Response to Comments for the Nature and Extent Investigation Well Placement/Development Plan

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Jared Morrison

Digitally signed by Jared Morrison
Date: 2023.05.31 16:23:45 -05'00'

05/31/2023

Jared Morrison
Director Environmental Services
Evergy, Inc.

Date

May 31, 2023
File No. 0129778

U.S. Environmental Protection Agency – Region 7
11201 Renner Boulevard
Lenexa, Kansas 66219

Subject: Response to Comments for the Nature and Extent Well Placement / Development Plan dated January 25, 2023
Bottom Ash Settling Area, Tecumseh Energy Center, Tecumseh, Kansas

The Tecumseh Energy Center (TEC) Bottom Ash Settling Area (BASA) Nature and Extent Investigation Well Placement/Development Plan (N&E Development Plan), dated January 25, 2023, was prepared pursuant to Paragraph 10.d. of the Consent Agreement and Final Order (CAFO) between the U.S. Environmental Protection Agency (USEPA) and Evergy Kansas Central, Inc. (Evergy) In the Matter of Evergy Kansas Central, Inc.: Docket No. RCRA-07-2023-0001 dated November 7, 2022. Paragraph 10.d. of the CAFO requires that Evergy provide USEPA a Nature and Extent Investigation Well Placement/Development Plan for the implementation and schedule for a nature and extent investigation at the location of the former BASA surface impoundment. Evergy provided the required plan on January 25, 2023.

This Evergy response letter responds to the USEPA's April 27, 2023 email from Ms. Cynthia Sans (Email) containing an attachment with USEPA comments regarding the January 25, 2023 N&E Development Plan for the BASA. This response presents each individual comment from the Email in italics followed by the specific Evergy response to the comment.

## Evergy Comment Responses

***USEPA Comment #1:* Section 2, Nature and Extent Groundwater Monitoring Well Installation, Page 4.**
*Consider use of direct-push technology with electrical conductivity and hydraulic profiling tool to better characterize hydrostratigraphy prior to monitoring well placement.*

**Response to Comment #1:**
Evergy has considered using direct-push and hydraulic profiling technology to characterize the uppermost aquifer as part of the N&E Development Plan and has elected not to implement those methods at this time. Previous experience drilling at the BASA indicates that the uppermost aquifer is a relatively thin deposit of glacial till with little differentiation. The thickness of the glacial till at the BASA was approximately 40 to 50 feet and is underlain by shale which will not allow push probe tools to go deeper. The current development plan is to drill down to the shale using conventional drilling methods

to collect soil samples, followed by coring into the shale at the planned locations. This method will also allow the borings to be used to construct monitoring wells for additional characterization.

***<u>USEPA Comment #2:</u> Section 2, Nature and Extent Groundwater Monitoring Well Installation, Page 4.***
*All monitoring wells should be installed by a Kansas licensed water well driller in compliance with Kansas Department of Health and Environment statutes and regulations.*

**<u>Response to Comment #2:</u>**
The N&E Development Plan has been revised to state that monitoring wells will be installed in accordance with Kansas Administrative Regulations (K.A.R.) Article 30. This revision is included in Paragraph 3 of Section 2.1 (Nature and Extent Well Installation) of the revised N&E Development Plan.

***<u>USEPA Comment #3:</u> Section 2.1, Nature and Extent Well Installation, Page 4, second paragraph.***
*Please include cross sections, potentiometric and other supporting maps to further justify monitoring well placement.*

**<u>Response to Comment #3:</u>**
The N&E Development Plan has been revised to include additional site-specific characteristics to justify the nature and extend monitoring well placements, along with one cross section and potentiometric map. These revisions are included in Section 1.1.1 (Monitoring Network), Section 2.1 (Nature and Extent Well Installation), Figure 2, and Figure 3 of the revised N&E Development Plan.

***<u>USEPA Comment # 4:</u> Section 2.1, Nature and Extent Well Installation, Page 4, third paragraph.***
*The length of the screen/screened interval to be used should be included.*

**<u>Response to Comment #4:</u>**
The N&E Development Plan has been revised to include the length of the screen / screened interval. These revisions are included in Section 2.1.3 (Monitoring Well Completion) of the revised N&E Development Plan.

***<u>USEPA Comment #5:</u> Section 2.1, Nature and Extent Well Installation, Page 5, final paragraph.***
*Consider 24 hours before development to ensure the bentonite seal is properly hydrated.*

**<u>Response to Comment #5:</u>**
The N&E Development Plan has been revised to provide 24 hours before monitoring well development. These revisions are included in Section 2.1.4 (Monitoring Well Development) of the revised N&E Development Plan.

***<u>USEPA Comment #6:</u> Section 2.1, Nature and Extent Well Installation, Page 5, final paragraph.***
*Management of development and purge water is not discussed. Please include a discussion of development and purge water management.*

**Response to Comment #6:**
The N&E Development Plan has been revised to provide a discussion of handling development and purge water. These revisions are included in Section 2.2 (Development and Purge Water Management) of the revised N&E Development Plan.

***USEPA Comment #7:* Section 2.1, Nature and Extent Well Installation, Page 5.**
*Surveying of wells is not mentioned. A Kansas licensed surveyor should conduct the survey.*

**Response to Comment #7:**
The N&E Development Plan has been revised to provide details for surveying of the new monitoring wells. These revisions are included in Section 2.3 (Survey) of the revised N&E Development Plan.

***USEPA Comment #8:* Section 2.1, Nature and Extent Well Installation, Page 5.**
*The Sampling and Analysis Plan (SAP) should be updated to include the nature and extent investigation activities and all standard operating procedures (SOPs) updated as well.*

**Response to Comment #8:**
The N&E Development Plan has been revised to include the SOPs for monitoring well drilling, completion, installation, and development. These revisions are included in Section 2.1 (Monitoring Well Installation) of the revised N&E Development Plan. The SAP will be revised to include figures and text describing relevant sampling and analysis information and procedures for the nature and extent investigation at BASA and to reflect USEPA comments on both the N&E Development Plan and the "Well Placement and Development Plan for the Installation of Additional Monitoring Wells at the Bottom Ash Settling Area Surface Impoundment" (Well Development Plan).

***USEPA Comment 9:* Section 2.1, Nature and Extent Well Installation, Page 5.**
*The methodology, precision, SOPs, etc. for water level measurements should be referenced.*

**Response to Comment #9:**
The SAP will be revised to include water level measurement procedures for the BASA. As discussed in response to Comment #8, the SAP will be revised to reflect USEPA comments on both the N&E Development Plan and the Well Development Plan.

***USEPA Comment #10:* Section 3.1, Groundwater Sampling, Page 6.**
*Consistent with Comments 5 and 6, the updated SAP, SOPs, etc. should be referenced for the nature and extent groundwater sampling.*

**Response to Comment #10:**
The N&E Development Plan has been revised to clarify that the SAP will be updated to include relevant information in support of the nature and extent investigation groundwater sampling pursuant to 40 CFR

§ 257.95(g)(1). These changes are included in Paragraph 3 of Section 3.1 (Groundwater Sampling) of the revised N&E Development Plan.

***<u>USEPA Comment #11:</u> Section 3.1, Groundwater Sampling, Page 6.***
*The number of proposed nature and extent groundwater sampling events should be included along with sampling frequency.*

**<u>Response to Comment #11:</u>**
The N&E Development Plan has been revised to provide details for the number and frequency of proposed nature and extent investigation groundwater sampling events. These changes are included in Paragraph 1 of Section 3.1 (Groundwater Sampling) of the revised N&E Development Plan.

***<u>USEPA Comment #12:</u> Section 3.2, Groundwater Protection Standards, Page 6.***
*Please reference the document containing the established groundwater protection standards and include a table with the groundwater protection standards.*

**<u>Response to Comment #12:</u>**
The N&E Development Plan has been revised to reference the statistical analysis report completed pursuant to Paragraph 10.c. of the CAFO, which contains the groundwater protection standards. These changes are included in Paragraph 1 of Section 3.2 (Groundwater Protection Standards) of the revised N&E Development Plan. Table 2 has also been included in the revised N&E Development Plan, which summarizes the current detected Appendix IV constituents from the January 2023 annual assessment monitoring sampling event with corresponding GWPS.

***<u>USEPA Comment #13:</u> Section 4, Assessment of Corrective Measures, Page 7.***
*The assessment of corrective measures is contingent on completion of the nature and extent investigation. Pending the results of the work proposed in this plan, additional phases of investigation may need to occur. Please clarify.*

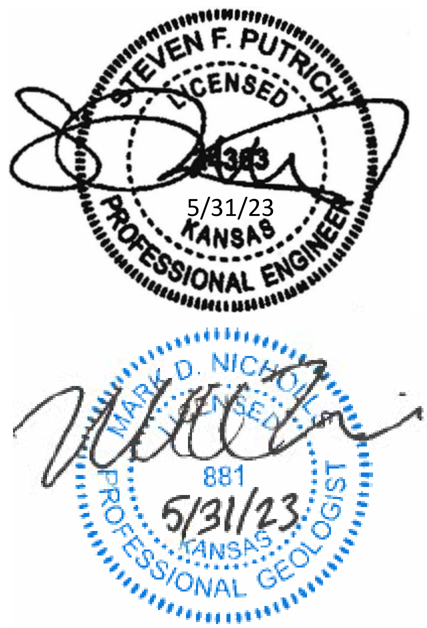
**<u>Response to Comment #13:</u>**
The N&E Development Plan has been revised to clarify the schedule pertaining to the completion of the assessment of corrective measures. These revisions are included in Section 4.1 (Assessment of Corrective Measures) and Table 3 of the revised N&E Development Plan.

Please contact Jared Morrison (jared.morrison@evergy.com) with any questions that you may have regarding the information contained in this letter.

www.haleyaldrich.com

# NATURE AND EXTENT INVESTIGATION WELL PLACEMENT/DEVELOPMENT PLAN

TECUMSEH ENERGY CENTER
BOTTOM ASH SETTLING AREA
TECUMSEH, KANSAS




by
Haley & Aldrich, Inc.
Phoenix, Arizona

for
Evergy Kansas Central, Inc.

File No. 0129778
January 2023
Rev 1: May 2023

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# 1. Introduction

This document is a well placement and development plan prepared pursuant to Paragraph 10.d. of the Consent Agreement and Final Order (CAFO) between the U.S. Environmental Protection Agency (USEPA) and Evergy Kansas Central, Inc. (Evergy) In the Matter of Evergy Kansas Central, Inc.: Docket No. RCRA-07-2023-0001 dated November 7, 2022. Paragraph 10.d. of the CAFO requires that Evergy provide a Nature and Extent Investigation Well Placement/Development Plan (Plan) for the Bottom Ash Settling Area (BASA) impoundment at the Tecumseh Energy Center (TEC).

## 1.1 BACKGROUND

TEC is a closed coal fired power generation facility. While TEC was active, coal combustion residuals (CCR) were dewatered at the BASA and permanently disposed of at the TEC solid waste landfill referred to as Ash Landfill 322. The BASA CCR management unit has ceased operations and been removed. All CCR material within the BASA has been removed, together with the berms that created the impoundment and all visible CCR material. The BASA site has been returned to its approximate pre-development surface grade.

Bottom ash slurry generated at TEC was sluiced and gravity fed to the BASA for settling. Excess water was decanted via gravity to the Clear Pond located north of the BASA, where it was gravity decanted again to Tecumseh Creek. Ultimately, the clear process water flowed into Tecumseh Creek and the Kansas River in accordance with the terms of a Kansas Pollutant Discharge Elimination System permit at Outfall 002X1. Bottom ash was recovered from the BASA, dewatered, and transported by truck to Ash Landfill 322.

Pursuant to Paragraph 10.d. of the CAFO, this Plan has been prepared for the BASA surface impoundment. The items requested by the USEPA in Paragraph 10.d. of the CAFO are provided below.

### 1.1.1 Monitoring Network

Consistent with Code of Federal Regulations Title 40 (40 CFR) § 257.90 through § 257.95, Evergy installed and certified a groundwater monitoring network for the BASA at TEC and collected eight rounds of groundwater samples for the analysis of Appendix III and Appendix IV baseline constituents. The groundwater monitoring network at the BASA includes one upgradient monitoring well (MW-7) and three downgradient monitoring wells (MW-8, MW-9, and MW-10); and one cross gradient well (MW-11) is used to monitor groundwater elevations for the purpose of establishing groundwater flow direction at each sampling event (Figure 1).

The monitoring network was designed to monitor the glacial till material, which constitutes the uppermost aquifer beneath the CCR unit and has a saturated thickness of approximately 4 to 18 feet based on observations made during drilling at TEC (Figure 2). The hydraulic conductivity of the uppermost aquifer was calculated using data generated from slug tests conducted after monitoring well installation and development and is approximately $1.6 \times 10^{-3}$ centimeters per second (cm/sec). Based on slug test results, effective porosity of the uppermost aquifer is estimated to be 5 percent. The groundwater flow velocity was calculated to be approximately 280 feet per year (feet/year) toward the northwest during the March 2023 semi-annual assessment monitoring sampling event (Figure 3). Groundwater flowing at this velocity and direction will flow from beneath the BASA, past the former waste boundary within the monitoring timeframe.

The monitoring wells have been constructed at the former waste boundary at locations on the west, northwest, and north sides of the unit to intercept representative groundwater flow paths passing beneath the unit. Due to space constraints, the downgradient monitoring wells were constructed in the berms surrounding the BASA. The locations of the monitoring wells are shown on Figure 1, and well construction details are provided in Table 1.

#### 1.1.2 Statistically Significant Levels

Results of the detection monitoring statistical evaluation completed in January 2018 identified statistically significant increased (SSI) concentrations of Appendix III constituents in downgradient monitoring wells relative to concentrations observed in upgradient monitoring wells. No alternative source was identified for the Appendix III constituents with SSIs. Accordingly, the groundwater monitoring program transitioned to assessment monitoring in June 2018.

In January 2019, Evergy completed statistical evaluations of groundwater quality results collected in September 2018, with data reviewed and accepted in October 2018, to determine if any of the Appendix IV constituents were present in groundwater samples collected from downgradient monitoring wells at concentrations at a statistically significant level (SSL) above the groundwater protection standard (GWPS). The statistical evaluation of the Appendix IV constituents identified a SSL for arsenic (MW-9 and MW-10) and cobalt (MW-9) above the GWPSs downgradient of the BASA.

An alternate source demonstration (ASD) was completed in February 2019 to address SSLs identified during the September 2018 semi-annual assessment monitoring sampling event which kept the BASA operating under an assessment monitoring program. In accordance with Paragraph 10.b. of the CAFO, the ASD was withdrawn. Statistical evaluation completed in December 2022 pursuant to Paragraph 10.c. of the CAFO identified SSLs for arsenic (MW-9 and MW-10) and cobalt (MW-9) above the GWPSs downgradient of the BASA.

## 1.2 PURPOSE AND SCOPE

### 1.2.1 Purpose

This document addresses requirements set forth in Paragraph 10.d. of the CAFO. In Paragraph 10.d., Evergy has consented to the following:

> "Within ninety (90) days of the Effective date of this Consent Agreement and Final Order, Respondent shall provide a Nature and Extent Investigation Well Placement/Development Plan for the implementation and schedule for a nature and extent investigation at the BASA surface impoundment for historical statistically significant levels of arsenic and cobalt and any other appendix IV constituents identified as a statistically significant level in actions completed in (c) above. The plan shall include provisions that ensure compliance with all requirements set forth at 40 CFR § 257.95(g), except that any and all associated compliance requirements will be completed pursuant to the plan's schedule. The schedule shall provide for the initiation of nature and extent well drilling within one hundred and eighty (180) days of EPA approval of the Nature and Extent Investigation Well Placement/Development Plan."

The well installation program has been designed based on site-specific hydrogeology to meet the requirements of 40 CFR § 257.95(g). The subject monitoring wells will be sited at locations to characterize the extent of migration, if any, of cobalt and arsenic from TEC BASA. Depending on the concentration of cobalt and arsenic detected in groundwater samples collected from the newly installed wells, additional monitoring wells may be required to further delineate the plume.

### 1.2.2 Scope

This document constitutes the Nature and Extent Well Placement/Development Plan described in Paragraph 10.d. of the CAFO and describes the placement of groundwater monitoring wells for characterization of the nature and extent of cobalt and arsenic concentration in groundwater at TEC BASA and the surrounding area pursuant to 40 CFR § 257.95(g). The specific requirements for this Plan listed in 40 CFR § 257.95(g) of the Rule are provided in Sections 2 through 5 of this Plan and are in bold italic font, followed by a short narrative describing how each Rule requirement has been met.

# 2. Nature and Extent Groundwater Monitoring Well Installation

## 2.1 40 CFR § 257.95(g)(1)(i)-(iii) – NATURE AND EXTENT WELL INSTALLATION

***(i)*** ***Install additional monitoring wells necessary to define the contaminant plume(s)***

***(ii)*** ***Collect data on the nature and estimated quantity of material released including specific information on the constituents listed in appendix IV of this part and the levels at which they are present in the material released;***

***(iii)*** ***Install at least one additional monitoring well at the facility boundary in the direction of contaminant migration and sample this well in accordance with paragraph (d)(1) of this section***

In accordance with 40 CFR § 257.95(g)(1)(i)-(iii) of the Coal Combustion Residuals Rule, the Plan will define the horizontal and vertical extent of cobalt and arsenic in groundwater and will include installation of additional monitoring wells both upgradient and downgradient of the TEC BASA, and at least one monitoring well at the Evergy property boundary downgradient of the TEC BASA (MW-15; Figure 4). The new wells will also allow the collection of data to estimate the quantity of material released, the corresponding Appendix IV constituents, and quantities of those constituents.

The proposed monitoring well locations were selected based on available site-specific technical information obtained during drilling, installation, and testing of the original monitoring wells at the BASA, including stratigraphy, lithology, hydraulic conductivity, and porosity, and with site-specific data developed during previous characterization activities (Figure 4). Supporting site-specific technical information is provided in Section 1.1.1, Figure 2, and Figure 3. The final location of the monitoring wells may be adjusted based on drill rig clearance, minor topographic features, and Evergy property location.

Monitoring wells will be drilled and installed by a Kansas Department of Health and Environment licensed water well driller in accordance with Kansas Administrative Regulations (K.A.R.) Article 30.[1] Procedures for monitoring well drilling, completion, installation, and development are summarized below and will be completed in accordance with Article 30 and the standard operating procedures (SOP) provided in Appendix A.

Prior to any subsurface work, federal and state laws require excavators to notify appropriate utility companies before digging. Kansas 811 will be contacted at least 72 hours in advance of any subsurface work to mark public utilities. Evergy will clear site utilities by reviewing facility as-built drawings and potential drilling locations for the presence of underground utility hazards (utility lines, subsurface structures, etc.). Each proposed monitoring well location will be cleared by hand augur to a depth of 5 feet below ground surface (bgs).

### 2.1.1 Monitoring Well Drilling

The proposed shallow monitoring wells will be drilled using hollow stem auger to a depth of approximately 20 to 40 feet where hard shale (bedrock) is expected to be encountered (Figure 5). Proposed shallow monitoring wells MW-15 through MW-17 are sited at locations hydraulically downgradient of the BASA to define the horizontal extent of arsenic and cobalt in the uppermost

[1] Kansas Department of Health and Environment, 2013. Kansas Administrative Regulations, Article 30, Water Well Contractor's License; Water Well Construction. June 2013.

aquifer. Well MW-15 is also located at the Evergy property boundary pursuant to 40 CFR § 257.95(g)(1)(iii). The proposed location of shallow monitoring wells MW-18 and MW-19 are located hydraulically upgradient of the BASA to assist in defining the groundwater flow direction and providing additional analytical data representative of background groundwater quality that has not been affected by leakage from the unit.

The proposed deep boring locations will be utilized to provide characterization of bedrock underlying the BASA. These borings will be drilled using a hollow stem auger to the top of bedrock followed by coring in bedrock. Depending on the thickness of the shale, two deep contingency monitoring wells may be installed and screened within a lower water bearing unit below the shale confining unit, not greater than 100 feet bgs (Figure 6). These deep contingency monitoring wells (MW-20 and MW-21), if installed, will be located upgradient and downgradient of the BASA, respectively, to define the vertical extent of arsenic and cobalt beneath the BASA as well as providing additional characterization of the shale confining unit. The deep contingency well MW-20 is located upgradient and will provide additional background information from the water bearing unit beneath the shale confining unit.

A lithologic log will be created for each boring, which will note depth of groundwater, characterize soil samples, in accordance with the Unified Soil Classification System, and describe each bedrock core. Split spoon soil samples will be collected every 5 feet, to the top of bedrock, to support continued lithologic logging.

Following initial groundwater sampling from the monitoring wells described above, additional contingency monitoring wells (MW-22 [deep] and MW-23 [shallow]) may be installed to further define the extent of arsenic and cobalt in groundwater downgradient of the BASA. The MW-23 proposed location is sited at the Evergy property boundary.

### 2.1.2 Monitoring Well Installation

The proposed shallow monitoring wells will be installed to a depth of approximately 20 to 40 feet bgs and will be screened within the glacial till material directly above bedrock. The proposed deep monitoring wells may be installed in bedrock to a depth of not greater than 100 feet bgs. The proposed monitoring wells will be designed and installed in accordance with 40 CFR § 257.91(e), and K.A.R. 28-30-6. The planned well designs are provided in Figures 5 and 6.

### 2.1.3 Monitoring Well Completion

Monitoring wells will be completed with 2-inch inside diameter flush threaded, 2-inch polyvinyl chloride (PVC) plug, well screen, and riser. The well screen will be up to 10 feet long and have 0.020-inch slots. The annular space between the borehole walls and the PVC materials will be filled with appropriately sized sand pack (No. 8-12 silica sand) to approximately 5 feet above the well screen. A bentonite seal of fine chips or pellets of approximately 5 feet will be placed above the filter pack. Bentonite grout will be used to backfill the hole to surface grade and will be placed via tremie pipe. The top of the riser will be secured with a locking watertight cap. Each well will be completed with an above ground protective casing that will be locked once installation is complete. Monitoring well construction may be adjusted based on field observations. The planned well designs are provided in Figures 5 and 6.

### 2.1.4 Monitoring Well Development

All newly installed monitoring well seals will be allowed to set for a minimum of 24 hours prior to well development. The wells will be developed by the swabbing, bailing, airlifting, and/or pumping methods in accordance with the SOP in Appendix A. Monitoring well development will be complete once the monitoring well is visibly clear and sediment free, turbidity is reduced to less than 10 Nephelometric Turbidity Units (NTU) or has stabilized, and when pH, temperature, and conductivity have stabilized. Water level elevations will be measured with a decontaminated water level indicator throughout the well development.

## 2.2 DEVELOPMENT AND PURGE WATER MANAGEMENT

Development and purge water will be discharged to the ground at the site following drilling activities. The drilling subcontractor will be responsible for ensuring that no development or purge water will enter any on-site surface water pathways.

## 2.3 SURVEY

Following monitoring well drilling, installation, and development, a surveyor licensed in the state of Kansas will be contracted to establish final well locations and the vertical elevation (surface and casing) at each monitoring well.

# 3. Nature and Extent Groundwater Sampling

## 3.1 40 CFR § 257.95(g)(1)(iv) – GROUNDWATER SAMPLING

***Sample all wells in accordance with paragraph (d)(1) of this section to characterize the nature and extent of the release.***

Nature and extent groundwater samples will be collected from the newly installed nature and extent monitoring wells in accordance with 40 CFR § 257.95(g)(1)(iv) within 30 days of monitoring well development. Representative groundwater samples will be collected from the wells using a portable bladder pump in accordance with the sampling and analytical procedures outlined in the site-specific Sampling and Analysis Plan (SAP). Groundwater samples will continue to be collected at the newly installed nature and extent monitoring wells on at least a semi-annual basis, in accordance with 40 CFR § 257.95(d)(1), for at least two years. These samples will provide an adequate quantity of analytical results to establish a statistically defensible dataset. This dataset will capture seasonal variability of constituents downgradient of the BASA and characterize the nature and extent of the release and any relevant site conditions that may affect the remedy ultimately selected. Additional sampling time may be required to support a complete and accurate assessment of the corrective measures necessary to effectively clean up all releases from the BASA.

