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**PRE-DESIGN INVESTIGATION WORK PLAN
CORRECTIVE MEASURES**

**FORMER COKE OVEN AREA
SPARROWS POINT TERMINAL, LLC
BALTIMORE COUNTY, MARYLAND**

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TABLE OF CONTENTS

1.0 INTRODUCTION 1

1.1 Site Description 1

1.2 Site Ownership History 2

1.3 Regulatory Authority..... 2

1.4 Work Plan Basis 3

1.5 Description of Interim Measures 3

1.6 Work Plan Outline..... 9

2.0 PROJECT OBJECTIVES 10

2.1 General Objective..... 10

2.2 Specific Objectives..... 10

3.0 AVAILABLE INFORMATION AND SCOPE OF WORK 12

3.1 Conceptual Site Model 13

3.2 Scope of Work..... 16

3.3 Sampling Summary and Analytical Methods..... 25

3.4 Data Quality Objectives 26

4.0 REPORTING 30

4.1 Internal Reporting..... 30

4.2 External Reporting 30

5.0 PROJECT SCHEDULE..... 31

6.0 REFERENCES..... 32

APPENDICES

- A Health and Safety Plan
- B Standard Operating Procedures
- C Historical Groundwater Contour Maps (Shallow and Intermediate Zone)
- D Historical Benzene and Naphthalene Isoconcentration Contour Maps
- E Monitoring Well Designation Revisions

TABLES

- 1 Summary of Investigative Components
- 2 Summary of Wells to be Included in Supplemental Monitoring Program
- 3 Summary of VOC and SVOC Quantitation Limits

FIGURES

- 1 Site Location Map
- 2 Historical General Arrangement - Coke Oven Area
- 3 Subsurface Utility Lines
- 4 Current General Arrangement - Coke Oven Area
- 5 Interim Measure Configuration - Cell 1
- 6 Interim Measure Configuration - Cell 2
- 7 Interim Measure Configuration - Cell 3
- 8 Interim Measure Configuration - Cells 4 and 5
- 9 Interim Measure Configuration - Cell 6
- 10 Investigation Locations and Scope - Cells 1 and 2
- 11 Investigation Locations and Scope - Cell 3
- 12 Investigation Locations and Scope - Cells 4 and 5
- 13 Investigation Locations and Scope - Cell 6
- 14 Investigation Locations and Scope - Comprehensive Monitoring Program

ACRONYMS/ABBREVIATIONS

COI	Constituents of Interest
DNAPL	Dense Non-Aqueous Phase Liquid
EAG	EnviroAnalytics Group, LLC
IM	Interim Measure
KEY	Key Environmental, Inc.
LNAPL	Light Non-Aqueous Phase Liquid
MDE	Maryland Department of the Environment
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PAH	Polycyclic Aromatic Hydrocarbons
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SCCP	Site Conceptual Cleanup Plan
SPLLC	Sparrows Point, LLC
SPT	Sparrows Point Terminal, LLC
SVOCs	Semivolatile Organic Compounds
SOP	Standard Operating Procedure
SWMU	Solid Waste Management Unit
TCLP	Toxicity Characteristic Leaching Procedure
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

1.0 INTRODUCTION

This pre-design investigation work plan for the former Coke Oven Area at the Sparrows Point Terminal, LLC property has been prepared by Key Environmental, Inc. on behalf of EnviroAnalytics Group, LLC. This work plan provides for the collection of data necessary to evaluate potential corrective measures for the Coke Oven Area, with specific emphasis on various impacted areas that have been identified as a result of multiple prior investigations. Various Interim Measures (IMs) have been implemented at these impacted areas, as subsequently discussed.

The intent of the data collection activities specified in this work plan is to provide proof-of-concept information regarding potential responses such that the existing IMs may be supplanted, supplemented, or improved/expanded upon to ultimately result in a final remedy for the Coke Oven Area that complies with the requirement of the Resource Conservation and Recovery Act (RCRA) and the Maryland Voluntary Cleanup Program (VCP). In addition, this work plan specifies the scope of work necessary to characterize current groundwater conditions for the Coke Oven Area and the proximate surrounding area.

The remainder of this introduction provides a brief description of the site, a summary of relevant site ownership history, a discussion of the regulatory authority for the environmental responses at the site, a review of the basis for the scope of work specified in this work plan, a description of the existing IMS, and an outline for the remainder of the work plan.

1.1 Site Description

The Sparrows Point Terminal, LLC property is located on Sparrows Point in Baltimore County, Maryland as depicted Figure 1 which was prepared from the United States Geological Survey Curtis Bay and Sparrows Point 7.5 minute quadrangles. The former Coke Oven Area comprises approximately 180 acres and was historically the location of the integrated mill's coke ovens and coal chemical byproduct plants. The historical configuration of the coking operations at the mill is shown on Figure 2 which depicts the coal conveyors, the coke batteries, and various byproduct processing areas including the light oil recovery plant and biological wastewater treatment plant. Figure 3 depicts various subsurface utilities which exist in the area, specifically the alignments of storm sewers, sanitary sewers, former process water lines, potable water lines, and natural gas lines. A description of the coking operations and the coal chemicals byproduct operations is provided in the Final Phase II RCRA Facility Assessment (RFA) Report dated August 12, 1993 (ATK, August 1993). Coking operations ceased at the site in 1991. The coke ovens and the byproduct plant have been demolished and no surface structures associated with the former operations remain. The recent condition of the Coke Oven Area is depicted on an aerial photograph dated October 2013 which is provided as Figure 4. As is shown on Figure 4, very few

structures remain in the Coke Oven Area and none of these were related to coke production or byproduct processing.

1.2 Site Ownership History

Bethlehem Steel Corporation (BSC) operated an integrated steelmaking facility at the site from approximately 1916 through 2003. As a result of multiple market factors, BSC declared bankruptcy in 2001 and the facility was subsequently operated by a succession of owners, the last of which (RG Steel Sparrows Point, LLC) filed for bankruptcy in 2012. The site was subsequently purchased by Sparrows Point, LLC (SPLLC) at a bankruptcy sale on August 7, 2012. Sparrows Point Terminal, LLC (SPT) purchased the real property on September 18, 2014 subject to the provisions of a Purchase and Sale Agreement wherein SPLLC and SPT have allocated various environmental responsibilities, liabilities, and obligations among themselves.

1.3 Regulatory Authority

Environmental responses for the Coke Oven Area, and for the site in general, are being implemented pursuant to the following:

- Multimedia Consent Decree between Bethlehem Steel Corporation, the United States Environmental Protection Agency, and the Maryland Department of the Environment (effective October 8, 1997); this Consent Decree has been modified in accordance with a stipulated order entered into by Sparrows Point LLC and the respective agencies effective July 28, 2014
- Administrative Consent Order (ACO) between Sparrows Point Terminal, LLC and the Maryland Department of the Environment (effective September 12, 2014);
- Settlement Agreement and Covenant Not to Sue (SA) between Sparrows Point Terminal, LLC and the United States Environmental Protection Agency (effective November 25, 2014).

The original Multi-Media Consent Decree (Decree) for the Sparrows Point facility dealt with many issues associated with ongoing iron-making, steel-making, coking, byproduct, plating, and finishing operations. To the extent that these operations are no longer conducted, and the associated facilities no longer exist, many specific requirements of the Decree are no longer applicable and have been removed in accordance with the stipulated order implementing modifications to the Decree. Nonetheless, the aforementioned ACO and SA incorporate the relevant aspects of the Decree by reference.

1.4 Work Plan Basis

This work plan has been prepared based on review of historical information contained in numerous reports. The USEPA and the MDE maintain websites related to the site and multiple documents that constitute a portion of the administrative record for the site are available at the following web pages:

- <http://www.epa.gov/reg3wcmd/ca/md/webpages/mdd053945432.html>
- <http://www.mde.state.md.us/programs/Land/MarylandBrownfieldVCP/ERRP/Superfund/Pages/sparrowspt.aspx>

In addition, this work plan has been developed in view of the conceptual approach for site cleanup as specified in a Site Conceptual Cleanup Plan (SCCP) dated August 29, 2014 (EAG, August 2014a). Furthermore, a project scoping meeting was held with the USEPA and MDE on November 19, 2014. Comments, observations, and suggestions offered by USEPA and MDE representatives during the project scoping meeting have been considered and incorporated during preparation of this work plan.

1.5 Description of Interim Measures

As previously discussed, IMs are in place for primary areas of interest for the Coke Oven Area. A brief description of the IMs for each of the areas of interest (i.e., Cells) is provided in the remainder of this subsection.

Cell 1 – Cell 1 is located at the western edge of the former light oil processing area of the byproduct coke plant. The IM for this area was installed and placed on line in 2010 and consists of an air sparging and soil vapor extraction (AS/SVE) system to address dissolved phase constituents in groundwater (primarily benzene from the benzol (benzene recovery) plant, but also other constituents typically associated with light oil recovered from coke oven gas – toluene, ethylbenzene, and xylenes). The general configuration of the Cell 1 IM is depicted on Figure 5. As shown, a total of sixteen (16) air sparge wells and fifteen (15) soil vapor recovery wells exist in the Cell 1 Area. Based on performance monitoring information, system operation has been optimized and eight (8) air sparging wells and six (6) soil vapor extraction wells are currently operated in the Cell 1 area.

The soil vapor collected via the vacuum system is thermally treated via catalytic oxidation using a mobile treatment unit located adjacent to the sparge/vapor recovery well field and is discharged to the atmosphere in accordance with an air permit. As of the most recent quarterly report (EAG, August 2014b), it is estimated that a total of 12,275 lbs of volatile organic hydrocarbons have been

recovered and destroyed in the Cell 1 area to date with an estimated 231 lbs recovered and destroyed during the most recent (reported) quarter. Data obtained during the 3rd quarter 2014 indicate that 12,422 lbs of hydrocarbons have been destroyed with a quarterly total of 146.7 additional lbs (quarterly report in preparation). The AS/SVE system at Cell 1 was initially operated on a continuous basis. Currently, the system is operated on an intermittent basis wherein the system is run for approximately one day and is idled for two to three days to allow for rebound. The pulsed operation has been determined to be more effective for hydrocarbon recovery than continuous operation.

The primary component in the recovered vapor is benzene which was measured at an air phase concentration of 302.4 mg/m³ in June 2014 and 282.2 mg/m³ in September 2014. The average benzene concentration for the most recent groundwater samples (June and September 2014) from the Cell 1 area [as measured for monitoring wells CO02-PZM006, CO18-PZM006, and BP-MW-09 (CO93-PZM)] was approximately 130 mg/L in June and 83.5 mg/L in September. Historically, the benzene concentration for samples from these three wells averaged approximately 568 mg/L as demonstrated by samples obtained in July, August, and September 2010 (URS, October 2010). Consequently, it is apparent that a significant reduction in benzene concentrations has been realized in the Cell 1 Area between 2010 and 2014. Additional discussion of the results for monitoring well BP-MW-09 (CO93-PZM) is provided in the Cell 6 discussion as this well is downgradient of Cell 6.

Cell 2 – Cell 2 is located within a former coal storage area adjacent to a surface water inlet historically used for the offloading of raw materials. Installation of various components of an IM for Cell 2 was completed in September 2014. The IM consists of a combination of an AS/SVE system for the shallow groundwater and groundwater pumping and treatment for the intermediate zone groundwater.

The AS/SVE system consist of eight (8) air sparge points and a recovery trench equipped with 500 feet of perforated pipe and five (5) vertical risers (soil vapor extraction points). The intermediate zone system consists of six (6) groundwater pumping wells. The general arrangement of the IM for Cell 2 is depicted on Figure 6. The Cell 2 system was placed in operation in October 2014 and is currently in the final stages of shakedown to optimize water and air flow rates and to address any conditions that may affect system performance.

Soil vapor recovered via the SVE system is currently treated via catalytic oxidizer and is discharged to the atmosphere in accordance with the requirements of an air permit. Groundwater is treated via stripping in a shallow tray, low profile air stripper and is discharged to an infiltration well field consisting of six (6) wells screened in the shallow groundwater zone as is depicted on Figure 6. Groundwater treatment and discharge is conducted in accordance with the requirements

of MDE State Discharge Permit. The air stream from the stripper is treated in the catalytic oxidizer.

Historically, concentrations of the primary dissolved phase constituent (benzene) in Cell 2 area groundwater samples ranged as high as 42 mg/L in the shallow zone and 390 mg/L in the intermediate zone as evidenced by samples obtained in the summer of 2004 from a well cluster (CO27-PZM012 and CO27-PZM046) located immediately downgradient of the current location of the Cell 2 treatment zone (URS, January 2005). As part of the IM for Cell 2, additional shallow and intermediate zone groundwater monitoring wells were installed to support monitoring of the effectiveness of the IM. These wells have been sampled since installation as part of performance monitoring. Benzene concentrations measured in November 2014 samples from the new wells ranged as high as 111 mg/L in the shallow well samples [Cell 2-MW6 (S) (CO41-PZM001)] and 437 mg/L in the intermediate well samples [Cell 2 MW-12 (I) (CO41-PZM036)]. The benzene concentration measured in the November 2014 sample from CO27-PZM012 was 22.6 mg/L. This result may be indicative of a relatively rapid reduction as a result of air sparging (versus the 2005 result of 42 mg/L) or may simply be attributable to temporal variability associated with seasonal fluctuations. It is also noteworthy that the accumulation of a small quantity of LNAPL (2 inches or ~0.03 gallons in a 2-inch well) was observed in new shallow well Cell2-MW2(S) (CO37-PZM003) during the 2014 sampling program

Cell 3 – Cell 3 is located in the southwestern portion of the Coke Oven Area in a location historically referred to as the “Cove” area. A surface water “inlet” exists immediately south of Cell 3. The inlet is an area where slag fill was not placed during expansion of the Coke Point area. Installation of an AS/SVE system in the Cell 3 area was completed in 2010 to address dissolved phase groundwater impacts in the shallow water bearing zone. The AS/SVE system consist of fourteen (14) air sparge points on 40-foot centers and a recovery trench equipped with approximately 600 feet of perforated pipe and five (5) vertical risers (soil vapor extraction points). The general arrangement of the IM for Cell 3 is depicted on Figure 7. The system was placed in operation in August of 2010.

Soil vapor recovered via the SVE system is currently treated via vapor phase carbon and is discharged to atmosphere in accordance with the requirements of an air permit. As summarized in the most recent IM progress report (EAG, August 2014b), it is estimated that 1,402 lbs of hydrocarbons have been destroyed via operation of the Cell 3 AS/SVE system with a total of 6.4 lbs destroyed during the most recent reported quarter. Additional data collected since the most recent report indicates a total of 1,428.6 lbs of hydrocarbons destroyed with an additional 26.6 lbs destroyed in the 3rd quarter of 2014. The primary component in the recovered vapor is benzene which was measured at air phase concentrations of approximately 15.7 mg/m³ and 49.8 mg/m³ in June and September 2014, respectively.

Four shallow monitoring wells were also installed as part of the IM. Groundwater samples were obtained from these wells, as well as from two other existing monitoring well locations (CO32-PZM004 and CO30-PZM15) shortly after system startup. Historical analytical results for wells located in the Cell 3 area are summarized in the design report for the Cell 3 AS/SVE system (URS, March 2011).

Concentrations in samples from four of the other wells in this area [MW-Cell 3-1 through MW-Cell 3-3 (a/k/a CO101-PZM, CO102-PZM, CO103-PZM) and CO2-PSM15] ranged from 28 mg/L to 80 mg/L with an average concentration of approximately 47 mg/L. The westernmost monitoring well [MW-Cell 3-4 (CO104-PZM)] yielded a sample with a benzene concentration of 1.5 mg/L indicating that it is located near the western edge of the Cell 3 benzene plume. The most recent sampling and analysis for the Cell 3 groundwater was completed in June and September 2014. The four monitoring wells exhibiting the greatest historical concentrations were sampled [i.e., MW-Cell 3-1 through MW-Cell 3-3 (a/k/a CO101-PZM, CO102-PZM, CO103-PZM, and CO30-PZM015), respectively]. Benzene concentrations in these samples ranged from 13.6 mg/L to 75.3 mg/L based on the June 2014 sampling and analysis (EAG, August 2014b) with an average of approximately 30 mg/L (i.e., a 36% reduction since August of 2010).

The most recent quarterly reports for the IMs are in preparation. Benzene concentrations measured in samples from the four wells of interest obtained in September 2014 ranged from 18 mg/L to 237 mg/L with an average of approximately 92 mg/L. A significant increase was noted for monitoring well MW-Cell 3-3 (CO103-PZM) which increased from 14 mg/L in June to 237 mg/L in September. It is possible that the observed increase for this well was a delayed response to significant rainfall in the month of April 2014 which came within 1/10th of an inch of setting a record for Baltimore (4.3 inches of rain fell on April 29 and April 30, 2014). Another round of sampling was completed for Cell 3 in November 2014. Concentrations ranged from 17.7 mg/L to 73.7 mg/L and averaged approximately 41 mg/L. The benzene concentration detected in the sample from MW-Cell 3-3 (CO103-PZM) declined to 48 mg/L (from 237 mg/L in September 2014).

Although the benzene concentrations in the Cell 3 area shallow groundwater have generally been lower than those in the Cell 1 area, the Cell 3 AS/SVE system does not appear to be performing as well as the Cell 1 system. While some reductions are evident for monitoring wells MW-Cell 3-1 and MW-Cell 3-2 (CO101-PZM and CO102-PZM, respectively), concentrations for downgradient well samples (CO30-PZM015) have remained fairly consistent over time (~80 mg/L). Furthermore, substantial fluctuations have been observed for samples from monitoring well MW-Cell 3-3 (CO103-PZM).

Cell 4/5 – Cells 4 and 5 – Cells 4 and 5 are located in the southwestern corner of the Coke Oven Area in the vicinity of the former coal tar recovery operations. Historically, an attempt to address

dissolved phase impacts (primarily benzene, toluene, and naphthalene) via bioaugmentation (nutrient addition) was conducted for the Cell 4 area. This attempt proved to be ineffective, likely as a result of the elevated pH of the groundwater.

Recently (October 2014), a dual phase extraction system was installed and started up as an alternative remedial approach. Cells 4 and 5 are being addressed as one operable unit for this approach. A total of twelve (12) dual phase extraction wells (vapor and groundwater) were installed. The recovered vapors and groundwater are treated via a combination of air stripping and carbon absorption. Vapor and the air stream from the stripper are treated using vapor phase carbon subject to the requirements of an air permit. Treated groundwater is returned to the subsurface via a reinjection well field subject to the requirements of a State Discharge Permit. The general configuration of the Cell 4/5 IM is depicted on Figure 8.

Historically, concentrations of dissolved phase constituents in the Cell 4/5 area have been on the order of 5.3 mg/L (benzene), 4.0 mg/L (toluene), and 22 mg/L (naphthalene). These concentrations were reported for a sample from a well located in the center of the Cell 4 area [AS-2 (CO112-PZM)]. Recent concentrations (June 2014) for a sample obtained from this well were 5.65 mg/L (benzene), 3.38 mg/L (toluene), and 245 mg/L (naphthalene) which is indicative of the ineffectiveness of the bioaugmentation approach. Further, it should be noted that the recent reported naphthalene concentration exceeds its pure component solubility limit (30 mg/L). This result indicates that it is likely that DNAPL droplets were entrained in the sample. As data are compiled for the current IM (i.e., the dual phase recovery system) analytical data will be evaluated to determine if the current approach is more effective for the area. Source control (i.e., DNAPL recovery) also appears to be appropriate based on the observations for well AS-2 (CO112-PZM).

Cell 6 – Cell 6 – Is located in the former benzene and light oil processing portion of the Coke Oven Area byproduct plant. Cell 6 constitutes a primary source area for dissolved phase groundwater impacts in the Coke Oven Area as a result of the presence of a Light Non-Aqueous Phase Liquid (LNAPL) body at the capillary fringe above the water table. An IM has been implemented in the Cell 6 area to recovery LNAPL. The IM was initiated in July 2010 and consists of LNAPL skimming from monitoring and recovery wells located in the Cell 6 area. As of the most recent quarterly report (EAG, August 2014b), almost 80,000 lbs of LNAPL had been recovered via skimming operations. The general arrangement of the Cell 6 area is depicted on Figure 9. A summary of LNAPL apparent thicknesses measured during the most recent reporting period is as follows:

- RW-01 (CO96-PZM) 0.11 feet
- RW-02 (CO97-PZM) 0.13 feet
- BP-MW-08 (CO92-PZM) 0.25 feet
- BP-MW-05 (CO89-PZM) 0.96 feet

- RW-03 (CO98-PZM) 1.91 feet
- RW-04 (CO99-PZM) 3.02 feet
- BP-MW-11 (CO95-PZM) 5.99 feet
- BP-MW-10 (CO94-PZM) 8.47 feet

LNAPL was not observed in wells RW-02 (CO97-PZM), RW-05 (CO100-PZM), BP-MW-07 (CO91-PZM), BP-MW-06 (CO90-PZM), BP-MW-09 (CO93-PZM), or CO19-PZM004 during the most recent reporting period. The LNAPL thickness reported above do not provide a direct indication of the thickness of the actual LNAPL body in the Cell 6 area. LNAPL typically exists above the water table and will enter the screens of partially-penetrating wells and depress the water level in the well as LNAPL accumulates. This is evident via consideration of the most recent reported results of LNAPL and water level measurement for the preceding wells (June 14, 2014), which are as follows:

Well Number	Depth to LNAPL (ft)	Depth to Water (ft)	Apparent Thickness (ft)
RW-01 (CO96-PZM)	10.8	10.91	0.11
RW-02 (CO97-PZM)	9.99	10.12	0.13
RW-03 (CO98-PZM)	8.69	10.60	1.91
RW-04 (CO99-PZM)	8.65	11.67	3.02
BP-MW-05 (CO89-PZM)	10.55	11.51	0.96
BP-MW-08 (CO92-PZM)	11.76	12.01	0.25
BP-MW-10 (CO94-PZM)	7.45	15.92	8.47
BP-MW-11 (CO95-PZM)	12.01	18.00	5.99

The preceding wells are located in a relatively small area with flat topography and one would expect that the water levels would be relatively consistent for the various wells (within a couple of feet). However, the water levels for some wells [most notably BP-MW-10 (CO94-PZM) and BP-MW-11 (CO95-PZM)] are substantially depressed (by four to either feet versus the other wells) which is evidence of the water table depression exerted by the LNAPL once it enters the wells. For comparative purposes, the water levels in these wells prior to the accumulation of LNAPL were reported to be on the order of 7.60 to 7.96 feet [BP-MW-10 (CO94-PZM)] and 10.79 to 11.61 feet [BP-MW-11 (CP95-PZM)] during a 5 week study completed in December 2011 (URS, January 2011). Further evaluation of the relationship between apparent LNAPL thickness and actual LNAPL thickness, distribution, recoverability and residual saturation may be helpful. API published modeling tools (LDRM) or similar may be employed as appropriate to better define LNAPL properties and to guide future recovery efforts.

Some evidence of the effect of the skimming operations is offered by the analytical results for monitoring well BP-MW-09 (CO93-PZM), which is downgradient of Cell 6 and upgradient of Cell 1. BP-MW-09 (CO93-PZM) is subjected to quarterly groundwater monitoring as the

upgradient well for Cell 1. The benzene concentration in samples from this well ranged from 204 mg/L to 239 mg/L in three samples obtained in July, August, and September of 2010 (URS, October 2010). The benzene concentration reported for this well as of the most recent quarterly report was 95.8 mg/L. The apparent decrease in concentration may be a result of the combined effects of the operation of the Cell 1 AS/SVE system and LNAPL recovery in Cell 6.

