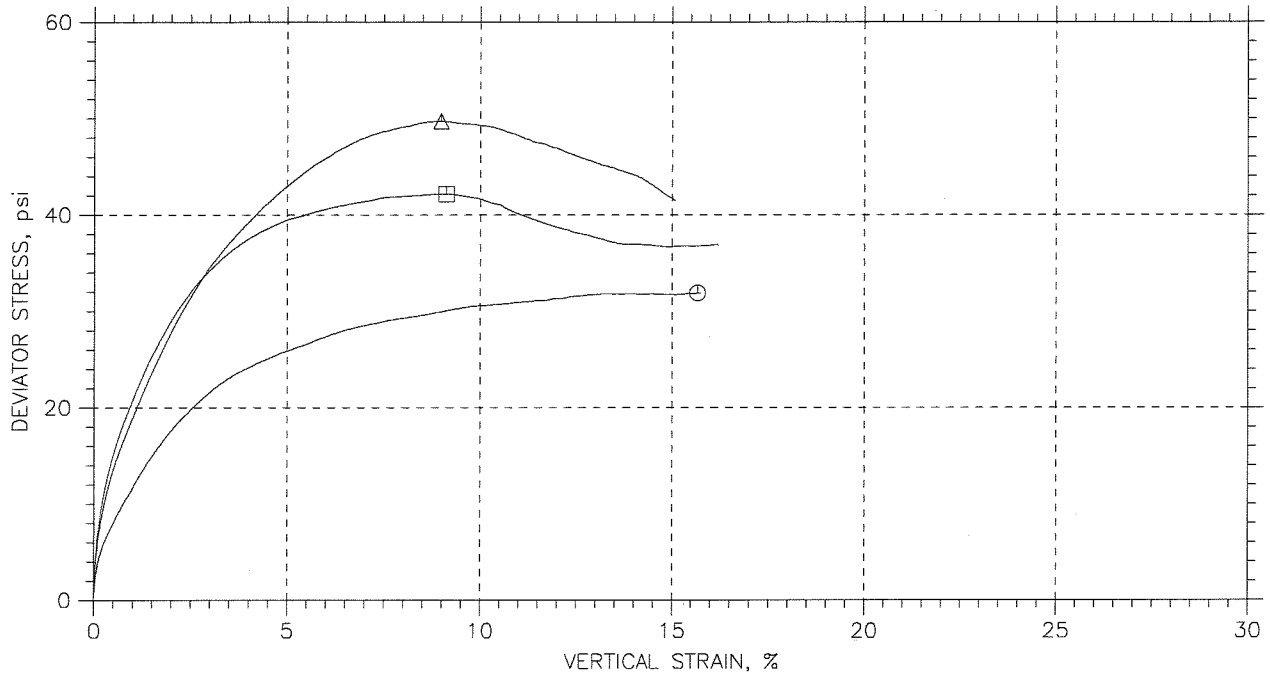
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	---	3.1	17.4-18.0	jm	12/15/09	mm		1516-3.1.dat
△	---	3.2	19.4-20.0	jm	12/16/09	mm		1516-3.2Adat.dat
□	---	3.3	20.8--21.4	jm	12/10/09	mm		1516-3.3.dat

GeoTesting express <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek		Location: Jefferson, IN		Project No.: GTX-1516	
	Boring No.: B-9		Sample Type: UD			
	Description: Brown lean clay with sand					
	Remarks: System 1057					