All samples will be analyzed for Appendix III and detected Appendix IV constituents pursuant to 40 CFR § 257.95(d)(1) by a laboratory certified by the State of Kansas. Data validation and usability assessment will be performed in accordance with guidance and requirements established in the documents titled *USEPA National Functional Guidelines for Inorganic Data Review (USEPA, 2020)*[2] and *the Evaluation of Radiochemical Data Usability* (Paar, 1997).[3]

The SAP for TEC will be revised to include additional wells, analytical constituents, and sampling procedures to support the implementation of the nature and extent investigation at the BASA pursuant to 40 CFR § 257.95(g)(1).

## 3.2 GROUNDWATER PROTECTION STANDARDS

Data generated from this effort will be compared to the GWPS previously established for the BASA in the statistical analysis report completed pursuant to Paragraph 10.c of the CAFO.[4] The list of GWPS for detected Appendix IV constituents from the January 2023 annual assessment monitoring sampling event, in accordance with 40 CFR § 257.95(d)(2), are provided in Table 2.

If the concentration of detected Appendix IV constituents is less than the GWPS, the delineation of the extent of the plume in that area will be considered complete. If Appendix IV constituents are detected at levels above the GWPS, additional sampling and/or monitoring wells may be installed to fully delineate the plume.

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[2] U.S. Environmental Protection Agency, 2020. National Functional Guidelines for Inorganic Superfund Methods Data Review. EPA-540-R-2017-001. January.

[3] Paar, J.G., 1997. Evaluation of Radiochemical Data Usability. April.

[4] Haley & Aldrich, Inc., 2022. Semi-Annual Groundwater Monitoring Data, Assessment Monitoring Statistical Evaluation, Tecumseh Energy Center, Bottom Ash Settling Area. December.

# 4. Assessment of Corrective Measures

## 4.1 40 CFR § 257.95(g)(3)(i) – ASSESSMENT OF CORRECTIVE MEASURES

***Initiate an assessment of corrective measures as required by § 257.96***

Based on the requirements of paragraph 10.c. of the CAFO and subsequent actions by Evergy, Evergy initiated a Corrective Measures Assessment (CMA) at the BASA on March 13, 2023. The timeline for completion of the CMA is dependent on the installation of wells described in this and subsequent plans required by CAFO. The requirement to complete these plans and obtain approval with USEPA is not included under the standard timeline for CMA completion in 40 CFR § 257.96.

Following completion of the nature and extent investigation scope of work proposed in this Plan, and additional phases of investigation that may need to occur, the assessment of corrective measures will be completed within 180 days, unless there is a demonstrated need for additional time to complete assessment due to site-specific conditions or circumstances.

# 5. Notifications

## 5.1 40 CFR § 257.95(g) – STATISTICALLY SIGNIFICANT LEVELS NOTIFICATION

***If one or more constituents in appendix IV to this part are detected at statistically significant levels above the groundwater protection standard established under paragraph (h) of this section in any sampling event, the owner or operator must prepare a notification identifying the constituents in appendix IV to this part that have exceeded the groundwater protection standard. The owner or operator has completed the notification when the notification is placed in the facility's operating record as required by § 257.105(h)(8).***

Within 30 days of detecting one or more constituents in Appendix IV at SSLs above the GWPS from the statistical evaluation completed in accordance with Paragraph 10.c. of the CAFO, Evergy will prepare an SSL notification and place the notification in the facility's operating record.

## 5.2 40 CFR § 257.95(g)(2) – PROPERTY OWNER NOTIFICATION

***Notify all persons who own the land or reside on the land that directly overlies any part of the plume of contamination if contaminants have migrated off-site if indicated by sampling of wells in accordance with paragraph (g)(1) of this section. The owner or operator has completed the notifications when they are placed in the facility's operating record as required by § 257.105(h)(8).***

Within 30 days of detecting one or more constituents in Appendix IV at SSLs above the GWPS at nature and extent monitoring wells located off Evergy property, a notification will be provided to all persons who own or reside on land that directly overlies any part of the plume of contamination.

Following monitoring well drilling, installation, and development, new nature and extent monitoring wells may take 12 months or longer to provide representative concentrations of constituents. The proposed 30-day notification will be provided following at least three groundwater sampling events at off-site nature and extent monitoring wells following a sampling schedule outlined in Section 3.1 of this Plan.

## 5.3 40 CFR § 257.95(g)(5) – CORRECTIVE MEASURES NOTIFICATION

***Notification stating that an assessment of corrective measures has been initiated.***

Within 30 days of detecting one or more constituents in Appendix IV at SSLs above the GWPS from the statistical evaluation completed in accordance with Paragraph 10.c. of the CAFO, Evergy will prepare a notification stating that an assessment of corrective measures has been initiated.

# 6. Schedule

## 6.1 MONITORING WELL INSTALLATION SCHEDULE

In accordance with Paragraph 10.g. of the CAFO, within 180 days of USEPA approval of this Plan, Evergy will install the additional wells and initiate sampling according to the schedules included in the approved Plan.

## 6.2 NATURE AND EXTENT INVESTIGATION SCHEDULE

Nature and extent investigation items outlined in Sections 2 through 5 of this Plan will be initiated in accordance with the schedule provided in Table 3.

# TABLES

**TABLE 1**
**MONITORING WELL CONSTRUCTION INFORMATION**
EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS

| Location | Well Identification | Well Installation Date | Casing Diameter (inches) | Blank Casing Type | Screened Casing Type | Slot Size (inch) | Top of Screen (feet bgs) | Bottom of Screen (feet bgs) | Well Depth (feet bgs) | Depth to Water[a] (feet btoc) | Water Level Elevation (feet amsl) | Water Column Depth (feet) | Northing[b] | Easting[b] | Ground Surface Elevation (feet amsl)[c] | Top of Casing Elevation (feet amsl)[c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bottom Ash Settling Area** | | | | | | | | | | | | | | | | |
| Downgradient | MW-8 | 5/27/2015 | 2 | Schd 40 PVC | Schd 40 PVC | 0.020 | 12 | 22 | 22 | 18.40 | 851.34 | 3.60 | 271159.2111 | 2001886.2591 | 867.09 | 869.84 |
| | MW-9[d] | 7/6/2015 | 2 | Schd 40 PVC | Schd 40 PVC | 0.020 | 12 | 22 | 22 | - | - | - | 271115.6500 | 2001608.3036 | 864.89 | 868.66 |
| | MW-10 | 5/27/2015 | 2 | Schd 40 PVC | Schd 40 PVC | 0.020 | 12 | 22 | 22 | 18.10 | 851.54 | 3.9 | 270957.7952 | 2001594.1357 | 864.84 | 869.11 |
| | MW-11 | 4/9/2016 | 2 | Schd 40 PVC | Schd 40 PVC | 0.020 | 20 | 30 | 30 | 25.56 | 851.29 | 4.44 | 270892.7851 | 2001649.954 | 873.94 | 876.85 |
| Upgradient | MW-7 | 7/6/2015 | 2 | Schd 40 PVC | Schd 40 PVC | 0.020 | 24 | 34 | 34 | 25.04 | 854.69 | 8.96 | 270755.4546 | 2001876.9832 | 875.38 | 878.19 |

***Notes:***
*Monitoring Well Used for Piezometric Observation Only*
[a] *Depth to water from groundwater elevation survey on December 5, 2019.*
[b] *Data Source: Evergy Kansas Central, Inc (f/k/a Westar Energy, Inc.) Tecumseh Energy Center, August 2016.*
[c] *Survey elevations revised February 2020 after well casings were shortened during unit closure activities prior to the September/October 2019 groundwater sampling event.*
[d] *Monitoring Well MW-9 was dry during the December 2019 sampling event and a depth to water was unsuccessful.*
*amsl - above mean sea level*
*bgs - below ground surface*
*btoc - below top of casing*
*Schd 40 PVC - Schedule 40 polyvinyl chloride*

**TABLE 2**

**JANUARY 2023 ANNUAL ASSESSMENT GROUNDWATER MONITORING - DETECTED APPENDIX IV GWPS**

EVERGY KANSAS CENTRAL, INC.

TECUMSEH ENERGY CENTER, BOTTOM ASH SETTLING AREA

TECUMSEH, KANSAS

| Well Number | Background Value (UTL)[1] | MCL | CFR § 257.95(h)(2)* | GWPS (Higher of MCL/40 CFR § 257.95(h)(2) or UTL) |
|---|---|---|---|---|
| **CCR Appendix-IV Arsenic, Total (mg/L)** | | | | |
| MW-7 (upgradient) | 0.0021 | 0.010 | NA | NA |
| MW-10 | | 0.010 | NA | 0.010 |
| MW-8 | | 0.010 | NA | 0.010 |
| MW-9 | | 0.010 | NA | 0.010 |
| **CCR Appendix-IV Barium, Total (mg/L)** | | | | |
| MW-7 (upgradient) | 0.0937 | 2 | NA | NA |
| MW-10 | | 2 | NA | 2 |
| MW-8 | | 2 | NA | 2 |
| MW-9 | | 2 | NA | 2 |
| **CCR Appendix-IV Cobalt, Total (mg/L)** | | | | |
| MW-7 (upgradient) | 0.0035 | NA | 0.006 | NA |
| MW-10 | | NA | 0.006 | 0.006 |
| MW-8 | | NA | 0.006 | 0.006 |
| MW-9 | | NA | 0.006 | 0.006 |
| **CCR Appendix-IV Lithium, Total (mg/L)** | | | | |
| MW-7 (upgradient) | 0.0319 | NA | 0.040 | NA |
| MW-10 | | NA | 0.040 | 0.040 |
| MW-8 | | NA | 0.040 | 0.040 |
| MW-9 | | NA | 0.040 | 0.040 |
| **CCR Appendix-IV Molybdenum, Total (mg/L)** | | | | |
| MW-7 (upgradient) | 0.0139 | NA | 0.100 | NA |
| MW-10 | | NA | 0.100 | 0.100 |
| MW-8 | | NA | 0.100 | 0.100 |
| MW-9 | | NA | 0.100 | 0.100 |
| **CCR Appendix-IV Radium-226 & 228 Combined (pCi/L)** | | | | |
| MW-7 (upgradient) | 5.88 | 5 | NA | NA |
| MW-10 | | 5 | NA | 5.88 |
| MW-8 | | 5 | NA | 5.88 |
| MW-9 | | 5 | NA | 5.88 |

***Notes:***

[1] *Based on background data collected from 08/30/2016 through 01/05/2023, unless otherwise noted.*

** Values obtained from U.S. Environmental Protection Agency Federal CCR Rule Title 40 Code of Federal Regulations (CFR) §§ 257.95(h)(2).*

*CCR = Coal Combustion Residuals*

*GWPS = Groundwater Protection Standard*

*mg/L = milligrams per Liter*

*pCi/L = picoCuries per Liter*

*MCL = Maximum Contaminant Level*

*NA = Not Applicable*

*UTL = Upper Tolerance Limit*

**TABLE 3**
**PROPOSED SCHEDULE FOR NATURE AND EXTENT INVESTIGATION**
EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS

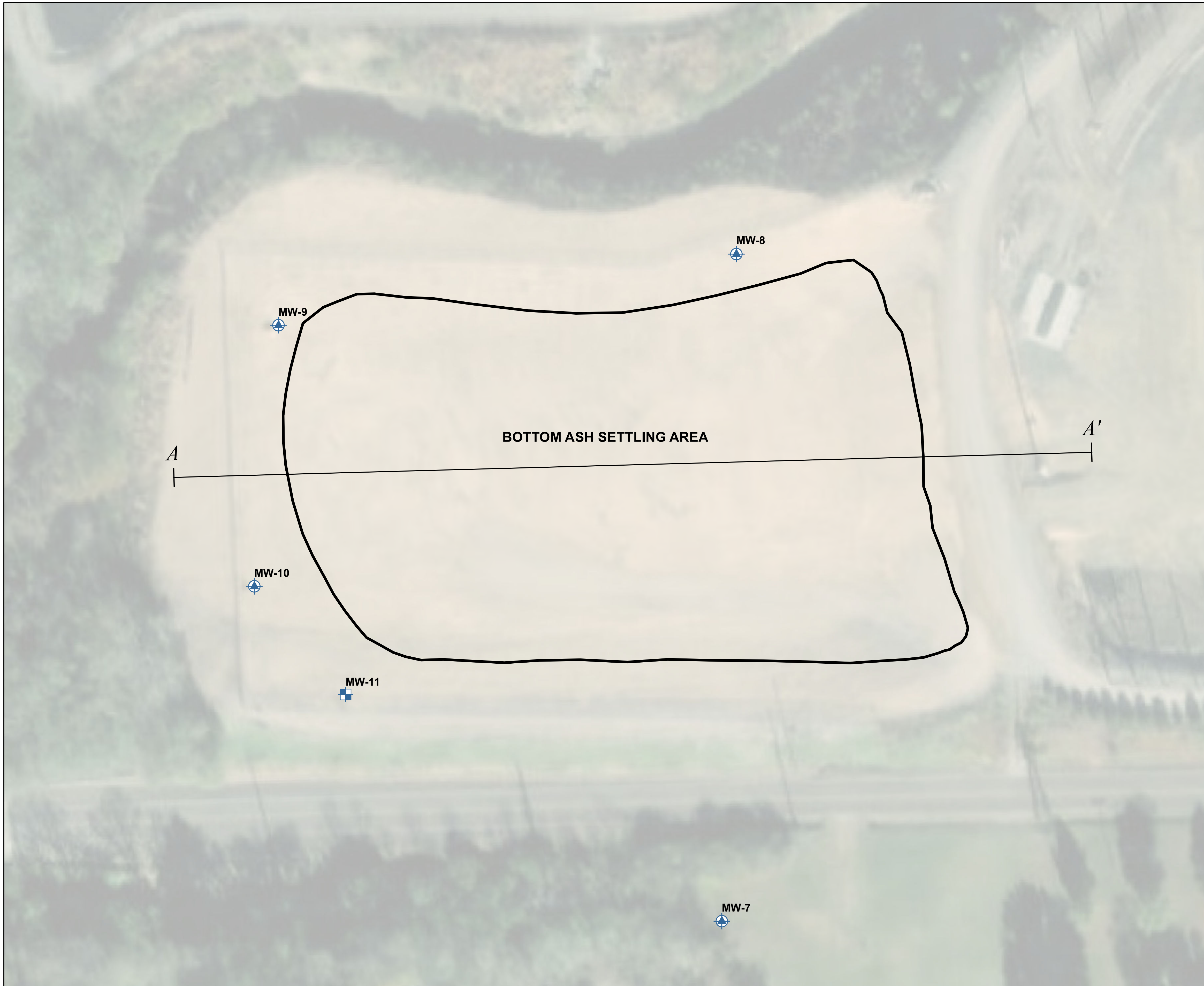
| Schedule Item[1] | CCR Rule Regulation | Estimated Start Date |
|---|---|---|
| **Assessment Monitoring Program and Nature & Extent Investigation** | | |
| Initiate an Assessment of Corrective Measures | *40 CFR § 257.95(g)(3)(i)*<br>*40 CFR § 257.96(a)* | Within 90 days of detecting Appendix IV SSLs from statistical analyses completed under Paragraph 10.c. of the CAFO |
| Initiated Nature and Extent Investigation Drilling | *40 CFR § 257.95(g)(1)(i)-(iii)* | Within 180 days of USEPA approval of this Plan[2] |
| Initial Groundwater Sampling for newly installed Nature and Extent Monitoring Wells | *40 CFR § 257.95(g)(1)(iv)* | Within 30 days of monitoring well development at newly installed nature and extent monitoring wells, and then on a semi-annual basis |
| Groundwater Protection Standards comparison | *40 CFR § 257.95(d)(2)* | Within 30 days of obtaining validated results from nature and extent groundwater sampling events |
| Completion of Assessment of Corrective Measures | *40 CFR § 257.96* | Within 180 days of completion of the nature and extent investigation[3], unless there is a demonstrated need for additional time to complete assessment due to site-specific conditions or circumstances. |
| **Notifications** | | |
| Statistically Significant Level Notification | *40 CFR § 257.95(g)* | Within 30 days of detecting Appendix IV SSLs from statistical analyses completed under Paragraph 10.c. of the CAFO |
| Corrective Measures Notification | *40 CFR § 257.95(g)(5)* | Within 30 days of detecting Appendix IV SSLs from statistical analyses completed under Paragraph 10.c. of the CAFO |
| Property Owner Notification | *40 CFR § 257.95(g)(2)* | Within 30 days of detecting Appendix IV SSLs at nature and extent monitoring wells located off Evergy property following at least three (3) groundwater sampling events as outlined in Section 5.2 of this Plan. |

***Notes:***

*1. Proposed schedule address the requirements in Paragraph 10.d. of a consent agreement between the U.S. Environmental Protection Agency (EPA) and Evergy Kansas Central, Inc. dated November 7, 2022*
*2. Well Placement/Development Plan (Plan) for Nature and Extent Investigation of Appendix IV Constituents at the BASA surface impoundment*
*3. The nature and extent investigation is anticipated to least 2 years to complete.*
*CAFO = Consent Agreement and Final Order*
*CCR = Coal Combustion Residual*
*CFR = Code of Federal Regulation*
*SSL = Statistically Significant Level*
*USEPA = U.S. Environmental Protection Agency*

# FIGURES

DRAFT




LEGEND

MONITORING WELL

PIEZOMETER OBSERVATION ONLY

CROSS SECTION TRACE

BOTTOM ASH SETTLING AREA UNIT BOUNDARY/APPROXIMATE EDGE OF FORMER WASTE BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.

2. AERIAL IMAGERY SOURCE: ESRI, NOVEMBER 7, 2019

0 60 120

SCALE IN FEET

HALEY ALDRICH

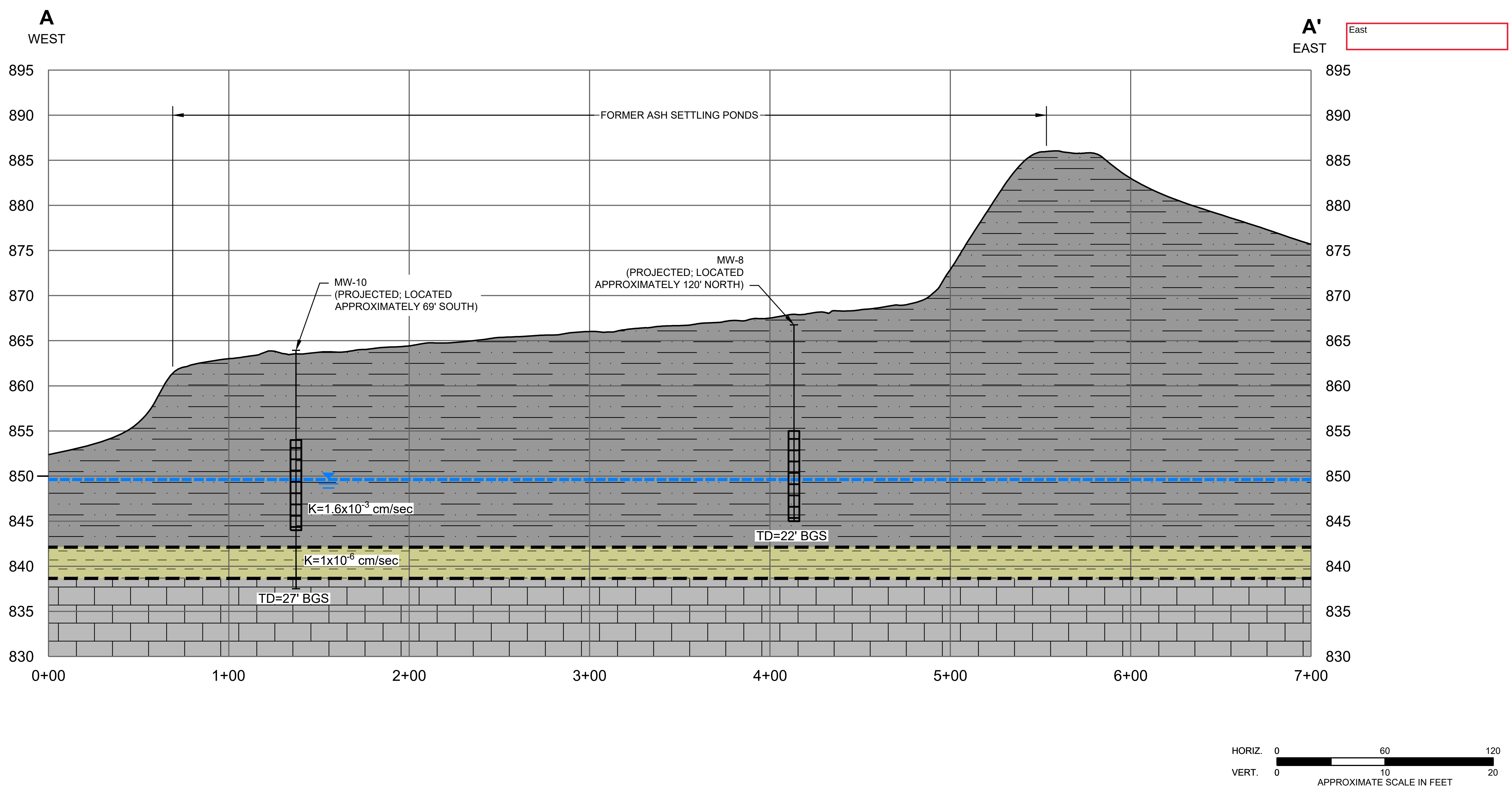
EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS

BOTTOM ASH SETTLING AREA
MONITORING WELL LOCATION MAP

evergy

MAY 2023

FIGURE 1




**LEGEND**

- GLACIAL DEPOSITS/OVERBURDEN
- SHALE MEMBER OF THE SCRANTON FORMATION
- LIMESTONE MEMBER OF THE SCRANTON SHALE FORMATION
- APPROXIMATE GEOLOGIC CONTACT
- INFERRED GEOLOGIC CONTACT
- APPROXIMATE WATER TABLE
- INFERRED WATER TABLE
- MW-10 WELL IDENTIFICATION
- GROUND SURFACE
- WATER LEVEL
- WELL SCREEN
- TD=4X' BGS TOTAL DEPTH OF BOREHOLE

**NOTES**

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. BGS = BELOW GROUND SURFACE
3. K = HYDRAULIC CONDUCTIVITY
4. THE HYDRAULIC CONDUCTIVITY WAS CALCULATED USING DATA GENERATED FROM SLUG TESTS CONDUCTED AFTER MONITORING WELL INSTALLATION AND DEVELOPMENT IN 2016

HALEY ALDRICH

EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS

GEOLOGIC CROSS SECTION A-A'

SCALE: AS SHOWN
MAY 2023

FIGURE 2


**LEGEND**

MW-8 849.64 — WELL NAME AND GROUNDWATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL (AMSL), MARCH 2023

MONITORING WELL

PIEZOMETER OBSERVATION ONLY

ESTIMATED GROUNDWATER POTENTIOMETRIC OBSERVATION ELEVATION CONTOUR, 0.5-FT INTERVAL (AMSL), DASHED WHERE INFERRED

GROUNDWATER FLOW DIRECTION AND APPROXIMATE GROUNDWATER FLOW RATE (FEET/YEAR)

BOTTOM ASH SETTLING AREA UNIT BOUNDARY/APPROXIMATE EDGE OF FORMER WASTE BOUNDARY

**NOTES**

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. GROUNDWATER POTENTIOMETRIC ELEVATIONS WERE MEASURED 06 MARCH 2023.
3. THE GROUNDWATER FLOW RATE WAS APPROXIMATED USING THE HYDRAULIC GRADIENT CALCULATED FROM GROUNDWATER POTENTIOMETRIC ELEVATIONS MEASURED 06 MARCH 2023 AND THE CONDUCTIVITY VALUES AND EFFECTIVE POROSITY VALUES OBTAINED FROM SLUG TESTS COMPLETED APRIL 2016.
4. AERIAL IMAGERY SOURCE: ESRI, NOVEMBER 7, 2019

