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December 1, 2020

Delivered Electronically

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 Revision to Assessment of Corrective Measure Report

As required by 40 CFR 257.106(h)(7), on May 15, 2019, the Indiana-Kentucky Electric Corporation (IKEC) provided notification to the Commissioner of the Indiana Department of Environmental Management that an Assessment of Corrective Measures had been initiated for a confirmed Statistically Significant Increase (SSI) of Appendix IV constituent Molybdenum at Clifty Creek Station's landfill runoff collection pond.

Further, as required by 40 CFR 257.96(d), a report detailing the effectiveness of potential corrective measures was prepared by AGES, Inc. using 40 CFR 257.27 as a basis for the selection of potential remedies. Per 40 CFR 257.106(h)(8), this letter provides notification that the original report, dated September 19, 2019, has been revised to include additional information to further characterize the extent of the Appendix IV exceedance, as well as provide additional discussion on potential remedies. An updated version has been placed in the facility's operating record, as well as on the company's publicly accessible internet site, and can be viewed at http://www.ovec.com/CCRCompliance.php.

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

Sincerely,

Tim Fulk

Tim Fulk
Engineer II

TLF:gsc

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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 REVISON 1.0

Prepared for:

INDIANA-KENTUCKY ELECTRIC CORPORATION (IKEC)

By:

APPLIED GEOLOGY AND ENVIRONMENTAL SCIENCE, INC.

COAL COMBUSTION RESIDUALS REGULATION
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APPLIED GEOLOGY AND ENVIRONMENTAL SCIENCE, INC.

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COAL COMBUSTION RESIDUALS REGULATION
ASSESSMENT OF CORRECTIVE MEASURES REPORT
LANDFILL RUNOFF COLLECTION POND (LRCP)
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MADISON, INDIANA

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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 LCRP 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^{o}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 LCRP 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 <u>Potential Safety Impacts</u>

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

Applied Geology and Environmental Science, Inc. (AGES) 2019a. Coal Combustion Residuals Regulation 2018 Groundwater Monitoring and Corrective Action Report. Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. January 2019.

Applied Geology and Environmental Science, Inc. (AGES) 2019b. Coal Combustion Residuals Regulation Alternate Source Demonstration Report March 2018 Detection Monitoring Event. Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. June 2019.

Applied Geology and Environmental Science, Inc. (AGES) 2018a. 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) 2018b. Coal Combustion Residuals Regulation Monitoring Well Installation Report. Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. Revision 1.0. November 2018.

Applied Geology and Environmental Science, Inc. (AGES) 2018c. Coal Combustion Residuals Regulation Groundwater Monitoring Program Plan, Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. Revision 1.0. November 2018.

Fetter, Charles W. 1980. Applied Hydrogeology. Merrill, 1980.

Smedley, P. and Kinniburgh, D. 2017. Molybdenum in Natural Waters, A Review of Occurrence, Distributions and Controls, Journal of Applied Geochemistry, Volume 84.

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.

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 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

h_1 = Head elevation in well #1
h_2 = 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, SO4	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

	Source Control Technologies		
	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

	In-Situ Groundwater Remedial Technologies				***Ex-Situ Groundwater Remedial Technologies***		
	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

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019042-8-CLIFTY
DWG FILE	2019_IKEC_Clifty_ACM_Fig 2-1_location map.dwg
DRAWING SCALE	AS SHOWN

AGES
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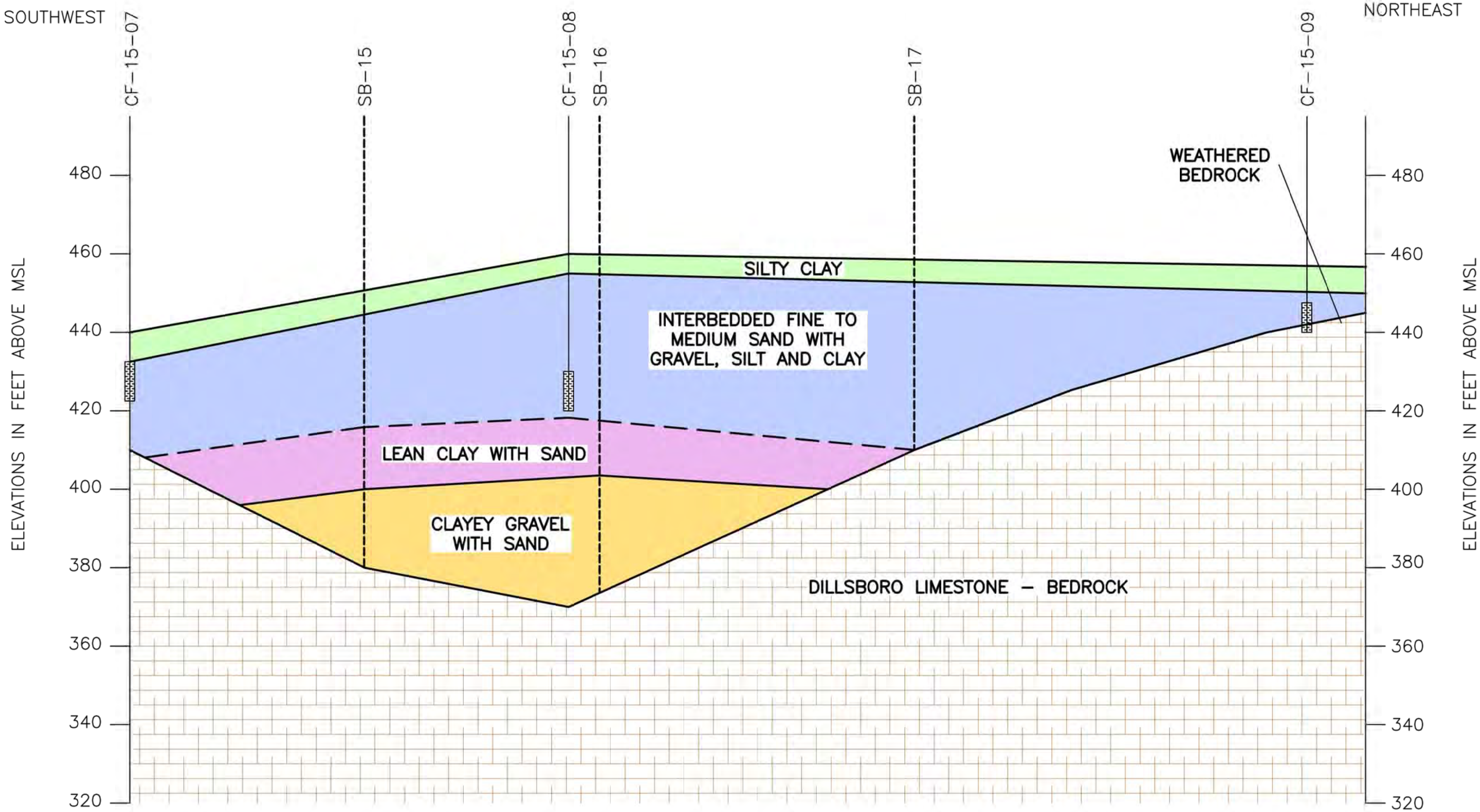
INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
SITE LOCATION MAP

DRAWING NAME: FIGURE 2–1
REV. 0

Plot: 08/09/2019 10:24 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 Assessment of Corrective Measures\2019_IKEC_Clifty_ACM_Fig 2-1_location map.dwg



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.

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019042-8-CLIFTY
DWG FILE	2019_IKEC_Clifty_ACM_Fig 3-1_X-Section_LRCP.dwg
DRAWING SCALE	NOT TO SCALE

AGES
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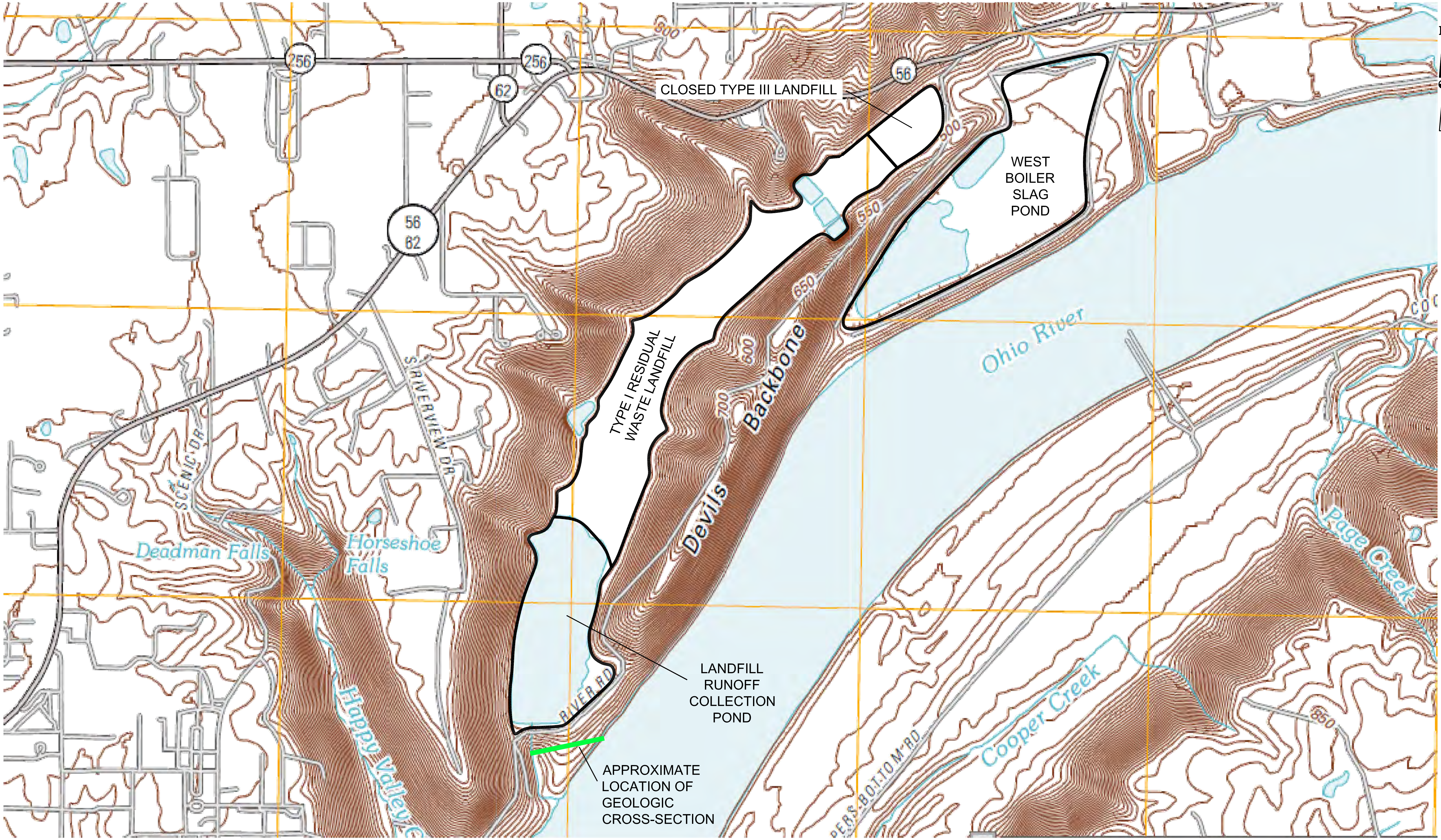
INDIANA-KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
GEOLOGIC CROSS-SECTION AT
LANDFILL RUNOFF COLLECTION POND

DRAWING NAME: FIGURE 3-1

REV. 0

Plot: 09/09/2019 14:37 _PROGRAM-IKEC\Clifty Creek-CCR Program\CAD\2019 Assessment of Corrective Measures\2019_IKEC_Clifty_ACM_Fig 3-1_X-Section_LRCP.dwg



APPROXIMATE LOCATION OF THE GEOLOGIC CROSS-SECTION (FIGURE 3-1).

SOURCE: USGS MADISON WEST 7.5 MINUTE TOPOGRAHIC QUADRANGLE, 2010.

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019042-8-CLIFTY
DWG FILE	2019_IKEC_Clifty_ACM_Fig 3-2_USGS_topo_map.dwg
DRAWING SCALE	NOT TO SCALE

AGES
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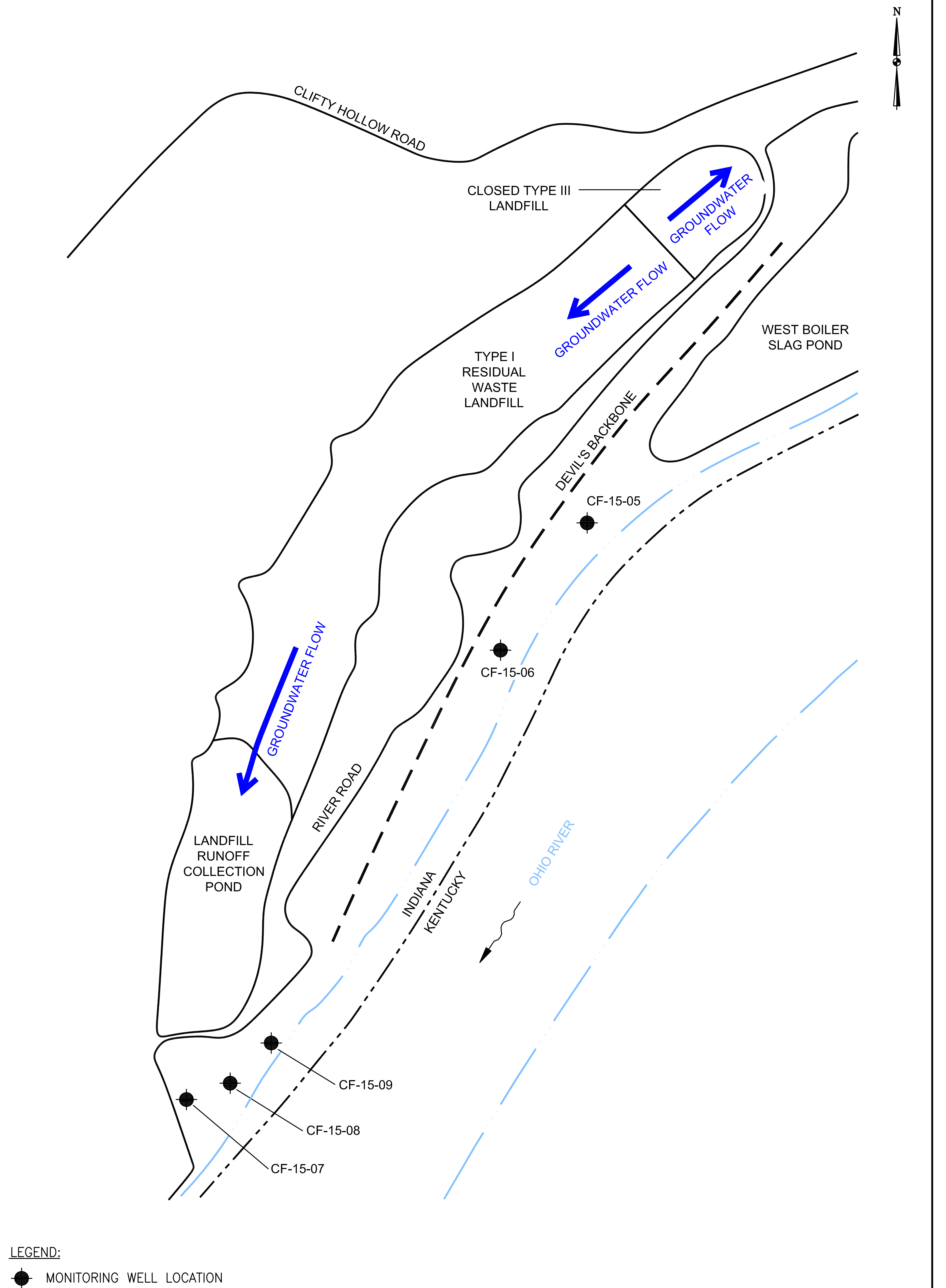
INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
TOPOGRAPHIC MAP

DRAWING NAME: FIGURE 3-2

REV. 0

Plot: 09/09/2019 14:51 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 Assessment of Corrective Measures\2019_IKEC_Clifty_ACM_Fig 3-2_USGS_topo_map.dwg



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JOB NO.	2019042-8-CLIFTY
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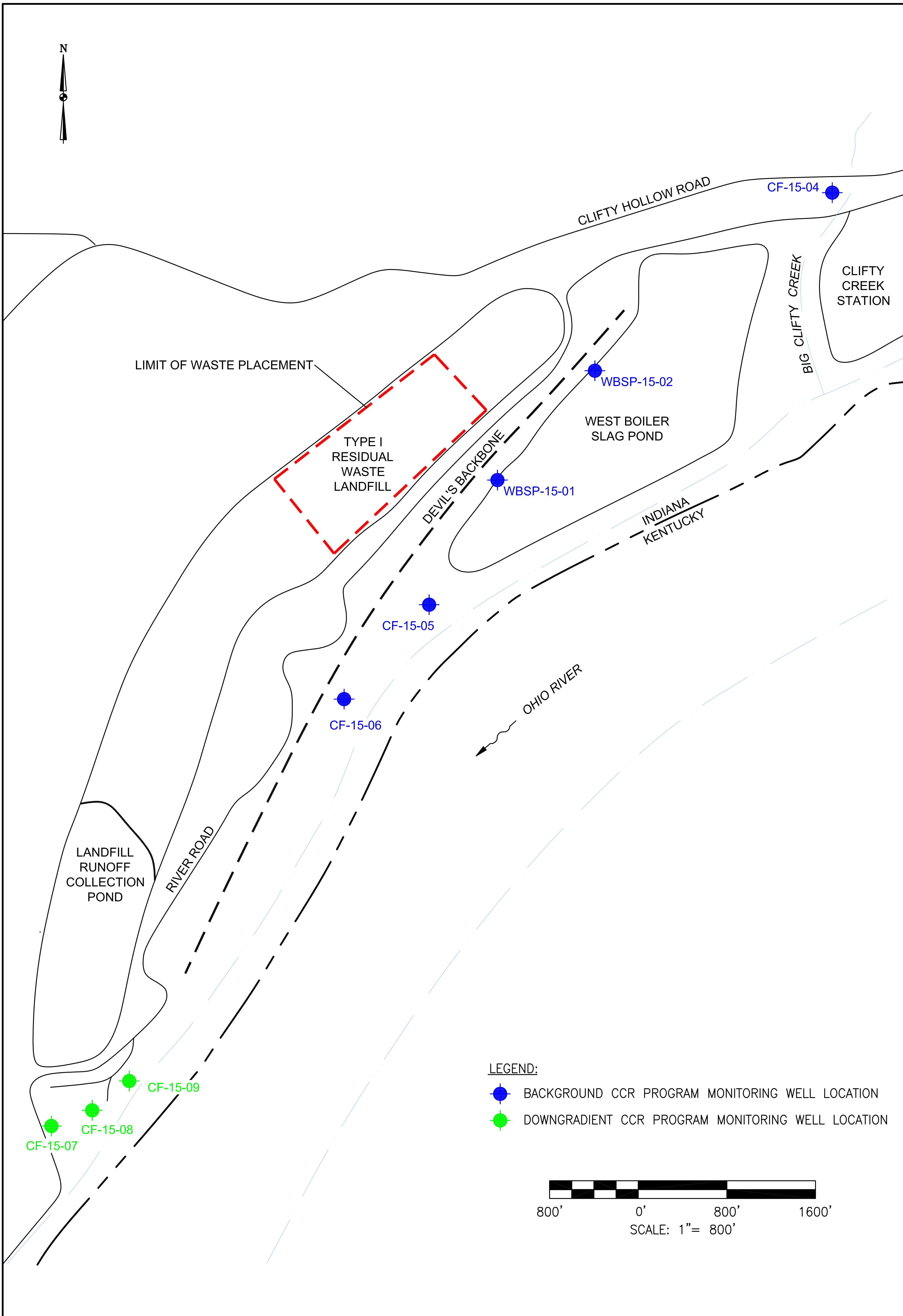
CLIFTY CREEK STATION
MADISON, INDIANA
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
EXISTING MONITORING WELL LOCATIONS AND
GENERALIZED GROUNDWATER FLOW MAP

DRAWING NAME: FIGURE 3-3
REV. 0

Plot: 08/09/2019 10:41 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 Assessment of Corrective Measures\2019_IKEC_Clifty_ACM_Fig 3-3_Gen_GW Flow Map.dwg



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JOB NO.	2019042-8-CLIFTY
DWG FILE	2019_IKEC_Clifty_ACM_Fig 4-1_MW Locs.dwg
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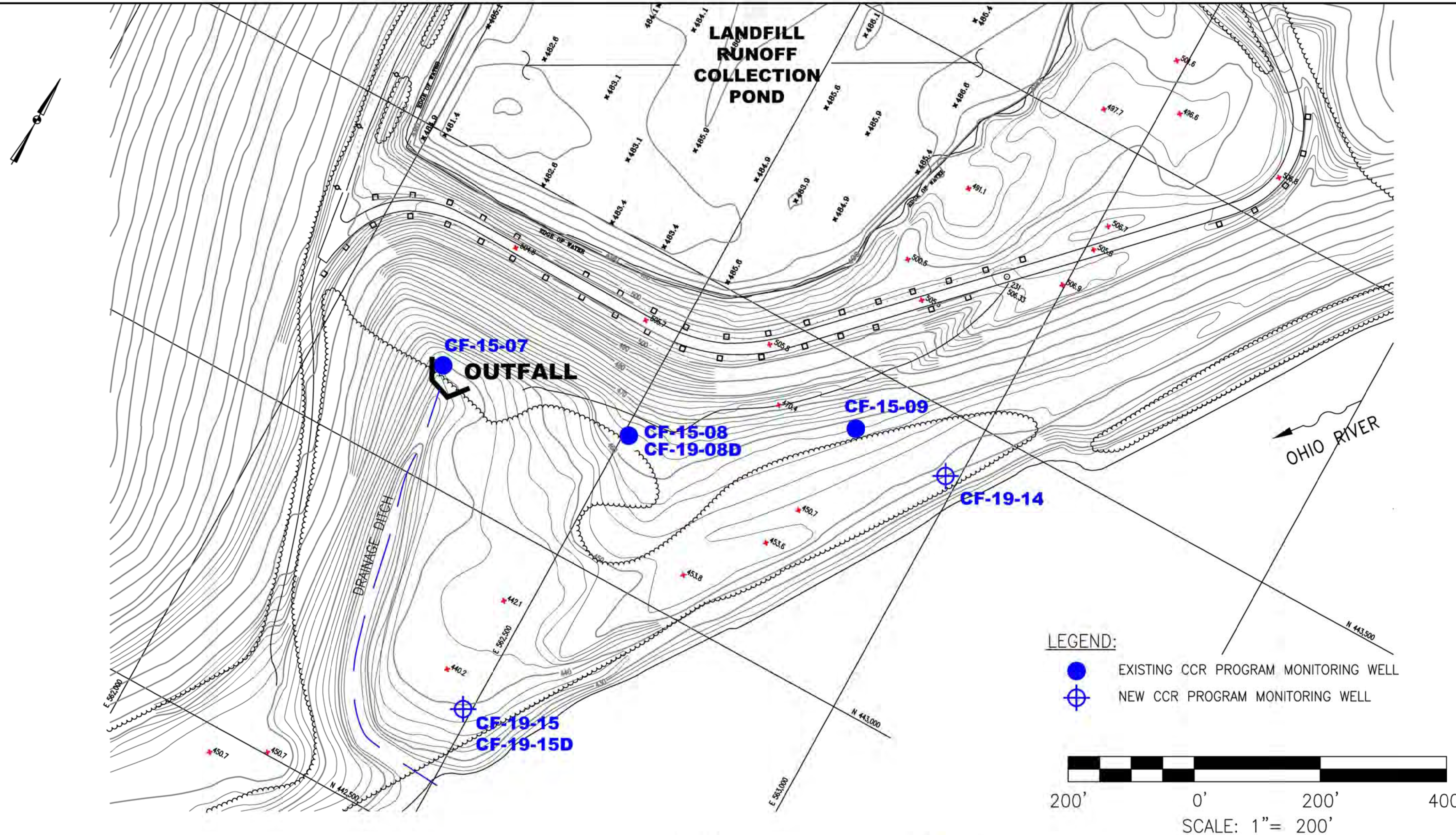
INDIANA–KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
EXISTING MONITORING WELL LOCATIONS

DRAWING NAME: FIGURE 4–1
REV. 0

Plot: 08/08/2019 11:13 _PROGRAMS–IKEC\Clifty Creek–CCR Program\CAD\2019 Assessment of Corrective Measures\2019_IKEC_Clifty_ACM_Fig 4–1_MW Locs.dwg



DRAWN BY	JM
DATE	
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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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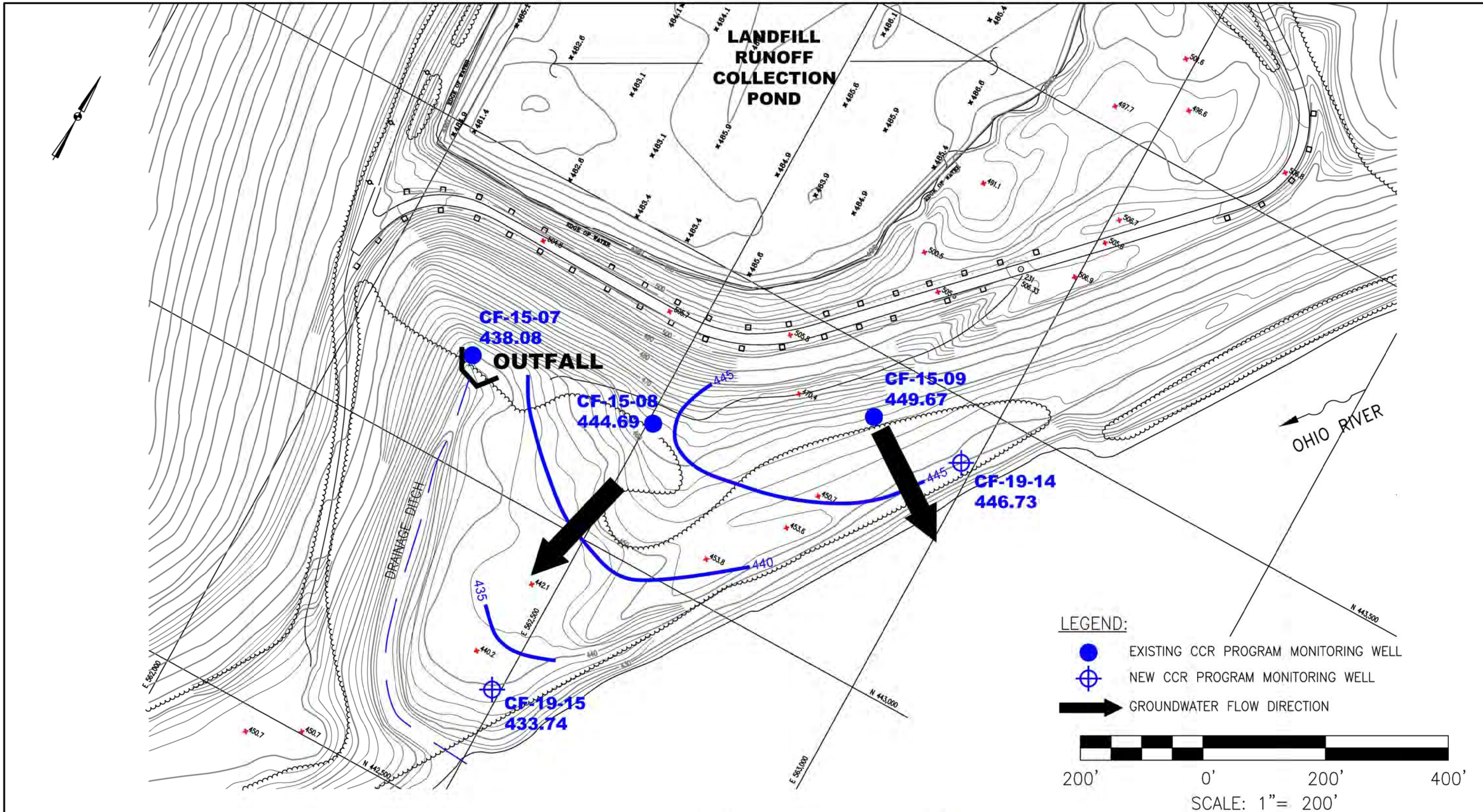
INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
EXISTING AND NEW MONITORING WELL LOCATIONS

