Ms. Carolyn Bury
U.S. Environmental Protection Agency
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Remediation and Re-use Branch
Corrective Action Section 2 – LU9J
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ENVIRONMENT

Subject:

Former Koppers Wood-Treating Site – Carbondale, IL
Final Groundwater Monitoring Plan

Date:

November 25, 2015

Contact:

David Bessingpas

Phone:

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Email:

david.bessingpas@arcadis.com

Our ref:

B0039314.0000

Dear Ms. Bury:

On behalf of Beazer East, Inc. (Beazer), enclosed please find the final Groundwater Monitoring Plan (GMP) for the Former Koppers Wood-Treating Site in Carbondale, Illinois. Beazer is prepared to begin implementing the monitoring program outlined in the GMP following receipt of USEPA's approval.

Please contact Michael Slenska of Beazer (412 208 8867) or me if you have any questions or comments.

Sincerely,

Arcadis U.S., Inc.

David Bessingpas

David Bessingpas
Sr. Project Manager

Copies:
Jim Moore, IEPA
Michael Slenska, Beazer
Jeffrey Holden, Arcadis
Keith White, Arcadis
Angie Gatchie, FTS

Imagine the result

Beazer East, Inc.

Groundwater Monitoring Plan

Former Koppers Wood-Treating Site
Carbondale, Illinois

November 2015

ARCADIS

David Bessingpas
Project Manager

Keith A. White, P.G.
Principal Geologist

Groundwater Monitoring Plan

Former Koppers Wood-Treating Site, Carbondale, Illinois

Prepared for:
Beazer East, Inc.

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ARCADIS

Table of Contents

Appendices

1. Introduction

The purpose of this document is to identify the basis for, scope of, and procedures associated with implementing a post-remediation groundwater monitoring plan (GMP) for the Former Koppers Wood-Treating Site ("the Site") in Carbondale, Illinois. This GMP has been prepared by Arcadis on behalf of Beazer East, Inc. (Beazer), to address one requirement of the United States Environmental Protection Agency's (USEPA's) Final Decision and Response to Comments on the Selection of Remedies to Address Contamination at Beazer East, Inc., Carbondale, Illinois (hereafter referred to as the "Final Decision Document").

A draft GMP was initially submitted to USEPA on November 15, 2007. A revised draft GMP was submitted to USEPA on October 6, 2008, which included revisions made to address USEPA comments dated April 8, 2008 and reflect agreements made during meetings held on June 12 and July 16, 2008. Additional modifications to the draft GMP were discussed and agreed to during a conference call on November 24, 2014. USEPA provided additional comments on and conditional approval of the draft GMP in a letter to Beazer dated June 12, 2015. This revised/final GMP reflects revisions made to address USEPA's June 12, 2015 comments, and subsequent agreements reached during conference calls on June 30 and July 14, 2015.

2. Purpose

Implementation of this GMP is intended to provide the data necessary to demonstrate that the groundwater and source control remedies set forth in the Final Decision Document, issued by the USEPA,[1] continue to be effective. To this end, the GMP identifies anticipated sample locations, frequencies, parameters, procedures, and action levels. It also identifies contingency activities in the event groundwater action levels are exceeded at defined "points of compliance," which generally correspond to the Site perimeter.

The Final Decision Document requires that the groundwater conditions be monitored for a period of 30 years or longer after construction of the remedies. Due to the anticipated duration of the program, this plan is designed to be flexible so that it can be adapted to accommodate potential changes in Site conditions and groundwater quality over the course of the monitoring program.

Because a closed surface impoundment and Corrective Action Management Unit (CAMU) exist at the Site,[2] this plan has been designed to satisfy groundwater monitoring requirements associated with those facilities as set forth in 35 Illinois Administrative Code (IAC) 725 Subpart F and in 35 IAC 724 Subpart S, Section 652. Note, however, that groundwater surrounding these regulated units is known to be impacted by historical operations such that detections of Site-related constituents are not specifically indicative of releases from the units. This factor will be considered when evaluating data for the unit-specific monitoring wells, which is consistent with groundwater monitoring data collected prior to and during the remedial construction phase as part of the prior Interim Groundwater Monitoring Program (IGMP).

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[1] http://www3.epa.gov/region5/cleanup/rcra/koppers/pdfs/beazereast_final_decision_response_to_comments.pdf

[2] The CAMU is constructed on top of the closed surface impoundment.

3. Background

The Site is located at 1555 North Marion Street, Carbondale, Jackson County, Illinois. In approximately 1905, Ayer and Lord Tie Company began producing pressure-treated railroad crossties, utility poles, and other wood products at the Site. Wood treatment continued at the Site until July 1991. As indicated above, the plant was originally owned by Ayer and Lord Tie Company. In 1940, the site was acquired by Koppers Company, who retained ownership until 1988. On June 30, 1988 BNS Acquisitions, Inc. (an indirect, wholly-owned subsidiary of Beazer PLC) acquired all stock of Koppers Company. On December 28, 1988, Koppers Company (now Beazer) sold the assets of its Tar and Treated Wood Sector, including the Carbondale facility and the Koppers name, to a management buy-out group who became known as Koppers Industries, Inc. (KII). KII maintained ownership of the plant from December 28, 1988 until closure of the facility in July 1991. At that time, the property was again purchased by Beazer, who currently owns the property. As agreed between the parties at the time of the sale, Beazer has retained responsibility to satisfy the obligations under the Consent Orders with USEPA and Illinois Environmental Protection Agency (IEPA).

During the years of operation, Koppers used a variety of chemicals at one time or another, including creosote, pentachlorophenol, fluoro-chrome-arsenate phenol, and chromated zinc chloride. The latter two chemicals were only used for a brief period during the late 1960s to early 1970s.

The USEPA and the IEPA identified the following eleven areas of concern (AOCs) for the Site-wide monitoring program:

- Area 1 – wood treating cylinders
- Area 2 – former sprayfield
- Area 3 – drip track
- Area 4 – former north drainage ditch
- Area 5 – former wastepile area
- Area 6 – former lagoon area
- Area 7 – offsite spill area
- Area 8 – service yard
- Area 9 – storage tanks
- Area 10 – closed RCRA surface impoundments
- Area 11 – plant production area

Koppers Company discontinued use of the RCRA surface impoundment system (AOC 10) and sprayfield (AOC 2) in 1988, and excavated all sludge and visibly impacted soil from within the impoundments for disposal in a permitted landfill. Beazer subsequently closed the surface impoundment system as a landfill (pursuant to RCRA).

In 1991, the structures associated with treating wood were demolished, with the exception of the water treatment plant and a few support buildings. The remaining structures were demolished by 2004.

Between 2004 and 2010, Beazer conducted various remediation activities as part of the RCRA corrective action program identified in the Final Decision Document, including:

- Relocation of a portion of Glade Creek and installation of a trench-based Dense Non-Aqueous Phase Liquid (DNAPL) barrier near the former Glade Creek channel.
- Construction of a containment cell within a CAMU to consolidate/manage various materials generated during the remediation activities. The CAMU was constructed on top of the closed RCRA surface-impoundment system described above. Installation of a final cover system on the CAMU was completed in November 2010.
- Excavation of waste/debris piles, surficial coal tar/asphalt materials, and surficial soils from various areas of the Site.
- Installation of a surface cover over the Former Process Area and Former Lagoon Area.
- Installation of DNAPL recovery well RW-23.
- Excavation of visually impacted Glade Creek sediments downstream of the channel relocation.

These remediation activities are summarized in the Final Documentation Report (Arcadis, 2011). The completed remediation activities, and continued operation of the DNAPL recovery systems (trench-based DNAPL barrier and recovery well RW-23) are expected to help improve groundwater quality by reducing the amount of groundwater that comes in contact with DNAPL or reducing the mass of DNAPL in the subsurface.

3.1 Hydrostratigraphy

The geologic materials beneath the Site are divided into four hydrostratigraphic units: the A/B Unit[3], the C Unit, the D Unit, and the E Unit. The boundaries of the hydrostratigraphic units are defined by lithology and water-transmitting properties. The hydrostratigraphic units are generally described as follows:

- A/B Unit: Wisconsinan Age slackwater deposits consisting of reddish-brown colored fractured silty clay with frequent organics and occasional, discontinuous sand stringers. The observed thickness of this unit ranges from approximately 25 to 45 feet.

- C Unit: Gray or gray-and-pink colored, massive silty clay. This unit appears to be continuous beneath the Site and is at least 20 feet thick.

- D Unit: Fine-to-medium sand with varying amounts of silt and occasional silty-clay lenses. This unit ranges from 15 to 40 feet thick and is generally encountered between 60 and 90 feet below ground surface (bgs). Included in this unit at its base is a thin, discontinuous layer (up to several feet thick) of dense sand and gravel with significant amounts of clay, silt, and particles of coal.

- E Unit: Pennsylvanian age sedimentary rock consisting predominantly of light-to-dark gray colored shale with occasional thin layers of coal or limestone.

3.2 Groundwater Movement

Groundwater flow at the Site is well understood. Groundwater data have been collected several times a year for many years, and those data are examined and discussed every year in RCRA Annual Groundwater Monitoring Reports. Over the years, as new groundwater monitoring points have been added, the discussion of groundwater flow presented in those reports has been updated as necessary. The following bullets summarize groundwater flow in the various hydrostratigraphic units:

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[3] Early in the investigation stage of this site, the A Unit and the B Unit were identified as two distinct hydrostratigraphic units. Subsequent studies determined that the geologic materials and hydrogeologic properties of these units were the same, and therefore it was appropriate to combine the units into one (i.e., the A/B Unit) for characterization purposes.

- Groundwater in the A/B Unit is mounded at the Former Process Area. As a result, movement in this unit is directed downward and radially outward toward Glade Creek and Piles Fork, and to a much lesser extent to Smith Ditch. As groundwater approaches these surface-water bodies, it moves laterally and upward, discharging into them. During drier periods (typically the summer months), Smith Ditch ceases to flow. It is likely that an insignificant amount of A/B Unit groundwater leaks through the C Unit into the D Unit. The water table in the A/B Unit is typically on the order of approximately 3 to 7 feet bgs near the former process area of the Site and approximately 0 to 6 feet bgs near Glade Creek in the eastern part of the Site.

- Groundwater movement in the C Unit is predominantly vertical. Beneath most of the Site, the direction of movement is downward. Near Glade Creek, it appears that groundwater in the upper portion of the C Unit moves upward into the A/B Unit, while groundwater near the bottom of the C Unit moves downward into the D Unit.

- Groundwater flow patterns in the D and E Units are similar. Groundwater generally moves toward the east-northeast in the eastern portion of the Site, and toward the northwest in the western portion of the Site. Hydraulic heads between the two units are similar, suggesting a reasonable degree of hydraulic communication. The direction of vertical hydraulic gradients is variable and their magnitude is relatively slight.

3.3 DNAPL Occurrence

The source of dissolved-phase constituents in groundwater at the Site is principally creosote DNAPL. Nearly all of the subsurface materials that contain DNAPL reside in the A/B Unit, and are concentrated in three main areas: the Former Process Area, the Former RCRA Surface Impoundments, and the Former Lagoon Area/Offsite Spill Area (Figure 1). DNAPL is present in all of these areas, and is being removed from the Former Process Area at recovery well RW-23 and from the Former Lagoon Area/Offsite Spill Area by a trench-based DNAPL barrier. In addition to RW-23 and the trench-based DNAPL barrier, DNAPL has also been observed in a few A/B-Unit monitoring wells and piezometers at the Site. DNAPL is present at monitoring well OB23-04B, located in the Former Process Area near recovery well RW-23. A small amount of DNAPL has also accumulated in monitoring well OW-205B and piezometer P-8A in the Glade Creek Channel Relocation Area. Historically, DNAPL has periodically accumulated in monitoring well R-8A, located near the Former RCRA Surface Impoundments. When DNAPL has been observed in OW-205B, P-8A and R-8A it has been removed once it reaches a sufficient thickness (typically 1 to 2 feet) and properly disposed. DNAPL at OB23-04B is captured by recovery well RW-23.

DNAPL is also present in the E Unit at monitoring well R-13E, located north of the Former RCRA Surface Impoundments. This issue has previously been examined[4] and additional E-Unit wells were installed around R-13E. None of those additional wells, or other D- or E-Unit wells in the general vicinity, have indicated the presence of DNAPL. Analytical results for groundwater samples collected from other D- and E-Unit wells in this area do not suggest that there is DNAPL near their screens. Also, there is no evidence that there is appreciable DNAPL in the overlying D Unit. Based on this information, we surmise that the source of the DNAPL to R-13E was likely one or more isolated, unsealed boreholes drilled – either historically or early in the RCRA investigation process – through DNAPL-containing regions to the top of the E Unit in the Former Process Area and/or the Former RCRA Surface Impoundments.

Since implementation of DNAPL-removal activities, DNAPL accumulation has ceased at R-8A (no DNAPL observed since August 2013) and P-8A (no DNAPL observed since February 2013), and the DNAPL accumulation rate has slowed significantly at OW-205B and R-13E. Only minimal volumes of DNAPL have been recovered from these locations since 2012, as summarized in the table below:

Location	Volume of DNAPL Recovered Since 2012 (gallons)
OW-205B	0.5
P-8A	0.2
R-8A	0.2
R-13E	0.1

It should also be noted that DNAPL recovery rates in the trench-based DNAPL barrier and recovery well RW-23 have declined significantly. In 2005, a total of 3,589 gallons of DNAPL were recovered from the trench-based DNAPL barrier, compared to 1,255 gallons in 2014. In 2006, a total of 1,604 gallons of DNAPL were recovered from RW-23, compared to 365 gallons in 2014.

Given the presence of DNAPL at the Site, this GMP includes provisions for monitoring for DNAPL, and if need be addressing locations where DNAPL may accumulate but may not be captured by recovery well RW-23 or the trench-based DNAPL barrier.

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[4] March 10, 2000 letter report to USEPA, regarding investigation of the presence of DNAPL at monitoring well R-13E (BBL, 2000).