N

0 75 150

SCALE IN FEET

HALEY ALDRICH

EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS

BOTTOM ASH SETTLING AREA
GROUNDWATER POTENTIOMETRIC
ELEVATION CONTOUR MAP
MARCH 06, 2023

evergy

MAY 2023

FIGURE 3

DRAFT


LEGEND

- SHALLOW NATURE AND EXTENT MONITORING WELL
- CONTINGENCY DEEP MONITORING WELL
- CONTINGENCY SHALLOW MONITORING WELL
- COMPLIANCE MONITORING WELL
- PIEZOMETRIC OBSERVATION ONLY
- BOTTOM ASH SETTLING AREA UNIT BOUNDARY/APPROXIMATE EDGE OF FORMER WASTE BOUNDARY
- EVERGY KANSAS CENTRAL INC. PROPERTY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGERY SOURCE: ESRI, NOVEMBER 7, 2019

N

0 200 400
SCALE IN FEET

HALEY ALDRICH

EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS

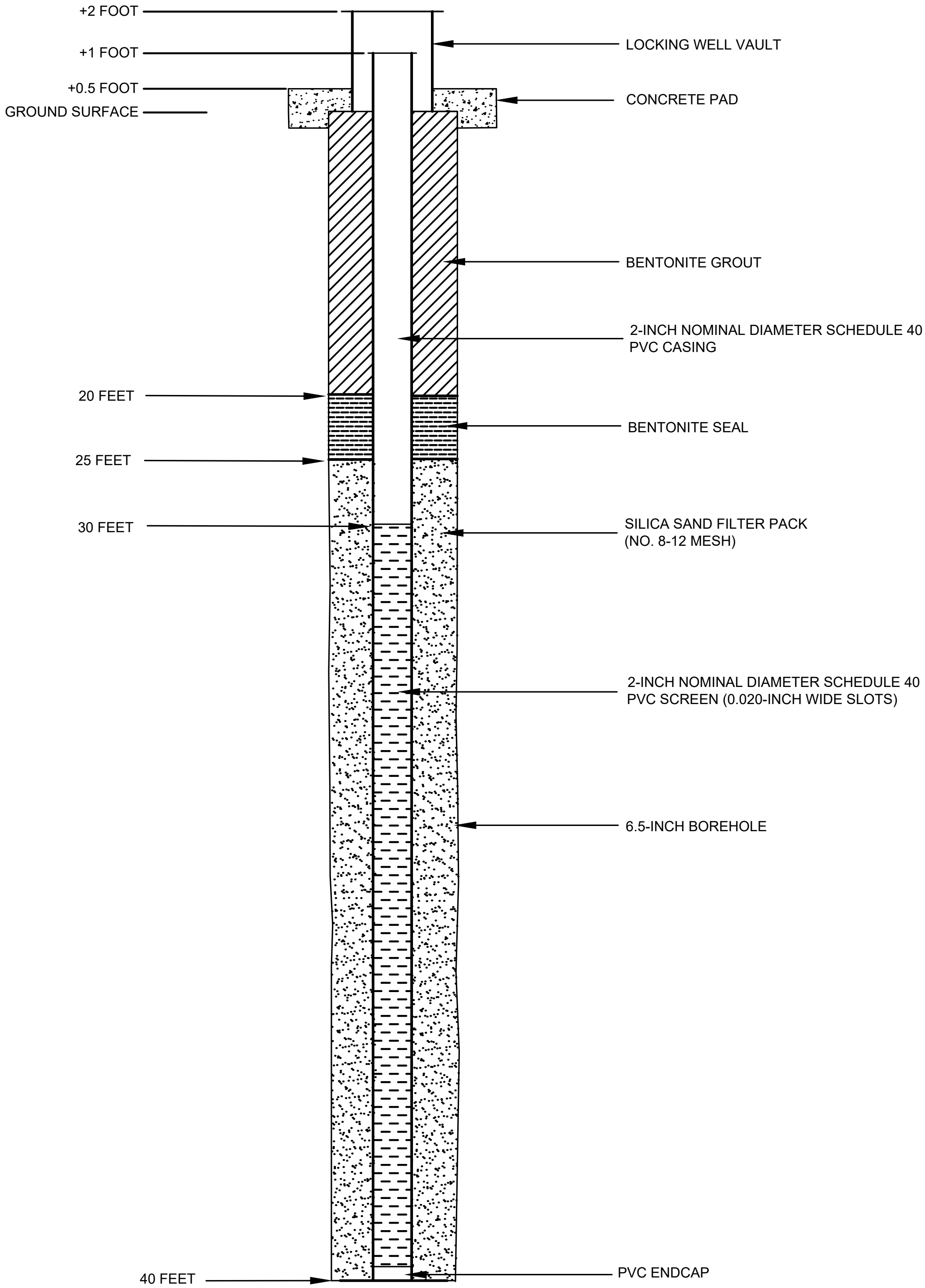
PROPOSED NATURE AND EXTENT GROUNDWATER MONITORING WELLS

evergy

MAY 2023

FIGURE 4

DRAFT




HALEY ALDRICH

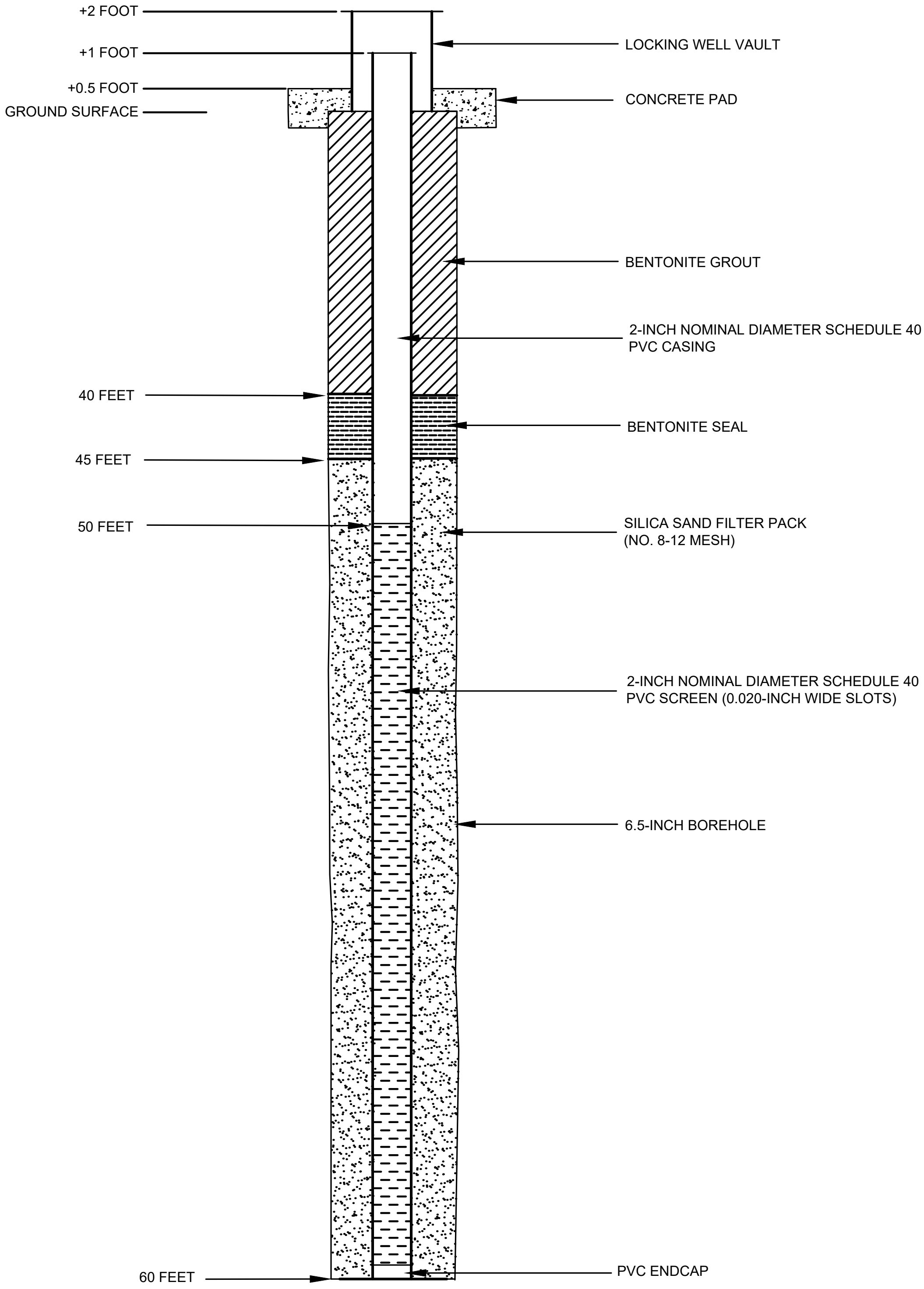
EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS

PROPOSED SHALLOW MONITORING WELL DESIGN

NOT TO SCALE
MAY 2023

FIGURE 5

DRAFT




HALEY ALDRICH

EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS

PROPOSED DEEP MONITORING WELL DESIGN

NOT TO SCALE
MAY 2023

FIGURE 6

# APPENDIX A
## Standard Operating Procedures

# OPERATING PROCEDURE: OP2000

# MONITORING FIELD EXPLORATIONS



**PREPARATION AND APPROVALS**

| VERSION | AUTHORED/DATE | REVIEWED / DATE | REVIEWED / DATE | REVIEWED / DATE | APPROVED / DATE |
|---|---|---|---|---|---|
| Ver. 0.0 | CSO/ 12-02 | JAM/ 01-03 | | STP/6-1-03 | SRK/7-1-03 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

**Total Pages: 56**

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**OPERATING PROCEDURE: OP2000**

**MONITORING FIELD EXPLORATIONS**

## 1. PURPOSE

Exploratory test borings, probes and test pits represent important sources of subsurface information relating to geologic conditions and site suitability fundamental to environmental site assessment and geotechnical engineering design recommendations. The following procedure is an outline of the field staff responsibilities while monitoring subsurface exploration methods utilized by Haley & Aldrich Inc. (H&A) to obtain the best possible data for geologic characterization, laboratory testing and subsequent engineering evaluations and environmental assessment.

## 2. EQUIPMENT & MATERIALS

### 2.1 Standard Required Equipment

| | Required | | Additional as Required |
|---|---|---|---|
| 1. | Proposal (signed by Client) | 20. | First Aid Kit |
| 2. | Site Plan | 21. | Cellular Phone |
| 3. | Contract with Subcontractor (pay items) | 22. | Health & Safety Plan |
| 4. | Exploration Criteria/Specifications | 23. | Respirator & Tyvek Suit |
| 5. | Field Book | 24. | Laptop Computer |
| 6. | Clipboard | 25. | Camera & Film |
| 7. | Logs & Forms | 26. | Field Procedures |
| 8. | Office Supplies (pencils & markers) | 27. | Maps and References |
| 9. | Engineer's Scale | 28. | Sample Bags & Jars with Labels |
| 10. | 6 ft. Ruler | 29. | Survey Stakes/Paint/Flagging |
| 11. | 100 ft. Measuring Tape | 30. | Shovel |
| 12. | Hand Lens, magnifying | 31. | Geologist's Pick |
| 13. | Pocket Knife | 32. | Flashlight |
| 14. | Hard Hat | 33. | Roadway Box Key/Socket Wrench |
| 15. | Safety Glasses | 34. | Water Level Indicator |
| 16. | Sound Dampeners | 35. | Hand Level |
| 17. | Steel Toe Boots | 36. | Brunton Compass |
| 18. | Protective Gloves | 37. | Pocket Penetrometer |
| 19. | Rain Gear | 38. | Torvane |

### 2.2 Required Environmental Equipment

Most environmental fieldwork will have extensive equipment requirements and supplies specifically related to the project needs. The following list is a representative list of equipment classed as type-specific groups. A comprehensive list of equipment and materials must be developed for each project in coordination with the Project Manager (PM) and Health & Safety (H&S) Coordinator prior to the start of the field program.

1. Personal Protection Equipment (PPE)
   - Air Purifying Respirator & Cartridges (Type GMC-Type H)
   - Latex/Nitrile Inner Gloves/Boot Covers
   - Tyvek/Saranex Coveralls/Sleeves/Apron

2. Decontamination Equipment and Supplies
   - Decontamination Kit
     - 5 gallon bucket
     - 5 gallon water jug
     - alconox detergent
     - brushes & paper towels
     - methanol/hexane/deionized water
   - Decontamination Tub
   - Absorption Pads
   - Polyethylene Sheeting
   - Polyethylene Trash Bags

3. Air Quality/Headspace Monitoring Equipment
   - Photo-Ionization Detector (PID)
   - Flame Ionization Detector (FID)
   - Organic Vapor Analyzer (OVA)
   - Combustible Gas Meter-LEL/O2
   - Dust Monitor
   - Multigas Meter-HCn/Methane/H2S
   - Gas Pointer
   - Draeger Tube Sampling Kit
   - Radiation Survey Meter

4. Soil Sampling Equipment and Supplies
   - Hand Auger
   - Soil Core Sampler
   - Shovel/Trowel/Remote Sampler
   - Stainless Steel Bowl
   - Aluminum Foil
   - Tongue Depressors
   - Sample Bags/Laboratory Glassware & Labels
   - Cooler & Ice Blocks

5. Water Sampling Equipment and Supplies
   - Water Level Indicator
   - Oil/Water Interface Probe
   - Centrifugal Pump-Volume
   - Submersible Pump-Low Flow
   - Peristaltic Pump & Silicone Tubing
   - Purge Pump & DC Supply
   - Waterra® Tubing/Foot Valves/Filters
   - Stainless Steel/Teflon Bailers & Rope
   - Remote Sampler
   - Water Testing Equipment
     - Flow Cell (pH, temperature, conductivity, DO, turbidity, ORP and salinity)
     - Dissolved Oxygen (DO) Meter
     - Oxidation-Reduction Potential (ORP) Meter
     - Turbidity Meter
     - Downhole Temperature/Resistivity/Conductivity/Salinity Meter
     - pH/ Turbidity/DO/ Temperature/Resistivity/Conductivity/Salinity Meter
   - Laboratory Glassware & Labels
   - Cooler & Ice Blocks

### 2.3 Additional Equipment, Specialized Instrumentation, Materials & Company Vehicles

Company-wide, Haley & Aldrich maintains an array of equipment, vehicles and specialized instrumentation for a broad variety of uses in addition to the selected equipment listed above. Additional equipment, vehicles and materials may be rented or purchased as needed with the approval of the project manager. Project equipment needs should be addressed proactively so that interoffice allocation can take place. It is recommended that the field staff familiarize themselves with the use, function and availability of all types of equipment standard to the industry. The following list is representative of the additional equipment currently available but is not intended to be a comprehensive list.

1. Survey Instrumentation
   - Theodolite/Transit/ Level & Rod
   - Global Positioning System (GPS)

2. Subsurface Locating Equipment
   - Ground Penetrating Radar (GPR)
   - Metal Detector
   - Magnetometer

3. Air-Soil-Water Quality/Analytical Equipment
   - Gas Chromatograph (GC)
   - TPH Analyzer
   - Infrared Oil Analyzer
   - Radiation Survey Meter
   - Oxidation-Reduction Potential Meter (ORP)

4. Geotechnical Equipment & Instrumentation
   - Vane Shear Test Equipment
   - Vibrating Wire Piezometer Equipment
   - Pressuremeter Testing Equipment
   - Seismograph Equipment
   - Inclinometer Equipment
   - Nuclear Moisture-Density Gauge
   - Sound Level Meter

5. Hydrogeologic Equipment & Instrumentation
   - Datalogger/Levelogger Hardware & Software
   - Stream Flow Gauge & Equipment

6. Photographic Equipment
   - Video Camera
   - Digital Camera
   - 35mm Camera

7. Communication Equipment
   - Cellular Telephone
   - Satellite Telephone
   - Two-Way Radio

8. Computer Hardware & Software



### 2.4 Billing Equipment & Materials

Equipment and materials are billed to the project as used on a daily or per item basis. Completion of equipment usage and billing forms and submission of original receipts for items purchased or rented is required in order to charge the project for reimbursement.

## 3. PROCEDURE

### 3.1 Preliminary Preparations

#### 3.1.1 Project Briefing

Prior to the beginning of an exploration program all field staff should attend a project briefing with the project manager and office staff involved in the proposed project. At this time a file folder for the field activities should be created for the purpose of containing all relevant project information including: copies of the original proposal, site and utility plans, contract documents and drawings, applicable regulations, exploration and sampling criteria, site contacts, phone numbers of team members, health and safety (H&S) plans, log and report forms and any other related documents or references. The field folder should be organized and maintained such that all documents likely to be useful for the completion of field activities by others are readily available in the event of personnel changes.

During the project briefing each team member should become thoroughly familiar with the overall scope of the project in addition to the task items and individual requirements of the work plan. Development of an outline of the specific activities envisioned and a review of the details concerning each task may facilitate the formulation of alternate approaches to field methods as well as the creation of action, materials and equipment lists.

Field staff should review all existing applicable information that relates to site geology and possess detailed familiarity and understanding of the contract specifications in order that knowledgeable field decisions can be made.  Field staff should be experienced in all of the various field exploration procedures, instrumentation installation and sampling techniques required for the project. Requests for training, guidance or assistance should be made by the field staff as needed. Haley & Aldrich, Inc. fosters a supportive environment where all staff are encouraged to share knowledge and experiences with each other.

### 3.1.2 Health & Safety

Safety in the workplace is a prime concern of Haley & Aldrich, Inc. on all projects. It is essential that field personnel understand and comply with all regulations governing worker safety in the field including applicable OSHA guidelines. Certain projects will require the field staff to attend a Health & Safety briefing due to specific occupational safety concerns. The nature of these concerns will be addressed by a site specific Health & Safety Plan. It is the responsibility of the project manager to notify the field staff of the existence of the Health & Safety Plan, however all field staff are encouraged to inquire with the Project Manager and with the Health & Safety Coordinator directly to avoid any possible oversight. Safety awareness and safe work practices are the responsibility of the field staff at all times and on all projects whether or not site or task specific guidelines are in existence. In the event of an accident, exposure or if unexpected contamination is encountered, the Project Manager and the Health & Safety Coordinator must be contacted immediately. Standard H&A safety recommendations for subsurface explorations are provided OP1001 Excavation and Trenching Safety and OP1002 Drilling Safety.

## 3.2 Duties and Responsibilities

### 3.2.1 General

The principal reason for providing Haley & Aldrich field representation is to assure that the field data being collected is accurate and of the type necessary to properly evaluate the site geologic conditions for use in the subsequent engineering analyses and environmental assessment.

### 3.2.2 Supervision of Subsurface Exploration Programs

Each subsurface exploration program carried out under H&A supervision is designed to accommodate the specific requirements of a given project. Subsurface exploration programs routinely include the excavation of test pits and the drilling of test borings with associated instrumentation installation, special testing and sampling requirements. Modifications to the fieldwork criteria, sampling and testing are often made during the execution of the subsurface exploration program as the accumulated geologic data and test results are interpreted. For this reason it is essential that all records are current and complete and that uncertainties are identified for resolution. Field staff are responsible for maintaining communication with the project manager and logistical coordination of the field effort within the workscope and budgetary limits.

### 3.2.3 Verification of Subsurface Exploration Techniques and Services

It is the role of H&A field staff to verify that instrumentation installation, subsurface sampling and testing methods are in conformance with applicable approved standards and specifications and to document conditions and results. Performance of sampling and testing is commonly conducted with subcontractor support and equipment. It is the responsibility of the H&A field staff to verify that proper equipment and techniques are employed and to obtain measurements and make observations independently. H&A field staff are responsible for complete field logging of groundwater, soil and bedrock conditions, the maintenance of accurate test records and field exploration location sketches, and ensuring proper instrumentation installation, sample preservation and handling. In addition, payment for services rendered on behalf of the client is commonly handled with H&A providing a daily field report (DFR) including an accurate breakdown of the work activities and itemized costs on a daily basis. Subcontractor pay items and method of payment are defined in their contract.

### 3.2.4 Right of Access

Prior to site entry, Haley & Aldrich staff members must ensure that permission has been gained from the property owner to access the property.

### 3.2.5 Layout and Utility Clearance

Prior to the start of any subsurface exploration all proposed locations must have utility clearance from all appropriate agencies and utility owners. Utility owners typically do not enter private properties. If there are particular concerns regarding utilities on private property, arrangements can be made with a private utility locating service. Prior to contacting any utility agency or service all proposed exploration locations must first be clearly marked in the field either with white paint or staked and white flagged. Additional colors can be used to highlight the location if the ground is snow covered. Alternate locations should be laid out in areas of suspected utilities. H&A requires the subsurface exploration subcontractor to obtain the utility clearance within the terms of the contract or services agreement. H&A field staff should verify with the driller/test pit contractor that the utilities have been cleared and obtain the clearance number prior to the start of subsurface explorations. Pre-excavation may be necessary in areas of closely spaced utilities either by hand, vacuum, or other means. Additional guidance is provided in OP1003 Utility Clearance.

### 3.2.6 Site Safety and Subcontractor Briefing

At the start of fieldwork, H&A field staff should coordinate a site briefing to review the schedule and workscope with all subcontractors involved with the project. This briefing should include a review of the equipment and material needs, exploration criteria and priority, testing and sampling specifics, pay items, site conditions, environmental concerns, known or suspected contamination, H&S information, decontamination requirements, site restoration and waste disposal issues, a site walkover and utility check. While it is the subcontractor's responsibility to obtain the utility clearance, the field representative should pay attention to the utility plans as well as surface manifestations of utilities involving manholes or catch basin grates, and gate or roadway boxes. Distance to overhead utilities must be considered as well. Observations of potential conflicts with utilities should be addressed with the subcontractor for their consideration.

### 3.2.7 Exploration Monitoring

3.2.7.1 General

Haley & Aldrich field staff should become familiar with the technical details and suitability of all exploration equipment and methods. Test borings are the most common method employed by H&A to obtain high quality data on subsurface conditions. Unsampled probes can be used in a limited capacity to document overburden thickness. Specialty equipment is routinely used in sampled probes for environmental sampling. Test pits are preferred for surficial geological mapping and to document fill or overburden thickness. In addition to these typical exploration methods a variety of special testing techniques and instrumentation installations may supplement the subsurface exploration program. Specific H&A procedures must be consulted for details relating to special testing, sampling and instrumentation installation.

3.2.7.2 Exploration Equipment and Use

Exploration equipment selection is based upon a detailed understanding of the capabilities of the equipment with regard to the anticipated site geological conditions. In addition, the particular project needs may necessitate or preclude certain techniques and equipment. During the initial site walkover or layout, equipment access is considered and the type of exploration method is determined. Relatively small drill rigs are routinely used for overburden sampling, bedrock coring and groundwater monitoring well installations on a variety of projects. Larger pneumatic-percussive well rigs are used for drilling aquifer test and production wells. Excavation equipment may be preferred for initial surficial geologic mapping and to provide access prior to drilling. Various probe equipment may be considered for preliminary estimation of overburden thickness. Access to a water supply must be arranged for cased test borings and rock coring. Shallow water conditions and potentially liquefaction-susceptible soils preclude the use of augers. Bedrock monitoring wells must be cored in sufficient diameter to allow sand pack and seals. Enclosed areas may necessitate alternate fuels or low overhead equipment. Ecologically sensitive areas may require non-petroleum-based hydraulics or lightweight equipment. Many factors affect the equipment selection resulting in some trade-off in performance, cost and reliability of data.