DRAWING NAME: FIGURE 5–1 REV. 0

Plot: 08/09/2019 10:45 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 Assessment of Corrective Measures\2019_IKEC_Clifty_ACM_Fig 5-1_MW locs.dwg



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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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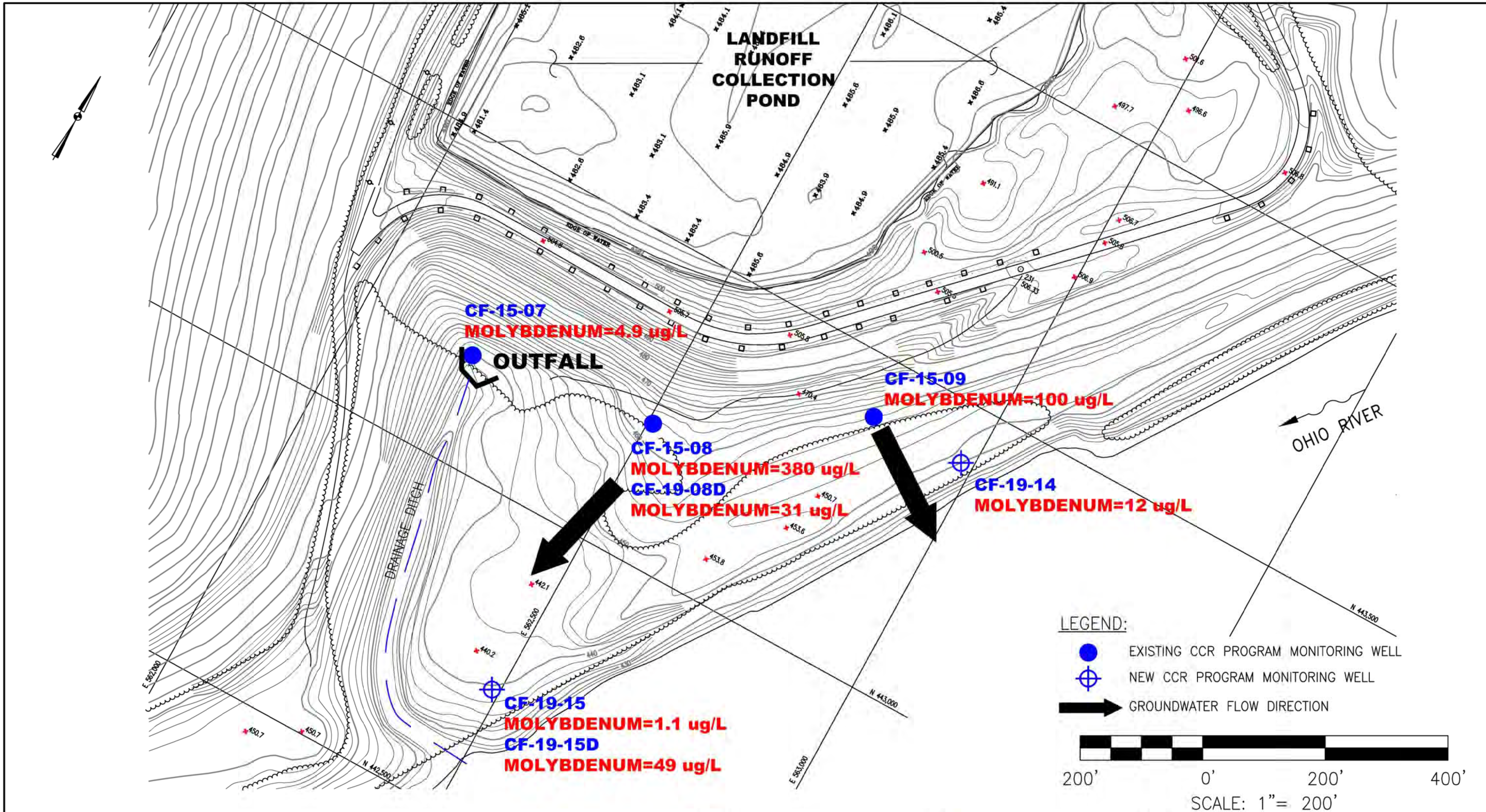
INDIANA–KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
GROUNDWATER FLOW – UPPERMOST AQUIFER
MARCH 2019

DRAWING NAME: FIGURE 5–2 REV. 0

Plot: 09/09/2019 14:59 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 Assessment of Corrective Measures\2019_IKEC_Clifty_ACM_Fig 5-2_GW Flow-Upper Aquifer.dwg



DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019108-CLIFTY
DWG. FILE	2019_IKEC_Clifty_ACM_Fig 5-3_Molybdenum GW_Mar19.dwg
DRAWING SCALE	AS SHOWN

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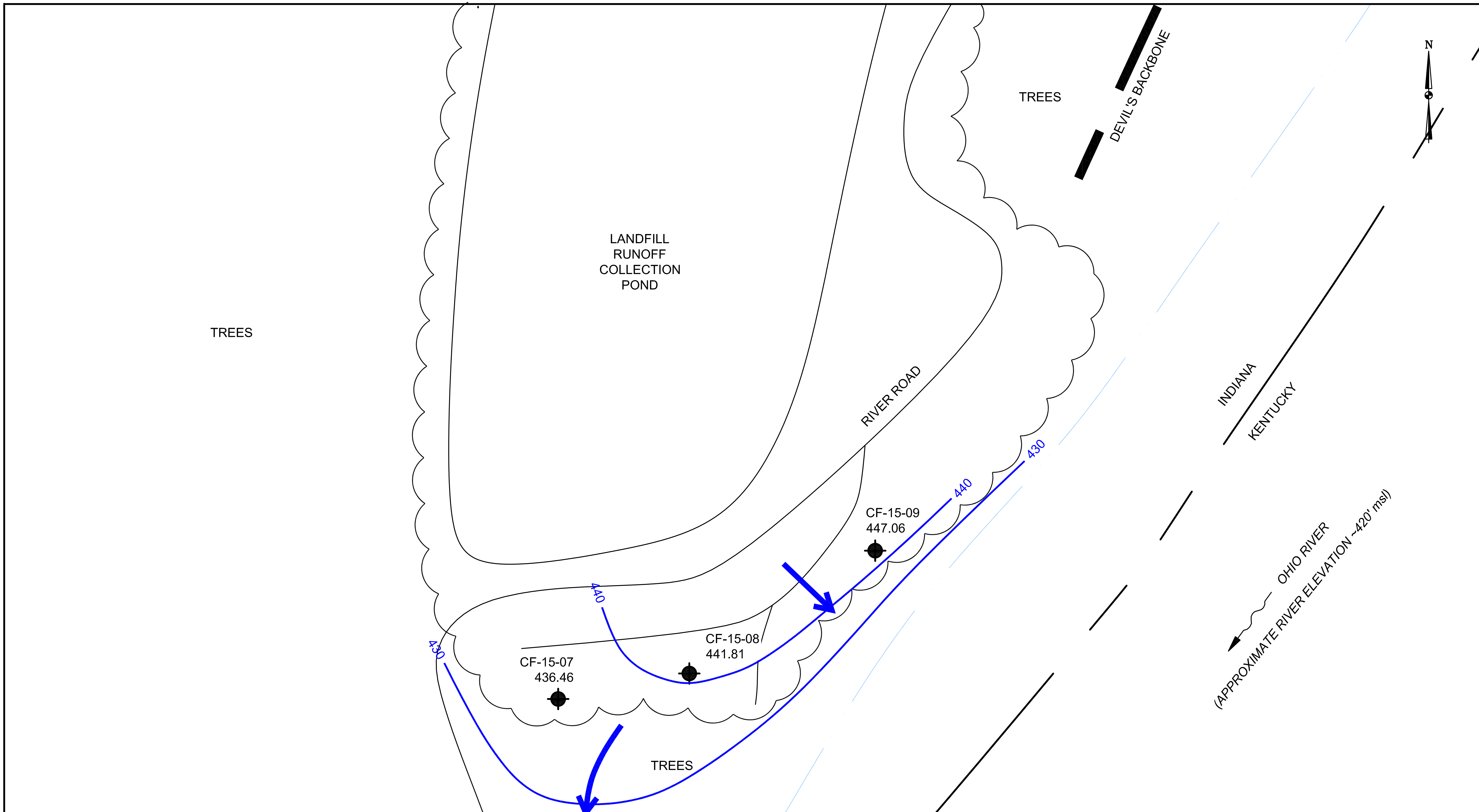
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
MOLYBDENUM CONCENTRATIONS IN GROUNDWATER
MARCH 2019

DRAWING NAME: FIGURE 5-3
REV. 0

Plot: 09/09/2019 15:03 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 Assessment of Corrective Measures\2019_IKEC_Clifty_ACM_Fig 5-3_Molybdenum GW_Mar19.dwg

APPENDIX A

GENERALIZED GROUNDWATER FLOW MAPS FOR 2018



LEGEND:

MONITORING WELL LOCATION

GROUNDWATER FLOW DIRECTION

200' 0' 200' 400'

SCALE: 1"= 200'

DRAWN BY	JM
DATE	
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JOB NO.	2019042-8-CLIFTY
DWG FILE	2019_IKEC_Clifty_ACM_Appx A_MAR18.dwg
DRAWING SCALE	AS SHOWN

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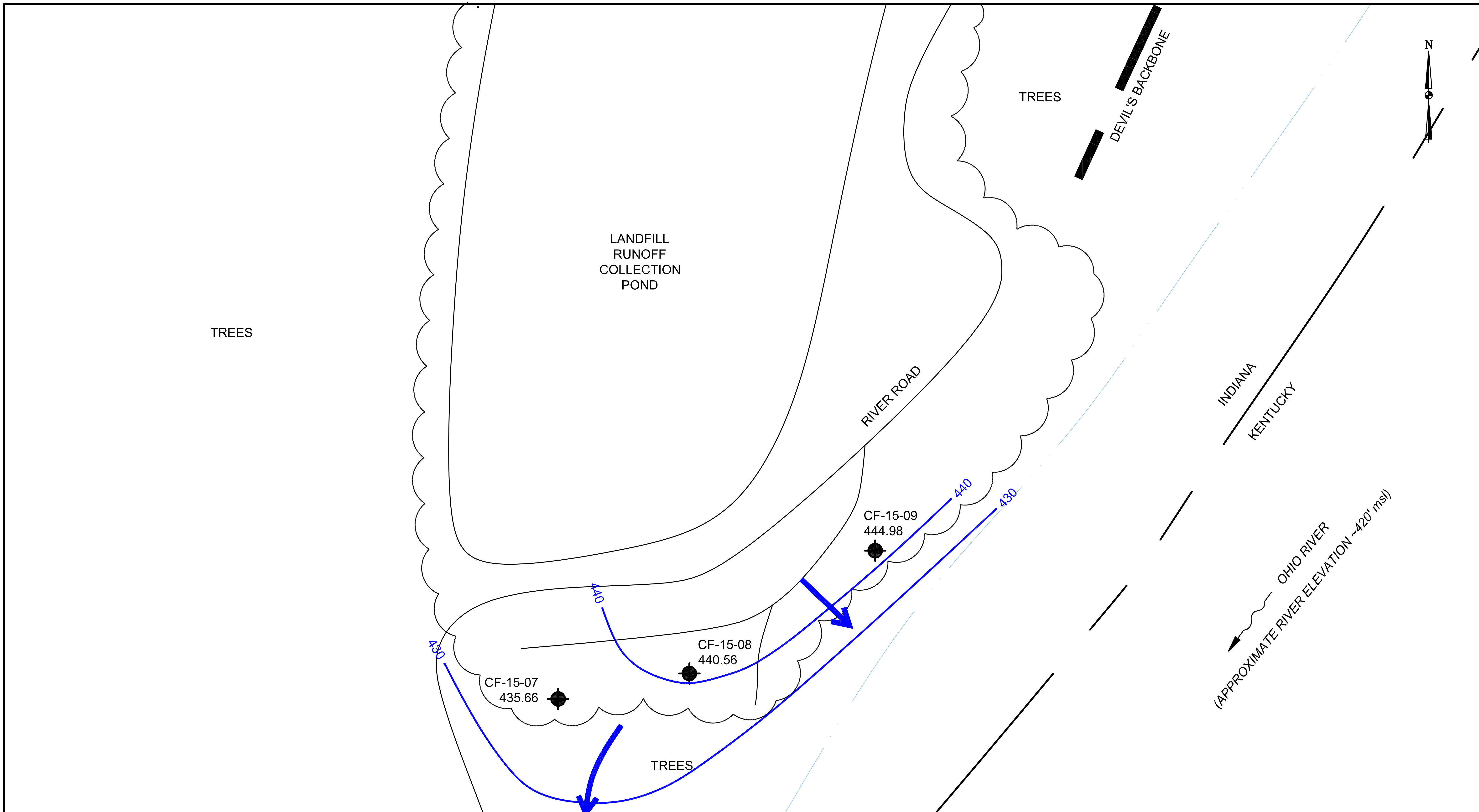
INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
LANDFILL RUNOFF COLLECTION POND
GENERALIZED GROUNDWATER FLOW MAP
MARCH 2018

DRAWING NAME: FIGURE A–1

REV.: 0



LEGEND:

MONITORING WELL LOCATION

GROUNDWATER FLOW DIRECTION

200' 0' 200' 400'

SCALE: 1"= 200'

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

AGES

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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

Plot: 08/09/2019 13:23 _PROGRAMS–IKEC\Clifty Creek–CCR Program\CAD\2019 Assessment of Corrective Measures\Appx A\2019_IKEC_Clifty_ACM_Appx A_OCT18.dwg\A–2

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

Stantec

Summary of Soil Tests

Project Name	IKEC Clifty Creek	Project Number	175534018
Source	CF-19-150-22-33	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)	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 (%)

	ASTM	AASHTO
Range	(%)	(%)
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/ft^3): N/A
Maximum Dry Density (kg/m^3): 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/ft^3): 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

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Approved By: RJ

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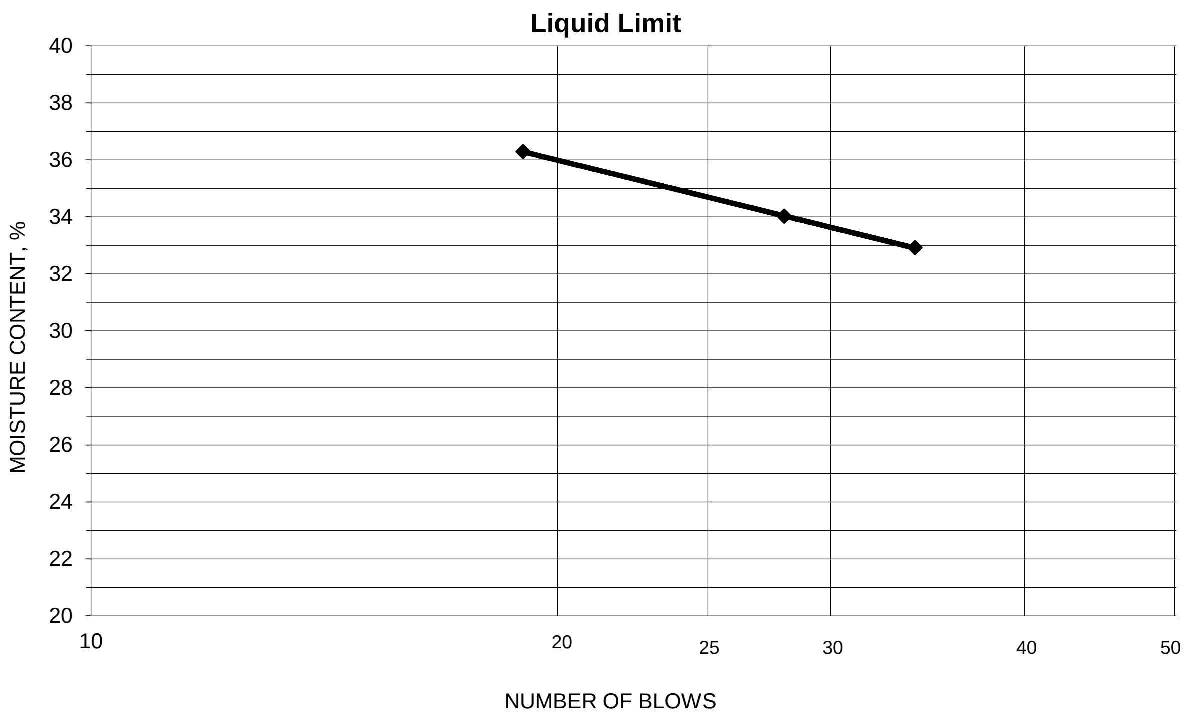
ATTERBERG LIMITS

Project	IKEC Clifty Creek			Project No.	175534018
Source	CF-19-150-22-33			Lab ID	5
				% + No. 40	7
Tested By	MP	Test Method	ASTM D 4318 Method A	Date Received	03-18-2019
Test Date	03-19-2019	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
23.87	20.70	11.07	34	32.9	
22.90	19.76	10.53	28	34.0	
22.84	19.69	11.01	19	36.3	35



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

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Particle-Size Analysis of Soils

ASTM D 422

Project Name	IKEC Clifty Creek	Project Number	175534018
Source	CF-19-150-22-33	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

Maximum Particle size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	98.6
3/8"	98.3
No. 4	97.6
No. 10	95.3

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity: 2.7

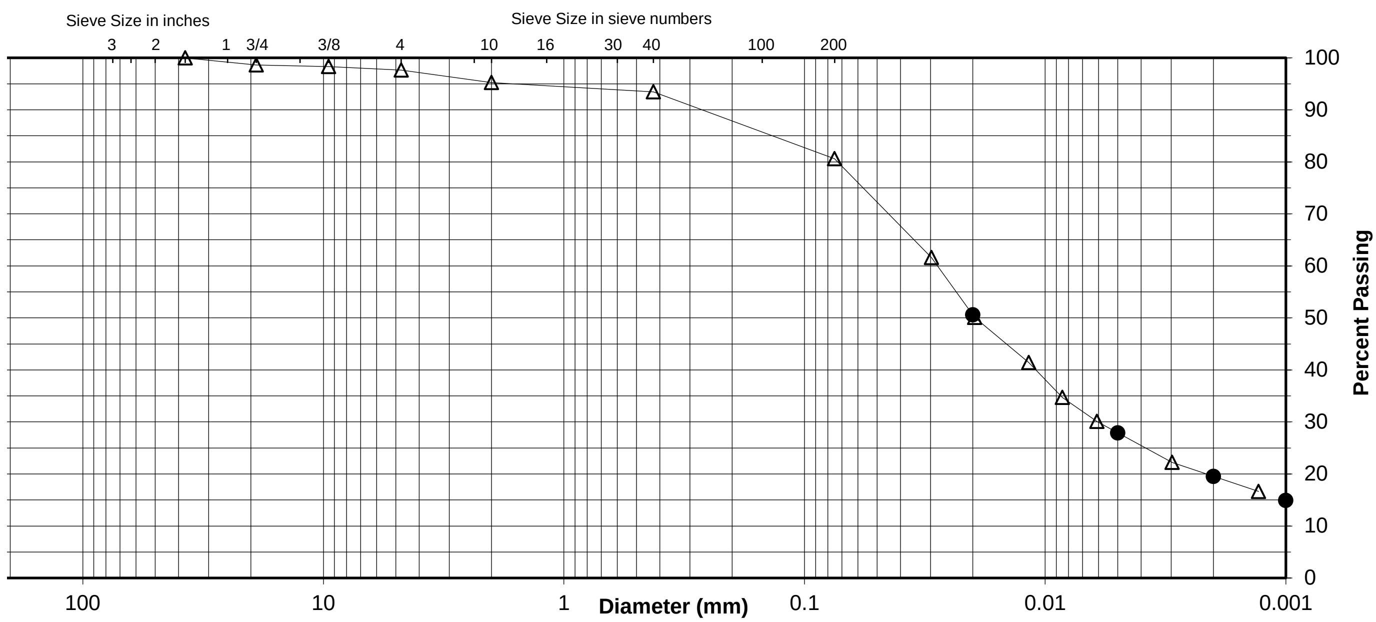
Dispersed using Apparatus A - Mechanical, for 1 minute

Sieve Size	% Passing
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 ____________________

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Summary of Soil Tests

Project Name	IKEC Clifty Creek	Project Number	175534018
Source	CF-19-150-64-70	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 Sieve Size	Particle Size (mm)	% Passing
	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/ft^3): N/A
Maximum Dry Density (kg/m^3): 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/ft^3): 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)

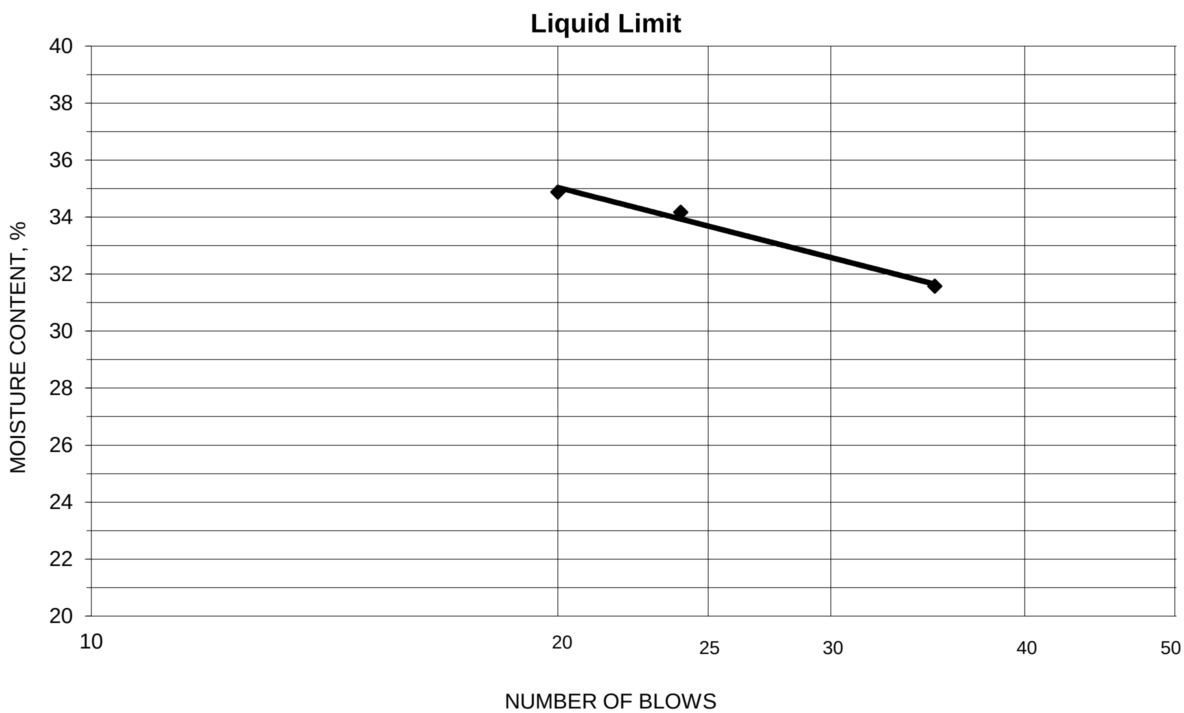
Comments:

Reviewed By JS

ATTERBERG LIMITS

Project	IKEC Clifty Creek	Project No.	175534018
Source	CF-19-150-64-70	Lab ID	6
		% + No. 40	38
Tested By	MP	Test Method	ASTM D 4318 Method A
Date Received	03-18-2019		
Test Date	03-19-2019	Prepared	Dry

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	
24.96	21.30	10.59	24	34.2	
24.74	21.20	11.05	20	34.9	34



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

Particle-Size Analysis of Soils
ASTM D 422

Project Name	IKEC Clifty Creek	Project Number	175534018
Source	CF-19-150-64-70	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

Maximum Particle size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	92.8
3/8"	84.2
No. 4	77.2
No. 10	69.1

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity: 2.7

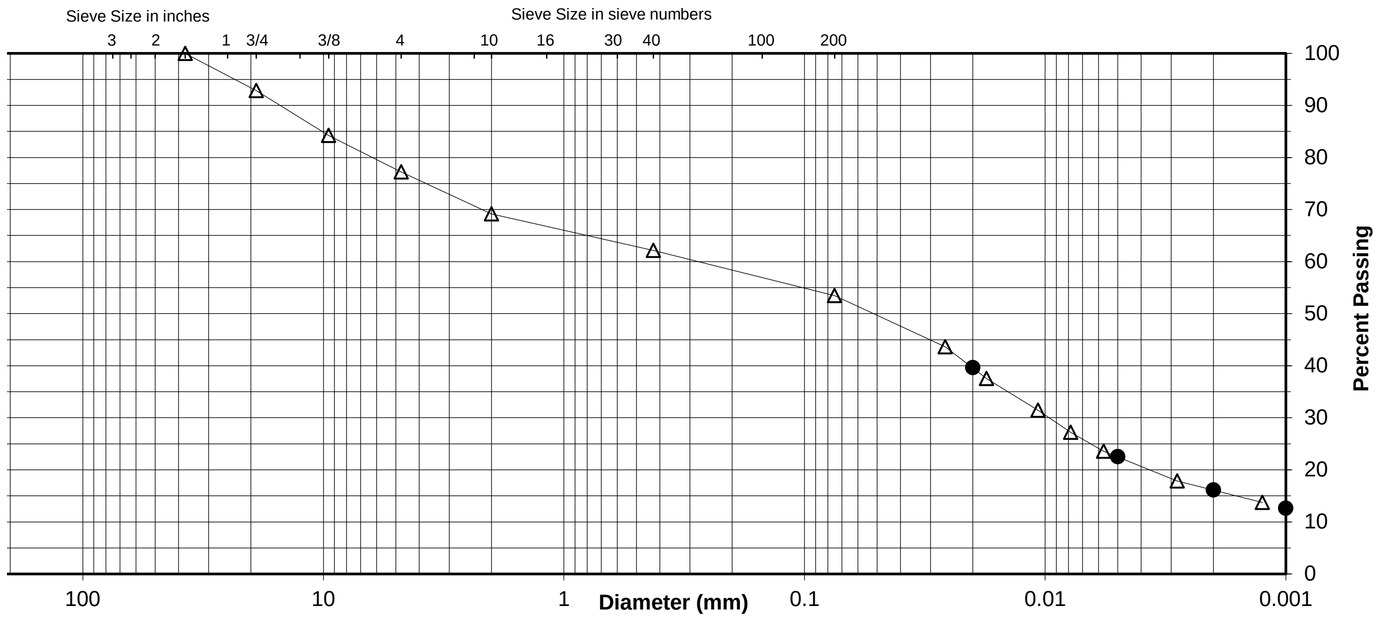
Dispersed using Apparatus A - Mechanical, for 1 minute