3.4 Groundwater Quality

The quality of groundwater beneath the Site is well understood, being supported by a robust monitoring-well network. Since 1981, over 177 monitoring wells have been installed at the Site. An IGMP was implemented in 1994 to provide groundwater quality data subsequent to the Remedial Investigation and prior to implementing the remedy. The program has been modified over time and currently consists of fluid level monitoring at 69 monitoring wells, 15 piezometers, 2 trench-based DNAPL barrier sumps, and 5 surface water gauges, and groundwater sampling at 48 monitoring wells. Monitoring wells are sampled semi-annually. Laboratory analyses performed on the collected samples include:

- Benzene, toluene, ethylbenzene and total xylenes (BTEX)
- Polycyclic aromatic hydrocarbons (PAHs)
- Pentachlorophenol
- Total recoverable phenolics (TRP)
- Arsenic, chromium, and copper (total and dissolved)

The extent of groundwater that exceeds applicable criteria[5] is adequately defined at the Site, does not extend to the Site property lines, and has generally not changed in recent years, suggesting that the extent of affected groundwater is generally stable and may be shrinking. A possible exception is the area near the portion of Glade Creek that was relocated, specifically near the OW-205 well cluster. As expected, relocating Glade Creek has altered groundwater flow conditions in the A/B unit in this area due to the alteration of this groundwater discharge feature. Groundwater that previously discharged to the old channel now must move up to 500 feet east-northeastward to reach the new channel. A series of monitoring wells that was installed in this area provides data to help understand the changes in groundwater flow and quality. Data from the two most-recent samplings[6] of OW-205A show several constituents of concern (COCs) in excess of their Tiered Approach to Corrective Action Objectives (TACO) Tier I standards for Class II groundwater. This well is located near the confluence of the old and new creek channels (Figure 1). Also, a thin zone of DNAPL-containing material was noted at the base of the A/B unit during drilling of OW-205B and is included in the interval screened by the well (as indicated above, a small amount of DNAPL has accumulated in OW-205B). This area was investigated further in 2008, including drilling additional delineation soil borings and installing additional

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[5] 35 IAC 742, Table E: Tier 1 Groundwater Remediation Objectives for the Groundwater Ingestion Route. In correspondence dated September 7, 2006, the IEPA designated groundwater in the A/B and C Units as Class II, and groundwater in the D and E Units as Class I.

[6] August 2014 and February 2015.

monitoring wells (OW-206A, OW-207A). No DNAPL was observed in any of the surrounding borings (Arcadis, 2009). Wells OW-206A and OW-207A have been incorporated into the IGMP (no TACO Class II groundwater standard exceedances to date), and are part of the monitoring program scope described in Section 4.

Near DNAPL-containing subsurface materials, groundwater commonly contains several PAHs, benzene, and/or pentachlorophenol at concentrations in excess of applicable groundwater criteria; but away from these areas concentrations are below the criteria. As indicated above, nearly all of the DNAPL-containing materials reside in the A/B Unit, and are concentrated in the Former Process Area, the Former RCRA Surface Impoundments, and the Former Lagoon Area/Offsite Spill Area. The quality of groundwater in DNAPL-containing regions is not expected to change appreciably until much of the leachable fraction of the DNAPL is dissolved, which could take many years (Malcolm Pirnie, 2004). The timeframe for cleanup, however, has been accelerated by the implementation of remedial measures that remove DNAPL from the subsurface. This includes DNAPL recovery efforts at various monitoring wells/piezometers, RW-23, and the trench-based DNAPL barrier.

Arsenic, chromium, and copper were among the IGMP original analytes because some of the wood-preserving chemicals that were used at one time at the facility contained these metals. The many years of monitoring data, however, demonstrate that, with the exception of arsenic at one location (OW-26A), these metals are not a concern at the Site. No groundwater plumes containing these metals at concentrations above applicable criteria have been identified. The concentration of arsenic at OW-26A is elevated relative to other monitoring wells and has occasionally exceeded its TACO Class II groundwater standard of 200 µg/L.

As indicated above, TRP has historically been analyzed under the IGMP. However, there is no applicable regulatory criteria for TRP; thus TRP is not useful for decision-making purposes. Because of this, and the fact that TRP has historically been detected infrequently, Beazer proposes to discontinue analysis of TRP as part of the GMP (Section 4). Analysis of pentachlorophenol, the primary phenolic compound of concern at the Site, will be continued.

Based on the above discussion, the COCs at the Site are BTEX, PAHs, pentachlorophenol, and, near monitoring well OW-26A, arsenic.

At the request of USEPA, groundwater samples from selected monitoring wells were analyzed for dioxins/furans in August 2008 and February 2009. Dioxin/furan levels in all samples were well below USEPA's Maximum Contaminant Level (MCL).[7] As requested by USEPA, and as further discussed below, periodic additional sampling for dioxins/furans is planned as part of the GMP.

7 The MCL value is not applicable, as the wells sampled are not potential drinking water sources. Comparison to the MCL was made only to demonstrate that the detected concentrations were low, and because Illinois regulations do not have groundwater standards for dioxins/furans.

4. Groundwater Monitoring Plan

As stated in Section 2, the purpose of the monitoring program is to provide the data necessary to demonstrate the continued effectiveness of the groundwater and source control remedies. Given that the selected remedy for groundwater is containment, the remedy is considered effective so long as no groundwater containing COCs above the limits specified in 35 IAC 742 migrates beyond points of compliance.

The remainder of this section identifies the points of compliance for the Site; identifies monitoring objectives, locations, parameters and frequencies; presents a contingency monitoring plan; and discusses quality assurance/quality control and data-quality objectives.

4.1 Points of Compliance

This section defines points of compliance for each of the hydrostratigraphic units targeted for monitoring. These units are the A/B Unit, the D Unit, and the E Unit. Note that the massive confining layer that underlies the Site, the C Unit, is not targeted for monitoring. This is because groundwater movement through the unit is predominantly vertical and occurs very slowly. Such conditions are not conducive to effective monitoring with monitoring wells. A more appropriate monitoring strategy, as employed herein, is to monitor the quality and movement of groundwater above and below the confining unit, where lateral movement generally predominates.

In general, the point of compliance for all of the units will be the facility property boundary. An exception is for a portion of the A/B Unit. Because the majority of the groundwater in this unit discharges to Glade Creek, and the creek passes through the eastern end of the property, the point of compliance in that area will be wells adjacent to Glade Creek, as depicted on Figure 1.

4.2 Monitoring Objectives, Locations, Parameters, and Frequencies

The overall purpose of the monitoring program, as presented in Section 2, is to provide the data necessary to demonstrate that the remedy set forth in the Final Decision Document continues to be effective at the Site. This section presents the monitoring objectives developed for each unit, and the monitoring required to meet those objectives.

4.2.1 A/B Unit

Because the underlying C Unit is an effective capillary barrier to creosote, the vast majority of source material (i.e., creosote), and therefore affected groundwater, exists in the A/B Unit. Also, this unit represents the uppermost water-bearing unit beneath the Site. Groundwater in this unit is classified as Class II by the IEPA. The objectives of monitoring in this unit are to:

- Monitor water levels to identify potential changes in historical groundwater flow patterns. Changes in groundwater flow patterns may warrant changes to the groundwater quality monitoring program.

- Monitor groundwater quality downgradient of DNAPL zones, at or beyond the plume fringe. Data collection for the program will be concentrated at these areas to demonstrate compliance. Special attention is given to the area near the relocated portion of Glade Creek, where changes to groundwater flow patterns occurred as part of the remedial activities conducted in that area of the Site.

- Monitor arsenic concentrations downgradient of well OW-26A to confirm that groundwater containing arsenic above the Class II standard does not leave the Site.

- Monitor the quality of water in Glade Creek upstream and downstream of the Site.

- Monitor selected locations inside dissolved-phase plumes to periodically assess improvement in groundwater quality.

- Monitor all wells in the program for accumulated DNAPL to assess changes in DNAPL presence and extent that could be indicative of adverse DNAPL migration. All wells and piezometers will be monitored for DNAPL annually. Monitoring points where DNAPL accumulates will be monitored for DNAPL semiannually. Accumulated DNAPL will be removed from wells/ piezometers when it reaches a sufficient thickness (i.e., 1 to 2 feet). By removing DNAPL that accumulates in any monitoring points, the program will also serve to reduce DNAPL saturations and potential mobility in the A/B-Unit.

- Satisfy the groundwater monitoring requirements associated with the Former RCRA Surface Impoundments and CAMU as set forth in and 35 IAC 725 Subpart F and in 35 IAC 724 Subpart S, Section 652.

The locations comprising the monitoring network for the A/B Unit consist of 63 monitoring wells and piezometers (49 existing and 14 new[8]) and eight surface-water gauges (five existing, three new). These locations are listed, along with their intended purposes and monitoring scope/frequencies, in Table 1, and are shown on Figure 1. In general, perimeter (i.e., point of compliance) monitoring wells will be sampled annually, and interior wells will be sampled biennially (i.e., once every other year). However, existing monitoring wells OW-205A, OW-206A, and OW-207A, and all new A/B monitoring wells[9] will be sampled semiannually (twice a year) for a period of two years, after which they will be sampled annually or as otherwise proposed to and approved by the USEPA. Collected samples from all wells will be analyzed for BTEX, PAHs, and pentachlorophenol. To monitor arsenic concentrations downgradient of well OW-26A, samples collected from well OW-202B, which is hydraulically downgradient of OW-26A, will also be analyzed for arsenic.

The following monitoring wells will be sampled for dioxins/furans during the first two consecutive semiannual sampling events conducted under this GMP: existing wells OW-22BR, OW-35B, and OW-102B, and new wells OW-209A, OW-209B, OW-210A, OW-210B, OW-211A, and OW-211B. Based on the results of these two rounds of sampling, the need for and scope of any additional sampling for dioxins/furans will be discussed with USEPA. It is anticipated that a limited number of wells may continue to be sampled for dioxins/furans every five years.

The monitoring locations listed in Table 1 include one monitoring well located upgradient of the CAMU/Former RCRA Surface Impoundments (OW-31A) and five located downgradient of the former impoundments (OW-27A, OW-42B, OW-212A, OW-212B, and R-13A). This addresses the requirements of 35 IAC 725 Subpart F.

Because the nature of groundwater impacts resulting from source areas are well understood at this Site, the additional analyses and sampling frequencies described in 35 IAC 725.192 (e.g., sulfate) are not applicable. Similarly, because the primary objective of this program is to demonstrate the continued effectiveness of the containment remedy (i.e., demonstrate that groundwater containing COCs at concentrations above applicable criteria does not extend beyond a point of compliance), calculation of average background concentrations and using such values as the basis for determining whether a release has occurred is not applicable for this application.

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[8] "New" refers to wells and piezometers that are planned for installation as part of GMP implementation.

[9] OW-207B, OW-208A/B, OW-209A/B, OW-210A/B, OW-211A/B, and OW212A/B.

4.2.2 C Unit

The C Unit is a massive confining unit with primarily vertical flow that is not conducive to monitoring hydraulic heads (groundwater elevations) and water quality using monitoring wells. As such, the GMP does not include monitoring of C-Unit wells. Rather, hydraulic heads and water quality will be monitored above and below the C Unit and Beazer will decommission the seven existing C-unit wells at the Site (OW-17C, OW-23C, OW-27C, OW-35C, OW-36C, R-13C and R-14C). Another important reason for decommissioning these wells is to help ensure the integrity of the confining unit. Penetrations into and through the unit should be minimized, particularly in regions where the overlying A/B Unit contains DNAPL.

Decommissioning will be performed in accordance with Arcadis' SOP previously submitted to the USEPA on May 14, 2004 entitled *Monitoring Well Decommissioning Standard Operating Procedure* (Appendix A). Following the decommissioning, Illinois Water Well Sealing Forms will be completed and submitted to the Jackson County Health Department.

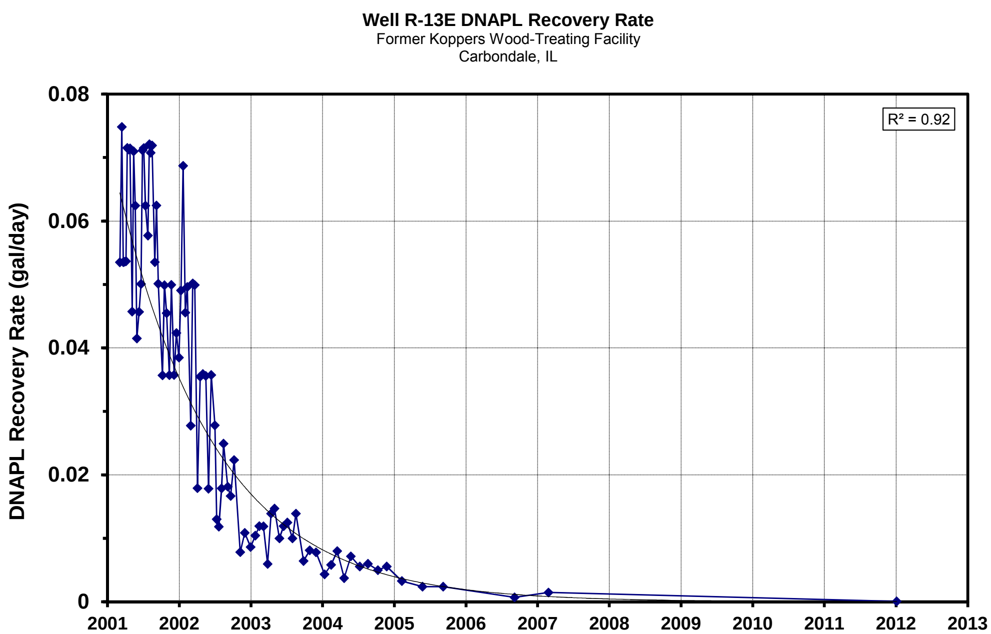
4.2.3 D Unit

As noted in Section 3.2, the D-Unit groundwater, which is classified as Class I by the IEPA, is generally unaffected by the Site. No DNAPL has been identified in the Unit. Historically, low levels of potentially Site-related compounds such as PAHs have been sporadically detected in samples collected from several D-Unit wells; however, rarely at concentrations exceeding applicable criteria. In addition, other potential, albeit relatively minor, sources of PAHs (e.g., coal) occur naturally in the area.

The strategy for monitoring groundwater quality in this unit is to select sentinel well locations beneath or downgradient of areas in the overlying A/B Unit that contain DNAPL. These wells would be used to detect potential future impacts should affected groundwater (or DNAPL) migrate through the C Unit (confining unit) and into the D Unit. As shown in Table 1, the following wells will comprise the D-Unit water-quality monitoring network: OW-23D, OW-40D, and R-13D. Groundwater samples from these wells will be sampled biennially and analyzed for BTEX, PAHs, and pentachlorophenol. In addition, 18 D-Unit wells will be monitored annually for water levels, total depth and DNAPL accumulations.

4.2.4 E Unit

Like the D-unit that directly overlies it, groundwater in the E Unit, which is classified as Class I by the IEPA, is generally unaffected by the Site. No DNAPL has been identified in the Unit, except at monitoring well R-13E. As previously discussed in Section 3.3, additional investigation activities concluded that the impacts at R-13E were localized and likely attributed to one or more improperly sealed boreholes that allowed DNAPL to migrate directly downward to the E Unit. Data from the DNAPL-removal program implemented at R-13E, as depicted in the figure below, show that the source of DNAPL to this well appears to be nearly exhausted (Note that DNAPL is removed from R-13E when it reaches approximately 1 foot in thickness; since 2006, DNAPL has been removed from R-13E on only three occasions, recovering a total of approximately 0.6 gallons).



DNAPL-recovery data from well R-13E showing an exponential decline in recovery rate and good correlation with a "best-fit" exponential decay curve.