1.6 Work Plan Outline

The remainder of this work plan provides detailed information regarding the pre-design investigation for the Coke Oven Area. The objectives of the investigation are described in Section 2.0. The scope of work for each of the areas of interest (i.e., Cells 1 through 6) is described in Section 3.0. Section 4.0 addresses reporting considerations for the project while the planned project schedule is discussed in Section 5.0. References are provided in Section 6.0. Various figures, tables, and appendices are also provided as appropriate to support the development and description of the scope of work.

2.0 PROJECT OBJECTIVES

As a result of extensive historical investigations, the major environmental issues for the Coke Oven Area have been identified and appropriate IMs have been implemented to address these issues as discussed in Section 1.5. An overall project objective, as well as specific objectives, has been identified for the Coke Oven Area

2.1 General Objective

The general objective of the pre-design investigation is to provide additional information to support development and implementation of a final remedy for the Coke Oven Area that is protective of human health and the environment. Various alternative approaches, or combinations thereof, are under consideration as summarized in the SCCP. Evaluation of the potential effectiveness and implementability of various responses/approaches requires that additional data be collected. This work plan identifies the additional data needs and discusses the procedures that will be employed to satisfy the data needs. In several cases, the data collection effort is geared toward a proof-of-concept approach. For example, preliminary investigation will be completed to assess the potential viability of a containment option using a slurry wall. In the event that such proof-of-concept studies demonstrate that the technology is viable, additional data (e.g., slurry wall alignment borings) would be obtained as part of detailed design.

2.2 Specific Objectives

In addition to the aforementioned general objective, specific objectives have been identified on a Cell-specific or area-wide basis and are as follows:

Cell-Specific Objectives:

- Delineate lateral extent of LNAPL in Cell 6 Area
- Delineate lateral extent of LNAPL in eastern portion of Cell 2 Area
- Assess potential communication of LNAPL between Cell 6 and Cell 2 Areas
- Assess potential recoverability of LNAPL via vacuum extraction in the Cell 6 area
- Assess potential LNAPL migration pathways (utility corridors/foundations) in the Cell 6 area
- Assess viability of containment options for Cell 1, 2, and 6
- Assess viability of bioremediation for intermediate zone groundwater (Cell 1, 2 and 6 areas)
- Investigate potential sources and dissolved phase concentrations in Cell 3 Area
- Investigate and evaluate effectiveness of Cell 1 and Cell 3 treatment systems

- Delineate lateral and vertical extent of DNAPL in Cell 4/5 Area
- Assess recoverability of DNAPL in Cell 4/5 Area (gravity separation and collection)

Area-Wide Objectives:

- Define Area-Wide groundwater elevations, flow directions, and gradients (shallow and intermediate zones)
- Define Area-Wide dissolved phase constituent concentrations (shallow and intermediate zones)

The preceding objectives will be satisfied via the consideration of historical data, including investigation results and data generated as a result of operation of the IMs, and through the collection of supplemental data during the pre-design investigation. Routine groundwater monitoring is conducted for the various Cells. Data generated as a result of the ongoing monitoring programs will be supplemented as necessary to address the Area-Wide objectives. Sampling and analysis of wells that are included in the routine monitoring and reporting activities will not be completed as part of the pre-design investigation. Rather, the most recent data obtained as a result of routine monitoring will be employed. Because temporal consistency will be necessary for groundwater level measurements as a result of water level fluctuations, it is desirable that water levels be measured over a short period of time (e.g., 48 hours or less given the number of wells that exist in the Coke Oven Area and the surrounding areas). Consequently, a comprehensive round of water level (and LNAPL/DNAPL) measurements will be conducted regardless of the availability of routine monitoring data.

3.0 AVAILABLE INFORMATION AND SCOPE OF WORK

This section provides a brief summary of available information and the planned scope of work for each of the areas of interest (Cells) in the Coke Oven Area. A brief discussion of the conceptual understanding of the site is provided and the scope of work for each cell is summarized. Graphics depicting the planned scope of work area provided for each area of interest.

The scope of work for the Coke Oven Area is designed to be flexible in nature. Although locations of borings for delineation purposes have been identified on a preliminary basis, these locations may be adjusted based on conditions encountered in the field. Some areas may be inaccessible as a result of ongoing operations (e.g., scrap or processed slag management) or refusal might be encountered as a result of the presence of foundations.

In addition, the intent of the investigatory efforts, particularly for LNAPL delineation, is to develop a thorough understanding of the distribution of the impacts. Consequently, additional borings may be deemed to be necessary as the field work progresses. In addition, some borings that are planned for completion at this time might be eliminated from the boring program if other borings closer to suspected source areas indicate that source material is not present.

The flexible nature of the field investigation efforts will require routine communications between the field crew and project management staff, and real-time information will be considered to focus and streamline the investigative process. Rotasonic drilling is planned to provide good continuous core samples and hence many of the borings are likely to be completed quite rapidly. Consequently, communication will be necessary on a daily (if not an hourly) basis as various aspects of the investigative work progresses.

The scope of work for the Coke Oven Area as presented herein is supplemented by additional project planning documents. Specifically, a task-specific Health and Safety Plan (HASP) has been prepared for the Coke Oven Area scope of work. The HASP complies with the requirements of the Occupational Safety and Health Administration regulation 1910.120 and is provided as Appendix A. Standard Operating Procedures (SOPs) have also been developed by KEY for all aspects of field investigation and the SOPs will be utilized during the implementation of the field investigation. The SOPs are provided as Appendix B and consist of the following:

- SOP 01 – Pre-Investigation Work Tasks
- SOP 02 – Utilities Clearance
- SOP 03 – Field Logbook
- SOP 04 – IDW Management
- SOP 05 – GIS Electronic Data Deliverables
- SOP 10 – Drilling Methods for Subsurface Investigation and Well Installation

- SOP 12 – Monitoring Well Construction in Unconsolidated Formations
- SOP 13 – Monitoring Well Grouting Techniques
- SOP 14 – Well Development
- SOP 15 – Groundwater Flow Direction and Hydraulic Gradient Determination
- SOP 20 – Volatile Organic Screening
- SOP 21 – Groundwater Field Testing
- SOP 22 – Environmental Sample Preparation
- SOP 23 – Sample Handling, Preservation, Packaging and Shipping
- SOP 24 – Chain-of-Custody
- SOP 25 – Equipment Decontamination
- SOP 26 – Depth to Groundwater and NAPL Measurements
- SOP 34 – Groundwater Sampling
- SOP 36 – Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures

In the event that SOPs in addition to those listed are required for field activities, they will be identified and provided to the Field Operations Leader.

3.1 Conceptual Site Model

The scope of work for the design investigation is, in part, based on a conceptual understanding of issues related to sources, hydrogeology, and geochemistry for the Coke Oven Area. The significance of each of these issues and the overall Conceptual Site Model for the Coke Oven Area is discussed in the remainder of this subsection:

Sources

Two primary sources are believed to exist in the Coke Oven Area. The first is the light oil-related LNAPL body located in central portion of the Coke Oven Area, specifically the Cell 6 area where ongoing LNAPL recovery operations are underway via skimming from recovery wells. The second primary source is (suspected) coal tar DNAPL associated with decanting and coal tar recovery operations in the southeastern portion of the Coke Oven Area, specifically in the vicinity of Cell 4. Additional discrete, localized sources may also exist, specifically at the eastern end of the Cell 2 area given that LNAPL has accumulated to a small extent in monitoring well Cell 2-MW2 (S) (CO37-PZM003) and in the vicinity of Cell 3 given that a marked fluctuation in benzene concentrations was observed in 2014 for quarterly monitoring samples from MW-Cell 3-3 (CO103-PZM).

As previously discussed, approximately 2 inches of LNAPL has accumulated in monitoring well Cell 2-MW2 (S) (CO37-PZM003) which equates to approximately 0.03 gallon in this two inch well. Benzene concentrations for samples from MW-Cell 3-3 (CO103-PZM) were 14 mg/L, 237

mg/L, and 48 mg/L for the June, September, and November events respectively. Given that the light oil-related impact in the Coke Oven Area is predominantly benzene from the benzol operations, the effective solubility of benzene should not be substantially different from its pure component water solubility (1,780 mg/L). Hence, the detection of 237 mg/L of benzene in the September 2014 sample from MW-Cell 3-3 (CO103-PZM), which is 13% of its theoretical solubility, indicates that some free phase light oil may be present in the area.

Hydrogeology

Groundwater contour maps prepared based on historical water level measurements were reproduced from a historical report (CH2MHill, June 2002) and are provided as Appendix C. Previous groundwater studies have demonstrated that shallow groundwater flow in the Coke Oven Area is from the former upland area (i.e., the northeastern corner) toward the surrounding, tidally influenced surface water bodies (i.e., Patapsco River/ Bear Creek, and the Turning Basin). Under natural conditions, groundwater flow in the vicinity of Cell 1 and Cell 2 is primarily expected to be toward the inlet/slip to the north and to the northwest and west. Under natural conditions, shallow groundwater flow in the vicinity of Cell 3 is expected to be toward the “Cove”. Under natural conditions, groundwater flow in the Cell 4 and Cell 5 area is expected to be to the southeast toward the turning basin. Under natural conditions, shallow groundwater flow in the vicinity of Cell 6 would be expected to be radial to the west, southwest, south, and southeast.

Groundwater flow in the intermediate zone would be expected to mirror the flow in the shallow zone under natural conditions. However, Sparrows Point Shipyard operates a graving dock to the north/northwest of the Coke Oven Area which appears to significantly affect groundwater flow in the intermediate zone. The graving dock is located north of the Cell 2 shoreline has and contains a pumped underdrain system that affects the migration of constituents from the Coke Oven Area. The underdrain system is pumped aggressively to mitigate buoyant uplift forces on the structure. While a significant portion of this water likely originates from locations to the west, north, and east of the graving dock, and may in fact originate from the adjacent surface water body as a result of interconnection, a portion also likely originates from areas to the south and southeast (i.e., from the Coke Oven Area).

The effect of pumping of the graving dock underdrain is expected to be threefold. First, pumping may result in localized decreased head in the intermediate zone and consequently a downward vertical gradient from the shallow zone to the intermediate zone might be expected. Second, groundwater in the intermediate zone that would generally flow to the northwest, west, southwest and south could preferentially flow to the north and northwest toward the graving dock. Third, increased hydraulic gradients in the intermediate zone could result in greater interstitial groundwater velocities and consequently increased dissolved phase constituent migration rates.

As shown by the potentiometric surface contours provided in Appendix A, the elevation head in the intermediate zone was on the order of -1 to -2 feet above mean sea level (msl), whereas the elevation head in the shallow zone ranges from 7 feet msl to the northeast of the Coke Oven Area to -1 foot msl around the perimeter of the area. Hence, based on the measurement data obtained in 2002 (the date of the water level measurements used to generate the potentiometric surface contours in Appendix C), it is evident that a downward vertical gradient exists between the shallow and intermediate groundwater zones. In addition, the pumping of water from the intermediate zone and its attendant impact on the shallow zone is likely to result in more rapid dissolution of the LNAPL body than would occur under natural conditions.

Benzene concentrations in groundwater samples from the intermediate zone are substantially higher than one would typically expect under natural flow conditions given the nature of the primary source (i.e., an LNAPL body consisting of light oil). Benzene and naphthalene are considered the two best indicators of groundwater impacts at the facility and consequently, historical benzene and naphthalene isoconcentration contour maps for the shallow and intermediate groundwater were identified in a historical report (CH2MHill, June 2002) and are provided as Appendix D. As discussed in Section 3.6 (Area-Wide Groundwater Investigation) it is planned that the potentiometric surface maps and isoconcentration contours will be updated during the pre-design investigation. Comparison of the maps developed in 2002 versus those to be developed as part of pre-design will provide information regarding groundwater hydraulic conditions over time and provide information regarding plume stability and the effectiveness of the IMs implemented to date.

Geochemistry

From a geochemical standpoint, the most significant issue is the elevated pH of the shallow groundwater. The majority of the land in the Coke Point area in general and a large portion of the land in the Coke Oven Area is “made land” resulting from the placement of iron and steel-making slag. The fluxing agent for iron-making is typically limestone or dolomite and the fluxing agent for steel-making is typically lime. The use of these materials results in slags with water soluble calcium and magnesium oxides which react with water to result in alkaline conditions (the pH of water in equilibrium with iron and steel-making slags can range as high as 11.5 to 12.5 SU). Such conditions have been observed for the shallow groundwater in the Coke Oven Area.

The primary implication of this geochemical consideration is biological in nature. Specifically, benzene, toluene, ethylbenzene, xylenes and other aromatic hydrocarbons are typically recognized to be biodegradable under aerobic (and anaerobic) conditions. Groundwater plumes consisting of these constituents are generally attenuated as a result of sorption, hydrodynamic dispersion, diffusion, and biodegradation. As a result of the elevated pH in the shallow water bearing zone in the Coke Oven Area, biodegradation appears to be a negligible component of natural attenuation

for the dissolved constituents in groundwater. This phenomenon has been observed elsewhere in areas with elevated or low pH conditions and is evident for the Coke Oven Area as a result of the ineffectiveness of the attempted augmented biological remedy for Cell 4. In addition, the slag matrix is essentially a glasslike material which is expected to be very low in organic carbon content. Hence, in addition to inhibition of biological processes, the slag may offer very limited sorption potential for dissolved phase constituents.

By contrast, the pH of the groundwater in the intermediate zone is near neutral and hence the potential for biological degradation of dissolved phase constituents in the intermediate zone is not inhibited. In addition, the intermediate groundwater zone also consists of native materials such as former open water sediments or marsh deposits that are likely to exhibit higher levels of organic carbon and hence greater sorption potential.

3.2 Scope of Work

The preceding understanding of the conceptual aspects of the Coke Oven Area has been considered during the development of the scope of work for the pre-design investigation. The planned scope of work is provided on a cell-specific basis in the subsections that follow. An overall summary of the scope of work for the Coke Oven Area pre-design investigation is provided in Table 1.

3.2.1 Cells 1 and 2

As previously described, IMs are in place and operational for Cells 1 and 2. A general description of the IMs and a summary of relevant analytical data indicative of the performance/effectiveness of the IMs are provided in Section 1.5. The scope of work for Cells 1 and 2 is designed to provide information regarding the extent and recoverability of LNAPL in the vicinity of shallow monitoring well Cell2-MW2(S) (CO37-PZM003), the feasibility of containment and augmented bioremediation options for control of the dissolved phase plume in the shallow and/or intermediate water bearing zones. Investigation of water levels and current dissolved phase concentrations in groundwater in both the shallow and intermediate zones is planned based on input from the USEPA and MDE during the aforementioned project scoping meeting is also planned. In addition to the investigation of the groundwater conditions, it is also planned that the existing IM (i.e., the AS/SVE system) in Cell 1 will be evaluated from an engineering perspective. A review of historical operating and performance data and system inspection will be completed. Air flows for sparge points will be measured and groundwater recovery rates into sparge wells (rebound) will be studied. The Cell 1 AS/SVE system was installed as a pilot and has been operational since 2010. It is expected that improvements to the system including, but not necessarily limited to, more permanent piping, additional valves, sample/flow measurement port installation, additional sparge points, moisture knockouts, and air flow balancing, are likely appropriate. The data

evaluation and inspection process will be conducted to support design of system improvements to enhance recovery.

The scope of work for Cells 1 and 2 is summarized on Figure 10 which depicts the locations of test borings along two potential slurry wall alignments (containment option), the location of two additional wells to be installed to delineate potential LNAPL and dissolved phase impacts in the vicinity of monitoring well Cell2-MW2(S) (CO37-PZM003), and the locations of various shallow and intermediate wells to be subjected to water level elevation measurement, LNAPL measurements, and sampling and analysis for dissolved phase concentrations of VOCs and SVOCs.

Four borings, designated as CO121-SBXXX, CO123-SBXXX, CO124-SBXXX and CO125-SBXXX are planned along two potential slurry wall alignments as shown on Figure 10. The borings will be completed to a depth of approximately 60 feet using a rotosonic drilling rig and will be completed to ascertain if a clay layer present at that depth in the Patapsco formation is present and will form a competent confining layer for the installation of a barrier wall between the graving dock and onsite sources of dissolved phase constituents. It is planned that two representative subsoil (clay) samples will be obtained from the borings for laboratory permeability testing.

One of these borings (CO121-SBXXX) is located in the vicinity of monitoring well Cell2-MW2(S) (CO37-PZM003) and it is planned that a shallow water table monitoring well (2-inch Schedule 40 PVC, 10 foot 10-slot well screen) will be installed at this location to investigate the potential presence of LNAPL. This well will be designated as CO121-PZMXXX to coincide with the well designations employed for the wells installed as part of the recent Cell 2 IM. Another shallow water table well of similar construction is planned at a location just to the south-southwest of this location (CO122-PZMXXX).

It is also planned that multiple low flow groundwater samples will be obtained from the intermediate zone wells to provide information regarding general geochemical conditions. As previously discussed, the pH of the intermediate zone groundwater is near neutral and enhanced biological remediation may be achievable in the intermediate zone by increasing the dissolved oxygen content or by relying on sulfate-reducing bacteria. Injection of sulfate in the form of sodium, calcium, or magnesium sulfate is considered a possible means to achieve bioremediation, subject to the constraint that an Underground Injection Control permit would be required.

It is planned that the intermediate zone groundwater samples will be analyzed for field parameters (dissolved oxygen, pH, turbidity, oxidation-reduction potential, and temperature) as well as sulfate via laboratory analysis. Analysis of intermediate zone groundwater samples for chloride is also

planned to provide information regarding general water quality (saltwater intrusion) and implications regarding the potential suitability of groundwater as a potable water source.

In addition to the preceding, it is also planned that multiple shallow and intermediate zone wells be sampled to accommodate analysis of volatile and semivolatile organic constituents in the dissolved phase. The ultimate objective of such sampling and analysis is to provide information regarding the current distribution of dissolved phase constituents such as benzene and naphthalene such that current isoconcentration contour maps may be prepared. Such data will provide information to assess plume stability, the effectiveness (on a preliminary basis) of the operating IMs, and to support groundwater modeling and discharge estimation at a later date if appropriate. Table 2 provides a summary of the planned analytical program for groundwater samples from Cells 1 and 2 (as well as for the other Cells in the Coke Oven Area). Figure 10 depicts the locations of all of the wells of interest for the Cells 1 and 2 groundwater study.

Finally, contingent upon the findings regarding the LNAPL distribution in the vicinity of Cell2-MW2(S) (CO37-PZM003), it is planned that an evaluation of the potential recoverability of LNAPL in the area will be completed. Such a study would be precipitated by the detection of a LANPL body that is more extensive, and thicker, than that believed to exist based on available data. If a substantial LNAPL body is encountered, a proof-of-concept pilot study will be completed using high vacuum recovery techniques. The procedure to be followed would be similar to that planned for the Cell 6 area (subsequently discussed in subsection 3.5) where a substantial LNAPL body is already known to exist.

3.2.2 Cell 3

As previously discussed, little change has occurred in dissolved phase groundwater concentrations immediately downgradient of Cell 3, and an indication of the potential presence of source material near Cell 3 has been observed recently. The scope of work for Cell 3 consists of delineation effort to further define the extent of dissolved phase groundwater impacts in the area and the possible presence of LNAPL in the area. It is planned that a total of five (5) rotosonic borings be completed in the Cell 3 area at the locations depicted on Figure 11. It is planned that IsoFlow groundwater samples be obtained from three discrete depths in each of the borings (water table, 25 feet bgs, and 35 feet bgs). Groundwater samples will be analyzed for volatile and semivolatile organics. As with the other components of the field investigation, flexibility will be maintained. Additional borings may be completed if necessary to provide information regarding the horizontal and vertical extent of impacts.

In addition to the investigation of the groundwater conditions, it is also planned that the existing IM (i.e., the AS/SVE system) be evaluated from an engineering perspective. Given the absence of an appreciable change in the downgradient benzene concentrations, and the low influent vapor

concentrations to the air stripper, it is suspected that either 1) an unidentified source exists which is bypassing the system, 2) the AS/SVE system is not operating in an optimum manner, or 3) the system is undersized for actual site conditions. The groundwater investigation discussed in the preceding section is designed to assess the potential existence of an unidentified source. To investigate the AS/SVE effectiveness issue, it is planned that a general inspection of the AS/SVE system be completed to determine if equipment is operating correctly, to ensure that there are no leaks in the air side of the AS/SVE system, to evaluate the potential for short circuiting of injected air, and to evaluate imbalances in the air injection site. To this end, in addition to a general inspection, it is planned that each sparge point will head will be equipped with an air flow monitoring point and the air flow at each individual sparge point be measured. In addition, it is planned that the system will be shut down temporarily to allow groundwater to equilibrate fully such that optimum delivery of air into the shallow groundwater can be assessed. If scaling or chimney effects exist, the water levels may not rebound in the sparge points.

Finally, it is also planned that multiple shallow and intermediate zone wells will be sampled to accommodate analysis of volatile and semivolatile organic constituents in the dissolved phase. The ultimate objective of such sampling and analysis is to provide information regarding the current distribution of dissolved phase constituents such as benzene and naphthalene such that current isoconcentration contour maps may be prepared. Such data will provide information to assess plume stability, the effectiveness (on a preliminary basis) of the operating IMs, and to support groundwater modeling and discharge estimation at a later date if appropriate. Table 2 provides a summary of the planned analytical program for groundwater samples from Cell 3 (as well as for the other Cells in the Coke Oven Area). Figure 11 depicts the locations of all of the wells of interest for the Cell 3 groundwater study.

3.2.3 Cells 4 and 5

As previously described, the bioaugmentation approach for Cell 4 was deemed ineffective and was therefore discontinued. Although the revised IM (dual phase extraction) system has only been operational for a short period of time, influent concentrations to the system indicate that the IM may be removing a significant mass of dissolved and vapor phase constituents from the subsurface. As part of the pre-design investigation, performance monitoring data for the Cell 4/5 system will be evaluated. In addition, as previously discussed, it is suspected, based on measured naphthalene concentrations in a groundwater sample from monitoring well CO112-PZM, that Dense Non-Aqueous Phase Liquid (DNAPL) may be present in the Cell 4/5 area.

The pre-design investigation for the Cell 4/5 area has been configured as a DNAPL source investigation to delineate the presence of DNAPL and to assess the recoverability of DNAPL via gravimetric collection methods. It is planned that the first component of the investigation will be an assessment of water levels, LNAPL (if any), and DNAPL in all wells located in the Cell 4/5

area. An interface probe will be used to gauge the wells which are listed in Table 2 and depicted on Figure 12.

Once well gauging is complete, any information regarding the presence of DNAPL will be evaluated to support identification of six (6) boring locations to further define the lateral and vertical extent of DNAPL, if it is in fact present in the area. Coal tar DNAPL is typically easily identifiable in the subsurface and rotonomic cores will provide good recoveries for the assessment of the presence and depth of DNAPL seams, if any. As before, flexibility will be employed during the drilling program such that ongoing data evaluation will guide subsequent borings. Ultimately, more or less than six borings may be required for delineation purposes.

It is also planned that the potential for passive recovery of DNAPL be assessed. This will be accomplished via the conversion of up to three (3) of the boring locations to DNAPL recovery wells, as warranted by the results of the boring program. Recovery wells will be installed to target DNAPL zones and will be constructed of 6-inch diameter high-density polyethylene (HDPE) or carbon steel equipped with 10-foot collection sumps and 10-foot, 20 slot well screens. The wells will be used to monitor accumulation rates of DNAPL over time and hence will provide information regarding DNAPL mobility and recoverability. These wells will provide the information necessary to design a full-scale DNAPL recovery system if warranted, or it could be determined that they may serve as adequate recovery points as they are.

3.2.4 Cell 6

As previously described, an IM consisting of recovery well LNAPL skimming systems are in place for Cell 6 and approximately 79,000 lbs of LNAPL have been recovered as of the most recent quarterly report (June 2014). The scope of work for Cell 6 is intended to more fully define the extent of LNAPL in the area, which may extend farther to the east than previously known, to evaluate the potential for more aggressive recovery of LNAPL using a high vacuum approach, and to provide data sufficient to design a vacuum recovery network if found to be feasible. In addition, investigation of water levels and current dissolved phase concentrations in groundwater in both the shallow and intermediate zones is planned based on input from the USEPA and MDE during the aforementioned project scoping meeting.