Sieve Size	% Passing
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	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	7.2	15.6	8.1	7.0	8.6	31.0	22.5

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	30.9	7.0	8.6	37.4	16.1



Comments ______

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Summary of Soil Tests

Project Name	IKEC Clifty Creek	Project Number	175534018
Source	CF-19-80-30-40	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		%
Sieve Size	(mm)	Passing
	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 (%)

	ASTM	AASHTO
Range	(%)	(%)
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/ft^3): N/A

Maximum Dry Density (kg/m^3): 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/ft^3): 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:

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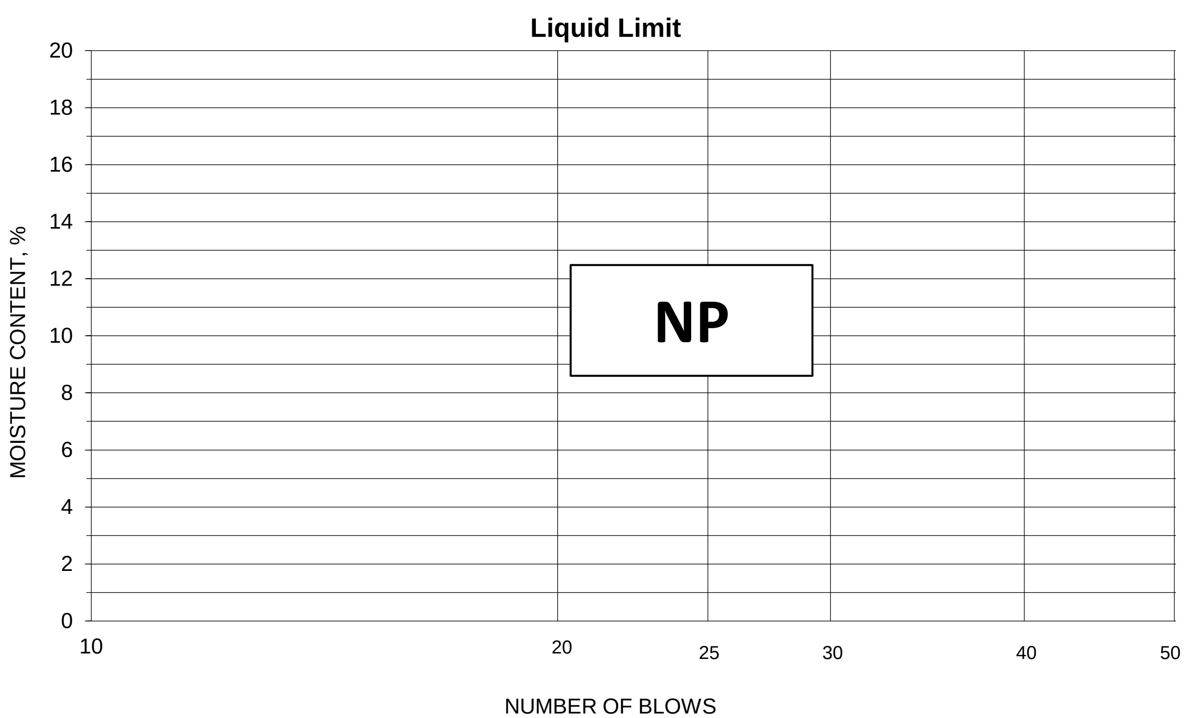
ATTERBERG LIMITS

Project	IKEC Clifty Creek	Project No.	175534018
Source	CF-19-80-30-40	Lab ID	7
		% + No. 40	12
Tested By	MP	Test Method	ASTM D 4318 Method A
Date Received	03-18-2019		
Test Date	03-19-2019	Prepared	Dry

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:

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Particle-Size Analysis of Soils

ASTM D 422

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

Maximum Particle size: 3/8" Sieve

Sieve Size	% Passing
3/8"	100.0
No. 4	99.6
No. 10	97.7

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity: 2.7

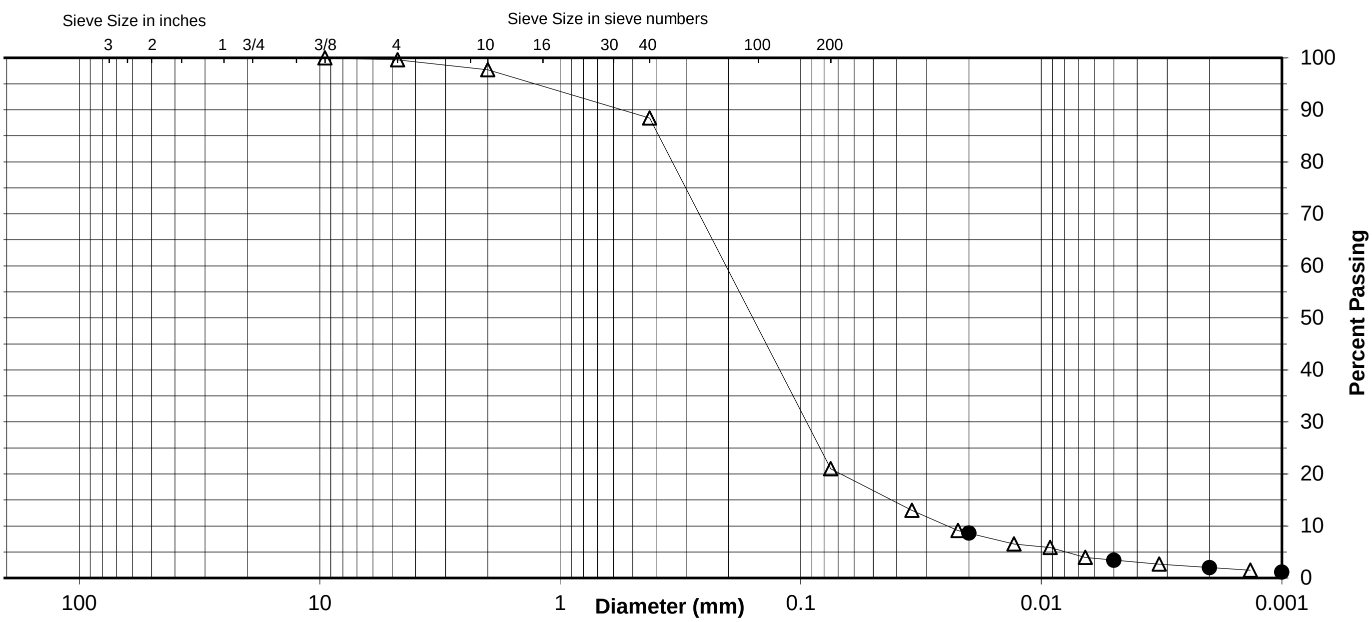
Dispersed using Apparatus A - Mechanical, for 1 minute

Sieve Size	% Passing
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	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.4	1.9	9.3	67.4	17.6	3.4

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	2.3	9.3	67.4	19.0	2.0



Comments ______

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Summary of Soil Tests

Project Name	IKEC Clifty Creek	Project Number	175534018
Source	CF-19-80-84-89	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

Particle Size Analysis

Preparation Method: ASTM D 421

Gradation Method: ASTM D 422

Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	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

Atterberg Limits

Test Method: ASTM D 4318 Method A

Prepared: Dry

Liquid Limit: 27

Plastic Limit: 16

Plasticity Index: 11

Activity Index: 1.7

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A

Maximum Dry Density (kg/m^3): 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/ft^3): 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:

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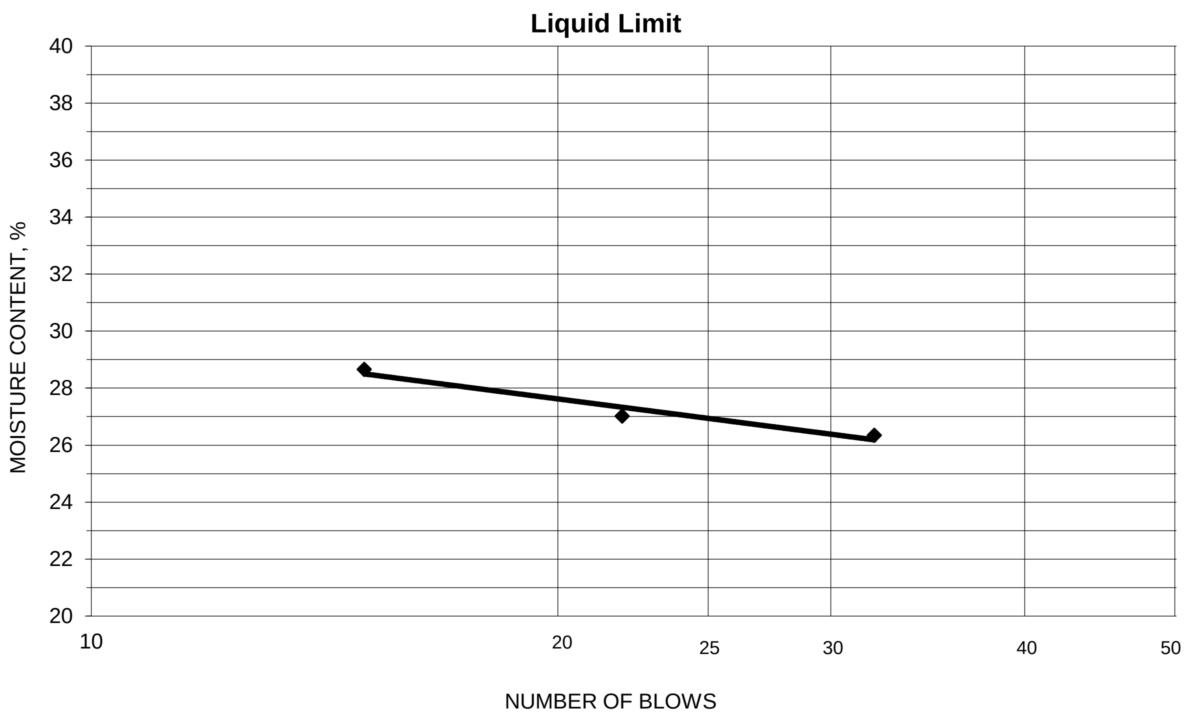
ATTERBERG LIMITS

Project	IKEC Clifty Creek	Project No.	175534018
Source	CF-19-80-84-89	Lab ID	8
		% + No. 40	65

Tested By	MP	Test Method	ASTM D 4318 Method A	Date Received	03-18-2019
Test Date	03-19-2019	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
22.33	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

Particle-Size Analysis of Soils
ASTM D 422

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

Maximum Particle size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	78.9
3/8"	61.7
No. 4	50.7
No. 10	41.1

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity: 2.7

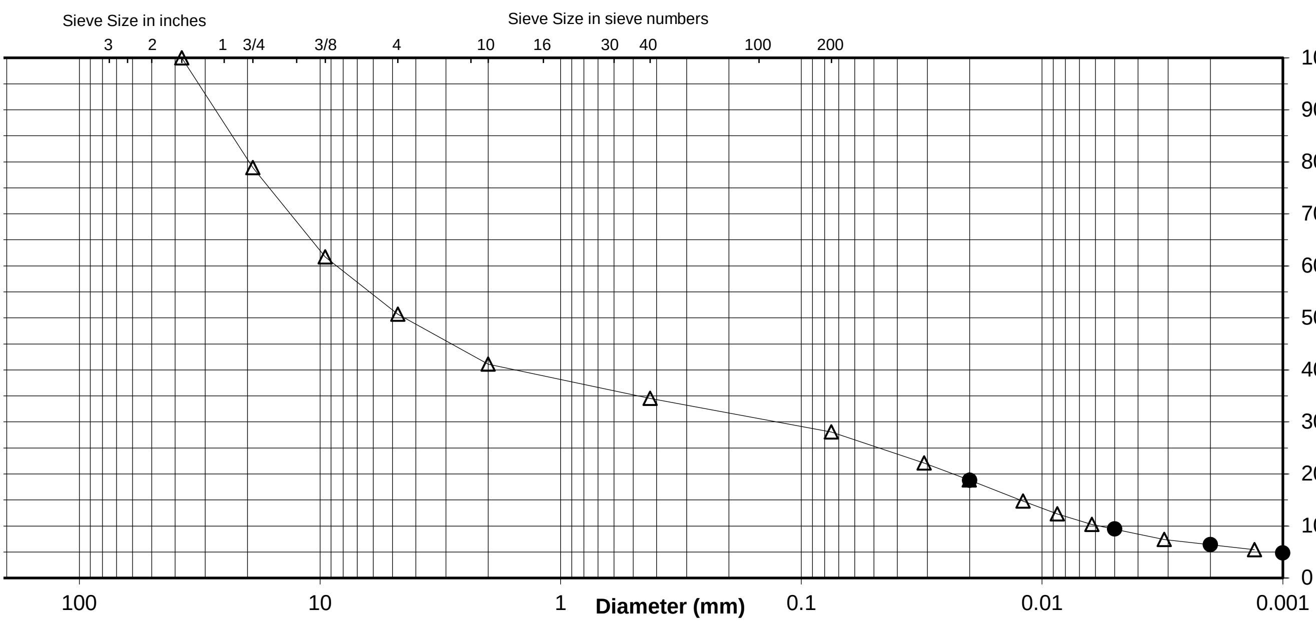
Dispersed using Apparatus A - Mechanical, for 1 minute

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

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APPENDIX D

WELL BORING AND CONSTRUCTION LOGS

BORING NO. _____CF-19-08D _
SAMPLE/CORE LOG

Project Number:	2019042	Log Page	1 of 2
Project Location:	Clifty Creek Plant LRCP	Drilling Contractor:	Bowser Morner
Drilling Date(s):	3/5/2019-3/6/2019	Geologist:	Michael Gelles

Drilling Method:	Hollow Stem Auger	Coring Device Size:	NA	Hammer Wt.	160lb	and Drop	2ft
Sampling Method:	Split Spoon	Borehole Diameter:	6”	Drilling Fluid Used:	Water		
Sampling Interval:	2’	Borehole Depth:	89’	Surface Elevation:	460.68’ MSL		

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 at14 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: 2019042

Project Location: Clifty Creek Plant – LRCP

Installation Date(s): 3/5/2019-3/8/2019

Drilling Method: Hollow Stem Auger

Drilling Contractor: Bowser Morner

Development Date(s): 3/14/2019-3/20/2019

Development Method: Submersible Pump and Bladder Pump

Field parameters stabilized.

Volume Purged: 52 gallons

Static Water-Level* 20.71’

Top of Well Casing Elevation: 463.49’

Well Purpose:
Groundwater Monitoring

Northing (Y): 443224.617

Easting (X): 562551.033

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: Michael Gelles

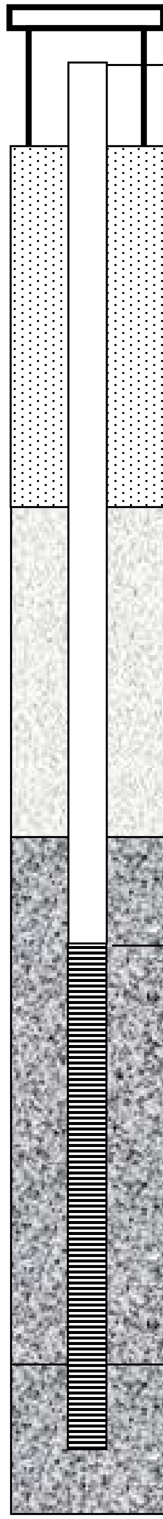
CONSTRUCTION MATERIALS USED:

3.5 Bags of Sand

1 Bags/Buckets Bentonite Pellets

10 Bags Portland for Grout

____ Bags Concrete/Sakrete



Protective Casing with Locking Cap

Top of Casing Elevation: 463.49 ft.

Stick-up: 2.81 ft.

Land Surface Elevation: 460.68 ft.

Grout; Type: Portland cement/ Grout

Borehole Diameter: 6 inch

Casing Diameter: 2 Inch

Casing Material: PVC

Top of Seal: 81 ft*

Seal Type: Bentonite Pellets/Chips

Top of Sand/Gravel Pack: 83 ft*

Top of Well Screen 84 ft*

Sand/Gravel Pack; Type: Global #5

Screen Diameter: 2 Inch

Screen Slot-Size: 0.010 Inch

Screen Material: PVC

Bottom of Well Screen 89 ft.*

Base of Borehole: 89 ft.*

Total Depth of Well Below Top of Casing: 91.81 ft.

*Indicates Depth Below Land Surface

BORING NO. ____CF-19-14_
SAMPLE/CORE LOG

Project Number:	2019042	Log Page	1 of 1
Project Location:	Clifty Creek Plant LRCP	Drilling Contractor:	Bowser Morner
Drilling Date(s):	3/7/2019	Geologist:	Michael Gelles

Drilling Method:	Hollow Stem Auger	Coring Device Size:	NA	Hammer Wt.	160lb and Drop 2ft
Sampling Method:	Split Spoon	Borehole Diameter:	6”	Drilling Fluid Used:	Water
Sampling Interval:	2’	Borehole Depth:	20’	Surface Elevation:	452.29’ msl

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: 2019042

Project Location: Clifty Creek Plant – LRCP

Installation Date(s): 3/7/2019-3/8/2019

Drilling Method: Hollow Stem Auger
Drilling Contractor: Bowser Morner

Development Date(s): 3/14/2019-3/20/2019

Development Method: Submersible Pump and Bladder Pump
Field parameters stabilized.

Volume Purged: 16.5 gallons

Static Water-Level* 7.09’

Top of Well Casing Elevation: 454.88’

Well Purpose:
Groundwater Monitoring
Northing (Y): 443401.75
Easting (X): 562901.929

Comments/Notes:
2 inch PVC riser and screen
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.

Inspector: Michael Gelles

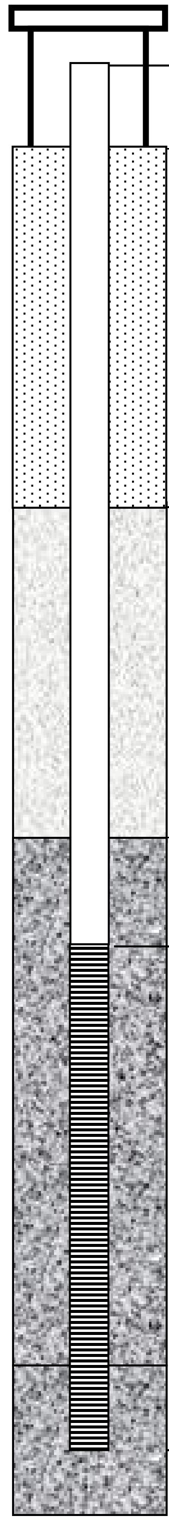
CONSTRUCTION MATERIALS USED:

6.5 Bags of Sand

1 Bags/Buckets Bentonite Pellets

2 Bags Portland for Grout

____ Bags Concrete/Sakrete



Protective Casing with Locking Cap

Top of Casing Elevation: 454.88 ft.
Stick-up: 2.59 ft.

Land Surface Elevation: 452.29 ft.

Grout; Type: Portland cement/ Grout

Borehole Diameter: 6 inch

Casing Diameter: 2 Inch
Casing Material: PVC
Top of Seal: 7 ft*

Seal Type: Bentonite Pellets/Chips

Top of Sand/Gravel Pack: 9 ft*

Top of Well Screen 10 ft*

Sand/Gravel Pack; Type: Global #5

Screen Diameter: 2 Inch
Screen Slot-Size: 0.010 Inch
Screen Material: PVC

Bottom of Well Screen 20 ft.*

Base of Borehole: 20 ft.*

Total Depth of Well Below Top of Casing: 22.59 ft.

*Indicates Depth Below Land Surface

BORING NO. CF-19-15
SAMPLE/CORE LOG

Project Number:	2019042	Log Page	1 of 1
Project Location:	Clifty Creek Plant LRCP	Drilling Contractor:	Bowser Morner
Drilling Date(s):		Geologist:	Michael Gelles

Drilling Method:	Hollow Stem Auger	Coring Device Size:	NA	Hammer Wt.	160lb and Drop 2ft
Sampling Method:	Split Spoon	Borehole Diameter:	6”	Drilling Fluid Used:	Water
Sampling Interval:	2’	Borehole Depth:	33’	Surface Elevation:	441.10’ msl

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: 2019042

Project Location: Clifty Creek Plant – LRCP

Installation Date(s): 3/13/2019

Drilling Method: Hollow Stem Auger
Drilling Contractor: Bowser Morner

Development Date(s): 3/14/2019-3/21/2019

Development Method: Submersible Pump and Bladder Pump
Field parameters stabilized.

Volume Purged: 24 gallons

Static Water-Level* 9.90’

Top of Well Casing Elevation: 443.61’

Well Purpose:
Groundwater Monitoring
Northing (Y): 442704.784
Easting (X): 562483.023

Comments/Notes:
2 inch PVC riser and screen
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.

Inspector: Michael Gelles

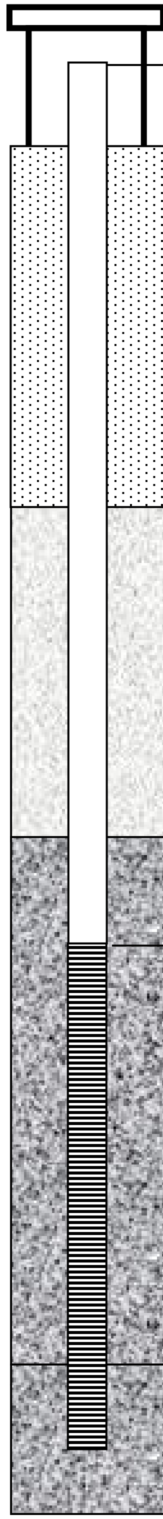
CONSTRUCTION MATERIALS USED:

6 Bags of Sand

1 Bags/Buckets Bentonite Pellets

3 Bags Portland for Grout

____ Bags Concrete/Sakrete



Protective Casing with Locking Cap

Top of Casing Elevation: 443.61 ft.
Stick-up: 2.51 ft.

Land Surface Elevation: 441.10 ft.

Grout; Type: Portland cement/ Grout

Borehole Diameter: 6 inch

Casing Diameter: 2 Inch
Casing Material: PVC
Top of Seal: 20 ft*

Seal Type: Bentonite Pellets

Top of Sand/Gravel Pack: 22 ft*

Top of Well Screen 23 ft*

Sand/Gravel Pack; Type: Global #5

Screen Diameter: 2 Inch
Screen Slot-Size: 0.010 Inch
Screen Material: PVC

Bottom of Well Screen 33 ft.*

Base of Borehole: 33 ft.*

Total Depth of Well Below Top of Casing: 35.51 ft.

*Indicates Depth Below Land Surface

BORING NO. _ ____CF-19-15D _
SAMPLE/CORE LOG

Project Number:	2019042	Log Page	1 of 2
Project Location:	Clifty Creek Plant LRCP	Drilling Contractor:	Bowser Morner
Drilling Date(s):	3/11/2019-3/12/2019	Geologist:	Michael Gelles

Drilling Method:	Hollow Stem Auger	Coring Device Size:	NA	Hammer Wt. 160lb	and Drop 2ft
Sampling Method:	Split Spoon	Borehole Diameter:	6”	Drilling Fluid Used:	Water
Sampling Interval:	2’	Borehole Depth:	72’	Surface Elevation:	441.78’ MSL

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: 2019042

Project Location: Clifty Creek Plant – LRCP

Installation Date(s): 3/11/2019-3/12/2019

Drilling Method: Hollow Stem Auger
Drilling Contractor: Bowser Morner

Development Date(s): 3/14/2019-3/21/2019

Development Method: Submersible Pump and Bladder Pump
Field parameters stabilized.

Volume Purged: 48 gallons

Static Water-Level* 15.51'

Top of Well Casing Elevation: 444.34'

Well Purpose:
Groundwater Monitoring
Northing (Y): 442713.897
Easting (X): 562487.596

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: Michael Gelles

CONSTRUCTION MATERIALS USED:

3.5 Bags of Sand

1 Bags/Buckets Bentonite Pellets

6 Bags Portland for Grout

___ 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.*

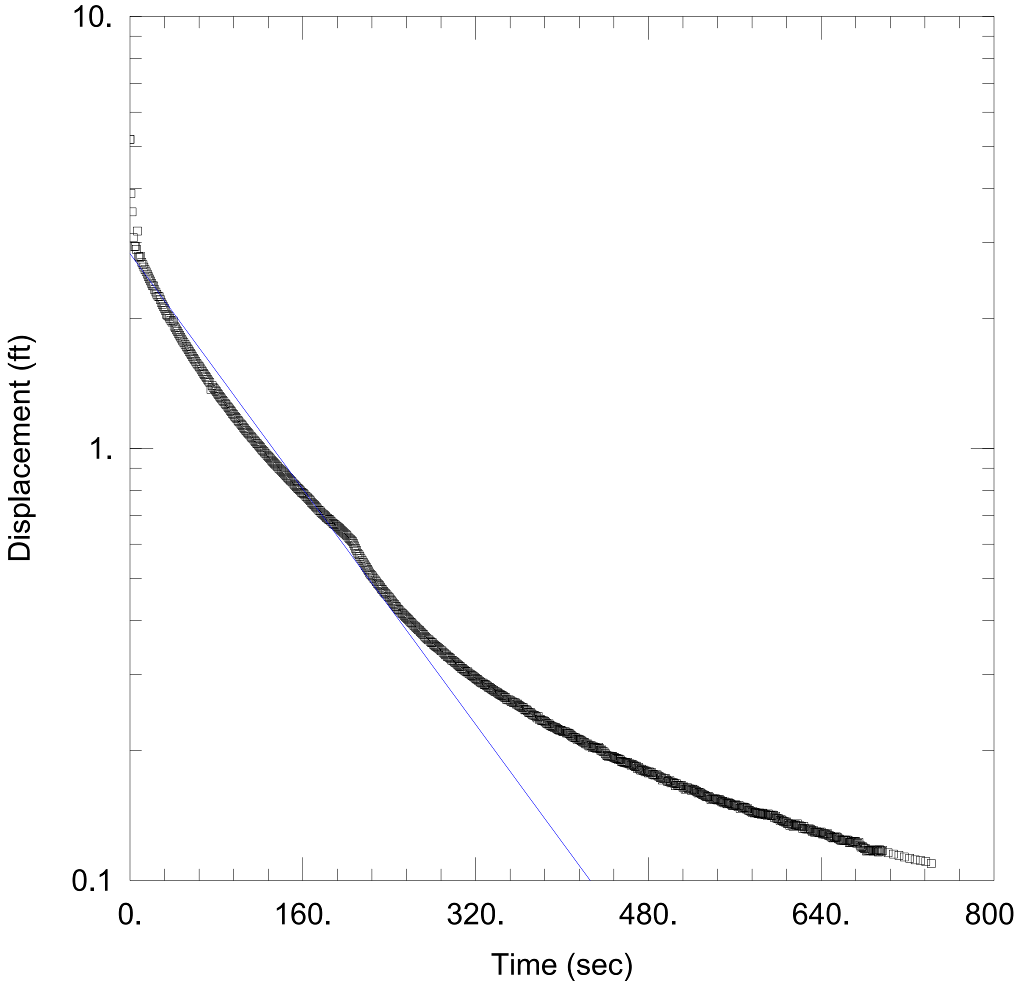
Base of Borehole: 70 ft.*

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.