Groundwater in the D and E Units is not separated by a confining layer; therefore, D Unit wells serve as sentinel wells to the underlying E unit. For this reason, the objective for monitoring groundwater quality in the E Unit is to monitor downgradient of well R-13E to demonstrate that affected groundwater from that area does not leave the Site (i.e., extend beyond a point of compliance). To meet this objective, the following three wells will comprise the E-Unit monitoring program (as shown on Table 1): OW-200E, OW-201E, and R-14E. These wells will be sampled annually and the collected samples analyzed for BTEX, PAHs, and pentachlorophenol. In addition, 12 E-Unit wells will be monitored annually for water levels, total depth and DNAPL accumulations (R-13E will be monitored semiannually for DNAPL).

4.3 Criteria Comparisons

Analytical results will be compared to various criteria, as follows:

- Results for all A- and B-Unit monitoring wells will be compared to TACO Tier I standards for Class II groundwater.
- To assess the quality of groundwater discharging to Glade Creek, the results for all surface water samples and the following A- and B-Unit wells located adjacent to Glade Creek in the eastern portion of the Site (Figure 1) will be compared to Illinois Water Quality Criteria (IWQC): OW-206A, OW-207A, OW-207B, OW-208A, and OW-208B[10].
- To assess the potential for indoor air impacts associated with shallow groundwater migrating to the residential area south of the Site, analytical results from the following A/B-Unit wells located along the southern property boundary will be compared to TACO indoor air screening values: OW-102B, OW-209A, OW-209B, OW-210A, OW-210B, OW-211A, and OW-211B.
- Dioxin/furan results, evaluated as 2,3,7,8 tetrachlorinated dibenzo-p-dioxin (TCDD) toxic equivalents (TEQ), will be compared to the MCL for 2,3,7,8-TCDD.
- Analytical results for all D- and E-Unit monitoring wells will be compared to TACO Tier I standards for Class I groundwater.

Numeric values for the various criteria outlined above are summarized in Table 2 for the COCs that will be analyzed for as part of this GMP.

[10] Note that groundwater data from these wells are not necessarily representative of the quality of groundwater discharging to the creek, as additional attenuation is expected to occur as groundwater moves from the wells to the creek. This is particularly the case for groundwater in B-Unit wells, which must travel a greater distance over a longer time interval (up through the A-Unit) prior to discharging to the creek. Accordingly, if groundwater samples collected from these wells exceed the IWQC, it does not necessarily mean that concentrations at the groundwater-surface water interface exceed the IWQC or that there is an unacceptable risk to surface water receptors. In the event that groundwater data for one or more of these wells routinely exceeds the IWQC, Beazer will coordinate with USEPA to discuss appropriate contingency actions.

4.4 Monitoring Schedule

As discussed above and indicated in Table 1, monitoring frequencies vary by location, but will either be semiannual (for existing wells OW-205A, OW-206A, and OW-207A, and all new wells[11]), annual, or biennial (once every other year). Consistent with the current IGMP schedule, semiannual monitoring events will be conducted in February and August. Annual and biennial events will be conducted in August.

4.5 Monitoring Procedures

All accessible monitoring wells and piezometers will be monitored for depths to water, well bottom, and presence of DNAPL annually. Monitoring points where DNAPL accumulates will be monitored for DNAPL semiannually. These measurements will be collected as described in the *Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures* (Appendix B), which was approved by the USEPA in correspondence dated September 4, 2007.

Groundwater samples will be collected in accordance with the SOP contained in Appendix B. Wells found to contain DNAPL will not be sampled.

Surface water will be sampled according to the procedure contained in Appendix C, during the groundwater sampling events.

During each sampling event, the field crew will note any defects, damage, or required maintenance activities associated with the monitoring network. Necessary repairs will be made by the completion of the next scheduled monitoring event.

All water generated during the groundwater sampling event will be contained and transferred to the existing on-site water treatment system, or otherwise appropriately disposed of.

If it is determined that additional monitoring wells are required in the future, they will be installed and developed according to the SOPs contained in Appendix D and E, respectively.

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[11] As indicated previously, these wells will be sampled semiannually for two years (total of four events), after which they will be sampled annually or as otherwise proposed to and approved by the USEPA.

4.6 Quality Assurance/Quality Control (QA/QC)

General QA/QC requirements for the GMP are described in the February 2008 *Quality Assurance Project Plan* (Arcadis, 2008). The following QA/QC samples are anticipated to be collected and analyzed during each GMP sampling event:

Parameter	Equipment Rinse Blank	Blind Duplicate	MS/MSD
PAHs/Pentachlorophenol	1 per day	1 per 10 samples	1 per 20 samples
BTEX	1 per day	1 per 10 samples	1 per 20 samples
Arsenic	1 per day	1 per 10 samples	1 per 20 samples
Dioxins/Furans	1 per day	1 per 10 samples	1 per 20 samples

Other information related to QA/QC sample types/numbers; target reporting limits; analytical QC limits; and sample containers, preservation, and holding times associated with the GMP sampling activities are summarized in Tables 1 through 4, respectively, of the February 2008 QAPP.

4.7 Data Quality Objectives (DQOs)

DQOs for the GMP are as follows:

- **Step 1 – State the Problem:** The problem at this Site is that wood-preserving chemicals, chiefly creosote, were released to the environment in the course of historical Site operations. Long-term groundwater quality monitoring is required to demonstrate that the containment-based groundwater remedy applied to the Site remains effective.

- **Step 2 – Identify the Goal of the Study:** This GMP establishes points of compliance for the Site and details the monitoring activities that will be performed to monitor the remedy's effectiveness. The goal of the study is to gather the water-level, DNAPL-level, and groundwater-quality data necessary to demonstrate that the remedy applied to the Site remains effective. The remedy remains effective as long as groundwater at points of compliance, as defined in this GMP, meets applicable quality standards.

- **Step 3 – Identify Information Inputs:** The scope of work presented in this GMP will provide the information inputs needed to accomplish the goals identified in DQO Step 2.

- **Step 4 – Define the Boundaries of the Study:** The property boundaries of the Site will be used as the lateral boundaries of the study. The current property boundary is shown on Figure 1. Vertically, the boundaries of the study will extend from the water table through the upper bedrock zone identified as the E Unit; however the focus of data collection will occur in the shallowest water-bearing unit, identified as the A/B Unit.

- **Step 5 – Develop the Analytic Approach:** The analytical methods that will be used for surface and groundwater samples are as follows[12]: PAHs and pentachlorophenol by USEPA SW-846 Method 8270D LL, BTEX by USEPA SW-846 Method 8260B, dioxins/furans by USEPA SW-846 Method 8290, and arsenic by USEPA SW-846 Method 6010B. Fluid-level data will be collected from monitoring wells and stream staff gages using electronic water-level tapes and oil-water interface probes.

- **Step 6 – Specify Performance or Acceptance Criteria:** By following field sampling SOPs and using the specified analytical methods, sampling errors and measurement errors, respectively, will be minimized and, as a result, the potential for making decision errors will also be minimized. Review of a Level 2 laboratory data package will also serve to assess any laboratory errors and the validity/usability of the sample data, and will be performed prior to making any decisions based on the sample data.

- **Step 7 – Develop the Detailed Plan for Obtaining Data:** The attached SOPs (Appendices B through E) and this GMP serve as a detailed plan for obtaining the data necessary to achieve the goal stated in DQO Step 2.

4.8 Contingency Actions

The need for contingency actions based on the monitoring program described in Section 4.2 could be identified in several ways, and the actions required will vary accordingly. The following outlines observations that could trigger the need for contingency actions and the actions that would potentially be performed:

- *Changes in groundwater flow patterns*. Groundwater elevation data from each monitoring event will be examined by producing potentiometric surface maps for all three monitored units. If two consecutive maps from any unit depict a clear change in groundwater flow patterns, the monitoring program will be reassessed and, if necessary, modified such that the monitoring objectives continue to be met. Groundwater flow patterns, and any significant changes, will be discussed in the Annual Groundwater Monitoring Report. Proposed changes to the program resulting from groundwater flow pattern changes will be submitted to the USEPA for approval prior to implementation.

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[12] Or other more recent USEPA-approved methods.

- *Accumulation of DNAPL at a location where it was not present before*. In this event, the DNAPL will be removed, the volume recorded, and a DNAPL monitoring/removal program will be instituted. A plan that outlines the scope of the program will be submitted to the USEPA.

- *Concentrations of one or more COCs exceed applicable criteria at a point of compliance for two consecutive sampling events*. In this event, the USEPA will be notified and a contingency plan prepared and implemented. Potential actions could include resampling the location(s) in question, installing and monitoring a new monitoring well further downgradient (in the event that the subject location is not situated at the facility property line), or instituting additional corrective actions.

4.9 Reporting

Each year an annual report will be submitted to the USEPA and IEPA[13]. The report will:

- Present the collected data, including groundwater sampling data, field parameters, analytical results, groundwater elevations, and DNAPL thickness and recovery measurements.

- Evaluate groundwater movement. Potentiometric surface maps for each monitored unit (A/B, D, and E) will be prepared and compared with historical maps.

- Evaluate groundwater and surface-water quality data (including QA/QC data) in relation to the continued effectiveness of the groundwater remedy.

- Evaluate whether DQOs are being adequately met.

- Propose modifications to the GMP, if necessary.

- Document any maintenance activities performed.

Consistent with the current reporting schedule, the annual report will be submitted to the agencies by March 1 of the following year.

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[13] Every other year, the report will contain the results from those wells that are sampled biennially.

5. References

Arcadis U.S., Inc. (Arcadis). 2008. *Quality Assurance Project Plan*. February 2008.

Arcadis. 2009. *DNAPL Extent and Groundwater Quality near OW-205A/B*. Letter report to USEPA. April 22, 2009.

Arcadis. 2011. *Final Documentation Report*. August 2011.

Blasland, Bouck & Lee, Inc. (BBL). 2000. Letter report to USEPA, regarding investigation of the presence of DNAPL at monitoring well R-13E. March 10, 2000.

Malcolm Pirnie, 2004. Technical Impracticability assessments: Guidelines for site applicability and implementation – Phase II report. Prepared for the U.S.AEC, March, 2004.

USEPA, 2004. Final Decision and Response to Comments on the Selection of Remedies to Address Contamination at Beazer East, Inc., Carbondale, Illinois. http://epa.gov/region5/sites/koppers/pdfs/beazereast-final-decision-response-tocomments.pdf.

USEPA, 2015. Letter to Beazer re: Conditional Approval Proposed Site-Wide Groundwater Monitoring Plan, dated October 2008; Updated November 2014. June 12, 2015.

ARCADIS

Tables

Table 1 - Summary of Groundwater Monitoring Plan (GMP) Scope of Work
Former Koppers Wood-Treating Site
Carbondale, Illinois

Monitoring Location	Existing/ New?	Monitored for Water Elevation (See Note 1)	Sampled for Water Quality (Frequency)	Analytical Parameters (See Note 3)			Criteria Comparison (See Note 4)				Comments
				A	B	C	i	ii	iii	iv	
Surface Water Gauges											
GC-1	Existing	X	N/A - no sampling								
GC-2	Existing	X	N/A - no sampling								
GC-3	New	X	X (Annual)	X					X		Background sampling location for Glade Creek
GC-4	New	X	X (Annual)	X					X		Sampling location near confluence of former and existing Glade Creek channels; assess groundwater discharge to surface water
GC-5	New	X	X (Annual)	X					X		Sampling location as Glade Creek leaves Site property boundary
Pond-1	Existing	X	N/A - no sampling								
Pond-2	Existing	X	N/A - no sampling								
Smith-1	Existing	X	N/A - no sampling								
A/B-Unit Wells/Piezometers											
P-2	Existing	X	N/A - no sampling								
P-3	Existing	X	N/A - no sampling								
P-4A	Existing	X	N/A - no sampling								
P-5B	Existing	X	N/A - no sampling								
P-6A	Existing	X	N/A - no sampling								
P-6B	Existing	X	N/A - no sampling								
P-7A	Existing	X	N/A - no sampling								
P-7B	Existing	X	N/A - no sampling								
P-8A	Existing	X	N/A - no sampling								
P-9A	New	X	N/A - no sampling								
P-10A	New	X	N/A - no sampling								
P-11A	New	X	N/A - no sampling								
OB23-04B	Existing	X	N/A - no sampling								
OW-3A	Existing	X	X (Biennial)	X				X			Interior well; monitors affected region near Former Lagoon/Off-Site Spill Area for improvement of groundwater quality through time
OW-10B	Existing	X	N/A - no sampling								
OW-17A	Existing	X	N/A - no sampling								
OW-22BR	Existing	X	X (Annual)	X		X		X			Point-of-compliance well
OW-26A	Existing	X	N/A - no sampling								
OW-27A	Existing	X	X (Annual)	X				X			Point-of-compliance well; downgradient monitoring location for CAMU/Former RCRA Surface Impoundments
OW-31A	Existing	X	X (Annual)	X				X			Upgradient monitoring location for CAMU/Former RCRA Surface Impoundments
OW-35B	Existing	X	X (Annual)	X		X		X		X	Point-of-compliance well
OW-36B	Existing	X	X (Annual)	X				X			Point-of-compliance well
OW-37B	Existing	X	N/A - no sampling								
OW-39BR2	Existing	X	X (Annual)	X				X			Monitoring location between barrier trench and new stream channel
OW-40B	Existing	X	X (Annual)	X				X			Monitoring location between barrier trench and new stream channel
OW-41A	Existing	X	N/A - no sampling								
OW-41B	Existing	X	N/A - no sampling								
OW-42B	Existing	X	X (Annual)	X				X			Point-of-compliance well; downgradient monitoring location for CAMU/Former RCRA Surface Impoundments

Table 1 - Summary of Groundwater Monitoring Plan (GMP) Scope of Work

Former Koppers Wood-Treating Site

Carbondale, Illinois

Monitoring Location	Existing/ New?	Monitored for Water Elevation (See Note 1)	Sampled for Water Quality (Frequency)	Analytical Parameters (See Note 3)			Criteria Comparison (See Note 4)				Comments
				A	B	C	i	ii	iii	iv	
A/B-Unit Wells/Piezometers (Cont.)											
OW-43B	Existing	X	N/A - no sampling								
OW-44A	Existing	X	N/A - no sampling								
OW-44B	Existing	X	N/A - no sampling								
OW-102B	Existing	X	X (Annual)	X		X		X		X	Point-of-compliance well
OW-202A	Existing	X	N/A - no sampling								
OW-202B	Existing	X	X (Annual)	X	X			X			Point-of-compliance well
OW-203A	Existing	X	N/A - no sampling								
OW-204A	Existing	X	N/A - no sampling								
OW-204B	Existing	X	X (Annual)	X				X			Monitoring location between barrier trench and new stream channel
OW-205A	Existing	X	X (Semiannual; See Note 2)	X				X			Monitors affected region near Glade Creek Channel Relocation Area for improvement of groundwater quality through time
OW-205B	Existing	X	N/A - no sampling								
OW-206A	Existing	X	X (Semiannual; See Note 2)	X				X	X		Point-of-compliance well
OW-207A	Existing	X	X (Semiannual; See Note 2)	X				X	X		Point-of-compliance well
OW-207B	New	X	X (Semiannual; See Note 2)	X				X	X		Point-of-compliance well
OW-208A	New	X	X (Semiannual; See Note 2)	X				X	X		Point-of-compliance well
OW-208B	New	X	X (Semiannual; See Note 2)	X				X	X		Point-of-compliance well
OW-209A	New	X	X (Semiannual; See Note 2)	X		X		X		X	Point-of-compliance well
OW-209B	New	X	X (Semiannual; See Note 2)	X		X		X		X	Point-of-compliance well
OW-210A	New	X	X (Semiannual; See Note 2)	X		X		X		X	Point-of-compliance well
OW-210B	New	X	X (Semiannual; See Note 2)	X		X		X		X	Point-of-compliance well
OW-211A	New	X	X (Semiannual; See Note 2)	X		X		X		X	Point-of-compliance well
OW-211B	New	X	X (Semiannual; See Note 2)	X		X		X		X	Point-of-compliance well
OW-212A	New	X	X (Semiannual; See Note 2)	X				X			Point-of-compliance well; downgradient monitoring location for CAMU/Former RCRA Surface Impoundments
OW-212B	New	X	X (Semiannual; See Note 2)	X				X			Point-of-compliance well; downgradient monitoring location for CAMU/Former RCRA Surface Impoundments
R-08A	Existing	X	X (Biennial)	X				X			Interior well; monitors affected region near CAMU/Former RCRA Surface Impoundments for improvement of groundwater quality through time
R-13A	Existing	X	X (Annual)	X				X			Point-of-compliance well; downgradient monitoring location for CAMU/Former RCRA Surface Impoundments