LNAPL was recently identified at apparent thicknesses of 5 to 6 feet in two wells on the eastern/northeastern side of the Cell 6 area [BP-MW-10 (CO94-PZM) and BP-MW-11 (CO95-PZM)] and has historically been detected in a monitoring well located approximately 700 feet to the east of Cell 6. In addition, subsurface utility lines exist in the area and the backfill around one of these utility lines (specifically a 72-inch storm sewer) may act as a preferential flow path or sink for LNAPL. Consequently, it is planned that multiple shallow (i.e., 15 foot) rotonomic borings be completed in the Cell 6 area to more fully define the extent of LNAPL. Rotonomic drilling will

result in intact cores and is expected to provide definitive information regarding the absence or presence and thickness of LNAPL in the area. A combination of visual inspection and Photoionization Detector Measurements (PID) will be used to ascertain the presence of LNAPL in the core samples. In addition, Sudan IV dye will be available onsite during the field investigation and will be used to assess the possible presence of LNAPL (via shake testing) if the visual inspection and PID approach is inconclusive.

The field investigation is designed to be flexible in that data will be evaluated on a real time basis during LNAPL delineation. Consequently, it is expected that additional borings beyond those depicted on Figure 13 may be completed to accommodate LNAPL delineation. Alternately, some borings might be eliminated if borings closer to known LNAPL areas are shown to be devoid of LNAPL.

It is also planned that up to three of the boring locations would be converted to monitoring/recovery wells based on the presence of potentially recoverable LNAPL. The locations of any such wells will be contingent upon the findings of the boring program. Given the nature of the overburden material in the area (consolidated slag) it is expected that the boreholes will remain open and wells may be installed after internal consultation is completed. Borings that do not exhibit the presence of LNAPL will be properly abandoned via being grouted to the ground surface. Wells will be constructed as discussed for the wells to be installed during the Cell 1 and 2 investigation with the following modifications: four-inch wells with 10 foot 20 slot screens will be used to accommodate LNAPL recoverability testing.

In addition to the LNAPL delineation effort, it is also planned that a proof-of-concept high vacuum pilot test be completed. A trailer mounted high vacuum system will be mobilized to the Coke Oven Area and testing will be completed for various wells in the Cell 6 area as denoted on Figure 13. The high vacuum LNAPL recovery equipment consists of a rotary vane pump, vacuum tank, and a knockout system where the fluids extracted can be captured in an individual 55-gallon drum. This affords determination of potential production rates per well and accommodates the determination of the “cut” of fluids (i.e., volume of LNAPL recovered versus volume of water recovered). The proof-of-concept pilot test will be completed to determine the recoverability of LNAPL via high vacuum as well as the radius of influence of individual monitoring/recovery wells. The high vacuum LNAPL recovery testing procedure to be used for the various wells located in the Cell 6 are will be as follows:

- A comprehensive round of water level and LNAPL measurements will be made for the wells of interest.
- Fitted J-plugs equipped with apertures for vacuum measurement will be placed on surrounding wells.

- The vacuum line will be connected to the head of the well to be studied. A stinger (drop) pipe may or may not be used contingent upon fluid levels and conditions observed in the field.
- Full throttle vacuum will be applied to the well head. The vacuum will be operated for a maximum of two hours or until the 55-gallon drum is full (auto shut off).
- Vacuum measurements will be obtained from the surrounding wells during the operation of the vacuum system. The vacuum for each surrounding well will be recorded.
- Upon completion of the vacuum test for each individual well fluid measurements (depth to LNAPL and depth to water) will be measured (rapidly) in the surrounding wells.
- Testing will be conducted such that the water table has recovered to equilibrium conditions from a prior test before a proximate well is tested (i.e., a non-linear “hop-scotch” approach).
- One 55-gallon drum will be used for each well to be studied. The fluids will be allowed to sit for 24-hours to accommodate phase separation.
- The cut of the fluids will be measured using an interface probe or using Kolor Kut® paste applied to a plumb string. The cut for each well will be recorded for subsequent evaluation.
- A comprehensive round of water level measurements will be made upon completion of vacuum testing for all wells of interest once the testing is complete.

In addition to the preceding it is also planned that multiple shallow and intermediate zone wells be sampled to accommodate analysis of volatile and semivolatile organic constituents in the dissolved phase. Again, the ultimate objective of such sampling and analysis is to provide information regarding the current distribution of dissolved phase constituents such as benzene and naphthalene such that current isoconcentration contour maps may be prepared. Such data will provide information to assess plume stability, the effectiveness (on a preliminary basis) of the operating IMs, and to support groundwater modeling and discharge estimation at a later date if appropriate. Table 2 provides a summary of the planned analytical program for groundwater samples from Cell 6 (as well as for the other Cells in the Coke Oven Area). The wells of interest are depicted on Figure 13.

3.2.5 Area-Wide Groundwater Investigation

Area-wide groundwater investigations have been completed previously for the Coke Oven Area and Coke Point. Those results are summarized via the figures (potentiometric surface maps and benzene and naphthalene isoconcentration contours) provided as Appendices C and D. A comprehensive study of groundwater elevations and dissolved phase concentrations of the constituents of interest is planned for the pre-design investigation to provide information regarding

plume stability and/or temporal changes. The majority of the wells to be included in the area-wide investigation have been included in the scope of work for the individual Cells. A number of additional wells, primarily at the perimeter of the Coke Oven Area or some distance from the Cells have been identified for inclusion in the groundwater sampling and analysis program. These wells consist of a number of shallow and intermediate water bearing zone wells, as follows:

SW-PZM003	CO08-PZM036
SW-PZM004	CO09-PZM007
CO06-PZM008	CO10-PZM006
CO06-PZM039	CO10-PZM029
CO07-PZM008	CO11-PZM007
CO07-PZM050	CO35-PZM013
CO08-PZM005	CO35-PZM056

These wells will be subjected to water level and LNAPL and DNAPL measurements as part of a comprehensive round of measurement to be completed for the entire Coke Oven Area. The comprehensive round of water level and fluids measurement will be completed in forty-eight hours or less. Groundwater samples will be obtained from these wells and the samples will be analyzed for field parameters (pH, dissolved oxygen, oxidation-reduction potential, temperature, specific conductance, and turbidity). Samples shall also be analyzed for dissolved phase constituents of interest (volatile and semivolatile organics). Figure 14 depicts the locations of the various wells to be included in the comprehensive study, including the wells identified above as well as all of the wells of interest for the various Cells. As shown, the wells to be measured and sampled are dispersed geographically across the Coke Oven Area and a substantial number of shallow and intermediate zone wells are included in the planned program. An overall summary of the groundwater monitoring program is provided as Table 2.

For the purposes of this work plan, it has been assumed that all of the wells identified for inclusion in the Cell-specific investigations and those identified for inclusion in the area-wide investigation are intact and can be located. Coordinates are available for all existing wells and best efforts will be expended to locate all of the wells. However, many of the wells were installed quite some time ago and ongoing operations at the facility may have damaged or destroyed some of the wells. Many of the wells are in traffic areas and consequently were installed as flush mounted wells which may make the wells difficult to locate if any grade changes have occurred. In the event that individual wells cannot be located, an assessment of the impact of missing data points on the overall program and objectives will be completed. If crucial wells are found to be missing, installation of replacement wells will be considered. Finally, and for the purposes of improved site data management, the designations of several existing monitoring wells have been revised; a summary of those revisions is provided in Appendix E.

3.2.6 Surveying

All newly-completed investigation locations (i.e., borings, wells, and trenches if employed) will be staked as the investigation proceeds for subsequent surveying by a surveyor licensed in the State of Maryland. Coordinates and elevations will be surveyed for locations of interest. Elevations of the ground surface will be obtained for all newly-completed locations. Casing elevations (measuring point elevations) and ground surface elevations will be surveyed for newly-completed monitoring wells. Horizontal surveying will be completed using the Maryland State Plane North American Datum 1983 coordinate system (MD83F) and will be to an accuracy of plus or minus 0.1 foot. Vertical surveying will be completed using National Geodetic Vertical Datum (NGVD) of 1988 and will be to an accuracy of 0.01 feet. Surveying will be completed and documented to allow for incorporation into a Geographic Information System database as necessary subject to the requirements of the USEPA and MDE.

3.2.7 Investigation-Derived Waste Management

Various types of Investigation-Derived Waste (IDW) will be generated during the course of the pre-design investigation. IDW will consist of the following:

- Drill cuttings
- Well development fluids
- Purge water
- LNAPL and DNAPL
- Decontamination fluids
- Personnel protective equipment
- Disposable sampling equipment
- Plastic sheeting

Management of IDW will be conducted in accordance with the procedures specified in KEY SOP 04 (Management of Investigation-Derived Wastes). SOP 04 is provided in Appendix B. Additional specific considerations for IDW are as follows:

- An appropriate secure IDW storage area will be identified based on security, accessibility, and the existence of secondary containment at the commencement of the project. Polyethylene tanks and steel drums will be employed for containerization.
- Appropriate labeling will be used for all containerized IDW and will include generation date, origin and a general description of the contents, and a notation regarding the waste classification (which may consist of “analysis pending”). Labels will be completed with indelible ink.

- Staged drums will be cleaned and placed on pallets and will be covered with secured plastic sheeting. Each drum will have a lid and bolt on collar and will also be numbered (on the label and the lid) with a drum identifying number. A log will be maintained that indicates the specific contents of each drum.
- Transportation and disposal of IDW will be conducted in accordance with all State, Federal, and DOT regulations. Manifesting procedures will be employed for both hazardous (if any) and non-hazardous waste.
- Purge water, development water, and decontamination water will be containerized on a temporary basis and will be metered into one or more of the existing groundwater treatment systems present on-site (i.e., the Cell 2 and/or Cell 4/5 treatment systems).
- To the extent possible, recovered LNAPL and DNAPL will be recycled. If appropriate permitted facilities are identified that can reuse such IDW (e.g., industrial boilers or similar facilities than can recover BTU content), they will be employed for IDW destruction purposes.
- Solid phase samples will be segregated to separate slag and native subsurface materials. It is possible that some slag materials could exhibit pH values in excess of 12.5 and segregation of these potentially corrosive materials from other non-corrosive solids will be appropriate.
- Waste profiling will be conducted to the satisfaction of the facilities accepting any materials for disposal. Analytical data sufficient to satisfy profiling requirements will be generated and will likely include characteristic analysis of representative samples (i.e., Toxicity Characteristic Leaching Procedure, corrosivity, ignitability).
- Generator knowledge will be employed as appropriate during waste profiling specifically with respect to constituents such as pesticides, herbicides, polychlorinated biphenyls, and polychlorinated dibenzodioxins and furans.

3.3 Sampling Summary and Analytical Methods

As discussed in the preceding subsections, multiple groundwater samples will be obtained during the pre-design investigation. Groundwater samples will be obtained to 1) provide information regarding current conditions (i.e., to facilitate preparation of volatile and semi-volatile organic isoconcentration contour maps for the shallow and intermediate zones); 2) to provide information regarding the suitability of groundwater as a potable water source (i.e., saltwater intrusion

considerations); and, 3) to provide information to support evaluation of the potential effectiveness of augmented bioremediation of intermediate zone groundwater. In addition, the groundwater sampling and analysis program may ultimately be used to support fate and transport evaluation and risk assessment.

The analytical suite for the various groundwater samples to be obtained from the existing and planned monitoring wells and the IsoFlow samples to be obtained from borings consists of the following parameters:

- Volatile Organic Compounds
- Semi-Volatile Organic Compounds
- Sulfate
- Chloride
- Hydronium Ion (pH)
- Oxidation-Reduction Potential
- Specific Conductance
- Dissolved Oxygen
- Turbidity
- Temperature

A tabular summary of the planned groundwater sampling and analysis program (as well as planned water level and NAPL measurement) for existing and planned monitoring wells is provided in Table 2. The wells (and IsoFlow borings) to be included in the sampling and analysis program to address the investigation of individual Cells and area-wide groundwater, the planned analytical program, and the planned analytical methods are identified in Table 2.

3.4 Data Quality Objectives

Data Quality Objectives (DQOs) specify the appropriate quantity and type of data required to make informed environmental and risk management decisions, including tolerable levels of uncertainty. USEPA has developed a systematic process for developing DQOs that includes consideration of several critical elements. The process requires definition of the problem and statement of the decisions that will be made based on the study results. Information needed to support the decision-making process can then be defined, and includes identification of the constituents or parameters of interest, delineation of the physical boundaries of the study area, definition of the quantity of data that will be needed, identification of the means to collect the required data, and the level of uncertainty that will be acceptable. Program design can then be optimized to collect defensible data in the most efficient manner. For the purposes of this Pre-Design Investigation Work Plan (PDIWP), the following specific decisions/questions have been identified:

Is the use of containment (via slurry wall installation) a viable option to control dissolved phase groundwater migration from the Coke Oven Area to the north/northwest as influenced by operation of the graving dock?

Is bioaugmentation a viable method for addressing dissolved groundwater impacts in the intermediate water bearing zone, particularly in the Cell 1 and Cell 2 areas?

Do additional sources of dissolved phase groundwater impacts exist in the Cell 3 area and is this AS/SVE system installed such that impacted groundwater horizons are intercepted?

Can improvements be made to the Cell 1 and/or Cell 3 IMs in the form of modifications or expansions to improve performance and accelerate remediation?

Does a DNAPL body exist in the Cell 4/5 area, how extensive is the DNAPL body if present and can it be recovered via gravimetric means?

Does significant mass of LNAPL exist in the Cell 6 area beyond the currently defined LNAPL body and can high vacuum extraction of LNAPL be used to accelerate product recovery?

This PDIWP serves as the controlling mechanism for the pre-design investigation (PDI) and specifies the scope of work and procedures which will ensure that all decisions based on laboratory and field data generated during this investigation are technically sound, statistically valid, and properly documented. Specific procedures for sampling, laboratory analyses, data reporting, and data validation will be presented in the aforementioned supporting project planning documents. Standard Operating Procedures are provided (Appendix B) for all investigative methods, field sampling procedures, field measurement procedures, sample handling and shipping, and documentation including chain-of-custody procedures.

As a result of the varying nature of the data required, there are several potentially applicable levels of data quality for the PDI. A primary component of data quality is selection of the appropriate analytical level for the intended data use. Analytical levels, as described in “Data Quality Objectives for Remedial Response Activities” (USEPA, March 1987), are as follows:

- Level I - Field screening or analysis using portable instruments. Results are often not compound-specific and not quantitative, but are available in real-time. Level I data are appropriate for initial field screening and for health and safety monitoring. They are frequently used to determine sample collection locations for laboratory analyses.

- Level II - Field analysis using more sophisticated portable analytical instruments; in some cases, the instruments may be set up in a mobile laboratory on location. There is a wide range in the quality of data that can be generated that is dependent on the use of suitable calibration standards, reference materials and sample preparation equipment. Results are available in real-time or within several hours.
- Level III - All analyses are performed in an off-site analytical laboratory. Level III provides quantitative data. Documented sampling and analysis procedures must be used. Level III analyses may or may not use Contract Laboratory Program (CLP) procedures, but at a minimum, abbreviated CLP-type deliverables are required. Level III may require data validation and QA/QC procedures conducted in accordance with USEPA guidelines. The laboratory may or may not be a CLP laboratory.
- Level IV – CLP-equivalent routine analytical services. All analyses are performed in an off-site analytical laboratory following CLP protocols. Level IV is characterized by rigorous QA/QC protocols and documentation with full validation of all data.
- Level V - Analysis by nonstandard methods. All analyses are performed in an off-site laboratory that may or may not be a CLP laboratory. Method development or method modification may be required for specific constituents or detection limits. CLP Special Analytical Services (SAS) are Level V.

For the purposes of the PDI, the Analytical Levels to be employed consist of Levels I and IV. The Analytical Levels to be employed consist of the following:

- Level I – Field Instrumentation Measurements
- Level IV – Contract Laboratory Program Equivalent Data

Level I - Level I analytical data will consist of information generated using portable field instrumentation, specifically, a Photoionization Detector (PID) and water quality monitoring meters for measurement of pH, dissolved oxygen, specific conductance, temperature, oxidation-reduction potential, and turbidity.

Level IV – Level IV analytical data will consist of information generated via analysis of aqueous phase samples by off-site fixed-base laboratories. SW-846 analytical methods (e.g., SW-846 8260B and SW-846 8270C) and EPA Method 300.0 will be employed for all offsite sample analyses. Detection limits for VOCs and SVOCs are provided in Table 3. Contract Laboratory Program level deliverables will be required such that validation of analytical data in accordance with the National Function Guidelines for organic and inorganic data review (USEPA, June 2008 and USEPA, January 2010) can be completed if necessary, at a later date. Data will not be

validated in support of the predesign investigation and will be labeled in accordance with USEPA requirements for labeling externally validated data. An NV (Not Validated) code will be applied to all predesign data provided to the USEPA and MDE in electronic or hardcopy format, in accordance with USEPA requirements (USEPA, January 13, 2009). In the event that validation is ultimately completed in support of risk assessment and/or fate and transport evaluations, the data will be relabeled accordingly.

In the event that data validation is completed, each relevant data package (i.e., Sample Delivery Group – SDG) from the laboratory will undergo USEPA level 2B verification/validation review. The verification/validation review will be conducted in accordance with USEPA guidance (USEPA, June 2008 and USEPA, January 2010). Raw data will not be reviewed. The following items will be reviewed as part of the Level 2B validation:

- Data completeness
- Technical holding times
- Summaries of Instrument Performance Check Results
- Summaries of Initial Calibrations
- Summaries of Calibration Verification
- Summaries of Blank Results
- Summaries of Matrix spike and Matrix Spike Duplicate results
- Summaries of Laboratory Duplicates (Inorganic Parameters Only)
- Summaries of Laboratory Control Samples
- Summaries of Internal Standards
- Field Duplicate Results
- Field Blanks
- Overall assessment of data

If data validation is completed for the PDI data, Data Validation Reports (DVRs) will be prepared to present the data validation findings. A DVR will be prepared for each relevant SDG data package reviewed. Analysis results forms, annotated by hand to reflect qualifier codes resulting from the data validation review, will be included with the reports. These qualifier codes will be presented in the far right margins of the analysis results forms, and will be clearly identifiable. A glossary defining each data validation qualifier code will also be included with the report.

4.0 REPORTING

Reporting for the project will consist of internal and external reporting. Internal reporting will be informal and will typically be conducted via telephone or e-mail communications. External reporting will be formal in nature and will be done in written form. Additional information regarding reporting is provided in the subsections that follow.

4.1 Internal Reporting

During implementation of the scope of work the Field Operations Leader will report to the project manager on a daily basis to summarize the work completed and two discuss upcoming activities. Given the planned flexible approach to the field work, the Project Manager will communicate information and planned activities to EAG for internal discussion purposes.

4.2 External Reporting

During implementation of the field work, it is planned that a monthly letter report will be provided to the USEPA and MDE. The letter report will summarize the work completed during the month, the implications of any observations (e.g., LNAPL presence), and the planned activities for the coming month. Monthly reporting in this manner will be completed to ensure that USEPA and MDE have the opportunity to provide “timely” input on the delineation activities, particularly with respect to LNAPL and DNAPL delineation. To the extent that figures are necessary to convey information, it is planned that informal drawings will be provided (i.e., sketches and hand mark ups of existing figures or aerial photographs). Key milestones will be identified, in addition to the monthly reports, as necessary to apprise the agencies of findings.

Upon completion of the field work, sample analysis, and data evaluation, a Pre-Design Investigation Summary Report (PDISR) will be prepared for review by the USEPA and MDE. A summary of the field activities and any deviations from the planned scope of work will be provided. The results of the investigation, and the implications thereof, will be provided in textual, graphical, and tabular form. A recommended approach for the area wide responses on a Cell-specific basis will also be provided. Recommendations for collection of additional information (e.g., barrier wall alignment boring) will be provided as appropriate based on interpretation of the proof-of-concept information. It is planned that a project meeting with the USEPA and MDE will be conducted to discuss the results of the investigation and recommendations at the time the PDISR is provided to the agencies.

5.0 PROJECT SCHEDULE

Given the scope of work as previously summarized, it is expected that the field investigation will take approximately ten (10) weeks to complete (including mobilization activities) once approval of the work plan is received. Groundwater sample analysis is expected to require an additional six (6) weeks to complete, and preparation of the PDISR, including an internal Quality Assurance Review cycle will require another six (6) weeks. Consequently, barring adverse weather conditions or other unforeseen eventualities that affect the implementation of the field work, it is expected that the investigation activities will be completed within six months of agency approval of this Work Plan. In addition, the PDISR will be submitted to the regulatory authorities within two months of completion of the investigation.

6.0 REFERENCES

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USEPA (United States Environmental Protection Agency), June 2008. National Functional Guidelines for Superfund Organic Methods Data Review. Office of Solid Waste and Emergency Response Directive 9240.1-48. EPA 540-R-08-01.

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URS (URS Corporation), October 2010. Coke Oven Area Interim Measures Progress Report (Through September 2010). Gaithersburg, MD.

URS (URS Corporation), January 2011. Coke Oven Area Interim Measures Progress Report (December 2011). Germantown, MD.

URS (URS Corporation), March 2011. Coke Oven Area Interim Measures Cell 3 “Cove” Area Air Sparge/Soil Vapor Extraction System Design. Gaithersburg, MD.