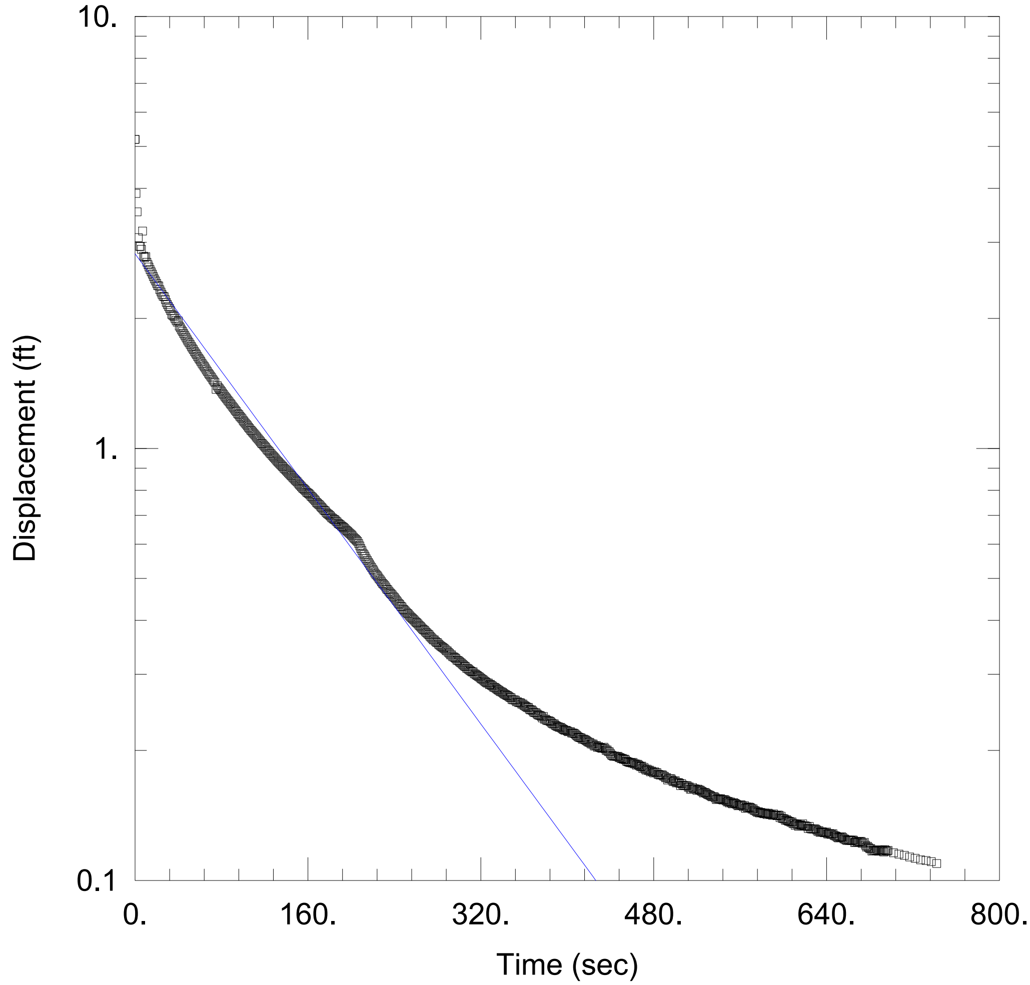
WELL DATA (CF-19-08D)

Initial Displacement: 5.191 ft
Static Water Column Height: 65.31 ft
Total Well Penetration Depth: 89.9 ft
Screen Length: 10. ft
Casing Radius: 0.083 ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.361E-5 ft/sec
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)

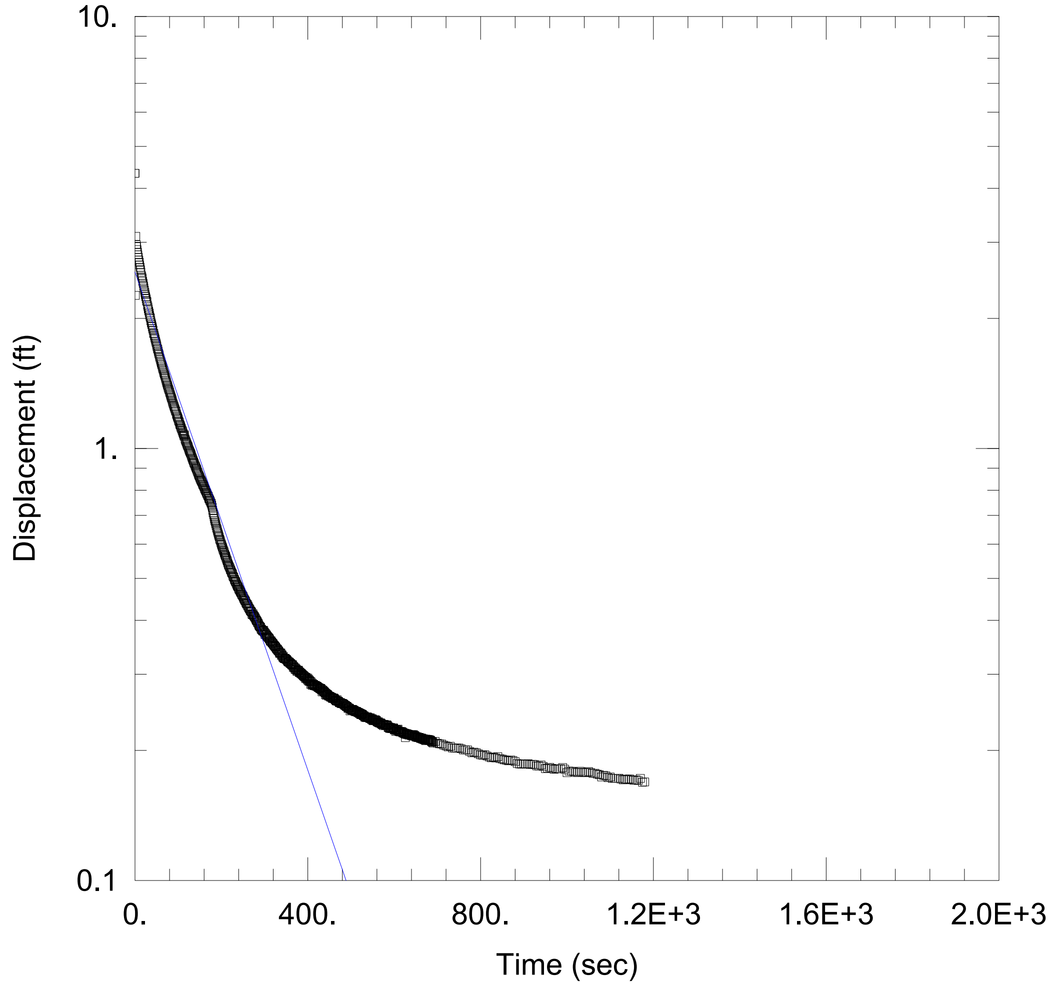
Initial Displacement: 5.191 ft
Total Well Penetration Depth: 89.9 ft
Casing Radius: 0.083 ft

Static Water Column Height: 65.31 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 1.429E-5 ft/sec 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.

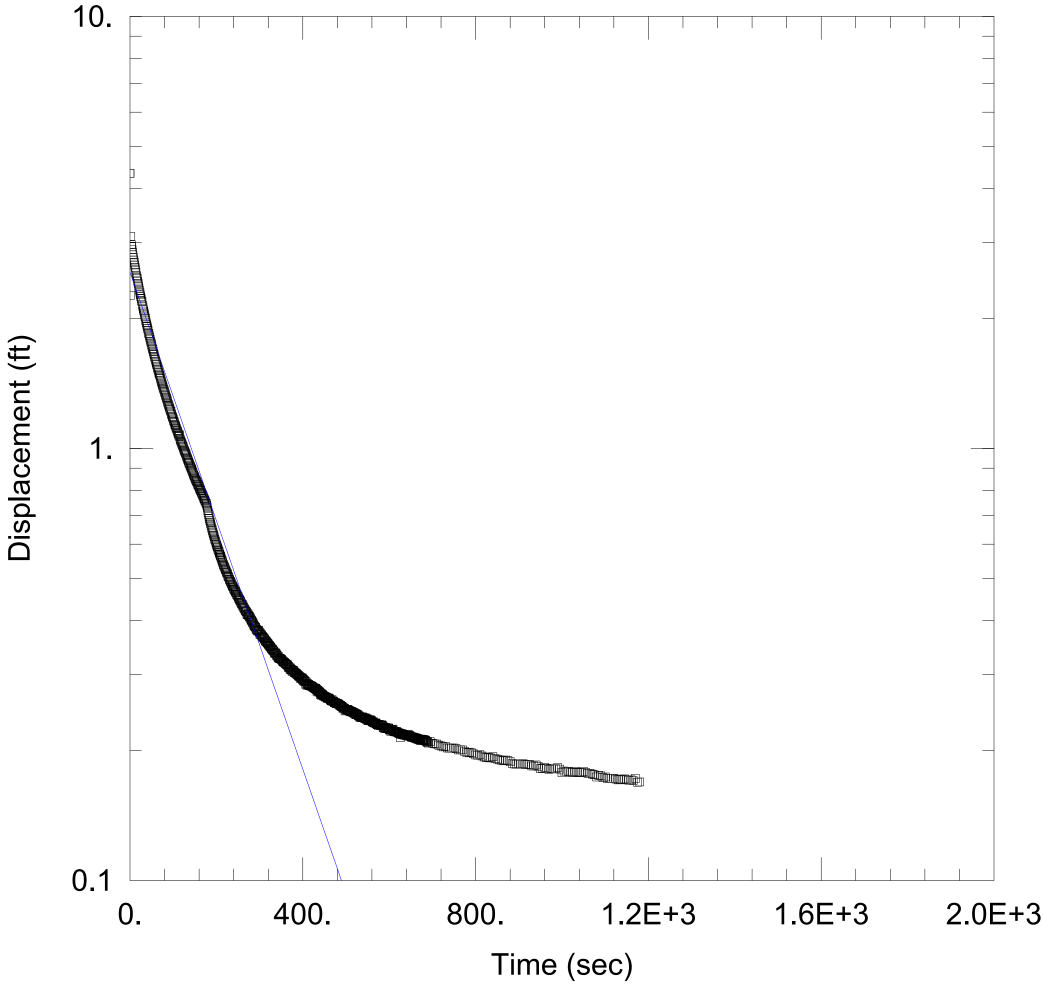
WELL DATA (CF-19-08D)

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
Solution Method: Bouwer-Rice

K = 1.152E-5 ft/sec
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.

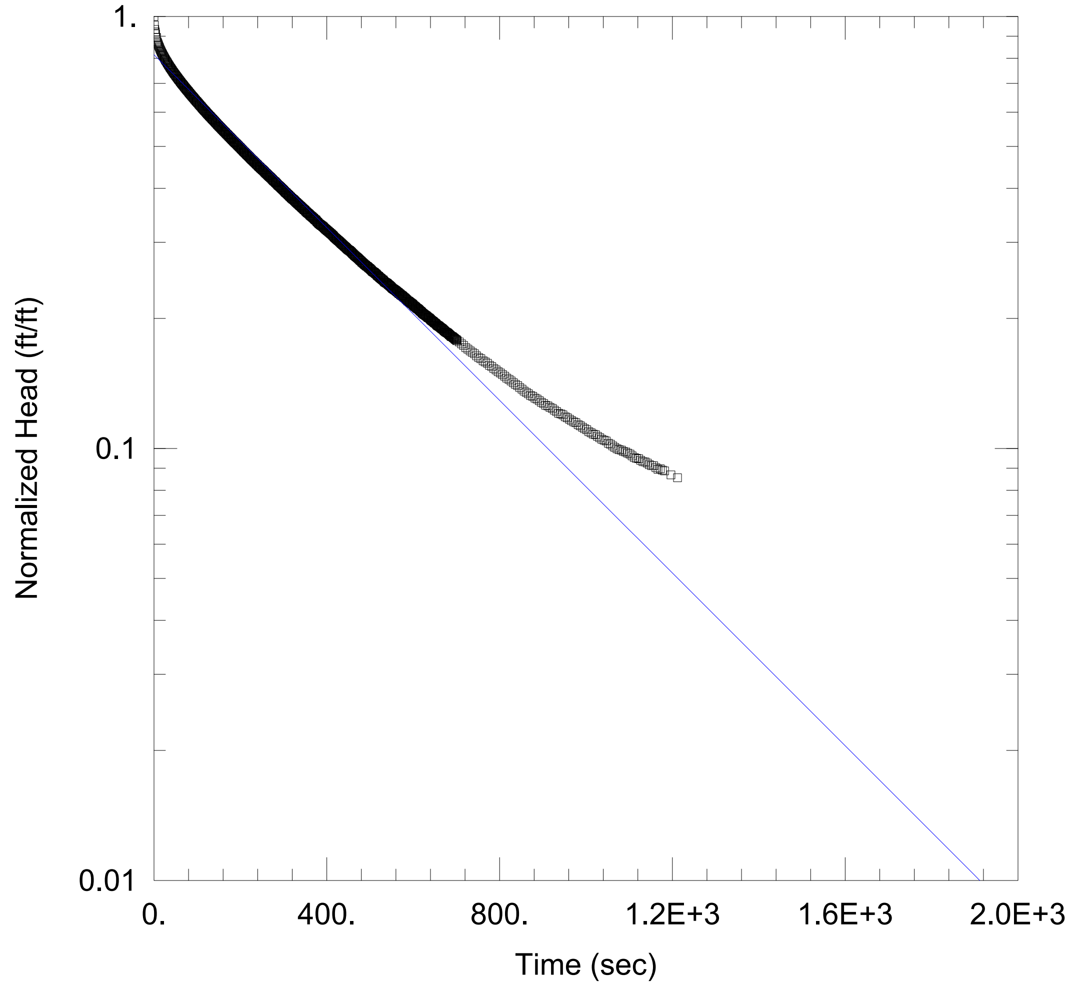
WELL DATA (CF-19-08D)

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 Solution Method: Hvorslev

K = 1.209E-5 ft/sec 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.

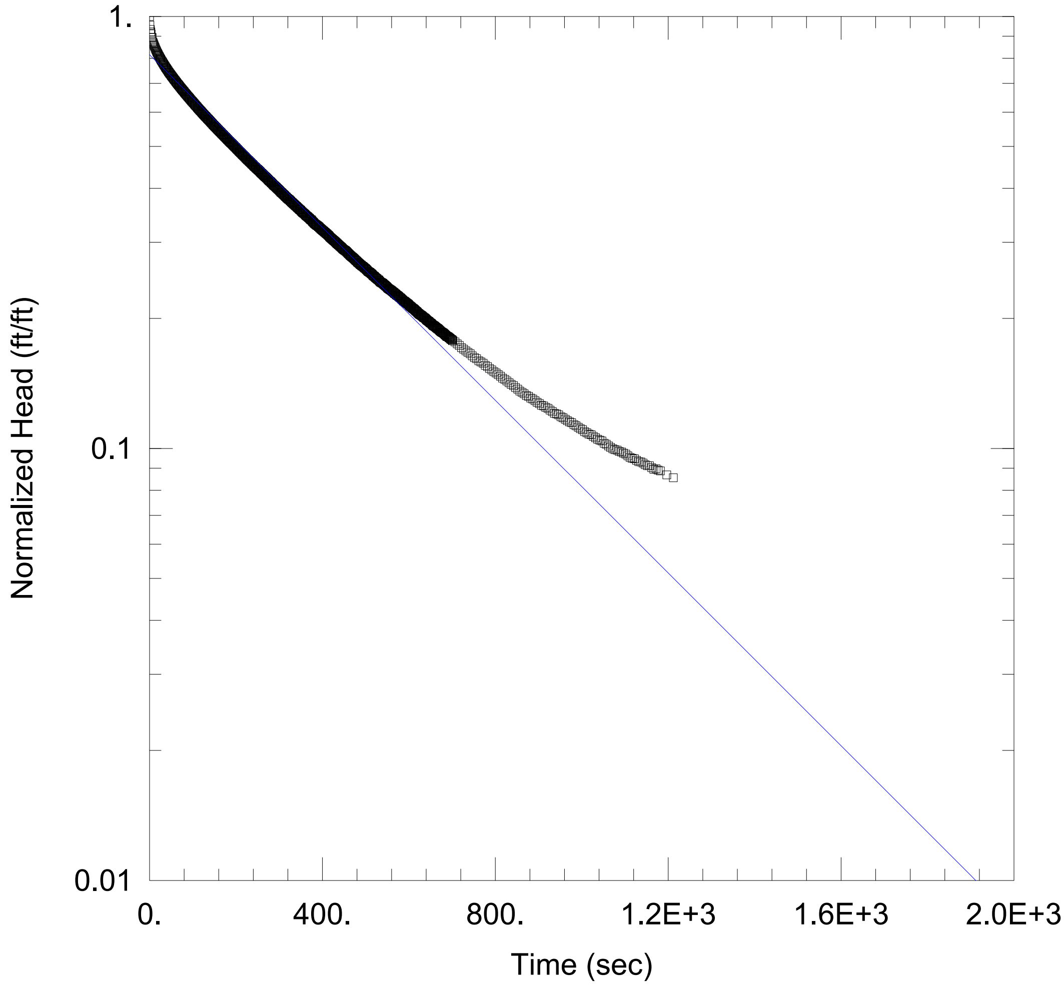
WELL DATA (CF-19-08D)

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
Solution Method: Bouwer-Rice

K = 3.995E-6 ft/sec
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.

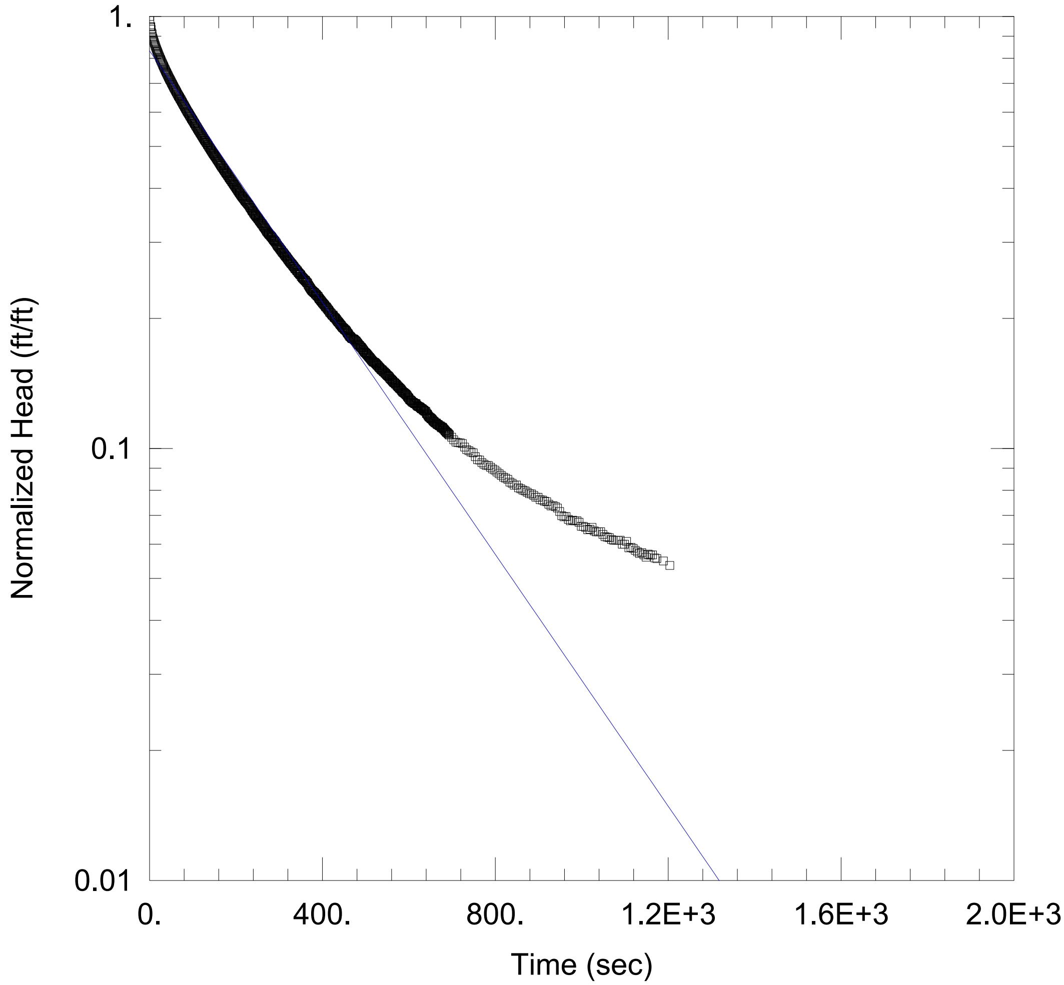
WELL DATA (CF-19-08D)

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 Solution Method: Hvorslev

K = 4.201E-6 ft/sec 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.

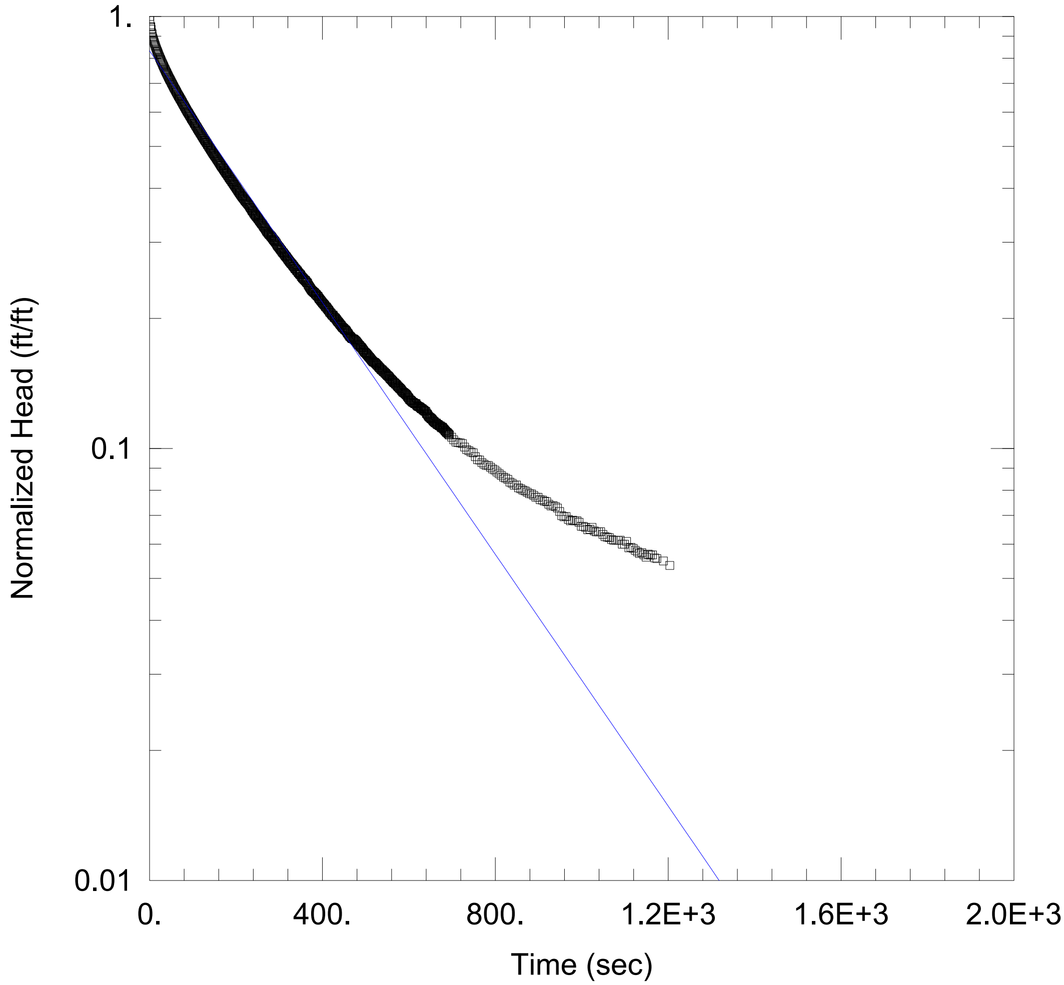
WELL DATA (CF-19-08D)

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
Solution Method: Bouwer-Rice

K = 5.823E-6 ft/sec
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.