Table 1 - Summary of Groundwater Monitoring Plan (GMP) Scope of Work
Former Koppers Wood-Treating Site
Carbondale, Illinois

Monitoring Location	Existing/ New?	Monitored for Water Elevation (See Note 1)	Sampled for Water Quality (Frequency)	Analytical Parameters (See Note 3)			Criteria Comparison (See Note 4)				Comments
				A	B	C	i	ii	iii	iv	
A/B-Unit Wells/Piezometers (Cont.)											
S-03B	Existing	X	X (Biennial)	X				X			Interior well; monitors affected region near CAMU/Former RCRA Surface Impoundments for improvement of groundwater quality through time
TP-5A	Existing	X	N/A - no sampling								
TP-11A	Existing	X	N/A - no sampling								
TP-12A	Existing	X	N/A - no sampling								
TP-13A	Existing	X	N/A - no sampling								
TP-14A	Existing	X	N/A - no sampling								
TP-15A	Existing	X	N/A - no sampling								
Trench Sump-N	Existing	X	N/A - no sampling								
Trench Sump-S	Existing	X	N/A - no sampling								
C-Unit Wells											
OW-17C	Existing	N/A - all C-Unit wells to be abandoned									
OW-23C	Existing										
OW-27C	Existing										
OW-35C	Existing										
OW-36C	Existing										
R-13C	Existing										
R-14C	Existing										
D-Unit Wells											
A-08D	Existing	X	N/A - no sampling								
OW-10D	Existing	X	N/A - no sampling								
OW-12D	Existing	X	N/A - no sampling								
OW-17D	Existing	X	N/A - no sampling								
OW-23D	Existing	X	X (Biennial)	X			X				Sentinel well; monitor beneath DNAPL-containing region in A/B-Unit (Former Process Area)
OW-27D	Existing	X	N/A - no sampling								
OW-35DR	Existing	X	N/A - no sampling								
OW-36D	Existing	X	N/A - no sampling								
OW-37D	Existing	X	N/A - no sampling								
OW-39DR	Existing	X	N/A - no sampling								
OW-40D	Existing	X	X (Biennial)	X			X				Sentinel well; monitor downgradient of DNAPL-containing region in A/B-Unit (Former Lagoon/Off-Site Spill Area)
OW-41D	Existing	X	N/A - no sampling								
OW-42DR	Existing	X	N/A - no sampling								
OW-44D	Existing	X	N/A - no sampling								
OW-102D	Existing	X	N/A - no sampling								
OW-202D	Existing	X	N/A - no sampling								
R-13D	Existing	X	X (Biennial)	X			X				Sentinel well; monitor downgradient of DNAPL-containing region in A/B-Unit (CAMU/Former RCRA Surface Impoundments)
R-14D	Existing	X	N/A - no sampling								

Table 1 - Summary of Groundwater Monitoring Plan (GMP) Scope of Work

Former Koppers Wood-Treating Site

Carbondale, Illinois

Monitoring Location	Existing/ New?	Monitored for Water Elevation (See Note 1)	Sampled for Water Quality (Frequency)	Analytical Parameters (See Note 3)			Criteria Comparison (See Note 4)				Comments
				A	B	C	i	ii	iii	iv	
E-Unit Wells											
A-08E	Existing	X	N/A - no sampling								
OW-03E	Existing	X	N/A - no sampling								
OW-12E	Existing	X	N/A - no sampling								
OW-27E	Existing	X	N/A - no sampling								
OW-33E	Existing	X	N/A - no sampling								
OW-35E	Existing	X	N/A - no sampling								
OW-39ER	Existing	X	N/A - no sampling								
OW-102E	Existing	X	N/A - no sampling								
OW-200E	Existing	X	X (Annual)	X			X				Sentinel well; monitor downgradient of DNAPL-containing well R-13E
OW-201E	Existing	X	X (Annual)	X			X				Sentinel well; monitor downgradient of DNAPL-containing well R-13E
R-13E	Existing	X	N/A - no sampling								
R-14E	Existing	X	X (Annual)	X			X				Sentinel well; monitor downgradient of DNAPL-containing well R-13E
Totals	**91 Existing 17 New**	**101**	**14 Semiannual 18 Annual 6 Biennial**	**38**	**1**	**9**					

Notes:

"N/A" = not applicable

"Annual" = once per year

"Biennial" = once every two years

"Semiannual" = twice per year

"DNAPL" = dense, non-aqueous phase liquid

1. Depth to water measurements will be obtained at all wells, piezometers, and surface water gauges. In addition, depth to bottom will be measured at all wells and piezometers to check for the presence of DNAPL and to monitor for siltation. These measurements will be performed annually, and each time a location is sampled (if sampled more frequently than annually; see Note 2). DNAPL thicknesses at the following wells, which historically have accumulated DNAPL, will occur semiannually: P-8A, R-8A, OB23-04B, OW-205B, and R-13E. More frequent DNAPL thickness measurements and DNAPL removal will continue at the north and south trench sumps and RW-23.

2. Existing wells OW-205A, OW-206A, and OW-207A, and all new wells, to be sampled semiannually (twice per year) for two years, and annually thereafter (or other frequency agreed to by Beazer and USEPA).

3. Analytical parameters:

A = benzene, ethylbenzene, toluene, and total xylenes (Method 8260); polycyclic aromatic hydrocarbons (PAHs) and pentachlorophenol (Method 8270LL)

B = arsenic (Method 6010)

C = dioxins/furans (Method 8290) (See Note 5)

4. Criteria (See Table 2 for additional details):

i = TACO Tier I, Class I Groundwater Remediation Objectives

ii = TACO Tier I, Class II Groundwater Remediation Objectives (and for dioxins/furans, Maximum Contaminant Level)

iii = Illinois Water Quality Criteria

iv = TACO Tier I Groundwater Remediation Objectives for the Indoor Inhalation Exposure Route

5. The wells specified in this table for dioxin/furan analysis will be sampled during two consecutive semiannual events. Based on the results, the need for and scope of any additional dioxin/furan sampling will be discussed with USEPA. It is anticipated that a limited number of wells will continue to be sampled for dioxins/furans every 5 years.

Table 2 - Summary of Numeric Criteria

Former Koppers Wood-Treating Site

Carbondale, Illinois

Analytical Parameter	Units	TACO Tier I GROs			IWQC				MCL
		Class I	Class II	Indoor Inhalation Exposure Route (Residential)	Aquatic Life		Human Health		
					Acute	Chronic	HTC	HNC	
Arsenic	ug/L	N/A	200	N/A	N/A	N/A	N/A	N/A	N/A
Benzene	ug/L	5	25	110	4,200	860	310		N/A
Ethylbenzene	ug/L	700	1,000	370	150	14	--		N/A
Toluene	ug/L	1,000	2,500	530,000	2,000	600	--		N/A
Total Xylenes	ug/L	10,000	10,000	30,000	920	360	--		N/A
Acenaphthene	ug/L	420	2,100	--	120	62	--	--	N/A
Acenaphthylene	ug/L	210	1,050	--	190	15	--	--	N/A
Anthracene	ug/L	2,100	10,500	--	0.66	0.53	35,000	--	N/A
Benzo(a)anthracene	ug/L	0.13	0.65	--	--	--	--	0.16	N/A
Benzo(a)pyrene	ug/L	0.2	2	--	--	--	--	0.016	N/A
Benzo(b)fluoranthene	ug/L	0.13	0.9	--	--	--	--	0.16	N/A
Benzo(ghi)perylene	ug/L	210	1,050	--	--	--	--	--	N/A
Benzo(k)fluoranthene	ug/L	0.17	0.85	--	--	--	--	1.6	N/A
Chrysene	ug/L	1.5	7.5	--	--	--	--	16	N/A
Dibenzo(a,h)anthracene	ug/L	0.3	1.5	--	--	--	--	0.016	N/A
Fluoranthene	ug/L	280	1,400	--	4.3	1.8	120	--	N/A
Fluorene	ug/L	280	1,400	--	59	16	4,500	--	N/A
Indeno(1,2,3-cd)pyrene	ug/L	0.43	2.15	--	--	--	--	0.16	N/A
Naphthalene	ug/L	140	220	75	510	68	--	--	N/A
Phenanthrene	ug/L	210	1,050	--	46	3.7	--	--	N/A
Pyrene	ug/L	210	1,050	--	--	--	3,500	--	N/A
Pentachlorophenol	ug/L	1	5	--	20	13	--	2.5	N/A
2,3,7,8-TCDD TEQ	ug/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00003

Notes:

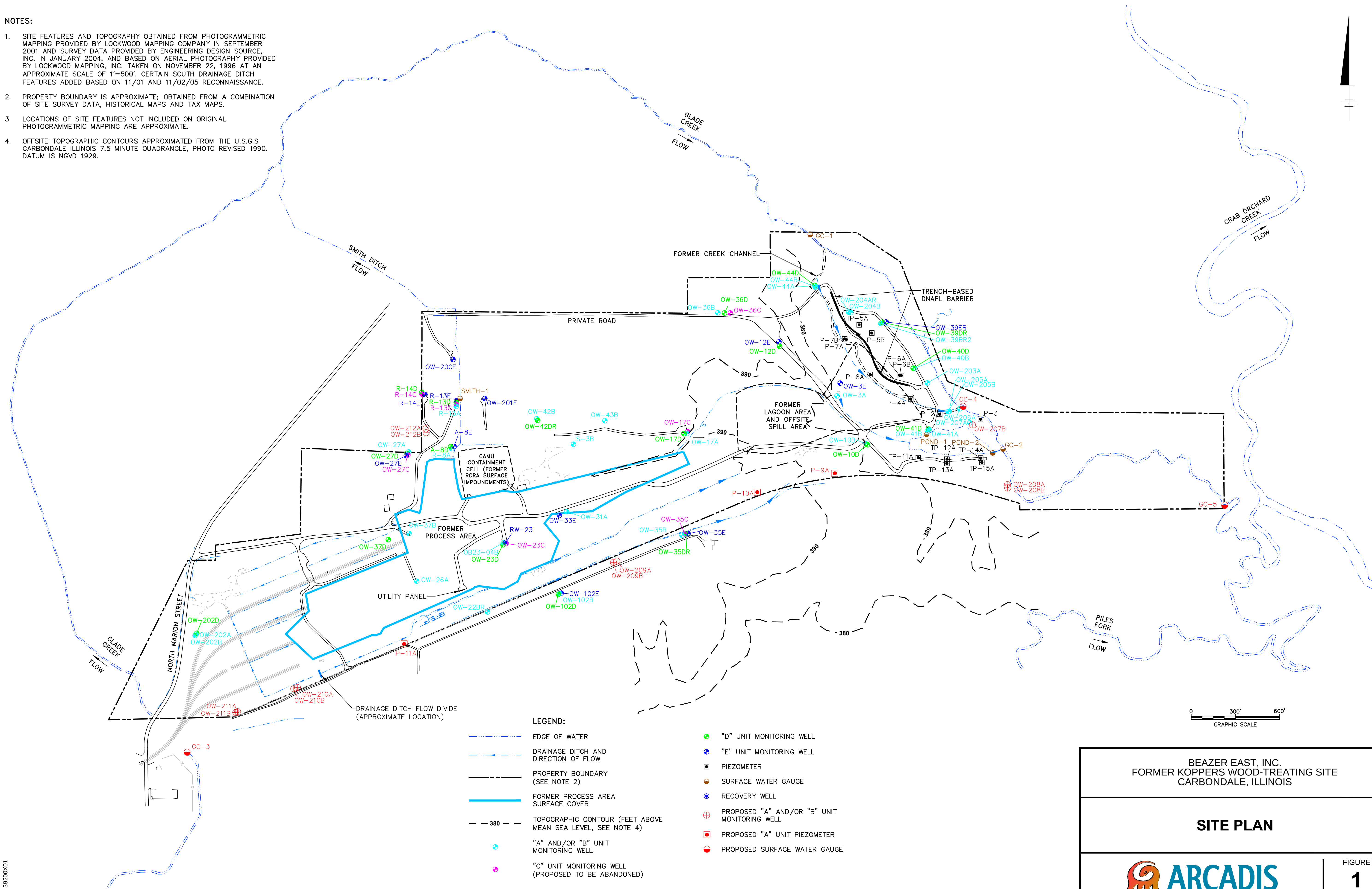
ug/L = micrograms per liter
N/A = not applicable
-- = no criteria available
TACO = Tiered Approach to Corrective Action Objectives
GROs = Groundwater Remediation Objectives
IWQC = Illinois Water Quality Criteria
HTC = Human Threshold Criterion
HNC = Human Nonthreshold Criterion
MCL = Maximum Contaminant Level
TCDD = tetrachlorinated dibenzo-p-dioxin
TEQ = toxicity equivalence

1. TACO Tier I GROs for Class I groundwater are applicable to groundwater samples from all D- and E-Unit monitoring wells. Values obtained from 35 IAC 742 Appendix B, Table E.
2. TACO Tier I GROs for Class II groundwater are applicable to groundwater samples from all A- and B-Unit monitoring wells. Values obtained from 35 IAC 742 Appendix B, Table E.
3. TACO Tier I GROs for the indoor inhalation exposure route (residential) are applicable to groundwater samples from the following A/B-Unit monitoring wells located along the southern property boundary: OW-102B, OW-209A, OW-209B, OW-210A, OW-210B, OW-211A, and OW-211B.
4. IWQC are applicable to all surface water samples and to groundwater samples from the following A-Unit monitoring wells located adjacent to Glade Creek in the eastern portion of the Site: OW-206A, OW-207A, OW-207B, OW-208A, and OW-208B. Values for BTEX obtained from 35 IAC 302.208. Values for PAHs and pentachlorophenol obtained from http://www.epa.state.il.us/water/water-quality-standards/water-quality-criteria-list.pdf. Acute aquatic life criteria are not to be exceeded at any time. Chronic aquatic life criteria are not to be exceeded by the arithmetic average of at least four consecutive samples. HTC are based on noncancerous effects. HNC are based on cancerous effects.
5. Groundwater sample analytical results for dioxins/furans (evaluated as 2,3,7,8-TCDD TEQ) will be compared to the MCL for 2,3,7,8-TCDD.