3.2.7.3 Test Boring Techniques

*A.* *Cased Borings* - Cased borings are the primary method of obtaining high quality overburden samples and for penetration to bedrock prior to rock coring. The drill casing (pipe) is typically advanced in 5 ft. increments either by driving or spinning and then is washed out with an axially discharging tricone rollerbit pumping water or drill slurry from the recirculation tub. Upon flushing, the rollerbit is removed and a splitspoon sampler is fixed to the drill string (rods), lowered to the bottom of the borehole and driven into the undisturbed soils below the bottom of the casing. The procedure is repeated until the termination depth criterion is reached or bedrock is encountered. Common casing inside diameter (I.D.) ranges from 3 inch to 6 inch depending upon conditions and criteria. Rollerbits are sized to fit inside the casing with approximately 1/16 to 1/8 in. clearance. Typically boreholes are started with 5 or 6 in. I.D. casing fitted with a hard-shoe or drive-shoe in the lead (bottom) section. The casing is driven and splitspoon sampling is conducted at 5 ft. intervals (standard sampling) until an obstruction is encountered or the casing is seated into material such as clay that will maintain itself uncased. In the event of an obstruction the rollerbit or a buttonbit may be used to advance through the obstruction. In some cases the obstruction may break or a boulder-buster may be successfully employed and the casing is advanced. In other cases the next smaller diameter casing will be telescoped down the borehole and advanced through the hole in the obstruction created by the buttonbit. In the event that material such as clay that will maintain itself uncased is encountered, the open hole is extended as deep as possible. The borehole may be maintained by a bentonite or polymer slurry (mud rotary drilling). Casing fitted with a spin-shoe (econoshoe) is advanced by drilling in a similar manner to rollerbit advancement. Slurry or water is pumped down the casing to cool the bit and flush away the drill solids. Prior to splitspoon sampling the rollerbit must be lowered down the borehole and the spun casing must be drilled out in the same fashion as with driven casing. Spun or driven casing must be seated into the top of the bedrock in order to achieve an effective seal prior to rock coring.

B. *Mud Rotary Drilling* - Mud rotary drilling typically is conducted in deeper overburden borings and on projects where there are special concerns for soil sample integrity or particularly soft soils. Various products are used to make drill mud depending upon conditions and project requirements. Some mud is bentonite-silica based (heavy mud), some are compatible with saline conditions for ocean drilling, and some polymers are biodegradable for use in boreholes intended for environmental groundwater monitoring well installation. In all cases, mud drilling requires that a positive head be maintained in the casing at all times to stabilize the borehole. The practice is to fit a bypass line to the recirculation circuit that can be easily used to fill the casing as the rollerbit is being withdrawn. Use of a mud balance is required under certain circumstances to ensure sample integrity at the bottom of the borehole. The specific gravity to maintain in the drill mud will be specified on these projects.

*C.* *Auger Borings* - Hollow stem augers (HSA) are an effective and fast method for drilling shallow borings in softer soils above the water table without introducing water or drill slurry. Hollow stem augers are preferred for environmental studies where continuous soil sampling and minimization of potential cross contamination due to the use of drilling fluids is desired. Hollow stem augers and solid stem augers are also used as shallow probes. Auger flights are typically 5 ft. in length and are commonly 3.5 to 4.25 in. I.D. The lead section is fitted with a cutter head upon which are fixed several hardened, replaceable teeth. Using a center plug fixed to the bottom of the rods, hollow stem augers are typically advanced by drilling to the desired depth whereupon the center plug is replaced by the splitspoon and driven below the bottom of the lead section. Disturbance below the bottom of the augers due to the cutter head is typically substantial and heave is common at the bottom of the borehole due to the piston like effect of the center plug during removal. As such, augers are not favored for test borings on many geotechnical projects where high quality samples and penetration resistance data are required.

*D.* *Splitspoon Sampling and the Standard Penetration Test (SPT)* - The typical method for obtaining representative samples and a measure of the penetrative resistance of soils in test borings is by means of the Standard Penetration Test (SPT). This is accomplished utilizing a hollow tube splitspoon sampler assembly attached to the drill rods and driven into the soils at the bottom of the borehole at regular intervals. Splitspoon samplers are manufactured in various sizes with the most commonly used being 1 3/8 in. I.D. (2 in. O.D.) and having an interior sample chamber length of 24 in. (approximately 36 in. overall length). Once lowered to the sampling depth, the sampler is typically driven 24 in. into the soils with a 140 lb. hammer freely-falling over a 30 in. drop and the number of blows (SPT blowcount) required for each 6 in. of penetration is recorded. The penetrative resistance in blows per foot obtained from the summation of the blowcounts from 6 in. to 18 in. is referred to as the “N-value”. Terminology for density of granular soils and consistency of cohesive soils has been correlated to N-values. When performed properly the SPT provides useful data for determination of the geotechnical behavior of soils and engineering design in addition to representative remolded soil samples for geological interpretation.

*E.* *Bedrock Coring* - Bedrock coring is conducted in cased borings to obtain accurate detail of the bedrock properties and high quality samples for laboratory testing. A wide variety of rock core equipment is available and rock coring techniques vary greatly depending upon the driller, rock type, equipment and many other factors. Observations related to drilling activities are a primary focus during rock coring including bit weight, feed restriction, head speed, engine speed and gear, pump volume, water loss and fluid return, core rate, drilling halts, jamming, rapid advances, equipment defects, bit type, bit wear, core barrel type, core barrel adjustment. For all projects it is essential that accurate measurements be made when determining the depth of the bedrock surface from drill action or SPT and that detailed observations are recorded concerning the effects noted and the procedures executed upon encountering bedrock. Coring should begin at the minimum depth below the bedrock surface required to seat the casing in order to document the bedrock condition in the uppermost zone where typically fracturing and weathering transitions are greatest. Core hole depth must be verified following each run to account for lost core. When necessary, logging should be broken down into a two step process beginning with sample preservation, labeling and recording of a simple description including recovery and RQD measurements followed by detailed logging of individual features and properties as time and conditions permit.

*F.* *Observation Well Installation* - Groundwater observation or monitoring wells are commonly installed in completed test borings as a means obtaining accurate stabilized groundwater readings essential to engineering design, and hydrogeologic modeling. In addition, permanent observation or monitoring well installations provide for continual long-term sampling for environmental analyses. A wide variety of material types and sizes are employed depending upon the intended use. Typical observation or monitoring wells installations consist of 2 in. I.D. PVC pipe with a machine slotted screen section backfilled with filter sand and sealed with bentonite within the desired stratum or zone. Solid riser sections above the sealed zone may be grouted or backfilled with a variety of materials depending upon the project needs and finished at the ground surface with either a flush-mount roadway box or with a protective casing such as a guard pipe and padlock for undeveloped sites. Careful attention to the placement of screens, backfill and seals is required and accurate depth measurements must be recorded during installation. Initial well development may occur immediately upon completion in order set the sand pack and remove the effects of drill fluids from the formation waters.



3.2.7.4 Probes

*A.* *Unsampled Probes* - The term probe has historically referred to the advancement of a solid drill bit or rod by various means without sampling in order to estimate potential soft sediment thickness and refusal or obstruction depths. Small diameter rods advanced by hand have been useful in determining minimum peat and organic thickness in wetlands. Mechanical advancement of solid stem augers with conventional drilling equipment and pneumatic-percussive air track drilling are routinely used to supplement or replace test borings in areas of known shallow bedrock. Direct-push methods include simple rod assemblies to sophisticated electro-piezocone mechanisms. The principle advantage to conducting probes is that a great deal of data points can be rapidly obtained to create detailed contours of the desired surface or stratum. Implicit in the conduct of non-instrumented unsampled probes is that variations in drill action or rod advance is used to estimate strata changes. Acoustic listening devices placed within a saturated bedrock well near an air track rig will enhance the listener's ability to hear the pneumatic-percussive bit encounter bedrock. Primary among the disadvantages to conducting probes is the uncertainty resulting from relying strictly upon drill action without a hard data sample. Close proximity probes in zones of shallow refusal and repeated probes adjacent to those terminated on suspected obstructions help boost confidence and define aberrations. Secondary among the disadvantages to conducting probes is the inaccuracy inherent in the measurement of an often rapidly moving reference point as the drill advances through obstructions or variable zones into progressively more competent bedrock. Solid stem augers with conventional drilling equipment are slow to progress through dense soils and may be defeated by boulders but can be advanced below the water table without problems. Pneumatic-percussive air track drilling will rapidly advance through dense soils, boulders and bedrock but is inhibited below the groundwater table by borehole collapse and particularly when the air evacuation is suspended as rods are added to the drill string. Depending upon site conditions and termination depth, dozens of probes may be conducted in a single day. As such, horizontal and vertical control should be established at each probe location separate from the probe effort in order to obtain the most use from the rig time and to maximize the accuracy of the data.

*B.* *Sampled Probes* - Small diameter hand augers, soil plugs and manual soil cores are routinely used for surface soil sampling for rudimentary site reconnaissance, environmental sampling and hydric soils mapping. Direct-push and percussive or vibration driven soil core equipment preferred for shallow environmental sampling ranges in size from small diameter hand held units to vehicle mounted machinery capable of obtaining soil cores within polycarbonate liners 3.6 in. I.D. by 8 ft. length. As with any uncased borehole, additional soil cores may be obtained until the termination depth criterion is reached or sample integrity is compromised due to borehole collapse. Care must be exercised in establishing collapsed or resampled zones when documenting direct-push samples or soil cores.

3.2.7.5 Test Pits

Test pits are an extremely economical and effective way to rapidly characterize shallow subsurface conditions. Test pits are particularly useful for surficial geologic mapping, determining fill thickness and content, contouring shallow bedrock conditions and in determining oversized (cobble and boulder) percentages. Small backhoes with an approximately ¼ cubic yard bucket capacity are capable of excavating test pits up to 12 ft. depth in most materials and can be used with minimal site damage. Larger excavators with an approximately ¾ cubic yard bucket capacity are capable of excavating test pits up to 16 to 20 ft. depth and can be used to construct access for drill rigs on difficult sites. Given sufficient area, excavators can safely enter the excavation and extend the test pit indefinitely. During test pit excavation careful consideration must be given to potential bearing surface disturbance within proposed structures. In addition, care must be taken to minimize other site impacts requiring costly restoration including damage to trees, pavement, curbing, landscaping and utilities.

3.2.7.6 Environmental Sampling & Monitoring

Environmental sampling combined with discrete field screening of soil and groundwater for contaminants is routinely conducted during the performance of subsurface explorations. In addition, continuous monitoring of air quality within the work zone or at the project site may be required to address H&S concerns. Potential contaminants and sources may be identified in the initial stage of project planning and prior arrangements made for PPE, monitoring, sampling and laboratory analysis.

To minimize the risk of cross-contamination typical environmental sampling programs work from known or suspected clean areas toward areas of known or suspected contamination. Contamination encountered unexpectedly may present serious exposure risks to field personnel without proper PPE and monitoring instrumentation, particularly if the contamination is gross or unidentified. In the event unexpected contamination is encountered, all fieldwork should be suspended and the area evacuated immediately until the Project Manager and the Health & Safety Coordinator can be contacted so that H&S and sampling guidelines can be developed.

*A.* *Decontamination Procedures & Waste Management* - Standard equipment decontamination practices may include the establishment of a decontamination area such that decontamination fluids are collected and properly stored for disposal. Typically a location within the site is chosen away from sensitive or occupied zones and a decontamination pad is created within a bermed area using polyethylene sheeting. A high-pressure steam cleaner is used to wash all equipment prior to each exploration and wastewater is pumped into adjacent drums. Splitspoons and hand sampling tools are scrubbed between samples at the exploration location using a detergent (water and alconox) solution rinsed with control (tap) water followed by a solvent (methanol) rinse, wiped with a paper towel and rinsed with deionized water before being allowed to air dry. Hexane may be needed for removal of heavy petroleum, grease and coal tar. Decontamination waste, sample residue and drill cuttings are typically drummed, labeled and staged onsite for proper disposal.

*B.* *Environmental Soil Sampling* - Environmental soil samples obtained for chemical analyses are collected in surface samples and by using many of the techniques employed in typical subsurface explorations with special attention given to decontamination procedures. Preservation, handling and glassware for environmental soil samples varies considerably depending upon several factors including the type and degree of contamination, the analytical method to be conducted, the analytical laboratory being used and the governing regulations. In addition, the depth and location of samples may be strictly controlled under agency guidelines. Documentation of volatile organic compounds (VOC) in the soil through headspace screening is required in order to provide real-time guidance in the field to direct the sampling.

Clean 8 oz. jars are partially filled with newly obtained soils and covered with aluminum foil and allowed to stabilized prior to screening with a photoionization detector (PID). The presence of metals in soils is not associated with odors, while coal tar, fuels and solvents are often easily distinguished. Particular attention is given to discoloration or odors noted, however it is company policy to avoid fumes and odors at all times. Soils collected from a discrete zone should be homogenized and a representative portion placed into laboratory glassware and labeled. Analytical samples are kept in a cooler with ice blocks and a Chain of Custody form is maintained until transfer to the analytical laboratory.

*C.* *Environmental Water Sampling* - Groundwater monitoring (observation) wells must undergo an initial well development following installation and prior to sampling. This is intended optimize well function and to produce formation-derived groundwater samples and valid analytical testing results. Groundwater sampling from existing monitoring wells for chemical analyses involves initially gauging the static groundwater level and the well depth in order to determine the well volume. Waterra® footvalves and tubing, bailers, submersible pumps or peristaltic pumps may be used to purge a minimum of three well volumes in order to minimize well effects. Turbidity, conductivity, resistivity, salinity, dissolved oxygen, oxidation-reduction potential, temperature and pH are recorded periodically after purging and groundwater parameters must be stable prior to sampling. Low-flow groundwater sampling is required for certain analyses to be valid. In such cases, variable speed submersible pumps are used at extremely slow rates to minimize drawdown and turbidity. Sampling of surface waters or open-body water at depth may be done with remote or variable depth, bottle-type samplers. Preservation, handling and glassware for environmental water samples varies considerably depending upon several factors including the type and degree of contamination, the analytical method to be conducted, the analytical laboratory being used and the governing regulations.

4.2.7.7 Special Testing, Sampling and Instrumentation

H&A utilizes a wide variety of well established and state-of-the-art soil, rock and groundwater testing procedures and instrumentation to supplement many subsurface exploration programs. Among the methods and techniques routinely used are fixed-piston tube sampling, vane shear testing, pressuremeter testing, permeability testing, water pressure (packer) testing in rock, inclinometer installation, multiposition borehole extensometers (MPBX) installation and aquifer (pump) testing. Prior to attempting an unfamiliar technique H&A field staff must review all related procedures and consult experienced personnel. Outside support or training that may be necessary to perform new procedures shall be sought with project manager approval. Notes and references obtained should be retained for potential development into new operating procedure.

# APPENDIX A
# REFERENCES

## A.1 References


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**APPENDIX B**
**RELATED HALEY & ALDRICH PROCEDURES**

- OP1001 Excavation and Trenching Safety
- OP1002 Drilling Safety
- OP1003 Utility Clearance
- OP2001 Identification & Description of Soils in the Field Using Visual-Manual Methods
- OP2002 Identification & Description of Rock in the Field Using Visual-Manual Methods
- OP2003 Surficial Geologic Mapping
- OP2005 Test Borings, Sampling, Standard Penetration Testing (STP) and Borehole Abandonment
- OP2017 Rock Coring
- OP2020 Groundwater Monitoring (Observation) Well Installation, Development and Abandonment
- OP2026 Exploratory Test Pits
- OP2028 Exploratory Probes
- OP2030 Direct Push Borings (Percussion-Vibration Driven Probes)

**APPENDIX C**
**FORMS AND EXAMPLES**

## C.1 Forms

All Haley & Aldrich field forms are maintained on the server at K:\techproc\sop\Forms. The following is a list of selected current forms available for use in routine field exploration programs.

Site Investigations

- Form 2024 Site Investigation Form

Test Borings

- Form 2004 Subcontractor Quantities For Test Borings
- Form 2029 Sampling Labels - Geotechnical
- Form 2003 Test Boring Daily Field Report
- Form 2001 Test Boring Reports
- Form 2002 Core Boring Reports
- Form 2028 Geotechnical Sample Receiving Form

Observation (Monitoring) Wells

- Form 2007 Observation Well Installation Form
- Form 2013 Well Decommissioning Report
- Form 3006 Monitoring Well Development Report
- Form 2021 Groundwater Monitoring Report

Test Pits

- Form 2006 Test Pit Logs
- Form 2028 Geotechnical Sample Receiving Form

Test Probes

- Form 2022 Test Probe Report
- Form 2023 Test Probe Summary
- Form 2025 Vibracore Report

Environmental Sampling

- Form 1010 Headspace Screening Report
- Form 3001 Sampling Labels – Environmental
- Form 3002 Chain of Custody Electronic
- Form 3003 Chain of Custody Field
- Form 3004 Sampling Record
- Form 3005 Groundwater Sampling Record

## C.2 Examples

The following examples of selected completed forms are intended to provide guidance in the standard documentation conventions practiced by H&A.

HALEY & ALDRICH

# SITE INVESTIGATION FORM



PROJECT ______ H&A FILE NO. ______
LOCATION ______ PROJECT MGR. ______
CLIENT ______ FIELD REP ______
CONTRACTOR ______ DATE ______

**SITE ACCESS**
☐ Paved ☐ Gravel ☐ Trails ☐ None ☐ Water ☐ Inside ☐ Other ______

**ENTRANCE**
☐ Enclosed ☐ Gate/Keys Comments: ______

**EXPLORATION EQUIPMENT**
☐ Truck Rig ☐ ATV Rig ☐ Skid Rig ☐ Tripod ☐ Geoprobe ☐ Other ______
☐ Backhoe ☐ Bobcat ☐ Excavator ☐ Sm Excavator ☐ Barge ☐ Other ______
☐ Chainsaw ☐ Haybales ☐ Plywood ☐ 4WD Vehicle ☐ Other ______

**WATER SUPPLY AVAILABLE**
☐ Hydrant ☐ Tap ☐ River/Lake ☐ None

**ELECTRIC AVAILABLE:**
☐ Yes ☐ No

**TOPOGRAPHY**
☐ Low Lying ☐ Level ☐ Sloping ☐ Cliffs ☐ Mountains ☐ Other ______

**PHYSIOGRAPHY**
☐ Bedrock ☐ Till Upland ☐ Valley Floor ☐ Flood Plain ☐ Coastal Plain ☐ Other ______
☐ Wetlands ☐ Tidal Marsh ☐ Estuarine ☐ Lakes/Ponds ☐ Outwash Plain ☐ Other ______
☐ Developed ☐ Filled Land ☐ Paved ☐ Landscaped ☐ Other ______

**DRAINAGE**
☐ Rivers ☐ Streams ☐ Rills ☐ Canals ☐ Ditches ☐ Culverts ☐ Other ______

**ESTIMATED GROUNDSURFACE ELEVATION:** ______ ft

**ESTIMATED GROUNDWATER DEPTH/ELEVATION:** ______ ft

**WOODED**
☐ Heavily ☐ Partially ☐ Sparsely ☐ Comments: ______

**VEGETATION**
☐ Brush ☐ Grass ☐ None ☐ Comments: ______

**BEDROCK OUTCROPS**
LOCATION: ______
TYPE: ______

**SOIL EXPOSURES**
LOCATION: ______
TYPE: ______

**EXISTING STRUCTURES**
☐ Buildings ☐ Warehouse ☐ Slabs ☐ Bridges ☐ Foundations ☐ Other ______

**UNDERGROUND STORAGE TANKS**
☐ Yes ☐ No

**VISIBLE EVIDENCE OF CONTAMINATION**
☐ Drums ☐ Staining ☐ Site history ☐ Unauthorized dumping ☐ Other ______

**OVERHEAD UTILITIES**
LOCATION: ______
TYPE: ______

**UNDERGROUND UTILITIES**
LOCATION: ______
TYPE: ______

**COMMENTS:** ______

HALEY & ALDRICH

# SITE INVESTIGATION FORM



| | | | |
|---|---|---|---|
| PROJECT | | H&A FILE NO. | |
| LOCATION | | PROJECT MGR. | |
| CLIENT | | FIELD REP | |
| CONTRACTOR | | DATE | |

## SITE SKETCH

North Arrow

| OVERALL DESCRIPTION AND REMARKS: | LEGEND |
|---|---|
| | Scale: 0 |

HALEY & ALDRICH

# SUBCONTRACTOR QUANTITIES FOR TEST BORINGS

Form #2005

| | |
|---|---|
| Project | File No. |
| Location | Date |
| Contractor | Project Manager |

| No. | Description | Unit | Quantity |
|---|---|---|---|
| I | **MOBILIZATION/DEMOBILIZATION** | | |
| 1 | Mob/Demob of Truck rig w/ OSHA-trained crew within 100 miles of contractor yard* | ea | |
| 2 | Mob/Demob of Skid rig with OSHA-trained crew within 100 miles of contractor yard* | ea | |
| 3 | Mob/Demob of Bomb/ATV rig with OSHA-trained crew within 100 miles of contractor yard* | ea | |
| 4 | Mob/Demob of Geoprobe rig w/ OSHA-trained crew within 100 miles of contractor yard* | ea | |
| II | **DRILLING - FOOTAGE RATE** | | |
| 5 | 3-in. dia. cased overburden drilling (0-100 ft.) with no sampling | lf | |
| 6 | cased overburden drilling (0-100 ft.) with standard 5-ft. interval sampling | lf | |
| 7 | cased overburden drilling (0-100 ft.) continuous sampling | lf | |
| 8 | 4-in. dia. cased overburden drilling (0-100 ft.) with no sampling | lf | |
| 9 | cased overburden drilling (0-100 ft.) with standard 5-ft. interval sampling | lf | |
| 10 | cased overburden drilling (0-100 ft.) continuous sampling | lf | |
| 11 | 4-¼ in. dia. hollow stem auger overburden drilling (0-100 ft.) with no sampling | lf | |
| 12 | hollow stem auger overburden drilling (0-100 ft.) w/ standard 5-ft. interval sampling | lf | |
| 13 | hollow stem auger overburden drilling (0-100 ft.) continuous sampling | lf | |
| 14 | NX rock core via double-tube core barrel (includes bit wear) | lf | |
| 15 | HX rock core via double-tube core barrel (includes bit wear) | lf | |
| 16 | Extra split spoon samples (for footage rates only) | ea | |
| 17 | 3-in. undisturbed tube samples | ea | |
| 18 | Standby Time for rig and crew/Decon of equipment | hr | |
| III | **DRILLING - DAY RATE** | | |
| 19 | Truck mounted drill rig with OSHA-trained crew | day | |
| 20 | Truck mounted drill rig with OSHA-trained crew (overtime rate) | hr | |
| 21 | Skid rig with OSHA-trained crew | day | |
| 22 | Skid rig with OSHA-trained crew (overtime rate) | hr | |
| 23 | Bomb/ATV drill rig with OSHA-trained crew | day | |
| 24 | Bomb/ATV drill rig with OSHA-trained crew (overtime rate) | hr | |
| 25 | Geoprobe rig with OSHA-trained crew | day | |
| 26 | Geoprobe rig with OSHA-trained crew (overtime rate) | hr | |
| 27 | NX rock core via double-tube core barrel (includes bit wear for day rates) | lf | |
| 28 | HX rock core via double-tube core barrel (includes bit wear for day rates) | lf | |
| 29 | Geoprobe push samples liners (4' section) | ea | |
| IV | **OBSERVATION WELL INSTALLATION** | | |
| 30 | 1-in. dia. piezometer (Sch 40 PVC) installed | lf | |
| 31 | 2-in. dia. well (Sch 40 PVC) installed (slotted and screened) | lf | |
| 32 | 4-in. dia. well (Sch 40 PVC) installed (slotted and screened) | lf | |
| 33 | Standard 4-in. dia. roadway box | ea | |
| 34 | Standard 8-in. dia. roadway box | ea | |
| 35 | 5 ft. protective guard pipe with padlock (4-in. diameter) | ea | |
| V | **ADDITIONAL ITEMS** | | |
| 36 | Utility Clearance | ea | |
| 37 | Permits - Determined on a job to job basis | ls | |
| 38 | State Police Detail | hr | |
| 39 | Laborer | hr | |
| 40 | Chain Saw | day | |
| 41 | Steam Cleaner with Generator | day | |
| 42 | Upgrade Crew Personnel Protection to Level "C" | hr | |
| 43 | 55 gal. soil/water drum | ea | |
| 44 | Borehole Grouting (4-in. diameter) | lf | |
| 45 | Sand | bag | |
| 46 | Concrete | bag | |
| 47 | Cold Patch | bag | |
| 48 | | | |
| 49 | | | |
| VI | **COMMENTS** | | |