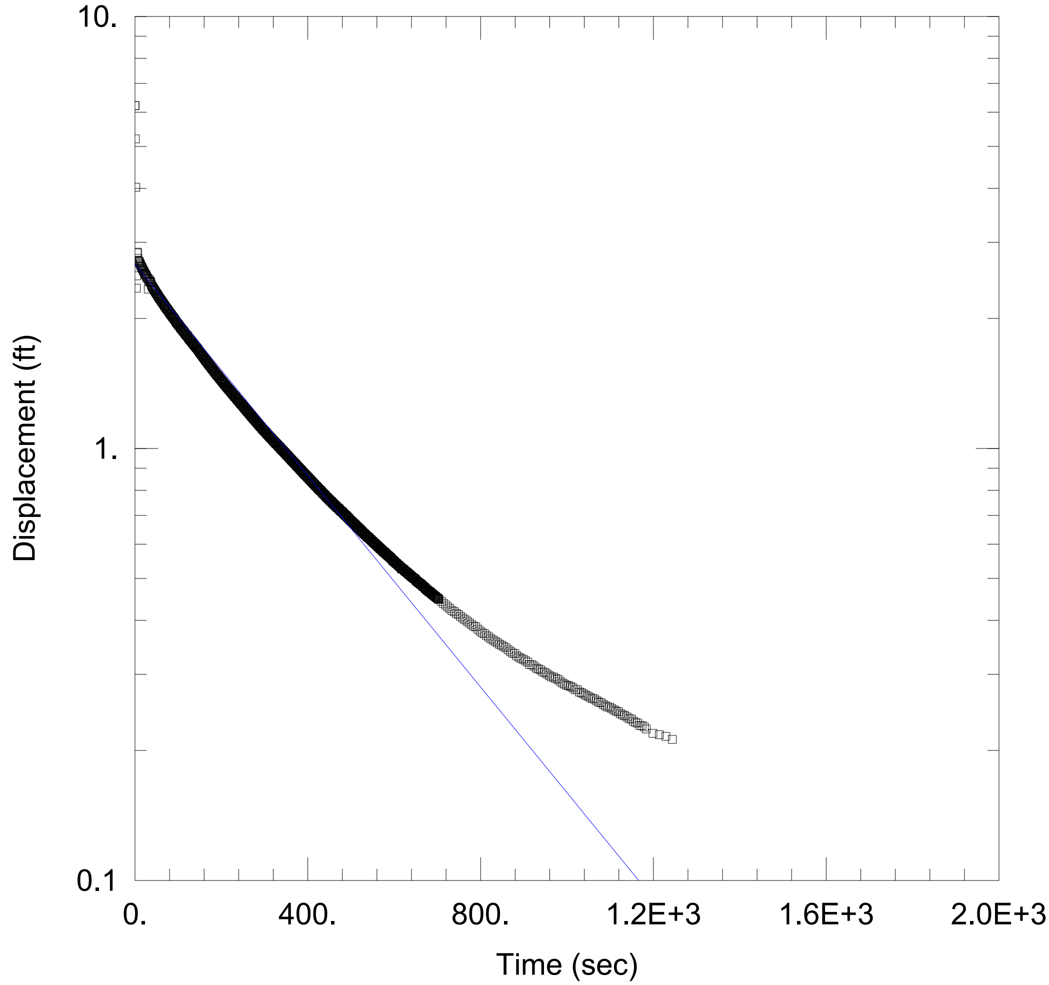
WELL DATA (CF-19-08D)

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
Solution Method: Hvorslev

K = 6.122E-6 ft/sec
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)

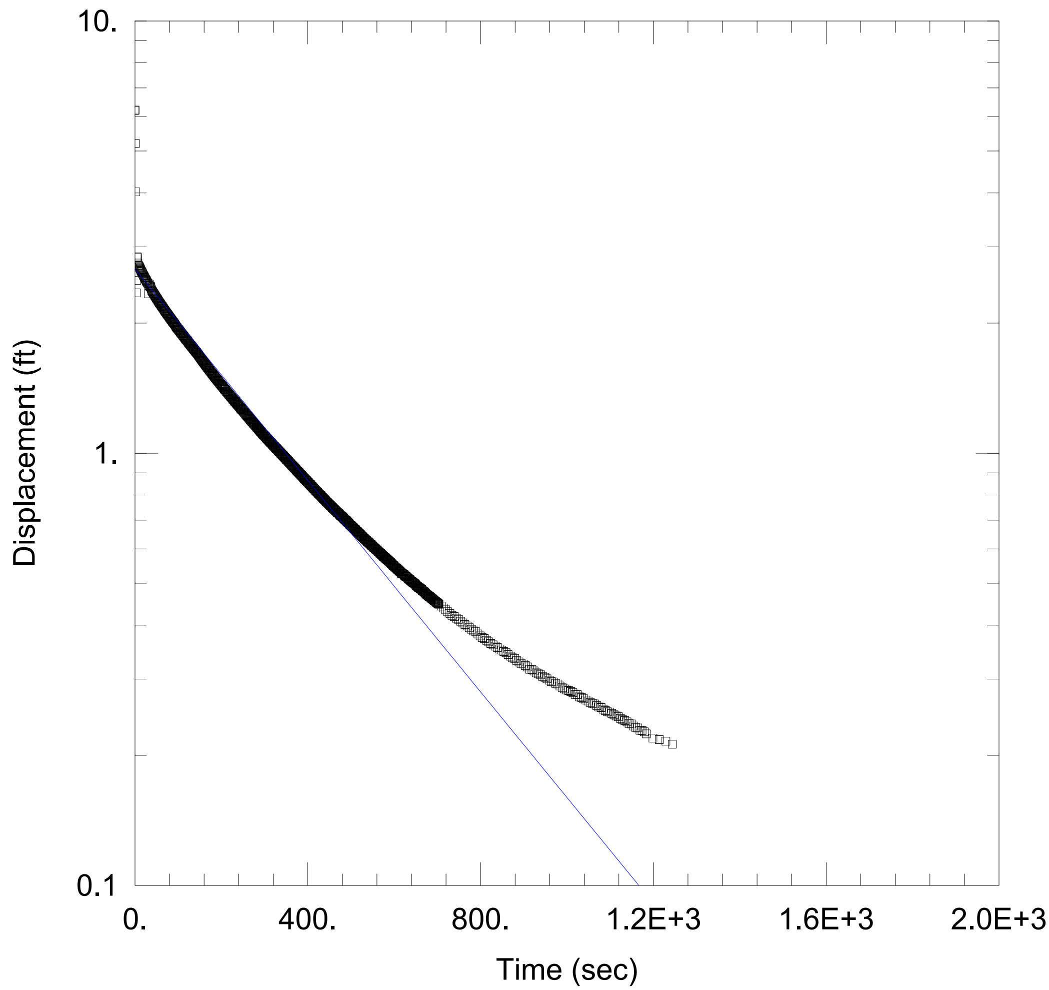
Initial Displacement: 6.214 ft
Total Well Penetration Depth: 22. ft
Casing Radius: 0.0833 ft

Static Water Column Height: 14.05 ft
Screen Length: 10. ft
Well Radius: 0.0833 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 4.099E-6 ft/sec 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.

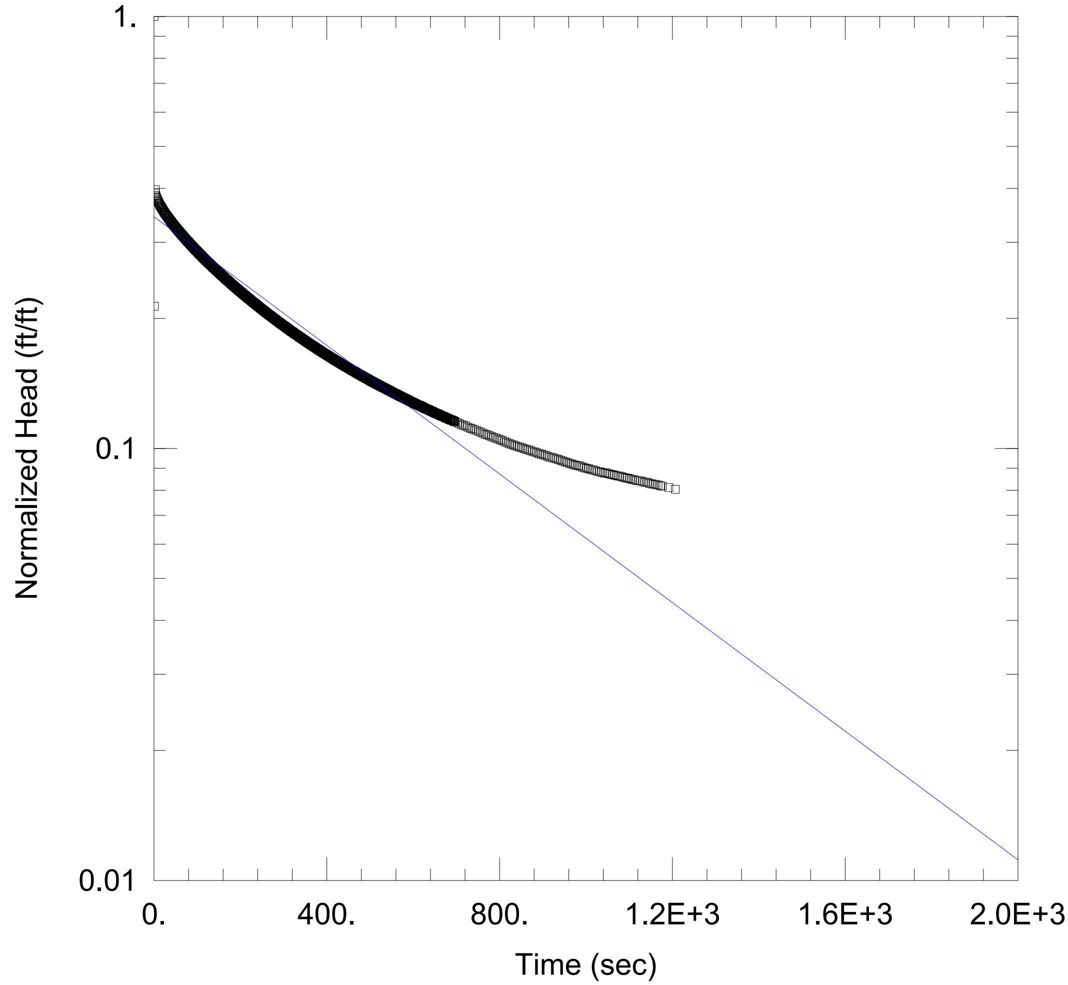
WELL DATA (CF-19-14)

Initial Displacement: 6.214 ft   Static Water Column Height: 14.05 ft
Total Well Penetration Depth: 22. ft   Screen Length: 10. ft
Casing Radius: 0.0833 ft   Well Radius: 0.0833 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined   Solution Method: Hvorslev

K = 5.354E-6 ft/sec   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.

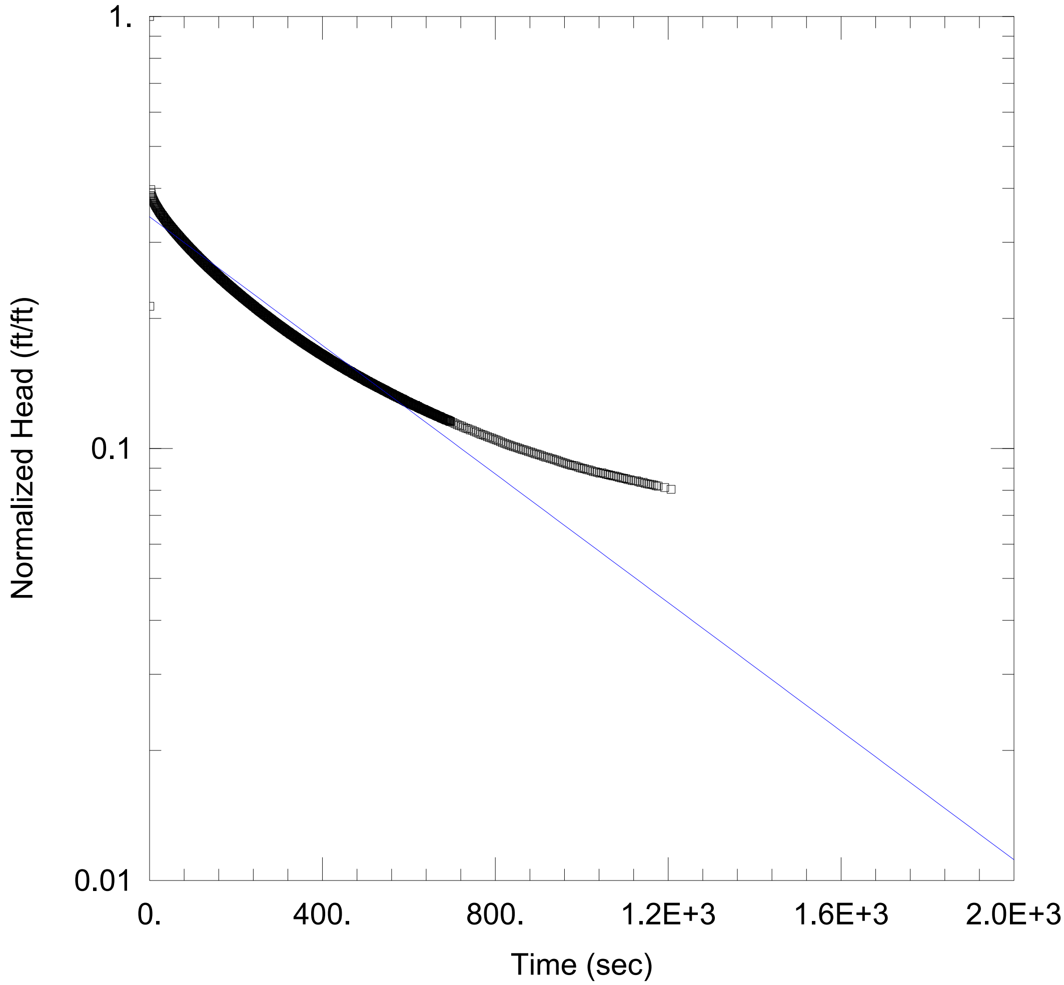
WELL DATA (CF-19-14)

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 Solution Method: Bouwer-Rice

K = 2.498E-6 ft/sec 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.

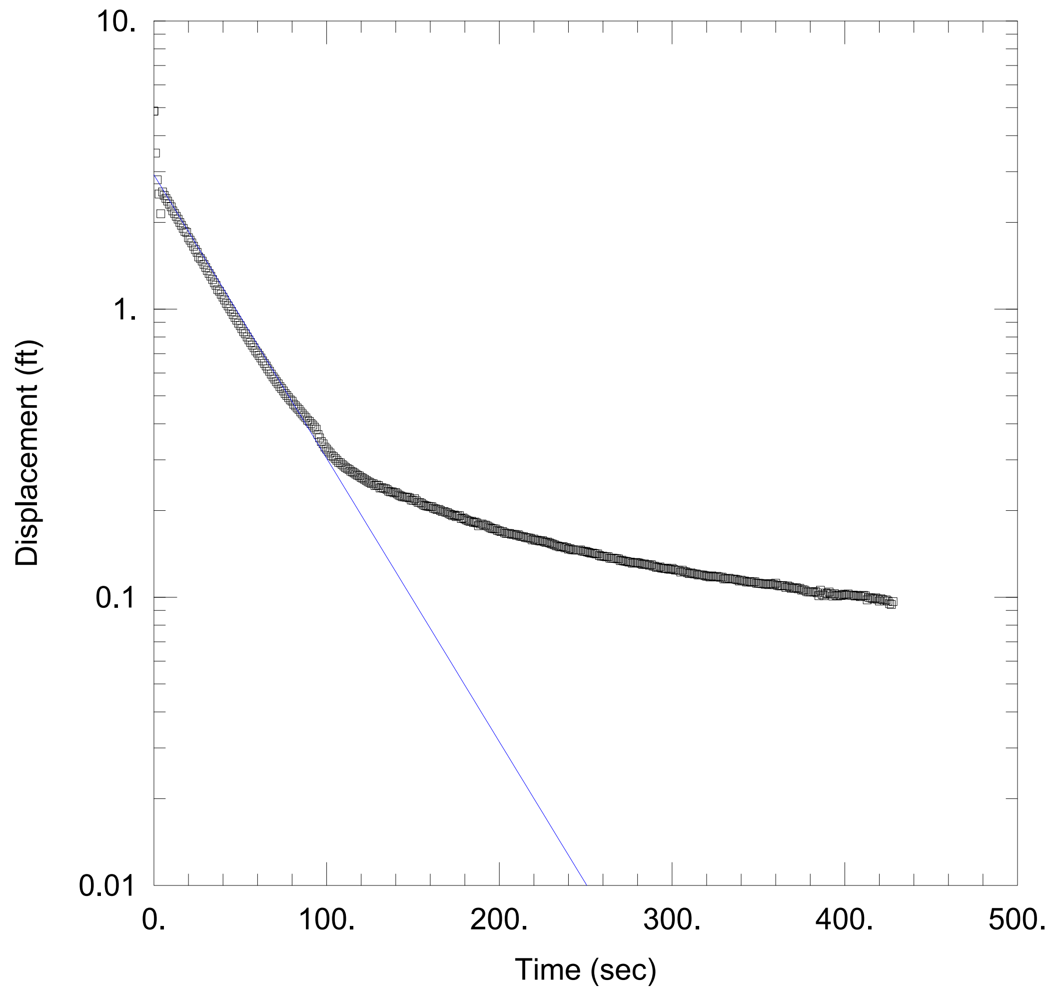
WELL DATA (CF-19-14)

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
Solution Method: Hvorslev

K = 3.258E-6 ft/sec
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.

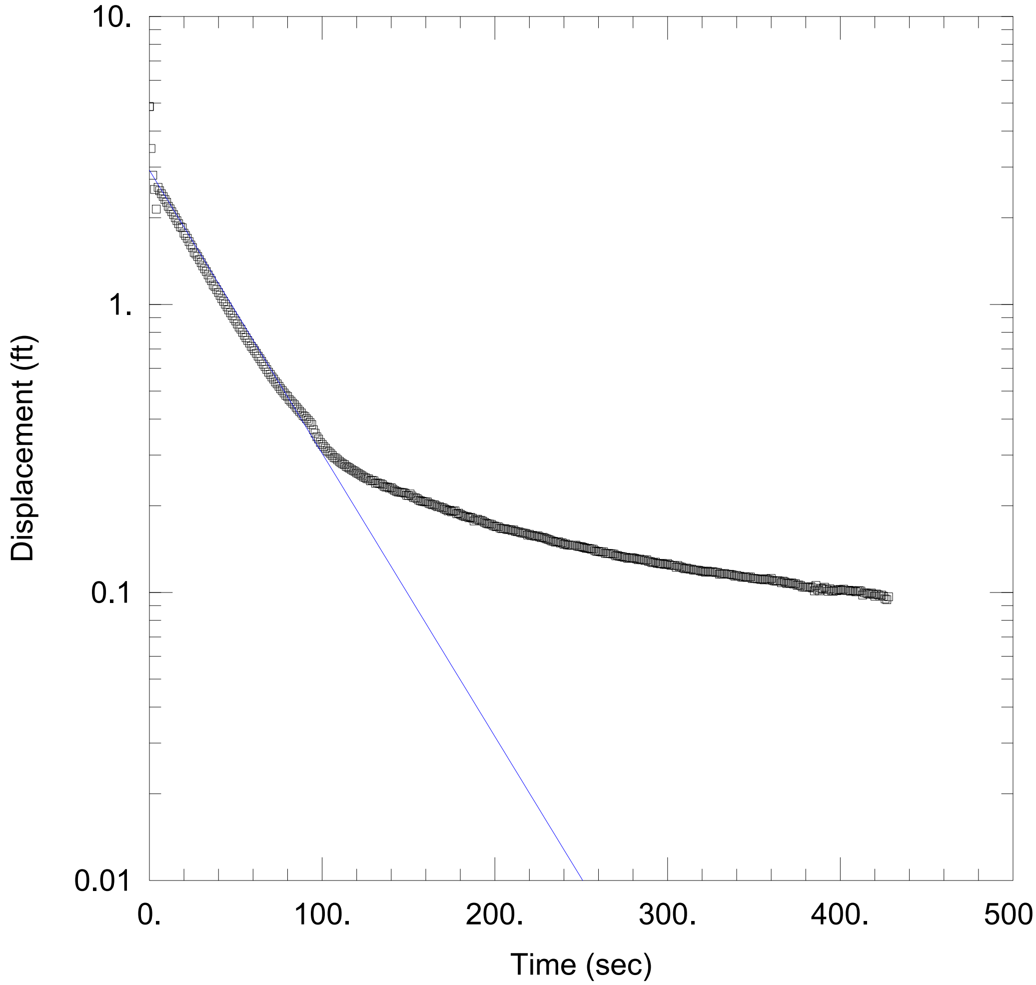
WELL DATA (CF-19-15D)

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
Solution Method: Bouwer-Rice

K = 4.728E-5 ft/sec
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.

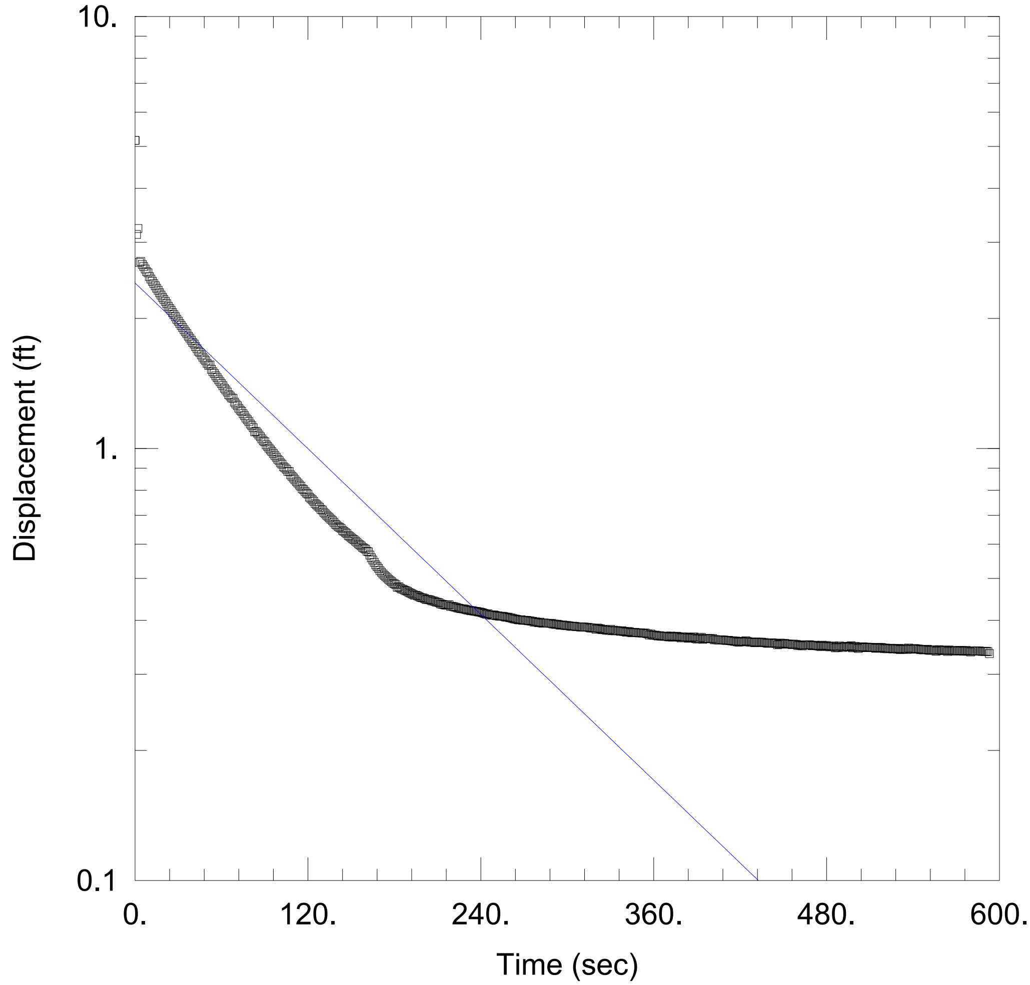
WELL DATA (CF-19-15D)

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 Solution Method: Hvorslev

K = 5.163E-5 ft/sec 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.

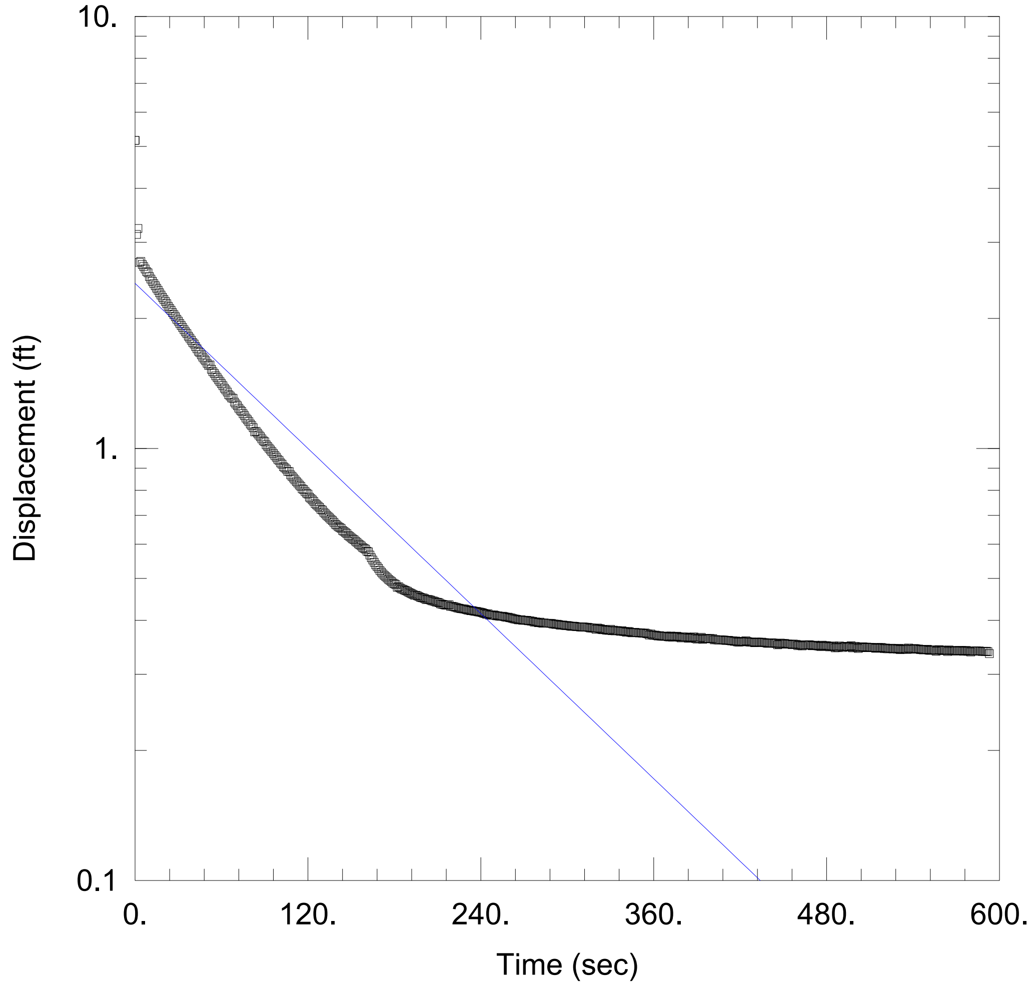
WELL DATA (CF-19-15D)

Initial Displacement: 5.168 ft Static Water Column Height: 53.91 ft
Total Well Penetration Depth: 72.07 ft Screen Length: 10. ft
Casing Radius: 0.083 ft Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.536E-5 ft/sec 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.

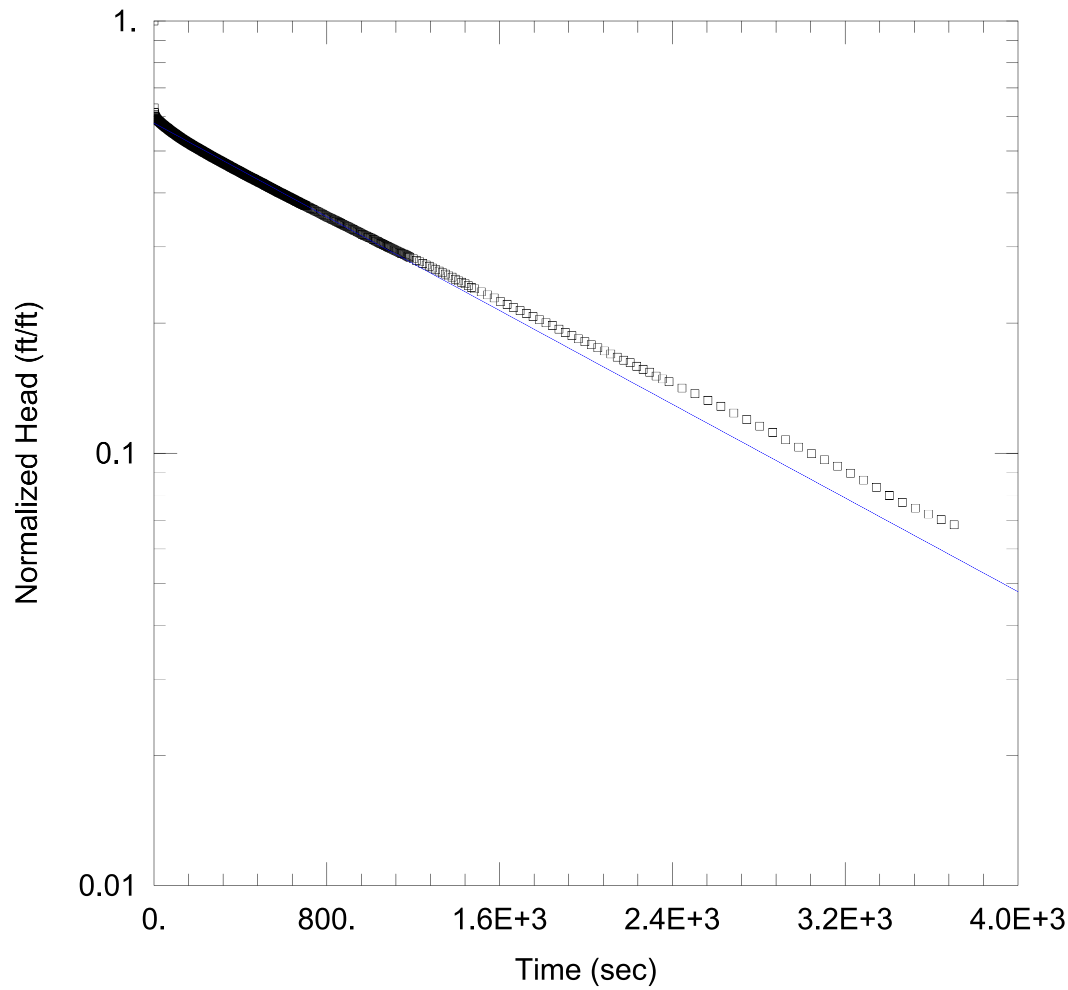
WELL DATA (CF-19-15D)

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
Solution Method: Hvorslev

K = 1.673E-5 ft/sec
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.