Figure

NOTES:

1. SITE FEATURES AND TOPOGRAPHY OBTAINED FROM PHOTOGRAMMETRIC MAPPING PROVIDED BY LOCKWOOD MAPPING COMPANY IN SEPTEMBER 2001 AND SURVEY DATA PROVIDED BY ENGINEERING DESIGN SOURCE, INC. IN JANUARY 2004. AND BASED ON AERIAL PHOTOGRAPHY PROVIDED BY LOCKWOOD MAPPING, INC. TAKEN ON NOVEMBER 22, 1996 AT AN APPROXIMATE SCALE OF 1"=500'. CERTAIN SOUTH DRAINAGE DITCH FEATURES ADDED BASED ON 11/01 AND 11/02/05 RECONNAISSANCE.
2. PROPERTY BOUNDARY IS APPROXIMATE; OBTAINED FROM A COMBINATION OF SITE SURVEY DATA, HISTORICAL MAPS AND TAX MAPS.
3. LOCATIONS OF SITE FEATURES NOT INCLUDED ON ORIGINAL PHOTOGRAMMETRIC MAPPING ARE APPROXIMATE.
4. OFFSITE TOPOGRAPHIC CONTOURS APPROXIMATED FROM THE U.S.G.S CARBONDALE ILLINOIS 7.5 MINUTE QUADRANGLE, PHOTO REVISED 1990. DATUM IS NGVD 1929.



LEGEND:

- EDGE OF WATER
- DRAINAGE DITCH AND DIRECTION OF FLOW
- PROPERTY BOUNDARY (SEE NOTE 2)
- FORMER PROCESS AREA SURFACE COVER
- 380 TOPOGRAPHIC CONTOUR (FEET ABOVE MEAN SEA LEVEL, SEE NOTE 4)
- "A" AND/OR "B" UNIT MONITORING WELL
- "C" UNIT MONITORING WELL (PROPOSED TO BE ABANDONED)
- "D" UNIT MONITORING WELL
- "E" UNIT MONITORING WELL
- PIEZOMETER
- SURFACE WATER GAUGE
- RECOVERY WELL
- PROPOSED "A" AND/OR "B" UNIT MONITORING WELL
- PROPOSED "A" UNIT PIEZOMETER
- PROPOSED SURFACE WATER GAUGE

BEAZER EAST, INC.
FORMER KOPPERS WOOD-TREATING SITE
CARBONDALE, ILLINOIS

SITE PLAN

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FIGURE 1

CITY: NASHVILLE DIV/GROUP: ENVCAD DB: L FORAKER LD: PIC: J. HOLDEN PM: D BESSINGPAS TM: D. BESSINGPAS LYR: ON=*;OFF=*REF* PAGESETUP: C-LD2B-PDF PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 8/14/2015 10:07 AM BY: FORAKER, LYDIA
C:\LOCAL-G\ENVCAD\SYRACUSE\ACT\B0039314\0000\00001\SITE\39314G01.dwg LAYOUT: 1 SAVED: 8/14/2015 10:03 AM ACADVER: 19.1S (LMS TECH)
XREFS: 39314X00 39200X01 IMAGES:

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Appendices

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Appendix A

Monitoring Well Decommissioning
Standard Operating Procedure

Monitoring Well Decommissioning Standard Operating Procedure

1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures for decommissioning groundwater monitoring wells. Monitoring wells may be decommissioned for a variety of reasons including, but not limited to:

- Eliminate physical hazards associated with an out-of-use monitoring well;
- Conserve the yield and hydrostatic head of confined aquifers;
- Prevent the intermingling of waters from separate aquifers;
- Remove a potential conduit for the vertical migration of constituents in groundwater along the borehole wall or well casing; and
- Remove a monitoring well from areas subject to construction, surface grading, or other disturbance.

This SOP is a procedural reference only. The need for or rationale for decommissioning any given well will be made in the work plan or scope of work governing the field effort. This SOP is organized as follows:

This SOP covers the decommissioning of single-cased overburden monitoring wells when a replacement well will not be installed within the same borehole. These procedures were developed by taking into account site-specific conditions and in accordance with the State of Illinois *Water Well Construction Code, Section 920.120 Abandoned Wells.* Two potential decommissioning methods (i.e., plugging-in-place and overdrilling) are described below.

Although some of these procedures are generally applicable for the decommissioning of double-cased monitoring wells or wells installed in bedrock, in most cases a decommissioning strategy for such wells should be developed on a well-by-well basis. Additional information regarding potential methods to decommission these types of wells may be found in ASTM D5299-92 - *Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities*.

2 Personnel Qualifications

The well decommissioning procedures described below will be conducted under the supervision of an experienced geologist, engineer, or other qualified individual.

3 Equipment List

The following materials, as required, shall be available during pre-decommissioning and decommissioning activities:

- Site Health and Safety Plan (HASP);
- Health and safety equipment, as required in the HASP (e.g., air monitoring equipment, personal protective equipment);
- Information concerning the construction of the well to be decommissioned;
- Appropriate field forms or field notebook;
- Well keys;
- Water level probe;
- Cleaning materials;
- Containers for collecting spoils; and
- Any necessary specialized well drilling/decommissioning equipment.

4 Notifications

The Illinois Department of Public Health, approved local health department, or approved unit of local government (e.g. United States Environmental Protection Agency) shall be notified by telephone or in writing at least 48 hours prior to the commencement of any work to seal a monitoring well (State of Illinois Health Department. *Water Well Construction Code, Section 920.120 Abandoned Wells*).

5 General Guidelines

The following are general drilling guidelines applicable for well decommissioning:

- Field tasks will be completed in compliance with the site specific Health and Safety Plan.

- All necessary permits and property access agreements shall be obtained before starting work.

- All investigation derived waste (IDW) will be placed in containers for appropriate disposal (Section 7, below).

- Drilling tools will be cleaned prior to first use on site, between each investigation location, and prior to demobilization. Equipment cleaning will be completed on an impervious pad, using a steam-cleaner.

6 Procedures

Monitoring wells at the site may be decommissioned by the plug-in-place method, or by overdrilling. Selection of an appropriate method will be made on a well-by-well basis in the governing work plan or at the direction of an Illinois Professional Geologist. Method selection will take into account the presence of confining units, the presence of potentially mobile dense, non-aqueous phase liquid (DNAPL), and the construction details and integrity of the original well.

Plug-In-Place Method

The plug-in-place method uses grout to seal a monitoring well screen and casing in place, thus leaving the well casing and materials in the ground but eliminating the possibility that fluids may move up or down the well casing. The decommissioning process will consist of the following steps:

1. Perform a search of available records concerning the well to be decommissioned. The following activities should be performed to identify the location, construction, and condition of the well, and to determine the appropriate equipment to be used based on the depth, diameter, and accessibility of the monitoring well:

    - Review the existing monitoring well log to identify construction characteristics (e.g., total depth, casing diameter, initial borehole diameter, type of casing, type of material(s) used);
    - Locate the monitoring well in the field;
    - Identify if the decommissioning equipment can access the monitoring well and/or if special considerations (e.g., construction of an access road) are necessary to gain access;
    - Conduct total depth measurements and water level measurements;
    - Calculate the volume of the well that will need to be filled using the field measurements and formulas provided in Section 7, below; and
    - Record all observations and measurements.

2. Prepare a cement grout containing bentonite at 4% by weight.

3. Pump the cement/bentonite grout in the well screen and casing via tremie method (i.e., the grout will be pumped from the bottom of the well upward. The grout will be added until the well is completely filled. If the total amount of grout that can be pumped into the well does not approximately equal or exceed the calculated volume of the casing and sandpack (i.e., if the grout has bridged), the well decommissioning should be finished by overdrilling (described below).

4. Carefully excavate soil and remove well casing materials to a depth of at least 2 feet below grade except where the well terminates within a building floor (see Step 5 below). Care should be taken not to disrupt any well sealants between the well and surrounding formation materials. Should there be any planned excavation in the area, well decommissioning activities should be performed in conjunction with area

excavation. This will assure that well is decommissioned to a safe depth beyond planned construction depth. Once the uppermost part of the well casing has been removed, the remainder of the borehole will be filled with concrete and/or other surface finish materials material(s) compatible with the surrounding land surface or subsurface construction (e.g., asphalt, gravel, topsoil or piping).

5. Where the well terminates with a concrete slab which is part of a building floor, the well material should be removed so as to be flush with the floor. Well sealing material shall also be added until flush with the floor.

6. When a monitoring well is sealed, a Water Well Sealing Form will be completed and submitted to the Illinois State Department of Health or approved local health department by the individual performing the well abandonment not more than 30 days after the well is sealed. A copy of the Water Well Sealing Form is provided as Attachment 1. The following information is required to complete a Water Well Sealing Form:

   a) the date the monitoring well was originally drilled;
   b) depth and diameter of the monitoring well;
   c) location of the monitoring well;
   d) type of sealing method used;
   e) original well permit number (if available);
   f) date the monitoring well was sealed;
   g) type of monitoring well (e.g., driven or drilled);
   h) whether the formation is clear of obstructions;
   i) casing record (explanation of the required well casing removal); and
   j) well driller's license number (if applicable) and name.

Overdrilling Method

The overdrilling method uses large-diameter augers or flush-joint casing to drill-out the existing monitoring well, including both the casing and annular materials, then tremie-grouting the entire resulting borehole. For this method, it is critical that the driller takes precautions to remain on-center with the existing well as the overdrilling progresses. The decommissioning process will consist of the following steps:

1. Perform a search of available records concerning the well to be decommissioned. The following activities should be performed to identify the location, construction, and condition of the well, and to determine the appropriate equipment to utilize based on the depth, diameter, and access to the monitoring well:

   - Review the existing monitoring well log to identify construction characteristics (e.g., total depth, casing diameter, initial borehole diameter, type of casing, type of material(s) used);

   - Locate the monitoring well in the field;

   - Identify if a drill rig can access the monitoring well and/or if special considerations (e.g., construction of an access road) are necessary to gain access;

   - Conduct total depth measurements and water level measurements;

   - Calculate volume of well/borehole that will need to be filled using the field measurements and formulas provided in Section 8, below; and

   - Record all observations and measurements.

2. Prepare a cement grout containing bentonite at 4% by weight.

3. Pump the cement/bentonite grout in the well screen and casing via tremie method until the well is completely filled. (Note: This step is a precaution against failure of the overdrilling method, so that the well will be decommissioned by the plug-in-place method at a minimum, even if the driller is unable to completely overdrill the well casing.)

4. Remove the protective surface casing.

5. Advance a hollow-stem auger or other drill casing (with an outside diameter larger than the well boring diameter) over the well casing to the bottom of the original borehole. If it is clear that the overdrilled boring has veered from the well boring; drilling will stop until the problem is corrected. If the driller cannot complete the boring on-center with the existing well; the incomplete boring will be terminated and tremie-grouted to grade, leaving the well decommissioned by the plug-in-place method (Step 3).

6. When overdrilling reaches the total depth of the existing well, remove the well casing (riser and screen).

7. Pump cement/bentonite grout in the borehole via the tremie method at the same time the hollow-stem augers or drill casing are removed from the borehole. The grout will be added until the borehole is filled to the ground surface. At certain shallow well locations installed in formations not prone to caving, it may be possible to remove the hollow-stem augers or drill casing prior to adding the sealant. If this is attempted, confirmatory measurements must be taken to verify that borehole remained open prior to plugging the hole.

9. Verify that the borehole has been filled with cement grout up to a depth of at least 2 feet below grade except where the well terminates within a building floor (see Step 10 below). The remainder of the borehole will be filled with concrete and/or other surface finish materials material(s) compatible with the surrounding land surface (e.g., asphalt, gravel, topsoil).

10. Where the well terminates with a concrete slab which is part of a building floor, the well material should be removed so as to be flush with the floor. Well sealing material shall also be added until flush with the floor.

11. When a monitoring well is sealed, a Water Well Sealing Form will be completed and submitted to the Illinois State Department of Health or approved local health department by the individual performing the well abandonment not more than 30 days after the well is sealed. A copy of the Water Well Sealing Form is provided as Attachment 1. The following information is required to complete a Water Well Sealing Form:

    a. the date the monitoring well was originally drilled;
    b. depth and diameter of the monitoring well;
    c. location of the monitoring well;
    d. type of sealing method used;
    e. original well permit number (if available);
    f. date the monitoring well was sealed;
    g. type of monitoring well (e.g., driven or drilled);
    h. whether the formation is clear of obstructions;
    i. casing record (explanation of the required well casing removal); and
    j. well driller's license number (if applicable) and name.

7 Waste Management

Investigation derived waste (IDW) will be segregated into three categories:

- Disposable equipment (including personal protective equipment), well materials, and debris;
- Purged groundwater and water generated during equipment cleaning;
- Soil cuttings.

Disposable equipment and soil cuttings will be placed in containers (e.g., 55-gallon drums) and appropriately labeled with contents, date, and source. These materials may be characterized for offsite disposal, or staged for subsequent placement into the Corrective Action Management Unit containment cell (depending upon the timing of the work). Groundwater and equipment-cleaning water will be transported to the influent tank of the onsite wastewater treatment system for treatment.

8 Data Recording and Management

BBL's field supervisor will maintain a field notebook as a record of the field program. With respect to monitoring well decommissioning, the following details will be recorded:

- Personnel present and involved in well decommissioning (including the names of drillers and technical personnel);
- A description of the location and identification of all wells decommissioned;
- Details of the procedures followed;
- Description and length(s) of any well materials;
- Rationale for field decisions, as appropriate;
- Deviations from the stated procedures in the Work Plan or SOPs; and
- Any health and safety incidents or "near-misses".

To assure that a well is properly plugged and that there has been no bridging of the plugging materials, verification calculations and measurements are required to determine whether the volume of material placed in the well/borehole equals or exceeds the volume of the void that is being filled. Some useful conversion factors and a formula for calculating well and material volumes are provided below.

- 7.481 gallons = 1 cubic foot
- 202.0 gallons = 1 cubic yard
- Volume of well/borehole (in gallons) = π TIMES well/borehole radius (in feet) squared TIMES length of well/borehole (in feet) TIMES 7.481 (gallons per cubic foot)

9 References

ASTM International. D5299-92. *Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities*.