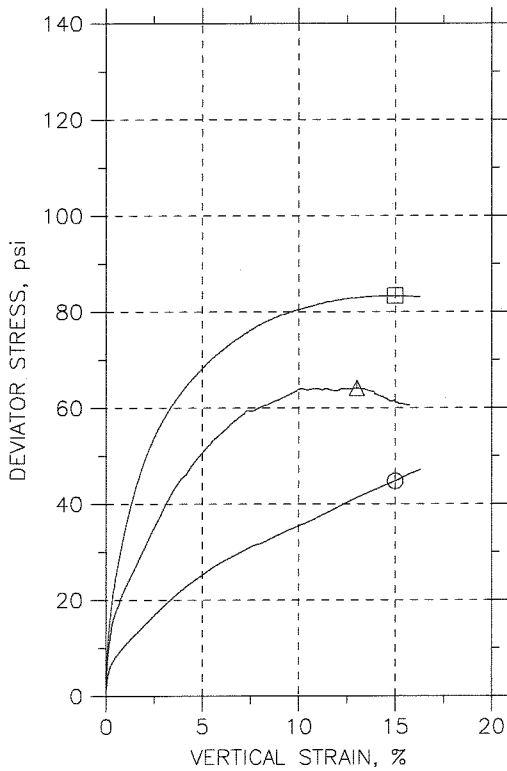
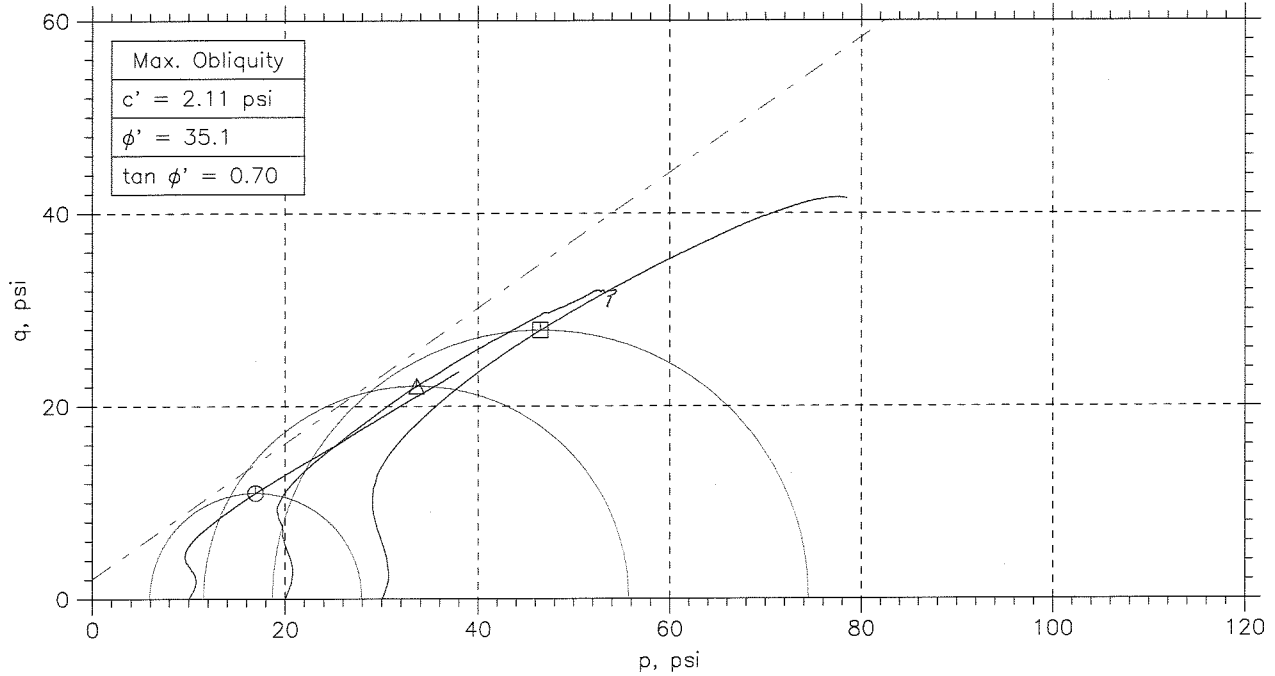
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊕	---	3.1	17.4-18.0	jm	12/15/09	mm		1516-3.1.dat
△	---	3.2	19.4-20.0	jm	12/16/09	mm		1516-3.2A.dat.dat
□	---	3.3	20.8--21.4	jm	12/10/09	mm		1516-3.3.dat

GeoTesting express <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek		Location: Jefferson, IN		Project No.: GTX-1516	
	Boring No.: B-9		Sample Type: UD			
	Description: Brown lean clay with sand					
	Remarks: System 1057					