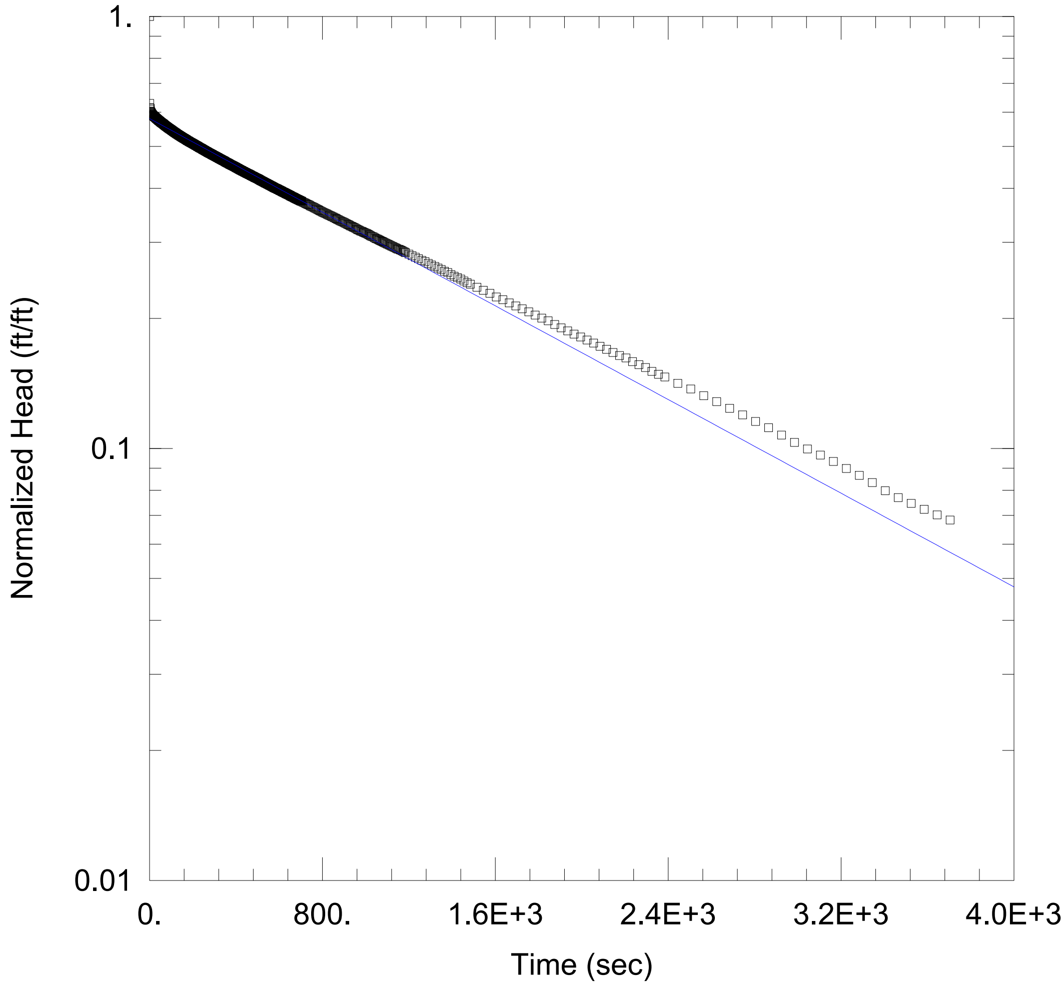
WELL DATA (CF-19-15D)

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
Solution Method: Bouwer-Rice

K = 1.303E-6 ft/sec
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.

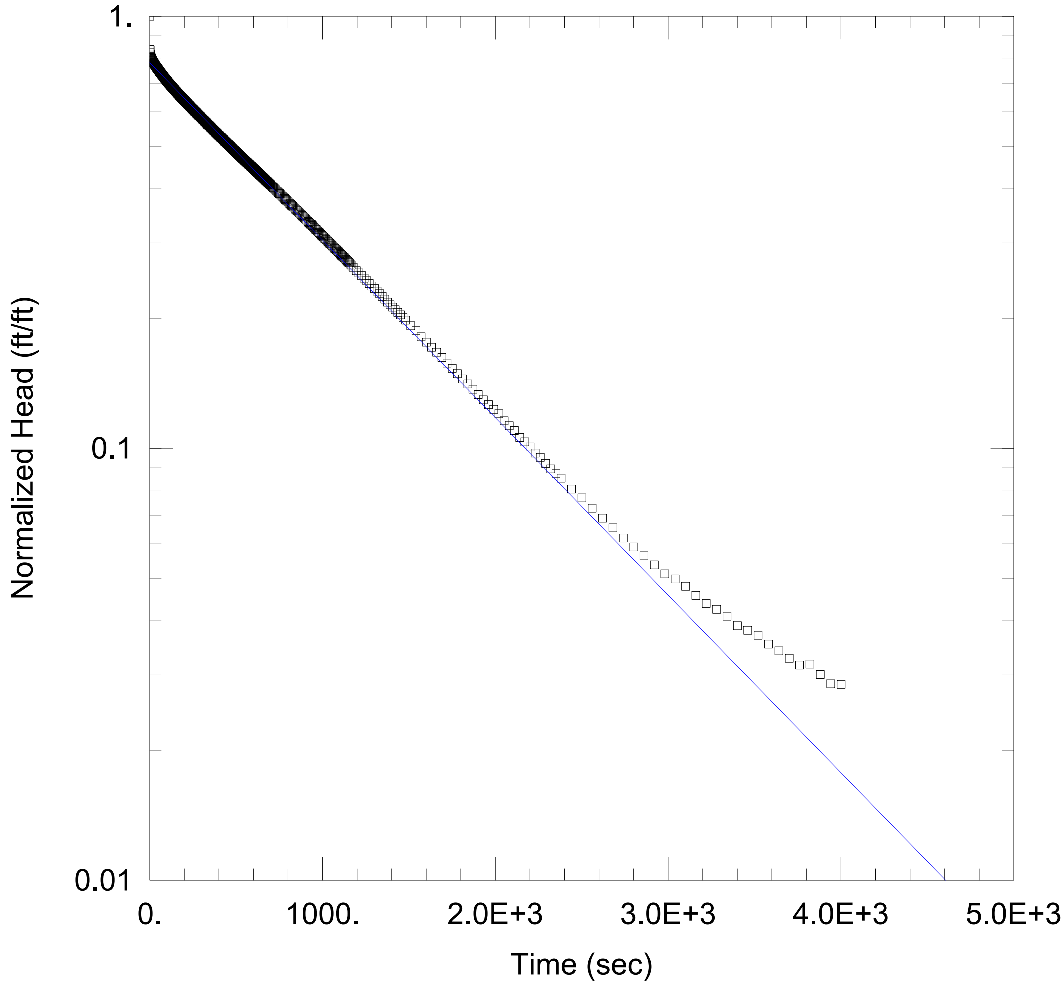
WELL DATA (CF-19-15D)

Initial Displacement: -5.008 ft Static Water Column Height: 53.91 ft
Total Well Penetration Depth: 72.07 ft Screen Length: 10. ft
Casing Radius: 0.083 ft Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 1.424E-6 ft/sec 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.

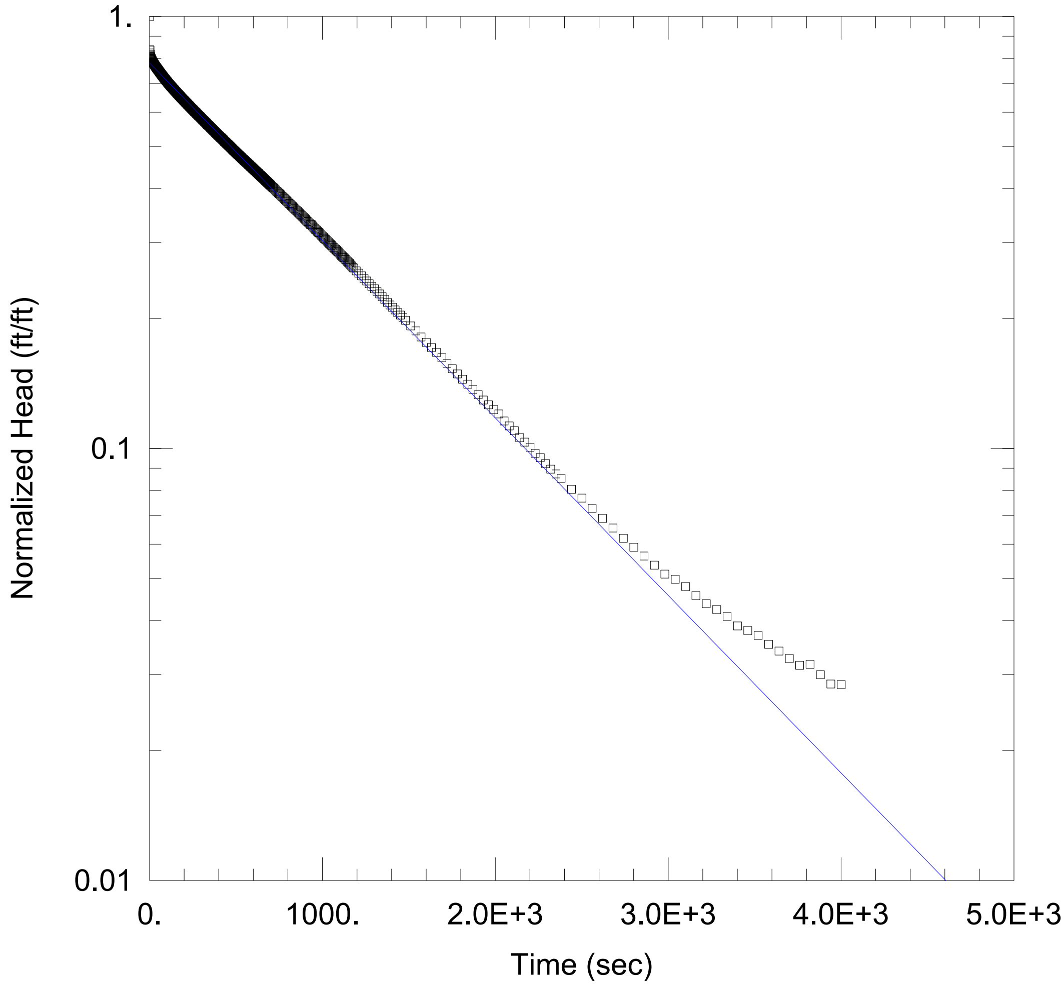
WELL DATA (CF-19-15D)

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
Solution Method: Bouwer-Rice

K = 1.975E-6 ft/sec
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.

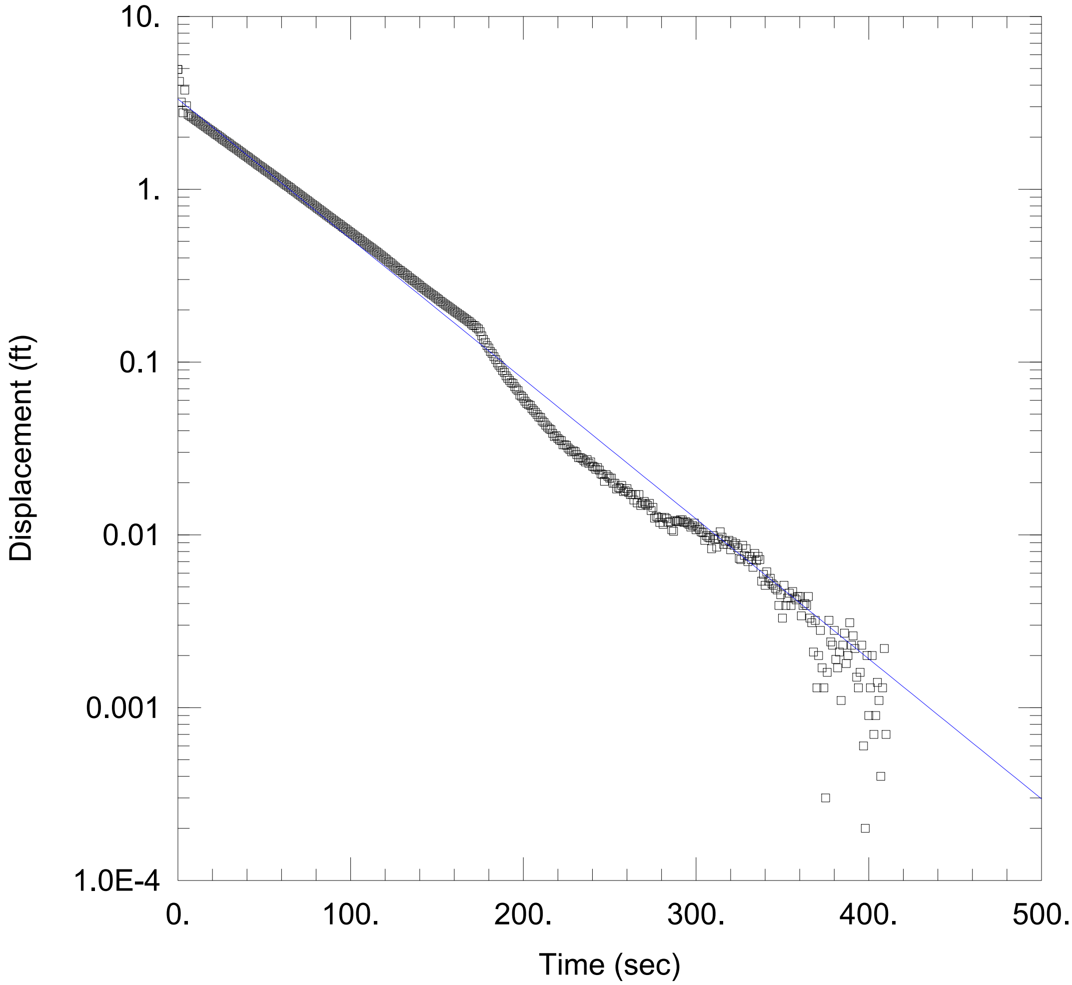
WELL DATA (CF-19-15D)

Initial Displacement: -3.748 ft
Static Water Column Height: 53.91 ft
Total Well Penetration Depth: 72.07 ft
Screen Length: 10. ft
Casing Radius: 0.083 ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 2.158E-6 ft/sec
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.

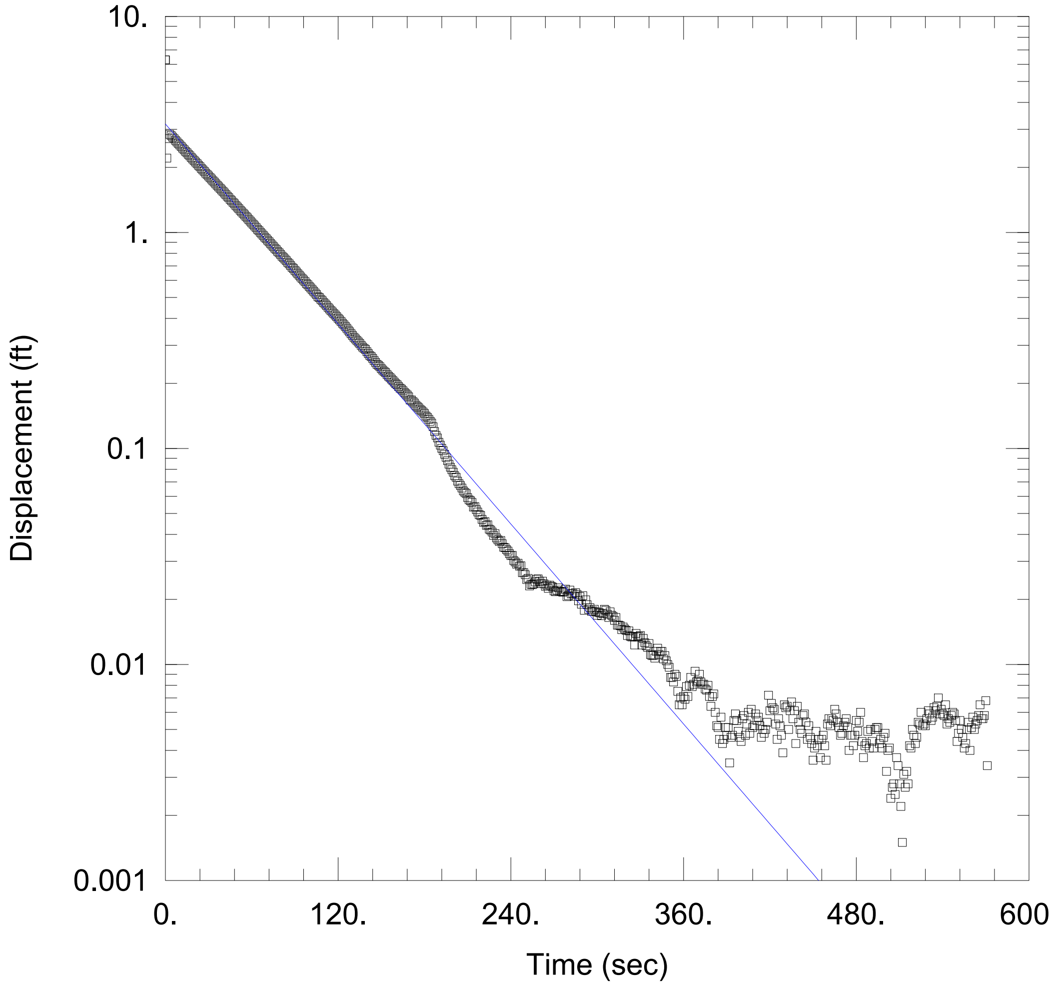
WELL DATA (CF-19-15)

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
Solution Method: Bouwer-Rice

K = 2.89E-5 ft/sec
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.

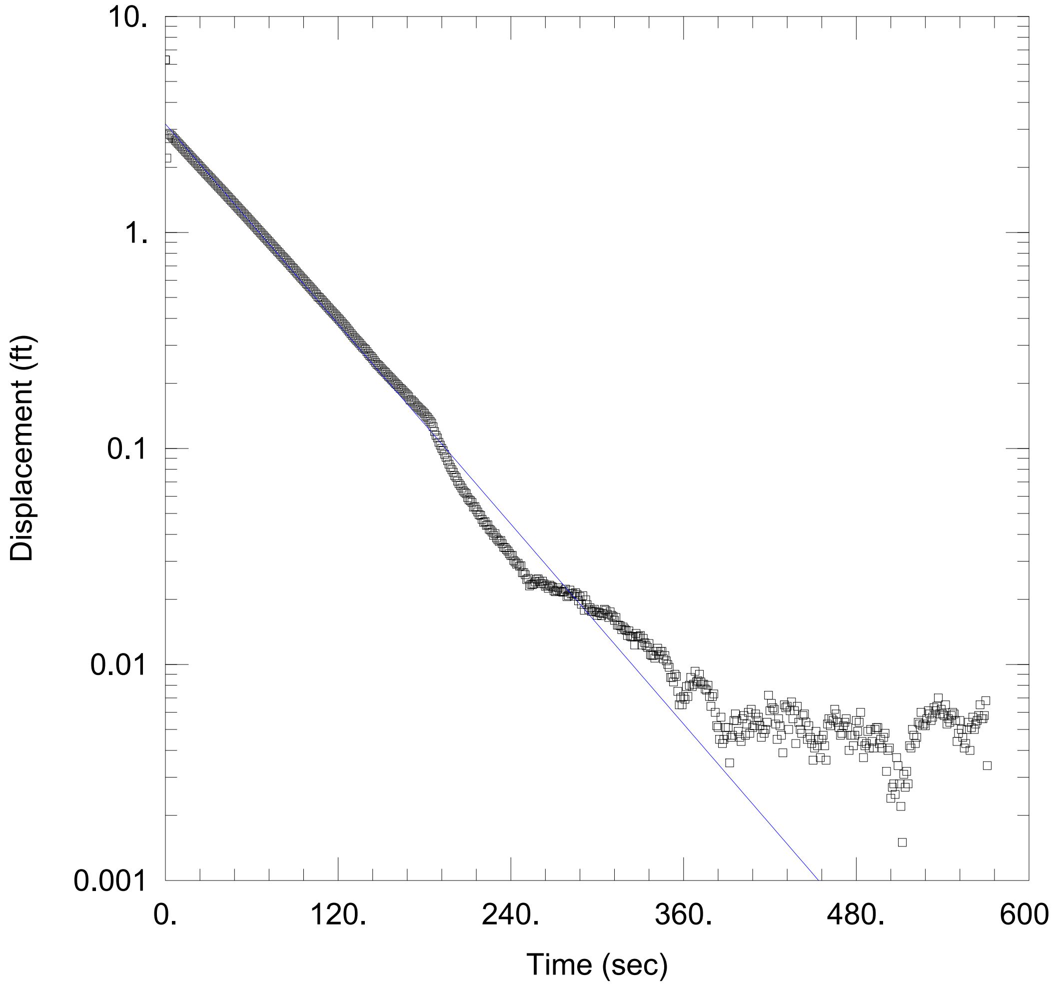
WELL DATA (CF-19-15)

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 Solution Method: Hvorslev

K = 3.356E-5 ft/sec 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.

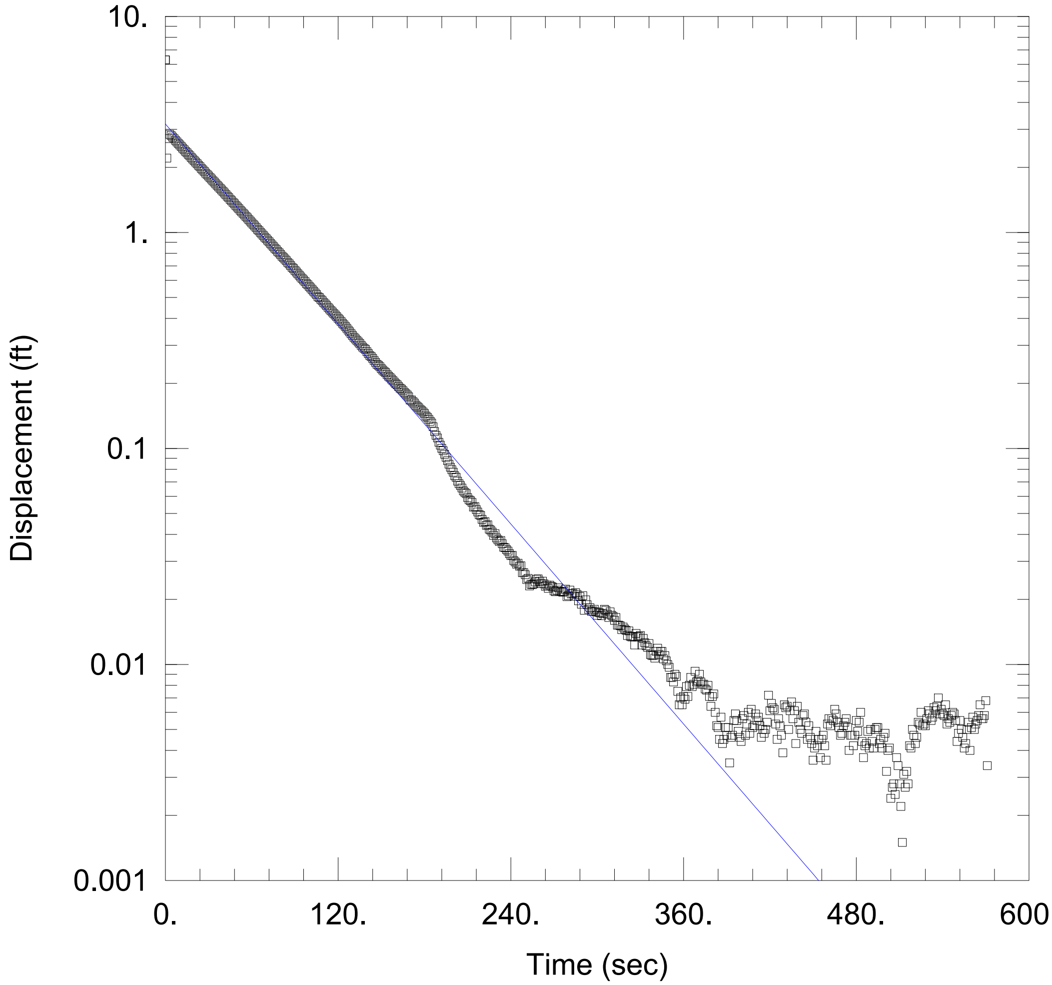
WELL DATA (CF-19-15)

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
Solution Method: Bouwer-Rice

K = 2.753E-5 ft/sec
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.