TABLES

TABLE 1
SUMMARY OF PROPOSED SCOPE OF WORK⁽¹⁾
COKE OVEN AREA PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND

AREA	PROPOSED ACTIVITY	LOCATIONS			OBJECTIVE/PURPOSE
Cells 1/2	Test Borings				
	Sixty foot deep test borings (4)	CO124-SBXXX CO125-SBXXX	CO123-SBXXX CO121-SBXXX		Barrier wall proof-of-concept; Stratigraphic characterization; Potential LNAPL investigation
	Shallow monitoring well completions (2)	CO121-PZMXXX CO122-PZMXXX			
	Geotechnical Laboratory Testing				
	Shelby tube samples (3)	To Be Determined as Borings Progress			Permeability testing of confining unit
	Water Level Measurement				
	Shallow well water level/LNAPL measurement (20)	CO36-PZM008	CO121-PZMXXX	CO16-PZM006	Support preparation of area-wide potentiometric surface maps (shallow and intermediate zones); Potential LNAPL delineation; Model input data
		CO37-PZM003	CO122-PZMXXX	CO18-PZM006	
		CO38-PZM006	CO79-PZMXXX	CO27-PZM012	
		CO39-PZM007	CO88-PZMXXX	CO28-PZM010	
		CO40-PZM008	CO02-PZM006	TS05-PPM007	
	Intermediate zone well water level measurement (8)	CO41-PZM001	CO03-PZM005	TS05-PDM004	
		CO42-PZM004	CO15-PZM005		
		CO36-PZM043	CO39-PZM042	CO27-PZM046	
		CO37-PZM038	CO41-PZM036	CO28-PZM048	
	CO38-PZM043	CO02-PZM041			
	AS/SVE System Effectiveness Investigation				
	General inspection of operating conditions	Cell 1 and 2 AS/SVE Systems			Investigate potential short-circuiting and air delivery issues; Support expansion/modification of AS/SVE system, as appropriate
Temporary shut down and water level measurement					
Air flow measurements for sparge points					
General inspection of operating conditions					
Proof-of-Concept Pilot Testing - Vacuum Recovery					
Pre-vacuum well gauging	To Be Determined as Investigation Progresses			Preliminary radius of influence; LNAPL recoverability assessment	
Vacuum extraction of product/water					
Vacuum measurement					
Post-vacuum well gauging					
Groundwater Sampling/Analysis					
Quarterly Groundwater Sampling (14)	CO36-PZM008	CO41-PZM001	CO38-PZM043	Delineation/characterization of dissolved phase impacts; Support preparation of area-wide benzene and naphthalene isoconcentration contour maps (shallow and intermediate zones)	
	CO37-PZM003	CO42-PZM004	CO39-PZM042		
	CO38-PZM006	CO27-PZM012	CO41-PZM036		
	CO39-PZM007	CO36-PZM043	CO27-PZM046		
Quarterly Sample Analysis for VOCs and SVOCs (14)	CO40-PZM008	CO37-PZM038			
	CO36-PZM008	CO41-PZM001	CO38-PZM043		
	CO37-PZM003	CO42-PZM004	CO39-PZM042		
	CO38-PZM006	CO27-PZM012	CO41-PZM036		
Pre-Design Investigation (PDI) Groundwater Sampling (20) ⁽²⁾	CO39-PZM007	CO36-PZM043	CO27-PZM046		
	CO40-PZM008	CO37-PZM038			
	CO121-PZMXXX	CO16-PZM006	CO38-PZM043		
	CO122-PZMXXX	CO18-PZM006	CO39-PZM042		
	CO79-PZMXXX	CO28-PZM010	CO41-PZM036		
PDI Analysis for VOCs and SVOCs (14)	CO88-PZMXXX	TS05-PPM007	CO02-PZM041		
	CO02-PZM006	TS05-PDM004	CO27-PZM046		
	CO03-PZM005	CO36-PZM043	CO28-PZM048		
	CO15-PZM005	CO37-PZM038			
PDI Analysis for DO, pH, ORP, SC, Turbidity, T, Sulfate, Chloride (8)	CO121-PZMXXX	CO03-PZM005	TS05-PPM007	In-situ aerobic/anaerobic treatability proof-of-concept	
	CO122-PZMXXX	CO15-PZM005	TS05-PDM004		
	CO79-PZMXXX	CO16-PZM006	CO02-PZM041		
CO88-PZMXXX	CO18-PZM006	CO28-PZM048			
CO02-PZM006	CO28-PZM010				
CO36-PZM043	CO39-PZM042	CO27-PZM046			
CO37-PZM038	CO41-PZM036	CO28-PZM048			
CO38-PZM043	CO02-PZM041				
Cell 3	Test Borings				
	Thirty-five foot deep test borings (5)	CO126-SBXXX CO127-SBXXX	CO128-SBXXX CO129-SBXXX	CO130-SBXXX	Source identification; Stratigraphic characterization; Delineation/characterization of LNAPL and dissolved phase impacts
	IsoFlow groundwater sampling (15)	Each of five test borings listed above designated as (CO126-SBXXX to CO130-SBXXX) at three depths: water table, 25' and 35'			
	Analysis for VOCs and SVOCs and LNAPL inspection (15)	Each of five test borings listed above designated as (CO126-SBXXX to CO130-SBXXX) at three depths: water table, 25' and 35'			
	AS/SVE System Effectiveness Investigation				
	General inspection of operating conditions	Cell 3 AS/SVE System			Investigate potential short-circuiting and air delivery issues; Support expansion/modification of AS/SVE system, as appropriate
	Temporary shut down and water level measurement				
	Air flow measurements for sparge points				
	General inspection of operating conditions				
	Water Level Measurement				
	Shallow well water level/LNAPL measurement (9)	CO101-PZMXXX	CO104-PZMXXX	CO32-PZM004	Support preparation of area-wide potentiometric surface maps (shallow and intermediate zones); Potential LNAPL delineation; Model input data
		CO102-PZMXXX	CO29-PZM010	SW17-PZM007	
Intermediate zone well water level measurement (4)	CO103-PZMXXX	CO30-PZM015	TS06-PPM008		
	CO29-PZM051	CO32-PZM041			
CO30-PZM060	SW17-PZM038				
Groundwater Quality Investigation					
Quarterly Groundwater Sampling (4)	CO101-PZMXXX	CO103-PZMXXX		Delineation/characterization of dissolved phase impacts; Support preparation of area-wide benzene and naphthalene isoconcentration contour maps (shallow and intermediate zones)	
	CO102-PZMXXX	CO30-PZM015			
Quarterly Sample Analysis for VOCs and SVOCs (4)	CO101-PZMXXX	CO103-PZMXXX			
	CO102-PZMXXX	CO30-PZM015			
Pre-Design Investigation (PDI) Groundwater Sampling (9)	CO104-PZMXXX	SW17-PZM007	CO30-PZM060		
	CO29-PZM010	TS06-PPM008	CO32-PZM041		
	CO32-PZM004	CO29-PZM051	SW17-PZM038		
PDI Analysis for DO, pH, ORP, SC, Turbidity, T, VOCs, SVOCs (9)	CO104-PZMXXX	SW17-PZM007	CO30-PZM060		
	CO29-PZM010	TS06-PPM008	CO32-PZM041		
	CO32-PZM004	CO29-PZM051	SW17-PZM038		
Cell 4/5	DNAPL Gauging				
	Shallow/Intermediate zone well DNAPL gauging (32) ⁽³⁾	CO114-PZM002	CO111-PZM006	CO55-PZM000	Vertical and horizontal extent of DNAPL; Accumulation rate assessment
		CO115-PZM006	CO113-PZM004	CO56-PZP001	
		CO116-PZM003	CO112-PZMXXX	CO57-PZP002	
		CO117-PZM003	CO105-PZMXXX	CO58-PZM001	
		CO118-PZM007	CO106-PZMXXX	CO59-PZP002	
		CO119-PZM009	CO12-PZM008	CO60-PZP001	
		CO120-PZM009	CO13-PZM008	CO13-PZM030	
		CO108-PZMXXX	CO24-PZM007	CO26-PZM032	
		CO109-PZMXXX	CO25-PZM008	CO34-PZM048	
		CO110-PZMXXX	CO26-PZM007		
		Additional 3 Locations to be converted from test borings designated as CO150-SBXXX to CO155-SBXXX			
	Test Borings				
	Thirty-five foot test borings (6)	To Be Determined as Investigation Progresses			Stratigraphic characterization; Vertical/horizontal extent of DNAPL; Accumulation rate assessment
	Monitoring point/recovery sump completions (3)				
Water Level Measurement					
Shallow well water level/LNAPL measurement (26)	CO114-PZM002	CO110-PZMXX	CO25-PZM008	Support preparation of area-wide potentiometric surface maps (shallow and intermediate zones); Potential LNAPL delineation; Model input data	
	CO115-PZM006	CO111-PZM006	CO26-PZM007		
	CO116-PZM003	CO113-PZM004	CO55-PZM000		
	CO117-PZM003	CO112-PZMXXX	CO56-PZP001		
	CO118-PZM007	CO105-PZMXXX	CO57-PZP002		
	CO119-PZM009	CO106-PZMXXX	CO58-PZM001		
	CO120-PZM009	CO12-PZM008	CO59-PZP002		
	CO108-PZMXXX	CO13-PZM008	CO60-PZP001		
	CO109-PZMXXX	CO24-PZM007			
	CO13-PZM030	CO34-PZM048			
Intermediate zone well water level measurement (6) ⁽⁴⁾	CO26-PZM032	Additional 3 Locations to be converted from test borings designated as CO150-SBXXX to CO155-SBXXX			
Groundwater Quality Investigation					
Quarterly Groundwater Sampling (6)	CO55-PZM000	CO57-PZP002	CO59-PZP002	Delineation/characterization of dissolved phase impacts; Support preparation of area-wide benzene and naphthalene isoconcentration contour maps (shallow and intermediate zones)	
	CO56-PZP001	CO58-PZM001	CO60-PZP001		
Quarterly Sample Analysis for VOCs and SVOCs (6)	CO55-PZM000	CO57-PZP002	CO59-PZP002		
	CO56-PZP001	CO58-PZM001	CO60-PZP001		
Pre-Design Investigation (PDI) Groundwater Sampling (12)	CO106-PZMXXX	CO24-PZM007	CO13-PZM030		
	CO12-PZM008	CO25-PZM008	CO26-PZM032		
	CO13-PZM008	CO26-PZM007	CO34-PZM048		
PDI Analysis for DO, pH, ORP, SC, Turbidity, T, VOCs, SVOCs (12)	Additional 3 Locations to be converted from test borings designated as CO150-SBXXX to CO155-SBXXX				
	CO106-PZMXXX	CO24-PZM007	CO13-PZM030		
	CO12-PZM008	CO25-PZM008	CO26-PZM032		
CO13-PZM008	CO26-PZM007	CO34-PZM048			
Additional 3 Locations to be converted from test borings designated as CO150-SBXXX to CO155-SBXXX					

TABLE 1
SUMMARY OF PROPOSED SCOPE OF WORK⁽¹⁾
COKE OVEN AREA PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND

AREA	PROPOSED ACTIVITY	LOCATIONS			OBJECTIVE/PURPOSE
Cell 6	Test Borings				
	Nineteen fifteen foot deep test borings (19)	C0131-SBXXX C0132-SBXXX C0133-SBXXX C0134-SBXXX C0135-SBXXX C0136-SBXXX C0137-SBXXX	C0138-SBXXX C0139-SBXXX C0140-SBXXX C0141-SBXXX C0142-SBXXX C0143-SBXXX	C0144-SBXXX C0145-SBXXX C0146-SBXXX C0147-SBXXX C0148-SBXXX C0149-SBXXX	Assess nature and extent of LNAPL (primarily east and north of Cell 6 and in vicinity of CO04-PZM004); Accumulation rate assessment
	Monitoring/recovery well completions (3)	3 Locations to be converted from test borings designated as C0131-SBXXX to C0149-SBXXX			
	Test Trenching				
	Optional test trenches (2) if necessary	To Be Determined as Investigation Progresses			Visual inspection of LNAPL occurrence/potential seams
	Proof-of-Concept Pilot Testing - Vacuum Recovery				
	Pre-vacuum well gauging	CO96-PZMXXX CO97-PZMXXX CO98-PZMXXX CO99-PZMXXX CO100-PZMXXX	CO89-PZMXXX CO90-PZMXXX CO91-PZMXXX CO92-PZMXXX	CO93-PZMXXX CO94-PZMXXX CO95-PZMXXX CO04-PZM004	Preliminary radius of influence; LNAPL recoverability assessment
	Vacuum extraction of product/water	CO96-PZMXXX CO97-PZMXXX CO98-PZMXXX CO99-PZMXXX CO100-PZMXXX	CO89-PZMXXX CO90-PZMXXX CO91-PZMXXX CO92-PZMXXX	CO93-PZMXXX CO94-PZMXXX CO95-PZMXXX CO04-PZM004	
	Vacuum measurement	CO96-PZMXXX CO97-PZMXXX CO98-PZMXXX CO99-PZMXXX CO100-PZMXXX	CO89-PZMXXX CO90-PZMXXX CO91-PZMXXX CO92-PZMXXX	CO93-PZMXXX CO94-PZMXXX CO95-PZMXXX CO04-PZM004	
	Post-vacuum well gauging	CO96-PZMXXX CO97-PZMXXX CO98-PZMXXX CO99-PZMXXX CO100-PZMXXX	CO89-PZMXXX CO90-PZMXXX CO91-PZMXXX CO92-PZMXXX	CO93-PZMXXX CO94-PZMXXX CO95-PZMXXX CO04-PZM004	
	Water Level Measurement				
	Shallow well water level/LNAPL measurement (20)	CO96-PZMXXX CO97-PZMXXX CO98-PZMXXX CO99-PZMXXX CO100-PZMXXX	CO90-PZMXXX CO91-PZMXXX CO92-PZMXXX CO93-PZMXXX CO94-PZMXXX CO95-PZMXXX	CO04-PZM004 CO05-PZM006 CO17-PZM005 CO19-PZM004 CO20-PZM004	Support preparation of area-wide potentiometric surface maps (shallow and intermediate zones); Potential LNAPL delineation; Model input data
		3 Additional locations to be converted from test borings designated as C0131-SBXXX to C0149-SBXXX			
	Intermediate zone well water level measurement (1)	CO04-PZM048			
Groundwater Quality Investigation					
Pre-Design Investigation (PDI) Groundwater Sampling (9)	CO04-PZM004 CO05-PZM006	CO17-PZM005 CO19-PZM004	CO20-PZM004 CO04-PZM048	Delineation/characterization of dissolved phase impacts; Support preparation of area-wide benzene and naphthalene isoconcentration contour maps (shallow and intermediate zones)	
	3 Additional locations to be converted from test borings designated as C0131-SBXXX to C0149-SBXXX				
PDI Analysis for DO, pH, ORP, SC, Turbidity, T, VOCs, SVOCs (9)	CO04-PZM004 CO05-PZM006	CO17-PZM005 CO19-PZM004	CO20-PZM004 CO04-PZM048		
	3 Additional locations to be converted from test borings designated as C0131-SBXXX to C0149-SBXXX				
Water Level Measurement					
Shallow well water level/LNAPL measurement (9)	SW13-PZM003 SW14-PZM004 CO06-PZM008	CO07-PZM008 CO08-PZM005 CO09-PZM007	CO10-PZM006 CO11-PZM007 CO35-PZM013	Support preparation of area-wide potentiometric surface maps (shallow and intermediate zones); Potential LNAPL delineation; Model input data	
	CO06-PZM039 CO07-PZM050	CO08-PZM036 CO10-PZM029	CO35-PZM056		
Intermediate zone well water level measurement (5)					
Groundwater Quality Investigation					
Pre-Design Investigation (PDI) Groundwater Sampling (14)	SW13-PZM003 SW14-PZM004 CO06-PZM008 CO07-PZM008 CO08-PZM005	CO09-PZM007 CO10-PZM006 CO11-PZM007 CO35-PZM013 CO06-PZM039	CO07-PZM050 CO08-PZM036 CO10-PZM029 CO35-PZM056	Delineation/characterization of dissolved phase impacts; Support preparation of area-wide benzene and naphthalene isoconcentration contour maps (shallow and intermediate zones)	
	SW13-PZM003 SW14-PZM004 CO06-PZM008 CO07-PZM008 CO08-PZM005	CO09-PZM007 CO10-PZM006 CO11-PZM007 CO35-PZM013 CO06-PZM039	CO07-PZM050 CO08-PZM036 CO10-PZM029 CO35-PZM056		

Notes:

1. A total of eight (8) new wells are to be installed as part of the pre-design investigation. The locations of some wells will be contingent upon preliminary investigation activities and locations will be identified based on real-time data evaluation.
2. Total of twenty wells includes some wells (6) sampled on a quarterly basis for VOCs and SVOCs. These wells will also be sampled for field parameters, sulfate, and chloride during the pre-design investigation.
3. Three of the proposed test borings will be converted to monitoring/recovery wells. These wells to be gauged for water levels and DNAPL after installation and after gauging of other wells gauged prior to new well installation.
4. The installation depth of the Cell 4/5 monitoring/recovery wells cannot be known *a priori*. Proposed monitoring wells are listed as intermediate wells but may actually be shallow wells.
5. See Appendix E for summary of well designation conversions from old system to new system.

TABLE 2
SUMMARY OF GROUNDWATER SAMPLING AND ANALYSIS⁽¹⁾
COKE OVEN AREA PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND

Area of Interest	Well or Boring Designation	Zone of Interest	Sample Type	Field Analysis/Measurement (Method)								Laboratory Analysis (Method)				
				H ₂ O Level (SOP 26)	LNAPL (SOP 26)	DNAPL (SOP 26)	pH (SOP 21)	ORP (SOP 21)	SC (SOP 21)	DO (SOP 21)	Turbidity (SOP 21)	Temp. (SOP 21)	VOCs (8260B)	SVOCs (8270C)	Sulfate (300)	Chloride (300)
Cells 1 and 2	C036-PZM008	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	QTY	QTY	--	--
	C037-PZM003	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	QTY	QTY	--	--
	C038-PZM006	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	QTY	QTY	--	--
	C039-PZM007	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	QTY	QTY	--	--
	C040-PZM008	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	QTY	QTY	--	--
	C041-PZM001	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	QTY	QTY	--	--
	C042-PZM004	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	QTY	QTY	--	--
	CO121-PZMXXX	Shallow	New Well ⁽²⁾	PDI	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
	CO122-PZMXXX	Shallow	New Well	PDI	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
	C079-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
	C088-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
	CO02-PZM006	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
	CO03-PZM005	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
	CO15-PZM005	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
	CO16-PZM006	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
	CO18-PZM006	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
	CO27-PZM012	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	QTY	QTY	--	--
	CO28-PZM010	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
	TS05-PPM007	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
	TS05-PDM004	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
	C036-PZM043	Intermediate	Well	PDI	--	--	PDI	PDI	PDI	PDI	PDI	PDI	QTY	QTY	PDI	PDI
	C037-PZM038	Intermediate	Well	PDI	--	--	PDI	PDI	PDI	PDI	PDI	PDI	QTY	QTY	PDI	PDI
	C038-PZM043	Intermediate	Well	PDI	--	--	PDI	PDI	PDI	PDI	PDI	PDI	QTY	QTY	PDI	PDI
	C039-PZM042	Intermediate	Well	PDI	--	--	PDI	PDI	PDI	PDI	PDI	PDI	QTY	QTY	PDI	PDI
	C041-PZM036	Intermediate	Well	PDI	--	--	PDI	PDI	PDI	PDI	PDI	PDI	QTY	QTY	PDI	PDI
	CO02-PZM041	Intermediate	Well	PDI	--	--	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI
	CO027-PZM046	Intermediate	Well	PDI	--	--	PDI	PDI	PDI	PDI	PDI	PDI	QTY	QTY	PDI	PDI
	CO28-PZM048	Intermediate	Well	PDI	--	--	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI
MS/MSD	NA	QC	--	--	--	--	--	--	--	--	--	PDI	PDI	--	--	
Duplicate	NA	QC	--	--	--	--	--	--	--	--	--	PDI	PDI	--	--	
Trip Blank	NA	QC	--	--	--	--	--	--	--	--	--	--	PDI	--	--	
Cell 3	CO101-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	QTY	QTY	--	--
	CO102-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	QTY	QTY	--	--
	CO103-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	QTY	QTY	--	--
	CO104-PZMXXX	Shallow	Well	PDI	PDI	--	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO29-PZM010	Shallow	Well	PDI	PDI	--	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO30-PZM015	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	QTY	QTY	--	--
	CO32-PZM004	Shallow	Well	PDI	PDI	--	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	SW17-PZM007	Shallow	Well	PDI	PDI	--	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	TS06-PPM008	Shallow	Well	PDI	PDI	--	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	Each of five test borings designated as C0126-SBXXX to C0130-SBXXX at two depths: water table and 25'	Shallow	IsoFlow ⁽³⁾	--	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
		Shallow	IsoFlow	--	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
		Shallow	IsoFlow	--	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
		Shallow	IsoFlow	--	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
		Shallow	IsoFlow	--	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
		Shallow	IsoFlow	--	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
		Shallow	IsoFlow	--	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
		Shallow	IsoFlow	--	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
	CO29-PZM051	Intermediate	Well	PDI	PDI	--	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO30-PZM060	Intermediate	Well	PDI	PDI	--	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO32-PZM041	Intermediate	Well	PDI	PDI	--	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	SW17-PZM038	Intermediate	Well	PDI	PDI	--	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	Each of five test borings designated as C0126-SBXXX to C0130-SBXXX at 35' depth	Intermediate	IsoFlow	--	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--
Intermediate		IsoFlow	--	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--	
Intermediate		IsoFlow	--	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--	
Intermediate		IsoFlow	--	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--	
Intermediate		IsoFlow	--	PDI	--	--	--	--	--	--	--	PDI	PDI	--	--	
MS/MSD	NA	QC	--	--	--	--	--	--	--	--	--	PDI	PDI	--	--	
Duplicate	NA	QC	--	--	--	--	--	--	--	--	--	PDI	PDI	--	--	
Trip Blank	NA	QC	--	--	--	--	--	--	--	--	--	--	PDI	--	--	

TABLE 2
SUMMARY OF GROUNDWATER SAMPLING AND ANALYSIS⁽¹⁾
COKE OVEN AREA PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND

Area of Interest	Well or Boring Designation	Zone of Interest	Sample Type	Field Analysis/Measurement (Method)								Laboratory Analysis (Method)				
				H ₂ O Level (SOP 26)	LNAPL (SOP 26)	DNAPL (SOP 26)	pH (SOP 21)	ORP (SOP 21)	SC (SOP 21)	DO (SOP 21)	Turbidity (SOP 21)	Temp. (SOP 21)	VOCs (8260B)	SVOCs (8270C)	Sulfate (300)	Chloride (300)
Cells 4 and 5	CO114-PZM002	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	--	--	--	--
	CO115-PZM006	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	--	--	--	--
	CO116-PZM003	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	--	--	--	--
	CO117-PZM003	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	--	--	--	--
	CO118-PZM007	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	--	--	--	--
	CO119-PZM009	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	--	--	--	--
	CO120-PZM009	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	--	--	--	--
	CO108-PZMXXX	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	--	--	--	--
	CO109-PZMXXX	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	--	--	--	--
	CO110-PZMXXX	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	--	--	--	--
	CO111-PZM006	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	--	--	--	--
	CO113-PZM004	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	--	--	--	--
	CO112-PZMXXX	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	--	--	--	--
	CO105-PZMXXX	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	--	--	--	--
	CO106-PZMXXX	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO12-PZM008	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO13-PZM008	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO24-PZM007	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO25-PZM008	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO26-PZM007	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO55-PZM000	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	QTY	QTY	--	--
	CO56-PZP001	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	QTY	QTY	--	--
	CO57-PZP002	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	QTY	QTY	--	--
	CO58-PZM001	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	QTY	QTY	--	--
	CO59-PZP002	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	QTY	QTY	--	--
	CO60-PZP001	Shallow	Well	PDI	PDI	PDI	--	--	--	--	--	--	QTY	QTY	--	--
	CO13-PZM030	Intermediate	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO26-PZM032	Intermediate	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
CO34-PZM048	Intermediate	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--	
3 Locations to be converted from test borings designated as C0150-SBXXX to C0155-SBXXX	Shallow/Inter.	New Well ⁽⁴⁾	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--	
	Shallow/Inter.	New Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--	
	Shallow/Inter.	New Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--	
MS/MSD Duplicate Trip Blank	NA	QC	--	--	--	--	--	--	--	--	--	PDI	PDI	--	--	
	NA	QC	--	--	--	--	--	--	--	--	--	PDI	PDI	--	--	
	NA	QC	--	--	--	--	--	--	--	--	--	--	PDI	--	--	
Cell 6	CO96-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	--	--	--	
	CO97-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	--	--	--	
	CO98-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	--	--	--	
	CO99-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	--	--	--	
	CO100-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	--	--	--	
	CO89-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	--	--	--	
	CO90-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	--	--	--	
	CO91-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	--	--	--	
	CO92-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	--	--	--	
	CO93-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	--	--	--	
	CO94-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	--	--	--	
	CO95-PZMXXX	Shallow	Well	PDI	PDI	--	--	--	--	--	--	--	--	--	--	
	CO04-PZM004	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO05-PZM006	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO17-PZM005	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO19-PZM004	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO20-PZM004	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO04-PZM048	Intermediate	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	3 Locations to be converted from test borings designated as C0131-SBXXX to C0149-SBXXX	Shallow	New Well ⁽⁵⁾	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
		Shallow	New Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
MS/MSD Duplicate Trip Blank	NA	QC	--	--	--	--	--	--	--	--	--	PDI	PDI	--	--	
	NA	QC	--	--	--	--	--	--	--	--	--	PDI	PDI	--	--	
	NA	QC	--	--	--	--	--	--	--	--	--	--	PDI	--	--	

TABLE 2
 SUMMARY OF GROUNDWATER SAMPLING AND ANALYSIS⁽¹⁾
 COKE OVEN AREA PRE-DESIGN INVESTIGATION
 SPARROWS POINT, MARYLAND

Area of Interest	Well or Boring Designation	Zone of Interest	Sample Type	Field Analysis/Measurement (Method)								Laboratory Analysis (Method)				
				H ₂ O Level (SOP 26)	LNAPL (SOP 26)	DNAPL (SOP 26)	pH (SOP 21)	ORP (SOP 21)	SC (SOP 21)	DO (SOP 21)	Turbidity (SOP 21)	Temp. (SOP 21)	VOCs (8260B)	SVOCs (8270C)	Sulfate (300)	Chloride (300)
Area Wide	SW13-PZM003	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	SW14-PZM004	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO06-PZM008	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO07-PZM008	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO08-PZM005	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO09-PZM007	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO10-PZM006	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO11-PZM007	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO35-PZM013	Shallow	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO06-PZM039	Intermediate	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO07-PZM050	Intermediate	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO08-PZM036	Intermediate	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO10-PZM029	Intermediate	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	CO35-PZM056	Intermediate	Well	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	PDI	--	--
	MS/MSD	NA	QC	--	--	--	--	--	--	--	--	--	--	PDI	PDI	--
Duplicate	NA	QC	--	--	--	--	--	--	--	--	--	--	PDI	PDI	--	--
Trip Blank	NA	QC	--	--	--	--	--	--	--	--	--	--	PDI	PDI	--	--

- Cell area investigations include a number of wells to be gauged and sampled/analyzed to support area wide evaluation.
 PDI - Measurement and/or sampling and analysis to be completed as part of pre-design investigation.
 QTY - Measurement and/or sampling and analysis to be completed as part of quarterly monitoring program.
- Borings installed in Cell 3 area to be sampled via IsoFlow sampling at three depth intervals. Cores to be inspected for presence of LNAPL.
- Cell 1 and 2 wells to be installed in the vicinity of C037-PZM003. One well to be installed at one of four deep boring locations (C0124-SBXXX, C0125-SBXXX, C0123-SBXXX and C0121-SBXXX). Two permeability samples to be obtained at depth from borings. LNAPL observations to be made.
- Six borings to be completed in the Cell 4 and 5 area. Locations to be determined via DNAPL gauging of existing wells. Cores to be inspected for presence of LNAPL and DNAPL. Three of 6 borings to be converted to wells.
- Fourteen rotonsonic borings planned for Cell 6 area. Three of the borings to be converted to shallow wells.