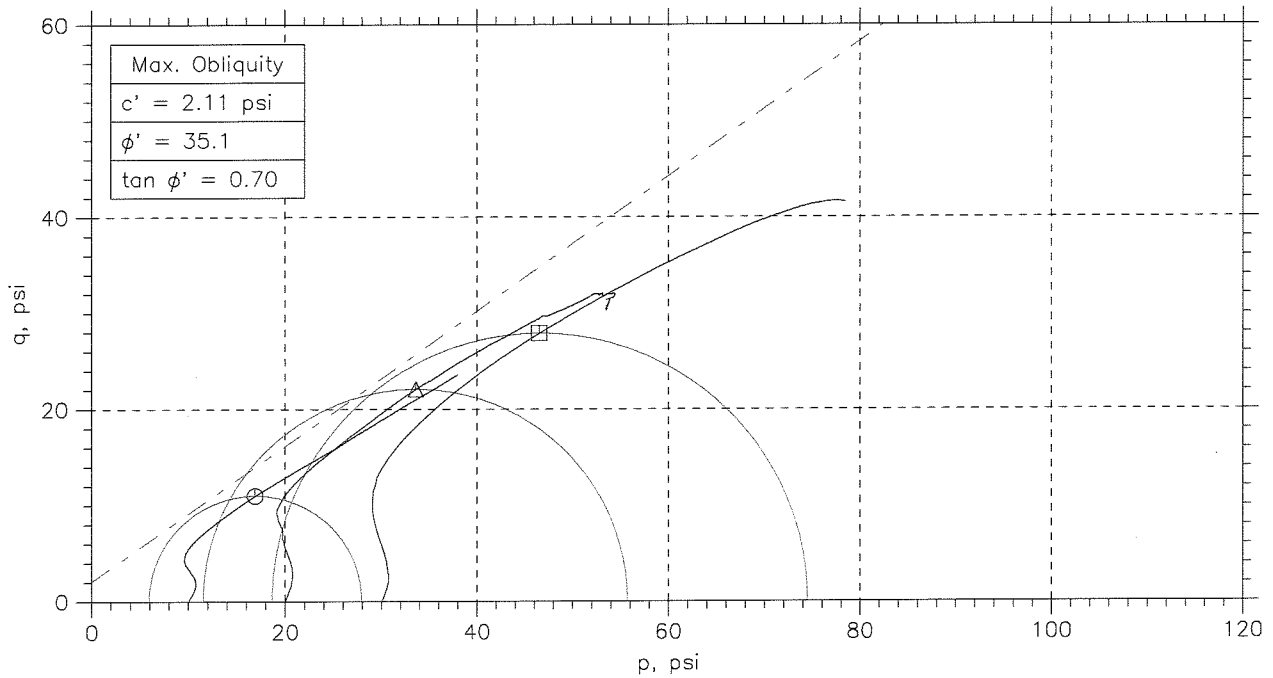
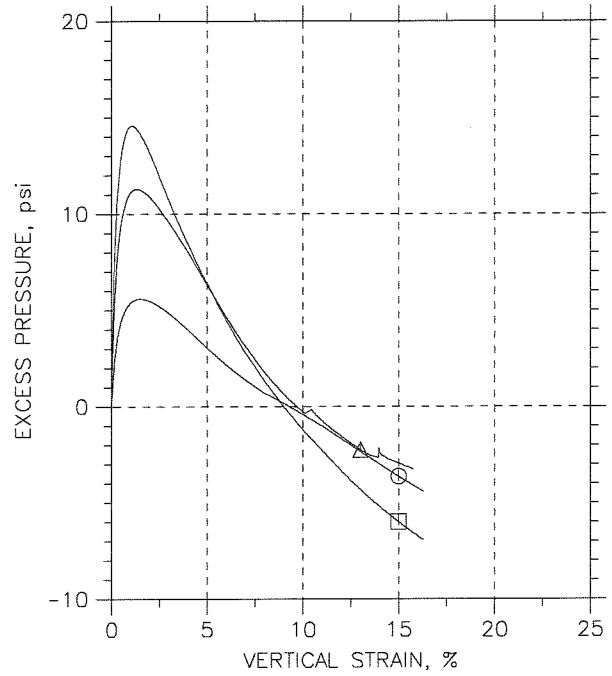
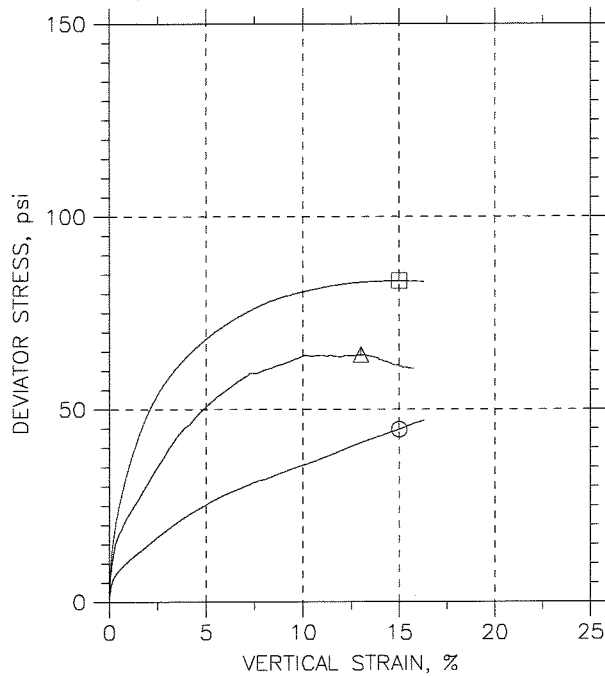
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