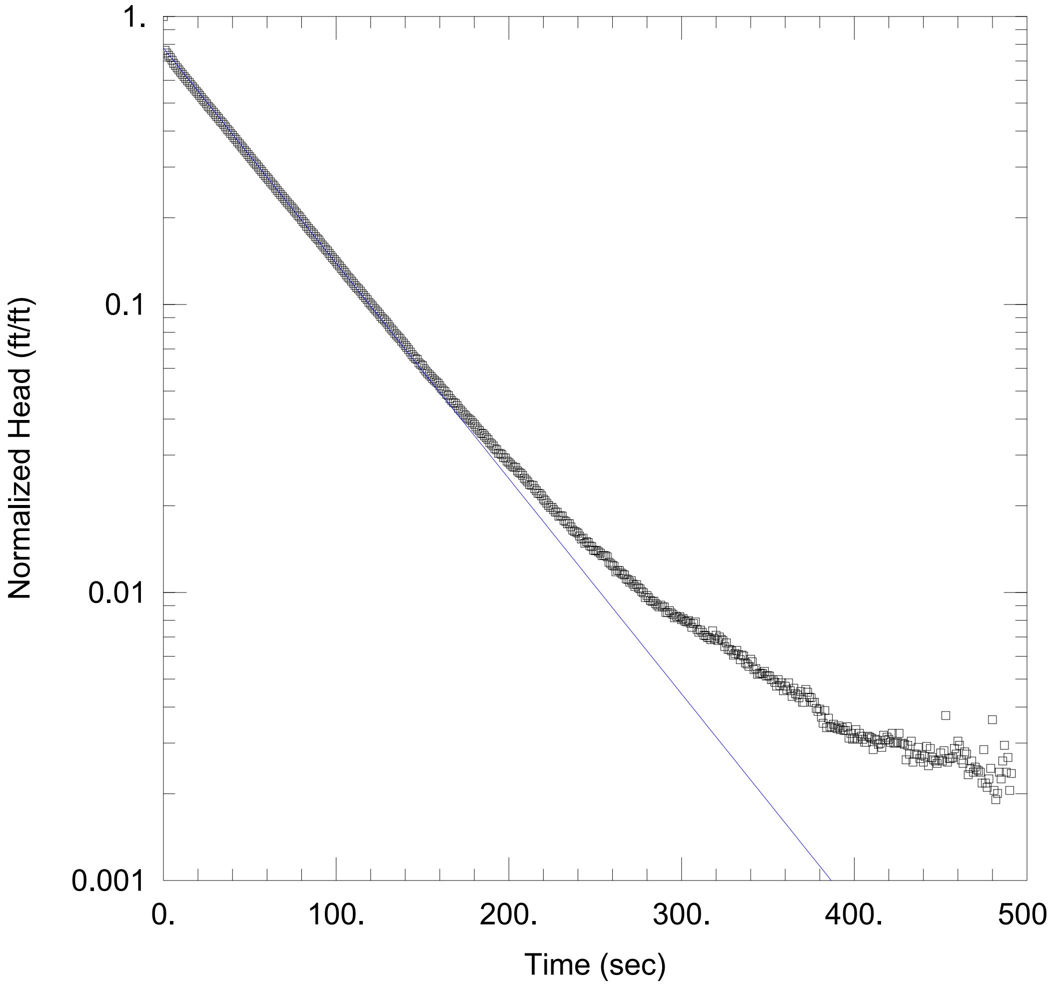
WELL DATA (CF-19-15)

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
Solution Method: Hvorslev

K = 3.356E-5 ft/sec
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.

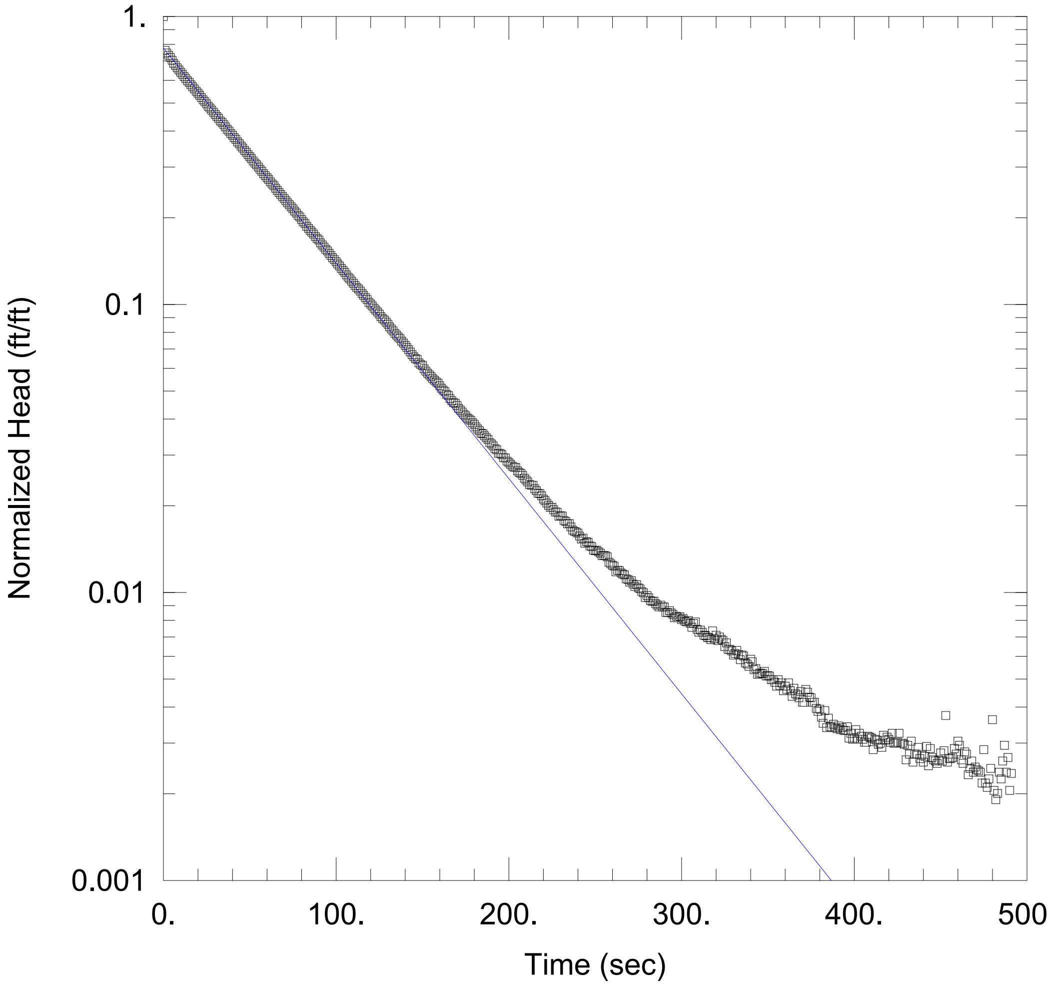
WELL DATA (CF-19-15)

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 Solution Method: Bouwer-Rice

K = 2.667E-5 ft/sec 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.

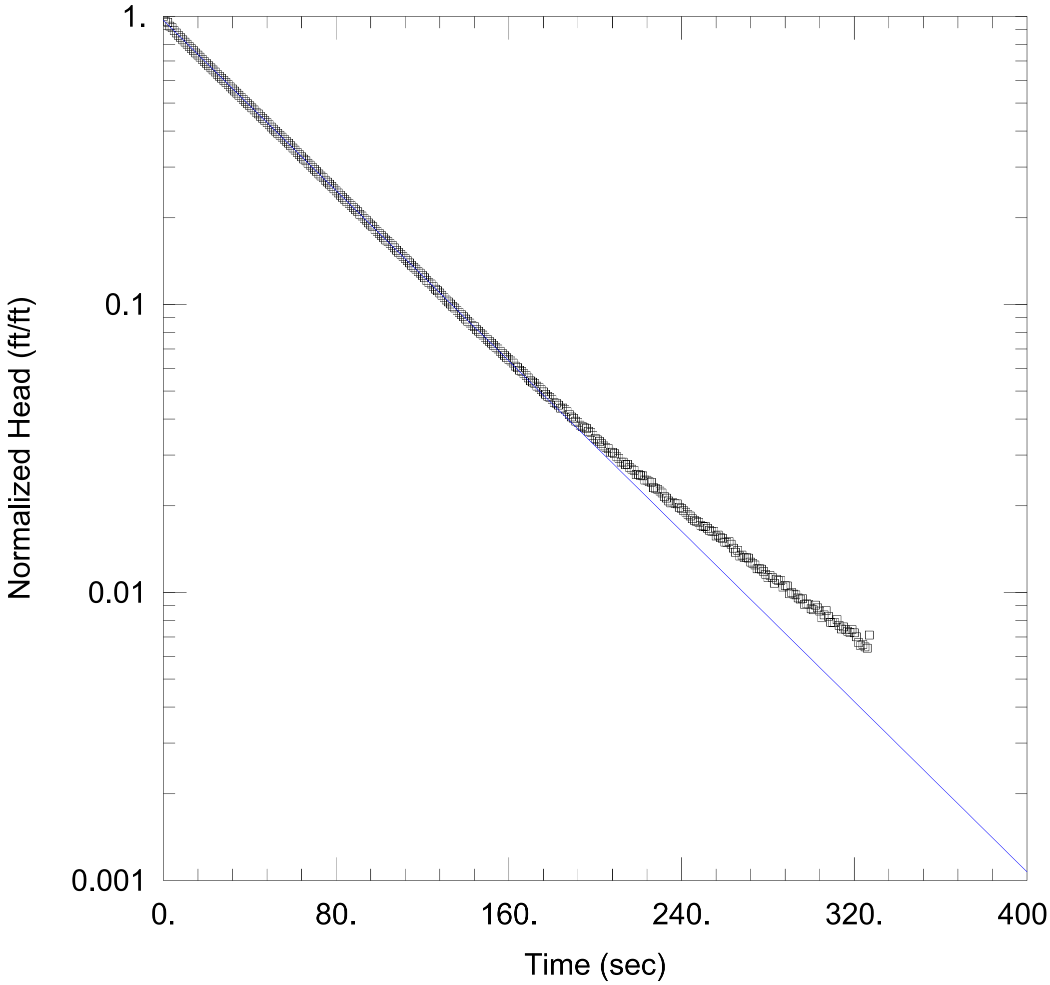
WELL DATA (CF-19-15)

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
Solution Method: Hvorslev

K = 3.251E-5 ft/sec
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.

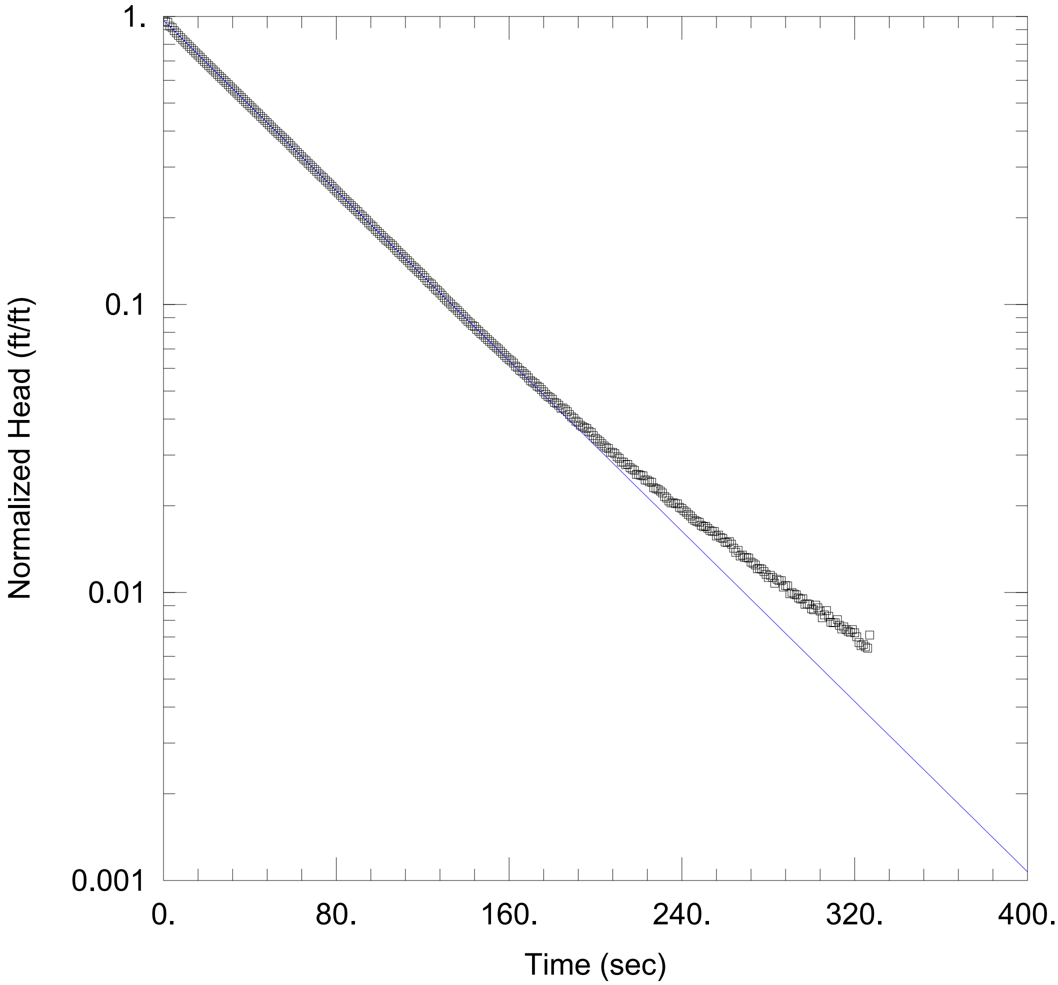
WELL DATA (CF-19-15)

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
Solution Method: Bouwer-Rice

K = 2.637E-5 ft/sec
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 | Solution Method: Hvorslev

K = 3.215E-5 ft/sec | 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

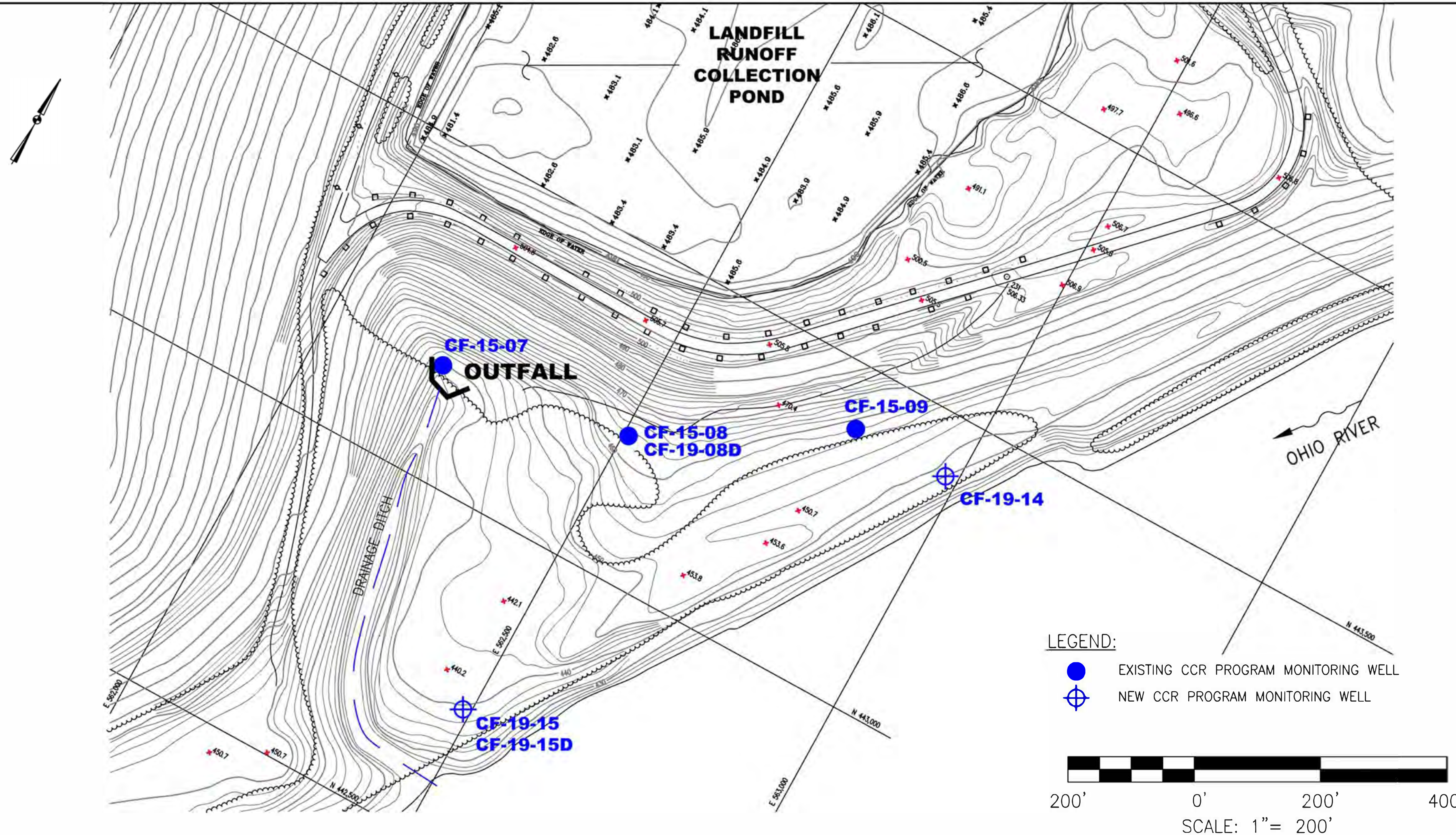
Applied Geology and Environmental Science, Inc. (AGES) 2018. Coal Combustion Residuals Regulation 2017 Groundwater Monitoring and Corrective Action Report. Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. January 2018.

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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CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
EXISTING AND NEW MONITORING WELL LOCATIONS

DRAWING NAME	REV.
FIGURE F–1	0

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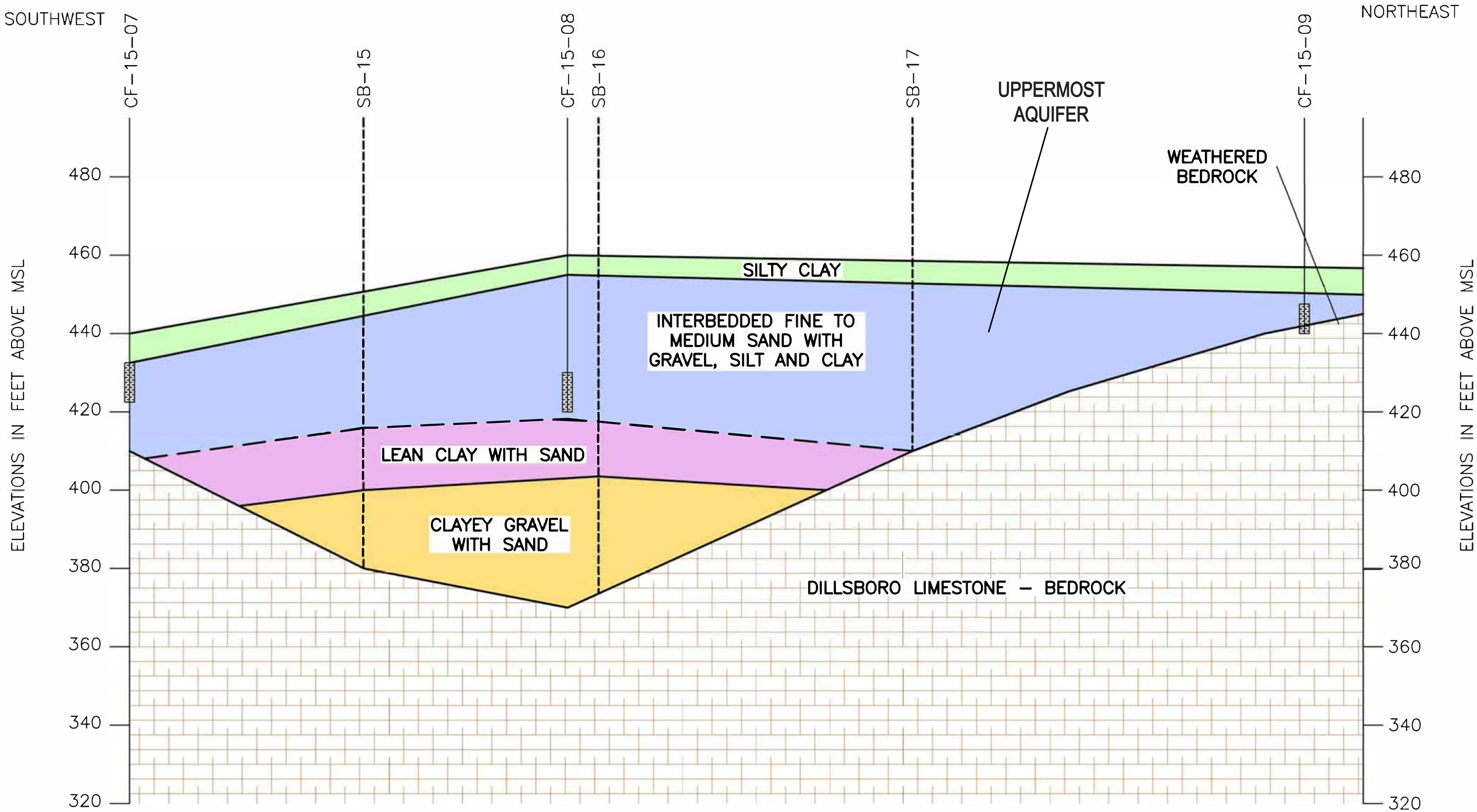

NOTES:

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 F-3.

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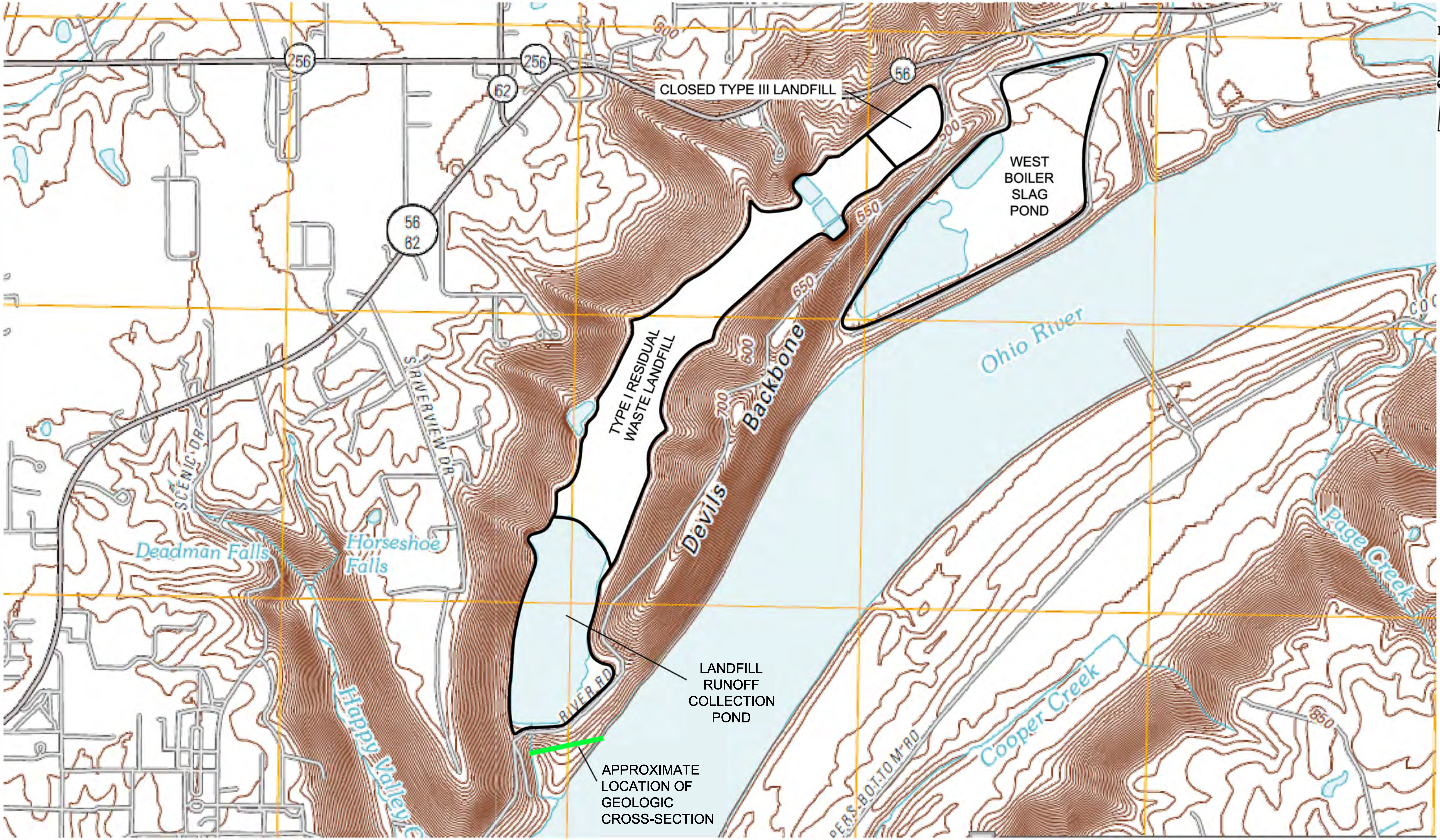
GEOLOGIC CROSS-SECTION AT
LANDFILL RUNOFF COLLECTION POND

DRAWING NAME: FIGURE F-2

REV. 0

Plot: 09/09/2019 14:37 _PROGRAM-IKEC\Clifty Creek-CCR Program\CAD\2019 Assessment of Corrective Measures\2019_IKEC_Clifty_ACM_Fig 3-1_X-Section_LRCP.dwg



APPROXIMATE LOCATION OF THE GEOLOGIC CROSS–SECTION (FIGURE F–2).

SOURCE: USGS MADISON WEST 7.5 MINUTE TOPOGRAHIC QUADRANGLE, 2010.