**SUMMARY OF VOC AND SVOC QUANTITATION LIMITS
COKE OVEN AREA PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND**

<i>Analyte</i>	MDE Groundwater Standard (ug/L)	Reporting Limit (ug/L)
<i>Volatile Organic Compounds (VOCs)</i>		
Acetone	550	10
Benzene	5	1
Bromodichloromethane	80	1
Bromoform	80	1
Bromomethane	0.85	1
2-Butanone (Methyl Ethyl Ketone)	700	10
Carbon Disulfide	100	1
Carbon Tetrachloride	5	1
Chlorobenzene	100	1
Chloroethane	3.6	1
Chloroform	80	1
Chloromethane	19	1
Dibromochloromethane	80	1
Dibromochloropropane	0.2	5
1,2-Dibromoethane (Ethylene Dibromide, EDB)	0.05	1
1,1-Dichloroethane	90	1
1,2-Dichloroethane	5	1
1,1-Dichloroethene	7	1
cis-1,2-Dichloroethene	70	1
trans-1,2-Dichloroethene	100	1
1,2-Dichloroethene (total)	5.5	2
1,2-Dichloropropane	5	1
cis-1,3-Dichloropropene	0.44	1
trans-1,3-Dichloropropene	0.44	1
Ethylbenzene	700	1
Isopropylbenzene (Cumene)	66	1
4-Methyl-2-pentanone (Methyl Isobutyl Ketone)	630	10
Methylene Chloride (Dichloromethane)	5	1
Methyl tert-butyl ether (MTBE)	20	1
Styrene	100	1
Tetrachloroethene	5	1
1,1,2,2-Tetrachloroethane	0.053	1
Toluene	1,000	1
1,1,1-Trichloroethane	200	1
1,1,2-Trichloroethane	5	1
Trichloroethene	5	1
Vinyl Chloride	2	1
Xylenes	10,000	3

**SUMMARY OF VOC AND SVOC QUANTITATION LIMITS
COKE OVEN AREA PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND**

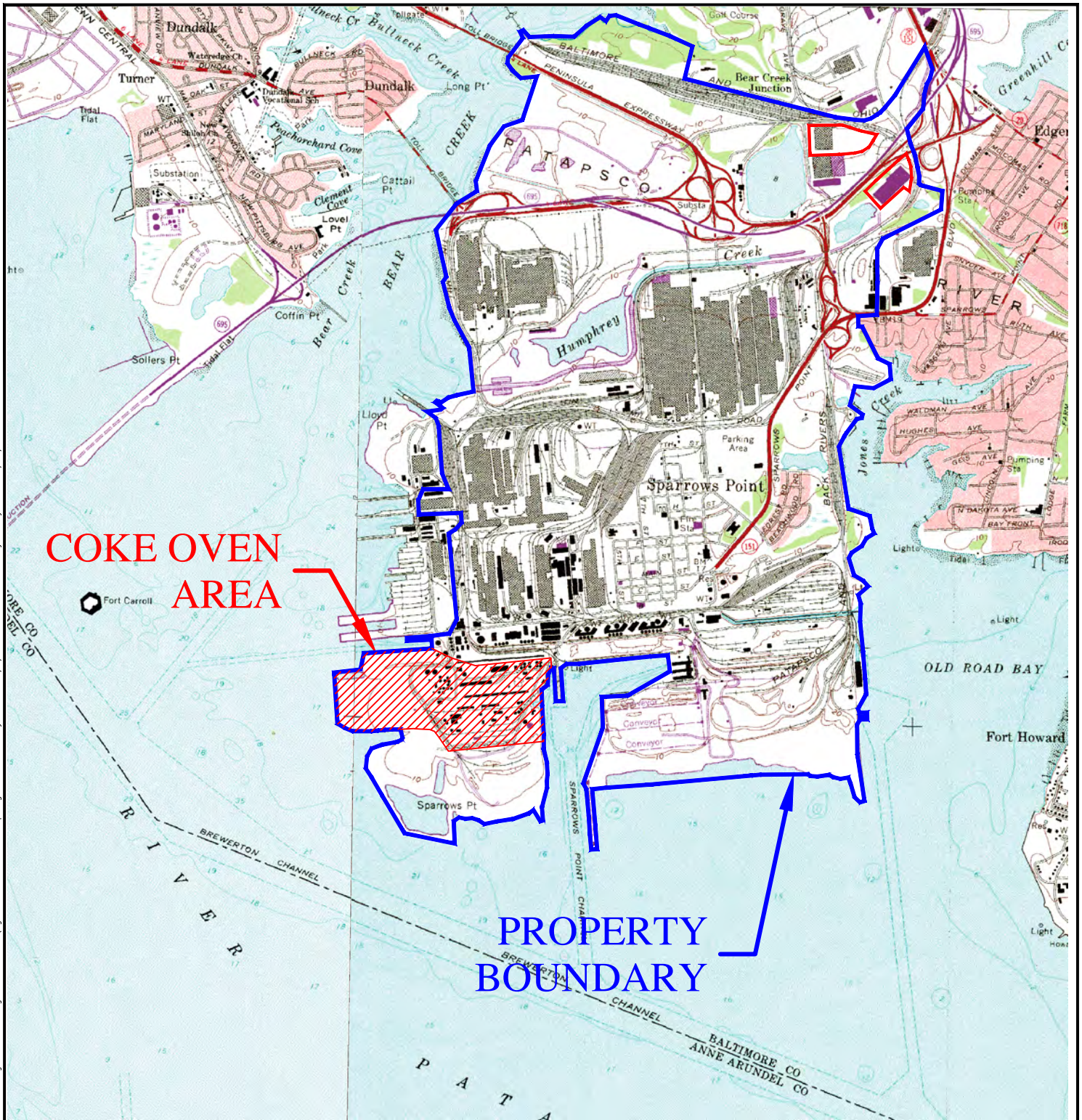
<i>Analyte</i>	MDE Groundwater Standard (ug/L)	Reporting Limit (ug/L)
<i>Semivolatile Organic Compounds (SVOCs)</i>		
Acenaphthene	37	10
Acenaphthylene	37	10
Anthracene	180	10
Benz[a]anthracene	0.2	10
Benzo[a]pyrene	0.2	10
Benzo[b]fluoranthene	0.2	10
Benzo[g,h,i]perylene	18	10
Benzo[k]fluoranthene	0.3	10
bis(2-Chloroethyl)ether	0.0096	10
bis(2-Ethylhexyl)phthalate	6	10
Carbazole	3.3	10
4-Chloroaniline	15	10
2-Chloronaphthalene	49	10
2-Chlorophenol	3	10
Chrysene	3	10
Dibenz[a,h]anthracene	0.2	10
Dibenzofuran	3.7	10
1,2-Dichlorobenzene	600	10
1,3-Dichlorobenzene	1.80	10
1,4-Dichlorobenzene	75	10
3,3-Dichlorobenzidine	0.15	10
2,4-Dichlorophenol	11	10
Diethylphthalate	2,900	10
2,4-Dimethylphenol	73	10
Di-n-butylphthalate	370	10
2,4-Dinitrophenol	7.3	25
2,4-Dinitrotoluene	7.3	10
2,6-Dinitrotoluene	3.7	10
Fluoranthene	150	10
Fluorene	24	10
Hexachlorobenzene	1	10
Hexachlorobutadiene	0.86	10
Hexachlorocyclopentadiene	50	10
Hexachloroethane	4.8	10
Indeno[1,2,3-c,d]pyrene	0.2	10
Isophorone	70	10
2-Methylnaphthalene	2.4	10

**SUMMARY OF VOC AND SVOC QUANTITATION LIMITS
COKE OVEN AREA PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND**

<i>Analyte</i>	MDE Groundwater Standard (ug/L)	Reporting Limit (ug/L)
<i>Semivolatile Organic Compounds (SVOCs) - Continued</i>		
2-Methylphenol	180	10
4-Methylphenol	18	20
Naphthalene	0.65	10
Nitrobenzene	0.35	10
N-Nitrosodiphenylamine	14	10
N-Nitroso-di-n-propylamine	0.0096	10
Bis(2-Chloroisopropyl)ether	0.26	10
Pentachlorophenol	1	25
Phenanthrene	180	10
Phenol	1,100	10
Pyrene	18	10
1,2,4-Trichlorobenzene	70	10
2,4,5-Trichlorophenol	370	25
2,4,6-Trichlorophenol	6.1	10

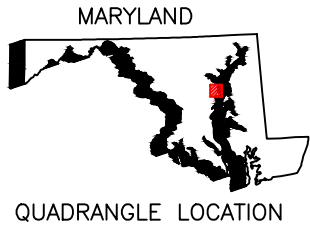
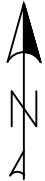
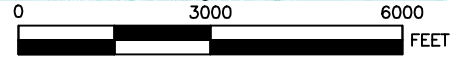
FIGURES

Y:\Sparrows Point\coke oven area drawings\14-933\interim measures configuration--investigation locations\Figure 1 site location map.dwg Last Saved By: Scomer 1/7/2015 5:52 AM Plotted By: Shelly Comer 1/22/2015 2:30 PM Scale: 1:1



**COKE OVEN
AREA**

**PROPERTY
BOUNDARY**



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COKE OVEN AREA
PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND

REFERENCE: - USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLES: - CURTIS BAY, MARYLAND 1969 REVISED 1974 - SPARROWS POINT, MARYLAND 1969 REVISED 1974	ISSUE DATE: KEY ENVIRONMENTAL, INC. 200 THIRD AVENUE CARNEGIE, PA 15106
---	--

SITE LOCATION MAP	PROJECT NO: 14-933 FIGURE 1
-------------------	---------------------------------------

Y:\spawrns_point\coke oven area drawings\14-933\interim measures configuration-investigation locations\figure 2 historical coke oven.dwg Last Saved By: Scanner 1/7/2015 5:53 AM Plotted By: Shelly Comer 1/22/2015 2:31 PM Scale: 1:1



LEGEND

FORMER STRUCTURES OR REMAINING STRUCTURES

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COKE OVEN AREA
PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND

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HISTORICAL GENERAL ARRANGEMENT
COKE OVEN AREA

PROJECT NO: 14-933
FIGURE 2

REFERENCE: THE GEOREFERENCED DIGITAL AERIAL PHOTOGRAPH WAS OBTAINED BY LINKING TO THE USGS EROS ORTHO IMAGE SERVER ON DECEMBER 1, 2014
([HTTP://RASTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER](http://raSTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER)). THIS AERIAL IMAGERY WAS COLLECTED FOR THE USGS ON SEPTEMBER 30, 2008.

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STORM SEWERS



SANITARY SEWERS



INDUSTRIAL WATER



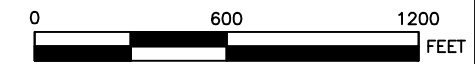
POTABLE WATER

LEGEND

- UTILITY LINE
- FLOW DIRECTION
- NOMINAL PIPE DIAMETER
- OUTFALL NUMBER

NOTE:
 1. NO KNOWN BURIED ELECTRICAL OR GAS LINES PRESENT IN COKE OVEN AREA.

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COKE OVEN AREA
 PRE-DESIGN INVESTIGATION
 SPARROWS POINT, MARYLAND

ISSUE DATE:
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SUBSURFACE UTILITY LINES PROJECT NO:
 FIGURE 3

REFERENCE: THE GEOREFERENCED DIGITAL AERIAL PHOTOGRAPH WAS OBTAINED BY LINKING TO THE USGS EROS ORTHO IMAGE SERVER ON DECEMBER 1, 2014.
 (HTTP://RASTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOMAGERY/USGS_EROS_ORTHO/IMAGESERVER). THIS AERIAL IMAGERY WAS COLLECTED FOR THE USGS ON SEPTEMBER 30, 2008.
 UTILITIES PROVIDED BY BETHLEHEM STEEL DRAWING NOS. 5594 STORM SEWERS, 5595 SANITARY SEWERS, 5690 INDUSTRIAL WATER LINES, 5698 POTABLE WATER LINES, AND 5899 NATURAL GAS LINES.

REV #	DATE	DESCRIPTION	APPD

Y:\spawns_point\coke oven area drawings\14-933\interim measures configuration-investigation_locations\figure 4 current coke oven.dwg Last Saved By: Scomer 1/7/2015 5:55 AM Plotted By: Shelly Comer 1/22/2015 2:32 PM Scale: 1:1



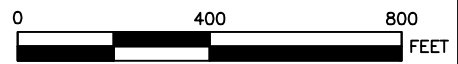
LEGEND

INTERIM MEASURE AREA

NOTES:

1. CELL 5 IM DESIGNED TO ADDRESS CELLS 4 AND 5 AS A COMBINED UNIT.
2. AS/SVE – AIR SPARGE AND SOIL VAPOR EXTRACTION.

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COKE OVEN AREA
PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND

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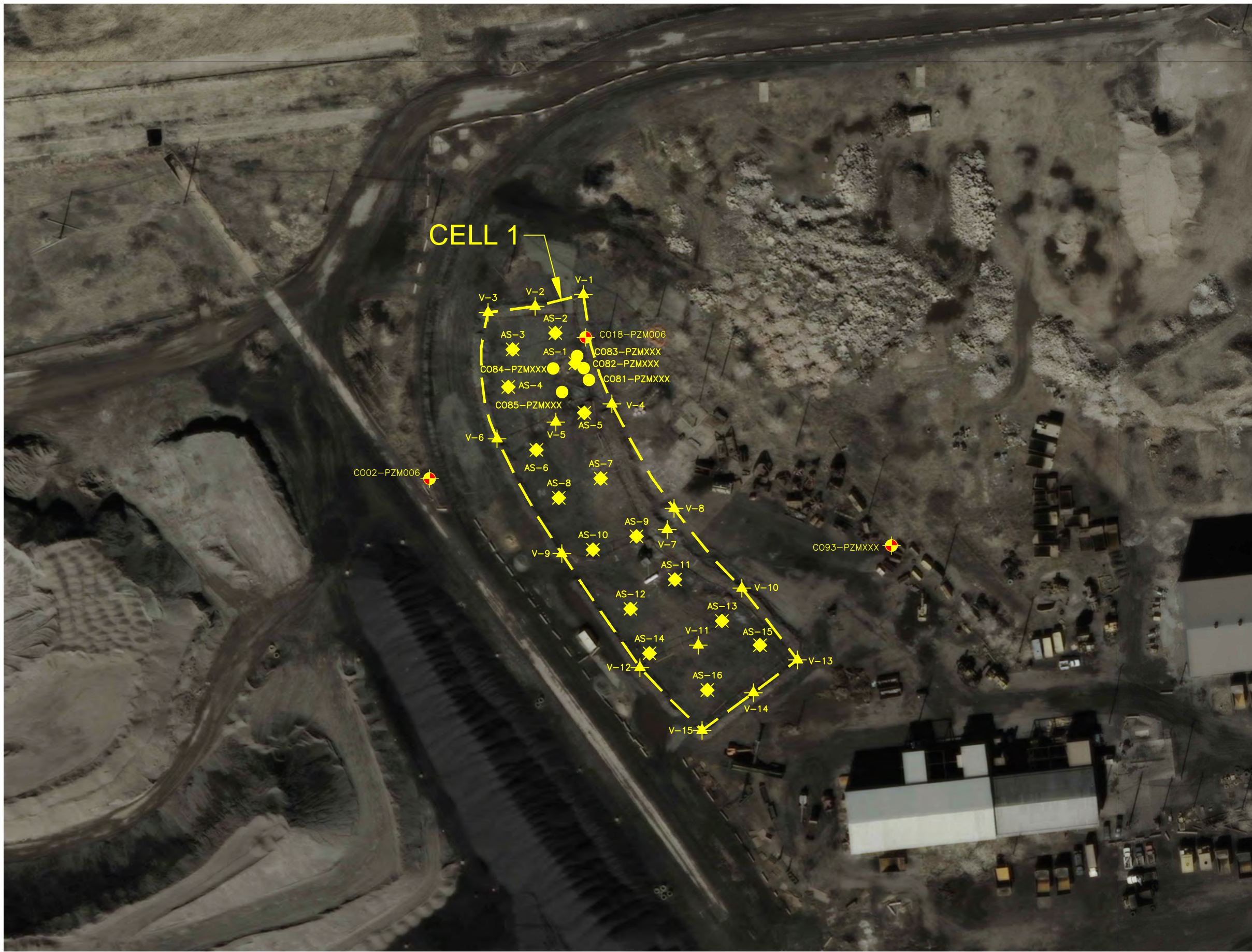
CURRENT GENERAL ARRANGEMENT
COKE OVEN AREA

PROJECT NO: 14-933
FIGURE 4

REFERENCE: THE GEOREFERENCED DIGITAL AERIAL PHOTOGRAPH WAS OBTAINED BY LINKING TO THE USGS EROS ORTHO IMAGE SERVER ON DECEMBER 1, 2014
([HTTP://RASTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER](http://raSTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER)). THIS AERIAL IMAGERY WAS COLLECTED FOR THE USGS ON SEPTEMBER 30, 2008.

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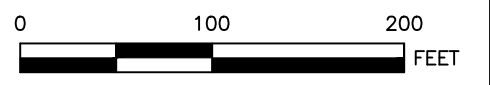
LEGEND

- INTERIM MEASURE AREA AND VAPOR COLLECTION TRENCH (EXISTING)
- SHALLOW WELL LOCATION (EXISTING)
- TRENCH VAPOR EXTRACTION RISER (EXISTING)
- SVE PILOT TEST OBSERVATION WELL (EXISTING)
- AIR SPARGE POINT (EXISTING)

NOTES:

1. EIGHT OF THE AIR SPARGE POINTS AND SIX OF THE SOIL VAPOR EXTRACTION POINTS CURRENTLY OPERATED.
2. DEPICTED SHALLOW MONITORING WELLS USED FOR CELL 1 PERFORMANCE MONITORING.

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COKE OVEN AREA
PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND

INTERIM MEASURE CONFIGURATION
CELL 1

PROJECT NO: 14-933
FIGURE 5

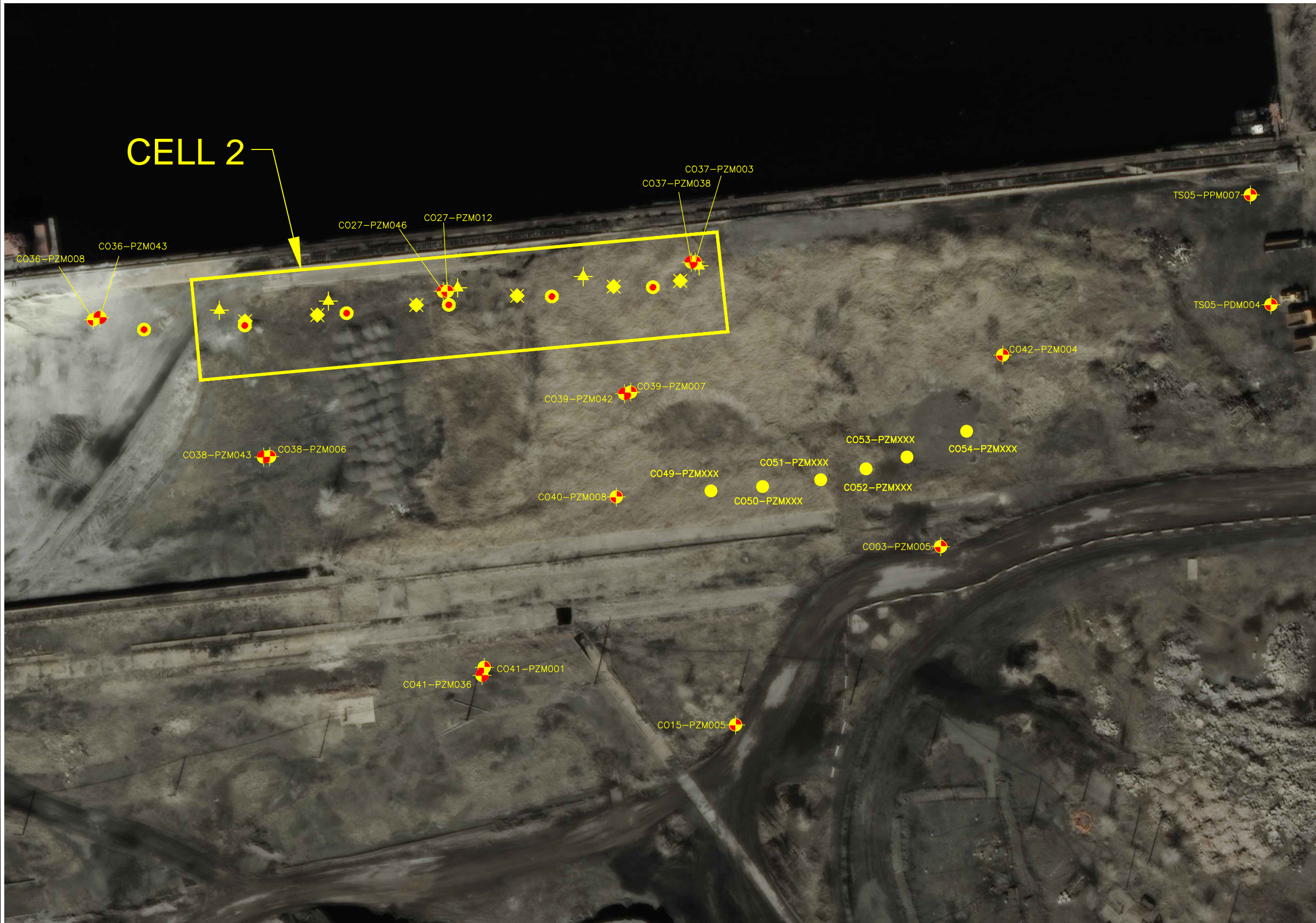
REFERENCE: THE GEOREFERENCED DIGITAL AERIAL PHOTOGRAPH WAS OBTAINED BY LINKING TO THE USGS EROS ORTHO IMAGE SERVER ON DECEMBER 1, 2014
([HTTP://RASTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER](http://raSTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER)). THIS AERIAL IMAGERY WAS COLLECTED FOR THE USGS ON SEPTEMBER 30, 2008.