**Driller Signature** ______________________ **Date** ________

**Geologist Signature** ______________________ **Date** ________

**WHITE** - FIELD SERVICE MANAGER **CANARY** - CONTRACTOR **PINK** - PROJECT MANAGER

Form 2004

HALEY & ALDRICH

**Haley & Aldrich, Inc.**
**465 Medford St., Suite 2200**
**Boston, MA 02129**
**Tel: 617-886-7400**

| | |
|---|---|
| **Boring ID:** | **File Number:** |
| **Sample Interval:** | **Project:** |
| **Depth:** | **PM:** |
| **Recovery:** | **Blow Counts:** |
| **Collected By:** | / / / |
| **Comments:** | |


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| **Collected By:** | / / / |
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| **Collected By:** | / / / |
| **Comments:** | |

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| **Collected By:** | / / / |
| **Comments:** | |

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| **Sample Interval:** | **Project:** |
| **Depth:** | **PM:** |
| **Recovery:** | **Blow Counts:** |
| **Collected By:** | / / / |
| **Comments:** | |

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| | |
|---|---|
| **Boring ID:** | **File Number:** |
| **Sample Interval:** | **Project:** |
| **Depth:** | **PM:** |
| **Recovery:** | **Blow Counts:** |
| **Collected By:** | / / / |
| **Comments:** | |

HALEY & ALDRICH

# TEST BORING DAILY REPORT



| | | | |
|---|---|---|---|
| PROJECT | | H&A FILE NO. | |
| LOCATION | | PROJECT MANAGER | |
| CLIENT | | FIELD REPRESENTATIVE | |
| CONTRACTOR | | DATE | |
| DRILLER | | DFR NUMBER | |
| TYPE OF RIG(S) | | NUMBER OF RIGS | |

## SUBCONTRACTOR'S TIME ON SITE

| Rig Type | Arrived | Left Site | Lunch/Other | Downtime | Standby Time | Total Billable Hours |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |

## HALEY & ALDRICH'S TIME ON SITE

| Field Representive(s) | Arrived | Left Site | Lunch/Other | Paperwork | Travel Time | Total Billable Hours |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |

## WORK PRODUCTION TO DATE

| Boring No. | Type of Drilling | Over Burden (lf) | Rock Core (lf) | Obstr. Drilling | Total Footage (lf) | Tubes Samples | Extra Split Spoons* | Misc. (Wells etc.) | Materials Encountered (Type and Depth Range) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
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## STATUS OF TOTAL PRODUCTION

| Unsampled | Continuos | Standard | Inside Dia. | Boring Footages | | | | | Additional pay Items | Today | Total to Date |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Item | Today | Total to Date | Estimate | % Complete | Observation Wells I.D. (ft) | | |
| | | | | | | | | | Roadway Boxes (ea) | | |
| | | | | H.S.A. | | | | | Guard Pipes (ea) | | |
| | | | | Casing | | | | | Steamer and Generator (day) | | |
| | | | | Casing | | | | | Grout (lf) | | |
| | | | | Casing | | | | | Undisturbed Tube Samples (ea) | | |
| | | | | Uncased | | | | | Extra Split Spoons (ea)* | | |
| | | | | Rock Core | | | | | 55 Gallon Drums (ea) | | |
| | | | | Geoprobe | | | | | Police Details (hr) | | |
| | | | | | | | | | Stand by Time (hr) | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

| No. of Borings Completed | Remaining | Rig-Days to Date | Remaining |
|---|---|---|---|

## SYMBOLS

| | | | | |
|---|---|---|---|---|
| **B** 2-1/2 inch Standard | **A** 4 inch Hollow Stem Auger | **Z** Probes of Soundings | **T** 2 inch Shelby Tube | **Y** Pressure Test |
| **N** 3 inch Standard | **W** Water Borings | **C** Rock Core | **V** Vane Shear Test | **S** Observation Well |
| **H** 4 inch Standard | **X** Continuous Sampling | **U** 3 inch Piston Tube | **P** Permeability Test | |

* Extra split spoon samples are for footage contracts only.

# TEST BORING DAILY REPORT



**REMARKS**

HALEY & ALDRICH

# TEST BORING REPORT

BORING NO.



| | | | |
|---|---|---|---|
| PROJECT | | H&A FILE NO. | |
| LOCATION | | PROJECT MGR. | |
| CLIENT | | FIELD REP. | |
| CONTRACTOR | | DATE STARTED | |
| DRILLER | | DATE FINISHED | |

| Elevation ft. | Datum | Boring Location | | | |
|---|---|---|---|---|---|
| **Item** | **Casing** | **Sampler** | **Core Barrel** | **Rig Make & Model** | |
| Type | | | | ☐ Truck ☐ Tripod ☐ Cat-Head | |
| Inside Diameter (in.) | | | | ☐ ATV ☐ Geoprobe ☐ Winch | |
| Hammer Weight (lb.) | | | | ☐ Track ☐ Air Track ☐ Roller Bit | |
| Hammer Fall (in.) | | | | ☐ Skid ☐ ___ ☐ Cutting Head | |

| Hammer Type | Drilling Mud | Casing Advance |
|---|---|---|
| ☐ Safety | ☐ Bentonite | Type Method Depth |
| ☐ Doughnut | ☐ Polymer | |
| ☐ Automatic | ☐ None | |

Drilling Notes:

| Depth (ft.) | Sampler Blows per 6 in. | Sample No. & Recovery (in.) | Sample Depth (ft.) | Well Diagram | Stratum Change (ft.) | USCS Symbol | Visual-Manual Identification & Description (density/consistency, color, GROUP NAME & SYMBOL, maximum particle size*, structure, odor, moisture, optional descriptions, geologic interpretation) | Gravel % Coarse | Gravel % Fine | Sand % Coarse | Sand % Medium | Sand % Fine | % Fines | Field Test Dilatancy | Field Test Toughness | Field Test Plasticity | Field Test Strength |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | | | | | | | | | |

| Water Level Data | | | | | |
|---|---|---|---|---|---|
| | | | Depth in feet to: | | |
| Date | Time | Elapsed Time (hr.) | Bottom of Casing | Bottom of Hole | Water |
| | | | | | |
| | | | | | |
| | | | | | |

| Sample ID | |
|---|---|
| O | Open End Rod |
| T | Thin Wall Tube |
| U | Undisturbed Sample |
| S | Split Spoon Sample |
| G | Geoprobe |

**Well Diagram**
- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

**Summary**

Overburden (Linear ft.) ______
Rock Cored (Linear ft.) ______
Number of Samples ______

BORING NO.

**Field Tests** Dilatancy: R - Rapid S - Slow N - None Plasticity: N - Nonplastic L - Low M - Medium H - High
Toughness: L - Low M - Medium H - High Dry Strength: N - None L - Low M - Meduim H - High V - Very High

***NOTE: Maximum Particle Size is determined by direct observation within the limitations of sampler size.**

**NOTE: Soil identifications based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.**

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# TEST BORING REPORT

BORING NO.

Page of

| Depth (ft.) | Sampler Blows per 6 in. | Sample No. & Recovery (in.) | Sample Depth (ft.) | Well Diagram | Stratum Change (ft.) | USCS Symbol | Visual-Manual Identification & Description (density/consistency, color, GROUP NAME & SYMBOL, maximum particle size*, structure, odor, moisture, optional descriptions, geologic interpretation) | Gravel | | Sand | | | | Field Test | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | % Coarse | % Fine | % Coarse | % Medium | % Fine | % Fines | Dilatancy | Toughness | Plasticity | Strength |
| | | | | | | | | | | | | | | | | | |

NOTES:

FILE NO.

BORING NO.

*NOTE: Maximum Particle Size is determined by direct observation within the limitations of sampler size.

NOTE: Soil identifications based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

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Form 2001 USCS p.2

HALEY & ALDRICH

# CORE BORING REPORT

BORING NO.

Page 1 of

PROJECT
LOCATION
CLIENT
CONTRACTOR
DRILLER

H&A FILE NO.
PROJECT MGR.
FIELD REP.
DATE STARTED
DATE FINISHED

Elevation ft | Datum | Boring Location

| Item | Casing | Sampler | Core Barrel |
|---|---|---|---|
| Type | | | |
| Inside Diameter (in) | | | |
| Hammer Weight (lb) | | | |
| Hammer Fall (in) | | | |

Rig Make & Model: ☐ Truck ☐ Tripod ☐ Cat-Head ☐ ATV ☐ Geoprobe ☐ Winch ☐ Track ☐ Air Track ☐ Roller Bit ☐ Skid ☐ ________ ☐ Cutting Head

Hammer Type: ☐ Safety ☐ Doughnut

Drill Mud: ☐ Bentonite ☐ Polymer ☐ None

Casing: ☐ Driven ☐ Spun

| Depth (ft) | Drilling Rate (min/ft) | Core No. Depth (ft) | Recovery (in) | RQD (%) | Weath-ering | Well Diagram | Stratum Change (ft) | Visual Classification and Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

| Water Level Data | | | | | |
|---|---|---|---|---|---|
| Date | Time | Elapsed Time (hr.) | Depth in feet to: Bottom of Casing | Bottom of Hole | Water |
| | | | | | |
| | | | | | |
| | | | | | |

Sample ID
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon Sample
G Geoprobe

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (Linear ft.)
Rock Cored (Linear ft.)
Number of Samples

BORING NO.

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HALEY & ALDRICH

# CORE BORING REPORT

BORING NO.

Page of

| Depth (ft) | Drilling Rate (min/ft) | Core No. Depth (ft) | Recovery RQD (in) | Recovery RQD (%) | Weath-ering | Well Diagram | Stratum Change (ft) | Visual Classification and Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

FILE NO. BORING NO.

I:\forms\final\Frm_3702

HALEY & ALDRICH

# GEOTECHNICAL SAMPLE RECEIVING REPORT

Page ____ of ____

| | | | |
|---|---|---|---|
| **PROJECT** | | **H&A FILE NO.** | |
| **LOCATION** | | **PROJECT MGR.** | |
| **CLIENT** | | **PROJECT ENGR.** | |
| **DELIVERED BY** | | **DATE** | |

## TYPE OF SAMPLE

**SOIL:**

Jar Samples ________ box(es)

Undisturbed Tube Samples:

Outside Diameter: ☐ 3-in. ☐ 2-in. ________ tube(s)

*** Bag Samples ________ bag(s)

*** 5-gal. Bucket Samples ________ bucket(s)

**ROCK CORE:**

Boxes: ________ box(es)

Other: ________ sample(s)

**OTHER:** ________________

HAZARDOUS MATERIALS?

☐ Yes ☐ No

CONTAMINANTS (please list major contaminants)

**If geology/pre-construction project, fill out Section A - If Con-Mon project, fill out Section B.**

**A:**

| **Box No.** | **Exploration No.** | **Sample No.(s) From - To** | **Depth From - To** | **Remarks** {if multiple types of samples, list type, (e.g., jars, tube, bag, rock)} |
|---|---|---|---|---|
| | | | | |
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**B:**

| **Explor. No.** | **Sample No.** | **Depth Range (ft)** | **Sample Description** (USCS or geologic unit) | **Sample Source** (on-site, Contractor Pit, etc.) | **Proposed Use** (see below) |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
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| | | | | | |
| | | | | | |

For "Proposed Use" try to use the term from the specifications (e.g., structural fill, common fill, dense graded, State Highway Spec. No., etc.)

Notes:

*** ANY BAG/BUCKET SAMPLE WHICH HAS NOT HAD TESTING ASSIGNED AFTER 3 WEEKS OF RECEIVING WILL BE AUTOMATICALLY DISPOSED OF UNLESS THE LABORATORY MANAGER IS GIVEN PRIOR WRITTEN NOTIFICATION OF THE NEED TO RETAIN THE SAMPLE.

**To be completed by lab personnel:**

Sample received by: ________________ Boxes Labeled? ☐ Yes ☐ No

STORAGE LOCATION:

☐ Geotechnical Laboratory

☐ Humid Room

☐ Storage Room / Shelf Location: ________________

☐ Other: ________________

Form 2028

HALEY & ALDRICH

# GEOTECHNICAL SAMPLE RECEIVING REPORT



| | | | |
|---|---|---|---|
| **PROJECT** | MAXIM OFFICE PARK | **H&A FILE NO.** | 11111-030 |
| **LOCATION** | BOSTON, MASSACHUSETTS | **PROJECT MGR.** | S. KRAEMER |
| **CLIENT** | BOSTON ARCHITECTS, INC. | **PROJECT ENGR.** | M. LALLY |
| **DELIVERED BY** | JOE SAND | **DATE** | 03/14/02 |

## TYPE OF SAMPLE

**SOIL:**
Jar Samples 2 box(es)
Undisturbed Tube Samples:
Outside Diameter: ☐ 3-in. ☐ 2-in. 2 tube(s)
*** Bag Samples 3 bag(s)
*** 5-gal. Bucket Samples ____ bucket(s)

**ROCK CORE:**
Boxes: 2 box(es)
Other: ____ sample(s)

**OTHER:** ____

HAZARDOUS MATERIALS? ☐ Yes ☑ No

CONTAMINANTS (please list major contaminants)

**If geology/pre-construction project, fill out Section A - If Con-Mon project, fill out Section B.**

**A:**

| Box No. | Exploration No. | Sample No.(s) From - To | Depth From - To | Remarks {if multiple types of samples, list type, (e.g., jars, tube, bag, rock)} |
|---|---|---|---|---|
| 1 | B-01 | S01 - S19 | - | jars |
| 1 | B-02 | S01 - S04 | - | jars |
| 2 | B-02 | S05 - S14 | - | jars |
| - | B-01 | U1 | 58.0 - 60.0 | tube R=24 |
| - | B-02 | U1 | 68.0 - 70. | tube R=22 |
| 1 | B-01 | C01 - C03 | - | rock core |
| - | TP-01 | B01 | 5.0 - 9.0 | ziplock bag |
| | | | | |
| | | | | |
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| | | | | |

**B:**

| Explor. No. | Sample No. | Depth Range (ft) | Sample Description (USCS or geologic unit) | Sample Source (on-site, Contractor Pit, etc.) | Proposed Use (see below) |
|---|---|---|---|---|---|
| TP-04 | B01 | 8.5 - 10.7 | Glacial Till | on-site | Common Fill |
| - | S12 | n/a | Brown silty sand | Joe's Borrow Pit, Stoughton, MA | Structural Fill |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

For "Proposed Use" try to use the term from the specifications (e.g., structural fill, common fill, dense graded, State Highway Spec. No., etc.)

Notes:

*** ANY BAG/BUCKET SAMPLE WHICH HAS NOT HAD TESTING ASSIGNED AFTER 3 WEEKS OF RECEIVING WILL BE AUTOMATICALLY DISPOSED OF UNLESS THE LABORATORY MANAGER IS GIVEN PRIOR WRITTEN NOTIFICATION OF THE NEED TO RETAIN THE SAMPLE.

**To be completed by lab personnel:**

Sample received by: ____ Boxes Labeled? ☐ Yes ☐ No

STORAGE LOCATION:

☐ Geotechnical Laboratory ☐ Storage Room / Shelf Location: ____

☐ Humid Room ☐ Other: ____

HALEY & ALDRICH

# OBSERVATION WELL INSTALLATION REPORT

Well No.

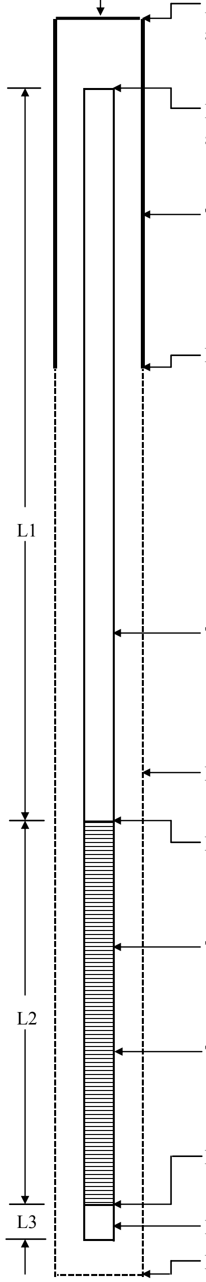
Boring No.

| | | | |
|---|---|---|---|
| PROJECT | | H&A FILE NO. | |
| LOCATION | | PROJECT MGR. | |
| CLIENT | | FIELD REP. | |
| CONTRACTOR | | DATE INSTALLED | |
| DRILLER | | WATER LEVEL | |

| | | |
|---|---|---|
| Ground El. ____ ft | Location ____ | ☐ Guard Pipe |
| El. Datum ____ | | ☐ Roadway Box |

| SOIL/ROCK CONDITIONS | BOREHOLE BACKFILL |
|---|---|
| | |

(Bottom of Exploration)
(Numbers refer to depth from ground surface in feet)




Type of protective cover/lock ____

Height/Depth of top of guard pipe/roadway box above/below ground surface ____ ft

Height/Depth of top of riser pipe above/below ground surface ____ ft

Type of protective casing: ____
- Length ____ ft
- Inside Diameter ____ in

Depth of bottom of guard pipe/roadway box ____ ft

| Type of Seals | Top of Seal (ft) | Thickness (ft) |
|---|---|---|
| Concrete | | |
| Bentonite Seal | | |
| | | |
| | | |

Type of riser pipe: ____
- Inside diameter of riser pipe ____ in
- Type of backfill around riser ____

Diameter of borehole ____ in

Depth to top of well screen ____ ft

Type of screen ____
- Screen gauge or size of openings ____ in
- Diameter of screen ____ in

Type of backfill around screen ____

Depth of bottom of well screen ____ ft

Bottom of Silt trap ____ ft

Depth of bottom of borehole ____ ft

(Not to Scale)

____ ft + ____ ft + ____ ft = ____ ft
Riser Pay Length (L1) + Length of screen (L2) + Length of silt trap (L3) = Pay length

COMMENTS: ____

Form 2007

HALEY & ALDRICH

# MONITORING WELL DEVELOPMENT REPORT

**Well No.**



| | | | |
|---|---|---|---|
| **PROJECT** | | **H&A FILE NO.** | |
| **LOCATION** | | **PROJECT MGR.** | |
| **CLIENT** | | **FIELD REP.** | |
| **CONTRACTOR** | | **DATE** | |
| **ELEVATION SUBTRAHEND** | | | |

**Estimated Volume of Water Lost During Drilling:** ______________ gallons

Comments: ______________

**Depth to Water Before Development:** ______________ feet

Comments: ______________

**Depth to Well Bottom Before Development:** ______________ feet

Comments: ______________

**Turubitiy of Water Before Development:** ______________ NTU

Comments: ______________

**Volume of Water Removed:** ______________ gallons

Comments: ______________

**Method of Removal (bailing, pumping):** ______________

Comments: ______________

**Depth to Well Bottom After Development:** ______________ feet

Comments: ______________

**Depth to Water After Development:** ______________ feet

Comments: ______________

**Turubitiy of Water After Development:** ______________ NTU

Comments: ______________

HALEY & ALDRICH

# GROUNDWATER MONITORING REPORT

OW/PZ NUMBER

Page of

PROJECT
LOCATION
CLIENT
CONTRACTOR
ELEVATION SUBTRAHEND

H&A FILE NO.
PROJECT MGR.
FIELD REP.
DATE

| Date | Time | Elapsed Time (days) | Depth of Water from Ground Surface | Elevation of Water | Remarks | Read By |
|---|---|---|---|---|---|---|
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Form 2021

HALEY & ALDRICH

# TEST PIT LOG

| Test Pit No. | |
|---|---|
| Page 1 of | |

| | | | |
|---|---|---|---|
| **PROJECT** | | **H&A FILE NO.** | |
| **LOCATION** | | **PROJECT MGR.** | |
| **CLIENT** | | **FIELD REP** | |
| **CONTRACTOR** | | **DATE** | |
| **EQUIPMENT** | | **WEATHER** | |

**Ground El.** ______ ft. **Location** ______ **Groundwater depths/entry rates (in./min.):**

**El. Datum** ______

| Depth (ft.) | Sample ID | Stratum Change Depth (ft.) | USCS Symbol | Visual Identification (Color, GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions, geologic interpretation) | Gravel | | Sand | | | | Field Test | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | % Coarse | % Fine | % Coarse | % Medium | % Fine | % Fines | Dilatancy | Toughness | Plasticity | Strength |
| | | | | | | | | | | | | | | |

**Obstructions:**

**Remarks:**

| **Field Tests** | |
|---|---|
| Dilatancy: | R - Rapid S - Slow N- None |
| Toughness: | L - Low M - Medium H - High |
| Plasticity: | N - Nonplastic L - Low M - Medium H - High |
| Dry Strength: | N - None L - Low M - Medium H - High V - Very High |

**Standing water in completed pit:**

at depth ______ ft.

measured after ______ hrs. elapsed

**Boulders:**

| Diameter (in.) | Number | | Approx. vol. (cu. ft.) |
|---|---|---|---|
| 12 to 24 | | = | |
| over 24 | | = | |

**Test Pit Dimensions (ft.):**

Pit Depth ______

Pit Length X Width ______

**NOTE: Soil identifications based on visual/manual methods of the USCS system as practiced by Haley & Aldrich, Inc.**

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Form 2006 USCS Geo.

HALEY & ALDRICH

# ENVIRONMENTAL TEST PIT LOG

Test Pit No.

Page of

PROJECT
LOCATION
CLIENT
CONTRACTOR
EQUIPMENT

H&A FILE NO.
PROJECT MGR.
FIELD REP
DATE
WEATHER

Ground El. ft.
El. Datum

Location

Groundwater depths/entry rates (in./min.):

| Depth (ft.) | Sample ID | PID Reading (ppm.) | Stratum Change Depth (ft.) | USCS Symbol | Visual Identification (Color, GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions, geologic interpretation) | Gravel | | Sand | | | | Field Test | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | % Coarse | % Fine | % Coarse | % Medium | % Fine | % Fines | Dilatancy | Toughness | Plasticity | Strength |
| | | | | | | | | | | | | | | | |

Obstructions:

Remarks:

Bucket Decontamination Method:

| Field Tests | |
|---|---|
| Dilatancy: | R - Rapid S - Slow N- None |
| Toughness: | L - Low M - Medium H - High |
| Plasticity: | N - Nonplastic L - Low M - Medium H - High |
| Dry Strength: | N - None L - Low M - Medium H - High V - Very High |

**Standing water in completed pit:**

at depth ft.

measured after hrs. elapsed

**Boulders:**

| Diameter (in.) | Number | | Approx. vol. (cu. ft.) |
|---|---|---|---|
| 12 to 24 | | = | |
| over 24 | | = | |

**Test Pit Dimensions (ft.):**

Pit Depth

Pit Length X Width

**NOTE: Soil identifications based on visual/manual methods of the USCS system as practiced by Haley & Aldrich, Inc.**

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# TEST PROBE REPORT

PROBE NO.