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MADISON, INDIANA
TOPOGRAPHIC MAP

DRAWING NAME: FIGURE F–3

REV. 0

Indiana LiDAR Color Hillshade

Date: 3/1/2018

Author:

IndianaMAP

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VIEW OF BEDROCK VALLEY

DRAWING NAME: FIGURE F–4

REV. 0

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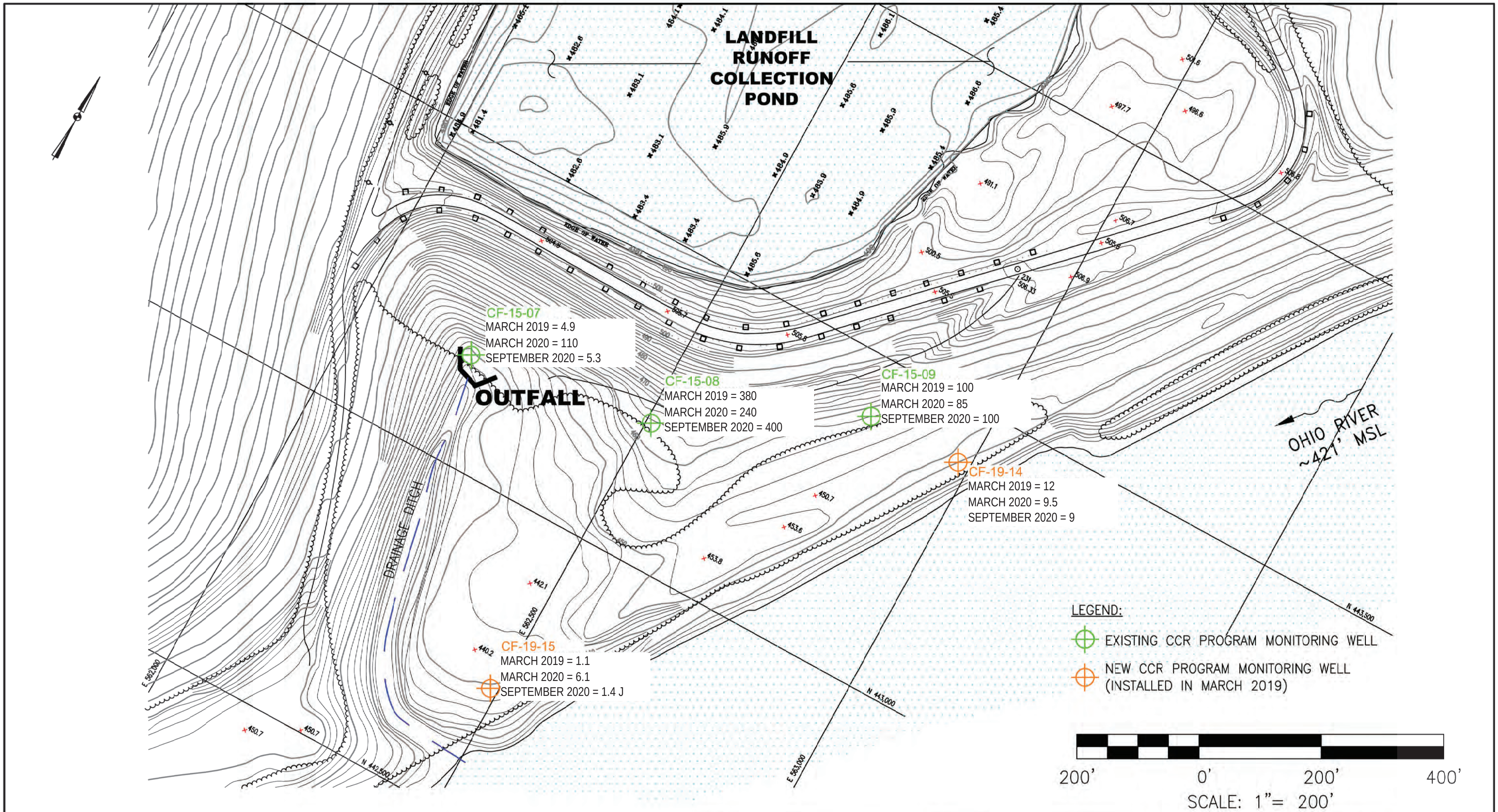

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DATE			CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM MOLYBDENUM CONCENTRATIONS IN GROUNDWATER MARCH 2020 THROUGH SEPTEMBER 2020
CHECKED BY			
JOB NO.	2020246–CLIFTY		
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ATTACHMENT F-1

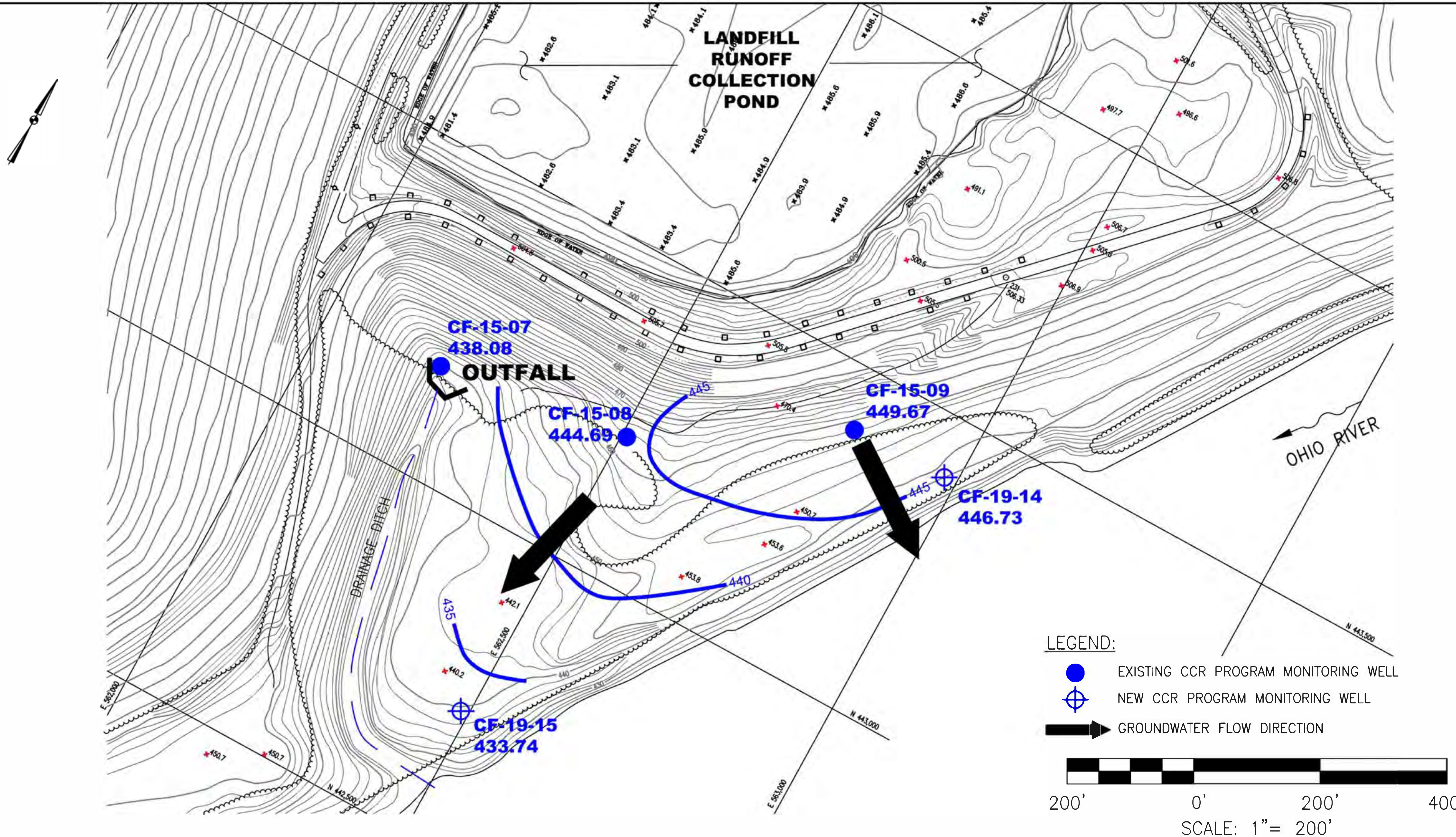
GROUNDWATER ELEVATION DATA

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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DRAWING SCALE	AS SHOWN

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CCR PROGRAM
GROUNDWATER FLOW – UPPERMOST AQUIFER
MARCH 2019

DRAWING NAME: ATTACHMENT F-2 FIGURE 1
REV. 0

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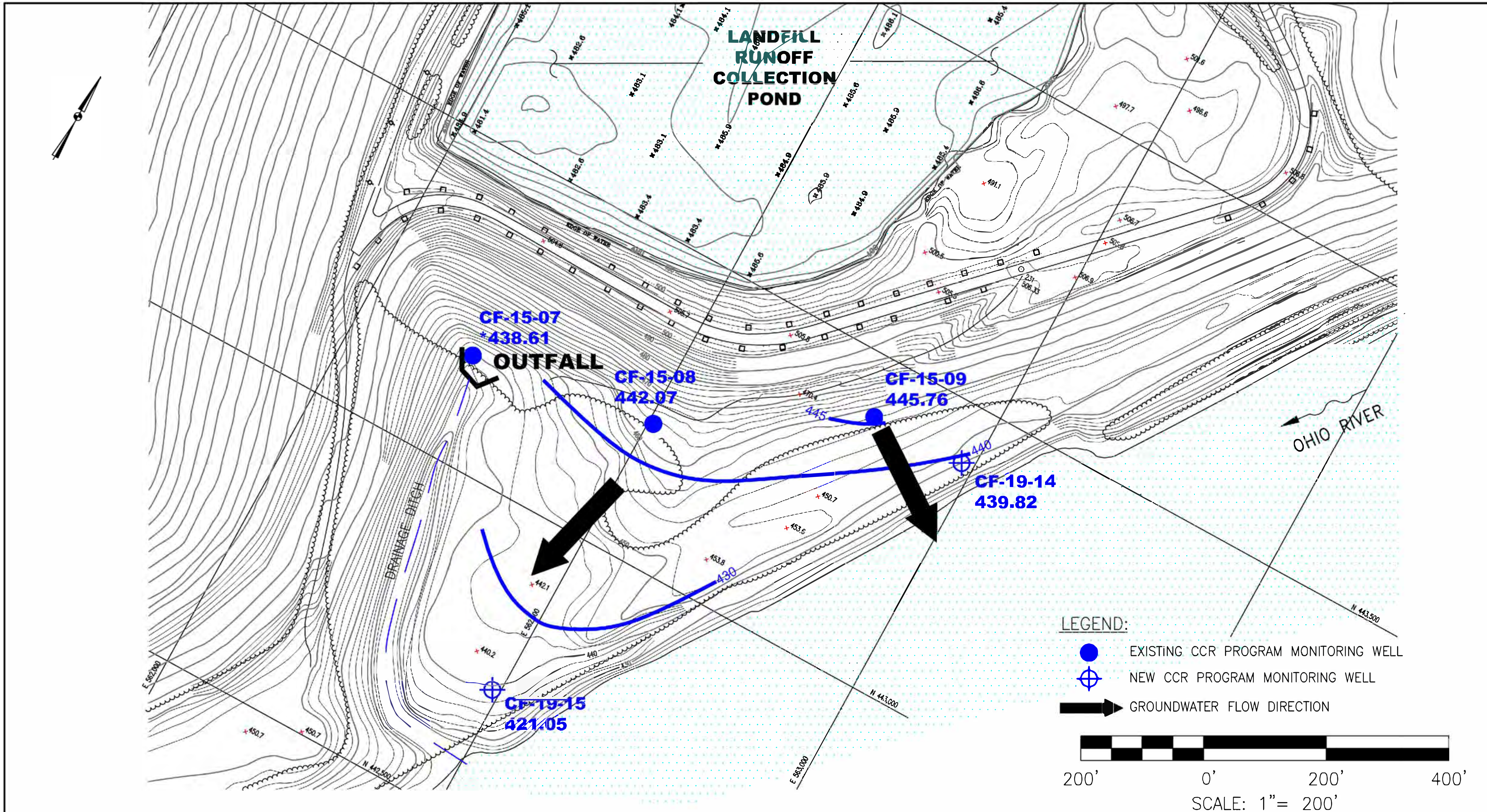

NOTE:

* 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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MADISON, INDIANA
CCR PROGRAM
GROUNDWATER FLOW – UPPERMOST AQUIFER
MARCH 2020

DRAWING NAME: ATTACHMENT F-2 FIGURE 2
REV. 0

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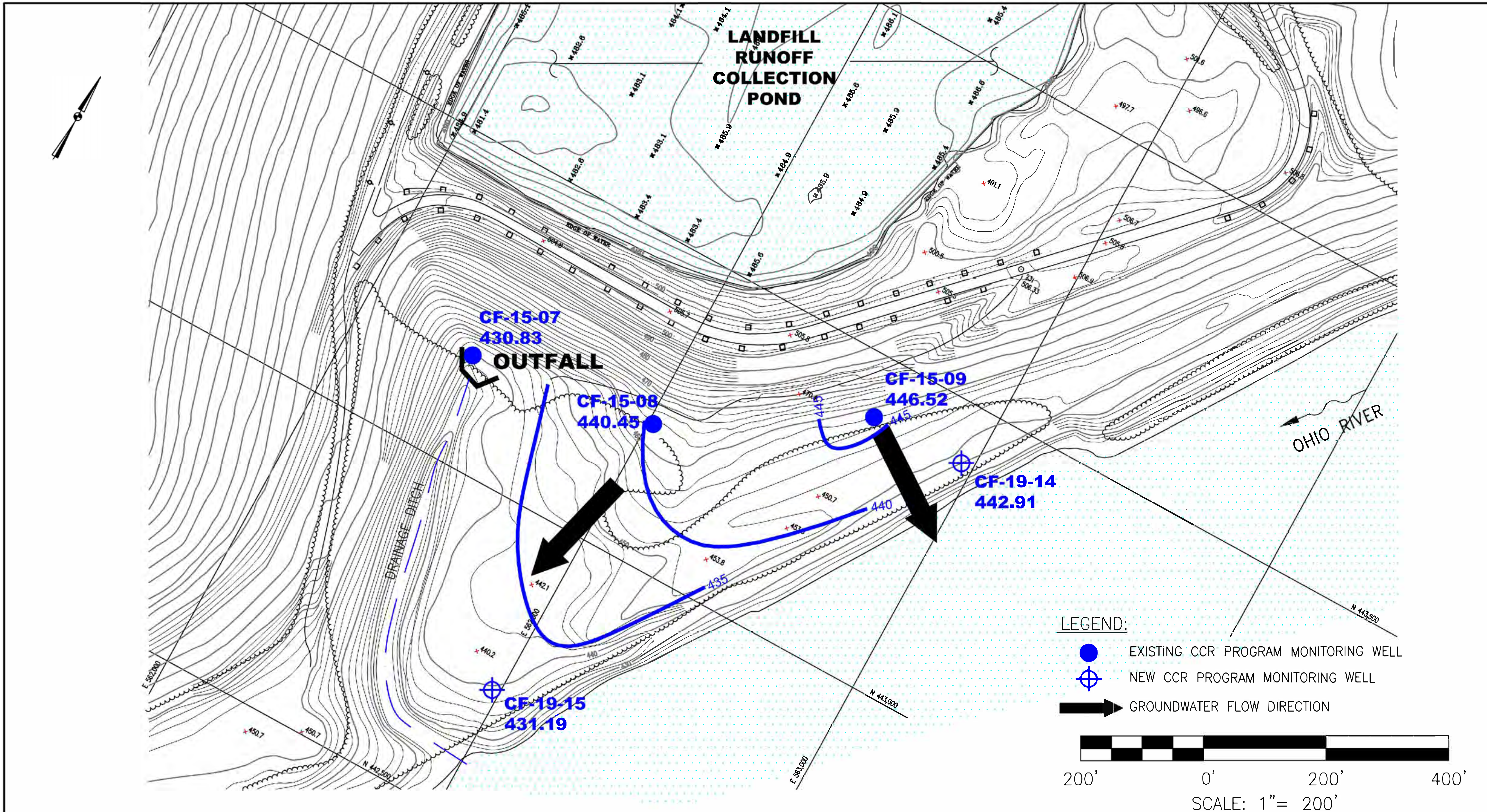

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DRAWING SCALE	AS SHOWN

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MADISON, INDIANA
CCR PROGRAM
GROUNDWATER FLOW – UPPERMOST AQUIFER
SEPTEMBER 2020

DRAWING NAME: ATTACHMENT F-2 FIGURE 3
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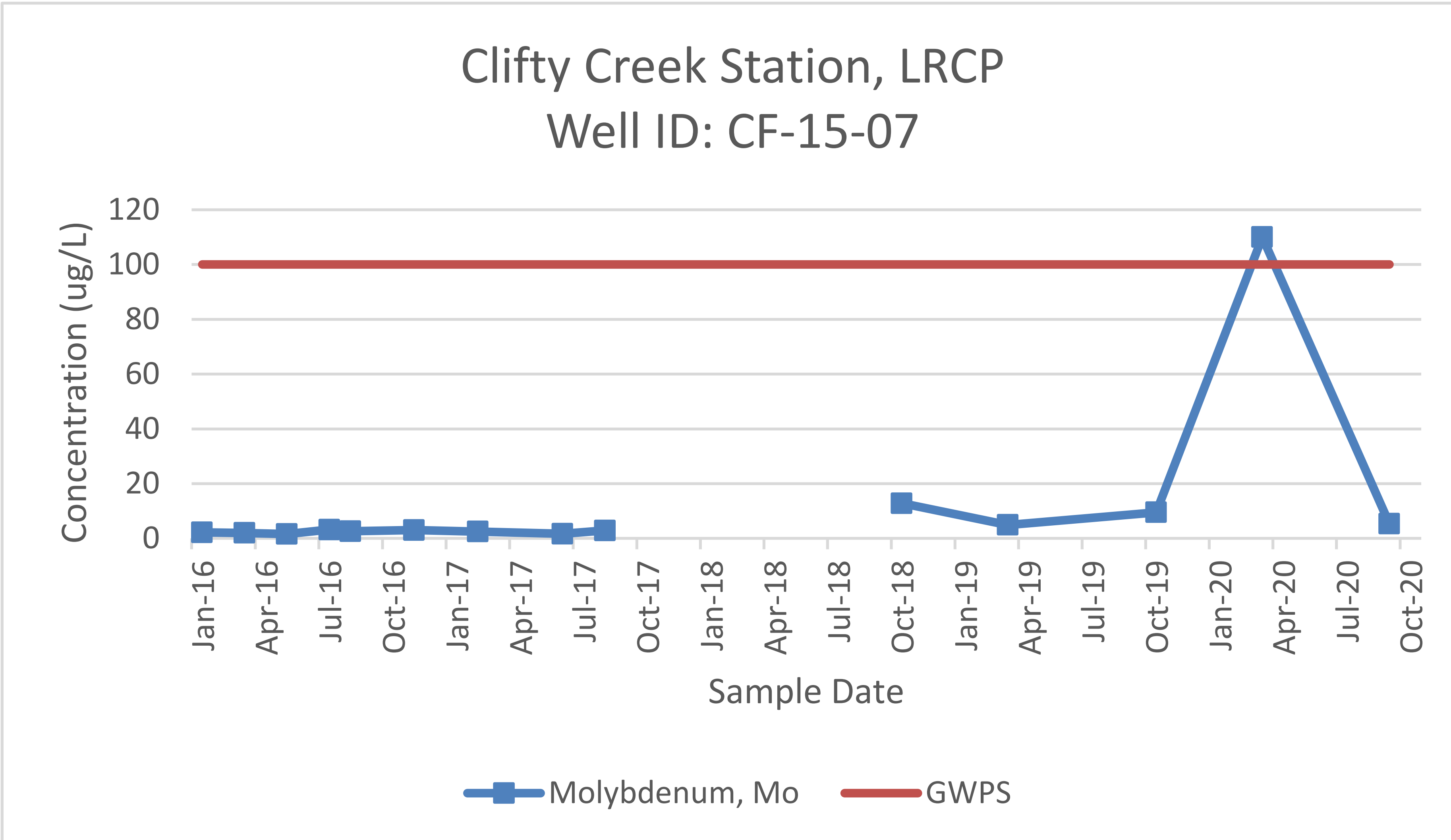
ATTACHMENT F-3

TIME-SERIES GRAPHS

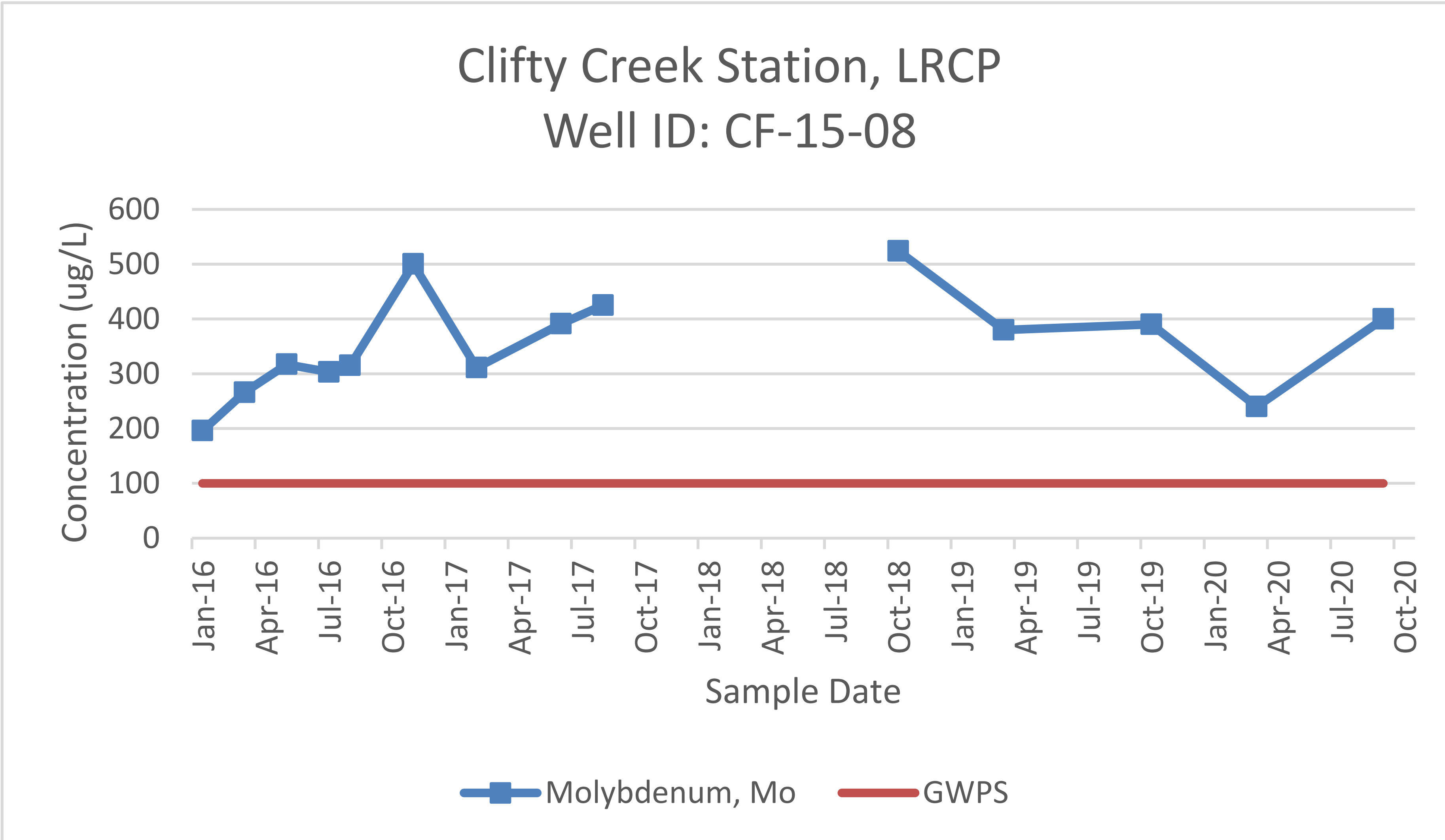
ATTACHMENT F-3
SUMMARY OF MOLYBDENUM CONCENTRATIONS IN GROUNDWATER
LANDFILL RUNOFF COLLECTION POND
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID / Sampling Event	CF-15-07	CF-15-08	CF-15-09
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

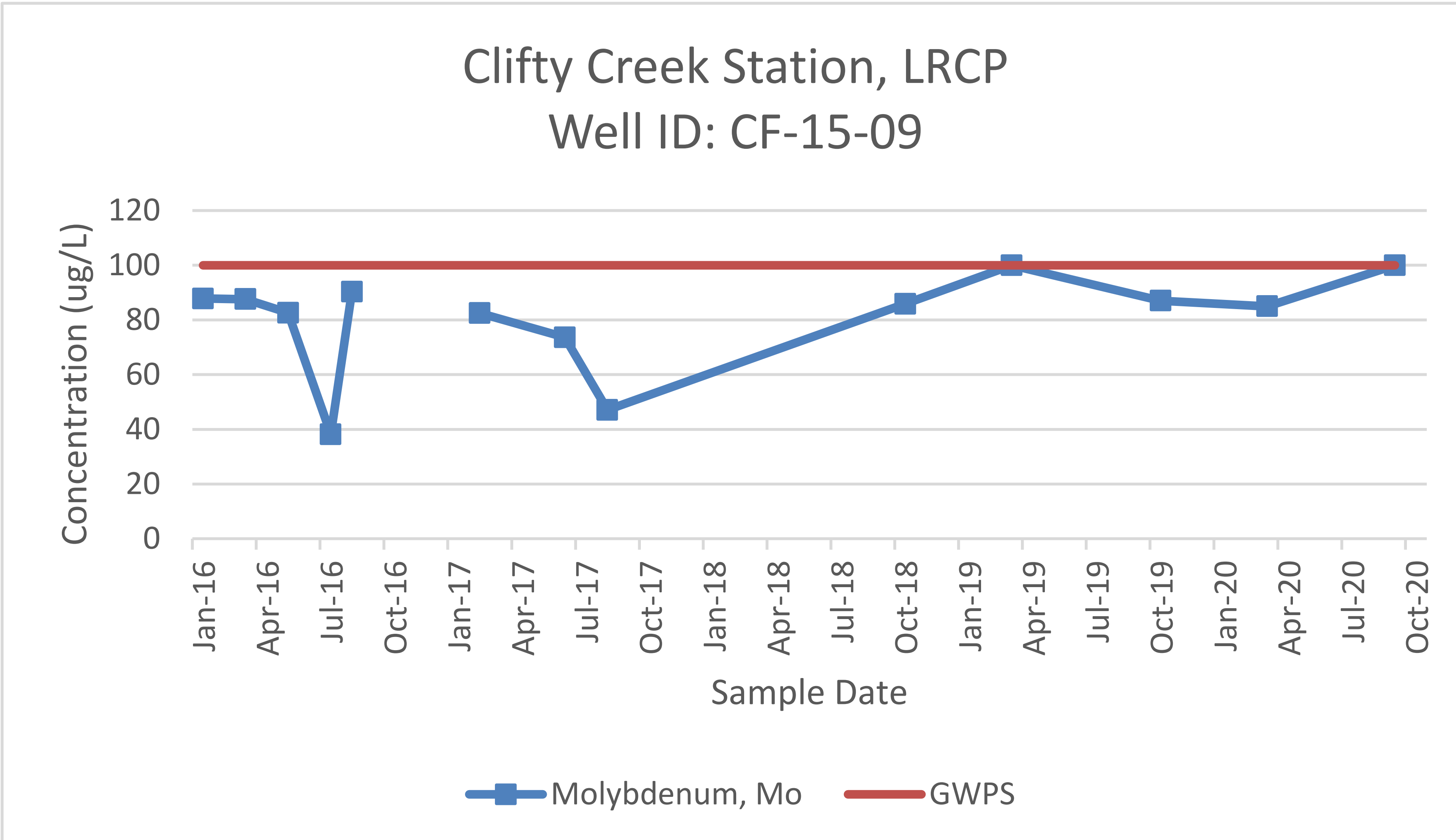
Notes:
1. Concentrations are provided in ug/L.
2. The results from SSI resampling event are not included.



Clifty Creek Station, LRCP
Well ID: CF-15-07
Concentration (ug/L)
120
100
80
60
40
20
0
Jan-16
Apr-16
Jul-16
Oct-16
Jan-17
Apr-17
Jul-17
Oct-17
Jan-18
Apr-18
Jul-18
Oct-18
Jan-19
Apr-19
Jul-19
Oct-19
Jan-20
Apr-20
Jul-20
Oct-20
Sample Date
Molybdenum, Mo
GWPS



Clifty Creek Station, LRCP
Well ID: CF-15-08
Concentration (ug/L)
0
100
200
300
400
500
600
Jan-16
Apr-16
Jul-16
Oct-16
Jan-17
Apr-17
Jul-17
Oct-17
Jan-18
Apr-18
Jul-18
Oct-18
Jan-19
Apr-19
Jul-19
Oct-19
Jan-20
Apr-20
Jul-20
Oct-20
Sample Date
Molybdenum, Mo
GWPS



Clifty Creek Station, LRCP
Well ID: CF-15-09
Concentration (ug/L)
120
100
80
60
40
20
0
Jan-16
Apr-16
Jul-16
Oct-16
Jan-17
Apr-17
Jul-17
Oct-17
Jan-18
Apr-18
Jul-18
Oct-18
Jan-19
Apr-19
Jul-19
Oct-19
Jan-20
Apr-20
Jul-20
Oct-20
Sample Date
Molybdenum, Mo
GWPS

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**

0 175 350 700 Feet

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JOB NO.	2020246
GIS FILE	Mass Calculations Maps June 2019
SCALE	1:2,400

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MADISON, INDIANA
CCR PROGRAM
MOLYBDENUM GROUNDWATER CONTOURS March/April 2019

FIGURE NAME

REV. 0

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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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COMPANY	INDIANA-KENTUCKY ELECTRIC CORPORATION
SITE / ADDRESS	CLIFTY CREEK STATION MADISON, INDIANA CCR PROGRAM MOLYBDENUM GROUNDWATER CONTOURS MARCH 2020
FIGURE NAME	
REV.	0

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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**

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FIGURE NAME	REV. 0

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