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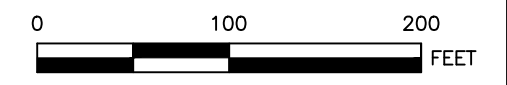
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LEGEND

- INTERIM MEASURE AREA
- + SHALLOW WELL LOCATION (EXISTING)
- + INTERMEDIATE WELL LOCATION (EXISTING)
- + VAPOR EXTRACTION RISER (EXISTING)
- REINJECTION WELLS (EXISTING)
- * AIR SPARGE WELL (EXISTING)
- INTERMEDIATE ZONE GROUNDWATER EXTRACTION WELL (EXISTING)

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COKE OVEN AREA
PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND

INTERIM MEASURE CONFIGURATION
CELL 2

PROJECT NO: 14-933
FIGURE 6

REFERENCE: THE GEOREFERENCED DIGITAL AERIAL PHOTOGRAPH WAS OBTAINED BY LINKING TO THE USGS EROS ORTHO IMAGE SERVER ON DECEMBER 1, 2014 (http://raSTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER). THIS AERIAL IMAGERY WAS COLLECTED FOR THE USGS ON SEPTEMBER 30, 2008.

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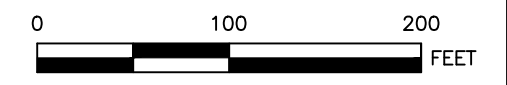



LEGEND

-  INTERIM MEASURE AREA
-  SHALLOW WELL LOCATION (EXISTING)
-  INTERMEDIATE WELL LOCATION (EXISTING)
-  VAPOR EXTRACTION RISER (EXISTING)
-  AIR SPARGE WELL (EXISTING)

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NOTE:
 1. MONITORING WELLS CO30-PZM005, AND CO101-PZMXXX THROUGH CO103-PZMXXX USED FOR PERFORMANCE MONITORING.



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COKE OVEN AREA PRE-DESIGN INVESTIGATION SPARROWS POINT, MARYLAND	
INTERIM MEASURE CONFIGURATION CELL 3	PROJECT NO: 14-933 FIGURE 7

REFERENCE: THE GEOREFERENCED DIGITAL AERIAL PHOTOGRAPH WAS OBTAINED BY LINKING TO THE USGS EROS ORTHO IMAGE SERVER ON DECEMBER 1, 2014 (http://raSTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER). THIS AERIAL IMAGERY WAS COLLECTED FOR THE USGS ON SEPTEMBER 30, 2008.

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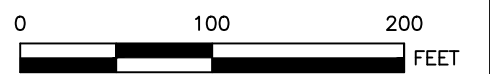


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LEGEND

- INTERIM MEASURE AREA
- ◆ SHALLOW WELL LOCATION (EXISTING)
- ◆ INTERMEDIATE WELL LOCATION (EXISTING)
- ◆ RECIRCULATION WELL LOCATION (EXISTING)
- REINJECTION WELL (EXISTING)
- DUAL PHASE EXTRACTION WELL (EXISTING)

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COKE OVEN AREA PRE-DESIGN INVESTIGATION SPARROWS POINT, MARYLAND	
INTERIM MEASURE CONFIGURATION CELLS 4 AND 5	PROJECT NO: 14-933 FIGURE 8

REFERENCE: THE GEOREFERENCED DIGITAL AERIAL PHOTOGRAPH WAS OBTAINED BY LINKING TO THE USGS EROS ORTHO IMAGE SERVER ON DECEMBER 1, 2014 (http://raster.nationalmap.gov/arcgis/rest/services/OrthoImagery/USGS_Eros_Ortho/ImageServer). THIS AERIAL IMAGERY WAS COLLECTED FOR THE USGS ON SEPTEMBER 30, 2008.

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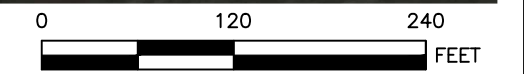
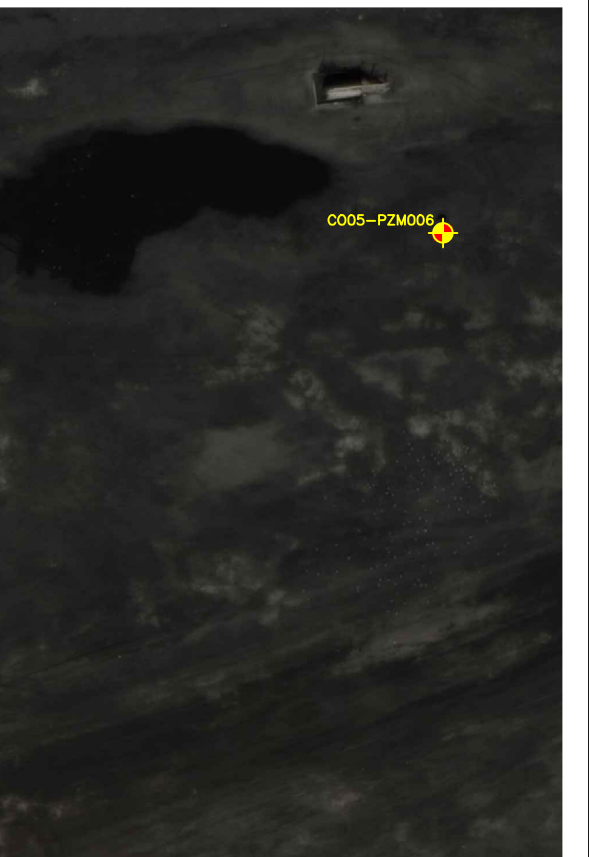


LEGEND

- INTERIM MEASURE AREA
- ◆ SHALLOW WELL LOCATION (EXISTING)
- ◆ RECOVERY WELL LOCATION (EXISTING)

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NOTE:
 1. LNAPL HISTORICALLY REPORTED TO BE PRESENT IN MONITORING WELL C004-PZM004.



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COKE OVEN AREA PRE-DESIGN INVESTIGATION SPARROWS POINT, MARYLAND	
INTERIM MEASURE CONFIGURATION CELL 6	PROJECT NO: 14-933 FIGURE 9

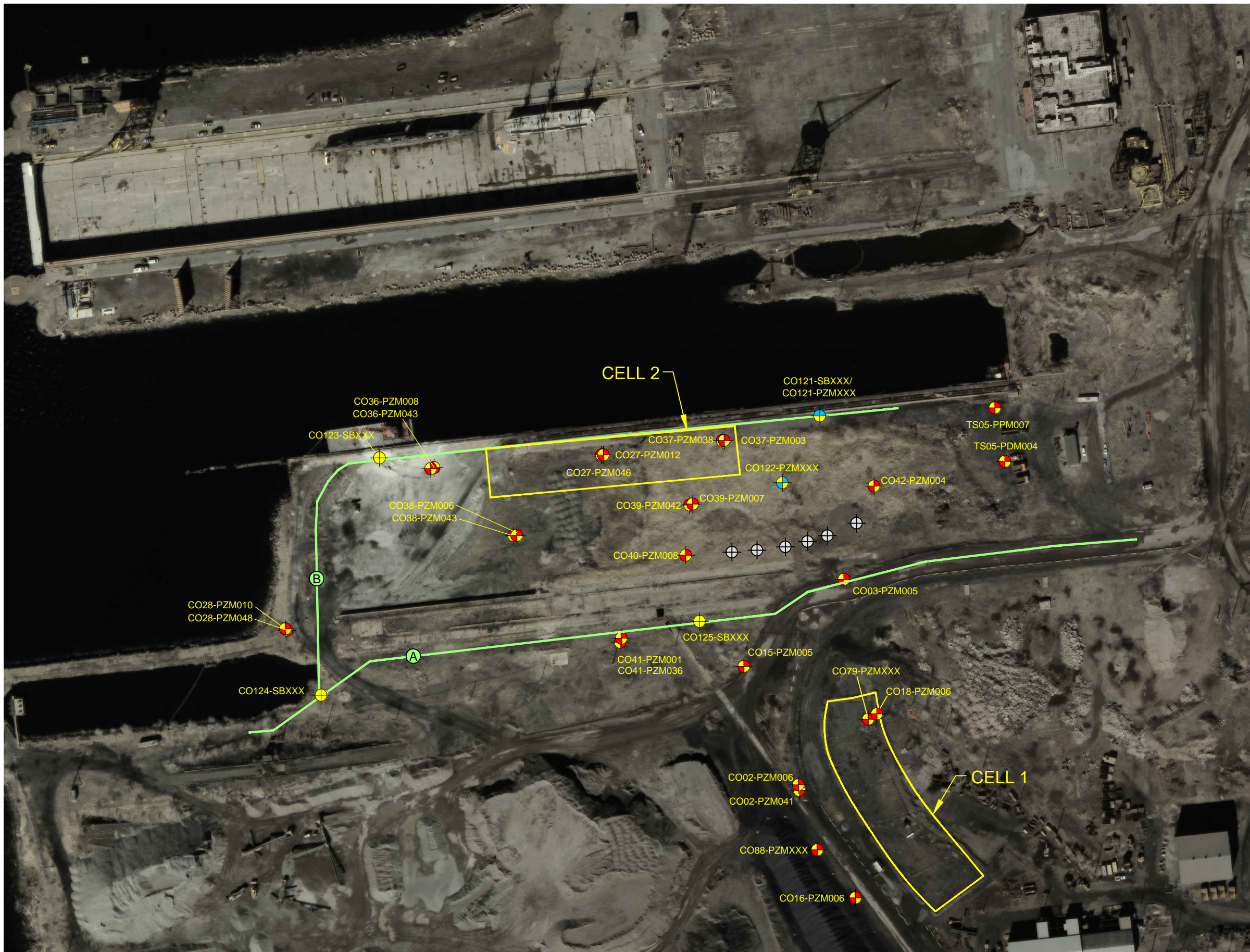
REFERENCE: THE GEOREFERENCED DIGITAL AERIAL PHOTOGRAPH WAS OBTAINED BY LINKING TO THE USGS EROS ORTHO IMAGE SERVER ON DECEMBER 1, 2014 ([HTTP://RASTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER](http://raSTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER)). THIS AERIAL IMAGERY WAS COLLECTED FOR THE USGS ON SEPTEMBER 30, 2008.

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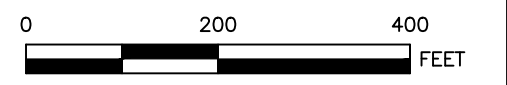
LEGEND

- INTERIM MEASURE AREA
- + DEEP BORING LOCATION (PLANNED)
- + DEEP BORING CONVERTED TO SHALLOW MONITORING WELL (PLANNED)
- + SHALLOW MONITORING WELL LOCATION (PLANNED)
- + SHALLOW WELL LOCATION (EXISTING)
- + INTERMEDIATE WELL LOCATION (EXISTING)
- + TREATED GROUNDWATER REINJECTION WELL LOCATION (EXISTING)
- A POTENTIAL SLURRY WALL ALIGNMENT (OPTIONS A & B)

NOTES:

1. ADDITIONAL DELINEATION BORINGS TO BE COMPLETED AS NECESSARY TO DELINEATE LNAPL BASED ON FIELD OBSERVATIONS.
2. DATA OBTAINED AS A RESULT OF CELL 6 INVESTIGATION WILL SUPPLEMENT THIS SCOPE OF WORK (SEE FIGURE 12).
3. LOCATIONS OF BORINGS/WELLS MAY BE MODIFIED BASED ON FIELD CONDITIONS.
4. REINJECTION WELL LOCATIONS SHOWN FOR INFORMATION PURPOSES ONLY.
5. CONDITIONS DEPICTED ARE AS OF 2008. LOCATIONS OF SCRAP PILES AND PROCESSED SLAG VARIABLE.
6. SEE TABLE 2 FOR DETAILS REGARDING GROUNDWATER SAMPLING AND ANALYSIS.

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COKE OVEN AREA
PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND

INVESTIGATION LOCATIONS AND SCOPE CELLS 1 AND 2	PROJECT NO: 14-933 FIGURE 10
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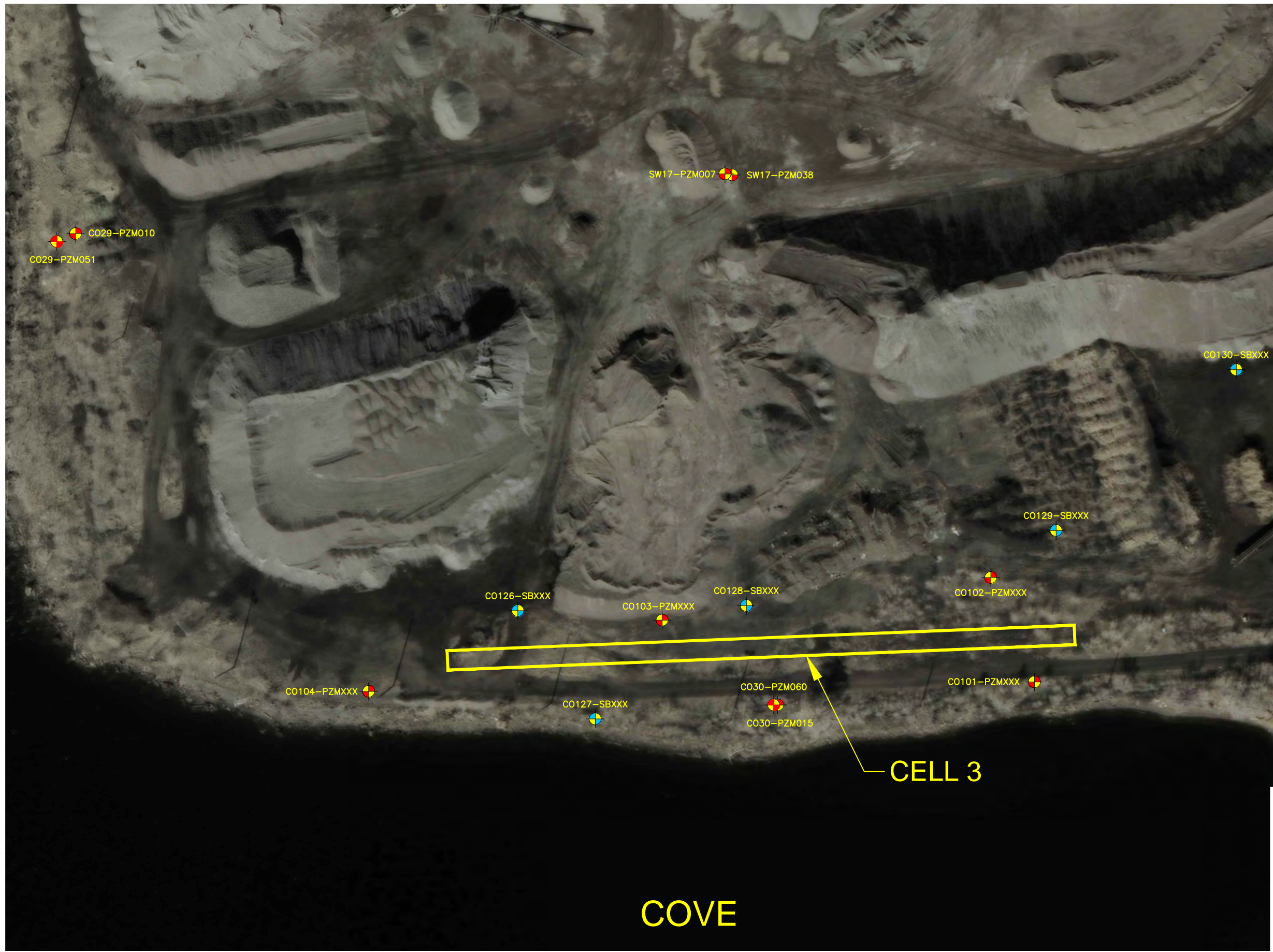
REFERENCE: THE GEOREFERENCED DIGITAL AERIAL PHOTOGRAPH WAS OBTAINED BY LINKING TO THE USGS EROS ORTHO IMAGE SERVER ON DECEMBER 1, 2014 ([HTTP://RASTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER](http://raSTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER)). THIS AERIAL IMAGERY WAS COLLECTED FOR THE USGS ON SEPTEMBER 30, 2008.

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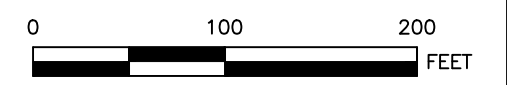


LEGEND

- INTERIM MEASURE AREA
- + SHALLOW BORING LOCATION (PLANNED)
- + SHALLOW WELL LOCATION (EXISTING)
- + INTERMEDIATE WELL LOCATION (EXISTING)

- NOTES:**
1. ADDITIONAL DELINEATION BORINGS TO BE COMPLETED AS NECESSARY TO DELINEATE LNAPL BASED ON FIELD OBSERVATIONS.
 2. ISOFLOW SAMPLES TO BE OBTAINED AT THREE DEPTHS FOR EACH OF FIVE BORINGS.
 3. SEE TABLE 2 FOR DETAILS REGARDING GROUNDWATER SAMPLING AND ANALYSIS.

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COKE OVEN AREA
PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND

INVESTIGATION LOCATIONS AND SCOPE
CELL 3

PROJECT NO: 14-933
FIGURE 11

REFERENCE: THE GEOREFERENCED DIGITAL AERIAL PHOTOGRAPH WAS OBTAINED BY LINKING TO THE USGS EROS ORTHO IMAGE SERVER ON DECEMBER 1, 2014
([HTTP://RASTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER](http://raSTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER)). THIS AERIAL IMAGERY WAS COLLECTED FOR THE USGS ON SEPTEMBER 30, 2008.

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COVE

CELL 3

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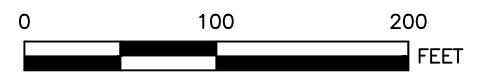
LEGEND

- INTERIM MEASURE AREA
- SHALLOW WELL LOCATION (EXISTING)
- INTERMEDIATE WELL LOCATION (EXISTING)
- RECIRCULATION WELL LOCATION (EXISTING)
- TREATED GROUNDWATER REINJECTION WELL LOCATION (EXISTING)

NOTE:

1. SOIL BORING LOCATIONS (5) TO BE DETERMINED BASED ON INITIAL WELL GAUGING.
2. ADDITIONAL DELINEATION BORINGS TO BE COMPLETED AS NECESSARY TO DELINEATE LNAPL BASED ON FIELD OBSERVATIONS.
3. SEE TABLE 2 FOR DETAILS REGARDING GROUNDWATER SAMPLING AND ANALYSIS.

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COKE OVEN AREA
PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND

KEY ENVIRONMENTAL, INC.
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INVESTIGATION LOCATIONS AND SCOPE
CELLS 4 AND 5

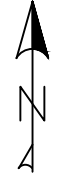
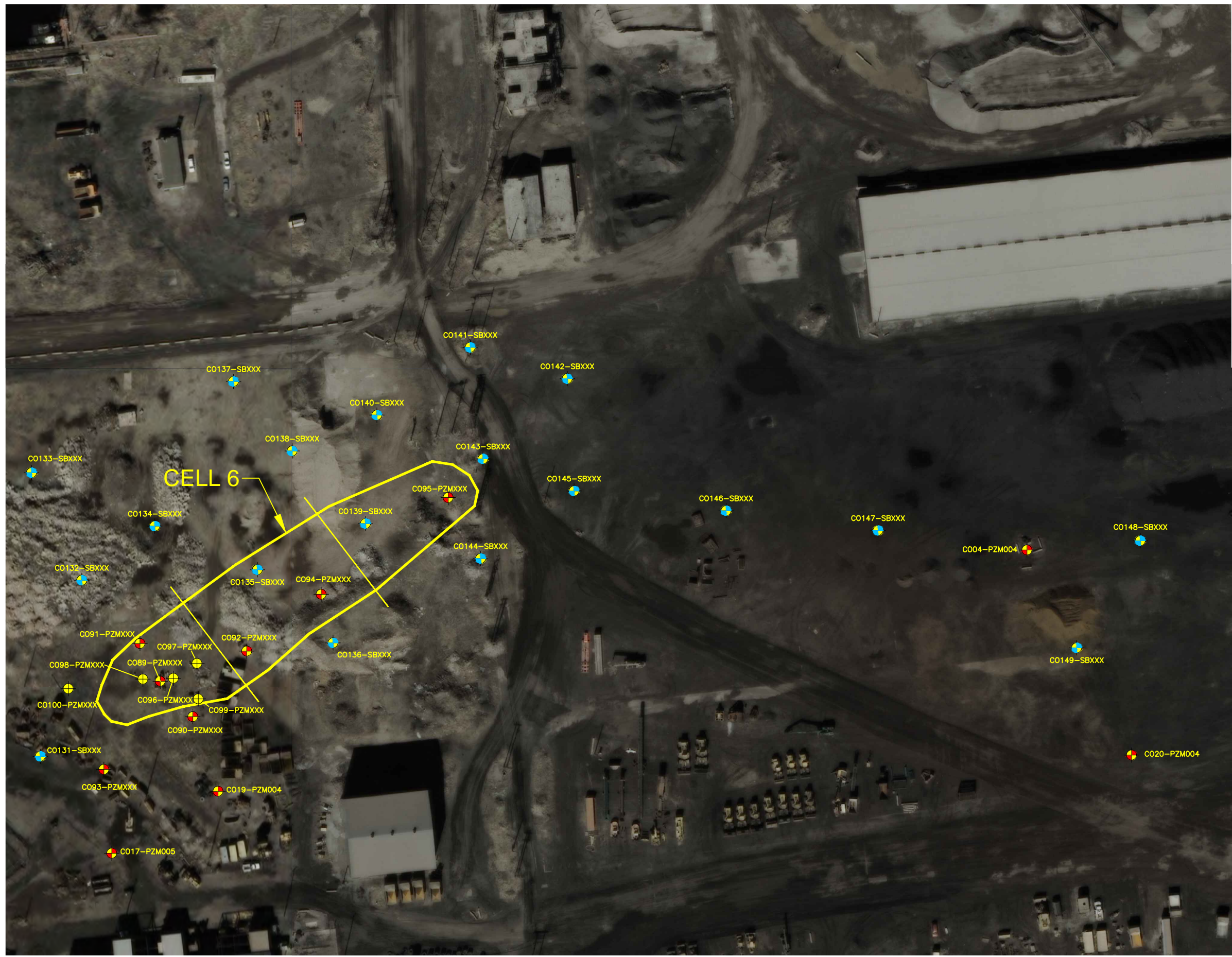
PROJECT NO: 14-933
FIGURE 12

REFERENCE: THE GEOREFERENCED DIGITAL AERIAL PHOTOGRAPH WAS OBTAINED BY LINKING TO THE USGS EROS ORTHO IMAGE SERVER ON DECEMBER 1, 2014 ([HTTP://RASTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER](http://raSTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER)). THIS AERIAL IMAGERY WAS COLLECTED FOR THE USGS ON SEPTEMBER 30, 2008.

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LEGEND

- INTERIM MEASURE AREA
- SHALLOW BORING LOCATION (PLANNED)
- SHALLOW WELL LOCATION (EXISTING)
- RECOVERY WELL LOCATION (EXISTING)
- TEST TRENCH (OPTIONAL)

- NOTES:**
1. ADDITIONAL DELINEATION BORINGS TO BE COMPLETED AS NECESSARY TO DELINEATE LNAPL BASED ON FIELD OBSERVATIONS.
 2. UP TO THREE BORINGS TO BE CONVERTED TO MONITORING WELLS IF LNAPL OBSERVED.
 3. SEE TABLE 2 FOR DETAILS REGARDING GROUNDWATER SAMPLING AND ANALYSIS.