Symbol	○	△	□	
Sample No.	---	---	---	
Test No.	CU-4.1	CU-4.2	CU-4.3	
Depth	13.4-14.0'	16.8-17.4'	17.4-18.1'	
Initial	Diameter, in	2.83	2.71	2.72
	Height, in	5.78	5.52	5.51
	Water Content, %	14.2	27.4	26.6
	Dry Density, pcf	102.9	93.8	93.72
	Saturation, %	59.9	93.0	89.9
	Void Ratio	0.638	0.797	0.798
Before Shear	Water Content, %	23.2	18.5	19.2
	Dry Density, pcf	103.7	112.4	111.
	Saturation*, %	100.0	100.0	100.0
	Void Ratio	0.625	0.5	0.519
Back Press., psi	27.99	73	84.99	
Ver. Eff. Cons. Stress, psi	10	19.99	30	
Shear Strength, psi	22.37	32.06	41.66	
Strain at Failure, %	15	13	15	
Strain Rate, %/min	0.032	0.032	0.032	
B-Value	0.95	0.95	0.96	
Estimated Specific Gravity	2.7	2.7	2.7	
Liquid Limit	---	---	---	
Plastic Limit	---	---	---	

 <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek				
	Location: ----				
	Project No.: GTX-1516				
	Boring No.: B-10				
	Sample Type: UD				
	Description:				
Remarks: 2054					