Page 1 of

| | | | |
|---|---|---|---|
| **PROJECT** | | **H&A FILE NO.** | |
| **LOCATION** | | **PROJECT MGR.** | |
| **CLIENT** | | **FIELD REP** | |
| **CONTRACTOR** | | **DATE** | |
| **EQUIPMENT** | | **DRILLER** | |

| | | | |
|---|---|---|---|
| Rig Type: | **TOP OF ROCK BASED ON:** | | Datum |
| Diameter of Hole: | ☐ Rate of Penetration | ☐ Acoustic Device | Ground El. |
| Drill Bit type: | ☐ Driller's Opinion | ☐ Other | Water El. |
| Drill Bit O.D.: | DEPTH TO TOP OF SOUND ROCK | | Location: |

| Scale In Feet | Cutting Description and Remarks |
|---|---|
| | |

# TEST PROBE SUMMARY

HALEY & ALDRICH

Page of

PROJECT
LOCATION
CLIENT
CONTRACTOR
EQUIPMENT

H&A FILE NO.
PROJECT MGR.
FIELD REP
DATE
DRILLER

Probe Type

| Probe No. | Location | Ground Surface Elevation | Depth to Water (ft) | Depth Probed | | Soil Strata Description | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | From (ft) | To (ft) | | |
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# VIBRACORE REPORT

Probe No.



| | | | |
|---|---|---|---|
| PROJECT | | H&A FILE NO. | |
| LOCATION | | PROJECT MGR. | |
| CLIENT | | GEOLOGIST | |
| CONTRACTOR | | DATE | |
| EQUIPMENT | | CHECKED BY | |

| Depth (ft) | Sketch | Visual Description | Recovery | | | |
|---|---|---|---|---|---|---|
| | | | Section | Tube Length | Sample Length | Total Weight |
| 0 | | | Top: | | | |
| 1 | | | Bottom: | | | |
| 2 | | | Notes: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc. | | | |
| 3 | | | | | | |
| 4 | | | Remarks: | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |

HALEY & ALDRICH

# HEADSPACE SCREENING REPORT



| | | | |
|---|---|---|---|
| PROJECT | | H&A FILE NO. | |
| LOCATION | | PROJECT MGR. | |
| CLIENT | | FIELD REP | |
| INSTRUMENT | | DATE SAMPLED | |
| DATE CALIBRATED (1) | LAMP (eV) | DATE SCREENED | |
| AMBIENT TEMPERATURE | CALIBRATED BY | SCREENING LOC. | |

| Exploration | Sample Number | Depth (ft) | Sample Description | Sample Reading (ppm)(2) | Back-Ground Reading (ppm)(2) | Remarks | GC(3) | Containers | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Drill Jar | | | |
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1. Instrument calibrated to the manufacturer standard.
2. ppm represents concentration of detectable volatile gaseous compounds in parts per million of air.
3. Sample assigned for gas chromatograph screening.

| Sampled and relinquished by: | Received by: | Relinquished by: | Received by: |
|---|---|---|---|
| Sign: | Sign: | Sign: | Sign: |
| Print: | Print: | Print: | Print: |
| Firm: | Firm: | Firm: | Firm: |
| Date: Time: | Date: Time: | Date: Time: | Date: Time: |

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| | |
|---|---|
| Sample ID: | File Number: |
| Depth: | Project: |
| Date: | Analysis: |
| Time: | Preservative: |
| Collected By: | Laboratory: |
| Comments: | |

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Fax (617) 886-7700

# CHAIN OF CUSTODY RECORD

Page ____ of ____

| | | | | | |
|---|---|---|---|---|---|
| H&A FILE NO. | | LABORATORY | | DELIVERY DATE | |
| PROJECT NAME | | ADDRESS | | TURNAROUND TIMI | |
| H&A CONTACT | | PROJECT MANAGER | | DELIVERY DATE | |

| Sample No. | Date | Time | Depth | Type | Container Size | No. of Containers | Analysis Requested | Preservatives | Comments - (special instructions, precautions, additional method numbers, etc.) |
|---|---|---|---|---|---|---|---|---|---|
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| Sampled and Relinquished by | Received by |
|---|---|
| Sign | Sign |
| Print | Print |
| Firm | Firm |
| Date Time | Date Time |
| **Relinquished by** | **Received by** |
| Sign | Sign |
| Print | Print |
| Firm | Firm |
| Date Time | Date Time |
| **Relinquished by** | **Received by** |
| Sign | Sign |
| Print | Print |
| Firm | Firm |
| Date Time | Date Time |

| PRESERVATION KEY | Sampling Comments |
|---|---|
| **A** Sample chilled | |
| **B** Sample filtered | |
| **C** NaOH | |
| **D** $HNO_3$ | |
| **E** $H_2SO_4$ | |
| **F** HCL | |
| **G** Methanol | |
| **H** Sodium Bisulfate | |
| **I** | |

**Evidence samples were tamperd with?** **YES** **NO**

**If YES, please explain in section below.**

**WHITE** - Laboratory **CANARY** - Project Manager **PINK** - Haley & Aldrich Laboratory **GOLDENROD** - Haley & Aldrich Contact

Form 3002

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|---|---|
| Sample ID: | File Number: |
| Depth: | Project: |
| Date: | Analysis: |
| Time: | Preservative: |
| Collected By: | Laboratory: |
| Comments: | |

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| Comments: | |

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| Date: | Analysis: |
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| Collected By: | Laboratory: |
| Comments: | |

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# CHAIN OF CUSTODY RECORD

Phone (617) 886-7400
Fax (617) 886-7600

Page of

| | | | | | |
|---|---|---|---|---|---|
| **H&A FILE NO.** | | **LABORATORY** | | **DELIVERY DATE** | |
| **PROJECT NAME** | | **ADDRESS** | | **TURNAROUND TIME** | |
| **H&A CONTACT** | | **CONTACT** | | **PROJECT MANAGER** | |

| **Sample No.** | **Date** | **Time** | **Depth** | **Type** | **Analysis Requested** VOA | ABNs PAH only | Metals RCRA (8) PP(13) | Pesticides PCBs | VPH Full Suite C-ranges only | EPH Full Suite C-ranges only | TPH (specify) | TCLP (specify) | Reactivity Ignitability Corrosivity | | | | **Number of Containers** | **Comments** (special instructions, precautions, additional method numbers, etc.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | |
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| **Sampled and Relinquished by** | **Received by** |
|---|---|
| Sign | Sign |
| Print | Print |
| Firm | Firm |
| Date Time | Date Time |
| **Relinquished by** | **Received by** |
| Sign | Sign |
| Print | Print |
| Firm | Firm |
| Date Time | Date Time |
| **Relinquished by** | **Received by** |
| Sign | Sign |
| Print | Print |
| Firm | Firm |
| Date Time | Date Time |

| **LIQUID** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | VOA Vial |
| | | | | | | | | | | | | Amber Glass |
| | | | | | | | | | | | | Plastic Bottle |
| | | | | | | | | | | | | Preservative |
| | | | | | | | | | | | | Volume |
| **SOLID** | | | | | | | | | | | | |
| | | | | | | | | | | | | VOA Vial |
| | | | | | | | | | | | | Amber Glass |
| | | | | | | | | | | | | Clear Glass |
| | | | | | | | | | | | | Preservative |
| | | | | | | | | | | | | Volume |

**Sampling Comments**

**Evidence samples were tampered with? YES NO**
**If YES, please explain in section below.**

**PRESERVATION KEY**

| | | | |
|---|---|---|---|
| **A** Sample chilled | **C** NaOH | **E** $H_2SO_4$ | **G** Methanol |
| **B** Sample filtered | **D** $HNO_3$ | **F** HCL | **H** Sodium Bisulfate |

**WHITE** - Laboratory **CANARY** - Project Manager **PINK** - Haley & Aldrich Laboratory **GOLDENROD** - Haley & Aldrich Contact

Form 3003

## WATER AND WASTEWATER METHODS

| Analysis Description | Method No. | Preservative | Solid Sample Volume/Container | Liquid | Holding Time |
|---|---|---|---|---|---|
| Alkalinity | 310 | Cool 4° C | N/A | 250 mL HDPE | 14 days |
| Amenable Cyanide | Std. Mth. 412 F. | pH>12 NaOH, Cool 4° C | N/A | 1 L HDPE | 14 days |
| Ammonia | 350 | pH<2 H2SO4, Cool 4° C | N/A | 1 L HDPE | 28 days |
| Base/Neutral & Acid Extractables | 625 | Cool 4° C | N/A | 1 L Amber | 7 days Ext/40 days Analyze |
| Biochemical Oxygen Demand (BOD) | 405.1 | Cool 4° C | N/A | 2 L HDPE | 48 hours |
| Chemical Oxygen Demand (COD) | 410 | pH<2 H2SO4, Cool 4° C | N/A | 125 mL HDPE | 28 days |
| Chloride | 300.0, 325 | None Required | N/A | 125 mL HDPE | 28 days |
| Chromium, Hexavalent | 3500D, 218.4/5 | None Required | N/A | 1 L HDPE | 24 hours |
| Fluoride | 300.0, 340 | None Required | N/A | 500 mL HDPE | 28 days |
| Hardness, Total (as CaCO3) | 130 | pH<2 H2SO4, Cool 4° C | N/A | 250 mL HDPE | 6 Months |
| Nitrate | 300.0, 352.1 | Cool 4° C | N/A | 250 mL HDPE | 48 Hours |
| Nitrite | 300.0, 354.1 | Cool 4° C | N/A | 125 mL HDPE | 48 Hours |
| Orthophosphate | 300.0, 365 | Filter, Cool 4° C | N/A | 125 mL HDPE | 48 Hours |
| PCBs | 608 | Cool 4° C | N/A | 1 L Amber | 7 days Ext/40 days Analyze |
| Pesticides | 608 | Cool 4° C | N/A | 1 L Amber | 7 days Ext/40 days Analyze |
| Physiologically Available Cyanide | MADEP draft | pH>12 NaOH, 4° C | N/A | 1 L HDPE | 14 days |
| Priority Pollutant Metals (13 Metals) | 200.7/AA, 200 Series | pH<2 HNO3, 4° C | N/A | 1 L HDPE | 28 days (Hg), 6 mos. (others) |
| Purgeable Halocarbons & Aromatics | 601/602 | pH 2 HCl, Cool 4° C | N/A | 40 mL Glass Vial | 14 days |
| RCRA Metals (8 Metals) | 200.7/AA, 200 Series | pH<2 HNO3, 4° C | N/A | 1 L HDPE | 28 days (Hg), 6 mos. (others) |
| Sulfate | 300.0, 375 | Cool 4° C | N/A | 250 mL HDPE | 28 days |
| Sulfide | 376 | pH>9 NaOH, Zn Acetate, Cool 4° C | N/A | 1 L HDPE | 7 days |
| Sulfite | 377.1 | None Required | N/A | 125 mL HDPE | Analyze Immediately |
| Total Cyanide | 335 | pH>12 NaOH, Cool 4° C | N/A | 1 L HDPE | 14 days |
| Total Dissolved Solids (TDS) | 209 | Cool 4° C | N/A | 250 mL HDPE | 7 days |
| Total Organic Carbon (TOC) | 415 | pH<2 HCl or H2SO4, Cool 4° C, Dark | N/A | 40 mL Amber | 28 days |
| Total Organic Halogen (TOX) | 506 | pH<2 HNO3, 4° C | N/A | 1 L Amber | check with lab |
| Total Phenolics | 420.1 | pH<2 H2SO4, Cool 4° C | N/A | 1 L Amber | 28 days |
| Total Phosphorus | 365 | pH<2 H2SO4, Cool 4oC | N/A | 125 mL HDPE | 28 days |
| Total Solids (TS) | 160.3 | Cool 4° C | N/A | 250 mL HDPE | 7 days |
| Total Suspended Solids (TSS) | 160.2 | Cool 4° C | N/A | 250 mL HDPE | 7 days |
| Volatile Organics | 624 | pH 2 HCl, Cool 4° C | N/A | 40 mL Glass Vial | 14 days |
| Weak and Dissociable Cyanide | Std. Mth. 412 H. | pH>12 NaOH, Cool 4° C | N/A | 1 L HDPE | 14 days |
| **DRINKING WATER ANALYSIS** | | | | | |
| Volatile Organics | 502.2 or 524.2 | pH 2 HCl, Cool 4° C | N/A | 40 mL Glass Vial | 14 days |
| **MICROBIOLOGY** | | | | | |
| Fecal Coliform | STDMTH | Cool 4o C | N/A | sterile, 125 mL | 6 hours |
| Standard Plate Count | STDMTH | Cool 4o C | N/A | sterile, 125 mL | 6 hours |
| Total Coliform | STDMTH | Cool 4o C | N/A | sterile, 125 mL | 6 hours |
| Yeast and Mold | STDMTH | Cool 4o C | N/A | sterile, 125 mL | 6 hours |

## SOIL/SEDIMENTS/WATER

| Analysis Description | Method No. | Solids (S) / Liquids (L) Preservative | Solid Sample Volume/Container | Liquid | Holding Time |
|---|---|---|---|---|---|
| Acid Extractables/Base/Neutral Extractables | 8270 | S/L: Cool 4° C | 8 oz. CWM | 1 L Amber | 7 days Ext/40 days Analyze |
| Amenable Cyanide | - | S: 4° C / L: pH>12 NaOH, 4° C | 4 oz. CWM | 1 L HDPE | 14 days |
| Chromium, Hexavalent | 3060A/7196 | S/L: Cool 4° C | 8 oz. CWM | 1 L HDPE | 24 hours |
| Extractable Hydrocarbons | 8015B | S: Cool 4° C / L: pH<2 HCl, 4° C | 8 oz. CWM | 1 L Amber | 7 days Ext/40 days Analyze |
| Herbicides | 8150 | S/L: Cool 4° C | 8 oz. CWM | 1 L Amber | 7 days Ext/40 days Analyze |
| Non-Halogenated Organics | 8015B | S: Cool 4° C / L: pH<2 HCl, 4° C | 4 oz. CWM | 40 mL Glass Vial | 14 days |
| PAH (low level) | 8310 or GC/MS SIM | S/L: Cool 4° C | 8 oz. AWM | 1 L Amber | 7 days Ext/40 days Analyze |
| Paint Filter Liquids Test | 9095 | S: Cool 4° C | 8 oz. CWM | 1 L Amber | Analyze ASAP |
| PCBs | 8082 | S/L: Cool 4° C | 8 oz. CWM | 1 L Amber | 7 days Ext/40 days Analyze |
| Pesticides | 8081 | S/L: Cool 4° C | 8 oz. CWM | 1 L Amber | 7 days Ext/40 days Analyze |
| Physiologically Available Cyanide | MADEP draft | S: 4° C / L: pH>12 NaOH, 4° C | 4 oz. CWM | 1 L HDPE | 14 days |
| Priority Pollutant Metals(13 Metals) | 6010&7000 | S: 4° C / L: pH<2 HNO3, 4° C | 8 oz. CWM | 1 L Amber | 28 days (Hg), 6 mos. (others) |
| RCRA Metals (8 Metals) | 6010&7000 | S: 4° C / L: pH<2 HNO3, 4° C | 8 oz. CWM | 1 L Amber | 28 days (Hg), 6 mos. (others) |
| Total Cyanide | 9010 | S: 4° C / L: pH>12 NaOH, 4° C | 4 oz. CWM | 1 L HDPE | 14 days |
| Volatile Hydrocarbons | 8015B | S: Cool 4° C / L: pH<2 HCl, 4° C | 4 oz. CWM | 40 mL Glass Vial | 14 days |
| Volatile Organics | 8260B, 8021 | S: methanol/$NaHSO_4$, 4° C / L: pH<2 HCl, 4° C | 4 oz. CWM | 40 mL Glass Vial | 14 days |
| **RCRA HAZARDOUS WASTE CHARACTERIZATION** | | | | | |
| Corrosivity (pH only) | SW846-7.2 | S: Cool 4° C | 4 oz. CWM | check with lab | Analyze ASAP |
| Ignitability/Flashpoint | SW846-7.1 | S: Cool 4° C | 4 oz. CWM | check with lab | Analyze ASAP |
| Reactivity (CN-/S2-) | SW846-7.3 | S: Cool 4° C | 4 oz. CWM | check with lab | Analyze ASAP |
| TCLP (RCRA 8) Metals (check for mercury) | 1311 | S: Cool 4° C | 16 oz. CWM | check with lab | 6 mos. Ext/6 mos. Analyze |
| TCLP Pesticides/Herbicides | 1311 | S: Cool 4° C | 16 oz. CWM | check with lab | 14 days Ext/40 days Analyze |
| TCLP Semivolatiles | 1311 | S: Cool 4° C | 16 oz. CWM | check with lab | 14 days Ext/40 days Analyze |
| TCLP Volatiles | 1311 | S: Cool 4° C | 8 oz. CWM | check with lab | 14 days Ext/14 days Analyze |
| **HYDROCARBON OIL & GREASE ANALYSIS** | | | | | |
| MADEP EPH Method | MADEP REV. 0 | S: Cool 4° C / L: pH<2 HCl, 4° C | 4 oz. Amber | 1 L Amber | S:7 days Ext / L:14 days Ext |
| MADEP EPH Method (C-Ranges only) | MADEP REV. 0 | S: Cool 4° C / L: pH<2 HCl, 4° C | 4 oz. Amber | 1 L Amber | S:7 days Ext / L:14 days Ext |
| MADEP VPH Method | MADEP REV. 0 | S: methanol, 4° C / L: pH<2 HCl, 4° C | 40 mL+2 oz. CWM. | 40 mL Glass Vial | S: 28 days / L: 14 days |
| MADEP VPH Method (C-Ranges only) | MADEP REV. 0 | S: methanol, 4° C / L: pH<2 HCl, 4° C | 40 mL+2 oz. CWM. | 40 mL Glass Vial | S: 28 days / L: 14 days |
| MADEP EPH Method - with selected PAHs (including acenaphthene, naphthalene, 2-methylnaphthalene, and phenanthrene) | MADEP REV. 0 | S: Cool 4° C / L: pH<2 HCl, 4° C | 4 oz. Amber | 1 L Amber | S:7 days Ext / L:14 days Ext |
| Petroleum Identification | ASTM D3328 | | | | |
| Quantitative (include Chromatograms) | | S: Cool 4° C / L: pH<2 $H_2SO_4$, 4° C | 4 oz. CWM | 1 L Amber | S: 7 days / L: 28 days |
| Total Petroleum Hydrocarbons (Infrared) | 418.1 | S: Cool 4° C / L: pH<2 $H_2SO_4$, 4° C | 4 oz. CWM | 1 L Amber | S: 7 days / L: 28 days |

## AIR METHODS

| Analysis Description | Method No. | Preservative | Sample Volume/Container | | Holding Time |
|---|---|---|---|---|---|
| Volatile Organic Compounds | EPA T01/T02 | tubes: 4° C; Tedlar Bags: dark | N/A | N/A | tube: 14 days; bag: 72 hours |
| Volatile Organic Compounds | EPA T014 | check with lab | N/A | N/A | can: 14 days; bag: 72 hours |
| VPH in air | EPA T01/T02 | tubes: 4° C; Tedlar Bags: dark | N/A | N/A | tube: 14 days; bag: 72 hours |
| VPH in air | EPA T014 | check with lab | N/A | N/A | can: 14 days; bag: 72 hours |

HALEY & ALDRICH

# SAMPLING RECORD

Page ______ of ______

| | | | |
|---|---|---|---|
| **PROJECT** | | **H&A FILE NO.** | |
| **LOCATION** | | **PROJECT MGR.** | |
| **CLIENT** | | **FIELD REP** | |
| **CONTRACTOR** | | **DATE** | |

**Weather** ____________________ **Temperature** ____________________

**Ground surface Conditions** ☐ Dry ☐ Wet ☐ Damp ☐ Standing Water ☐ Snow (_____in) ☐ Other___________

**Comments** ____________________

**SOIL SAMPLING AND SURFACE WATER SAMPLING INFORMATION**

| Sample No. | Location | Depth (ft) | Time | Sample Description | Sampling Device | Cleaning Prodedure | Container Type |
|---|---|---|---|---|---|---|---|
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**General Comments:** (ie: field filtrations, persons communicated with at site, etc.)

HALEY & ALDRICH

# GROUNDWATER SAMPLING RECORD

Page ____ of ____

PROJECT ____________________ H&A FILE NO. ____________
LOCATION ____________________ PROJECT MGR. ____________
CLIENT ____________________ FIELD REP ____________
CONTRACTOR ____________________ DATE ____________

**GROUNDWATER SAMPLING INFORMATION**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Well No. | | | | | | | |
| Water Depth (ft) | | | | | | | |
| Time | | | | | | | |
| Product | | | | | | | |
| Depth Of Well (ft) | | | | | | | |
| Inside Diameter (in) | | | | | | | |
| Standing Water Depth (ft) (1) | | | | | | | |
| Volume Of Water In Well (gal) | | | | | | | |
| Purging Device | | | | | | | |
| Volume of Bailer/Pump Capacity | | | | | | | |
| Cleaning Procedure | | | | | | | |
| Bails Removed/ Volume Removed | | | | | | | |
| Time Purging Started | | | | | | | |
| Time Purging Stopped | | | | | | | |
| Sampling Device | | | | | | | |
| Cleaning Procedure | | | | | | | |
| TIME SAMPLES TAKEN: VOA | | | | | | | |
| ABN | | | | | | | |
| Metals | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| PARAMETERS: Color | | | | | | | |
| Odor | | | | | | | |
| pH | | | | | | | |
| Conductivity | | | | | | | |
| Turbidity | | | | | | | |
| Dissolved Oxygen | | | | | | | |
| Temp, $^0$ C | | | | | | | |
| Salinity | | | | | | | |

Remarks: (ie: field filtrations, persons communicated with at site, etc.)