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0 120 240
FEET

ENVIROANALYTICS GROUP

DRWN: SCC	DATE: 01/23/15	
CHKD: RJH	DATE: 01/23/15	
APPD: AEB	DATE: 01/23/15	
SCALE: AS SHOWN		

COKE OVEN AREA
PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND

INVESTIGATION LOCATIONS AND SCOPE CELL 6	PROJECT NO: 14-933 FIGURE 13
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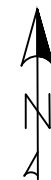
REFERENCE: THE GEOREFERENCED DIGITAL AERIAL PHOTOGRAPH WAS OBTAINED BY LINKING TO THE USGS EROS ORTHO IMAGE SERVER ON DECEMBER 1, 2014 ([HTTP://RASTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER](http://RASTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER)). THIS AERIAL IMAGERY WAS COLLECTED FOR THE USGS ON SEPTEMBER 30, 2008.

ISSUE DATE:

KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

REV #	DATE	DESCRIPTION	APPD

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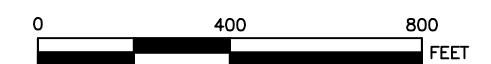
LEGEND

- INTERIM MEASURE AREA
- COMPREHENSIVE MONITORING POINT INCLUDED IN CELL-SPECIFIC STUDY (QUARTERLY OR PRE-DESIGN INVESTIGATION)
- COMPREHENSIVE MONITORING POINT TO SUPPLEMENT AREA-WIDE GROUNDWATER INVESTIGATION

NOTES:

1. UP TO THREE NEW WELLS TO BE INSTALLED IN CELL 4/5 AREA AND UP TO THREE NEW WELLS TO BE INSTALLED IN CELL 6 AREA. LOCATIONS NOT DEPICTED. LOCATIONS TO BE DETERMINED BASED ON DATA EVALUATION AS FIELD WORK PROGRESSES.
2. WATER LEVEL MEASUREMENTS TO BE OBTAINED FROM A REPRESENTATIVE SUBSET OF EXISTING MONITORING WELLS LOCATED IN THE COKE POINT LANDFILL AREA (I.E., TO THE SOUTH OF THE COKE OVEN AREA).
3. MONITORING WELLS TO BE GAUGED OR GAUGED/SAMPLED TO THE EXTENT THAT THEY CAN BE LOCATED, ARE UNDAMAGED, AND ARE SUITABLE FOR MONITORING PURPOSES.

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APPD: AEB	DATE: 01/23/15
SCALE:	AS SHOWN



COKE OVEN AREA
PRE-DESIGN INVESTIGATION
SPARROWS POINT, MARYLAND

INVESTIGATION LOCATIONS AND SCOPE
COMPREHENSIVE MONITORING PROGRAM

PROJECT NO: 14-933
FIGURE 14

REFERENCE: THE GEOREFERENCED DIGITAL AERIAL PHOTOGRAPH WAS OBTAINED BY LINKING TO THE USGS EROS ORTHO IMAGE SERVER ON DECEMBER 1, 2014 ([HTTP://RASTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER](http://raSTER.NATIONALMAP.GOV/ARCGIS/REST/SERVICES/ORTHOIMAGERY/USGS_EROS_ORTHO/IMAGESERVER)). THIS AERIAL IMAGERY WAS COLLECTED FOR THE USGS ON SEPTEMBER 30, 2008.

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APPENDIX A
HEALTH AND SAFETY PLAN

HEALTH AND SAFETY PLAN
FORMER COKE OVEN AREA INVESTIGATION

SPARROWS POINT, LLC
1430 Sparrows Point Boulevard
Baltimore, MD 21219

Prepared for:

EnviroAnalytics Group, LLC

Prepared by:

Key Environmental, Inc.
200 Third Avenue
Carnegie, Pennsylvania 15106

January 23, 2015

TABLE OF CONTENTS

LIST OF TABLES iii
LIST OF FIGURES iii
LIST OF APPENDICES iii

1.0 INTRODUCTION..... 1-1

2.0 PROGRAM ORGANIZATION AND RESPONSIBILITIES 2-1

2.1 WORK PERFORMED BY KEY PERSONNEL 2-1
2.2 SUBCONTRACTOR ACTIVITIES..... 2-2

3.0 SITE CHARACTERIZATION AND HAZARD ASSESSMENT 3-1

3.1 SITE DESCRIPTION AND BACKGROUND 3-1
3.2 SCOPE OF WORK..... 3-1
3.3 CHEMICAL HEALTH HAZARDS 3-1
3.3.1 BTEX and Other VOCs 3-1
3.3.2 Naphthalene 3-2
3.3.3 Work Task Chemical Hazard Assessment 3-2
3.4 PHYSICAL HAZARDS 3-3
3.5 CONFINED SPACES..... 3-3
3.6 COLD STRESS 3-3
3.6.1 Cold Stress Prevention 3-4
3.7 OUTDOOR HAZARDS 3-5

4.0 MEDICAL SURVEILLANCE 4-1

4.1 PRE-ASSIGNMENT SCREENING..... 4-1
4.2 SUBCONTRACTORS 4-1

5.0 WORK PRACTICES AND SITE CONTROL 5-1

5.1 SAFE WORK PRACTICES 5-1
5.1.1 Routine Safe Work Practices 5-1
5.1.2 Work Restrictions 5-1
5.1.3 Underground and Overhead Utilities 5-1
5.1.4 Excavation and Trenching 5-1
5.1.5 Heavy Equipment Operations 5-4
5.1.6 Rotosonic Drilling 5-5
5.1.7 Installing, Developing and Sampling Wells, Performing NAPL
Thickness Measurements 5-5
5.1.8 Noise 5-6
5.1.9 Use of Drinking Water or Liquids 5-6
5.1.10 Slip, Trip, Fall 5-6
5.2 SITE ACCESS/SITE CONTROL..... 5-7
5.2.1 Site Access 5-7
5.2.2 Work Zones..... 5-7
5.3 SITE HOUSEKEEPING..... 5-7
5.4 SANITATION/CHANGING FACILITIES..... 5-8
5.5 EXPOSURE PREVENTION 5-8

5.6	BUDDY SYSTEM.....	5-8
5.7	SITE COMMUNICATIONS	5-8
6.0	PERSONAL PROTECTIVE EQUIPMENT.....	6-1
6.1	SITE-SPECIFIC LEVELS OF PROTECTION.....	6-1
6.2	UPGRADE CONDITIONS	6-1
7.0	MONITORING.....	7-1
7.1	REAL-TIME MONITORING	7-1
7.2	INSTRUMENT CALIBRATION.....	7-1
7.3	AIR MONITORING ACTION LEVELS.....	7-2
8.0	MATERIAL HANDLING AND DECONTAMINATION.....	8-1
8.1	DECONTAMINATION	8-1
	8.1.1 Personnel Decontamination	8-1
	8.1.2 Equipment Decontamination	8-2
9.0	EMERGENCY PROCEDURES	9-1
9.1	EMERGENCY MEDICAL TREATMENT AND FIRST AID.....	9-1
9.2	EMERGENCY EVALUATION, INVESTIGATION AND DOCU- MENTATION.....	9-2
10.0	TRAINING	10-1
10.1	GENERAL.....	10-1
10.2	SITE-SPECIFIC TRAINING	10-1
10.3	SAFETY MEETINGS	10-1

LIST OF TABLES

<u>Table No.</u>	<u>Title</u>
1	Exposure Limits and Other Properties of Potential Site Constituents
2	Task-Specific Hazard Assessment with Proposed Initial Levels of Protection and Air Monitoring Requirements

LIST OF FIGURES

<u>Figure No.</u>	<u>Title</u>
1	Site Location Map
1-1	Site Location Map (Satellite Photo)

LIST OF APPENDICES

<u>Appendix</u>	<u>Title</u>
A	Material Safety Data Sheets
B	Health and Safety Forms
C	Emergency Contacts and Hospital Route Map

1.0 INTRODUCTION

This Health and Safety Plan (HASP) describes Site-specific procedures to be implemented by Key Environmental, Inc. (KEY) employees and sub-contractors when implementing the Coke Oven Area Investigation activities at the Sparrows Point Site in Baltimore, Maryland. All work must be performed in accordance with applicable federal, state, and local regulations, including, but not limited to:

U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) - 29 Code of Federal Regulations (CFR) 1910.120, "Hazardous Waste Operations and Emergency Response"; and,

OSHA - 29 CFR 1926, "Safety and Health Regulations for Construction."

The health and safety practices, procedures, and personal protective equipment (PPE) requirements established within this HASP are based on hazards known to be present at this Site. All protective measures employed must be commensurate with known hazards associated with specific work activities and job tasks, and must be modified if other hazards are identified during the course of the work.

This HASP should not be used for activities other than those outlined in the scope of work unless a task-specific hazard and exposure assessment is performed and any additional protective measures incorporated into the HASP. This HASP is intended for use by KEY and may not include all subcontractor activities. Contractors or subcontractors performing activities not included in this HASP must prepare their own HASP in accordance with OSHA 29 CFR 1910.120.

2.0 PROGRAM ORGANIZATION AND RESPONSIBILITIES

Certain activities covered by this HASP will be performed by subcontractors working under the direction of KEY while some activities covered by this HASP will be performed by KEY personnel. The following details the safety organization and responsibilities for both scenarios.

2.1 WORK PERFORMED BY KEY PERSONNEL

KEY Project Manager - The KEY Project Manager is responsible for ensuring that all activities are conducted in accordance with the HASP. The Project Manager has the authority to suspend field activities if employees are in danger of injury or exposure to harmful agents. The Project Manager's responsibilities include:

- Coordinating the development of a Site-specific HASP for all phases of the KEY project;
 - Ensuring that the appropriate health and safety equipment and PPE are available for KEY project personnel;
 - Ensuring that KEY personnel have received the appropriate training before they engage in activities that are potentially hazardous;
 - Ensuring that KEY personnel have received the required medical examination, testing, and screening before engaging in work activities; and,
 - Designating a Site Health and Safety Officer (SHSO) and other KEY Site personnel who will ensure compliance with the HASP.
- KEY Project Site Supervisor - The KEY Site Supervisor is responsible for ensuring that all KEY Site activities are conducted in accordance with the HASP. The KEY Site Supervisor reports to the KEY Project Manager. The Site Supervisor's responsibilities include:
 - Ensuring that KEY personnel, subcontractor personnel, and visitors comply with the requirements of this HASP; and,
 - Notifying the KEY Project Manager of any changes in work conditions or tasks which may require changes to the HASP.
 - KEY SHSO - The KEY SHSO reports to the KEY Site Supervisor (may be the same person) and is responsible for overall implementation of the KEY HASP. The SHSO's duties include:
 - Coordinating safety meetings and daily safety briefings, as necessary;
 - Managing health and safety equipment, including instruments, respirators, gloves, suits, and other PPE used in field activities;

- Acting as the Emergency Coordinator at the Site and arrange for emergency response in cooperation with local emergency and health officials;
- Monitoring conditions during field activities to assure compliance with HASP;
- Monitoring conditions during field activities to determine if more stringent procedures or a higher level of PPE should be implemented;
- Maintaining a log to record conditions, personnel involved in field activities, and other pertinent health and safety data;
- Overseeing the arrangement and execution of personnel and equipment decontamination;
- Suspending field activities, if necessary, and resume activities when appropriate; and,
- Controlling visitor, subcontractor, and employee access to hazardous areas.

KEY On-Site Personnel are responsible for:

- Their own safety;
- Ensuring that they have the proper PPE and other necessary safety equipment;
- Ensuring that their training and medical surveillance is up-to-date;
- Becoming familiar with and complying with the HASP;
- Attending training sessions to review the HASP and other safety/health information;
- Being alert to previously identified and new hazards;
- Reporting unidentified hazards to the KEY Health and Safety Manager; and,
- Conducting themselves in a manner that is orderly and appropriate for the Site.

2.2 SUBCONTRACTOR ACTIVITIES

Subcontractors are responsible for:

- Becoming familiar with the HASP;
- Complying with the contents of the HASP;
- Implementing their own HASP or work procedures not covered in this HASP, as necessary and applicable;
- Attending training sessions to review the HASP and other safety/health information;
- Being alert to previously identified and new hazards;
- Reporting unidentified hazards to the KEY SHSO; and,
- Conducting themselves in a manner that is orderly and appropriate for the Site.

3.0 SITE CHARACTERIZATION AND HAZARD ASSESSMENT

3.1 SITE DESCRIPTION AND BACKGROUND

The Site is a former Coke Oven Area (COA) at the Sparrows Point, LLC Site located at 1430 Sparrows Point Boulevard, Baltimore, Maryland. The COA encompasses approximately 150 acres of the Coke Point peninsula that makes up the southwestern most portion of the Site. The Coke Point peninsula is bordered to the west and south by the Patapsco River, to the east by the Turning Basin, and to the north by the former steelmaking operations areas. Coke Point is a man-made land mass composed of slag-fill materials (in thicknesses ranging from 10 to 25 feet) placed over native geologic materials. A topographic map showing the Site location is included as **Figure 1**.

Coke Point has several remediation areas, each labeled as a Cell. A Site Location Map (satellite photo) is provided as **Figure 1-1**.

3.2 SCOPE OF WORK

The installation scope of work includes the following activities:

- Installation of test borings and test trenches;
- Installation of groundwater monitoring wells using Rotosonic drilling techniques;
- Groundwater sampling, including Dense Non-Aqueous Phase Liquid (DNAPL) and Light Non-Aqueous Phase Liquid (LNAPL) thickness measurements; and,
- Vacuum extraction testing on certain wells.

3.3 CHEMICAL HEALTH HAZARDS

Potential chemical health hazards at the Site include the potential exposure to benzene, ethylbenzene, toluene, and xylene (BTEX), and other volatile organic compounds (VOCs) in groundwater and soils. The most likely routes of exposure to Site chemicals are through direct contact with soils and groundwater, and possible inhalation of vapors of constituents when soils are exposed.

3.3.1 BTEX and Other VOCs

Benzene, ethylbenzene, toluene, and xylene (BTEX) may be found in ground water and soils at the Site. Some of these VOCs are lighter than water and may be found as an upper floating layer or LNAPL. These and other volatile organic chemicals (VOCs) found at the Site may pose an inhalation hazard as well as a skin and eye hazard. These VOCs have similar health effects which are briefly summarized here. More information concerning health effects of specific chemicals can be found in the Material Safety Data Sheets (MSDSs) in Appendix A.

Acute or immediate effects of overexposure to BTEX include eye, nose, and respiratory tract

irritation, headache, dizziness, drowsiness, shortness of breath, intoxication, nausea, vomiting, abdominal pain, and dermatitis. Severe overexposure may lead to unconsciousness and convulsions, coma, and death. Other signs of overexposure may include heartbeat irregularities, bronchitis, pulmonary edema, muscle spasms, incoordination, and confusion.

Effects of frequent or long-term overexposure include headache, nervousness, lack of hunger, pale skin, rash, and sleeplessness. Chronic inhalation of many BTEX may result in lung, liver, and kidney damage. Long-term overexposure to benzene can cause blood disorders, such as leukemia and aplastic anemia. Benzene is a suspected human carcinogen.

3.3.2 Naphthalene

Naphthalene is a semi-volatile organic compound or SVOC. Other SVOCs may also be found at the Site. Some of these SVOCs are heavier than water (DNAPL) and may be encountered at the bottom of wells. Primary entry routes into the body are inhalation, ingestion, and skin contact. Naphthalene and other SVOCs pose less of an inhalation hazard than benzene because they are less likely to volatilize. However, SVOCs can be a potential constituent of airborne dust and pose an inhalation hazard. Inhalation of dust containing naphthalene and/or other SVOCs may irritate the respiratory tract. Eye contact may cause eye irritation, burning, and inflammation. Immediate or acute effects from short-term skin exposure may include irritation; burning, itching, redness, skin color changes, and rashes from skin contact. Photosensitization, a tendency to sunburn more easily or a worsening of rash with exposure to sunlight, may occur with skin contact to some SVOCs. If dust which contains SVOCs contacts the skin, minor burning and irritation may result, especially with exposure to sunlight. Wash any exposed skin, apply sunscreen (SPF 30), and cover the area with clothing. Skin contact and exposure to coal tar during Site activities can be eliminated by the use of gloves and skin protection.

Ingestion of naphthalene or SVOC vapors or dust may result in nausea, vomiting, abdominal pain, rapid pulse, respiratory distress, and shock. Absorption into the body systems by any route may cause trouble breathing, dizziness, headache, continuous or drawn out pulse, nausea, vomiting, salivation, and convulsions. Chronic or long-term effects of overexposure may cause dermatitis and cancer of the skin, kidneys, and respiratory tract.

Table 1 presents exposure limits and other properties of certain chemicals that may be present at this Site. More information concerning the health effects of Site chemicals can be found in the Material Safety Data Sheets (MSDS) in Appendix A.

3.3.3 Work Task Chemical Hazard Assessment

The overall chemical health hazard assessment for this Site is low to moderate. Potential exposure to Site constituents will be reduced or eliminated by following the work practices and using the personal protective equipment (PPE) designated in this HASP. Table 2 indicates the chemical hazards associated with Site work tasks, relative hazard assessment, proposed initial levels of personal protection, and air monitoring requirements.

3.4 PHYSICAL HAZARDS

The primary physical hazards on the Site are those associated with excavation activities where groundwater may be encountered. Physical hazards during the project may include muscle strain, lacerations, struck by and against, and slip, trip and fall. Safe work practices for these potential hazards are outlined in Section 5.0.

3.5 CONFINED SPACES

No confined space entry (CSE) is anticipated for work covered by this HASP. However, if a situation arises that requires entering a confined space, then KEY Environmental and OSHA CSE procedures must be followed, including atmospheric testing of the space and completion of a CSE permit before entry. A minimum of two trained employees must be present for any entry.

3.6 COLD STRESS

Cold weather conditions may result in cold stress ranging from mild frostbite to severe hypothermia. Cold injury and impaired ability to work are dangers at low temperatures and when the wind chill factor is low. Cold stress normally occurs in temperatures at or below freezing, or under certain circumstances at temperatures of 40°F. Extreme cold for a short period of time may cause severe injury to exposed body surfaces or result in profound generalized cooling, causing death. Areas of the body that have high surface area to volume ratio, such as fingers, toes and ears, are the most susceptible. Two factors influence the development of a cold weather injury: ambient temperature and wind speed. For instance, 10°F with a wind of 15 miles per hour is equivalent in chilling effect to still air at -7°F. A wind chill chart is presented on the following page.

It does not have to be extremely cold for systemic hypothermia to occur. *Hypothermia* may occur at outdoor temperatures approaching 50°F. Systemic hypothermia occurs when the body core temperature decreases. Symptoms begin with shivering, apathy, loss of coordination, followed by lethargy and coma; if allowed to continue, hypothermia may result in death. Get the victim out of the cold and into dry clothing. Warm up his or her body slowly. Give nothing to eat or drink until the victim is fully conscious. Warm fluids, but no stimulants such as tea, coffee, alcohol or tobacco should be given. Get medical attention immediately.

Frostnip, or incipient frostbite, usually involves the ears, nose, chin, cheeks, and fingertips and toe tips. It occurs during high wind, low temperature, or both. The skin suddenly blanches (becomes white). Frostnip is painless and can be reversed without tissue damage by warming the affected area by using warm water. The area should not be rubbed.

Superficial frostbite is a more severe local cold injury. This involves the skin and superficial tissue just beneath it. The skin becomes white, waxy, and firm; the tissue beneath it remains soft. Affected personnel should be taken out of the cold and the affected area slowly and carefully rewarmed. Again, the area should not be rubbed. Stinging and burning may follow warming and

superficial blisters may occur.

Deep frostbite involves freezing not only of skin and subcutaneous tissue, but even muscle and bone. The emergency treatment for deep frostbite is immediate warming. Affected persons should be kept dry, provided with external warming, and the frostbitten part covered by a dressing while being transported promptly to the nearest emergency department. Warm fluids, but no stimulants such as tea, coffee, alcohol or tobacco should be given to frostbite or hypothermia victims.

3.6.1 Cold Stress Prevention

To prevent or minimize the effects of cold stress, the following work practices should be followed:

- Use dry, insulated and/or layered work clothing, warm gloves, hard hat liners, and boots. Combine winter gear with chemical-resistant personal protective equipment and waterproof gear to provide the best protection for the given site task and weather conditions.
- Provide rest breaks in warm areas, as necessary.
- Use the following wind chill chart to estimate the effects of wind and temperature on the body. Be especially careful to note when frostbite is a potential hazard.

WIND CHILL CHART

		Temperature (°F)																	
		40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
Wind (mph)	Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
	5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
	10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
	15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
	20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
	25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
	30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
	35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
	40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
	45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
	50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
	55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98	
		Frostbite Times					30 min.	10 min.	5 min.										

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where T = Air Temperature (°F), V = Wind Speed (mph)

From National Oceanographic and Aeronautics Administration and the National Weather Service, 2002

3.7 OUTDOOR HAZARDS

Biological hazards present at the Site may include poisonous plants, insects, and animals. Poison ivy and/or poison oak may be present. Contact with the leaves, vine, roots, or sap of poison ivy or poison oak causes a skin rash on many people. All workers must be familiar with the appearance of poison ivy (three leaves) and wear impervious protective clothing, as necessary, to prevent contact with poison ivy. Poison ivy/oak can still cause a reaction even in cold weather because the sap is still in the plant.

Ticks may be present throughout the Site on brush, grass, and weeds. Some ticks carry disease, such as Lyme disease or Rocky Mountain spotted fever. Wear protective clothing or secure pant legs to lower leg or boot and apply bug repellent to this area as noted below for mosquitoes. Frequently assist each other in inspecting for ticks. If a tick is found attached to the skin, do not attempt to pick the tick off the skin with fingernails or scrape with a credit card, etc. Carefully remove the tick with tweezers taking care that all parts are removed. Thoroughly scrub the area with soap and water. Save the tick in a small jar or plastic bag and take it to a doctor or health department for identification. If a red circle or rash forms in the area of the tick bite, or if flu-like symptoms appear in a few days or weeks, consult a doctor for treatment.

Avoid unnecessary contact with animals. Some animals may carry disease or poison or may cause injury by biting. If an animal is acting strangely, or if a wild animal approaches humans, leave the area. If necessary, call animal control personnel. Do not try to feed wild animals.

4.0 MEDICAL SURVEILLANCE

4.1 PRE-ASSIGNMENT SCREENING

KEY employees who work at this Site must have a current medical screening and approvals for Site work in accordance with 29 CFR 1910.120 (f) and KEY medical screening policies and procedures. This screening includes:

- Medical history;
- Occupational history;
- Physical examination;
- Determination of fitness to work wearing protective equipment and respirators;
- Baseline laboratory studies; and,
- Medical evaluation to determine employee's ability to wear a respirator (for employees who may wear a respirator).

Employees engaged in work with potential exposure to hazardous materials must undergo a periodic update of medical and occupational history and a periodic physical examination equivalent to the pre-assignment exam. Medical examinations must also be made available to any employee that has developed, or believed he has developed, signs or symptoms indicating possible overexposure to hazardous substances or health hazards, or if the employee has been injured or exposed above the permissible exposure limit (PEL) or published exposure levels in an emergency situation.

4.2 SUBCONTRACTORS

Subcontractors performing work under this HASP are required to have medical training as above. In general, subcontractors who will perform work at this Site where there is a potential for contact with Site constituents are required to follow the medical surveillance requirements of 29 CFR 1910.120 and a medical surveillance program. Subcontractors who perform work where there is no potential for exposure to Site constituents are not required to follow the medical surveillance requirements of 29 CFR 1910.120.