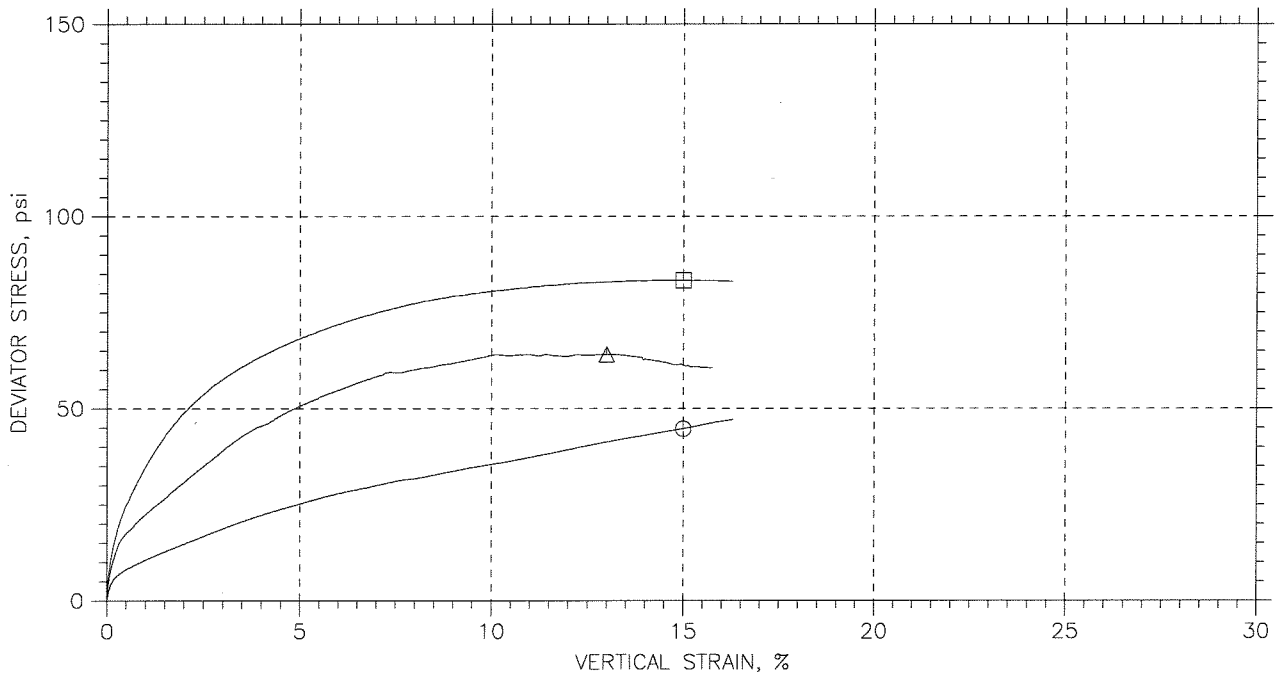
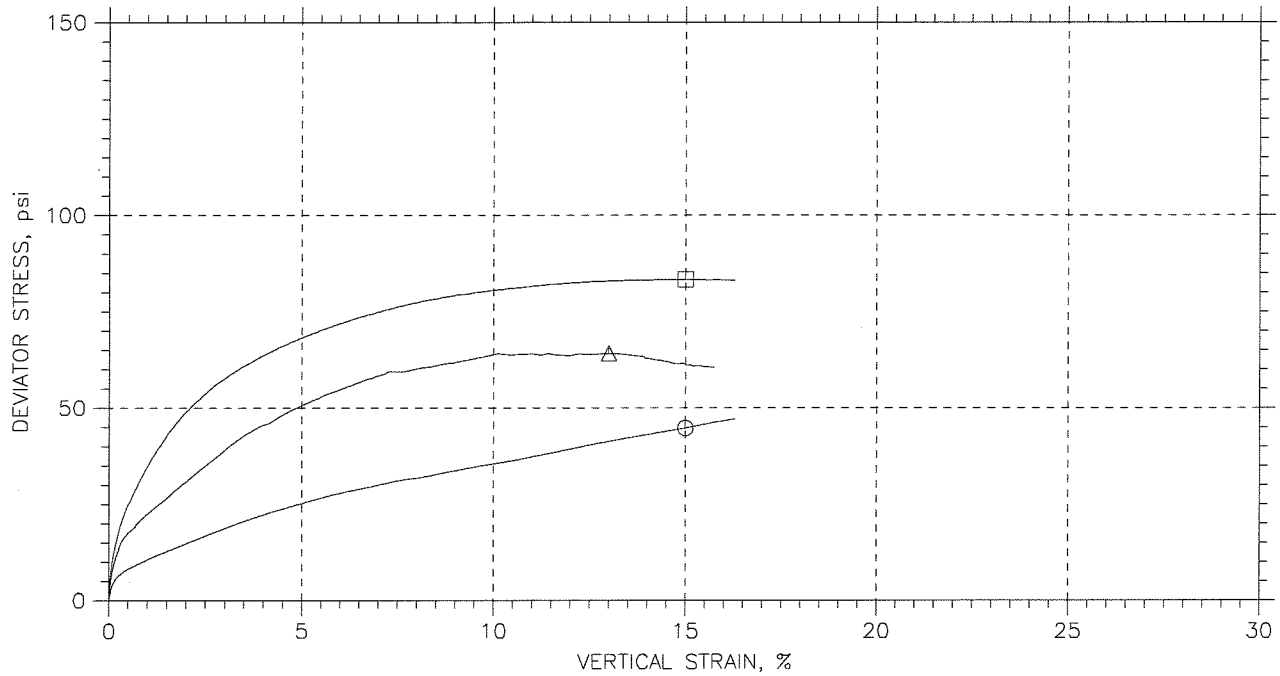
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	CU-4.1	13.4-14.0'	JM	12/12/09	MM		1516-4.1.dat
△	----	CU-4.2	16.8-17.4'	JM	12/13/09	MM		1516-4.2.dat
□	----	CU-4.3	17.4-18.'	JM	12/12/09	MM		1516-4.3.dat

GeoTesting express <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek		Location: ----		Project No.: GTX-1516	
	Boring No.: B-10		Sample Type: UD			
	Description:					
	Remarks: 2054					

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



Symbol	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	---	CU-4.1	13.4-14.0'	JM	12/12/09	MM		1516-4.1.dat
△	----	CU-4.2	16.8-17.4'	JM	12/13/09	MM		1516-4.2.dat
□	----	CU-4.3	17.4-18.'	JM	12/12/09	MM		1516-4.3.dat

GeoTesting express <small>a subsidiary of Geocomp Corporation</small>	Project: Clifty Creek		Location: ----		Project No.: GTX-1516	
	Boring No.: B-10		Sample Type: UD			
	Description:					
	Remarks: 2054					



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