1. Standing Water Depth = Depth of Well - Water Depth

Form 3005

HALEY & ALDRICH

# TEST BORING REPORT

**BORING NO.** B 7 (OW)

Page 1 of 2

| | | | |
|---|---|---|---|
| **PROJECT** | Greenspace Development | **H&A FILE NO.** | 27921-000 |
| **LOCATION** | 18 Riverside Road, Boston Massachusetts | **PROJECT MGR.** | S.R. Kraemer |
| **CLIENT** | Ecologic Investments | **FIELD REP.** | C.S. Osgood |
| **CONTRACTOR** | Guild Drilling Co., Inc. | **DATE STARTED** | 13-Feb-01 |
| **DRILLER** | Charlie O'Donnel | **DATE FINISHED** | 14-Feb-01 |

**Elevation** 23.3 ft. **Datum** Boston City **Boring Location** See sketch on reverse of form.

| Item | Casing | Sampler | Core Barrel | Rig Make & Model: CME 75 | | Hammer Type | Drilling Mud | Casing Advance |
|---|---|---|---|---|---|---|---|---|
| Type | NW | S | NV2 | ☑ Truck | ☐ Tripod / ☑ Cat-Head | ☑ Safety | ☑ Bentonite | Type Method Depth |
| Inside Diameter (in.) | 3 | 1.385 | 2 | ☐ ATV | ☐ Geoprobe / ☐ Winch | ☐ Doughnut | ☐ Polymer | NW Driven 29.0 ft. |
| Hammer Weight (lb.) | 300 | 140 | | ☐ Track | ☐ Air Track / ☑ Roller Bit | ☐ Automatic | ☐ None | |
| Hammer Fall (in.) | 24 | 30 | | ☐ Skid | ☐ ____ / ☐ Cutting Head | **Drilling Notes:** Flushed slurry prior to coring. | | |

| Depth (ft.) | Sampler Blows per 6 in. | Sample No. & Recovery (in.) | Sample Depth (ft.) | Stratum Change (ft.) | USCS Symbol | Visual-Manual Identification & Description (density/consistency, color, GROUP NAME & SYMBOL, maximum particle size*, structure, odor, moisture, optional descriptions, geologic interpretation) | Gravel % Coarse | Gravel % Fine | Sand % Coarse | Sand % Medium | Sand % Fine | % Fines | Dilatancy | Toughness | Plasticity | Strength |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 10 | | 0.0 | | SP-SM | Medium dense brown poorly graded SAND with silt (SP-SM), | | | | 20 | 70 | 10 | | | | |
| | 12 | S1 | | | | mps 2 mm, distinctly stratified, fines partially organic, no odor, dry. | | | | | | | | | | |
| | 15 | 21" | | | | | | | | | | | | | | |
| | 20 | | 2.0 | 2.0 | | -ALLUVIUM- | | | | | | | | | | |
| | 11 | | 2.0 | | SP | Dense brown poorly graded SAND (SP), mps 25 mm, no odor, dry. | 5 | 5 | 20 | 30 | 35 | 5 | | | | |
| | 15 | S2 | | | | | | | | | | | | | | |
| | 16 | 10" | | | | | | | | | | | | | | |
| | 17 | | 4.0 | | | -ALLUVIUM- | | | | | | | | | | |
| | | | | 4.5 | | | | | | | | | | | | |
| 5 | WOR | | 5.0 | | | Very soft, dark brown ORGANIC SOILS with sand (OL/OH), trace | | | | | 25 | 75 | S | M | H | VH |
| | WOR | S3 | | | OL/OH | seashell fragments and particles, soil mps 0.5 mm, strong | | | | | | | | | | |
| | WOH | 24" | | | | organic odor, moist. | | | | | | | | | | |
| | WOH | | 7.0 | | | -ORGANIC DEPOSIT- | | | | | | | | | | |
| | | | | 8.0 | | | | | | | | | | | | |
| | | | | | | Note: Drilling fluid returning medium to fine sand from 8.0 ft. to | | | | | | | | | | |
| | | | | | | 10.0 ft. Drilling fluid color change to yellow red at 8.5 ft. | | | | | | | | | | |
| | | | | | | -PROBABLE MARINE DEPOSIT- | | | | | | | | | | |
| | | | | 10.0 | | | | | | | | | | | | |
| 10 | 3 | | 10.0 | | CH | Stiff yellow brown fat CLAY (CH), trace fine sand, mps 0.5 mm, | | | | | | 100 | N | M | H | |
| | 6 | S4 | | | | apparently laminated with frequent fine sand partings and | | | | | | | | | | |
| | 6 | 22" | | | | possible organic fibers, no odor, moist. | | | | | | | | | | |
| | 6 | | 12.0 | | | -MARINE DEPOSIT- | | | | | | | | | | |
| | | | | 13.5 | | | | | | | | | | | | |
| | | | | | | Note: Drill action indicates gravel below 13.5 ft. | | | | | | | | | | |
| 15 | 12 | | 15.0 | | CL | Very stiff yellow brown to gray sandy lean CLAY with gravel (CL), | 5 | 10 | 10 | 10 | 15 | 50 | S | M | M | |
| | 14 | S5 | | | | mps 35 mm, distinct disrupted laminae in discrete zones, coarse | | | | | | | | | | |
| | 15 | 17" | | | | fraction consists of well rounded igneous and igneous and | | | | | | | | | | |
| | 19 | | 17.0 | | | metamorphic lithologies, no odor, moist. | | | | | | | | | | |
| | | | | | | -GLACIOMARINE DEPOSIT- | | | | | | | | | | |
| | | | | 18.0 | | | | | | | | | | | | |
| | | | | | | Note: Drill action and total loss of drilling fluid indicates gravel | | | | | | | | | | |
| | | | | 19.0 | | and cobbles from 18.0 ft. to 19.0 ft. | | | | | | | | | | |
| | | | | | | Very dense gray silty SAND (SM), mps 15 mm, very well bonded, | | | | | | | | | | |
| 20 | 21 | S6 | 20.0 | | SM | coarse fraction consists partly of platy argillite fragments, no odor, moist. | | 10 | 15 | 20 | 30 | 25 | R | | | |
| | 25 | 10" | 21.0 | 21.0 | | -GLACIAL TILL- | | | | | | | | | | |
| | 33 | S6A | 21.0 | | ML | Very dense gray SILT (ML), mps <0.1 mm, no structure, no odor, | | | | | | 100 | R | | N | |
| | 34 | 7" | 22.0 | | | dry. | | | | | | | | | | |
| | | | | | | -RESIDUAL SOIL- | | | | | | | | | | |
| | | | | | | Note: Drilling advanced smoothly from 21.0 ft. to 25.0 ft. | | | | | | | | | | |
| | | | | 25.0 | | PROBABLE TOP OF DECOMPOSED BEDROCK 25.0 FT. | | | | | | | | | | |
| 25 | 53 | | 25.0 | | | Very dense gray highly to completely weathered ARGILLITE. | | | | | | | | | | |
| | 28 | S7 | | | | Possible extremely thin relect bedding subparallel to strong | | | | | | | | | | |
| | 39 | 5" | | | | low angle foliation. Sample is generally well bonded and consists | | | | | | | | | | |
| | 35 | | 27.0 | | | of very soft angular fragments and particles which are easily | | | | | | | | | | |
| | | | | | | crushed with finger pressure. | | | | | | | | | | |
| | | | | | | -DECOMPOSED BEDROCK- | | | | | | | | | | |
| | | | | | | Note: Drill action indicates stratum change at 28.5 ft. | | | | | | | | | | |
| | | | | 28.5 | | TOP OF "SOUND" BEDROCK 28.5 FT. | | | | | | | | | | |
| | | | | | | SEE SHEET 2 FOR CORE BORING REPORT | | | | | | | | | | |
| 30 | | | | | | | | | | | | | | | | |

**Water Level Data**

| Date | Time | Elapsed Time (hr.) | Depth in feet to: Bottom of Casing | Bottom of Hole | Water |
|---|---|---|---|---|---|
| 13-Feb-01 | 15:30 | 0 | 29.0 | 29.0 | 2.0 |
| 14-Feb-01 | 7:00 | 15.5 | 29.0 | 29.0 | 6.2 |
| 14-Feb-01 | 15:00 | 1.0 | 39.5 | 39.5 | 10.4 |

**Sample ID**
- O Open End Rod
- T Thin Wall Tube
- U Undisturbed Sample
- S Split Spoon Sample
- G Geoprobe

**Well Diagram**
- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

**Summary**
- Overburden (Linear ft.) 29.5
- Rock Cored (Linear ft.) 10.0
- Number of Samples S7 C2

**BORING NO.** B 7 (OW)

**Field Tests** Dilatancy: R - Rapid S - Slow N - None  Plasticity: N - Nonplastic L - Low M - Medium H - High
Toughness: L - Low M - Medium H - High  Dry Strength: N - None L - Low M - Meduim H - High V - Very High

***NOTE: Maximum Particle Size is determined by direct observation within the limitations of sampler size.**

**NOTE: Soil identifications based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.**

# CORE BORING REPORT

HALEY & ALDRICH

BORING NO. **B 7 (OW)**



| Depth (ft) | Drilling Rate (min/ft) | Core No. Depth (ft) | Recovery (in) | RQD (%) | Weathering | Stratum Change (ft) | Visual Classification and Remarks |
|---|---|---|---|---|---|---|---|
| | | | | | | | SEE SHEET 1 TEST BORING REPORT FOR OVERBURDEN DETAILS. |
| | | | | | | 21.0 | TOP OF RESIDUAL SOIL 21.0 FT. |
| | | | | | | | Note: Advanced borehole with rollerbit and splitspoon and drove NW casing through residual |
| | | | | | | | soil from 21.0 ft. to 25.0 ft. |
| | | | | | Residual | | |
| | | | | | Soil | | -RESIDUAL SOIL- |
| | | | | | | 25.0 | TOP OF DECOMPOSED BEDROCK 25.0 FT. |
| 25 | | | | | | | |
| | | | | | High | | Note: Advanced borehole with rollerbit and splitspoon and drove NW casing through |
| | | | | | to | | decomposed bedrock from 25.0 ft. to 28.5 ft. |
| | | | | | Complete | | |
| | | | | | | | -DECOMPOSED BEDROCK- |
| | | | | | | 28.5 | TOP OF "SOUND" BEDROCK 28.5 FT. |
| | | | | | | | Note: Seated NW casing at 29.0 ft. Advanced borehole with rollerbit to 29.5 ft. without sampling |
| | | | | | | | prior to coring. |
| | | 29.5 | 56" | | Slight | | C1: Moderately hard, slightly weathered, gray, aphanitic ARGILLITE. Bedding extremely thin to |
| 30 | | | | | | | very thin, generally low angle (30-35 degrees). Foliation low angle, commonly subparallel to |
| | 6 | | | | | | bedding. Cleavage well developed along bedding/foliation planes where coincident. |
| | | | | | Mod. | | Cleavage joints very close to close 29.5 -31.0 ft. and close below 32.5 ft. smooth-planar, |
| | 3 | C1 | | | High | | slightly oxidized, occasionally calcite-infilled, tight. High angle to vertical joints moderately |
| | | | | | Mod. | | close, rough-undulatory, pyritized or highly oxidized and decomposed with silt infilling, open. |
| | 5 | | | | | | Soft, moderately to highly weathered zone 31.0-32.5 ft. associated with extremely close, |
| | | | | | Slight | | moderately dipping, slickensided-planar shears intersecting bedding plane and high angle features. |
| | 6 | | | | | | Note: Partial water loss below 31.0 ft. |
| | | 34.5 | 24" | 40% | | | Note: Lost core assumed 31.7-32.0 ft. |
| 35 | 6 | 34.5 | 60" | 100% | | | C2: Similar to bottom of run C1 except cleavage joints close to moderately close. High angle to |
| | | | | | | | vertical joints absent. Occasional thin zone of extremely close, extremely thin, moderately |
| | 7 | | | | | | dipping to high angle (50-60 degrees) calcite stringers. Occasional calcite-healed low angle |
| | | | | | | | joint. |
| | 6 | C2 | | | Slight | | -CAMBRIDGE FORMATION- |
| | 6 | | | | | 38.0 | |
| | | | | | | | Lithology change at 38.0 ft. to hard, slightly weathered, dark gray to black, fine grained to |
| | 8 | | | | | | aphanitic DIABASE. Single high angle joint at 38.7 ft. rough-stepped, slightly oxidized, tight. |
| | | 39.5 | 54" | 90% | | | |
| 40 | 8 | | | | | | BOTTOM OF EXPLORATION 39.5 FT. |

HALEY & ALDRICH

# TEST PIT LOG

**Test Pit No.** TP-1

Page 1 of 1

| | | | |
|---|---|---|---|
| **PROJECT** | New England Hospital | **H&A FILE NO.** | 10715-205 |
| **LOCATION** | Boston, Massachusetts | **PROJECT MGR.** | M.X. Haley |
| **CLIENT** | PFT Associates | **FIELD REP** | C. S. Osgood |
| **CONTRACTOR** | J. Marchese & Sons Const. | **DATE** | 07-Jan-02 |
| **EQUIPMENT** | CAT 416 Rubber Tire Extendahoe 0.24 cu.yd. bucket capacity | **WEATHER** | Mostly Clear 20s |

**Ground El.** 36.3 ft.
**El. Datum** NGVD
**Location** West of Pedestrian Tunnel
**Groundwater depths/entry rates (in./min.):** 7.8 ft. Steadily

| Depth (ft.) | Sample ID | Stratum Change Depth (ft.) | USCS Symbol | Visual Identification (density/consistency, color, GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions, geologic interpretation) | Gravel % Coarse | Gravel % Fine | Sand % Coarse | Sand % Medium | Sand % Fine | % Fines | Field Test Dilatancy | Field Test Toughness | Field Test Plasticity | Field Test Strength |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Dark brown silty SAND (SM), mps 5 mm, organic odor, moist. | | 5 | 5 | 10 | 45 | 40 | R | | | |
| | 0.5 | | SM | Fines largely organic. | | | | | | | | | | |
| | | | | -LOAM FILL- | | | | | | | | | | |
| | | 1.3 | | | | | | | | | | | | |
| 2 | S3 | | | Yellow brown to olive brown sandy fat CLAY (CH), trace roots, clinker fragments, | 5 | 5 | 5 | 10 | 15 | 60 | N | M | H | |
| | | | CH | cinder particles and fragments, clay pipe fragments, metal wire, asphalt fragments. | | | | | | | | | | |
| | | | | 10% cobbles, <5% boulders, mps 30 in., no odor, moist. | | | | | | | | | | |
| | | | | -FILL- | | | | | | | | | | |
| 4 | 4.0 | | | Note: Poured concrete foundation wall on east side of test pit from 0.0 -4.4 ft. | | | | | | | | | | |
| | 4.0 | | | | | | | | | | | | | |
| | | | | Note: Poured concrete foooting 4.4-5.4 ft. | | | | | | | | | | |
| 6 | S2 | | | | | | | | | | | | | |
| | 8.0 | 8.0 | | | | | | | | | | | | |
| 8 | 8.0 | | | Yellow brown fat CLAY (CH), trace fine sand. mps 0.5 mm, no odor, dry. | | | | | 5 | 95 | N | M | H | |
| | S1 | | CH | Appartantly laminated with frequent fine sand partings and possible organic fibers. | | | | | | | | | | |
| | 9.0 | | | -MARINE DEPOSIT- | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | |
| | | 11.0 | | | | | | | | | | | | |
| | | | | Yellow brown to gray sandy lean CLAY (CL) with gravel. mps 35 mm, | 5 | 10 | 10 | 10 | 15 | 50 | S | M | L | |
| | | | CL | Distinct disrupted laminae in discrete zones. Coarse fraction consists of well-rounded | | | | | | | | | | |
| | | | | igneous and metemorphic lithologies. | | | | | | | | | | |
| 12 | 12.0 | 12.0 | | -GLACIOMARINE DEPOSIT- | | | | | | | | | | |
| | | | | Note: Possible stratum change to gray lean CLAY with sand (CL) below 12.0 ft. | | | | | | | | | | |
| | | | | Coarse fraction apparantly less abundent. | | | | | | | | | | |
| | | | | -MARINE DEPOSIT- | | | | | | | | | | |
| | | | | **BOTTOM OF EXPLORATION 13.5 FT.** | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | |

**Obstructions:**

**Remarks:**
Note: Bag samples S1-S3 obtained for potential mechanical analysis from depths indicated.

**Field Tests**

| | |
|---|---|
| Dilatancy: | R - Rapid S - Slow N- None |
| Toughness: | L - Low M - Medium H - High |
| Plasticity: | N - Nonplastic L - Low M - Medium H - High |
| Dry Strength: | N - None L - Low M - Medium H - High V - Very High |

**Standing water in completed pit:**
at depth 13.2 ft.
measured after 0.1 hrs. elapsed

**Boulders:**

| Diameter (in.) | Number | | Approx. vol. (cu. ft.) |
|---|---|---|---|
| 12 to 24 | 1 | = | 1.8 |
| over 24 | 1 | = | 8.2 |

**Test Pit Dimensions (ft.):**
Pit Depth 13.5
Pit Length X Width 9.0 x 6.0

**NOTE: Soil identifications based on visual/manual methods of the USCS system as practiced by Haley & Aldrich, Inc.**

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# ENVIRONMENTAL TEST PIT LOG

HALEY & ALDRICH

Test Pit No. **TP 214**

Page 1 of 1

| | | | |
|---|---|---|---|
| PROJECT | Mirror Lake Watershed Study | H&A FILE NO. | 28675-309 |
| LOCATION | Essex, Massachusetts | PROJECT MGR. | D.H. Gevalt |
| CLIENT | Citizens Advisory Partnership | FIELD REP | C.S. Osgood |
| CONTRACTOR | Stanley Lynde Const. Co., Inc. | DATE | 19-Jul-02 |
| EQUIPMENT | Case 580 rubber tire backhoe - 1/4 cu. yd. bucket | WEATHER | Thunderstorms 90's |

| | | | | |
|---|---|---|---|---|
| Ground El. | 74.5 ft. | Location | N 2,089,041.101 | Groundwater depths/entry rates (in./min.): |
| El. Datum | NGVD | | E 801,444.238 | None |

| Depth (ft.) | Sample ID | PID Reading (ppm.) | Stratum Change Depth (ft.) | USCS Symbol | Visual Identification (density/consistency, color, GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions, | Gravel % Coarse | Gravel % Fine | Sand % Coarse | Sand % Medium | Sand % Fine | % Fines | Field Test Dilatancy | Field Test Toughness | Field Test Plasticity | Field Test Strength |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Note: Ground surface strewn with boulders. Numerous depressions indicating subsurface voids noted. | | | | | | | | | | |
| | 1.5 | | | | 15% coarse to fine sand, 15% cinder fragments and particles, 10% unidentifiable, white ash-like material, 10% fines (largely organic), 10% coarse to fine gravel, 10% wood (manufactured and treated), 5% glass fragments, 5% metal strips and wire, 5% charcoa | | | | | | | | | | |
| 2 | S2 | 15.9 | | | 5% plastic sheeting (possibly polyethelene bags), 5% brick particles, 5% clay pipe fragments. Matrix generally dark brown to gray in color with pockets of white and red. 15% boulders, 15 % cobbles. Maximum particle size 36 inches. | | | | | | | | | | |
| | 2.5 | | | | Distinct decomposed gasoline odor, possible faint napthalene odor. Visible irridescen sheen on moist solids 4.6 to 5.2 ft. | | | | | | | | | | |
| 4 | | | | | -FILL- | | | | | | | | | | |
| | 4.6 | | | | | | | | | | | | | | |
| | S1 | 140 | | | Note: Bedrock surface smooth and flat, consisting of very hard to hard, slightly | | | | | | | | | | |
| | 5.2 | | 5.2 | | weathered, light gray to pink, coarse to fine grained granite. Single high angle joint noted. | | | | | | | | | | |
| | | | | | REFUSAL ON BEDROCK 5.2 FT. | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | |

**Obstructions:**

**Remarks:**
Note: Sample S1 submitted for laboratory chemical analysis.
Note: Field monitoring of breathing zone and headspace screening conducted using an hNU 11.7 ev. PID.
**Bucket Decontamination Method:** Steam cleaned

**Field Tests**

| | |
|---|---|
| Dilatancy: | R - Rapid S - Slow N- None |
| Toughness: | L - Low M - Medium H - High |
| Plasticity: | N - Nonplastic L - Low M - Medium H - High |
| Dry Strength: | N - None L - Low M - Medium H - High V - Very High |

**Standing water in completed pit:**
at depth NE ft.
measured after 0.75 hrs. elapsed

**Boulders:**

| Diameter (in.) | Number | | Approx. vol. (cu. ft.) |
|---|---|---|---|
| 12 to 24 | 6.0 | = | 18.0 |
| over 24 | 1.0 | = | 33.0 |

**Test Pit Dimensions (ft.):**
Pit Depth 5.2
Pit Length X Width 10.5 x 4.3

**NOTE: Soil identifications based on visual/manual methods of the USCS system as practiced by Haley & Aldrich, Inc.**

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**APPENDIX D**
**CHECKLISTS**

## D.1 Field Monitoring Checklist

### D.1.1 Preliminary Preparation

A. Project Briefing
B. Field Project File and Document Assembly
  - Proposal
  - Contract Documents
  - Locus, Site & Utility Plans
  - Exploration Criteria
  - Subcontractor Agreement
  - Site and Project Contacts
  - Forms
    - DFR
    - Subcontractor Quantities
    - Test Boring Report
    - Core Boring Report
    - Observation Well Installation Form
    - Test Pit Log
    - Special Testing / Instrumentation Forms
    - COC
    - Equipment Usage and Billing Form
    - Sample Receiving Form

C. H&S Briefing
  - H&S Plan

D. Equipment Request and Assembly

### D.1.2 Onsite Duties

A. Site Walkover and Subcontractor Utility and Safety Briefing
B. Exploration Program Review
  - Exploration Layout
  - Site Conditions Sketch
  - Preliminary Surficial Geologic Map
  - Exploration Monitoring
    - Equipment Inventory
    - Exploration Layout & Utility Check
    - Field Logging Soil & Rock
    - Water Level Measurements
    - Production and Budget Quantities
    - Sample Handling & Transport
    - Instrumentation & Testing Records
    - As-Built Sketches & Exploration Locations

### D.1.3 Follow Up & Summary

- Proof Logs and Test Reports
- Finalize DFR and Subcontractor Quantities
- Sample Receiving and Disposition
- Equipment Return and Billing
- Exploration Program Summary
- Final Site & Geological Conditions Summary
- Geologic Profiles

# OPERATING PROCEDURE: OP3009

## MONITORING WELL DEVELOPMENT PROCEDURE



**PREPARATION AND APPROVALS**

| VERSION | AUTHORED/DATE | REVIEWED / DATE | REVIEWED / DATE | REVIEWED / DATE | APPROVED / DATE |
|---|---|---|---|---|---|
| Ver. 0.0 | BAM/ 08-02 | JCP/ 08-02 | GJM/ 06-03 | | JAK/ 06-03 |
| | | | | | |
| | | | | | |
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**Total Pages: 20**



HALEY & ALDRICH

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**OPERATING PROCEDURE: OP3009**

**MONITORING WELL DEVELOPMENT PROCEDURE**

## 1. PURPOSE

This procedure provides guidance on methods and techniques for groundwater monitoring well development typically performed after well installation, but prior to groundwater quality sampling, specifically for instrumentation installed in overburden or bedrock for environmental monitoring and geotechnical purposes. Groundwater well development increases the yield of the well by removing fine sediments and particles from within the well and the well filter pack, enhances the hydraulic communication between the well and the screened formation, decreases turbidity, increases precision of hydrologic measurements, and increases representativeness of groundwater quality data. Well development is an integral component of a groundwater sampling program, with the objective of obtaining high quality, reproducible groundwater quality data.

The selected method and duration of groundwater well development will be dependent on a number of factors, including: well construction method and materials, depth to groundwater, anticipated groundwater testing parameters and data quality objectives, presence of contamination (i.e., degree of contamination and presence of free-phase non-aqueous phase liquids), method of borehole advancement, and site physical setting/access.

IMPORTANT NOTES:

It is not necessary to follow all of the methods in this procedure for every monitoring well development performed. The procedures may be adapted to conform to specific local practice, site-specific geologic conditions, or to support local, municipal or state regulatory requirements.

The term "groundwater monitoring well" or "well" in the procedure is used to denote groundwater monitoring wells, groundwater observation wells, piezometers, gas monitoring wells, lysimeters or other devices constructed in similar manner to a well. Certain well constructions (i.e., large-diameter pumping test wells, injection/extraction wells, commercial, residential or industrial water supply wells) may be developed using the information contained in the procedure, but are typically installed using specialized drilling equipment and are typically developed using that equipment by specific methods that are beyond the scope and intent of this field procedure.

## 2. EQUIPMENT & SUPPLIES

Required

1. Water Level Indicator, Sinco or equivalent
2. Oil/Water Interface Probe
3. Thermometer
4. pH meter and buffering/calibration solutions
5. Conductivity meter and probe
6. Dissolved oxygen meter and probe
7. Turbidity meter and probe
8. Oxidation/Reduction Potential meter and probe
9. Salinity meter
10. Pump (Grundfos, peristaltic, whale etc.)
11. Pump accessories (Cables, fittings, tools)
12. ½ in. or 5/8 in. HDPE or Teflon discharge tubing; also silicon tubing for peristaltic pump
13. Power source for pump (generator with fuel; automotive battery, rechargeable battery)
14. Graduated plastic bucket (5-gallon) or flow meter
15. Stopwatch
16. Standard decontamination equipment (water jug, buckets or washtubs, brushes, Alconox, distilled water, tap water, methanol, squeeze bottles)
17. Ruler, engineer's 6 ft. folding
18. Scale, engineer's
19. Graduated tape, 100 ft. length, weighted end
20. Field Logs & Forms/Field Book
21. Site Plan, Maps, Boring and Well Installation Logs
22. Personal protective equipment
23. Calculator
24. Keys to well padlocks/covers
25. Paper towels
26. Trash bags

Optional:

1. Horiba MultiMeter (measures pH, temperature, conductivity, DO, turbidity, and salinity)
2. Horiba U-22 Flow Cell (measures pH, temperature, conductivity, DO, turbidity, ORP and salinity)
3. Inertial Pump Materials: Waterra Foot Valves, HDPE Tubing
4. Bailers; rope, knife

## 3. PROCEDURE

### 3.1 Summary of Procedure Purpose and Intent

The primary purpose of developing groundwater quality monitoring wells at sites containing, or potentially containing, solid or hazardous materials or their byproducts, is to create an effective filter pack around the well screen, rectify impact to the formation caused by drilling and the associated drilling fluid, remove fine particles from the formation near the borehole and assist in restoring the natural water quality of the aquifer in the vicinity of the well. The properly developed well ensures the reliable collection of representative ground water samples, of acceptably low turbidity.

Well development induces movement of water in two directions across the well screen and filter pack. This movement removes fines or other foreign materials from within the well, the filter pack, and the surrounding natural formation, creating a stable graded filter yielding water of relatively low turbidity.

### 3.2 Role of Environmental Professional or Engineer

Groundwater monitoring well development requires evaluation and consideration of a variety of site-specific characteristics, which precludes the use of one single development practice or procedure. The procedure is provided as a guide to aid the environmental professional, geologist or engineer in selecting the technical approach and methodology to effectively complete a well development program.

At the initiation of project planning, the Project Manager, Project Engineer or Scientist, and field personnel, determine any project-specific requirements for groundwater well development. Municipal, state or federal regulations, local practice, client requirements or project requirements may dictate the use of a different or modified well development method.