State of Illinois Health Department. *Water Well Construction Code, Section 920.120 Abandoned Wells.*

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Appendix B

Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures

LOW-FLOW (MINIMAL DRAWDOWN) GROUNDWATER SAMPLING PROCEDURES

1.0 SCOPE AND PURPOSE

This standard operating procedure (SOP) provides the procedures to be used to collect groundwater samples using the low-flow (minimal drawdown) sampling method. This method reduces sample turbidity, mixing between the overlying stagnant casing water and water within the screened interval, and the volume of purge water generated. Typically, flow rates on the order of 0.1-0.5 liter/minute are used, however, the actual flow rate used at a given well will depend in large part upon the hydraulic conductivity of its screened interval.

2.0 REQUIRED MATERIALS

The following list identifies the types of equipment which may be used during groundwater sampling. Project-specific equipment should be selected based upon project objectives, the depth to groundwater, required analytical parameters, and well construction information. The types of groundwater sampling equipment are as follows:

- Purging/Sample Collection Equipment
    - Low-flow (e.g., 0.1-0.5 liter/minute) pumps such as peristaltic pumps, bladder pumps, electrical submersible pumps, and gas-driven pumps;
    - Pumps are to be constructed of stainless steel or equipped with disposable and/or dedicated Teflon™ hardware;
    - (Note that bailers are inappropriate devices for low-flow sampling.)

- Related sampling and field measurement equipment will include some or all of the following:
    - A multi-parameter measurement unit with in-line sampling capability such as a YSI 556 or equivalent;
    - A photoionization detector (PID) to monitor for volatile organic constituents upon opening the monitoring well cap (the need for this instrument will be specified in the project specific work plan or health and safety plan);
    - Turbidity meter;
    - An in-line filtration apparatus, 0.45 µm, if dissolved metals are required analytes;
    - A water level meter; and,
    - An interface probe, if light non-aqueous phase liquid (NAPL) or dense NAPL are potentially present on site (the need for this instrument will be specified in the project-specific work plan).

- General Equipment:
  - Safety Glasses or equivalent eye protection;
  - Distilled water and dispenser bottle;
  - Decontamination solutions (such as Alconox and solvents);
  - Field data sheets;
  - Sample preservation solutions;
  - Sample containers;
  - Buckets and intermediate containers;
  - Coolers;
  - Shipping labels;
  - Permanent markers/pens;
  - Packing tape;
  - First aid kit;
  - Graduated cylinder;
  - Key(s) for well locks; and,
  - Stopwatch.

- Disposable Materials:
  - Plastic sheeting/bags;
  - Pump tubing (and bladders if bladder pumps are used);
  - Gloves;
  - Filters;
  - Chemical-free paper towels; and,
  - Protective coveralls (e.g., Tyvek), if necessary.

3.0 METHODOLOGIES

3.1 Pre-Sampling Considerations

Water samples should not be collected immediately following well development. Sufficient time should be allowed for the groundwater flow regime in the vicinity of the monitoring well to stabilize and to approach chemical equilibrium with the well construction materials. Unless stated otherwise in appropriate project-specific documents, or required by the lead regulatory agency for the site, the time between developing and sampling a well will be one week.

Several preparatory activities need to be completed prior to sampling of each well. These preparatory activities can be summarized as follows:

- Log in sample bottles received from laboratory, prepare any deionized water or preservatives needed for the sampling;

- If non-dedicated sampling pumps are used, prepare pumps with standard decontamination procedures;

- Don the necessary personnel protective equipment (PPE) stipulated in the Site health and safety plan (HASP);

- Measure static water level prior to well purging. Water levels will be measured to the nearest hundredth of a foot with an electronic probe from the established measuring point of the well casing. If water levels will be used to determine groundwater flow direction and/or hydraulic gradients, water levels from all locations requiring measurement shall be collected over as short a time period as possible. Unless specified otherwise in project-specific documents, light/dense NAPL thickness and total well depth will be measured at each well during the initial round of water level measurements. All well gauging data will be recorded on a site specific well gauging sheet.

3.2 Equipment Calibration

Prior to purging and sampling, all sampling devices and monitoring equipment should be calibrated according to manufacturer's recommendations and project-specific documents such as a Quality Assurance Project Plan (QAPP) or Field Sampling Plan (FSP). Note that some types of dissolved oxygen measuring devices require that corrections be made for local barometric pressure and elevation during calibration.

3.3 Well Purging

The low-flow, minimal drawdown method relies on minimizing drawdown in the well being sampled (which minimizes increases to in-situ groundwater velocities). Groundwater is determined to be representative of in-situ conditions and therefore ready to sample when selected indicator parameters have stabilized, as described later in this section.

The procedures used to purge a well may vary slightly depending upon the construction of the well and the type of pump used. Details regarding selecting a pump are provided later in this section. General purging requirements are as follows:

- establish a flow rate (when attainable between 0.1L/min and 0.5 L/min), that maintains minimal drawdown in the well during both purging and sampling;
- maximize pump discharge tubing wall thickness and minimize tubing length;
- place the sampling device intake at the middle of the saturated portion of the screened interval (or open bedrock interval for open borehole bedrock wells), unless specified otherwise in the project-specific work plan
- minimize disturbance of the stagnant water column above the screened interval when measuring water levels and inserting the sampling device;
- make proper adjustments to stabilize the flow rate as soon as possible;
- monitor water quality indicator parameters during purging (as described below in Section 3.4);
- either dedicate pump tubing to each well, or properly dispose of it after use;
- handle and dispose of all purge water and other investigation-derived wastes as specified in the appropriate project-specific document(s).

PUMP AND DISCHARGE_TUBING SELECTION

There are no unusual requirements for groundwater sampling devices when using low-flow, minimal drawdown techniques. The primary requirement is that the device give consistent results and minimal disturbance of the sample across a range of low flow rates (i.e., <0.5 liter/minute). Note that pumping rates that cause minimal to no drawdown in one well could easily cause significant drawdown in another well that has been installed in a less transmissive formation. Consistency in operation is critical to meet accuracy and precision goals. The goal is to achieve and maintain as low a flow rate as possible while maintaining non turbulent flow (i.e. no air bubbles in groundwater conveyance line with minimal flow rate variation).

There are several pumps which are used frequently for purging or sampling. These types include the peristaltic, bladder, and submersible pumps. It is desirable that the pump be easily adjustable and operates reliably at these lower flow rates. Gas-driven pumps should be of a type that does not allow the gas to be in direct contact with the sampled fluid. Bailers and other grab-type samplers are not suited for low-flow sampling and shall not be used.

A variety of tubing materials are available for use as pump discharge tubing. The type of tubing used to collect the sample will be contingent on the parameters of interest.

a. If conventional parameters (i.e., biological oxygen demand [BOD], total suspended solids [TSS], fecal coliform, pH, and oil and grease) are being analyzed, then standard Nalgene or polyethylene tubing is sufficient to collect the sample.

b. If volatile, semi-volatile, or metals parameters are the constituents of interest, Teflon™ or Teflon lined tubing will be used to collect the sample.

Unless specified otherwise in project-specific documents, or required by the lead regulatory agency for the site, the material used for sampling tubing shall be Teflon™ lined polyethylene (either high- or low-density). If a peristaltic pump is used, a short length of silicone tubing can be used through the pump head.

Peristaltic Pumps

Peristaltic pumps are operated above ground next to the well and are limited to water level depths of 20 to 30 feet below ground surface. The following procedure describes the use of peristaltic pumps for purging and sampling.

1. Carefully lower the pump tubing to the targeted depth down the well in a manner that minimizes mixing of the water column and disturbance of solids that may have collected at the well bottom.

2. Connect the tubing to a short length of silicone tubing in a manner that will allow the purge water to contact only polyethylene, Teflon or silicone materials (e.g., using connector fitting made of polyethylene or Teflon).

3. Run the silicone tubing through the pump head, connecting the discharge end to an in-line water-quality meter (these meters are described in Section 3.4). Place the discharge line from the water-quality meter into a container (e.g., 5-gallon bucket or 55-gallon drum) to collect the purged water.

4. Begin pumping at a low rate, while periodically monitoring the depth to water and the pumping rate. Measure the pumping rate using a calibrated container and a stopwatch. Record pumping-rate and water-level measurements.

5. Adjust the pumping rate as necessary to maintain minimal drawdown.

6. When the indicator parameters have stabilized (as described in Section 3.4), begin sampling (see section 3.5).

7. When sampling is completed, and before shutting the pump off, record the total pumping time and total volume of groundwater purged.

Bladder Pumps

The bladder pump is a compressed air or gas-operated, positive displacement submersible well pump that uses inert compressed gas, e.g., nitrogen, to inflate an internal bladder which pumps water up the discharge line. Usually these pumps are used on wells with diameters of 2 inches or greater and wells with depths up to 150 feet. For non-dedicated pumping assemblies, the air/water conveyance line will either be dedicated or properly disposed of. After use where practical, the tubing will be suspended within the well for future use in the well to which it is dedicated. For non-dedicated bladder pump assemblies, a new, disposable bladder will be used at each well

The following procedures should be followed for using the bladder pump:

1. Connect the line assembly to the pump by first attaching the cable and then connecting the sample and gas lines.

2. Lower the pump slowly down the well as to minimize excessive mixing of the stagnant water and solids that have collected at the bottom of the well by unrolling the line off the spool until the pump is located at the desired position inside the well.

3. Secure the cable to hold the pump at the desired depth.

4. Connect the gas line to the control box. Connect the discharge end to an in-line water-quality meter (these meters are described in Section 3.4). Place the discharge line from the water-quality meter into a container (e.g., 5-gallon bucket or 55-gallon drum) to collect the purged water.

5. Connect the gas supply to the control box and adjust the pressure according to the manufacturer's manual.

6. Begin pumping at a low rate, while periodically monitoring the depth to water and the pumping rate. Measure the pumping rate using a calibrated container and a stopwatch. Record pumping-rate and water-level measurements.

7. Adjust the pumping rate as necessary to maintain the lowest consistent flow rate with minimal drawdown.

8. When the indicator parameters have stabilized (as described in Section 3.4), begin sampling (see section 3.5).

9. When sampling is completed, and before shutting the pump off, record the total pumping time and total volume of groundwater purged.

10. Those non-disposable and/or non-dedicated portions of the pumping assembly that come in contact with water in the well must be decontaminated, as specified in the appropriate, project-specific document(s), before being used in another well.

Submersible Pumps

Submersible pumps that are specifically designed for groundwater sampling and can maintain the required low flow rates can be used for purging and sampling.

1. Connect tubing to the submersible pump and lower pump to the desired depth using a safety line that is secured to the well casing.

2. Connect the discharge line to the water quality meter or flow-through cell, with cell discharge line placed into a container (e.g., 5-gallon bucket or 55-gallon drum) to collect the purged water.

3. Connect the power cord to the power source and turn on the pump.

4. Begin pumping at a low rate, while periodically monitoring the depth to water and the pumping rate. Measure the pumping rate using a calibrated container and a stopwatch. Record pumping-rate and water-level measurements.

5. Adjust the pumping rate as necessary to maintain minimal drawdown.

6. When the indicator parameters have stabilized (as described in Section 3.4), begin sampling (see section 3.5).

7. When sampling is completed, and before shutting the pump off, record the total pumping time and total volume of groundwater purged.

8. Those portions of the pump and power line that come in contact with water in the well must be decontaminated, as specified in the appropriate, project-specific document(s), before being used in another well.

Continue to monitor the pumping rate and water level in the well, slowing the rate if drawdown occurs.

3.4 Monitoring Water Level and Water Quality Indicator Parameters

Check the water level periodically during purging and sampling to monitor drawdown in the well as a guide to flow rate adjustment. The goal is minimal drawdown (<0.3 feet) during purging. This goal may not be possible to achieve under some circumstances. If this goal cannot be met, pumping should continue at the lowest flow rate that can be maintained by the pump. In the event that the water level in the well reaches the pump intake, pumping will be discontinued, leaving the pump/tubing in place while the water level in the well recovers. When the water level has recovered sufficiently, pumping will be resumed at the same low flow rate and sampling will be completed. In this special case, the pumped groundwater can be directed into the sampling containers immediately.

The following indicator parameters will be monitored, unless specified otherwise in project-specific documents:

- temperature;
- pH;
- ORP;
- conductivity,
- dissolved oxygen; and,
- turbidity.

Unless specified otherwise in project specific documents, an in-line water-quality meter will be used to monitor all of these parameters, with the possible exception of turbidity. Turbidity can either be monitored with a flow-through cell or with a separate turbidity meter. Measurements of all of these parameters should be recorded every three to five minutes. The groundwater is considered representative and ready for sampling as soon as the indicator parameters meet the following criteria for three consecutive readings:

- ± 0.1° C for temperature;
- ± 0.1 standard units for pH;
- ± 3% for conductivity;
- ± 10 millivolts for ORP;
- ± 10% for turbidity; and,
- ± 10% for dissolved oxygen.

If one-or more of these criteria can not be met, field staff will contact the project manager, who will determine the appropriate course of action.

Pumping rate, drawdown, and the time or volume required to obtain stabilization of parameter readings can be used as a future guide to purging and sampling the well.

3.5 Groundwater Sampling

Once parameters have stabilized, begin collecting samples as soon as possible. Disconnect or bypass the in-line water-quality meter prior to collecting samples. The sampling flow rate should remain the same as that used during purging.

Samples will be collected in decreasing order of their volatility. This order is generally as follows:

- Volatile organic chemicals (VOCs);
- Total organic halogens (TOX);
- Gas sensitive parameters (e.g., Fe2+, CH4, H2S/HS-, alkalinity);
- Total organic carbon (TOC);
- Semivolatile organics chemicals (SVOCs);
- Inorganic parameters; and,
- If filtered samples are to be collected, these should be collected last. Filters are to be pre-rinsed following the manufacturer's recommendations. If there are no recommendations for pre-rinsing, when practical, a minimum of 1L or groundwater must pass through the filter prior to sample collection.

Samples collected for volatile organics should be carefully placed into 40 milliliter glass vials with Teflon septum lids. No air bubbles should be present in the vial after sealing the septum lid; if air bubbles are present, fill the vial more completely.

Samples collected for dissolved metals analyses, if required, will be filtered in the field. Filtering is performed using an in-line filtration device, hand vacuum pumps with transfer vessels, or peristaltic pumps with disposable funnels/filters. If using the vacuum pump method, a laboratory cleaned transfer vessel is used. If using a peristaltic pump, new silicone tubing is used in the pump head for each sample filtered and new Teflon tubing is used from the pump head to the filter. Samples are filtered through 0.45 micron filter unless specified otherwise in the appropriate, project specific document. Filtrate should be placed in a pre-preserved sampling container as soon as possible.

Sampling technicians must wear a clean pair of disposable gloves for each well.

4.0 QA/QC PROCEDURES

Refer to the appropriate, project-specific documents for the quality assurance/quality control procedures to be followed during low-flow (minimal drawdown) groundwater sampling.

5.0 DATA RECORDING AND MANAGEMENT

A written record of each monitoring event must be maintained. The record provides a summary of the sample collection procedures and conditions, shipment method, the analyses requested and the custody history. This record consists of the following:

- Groundwater Sample Collection Form (Example Form Attached);
- Chain of custody form; and,
- Shipping receipts.

Sample labels shall be completed at the time each sample is collected and will include the information listed below.

- Project name;
- Sample number;
- Time and date;
- Preservative (if applicable);
- Analyses to be performed; and,
- Sampler's name.

6.0 REFERENCES

U.S. EPA, Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures, by Robert W. Puls and Michael J. Barcelona, EPA/540/S-95/504, April 1996.

U.S. EPA, Region II, Ground Water Sampling Procedure - Low Flow Pump Purging and Sampling, March 1998.

ATTACHMENT A

LOW FLOW GROUNDWATER SAMPLE COLLECTION RECORD

GROUNDWATER SAMPLE COLLECTION RECORD

WELL NO.:

PERMIT NO.:

Project No.: ____________ **Client:** Beazer East, Inc.
Project Name: ____________ **Project Location:** ____________
Weather Conditions: ____________ **Sampling Date:** ____________

1. WATER LEVEL DATA (measured from top of inner well casing)

- **a. Depth to LNAPL:** ________ **(ft)** **b. Depth to Water:** ________ **(ft)**
- **c. Depth to DNAPL:** ________ **(ft)** **d. Total Well Depth:** ________ **(ft)**
- **e. LNAPL Thickness: (a-b)** ________ **(ft)** **f. DNAPL Thickness: (c-d)** ________ **(ft)**
- **g. Length of Water Column:** ________ **(ft) (b-d)**
- **h. Well Volume:** ________ **(gal)**

2. WELL PURGE DATA

- **a. Purge Method:** ____________
- **b. Field Testing Equipment:** ____________
- **d. Total Volume and Number of Well Volumes Removed:** ________
- **e. Begin Purge Time:** ________ **End Purge Time:** ________

Conversion Factors (g x cf = h)

Well I.D.	Conv. Fact. (cf)
1	0.041
2	0.163
4	0.653
6	1.470

Read No.	Lapse Time (min.)	Purge Rate	Temp (deg. C) (±10%)	pH (s.u.) (±0.1)	Spec. Cond. (ms/cm) (±3%)	Eh/ORP (mV) (±10mV)	Diss O2 (mg/L) (±10%)	TURB (NTU) (±10%)	Salinity %	TDS G/L	Water Level (ft)
PRE PURGE VALUES											
PURGING VALUES											

3. SAMPLE COLLECTION DATA **Sampling Personnel:** ____________

Sampling Method(s) & Equip: ____________
Sample I.D. (Name, Date, Time): ____________
Sample Analytical Parameters/Method: ____________

Sample Start Time: **End SampleTime:**
COMMENTS:

Appendix C

Surface Water Sampling Procedures

Standard Operating Procedure: Surface Water Sample Collection

I. Scope and Application

This Standard Operating Procedure (SOP) describes the procedures that will be followed to collect surface water samples at the Former Koppers Wood-Treating Site in Carbondale, Illinois.

II. Personnel Qualifications

Personnel conducting surface water sampling will have at least one year of relevant experience.

III. Equipment List

- copy of Work Plan;
- health and safety equipment, as required by the Site-specific Health and Safety Plan (HASP);
- aluminum boat with outboard motor (if needed, depending on water depths);
- chest and/or hip waders;
- 6-foot rule or survey rod;
- transport container with ice;
- appropriate sample containers and forms; and
- field notebook.

IV. Cautions

Sampling personnel should be cautious of working in and around water during sampling and sample processing activities. Sampling personnel must be aware of weather conditions at all times as creek water levels rise quickly during storm events. Uneven/slippery terrain and obstacles (e.g., brush, fallen tree, etc.) exist in the uplands area (which will need to be traversed to reach the creeks), on the creek banks, and in the creeks themselves; sampling personnel should exercise caution to avoid slips, trips, and falls.

V. Health and Safety Considerations

Refer to HASP.

VI. Procedure

1. Locate the targeted sampling location in the field and review the Work Plan to confirm sampling scope.

2. Identify the sample location in the field notebook along with a general description of the creek conditions at the sampling location.

3. Don personal protective equipment (PPE), as required by the HASP.

4. Measure and record the depth of water.

5. Fill sample containers by partially submerging into the water, taking care to avoid disturbing bottom sediment and entraining it in the sample. For pre-preserved sample containers, be careful not to release the preservative during sampling.

6. Record general surface water descriptions, including color, visual impacts, and odors.

7. Label all sample containers with sample ID, sample date/time, samplers' names, and requested analytical methods.

8. Handle, pack, and ship samples using standard chain-of-custody procedures.

VII. Waste Management

Waste materials generated during the surface water sampling activities will be placed into suitable containers for subsequent characterization and appropriate disposal by Beazer.

VIII. Data Recording and Management

The field supervisor will maintain a field notebook as a record of the field program and provide a copy to the Project Manager. With respect to surface water sampling, the following details will be recorded (in addition to the information discussed above):

- project name and location;
- project objectives;
- daily log of activities;
- personnel present and involved in the sampling;
- weather conditions;
- rationale for field decisions, as appropriate;
- deviations from the stated procedures in the Work Plan or SOPs; and
- any health and safety incidents or “near-misses”.

IX. Quality Assurance

Refer to the Site-specific Quality Assurance Project Plan.

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Appendix D

Monitoring Well Drilling and Installation Standard Operating Procedure

Monitoring Well Drilling and Installation Standard Operating Procedure

1 Scope and Application

This document presents the Standard Operating Procedure (SOP) that will be followed to drill and install monitoring wells at the Former Koppers Wood-Treating Site in Carbondale, Illinois.

The SOP is organized as follows:

This SOP has been designed as a guide for BBL's field staff; and therefore does not provide detail on drilling rig operations and equipment handling. Actual drilling and well installation services will be completed by a qualified drilling subcontractor.

2 Personnel Qualifications

- BBL staff responsible for observing monitoring well drilling and installation shall hold a degree in geology or a related science, or have at least one year of relevant experience.
- All drilling and well installation will be performed by an Illinois-licensed drilling subcontractor.

3 General Drilling Guidelines

The following are general guidelines applicable for all drilling tasks onsite:

- Drilling locations, target depths, and sample selection criteria will be identified in the work plan or other appropriate document governing the drilling work.

- Field tasks will be completed in compliance with the site-specific Health and Safety Plan (HASP).
- All necessary permits and property access agreements shall be obtained before starting work.
- All drilling and well installation will be performed by a licensed and qualified subcontractor.
- At a minimum, all drilling locations will be cleared of utilities in compliance with Illinois regulations. If reasonable uncertainty of utility clearance remains, drilling locations will be cleared by hand or using an air-knife to an appropriate depth.
- If nonaqueous-phase liquid (NAPL) is observed, drilling procedures will be modified to reflect the NAPL Contingency Plan (Section 4, below).
- All investigation-derived waste (IDW) will be contained for appropriate disposal (Section 5, below).
- Drilling tools will be cleaned prior to first use on site, between each drilling location, and prior to demobilization (Section 6, below).
- Where soils are collected for classification, the field staff will follow the procedures given in Section 7.
- All well locations will be marked for survey of position, grade elevation, and top-of-casing elevations.

4 NAPL Contingency Plan

This section specifies the procedures to be followed during drilling at the site to limit the potential for remobilization and induced migration of NAPL. These procedures apply to all soil borings and monitoring wells to be completed.

Soils will be sampled continuously for at least the first boring location in any well cluster. In bedrock, rock cores and/or return water will be observed for evidence of NAPL. If NAPL is observed or suspected, drilling will stop until a judgment can be made, within the guidelines described below, of whether additional drilling is appropriate.

Field assessments of soil and rock samples will pay particular attention to evidence of impacts, including (as appropriate) elevated headspace readings, suspect fill materials, staining, sheens, and NAPL. To the extent feasible, visible NAPL will be classified according to consistency (e.g., oil-like or tar-like), color, relative viscosity, density (LNAPL or DNAPL), general odor, and apparent quantity (e.g., whether the NAPL is present in isolated blebs, or present filling a significant portion of the available soil or rock porosity).

If NAPL is observed, the field staff will first judge if the NAPL is lighter or denser than water (i.e., LNAPL or DNAPL). If an easy determination cannot be made in a soil sample, a representative sample will be selected for a shake test. To perform a shake test, the field staff will place a small sample of NAPL-containing soil in a clear jar. The jar will then be filled ¾ full with distilled water, closed, and manually shaken for several seconds. The jar will then be allowed to sit for up to five minutes, if needed, to allow any emulsions to settle. Determination of light or dense NAPL can be made by observing whether the NAPL floats or sinks.

If the NAPL is judged to be denser than water, the field staff will make a qualitative judgment whether the DNAPL is pooled (i.e., potentially mobile) or residual (i.e., immobile). In granular soils, the presence of a DNAPL pool would be suggested by an apparent DNAPL volume of greater than 5 to 10 percent of the soil's porosity. In fractured media, including bedrock and some fine-grained, unconsolidated deposits, any DNAPL will be treated as potentially mobile.

Where the NAPL is determined to be LNAPL, or where DNAPL is present in soil at residual quantities, drilling may continue with caution. If the intent of drilling is to install a monitoring well below the impacted interval, the geologist should consider the likelihood for drilling drag-down, and revise the drilling method if necessary.

Where potentially mobile DNAPL has been identified, the geologist may consider the following options:

1. If an alternate drilling location will satisfy the drilling objectives, the borehole should be abandoned by tremie-grouting from the bottom of the borehole to land surface.

2. Drilling may continue through a DNAPL-impacted interval to determine the approximate vertical extent, except where continued drilling risks breaching a confining unit or a subsurface structure (e.g., a foundation) that may be confining with respect to DNAPL. If a confining unit or structure is not observed, drilling may continue as needed. The completed boring should be abandoned by tremie-grouting to grade.

3. If deeper drilling and characterization are desired where DNAPL has been identified above a potential confining unit (or an unimpacted interval of rock), the following actions may be taken:

    a. If the thickness of the apparent confining unit is unknown, or if it is suspected to be less than 4 feet thick, the boring should be abandoned.

    b. If the nature and thickness of the confining unit are well understood from other completed borings, drilling may continue only after the DNAPL-impacted interval has been effectively cased. Steel casing should be installed from grade to several feet into the underlying confining unit. The casing should be tremie grouted in place and allowed to sit undisturbed for at least 12 hours. Drilling may resume through the casing.

4. If DNAPL is observed above an impervious man-made structure (e.g., a building foundation) great care must be taken not to breach the structure. If deeper drilling and characterization are desired, the borehole should be properly abandoned and an alternate location selected immediately outside of the footprint of the structure.

5. If NAPL characterization data or NAPL recovery are desired, a monitoring well may be installed with a grouted sump below the well screen. Further detail on well and sump installation are included below.

5 Management of Investigation-Derived Wastes

Investigation-derived waste (IDW) generated during drilling and well installation may include the following:

- Disposable equipment (including personal protective equipment) and debris;
- All solids (e.g., soils and rock cuttings) associated with drilling of borings; and
- All purged groundwater and water generated during equipment cleaning.

Disposable equipment and soil cuttings will be placed in containers (e.g., 55-gallon drums) and appropriately labeled with contents, date, and source. These materials may be characterized for offsite disposal, or staged for subsequent placement into the Corrective Action Management Unit containment cell (depending upon the timing of the work). Groundwater and equipment-cleaning water will be transported to the influent tank of the onsite wastewater treatment system for treatment.

6 Equipment Cleaning

Drill Rig Cleaning

In no permanent equipment cleaning pad is available, the driller will construct a temporary cleaning pad, lined with plastic sheeting on a surface sloped to a sump. The sump must also be lined and of sufficient volume to contain approximately 20 gallons of cleaning water. All drilling equipment including the rear-end of drilling rig, augers, bits, rods, tools, split spoon samplers, and tremie pipe will be cleaned on the equipment cleaning pad with a high pressure hot water "steam cleaner" unit and scrubbed with a wire brush, as needed, to remove dirt, grease, and oil before beginning work in the project area. If heavy accumulations of tars or oils are present on the downhole tools, a citrus-based cleaner (e.g., Citra-Solv®) may be used to aid in equipment cleaning. Tools, drill rods, and augers will be placed on sawhorses, cleaned pallets, or polyethylene plastic sheets following steam cleaning. Direct contact with the ground will be avoided. The back of the drill rig, augers, rods, and tools will be cleaned between each drilling location according to the above procedures. Cleaning water will be managed in accordance with the MMP.

Unless sealed in manufacturers packaging, polyvinyl chloride (PVC) monitoring well casing and screens will be cleaned by the above procedures before installation.

Sampling Equipment Cleaning

Prior to collecting samples to be submitted for chemical analysis, all non-dedicated sampling equipment (e.g., bowls, spoons, hand augers, pumps, and filtering equipment) will be washed with potable water and a non-phosphate detergent (such as Alconox). Cleaning may take place at the sampling location as long as all liquids are contained in pails, buckets, etc. The sampling equipment will then be rinsed with potable water, followed by a 10 percent “pesticide-grade” methanol rinse, and finally a distilled water rinse. When sampling for inorganic constituents in an aqueous phase, an additional rinse step will be added prior to the rinse with methanol. The rinse step will entail a rinse with a 10 percent “ultra pure-grade” nitric acid followed by a distilled water rinse. Between rinses, equipment will be placed on polyethylene sheets or aluminum foil if necessary. At no time will cleaned equipment be placed directly on the ground. Equipment will be either be used immediately or wrapped in plastic or aluminum foil for storage or transportation from the designated cleaning area to the sampling location.

Personnel Cleaning

Where and whenever possible, single-use, external protective clothing must be used for work when there is potential exposure to site-related constituents. This protective clothing must be disposed of in properly labeled containers. Reusable protective clothing will be rinsed at the site with detergent and water. The rinsate will be collected for disposal. Additional guidelines regarding PPE and personnel cleaning are included in the HASP.

7 Drilling Methods

The drilling subcontractor may employ a variety of methods to advance a boring for well installation. The appropriate method will depend on the nature of the subsurface, the objectives of the drilling location, and the specific data needs. Where not specified in the work plan, the project manager will be responsible for selecting the appropriate method. The drilling methods that may be used at the site are described briefly below. Regardless of the method, drilling must comply with the NAPL Contingency Plan (Section 4).

Hollow-Stemmed Augers (HSA), Driven Casing, and Spun Casing

Hollow-stemmed augers are available in several sizes. The appropriate auger diameter will depend on the intended use of the boring. For installing a 2-inch diameter monitoring well, 4 ¼-inch inside diameter augers will be the minimum size used. For installing larger-diameter wells or steel casings (e.g., for bedrock wells), the outside auger diameter must be selected to provide adequate annular space for the well materials (generally 4-inches greater in diameter than the casing or screen).