### 3.3 General Methods of Monitoring Well Development

There are three general types of well development methods typically employed on small diameter monitoring wells (equal to or less than 4 in. I.D.) installed for environmental purposes:

- Pumping and overpumping
- Bailing
- Surging with a Surge Block

Well development methods that potentially alter the chemical composition of the groundwater are not acceptable. Therefore, methods that introduce fluids (including water pumped from the well) or air, to accomplish development are generally considered unsuitable. This eliminates several methods commonly used to develop large-diameter water supply wells. These methods include backwashing, jetting, airlift pumping or air surging.

The majority of well development for environmental purposes is conducted by mechanical pumping and overpumping, use of inertial lift pumps, inertial lift pumps with surge blocks, bailers, or a combination of these methods.

### 3.4 Preliminary Procedures

In preparation for well development activities (and subsequent groundwater quality sampling event), the Project Manager and groundwater developer/sampler reviews project-specific requirements and considerations of the well development and groundwater sampling program.

The information reviewed may include site map or plans, drilling methods and records, well construction records, depth to groundwater data, previous groundwater quality data, data trends, earlier sampling records and field procedures used, and preferred well sampling sequence or sampling order. Identify project documentation needs and records of well development execution.

Other information to be reviewed are specific laboratory analyses to be performed on samples to be obtained from each well, sampling glassware, need for field filtration and container preservatives. Related aspects of the procedure include site health & safety plan review, evaluation of the site physical setting, availability of electrical power, property access permission and constraints, and purge water disposal.

Design the well development program to support the data quality objectives of the chemical analyses of the groundwater samples to be obtained. Based on the types of data to be collected in the field, identify the appropriate types of mechanical purging required (by pumps or other specialized equipment), likelihood of the presence of non-aqueous phase liquid (NAPL) and accommodations for measuring NAPL. Generally, a series of wells are developed starting with the least contaminated well working towards the well exhibiting the most significant contamination, if known.

Other considerations are identifying protocol for personnel protective equipment (PPE) use and specialized handling of purged water and decontamination wastewater, as generated. Recently installed monitoring wells should not be developed before well sealant materials (bentonite annular seal, cement/bentonite grout) have set or cured, typically assumed to be approximately one week.

In some cases, groundwater obtained from wells installed and sealed with a column of cement grout has exhibited artificially high pH, due to migration and influence of the calcium carbonate from the cement. The Project Manager and field representative are cautioned of this possibility, manifested during the well development procedure by inconsistent, unstable or high pH readings.

Table I presents common well development equipment, and lists advantages/disadvantages of the equipment.

### 3.5 Calculate Volume of Standing Water in Well

Calculate the estimated volume of standing water in the well. Some useful formulae for calculating well volumes are provided below:

- $V = L\ r^2 (0.163)$

  Where:

  $V$ = volume of standing water in well, in gallons
  $r$ = internal radius of well, in inches
  $L$ = length of standing water column, in feet
  0.163 = derived constant converting well radius in inches to feet, and cubic feet to gallons

Other useful formulae:

- Gallons per 100 ft. = 4.08 * (D)2

  Where D = Inside well or borehole diameter, in inches

- Cubic feet of water per 100 ft. = 0.55 * (D)2

  Where D = Inside well or borehole diameter, in inches

- 7.48 gallons = 1 cubic foot

- 0.134 cubic feet = 1 gallon

## 3.6 Field Procedures

### 3.6.1 Locate Well

Locate the subject well in the field, using site plans, sketches, fixed references or other available documentation. Metal detectors may be useful in locating buried metal well casings; however, non-ferrous (i.e., aluminum or PVC) or missing well casings will not respond to metal detector signals.

Verify well designation, particularly individual wells located in closely spaced well clusters or well nests. If necessary, verify and document the location of the well to be decommissioned, referenced by taped distance to three fixed features, or acquire coordinates using global positioning system (GPS) methods or by instrument survey.

### 3.6.2 Evaluate Well Integrity and Construction

Evaluate and document condition of protective well casing and surface seal (padlock missing/broken, well cap missing, staining on well riser observed, concrete surface seal cracked, surface runoff entering well etc.). Record well construction material (stainless steel, PVC, fiberglass, galvanized steel, black carbon steel etc.).

Establish/verify monitoring well reference point (i.e., PVC rim, roadway box rim, protective guard pipe casing rim, ground surface).

## 3.7 Well Development Procedure – Mechanical Pump Method

Mechanical pumps include electrically powered submersible pumps (Grundfos and Whale brands), or suction lift surficial pumps, such as centrifugal or peristaltic types. Pumps may have variable speed controls to regulate discharge rate. Other types of suction lift surface pumps may be driven by internal combustion gasoline engines (not discussed in this procedure).

1. Follow Preliminary Procedures above, including evaluation of well integrity and documentation of well construction details.

2. Don appropriate personnel protective equipment (PPE) as identified in project health & safety plan. Pay particular attention to splash hazards.

3. Decontaminate all downhole development equipment prior to placement within wells, between uses in either the same well, or in other wells. Clean and prepare equipment using an Alconox soapy wash, tap water rinse, methanol rinse, and distilled/deionized water rinse. Containerize decontamination rinseate, if required.

4. If warranted, measure for possible presence of non-aqueous phase liquids (NAPL), using oil/water interface probe. Modify well development program based on findings and discussion with Project Manager, including postponing/canceling well development.

5. Measure well diameter, depth to water (static water level), depth to bottom of well using water level indicator or weighted graduated tape. Calculate standing water volume (see above).

6. Verify information on the respective well record, if available, and note any discrepancies. If well logs are not available, determine screen length and depth, if possible, to determine whether the well construction will provide useful data.

7. Evaluate obstructions present within the well or material accumulated in bottom of well. The presence of substantial quantity of accumulated materials (i.e., silt $>$ 0.5 ft.) in bottom of well may warrant modifying the well development method to remove the sediment (i.e., use of peristaltic pump or hand bailer to remove sediment).

8. Remove any unsuitable dedicated groundwater sampling devices, if present (i.e., Waterra-type inertial pumps and discharge tubing, bailers, SoakEase absorbent material). Retain and discard as solid waste.

9. Groundwater purged from the borehole may or may not require containment or may be discharged on the ground in vicinity of well head, depending on groundwater quality, site setting, regulatory considerations and project requirements. Resolve with Project Manager prior to entering field.

10. Cut a clean piece of discharge tubing for selected pump (typically ½ in. or 5/8 in. high density polyethylene (HDPE) or Teflon tubing) of sufficient length to fully penetrate the well to its screened depth and to accommodate measuring purge volumes and inorganic parameters at ground surface. Cut tubing should not fall or drop into the well.

11. For submersible pumps, attached tubing and lower pump intake into well, suspending pump intake at the approximate midpoint of the saturated zone for water table wells, or at the screen midpoint for deeper wells. Connect power cables and controller box, and operate the pump according to manufacturer's instructions.

12. Initially operate pump at a discharge rate approximately equal to well recharge rate, using graduated bucket or flow meter and stopwatch to estimate flow, and adjust until drawdown of approximately 0.3 ft. is obtained. At the start of purging, obtain inorganic field parameters of the discharge, in the following order: pH, temperature, specific conductance (conductivity), oxidation-reduction potential (ORP), dissolved oxygen (DO) and turbidity, and record on field forms or in logbook.

13. Well development continues until representative groundwater, free from drilling fluids, drill cuttings, accumulated sediment or other materials introduced during the well construction is obtained.

    Unless determined by project specific requirements, remove approximately 3 to 5 well volumes, measuring and recording inorganic field parameters for each well volume removed. If, during removal of 3 to 5 well volumes, field parameters have stabilized within 10% for two successive readings, and turbidity has been reduced to 5 nephelometric turbidity units (NTU) or less, then well development is considered complete. Based on discussion with the Project Manager or environmental professional, consider the applicability of Step 14 below, and complete if warranted.

    In certain circumstances and based on project objectives, well development may consist of removing a fixed volume of water from the well that is predicated on the drilling method used for well installation. For wells installed without the introduction of drilling fluids (i.e., hollow stem augers, driven well points), three (3) well volumes are removed. For wells where drilling fluids were introduced (i.e., cased borings, rock coring, mud rotary methods), ten (10) well volumes are removed. In these cases, inorganic field parameter readings may be obtained for informational purposes.

14. A parallel objective of well development may be to remove drilling fluid lost to the formation(s) that was introduced during the drilling process. This aspect of development is complete when the identified volume of fluid is removed, and stabilized inorganic parameters are achieved.

15. If field parameters have not stabilized after Step 13, increase pumping rate to dislodge fine-grained materials from the filter pack, or remove sediment in suspension. It may be necessary to lower pump intake to accommodate drawdown. Avoid pulling coarse sediment into well intake to prevent pump impeller damage.

16. If slow recharge rate does not allow for continuous operation, shut off pump, allow well to recharge, and resume pumping at slower rate and well evacuation until discharge water clears. Resume measuring field parameters (Step 13) until stabilized.

17. Complete documentation as appropriate.

### 3.8 Well Development Procedure – Inertial Pump Methods

Inertial pumps use a dedicated pre-cleaned single ball check valve ("foot valve") and HDPE discharge tubing to manually remove water from the well.

1. Follow Preliminary Procedures above, including evaluation of well integrity and documentation of well construction details, and Section 5.7, Steps 1 through 10.

2. Attach foot valve (i.e. Waterra type) to bottom end of HDPE tubing and lower into well. Allow approximately 2 to 4 ft. extra tubing above well casing for controlling discharge of purge water.

3. To remove groundwater from the well, manually lift and lower the HDPE tubing within the well bore by hand, approximately once every three to five seconds, timing the motion to optimize purge water volume removed with each stroke. Clean foot valve if it becomes clogged or obstructed by sediment by carefully removing tubing from well, unthreading the foot valve, and rinsing with distilled water.

4. Monitor inorganic field parameters as in Steps 12 to 14, above.

5. If slow recharge rate does not allow for continuous purging, allow well to recharge, and resume purging and well evacuation until discharge water clears. Resume measuring field parameters until stabilized. HDPE tubing and foot valves are typically dedicated and left in groundwater well following sampling.

6. Complete documentation as appropriate.

**3.9 Well Development Procedure - Surge Blocks**

Surge blocks can be used in conjunction with pre-cleaned, dedicated inertial pumps (single ball check valve or “foot valve”) and HDPE discharge tubing.

1. Follow Preliminary Procedures above, including evaluation of well integrity and documentation of well construction details, and Section 5.7, Steps 1 through 10.

2. Press fit the surge block device securely onto foot valve (i.e. Waterra type), attach foot valve to bottom end of HDPE tubing and lower into well. Allow approximately 2 to 4 ft. extra tubing above well casing for controlling discharge of purge water.

3. To surge the groundwater, lower the surge block into the water column and use as a “plunger” by manually lifting and lowering the HDPE tubing by hand, forcing water to flow into and out of the screened portion of the aquifer. Surge each well for a minimum of 30 minutes to remove the finer material from the aquifer surrounding the borehole, providing a developed zone of uniformly graded sand of higher porosity and higher permeability surrounding the well screen, allowing the water to flow more freely into the well, and reducing potential turbidity.

4. Following the surging portion of the well development, remove the surge block from the foot valve, and purge a minimum of one well volume from the well by removing the fine particles brought into the well during surging.

5. Monitor inorganic field parameters as in Steps 12 to 14, above.

6. If slow recharge rate does not allow for continuous purging, allow well to recharge, and resume purging and well evacuation until discharge water clears. Resume measuring field parameters until stabilized. HDPE tubing and foot valves are typically dedicated and left in well following sampling.

7. Complete documentation as appropriate.

### 3.10 Well Development Procedure - Bailers

Hollow, cylindrical bailers are a type of grab sampling device, and may be constructed of stainless steel, Teflon, or PTFE, typically with a single ball check valve fixed on the bottom. They are manually lowered into the well using a rope tether, allowed to collect well water, then lifted from the well. The collected water is discharged to a graduated bucket, and the process repeated until the well is deemed adequately developed. Stainless steel bailers are generally simple to decontaminate. Teflon or PTFE bailers are considered dedicated or disposable after one-time use.

In general, the use of bailers are not a preferred well development method, due to the time required to remove potentially large volumes of development water, especially in deep wells. Their use, however, creates agitation and mixing within the water column, which suspends sediment and fines, incrementally aiding in clearing the well and filter pack, thereby reducing turbidity.

PTFE ("clear") bailers are often used to collect NAPL for thickness measurements or product analysis. Although not discussed in this procedure, bailers are generally not recommended for groundwater sampling overall, and not acceptable for low-flow groundwater sampling in particular, especially sampling for volatile organic compounds (VOCs), volatile petroleum hydrocarbons (VPH), dissolved metals or other analytes requiring field filtration.

### 3.11 Restoration and Cleanup

The area around the well head and ground surface shall be completely cleaned up of any development materials (plastic sheeting, tubing, paper towels, litter, etc.), and the well secured.

### 3.12 Documentation

A complete record of the well development procedure should be documented and incorporated into the project file. Complete portions of the Groundwater Sampling Record form, recording the following information:

- Project information, date and personnel present
- Well location and designation
- Well condition inventory
- Presence of NAPL

- Diameter, depth of well, screened interval (if known), depth to static groundwater, volume of standing water column in well
- Detailed description of well development equipment and procedure used
- Time(s) development started and ended
- Incremental and total volume of purge water removed
- Inorganic field parameter measurements
- Comments on discharge water quality
- Modifications to procedures
- Decontamination method, and discharge water management method
- Drum count of accumulated discharge water, if applicable

Appendix C contains a blank Sampling Report (Form #3004), Groundwater Sampling Record (Form #3005), Monitoring Well Development Report (Form #3006) and Low Flow Field Sampling Form (Form #3010) for reference.

**3.13 Precision and Bias**

This procedure provides qualitative information only; therefore, a precision and bias statement is not applicable.

**TABLE 1**
**Common Well Development Equipment**

| Material | Type | Power Requirement | Positive Attributes | Negative Attributes |
|---|---|---|---|---|
| **Mechanical Pumps:** | | | | |
| Grundfos Pump | Submersible pump (variable speed) | 120V A.C. current | -Lift height only constrained by cable length (+/- 150 ft.)<br>-Controllable, variable flow rate from 0.01 to ≈35 L/minute<br>-Stainless steel disassembles for simple decontamination<br>See note 1 | -Requires generator if no power source available<br>-Risk of cross contamination of sample glassware or tubing from generator fuel<br>-Heavy/cumbersome<br>-Sediment may clog pump impellers<br>-2.0 in. minimum well diameter<br>See note 2 |
| GeoDurham | Submersible Pump (variable speed) | 12V D.C. current (Automotive battery) | -Portable power supply<br>-Lift height only constrained by cable length (+/- 75 ft)<br>-Controllable, variable flow rate<br>-Stainless steel for simple decontamination<br>See note 1 | -Limit on lowest pump speed/discharge<br>-Sediment may clog pump impellers<br>-Power supply limits duration of pump use<br>-2.0 in. minimum well diameter<br>See note 2 |
| Whale Pumps | Submersible pump (variable speed) | 12V D.C. current (Automotive battery) | -Portable power supply<br>-Lift height only constrained by cable length (+/- 30 ft.)<br>-Disassembles for simple decontamination<br>-1.5 in. minimum well diameter | -Power supply limits duration of pump use<br>See note 2 |
| Peristaltic Pumps | Suction lift surface pump (single speed) | 12V D.C. current (Automotive Battery) | -Good for purging sediment from silt trap during development<br>-Dedicated tubing<br>-Easy to operate<br>-0.5 in. minimum well diameter | -Not appropriate for sampling VOCs (agitation)<br>-Lift limited to ≈25 ft. BGS<br>-Pump rate 0.01 L/min. |
| **Manual Methods:** | | | | |
| Inertial Pump | Submersible foot valve with discharge tubing | Manually operated | -Dedicated tubing<br>-Inexpensive<br>-Simple to operate<br>-0.5 in. minimum well diameter | -Depth limited by manual capability to lift tubing (typically 70 to 80 ft.)<br>-Tiring for large volumes of development water<br>-Sediment may clog foot valve |
| Stainless Steel Bailer | Grab sample device with single check valve | Manually operated | -Disassembles for simple decontamination<br>-Simple to operate | -Not appropriate for groundwater sampling (agitation)<br>-Tiring for large volumes of development water<br>-Splash hazard |
| Teflon Bailer | Grab sample device with single check valve | Manually operated | -Dedicated<br>-Simple to operate<br>-Inexpensive | -Not appropriate for groundwater sampling (agitation)<br>-Tiring for large volumes of development water<br>-Splash hazard |
| Clear Bailer | Grab sample device with single check valve | Manually operated | -Dedicated<br>-Simple to operate<br>-Inexpensive<br>-Can collect NAPL for evaluation | -Not appropriate for groundwater sampling (agitation)<br>-Tiring for large volumes of development water<br>-Splash hazard |



Notes and References:
1. Appropriate for low flow/low stress groundwater sampling.
2. Not appropriate if DNAPL/LNAPL present in monitoring well.

**APPENDIX A**
**REFERENCES**

## A.1 Reference Procedures


- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D5521-94, "Standard Guide for Development of Groundwater Monitoring Wells in Granular Aquifers."

- Puls, R.W., Barcelona, M.J., 1996. "Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures," US EPA Ground Water Issue, US Environmental Protection Agency. Office of Solid Waste, EPA/540/S-95/504, pp. 1 to 12.

- US Environmental Protection Agency, Region I, (30 July 1996). "Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells," SOP # GW 0001, Revision 2.


## A.2 Other References


- US Environmental Protection Agency, 1992. Office of Solid Waste," RCRA Groundwater Monitoring: Draft Technical Guidance," EPA/530/R-93/001, NTIS PB 93-139350, November 1992, pp. 6-46 to 6-50.

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D6634-01, "Standard Guide for the Selection of Purging and Sampling Devices for Groundwater Monitoring Wells."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D5903-96 (Reapproved 2001), "Standard Guide for Planning and Preparing for a Groundwater Sampling Event."

- Massachusetts Department of Environmental Protection, "Standard References For Monitoring Wells," January 1991, document WSC-310-91, Section 4.5 Well Development.


## A.3 COMMENTS ON REFERENCE PROCEDURES

The procedures and equipment listed in EFP No. 01a and used by Haley & Aldrich are generally as specified in the ASTM and US EPA Reference Procedures. Deviations of EFP No. 01a from the Reference Procedures are not provided. The procedure described in Section 5 has been developed to assist Haley & Aldrich personnel in performing well development, and in some cases simplifies the Reference Procedures.

**APPENDIX B**
**RELATED HALEY & ALDRICH PROCEDURES**

- OP2020 Groundwater Monitoring (Observation) Well Abandonment
- OP2031 Groundwater Monitoring (Observation) Well Installation
- OP3000 General Environmental Field Procedures and Protocols
- OP3007 Procedures for Surface Water Sampling
- OP3008 Manual Water Level Measurement Procedure
- OP3010 Groundwater Quality Sampling Procedure
- OP3012 Low Stress/Low Flow Groundwater Sample Collection Procedure
- OP3014 NAPL Monitoring and Sampling
- OP3015 Aquifer Parameter Testing Procedure

**APPENDIX C**
**FORMS**

- 3004 Sampling Report
- 3005 Groundwater Sampling Record
- 3006 Monitoring Well Development Report
- 3010 Low Flow Field Sampling Form

HALEY & ALDRICH

# SAMPLING RECORD

Page ____ of ____

PROJECT ______________________ H&A FILE NO. ______________
LOCATION ______________________ PROJECT MGR. ______________
CLIENT ______________________ FIELD REP ______________
CONTRACTOR ______________________ DATE ______________

Weather ______________________ Temperature ______________
Ground surface Conditions ☐ Dry ☐ Wet ☐ Damp ☐ Standing Water ☐ Snow (_____in) ☐ Other___________
Comments ______________________

**SOIL SAMPLING AND SURFACE WATER SAMPLING INFORMATION**

| Sample No. | Location | Depth (ft) | Time | Sample Description | Sampling Device | Cleaning Prodedure | Container Type |
|---|---|---|---|---|---|---|---|
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**General Comments:** (ie: field filtrations, persons communicated with at site, etc.)

Form 3004

HALEY & ALDRICH

# GROUNDWATER SAMPLING RECORD

Page     of

| | |
|---|---|
| PROJECT | H&A FILE NO. |
| LOCATION | PROJECT MGR. |
| CLIENT | FIELD REP |
| CONTRACTOR | DATE |

## GROUNDWATER SAMPLING INFORMATION

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Well No. | | | | | | | |
| Water Depth (ft) | | | | | | | |
| Time | | | | | | | |
| Product | | | | | | | |
| Depth Of Well (ft) | | | | | | | |
| Inside Diameter (in) | | | | | | | |
| Standing Water Depth (ft) (1) | | | | | | | |
| Volume Of Water In Well (gal) | | | | | | | |
| Purging Device | | | | | | | |
| Volume of Bailer/Pump Capacity | | | | | | | |
| Cleaning Procedure | | | | | | | |
| Bails Removed/ Volume Removed | | | | | | | |
| Time Purging Started | | | | | | | |
| Time Purging Stopped | | | | | | | |
| Sampling Device | | | | | | | |
| Cleaning Procedure | | | | | | | |
| TIME SAMPLES TAKEN: VOA | | | | | | | |
| ABN | | | | | | | |
| Metals | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| PARAMETERS: Color | | | | | | | |
| Odor | | | | | | | |
| pH | | | | | | | |
| Conductivity | | | | | | | |
| Turbidity | | | | | | | |
| Dissolved Oxygen | | | | | | | |
| Temp, $^0$ C | | | | | | | |
| Salinity | | | | | | | |

Remarks: (ie: field filtrations, persons communicated with at site, etc.)

1. Standing Water Depth = Depth of Well - Water Depth

Form 3005

| HALEY & ALDRICH | # MONITORING WELL DEVELOPMENT REPORT | Well No. |
|---|---|---|
| | | Page 1 of 1 |

| | | | |
|---|---|---|---|
| PROJECT | | H&A FILE NO. | |
| LOCATION | | PROJECT MGR. | |
| CLIENT | | FIELD REP. | |
| CONTRACTOR | | DATE | |
| ELEVATION SUBTRAHEND | | | |

**Estimated Volume of Water Lost During Drilling:** ______________ gallons

Comments: ______________

**Depth to Water Before Development:** ______________ feet

Comments: ______________

**Depth to Well Bottom Before Development:** ______________ feet

Comments: ______________

**Turubitiy of Water Before Development:** ______________ NTU

Comments: ______________

**Volume of Water Removed:** ______________ gallons

Comments: ______________

**Method of Removal (bailing, pumping):** ______________

Comments: ______________

**Depth to Well Bottom After Development:** ______________ feet

Comments: ______________

**Depth to Water After Development:** ______________ feet

Comments: ______________

**Turubitiy of Water After Development:** ______________ NTU

Comments: ______________

HALEY & ALDRICH

# LOW FLOW/MNA FIELD SAMPLING FORM

Page ____ of ____

| | | | |
|---|---|---|---|
| PROJECT | | H&A FILE NO. | |
| LOCATION | | PROJECT MGR. | |
| CLIENT | | FIELD REP | |
| CONTRACTOR | | DATE | |

**Sampling Data:**

Well ID: ____________ Well Depth: ____________ ft Initial Depth To Water: ____________ ft Purging Device: ____________

Start time: ____________ Depth To Top Of Screen: ____________ ft Depth Of Pump Intake: ____________ ft Tubing Present In Well: ☐ Yes ☐ No

Finish Time: ____________ Depth To Bottom Of Screen ____________ ft Tubing Type: ____________

| Elapsed Time (24 hour) | Depth To Water From Casing (ft) | Pump Setting (ml/min) or (gal/min) | Purge Rate (ml/min) or (gal/min) | Cumulative Purge Vol. (liters) or (gal) | Temp-erature ( °F ) or ( °C ) | pH | Conduct-ivity (us/cm) | Dissolved Oxygen (mg/L) | Turbidity (NTU) | ORP/eH (mv) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
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