Driven or spun flush-joint casing may also be used in the overburden, generally where using HSA is not feasible (e.g., through previously installed steel casing). With the driven-casing method, the driller advances an open bottomed steel casing through the overburden, generally using a 300-lb hammer. The soil driven inside the casing is drilled out using a roller-bit and a potable supply of drilling water. With the spun-casing method, the flush-joint casing is spun with water added as the drilling fluid to break up unconsolidated material and return it to the surface. For both casing methods, all drilling water and cuttings returned to the surface will be contained. The diameter of flush-joint casing must be selected to provide adequate annular space for the well materials.

At both HSA and flush-joint casing borings, soils will be sampled according to the Standard Penetration Test (ASTM D 1586 84) using steel split-barrel samplers (split-spoons), if required by the scope of work. Where split-spoons are used, samples will be collected continuously at 2-foot intervals, each driven 2 feet or to refusal by repeated blows with a 140-lb hammer. Retrieved soil samples will be classified and logged as indicated in Section 8.

Rotosonic

Rotosonic drilling may be used as an alternative to HSA or driven casing, to drill through overburden and bedrock while simultaneously collecting soil samples. The rotosonic method uses a flush-joint casing advanced by high frequency vibrations. As the casing advances, soil is driven into retrievable liners inside the casing. At regular intervals (generally 5 or 10 feet), the liners are retrieved and opened. The soil retrieved will be classified and logged as indicated in Section 8.

Fluid Rotary

Fluid rotary may be used in both the overburden and in bedrock. This method uses a tri-cone roller bit to advance an uncased boring, commonly using water as the drilling fluid. To keep the boring open and recover drilling cuttings, a bentonite drilling mud rather than water may be used. It is anticipated that fluid rotary's principal use at the site will be to drill rock-sockets for the installation of casing, ream coreholes, or to drill through bedrock where coring is not required. In bedrock, water may be an adequate drilling fluid, and will be used if feasible. Fluid rotary's principal use in the overburden, if needed, would be for drilling borings where sampling is not required and where no monitoring well is expected to screen the drilling interval (e.g., to set a casing across the overburden for a bedrock well).

Bedrock Coring

For all but the rotosonic method, bedrock coring will be completed using a conventional or wire-line corer with and HQ or NX-sized diamond bit and core-barrel. By this method, a continuous core of the rock is retrieved in an inner sleeve as the core-barrel advances through the rock. Coring will be conducted in 5- or 10-foot runs, using water as a drilling fluid. Water may be recirculated as feasible, unless visible impacts are observed in the return water (e.g. NAPL or sheens). At the conclusion of each run, the driller will remove the inner sleeve and place the retrieved core in wood boxes with increasing depths aligned left to right and core runs separated by wood blocks.

The rotosonic method requires no special apparatus; rock cores are collected in the same fashion as soil cores. Given the larger diameter of cores produced by this method, larger core boxes are required.

Recovered rock core will be classified and logged as indicated in Section 9.

8 Soil Classification and Logging

A BBL geologist will classify and log all soil samples collected.

The geologist will assess each soil sample and make a field judgment of the soil type (including relative amounts of components), color, density, apparent structures, moisture content, obvious odors, and any indications of contamination (site-related or otherwise). Field assessments will pay particular attention to evidence of impacts, including suspect fill materials, staining, sheens, and NAPL. To the extent feasible, NAPL will be classified according to consistency (e.g., oil-like or tar-like), color, relative viscosity, density (LNAPL or DNAPL), general odor, and apparent quantity (e.g., whether the NAPL is present in isolated blebs, or present filling a significant portion of the available soil porosity). Other industrial fills materials (e.g., coal, ash, clinker, etc.) will be noted with as much detail as feasible.

In addition to the written classification, soil logging will incorporate the following:

- A record of sample recoveries, blow-counts (if applicable), and any notable changes in drilling characteristics.

- Headspace readings from all sampled intervals. Representative soil samples will be placed in a quart-sized air-tight plastic bag, and allowed to sit for at least 2 minutes. The relative VOC headspace concentration will then be assessed using a photoionization detector (PID). For rotosonic borings, headspace samples will be selected from discrete intervals of the retrieved core, not to exceed 5 feet.

- Photographs of selected representative soil samples for better documentation observed types of impacts and lithologic variety.

- A record of which samples were submitted for laboratory analyses, and any rationale, if appropriate.

If laboratory analysis is required; additional soil sample collection and handling requirements will apply. These requirements will be provided in a separate SOP or Quality Assurance Project Plan.

9 Bedrock Classification and Logging

While coring, the supervising geologist will track and record the drilling rate (feet per minute), changes in the water circulation rate, and any indications of sheens or NAPL in the return water.

After each run, bedrock core samples will be placed in wood boxes with increasing depths aligned left to right and core runs separated by wood blocks. Man-made breaks will be marked with a pen across the break. Wood blocks will be labeled and placed at the end of each core run to indicate run. A wooden spacer will be inserted if no sample is recovered and labeled "L.C." (lost core) with corresponding depth. The core box will be labeled on the outside top and inside lid for:

- Client,
- Date,
- Job number,
- Boring number,
- Run number,
- Run interval, and
- Box number/total box number.

The supervising geologist is responsible for recording rock core mechanical and geological characteristics. The mechanical characteristics will include:

- Penetration rates;
- Rock quality designation (RQD);
- Percent recovery;
- Water loss; and
- Bit type and size.

A geologic classification will include the following parameters:

- Lithology;
- Friability/fissility;
- Color;
- Strength of intact rock;
- Thickness;
- Weathered state;
- Particle angularity/shape;
- Voids;
- Particle sizes;
- Structure/bedding (bedding planes, joints, fractures);
- Description of discontinuities and filings;
- Rock type;
- Formation name (if known);
- Additional petrographic information;
- Water content;
- Texture;
- Odors/discoloration;
- Hardness;
- Fossils;
- Color; and
- Contacts when observed.

10 Monitoring Well Installation

Monitoring wells will be installed in borings completed to their target depth by the drilling, sampling and characterization methods described above. The following procedure for well installation assumes that the boring has been completed in compliance with the NAPL Contingency Plan (Section 4), and that the rationale for completion depth, screened interval, and any unique well construction requirements (e.g. greater casing diameter), have been provided in the governing work plan or scope of work.

- Where DNAPL has been observed, monitoring wells will be constructed of 2-inch diameter stainless steel, with 0.010-inch slotted wire-wrap screens.
- Where DNAPL is not present, monitoring wells may be constructed of 2-inch diameter schedule 40 PVC, with 0.010-inch machine-slotted screens.
- Well materials will be inspected and, if needed, steam-cleaned prior to installation.
- Screen lengths will be 10 feet, unless stratigraphic constraints make a longer or shorter well screen appropriate.
- Well centralizers may be used for wells greater than 75 feet deep.
- A silica filter sand pack will be installed in the well annulus extending at least 1-foot above the screened interval, if feasible.
- A bentonite chip seal of at least two feet will be installed in the annular space above the sand pack.
- The driller will monitor the placement of the sand pack and bentonite with a weighted tape measure.
- Cement/bentonite grout or additional bentonite chips may be used above the seal to fill the remaining annular space to near grade.
- Wells will be installed with locking stick-up steel protective surface casings, set in concrete pads of at least 2 feet by 2 feet. Flush-mounted bolting steel road-boxes may be used if a stick-up casing is not feasible.

Where DNAPL is observed, wells may be completed with grouted sumps of 2 or more feet, as indicated in the NAPL Contingency Plan (Section 4, above). Sumps will be installed as follows:

- Using a tremie pipe, the driller will pump a volume of cement/bentonite grout into the boring appropriate to fill the annular space of the sump up to the bottom of the screen.
- With the grout in place in the boring, the assembled stainless steel sump, screen and riser assembly is lowered into place.
- After allowing adequate time for the grout to harden (so that it can support the weight the sand pack), the remainder of the well may be installed as for a conventional monitoring well.

DNAPL monitoring wells may also use 0.020-inch slotted screens and appropriately-sized sand to promote DNAPL recovery, if appropriate for the screened formation.

11 Data Recording and Management

BBL's field supervisor will maintain a field notebook as a record of the field program. With respect to monitoring well installation, the following details will be recorded:

- Personnel present and involved in drilling and well installation;
- A description of the location and identification of all locations, with taped position measurements if appropriate;
- All subsurface classifications and related data;
- Rationale for field decisions, as appropriate;
- Deviations from the stated procedures in the work plan or SOPs;
- Any health and safety incidents or "near-misses"; and
- As-built well construction details, including measurements and materials used (e.g., screen and riser footages; bags of bentonite, cement, and sand) for all wells completed.

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Appendix E

Monitoring Well Development
Standard Operating Procedure

Monitoring Well Development Standard Operating Procedure

1 Scope and Application

All monitoring wells and piezometers that yield sufficient water will be developed to repair (to the extent practicable) damage to the formation caused by drilling and to remove fine-grained sediments and any drilling fluids so that the screen is transmitting groundwater representative of the surrounding formation. Development will be accomplished by surging (using a surge block, where possible) and evacuating well water using one of the following methods:

- electric submersible pump;
- inertial pump (e.g., Waterra™ pump);
- peristaltic pump; or
- bailing.

2 Equipment List

Materials for monitoring well development using a pump include:

- personal protective equipment (PPE) and any other safety equipment required by the site-specific Health and Safety Plan (HASP);
- cleaning equipment;
- photoionization detector (PID) to measure headspace vapors (if required);
- polyethylene tubing (discarded properly between well locations);
- plastic sheeting;
- water level meter and/or oil/water interface probe;
- power source (generator or battery);
- field notebook;
- graduated pails;
- pump;
- appropriate containers; and
- monitoring well keys.

Materials for monitoring well development using a bailer include:

- personal protective equipment (PPE) as required by the HASP;
- cleaning equipment;
- PID to measure headspace vapors (if required);
- water level meter and/or oil/water interface probe;
- bottom-loading weighted bailer;
- polypropylene rope;
- plastic sheeting;

- field notebook;
- graduated pails;
- appropriate containers; and
- monitoring well keys.

3 Procedures

The procedures for monitoring well development using a pump are described below:

1. Don appropriate PPE (as required by the HASP).

2. Place plastic sheeting on ground surface around the well.

3. Clean all non-dedicated equipment that will enter the well using a non-phosphate cleaner (e.g., Alconox) and potable water.

4. Open the well cover while standing upwind of the well; remove well cap. Insert PID probe approximately 4 to 6 inches into the casing or the well headspace and cover with gloved hand. Record the PID reading in the field notebook. If the well headspace reading is less than 5 PID units, proceed; if the headspace reading is greater than 5 PID units, screen the air within the breathing zone. If the PID reading in the breathing zone is below 5 PID units, proceed. If the PID reading is above 5 PID units, move upwind from well for 5 minutes to allow the volatiles to dissipate. Repeat the breathing zone test. If the reading is still above 5 PID units, don the appropriate respiratory protection in accordance with the requirements of the HASP. Record all PID readings.

5. Measure the depth to water and total well depth. Check for the presence of non-aqueous phase liquid (NAPL). Compare the well depth to the as-built construction details. Calculate the volume of water in the well casing.

6. Lower a surge block into the screened portion of the well on a rigid pipe or high-density tubing and cycle up and down to force water in and out of the screen slots and formation. The entire length of well screen must be surged

7. Surging may proceed for up to 30 minutes. The vigor and duration of surging should be adjusted with respect the well construction and formation type. If the formation is known to contain significant silt and clay, surging should be completely gently so as not to drawn fines into the sand pack. If NAPL is present; limit the amount of surging as a precaution against NAPL mobilization. After surging, check the total well depth and check for the presence of NAPL.

8. After surging, development will continue by pumping using dedicated polyethylene tubing or a clean electric submersible pump lowered to the screened portion of the well. The tubing/pump will be moved up and down the screened interval until the well yields relatively clear water or no significant improvement in clarity is observed. An inertial lift, peristaltic or submersible pump may be used, depending on the depth to water and required pumping rate. In most settings, pumping should be conducted at a rate high enough to create moderate drawdown (e.g., several feet). If NAPL is present, it may be advisable to use a lower pumping rate as a precaution against NAPL mobilization.

9. Development should continue until 5 to 10 well casing volumes of water have been removed, all sediment has been removed from the well bottom (if feasible), and the purge water is relatively clear. If no appreciable improvement in turbidity is realized, pumping may cease after 10 well volumes have been removed. If drilling mud or drilling water were lost during well drilling or installation, the target pumping volume may be increased to help recover the added fluids.

10. If well runs dry, shut off pump and allow well to recover. Iterative pumping and recovery cycles may be completed, as feasible.

11. Contain all water in appropriate containers.

The procedures for developing a well using the bailer method are outlined below

1. Don appropriate PPE (as required by the HASP).

2. Place plastic sheeting on ground surface around the well.

3. Clean bailers and attach new rope (or attach new rope to a dedicated/disposable bailer).

4. Open the well cover while standing upwind of the well; remove well cap. Insert PID probe approximately 4 to 6 inches into the casing or the well headspace and cover with gloved hand. Record the PID reading in the field notebook. If the well headspace reading is less than 5 PID units, proceed; if the headspace reading is greater than 5 PID units, screen the air within the breathing zone. If the breathing zone reading is less than 5 PID units, proceed. If the PID reading in the breathing zone is above 5 PID units, move upwind from well for 5 minutes to allow the volatiles to dissipate. Repeat the breathing zone test. If the reading is still above 5 PID units, don appropriate respiratory protection in accordance with the requirements of the HASP. Record all PID readings.

5. Measure the depth to water and total well depth. Check for the presence of NAPL. Compare the well depth to the as-built construction details. Calculate the volume of water in the well casing.

6. Lower bailer into well until bailer reaches the bottom of the well.

7. Surge by raising and lowering the bailer at 2-foot intervals at least 10 times for each 2-foot section of the well screen.

8. After surging, begin bailing the well from various depths in the water column.

9. Development should continue until 5 to 10 well casing volumes of water have been removed, all sediment has been removed from the well bottom (if feasible), and the purge water is relatively clear. If no appreciable improvement in turbidity is realized, bailing may cease after 10 well volumes have been removed. If drilling mud or drilling water were lost during well drilling or installation, the target purge volume may be increased to help recover the added fluids.

10. After purging, measure the depth to water, total well depth, and check for the presence of NAPL. Confirm that the total depth matches the as-built well depth within a reasonable tolerance. If a discrepancy exists, note it, and evaluate it to the degree feasible. Continue development if necessary.

4 Waste Management

Investigation derived waste (IDW) generated during well development may include the following:

- Disposable equipment (including PPE); and
- All purged groundwater and water generated during equipment cleaning.

Disposable equipment will be placed in containers (e.g., 55-gallon drums) and appropriately labeled with contents, date, and source. These materials may be characterized for offsite disposal, or staged for subsequent placement into the Corrective Action Management Unit containment cell (depending upon the timing of the work). Groundwater and equipment-cleaning water will be transported to the influent tank of the onsite wastewater treatment system for treatment.

5 Data Recording and Management

Date and time of well development, methods used, fluid depths, total depth of well, relative appearance prior to and after well development, volume of fluids removed, and any other pertinent information shall be recorded in the field notebook.