5.0 WORK PRACTICES AND SITE CONTROL

5.1 SAFE WORK PRACTICES

5.1.1 Routine Safe Work Practices

Proper personal hygiene and the buddy system are integral parts of safe work practices and must be followed by all KEY employees while working at the Site:

- Site activities that involve serious hazards should be performed by a work team of at least two people. Site personnel may use judgment and be flexible in defining when two persons must be present.
- Hygienic practices consistent with work hazards are necessary. Eating and food preparation will be prohibited in any area other than those designated and properly protected. No food or tobacco products will be permitted in work areas. Beverages are only permitted as noted in Section 5.1.8. Employees who handle potentially contaminated materials or articles will wash with soap or mild detergent and water before eating or using the rest room.

5.1.2 Work Restrictions

All outdoor work at the Site must be conducted during daylight hours unless adequate lighting is provided. Outdoor work must cease immediately upon the signs of impending thunderstorms and lightning or other severe weather, as determined by the SHSO.

5.1.3 Underground and Overhead Utilities

Underground utilities and pipelines can present special hazards such as electrocution, sudden release of pressure (gas or liquid), and explosion and fire. Check with Facility personnel and contact local utilities before drilling or other subsurface work and/or call the One Call center at 811. Check for any overhead wires before work. Keep equipment at least 20 feet away from overhead lines.

5.1.4 Excavation and Trenching

Excavation and trenching are major hazards of construction; a number of precautions must be taken to prevent cave-ins or other accidents.

The following site conditions must be taken into account when planning excavation work:

- Traffic
- Nearness to structures and their condition
- Soil type

- Surface and groundwater
- Depth to water table
- Overhead and underground utilities
- Weather

All excavations must be dug in accordance with OSHA 29 CFR 1926, Subpart P, “Excavation, Trenching, and Shoring.” The following is a summary of excavation requirements:

- Determine the exact location of underground utilities before excavation. While the excavation is open, protect, support, or remove the underground installation as necessary to safeguard personnel.
- All surface encumbrances (e.g., trees, boulders, etc.) must be removed or supported if they present a hazard to employees. Surface encumbrances can collapse on employees when undermined by excavation activities and can also interfere with traffic.
- Use support systems to ensure the stability of adjacent structures, if necessary.
- Employees exposed to vehicular traffic must wear warning vests made of reflective or high visibility material.
- Water must not be allowed to accumulate in excavations. Water can lead to cave-ins.
- Employees must not work on faces of sloped or benched excavations at levels above other employees unless the employees at the lower level are protected from the hazard of falling, rolling, or sliding material or equipment.
- Personnel are not permitted on the downgradient side of heavy equipment when operating on a grade. A safe pathway must be determined before moving equipment from one location to another.
- Employees are not permitted under loads handled by lifting or excavation equipment. To avoid being struck by debris, employees must also stand clear of trucks being loaded or unloaded.
- If a machine operator does not have a clear view of an excavations edge, a warning system such as barricades or hand signals must be used to ensure that equipment does not fall into the excavation.
- Walkways must be provided where employees or equipment are required to cross excavations. Standard guardrails must be provided where walkways are 6 feet or more above the lower level.

IF PERSONNEL ARE TO ENTER AN EXCAVATION OR TRENCH:

- The sides of trenches greater than 5 feet deep must be shored, unless they are sloped to the angle of repose, or unless the trench is in solid rock. Check the OSHA standard 29 CFR 1926.650-652 and Appendices for appropriate requirements depending on soil type. Soil classification must be performed when designing a sloping or benching system. Shoring must be adequate to prevent wall collapse in whatever soil condition encountered.
- Excavations more than 20 feet deep must be designed by a registered professional engineer.
- Trenches or excavations 4 feet deep or deeper must be provided with a means of entering and exiting (i.e., ramps or ladders). A worker must not be more than 25 feet away from a means of exit. Ladders must extend from the bottom of the trench to at least 3 feet above the surface of the ground.
- The atmosphere of any excavation 4 feet or deeper must be tested for oxygen content, flammable gas, and other potential hazardous substances before employees may enter if a hazardous atmosphere or lack of oxygen can reasonably be expected.
- Emergency equipment, such as breathing apparatus, a safety harness and line, or a basket stretcher, must be readily available where hazardous atmospheric conditions exist or may reasonably be expected to develop during work in the excavation. This equipment must be attended while in use.
- Employees must be protected from loose rock or soil that could pose a hazard by falling or rolling from an excavation face.
- Employees must be protected from excavated or other materials or equipment that could pose a hazard by falling or rolling into excavations. Materials and equipment must be kept at least two feet from the edge of the excavation, or by the use of retaining devices that are sufficient to prevent materials or equipment from falling or rolling into excavations.
- Water must not be allowed to accumulate in excavations; water can lead to cave-ins.
- Daily inspections of the excavation, adjacent areas, and protective systems must be made by a competent person for evidence of a situation that could result in possible cave-ins, failures of protective systems and equipment, hazardous atmospheres, or other hazardous conditions. Inspections are required before the start of work and as needed throughout the shift and after every rainstorm or other hazard-increasing occurrence. Inspections are only required when employee exposure to hazards is reasonable anticipated.

- If the competent person finds evidence of a dangerous situation, employees must be removed from the hazardous area until precautions are taken to protect employees.
- Additional information on soil classification, slope configuration, timber shoring, aluminum hydraulic shoring, and other alternatives are found in Appendix A through E at the end of the OSHA excavation standard 29 CFR 1926.650-652.

5.1.5 Heavy Equipment Operations

- Hard hats will be worn at all times in the vicinity of heavy machinery.
- No loose-fitting clothing or free long hair is permitted near moving machinery parts.
- A first-aid kit and fire extinguisher will be available at all times.
- All crews will consist of at least two persons.
- Seats or equal protection must be provided for each person required to ride on equipment.
- Getting off or on any equipment while it is in motion is prohibited.
- Machinery or equipment requiring an operator will not be permitted to run unattended with the exception of stationary equipment such as a water pump or generator.
- Machinery or equipment will not be operated in a manner that will endanger persons or property nor will the safe operating speeds or loads be exceeded.
- All machinery or equipment will be shut down and positive means taken to prevent its operation while repairs or manual lubrications are being performed. Exemption: Equipment designed to be serviced while running.
- All repairs on machinery or equipment will be made at a location that will provide protection from traffic for repair persons.
- Heavy machinery, equipment, or parts thereof that are suspended or held apart by slings, hoist, or jacks also will be substantially blocked or cribbed before personnel are permitted to work underneath or between them.

An equipment check will be performed at the beginning of each day by an equipment operator familiar with the specified equipment. Only trained, qualified, and authorized operators will be permitted to operate equipment. Hand signals will be prearranged between operators and personnel working in and around equipment. Personnel nonessential to the operation of the equipment will maintain a safe working distance from the equipment. Employees must exercise

caution to remain out of the paths of moving equipment and materials. Caution should be exercised around excavated areas to avoid slips, trips, and falls.

5.1.6 Rotosonic Drilling

Personnel working on or near drill rigs must be aware of the hazards of moving vehicles, pinch points, noise hazards, and overhead and underground utility hazards during the drilling process.

- Clear away all debris from the immediate area.
- Be sure that the area to be drilled is free of underground power lines, gas lines, water mains, sewers, or other utilities.
- Before erecting the derrick, be sure that there are no overhead power lines, tree branches, or other obstructions in the path.
- Use proper lifting and material handling techniques to avoid strains and sprains when handling the drill pipe and drive shoe.
- Be aware of and avoid pinch points on the drill rig.
- Only drilling company employees are allowed on the drill rig and drill platform.
- Make sure that the drill platform is securely supported on a flat, stable surface before drilling.
- Watch for slip hazards, especially during and after rain events. The drill platform, ladders, and other parts of the rig may become slippery, especially when muddy.

5.1.7 Installing, Developing and Sampling Wells, Performing NAPL Thickness Measurements

These activities increase the potential for exposure to Site constituents that can cause eye, skin, and respiratory tract irritation, burns, and photosensitization. Care must be taken to wear long sleeves, nitrile gloves, and safety glasses, especially when manually bailing, to limit exposure from NAPL on the rope and bailer. Attempt to bail in a manner that limits the whipping of rope during the process.

Installation of wells (sandpack, bentonite seal, cement/bentonite grout, stickup) may result in overexertion/twisting/bending when handling PVC pipe and bags of sand, cement, and bentonite; cuts when using hand saw to trim pipe, and overexposure to dust from sand, cement, and bentonite. The drill rig operator and helper must be in good physical shape to handle work. Other precautions include: Use proper lifting techniques, use hand saws properly, wear Level D protection, including appropriate work gloves, and pour bags of sand, bentonite, and cement slowly to avoid creating

excessive dust using water mist if necessary to keep dust under control.

Hazards that may be present or created when developing wells may be potential exposure to Site constituents in the water or air, electrical shock when setting up or using a pump, battery explosion, or a spill of battery acid. To reduce or eliminate these potential hazards opening wells and letting them vent before other activity, wear Level D protection – safety glasses to avoid splashes and nitrile gloves to avoid groundwater contact, and follow manufacturer’s instructions for proper pump use. If pump is run off car or other battery, make sure the battery is charged and has sufficient water and electrolyte before use, ensure that wires are connected to the proper battery terminals, and handle batteries with care to avoid spillage.

5.1.8 Noise

Employees working on or near noisy equipment must wear hearing protection if the 8-hour time-weighted average noise level exceeds 85 decibels. A general field rule is that hearing protection must be used if normal speech cannot be understood within an arm’s length of the person talking.

5.1.9 Use of Drinking Water or Liquids

All carrying containers and cup dispensers must be closed and covered to protect against dust and vapors.

- Only disposable cups may be used to dispense and drink liquids.
- Use a cup dispenser so that one cup may be easily removed at a time and no other cups are touched.
- Cups may not be reused. (One use may be several consecutive refills. Do not set a cup down and reuse that same cup during the next break.)
- Remove or clean soiled gloves before using a cup.
- Thoroughly clean and decontaminate the drink container and cup dispenser before refilling and before taking them off-Site.

5.1.10 Slip, Trip, Fall

Hazards found at the Site and areas where groundwater sampling occurs may include uneven terrain, holes, ditches, unstable slopes, slippery surfaces, unmarked projections, and ground debris that can cause employees to trip and fall. Take care to notice and avoid unsafe site conditions.

- Visually examine the walking area;
- Test your footing;

- Make sure the walking/work area is adequately lit;
- Be aware of ground debris; remove broken glass, nails, wire, and other debris if possible, or mark off and avoid areas of heavy debris.

5.2 SITE ACCESS/SITE CONTROL

Reduce or eliminate the possibility of exposure or transfer of contaminated substances through the following methods, as appropriate for the work task(s):

- Set up barriers to exclude personnel from contaminated areas;
- Minimize the number of personnel and equipment at the Site;
- Establish work zones within the Site;
- Establish control points with regular access to and egress from work zones;
- Conduct operations in a manner to reduce exposure of personnel and equipment; and,
- Implement appropriate decontamination procedures.

5.2.1 Site Access

The Site is enclosed by fencing and the Patapsco River. Access for authorized personnel is through a security entrance. The KEY SHSO will be responsible only for security around the KEY immediate work area.

5.2.2 Work Zones

Exclusion zones for investigation activities should be established approximately 20-25 feet around the trenches/excavations and wells. Unauthorized personnel may be kept out of these areas with signs or verbal warnings. Specific work zones are not necessary for tasks where there is little chance of overexposure to Site constituents to others.

At least partial decontamination of personnel and equipment should occur at work areas when appropriate. A separate, common decontamination area(s) should be set up to allow for personnel decontamination, as well as equipment decontamination after work is complete for each day. The SHSO must determine the appropriate Site zones upon arrival at the Site and before intrusive activities begin. The location of the Site work zones may change with the work and the type of activity performed.

5.3 SITE HOUSEKEEPING

The Site must be kept in a neat, organized, and orderly fashion. Items, such as tools, equipment, hoses, *etc.*, must be kept picked up to minimize tripping and falling hazards. Used disposable clothing and equipment must be placed in drums or plastic bags immediately upon removal and the drum lids replaced or bags closed.

5.4 SANITATION/CHANGING FACILITIES

Appropriate sanitation must be used on-Site, including, but not limited to, the following:

- Maintaining an adequate supply of potable water.
- Access to nearby sanitary facilities, including adequate toilets and wash facilities.

5.5 EXPOSURE PREVENTION

Exposure to hazardous or contaminated materials must be kept to a minimum by adherence to the recommended PPE and decontamination procedures. All Site personnel must avoid potential exposure to Site constituents when possible, e.g., do not handle potentially contaminated materials without proper PPE, do not stand downwind during excavation or other subsurface activities, etc.

5.6 BUDDY SYSTEM

Personnel must adhere to the buddy system when conducting field activities, meaning that they must work in groups of at least two when wearing PPE or when working in an exclusion zone.

5.7 SITE COMMUNICATIONS

- Verbal and Hand Signals - will be the main types of Site communication.
- Telephones - cell phones may be used for off-Site communication, if necessary.

6.0 PERSONAL PROTECTIVE EQUIPMENT

6.1 SITE-SPECIFIC LEVELS OF PROTECTION

The level of protection for most Site activities will be Level D or a modified Level D. Level D will consist of:

- Long shirts and long pants.
- Outer clothing appropriate for the weather.
- Appropriate gloves for material handling activities.
- Steel-toe and shank safety boots.
- Hard hat.
- Safety glasses with side shields.
- Reflective safety vest.
- Hearing protection as needed.

A Modified Level D may be needed for activities that increase the chance for skin exposure to groundwater in Cell 2. Modified Level D may consist of Level D as above plus the following as appropriate for the activity:

Modified Level D will consist of Level D as above plus:

- A regular Tyvek or polycoated Tyvek suit or apron to avoid body/clothes contact;
- Nitrile inner gloves;
- Nitrile outer gloves as necessary; and,
- Nitrile Rubber or chemically resistant overboots.

6.2 UPGRADE CONDITIONS

If conditions should change where there is a possibility of overexposure to organic vapors or dust, the work area should be ventilated, vapor and/or dust suppression techniques used, or employees should work upwind to reduce potential exposures. If these measures do not reduce vapor concentrations below the acceptable limits set forth in Chapter 7.0, then the level of protection will be upgraded to Level C as necessary and contact the KEY Health and Safety Manager for information on how to proceed.

Level C protection will consist of:

- NIOSH-approved full-face, air-purifying respirator equipped with appropriate organic vapor/dust cartridges (e.g., MSA Ultra-Twin respirators with GMC-H cartridges).
- Chemical-resistant clothing over work clothes, regular Tyvek®, or polycoated Tyvek®, as necessary.

- Nitrile outer gloves and latex inner gloves; tape gloves to suit.
- Steel-toe, steel shank safety boots with chemical-resistant outer boots, or PVC steel-toe boots; tape boots to suit.
- Hard hat.
- Hearing protection as required.

Level B protection consists of the same protocol as Level C, except for substituting a full-face air supplying respirator and air supply for the air-purifying respirator. However, Level B is not expected to be used at this site due to the low potential for exposure to potential site constituents and engineering and work controls employed.

The SHSO has the responsibility for monitoring site and work task conditions and deciding the appropriate level of protection based on the air monitoring guidelines presented in Chapter 7.0 and any other indications of potential exposure.

7.0 MONITORING

7.1 REAL-TIME MONITORING

Monitoring for organic vapors and flammable gas must be conducted prior to and during all intrusive Site activities. A Photoionization Detector (PID) with a 10.2 /10.6 electron volt (eV) bulb must be used to conduct air monitoring for organic vapors. Periodic air monitoring should be conducted in the work zone and in the breathing zone of workers. An oxygen/lower explosive limit (O₂/LEL) meter must be in conjunction with the PID. Readings should be recorded prior to and during initial subsurface activities, whenever there is a reading above background, and at least once per hour during work activities. Readings may be recorded on the Real-Time Monitoring Log (Appendix B) or in the field logbook.

For any work activity, a sustained (greater than 5 minutes) organic vapor level in the breathing zone above the concentrations in the following table will require vapor suppression techniques or working upwind of the source. If these methods are not feasible or do not reduce the potential exposure below acceptable levels, then employees must upgrade to Level C protection. A low oxygen reading or LEL reading above the limits in the following table must be addressed before work can continue. If benzene is present above the action level of 1 ppm, stop work, cover the area, and contact the Project Manager.

Benzene-specific detector tubes must be used to check for benzene at Cell 2 if the PID registers readings of 0.5 ppm or higher over a 15-minute time period, or if there are PID readings above 0.5 ppm several times throughout the workday.

7.2 INSTRUMENT CALIBRATION

Monitoring equipment must be calibrated and/or checked for proper operation daily according to manufacturer's recommendations before the start-up of any field activities requiring monitoring. Before initiating field activities, background measurements should be obtained with each instrument upwind and away from potential Site influences. Instrument calibrations and background levels must be documented on daily air monitoring logs or in a field log. A Rae Systems PID with a 10.2 eV or 10.6 eV lamp, or equivalent monitor, will be used to monitor for organic vapors. A MultiRAE with both a PID and O₂/LEL meter may be used during the project instead of two separate meters.

7.3 AIR MONITORING ACTION LEVELS

AIR MONITORING ACTION LEVELS			
Constituent	Concentration	Location	Response
Total Organic Vapors	1 to 10 ppm	Breathing Zone in Work Area in Trenches	Continue PID for 5 to 15 minutes. If reading still exceeds 1 ppm, use vapor suppression or work upwind. <i>Test for benzene if working in Cell 2.</i>
Benzene	>0.5 ppm	Cell 2 - Breathing Zone in Work Area	If detector tube readings indicate benzene above 0.5 ppm, ventilate the area or use vapor suppression. Contact the KEY H&S Manager before proceeding.
Benzene	>0.5 ppm	Cell 2 - Breathing Zone in Work Area	Upgrade to Level C with full-face respirator and organic vapor/dust cartridges if vapors cannot be controlled by ventilation or vapor suppression.
Total Organic Vapors – no benzene	>10 ppm	Breathing Zone in Work Area	Evacuate area until vapors dissipate. Monitor from a distance. Contact the KEY H&S Manager before proceeding.
Oxygen	<19.5% or >23.5%	Work Area	Evacuate area until vapors dissipate. Monitor from a distance. Control source of vapors by covering sections of the trench, using foam, etc.
Flammable vapors	>10% LEL	Work Area	Evacuate area until vapors dissipate. Monitor from a distance. Control source of vapors by covering sections of the trench, using foam, etc.

8.0 MATERIAL HANDLING AND DECONTAMINATION

All waste material, decontamination liquids, and decontamination equipment must be handled in a safe and healthful manner. Decontamination and material handling activities must be carried out within the appropriate work zone.

8.1 DECONTAMINATION

A personnel decontamination area must be provided where surface constituent(s) and outer protective equipment are removed. This area must be determined upon arrival at the Site and before any intrusive activities begin.

8.1.1 Personnel Decontamination

The general decontamination procedure is as follows.

Level D Decontamination:

- Equipment drop onto plastic drop cloth.
- Wash and rinse boot covers and gloves if to be reused.
- Remove and dispose of Tyvek suit in a plastic-lined container or plastic bag.
- Remove boot covers and gloves, dispose in plastic bag or lined containers if not to be reused. Place in "decontaminated PPE" container if to be used again.
- Field-wash hands and face.

Level C Decontamination:

- Equipment drop onto plastic drop cloth.
- Wash and rinse boot covers and outer gloves if to be reused.
- Remove tape from boots and gloves.
- Remove boot covers and other gloves, dispose in plastic lined container if not to be reused. Place in "decontaminated PPE" container if to be used again.
- Remove and dispose of Tyvek® suit in a plastic-lined container.
- Wash and rinse inner gloves.
- Remove respirator and place in container for later cleaning.

- Remove and dispose inner gloves.
- Field-wash face and hands.

There may be partial field decontamination before traveling from one work location to another. This may consist of removing or cleaning boots or boot covers and outer gloves after completing an activity and before moving to the next workstation. The SHSO must advise the field crew of any necessary field decontamination procedures. The SHSO is responsible for monitoring the effectiveness of decontamination procedures and modifying the procedures as necessary to ensure proper decontamination.

8.1.2 Equipment Decontamination

All equipment used in an exclusion zone must be decontaminated before it leaves the Site or is taken into a clean area. Small tools and equipment used in the EZ that become contaminated may be taken to the decontamination area taking care to isolate the tools/equipment from clean materials and equipment. Equipment may be decontaminated by washing with detergent and water then rinsing, or other appropriate decontamination methods. Vehicles that contact potentially contaminated soil or water must be decontaminated before leaving the Site by brushing clean and washing as necessary. Verification that equipment/vehicles leaving the Site have been adequately decontaminated is the responsibility of the SHSO.

9.0 EMERGENCY PROCEDURES

The HASP for this project has been established to allow project activities to be conducted without adverse impacts on worker health and safety. In addition, supplementary emergency response procedures have been developed to cover extraordinary conditions that might possibly occur at the Site. Emergency telephone numbers, directions to the nearest hospital, and a route map to the hospital are presented in Appendix C.

Pre-emergency planning consists of the preparation of this emergency response plan, posting of the emergency contact list and hospital route map, assigning emergency functions to on-Site personnel, training of personnel as necessary, and ensuring that emergency procedures and equipment are in place.

The KEY Supervisor/SHSO is designated as the Site Emergency Coordinator for KEY's activities and is responsible for field implementation of this emergency response plan and has full authority for KEY personnel and subcontractors in the event of an emergency. If outside agencies respond to an emergency, the KEY Site Emergency Coordinator will pass the responsibility and authority for emergency response to the Incident Commander for the outside agency as appropriate. The Site Emergency Coordinator will assist outside emergency response agencies as much as possible to control and resolve the emergency. In general, on-site personnel would immediately evacuate the area to the designated safe place of refuge. Communications consist of verbal and hand signals on-site and use of a portable telephone for off-site communication.

The KEY Site Emergency Coordinator, or if the Site Emergency Coordinator is unavailable, the designated alternate on Site will contact the Site Security who may summon emergency personnel. In the event of severe injury to KEY personnel or subcontractors, KEY personnel may start first aid then contact outside personnel for assistance.

PPE and emergency equipment will be available on-Site for response to minor emergencies. PPE includes gloves, protective clothing, protective booties, and safety glasses. An emergency first aid kit will also be available on-site.

Evacuation routes, safe distances, and places of refuge will be determined before the start of work at the Site and the locations made known to all personnel who enter the Site. These may be modified at the start of each work day based on site specific or work task factors. The SHSO will maintain security around the immediate Site work zones. Because of the limited number of personnel expected to be working on the Site, the SHSO will know who is on Site and can control entry of personnel into hazardous areas in an emergency.

9.1 EMERGENCY MEDICAL TREATMENT AND FIRST AID

In the event of a safety or health emergency at the Site, appropriate emergency measures will immediately be taken to assist those who have been injured or exposed and to protect others from hazards. The project field personnel will take the injured party and transport (if possible) to the

nearest hospital for treatment, after determining whether personnel decontamination can be performed on the injured party.

If the injury to a worker is chemical in nature (e.g., overexposure), the following first-aid procedures will be instituted:

- **Eye Exposure** - If a solid or liquid gets into the eyes, wash the eyes immediately at the emergency eyewash station using large amounts of water and lifting the lower and upper lids occasionally to help flush the eye. Do not let the victim rub eyes or keep eyes tightly closed. Flush for at least 15 minutes. Obtain medical attention immediately.
- **Skin Exposure** - Promptly wash the area using mild soap and flooding amounts of water for at least 15 minutes while removing contaminated clothing and shoes. Consult a physician for reddened or blistered skin.
- **Swallowing** - Do not induce vomiting! Never give anything by mouth to an unconscious person. Call poison control center: Akron Regional Poison Center, (800) 362-9922.
- **Breathing** - If a person has difficulty breathing, move the exposed person to fresh air at once. Do not use mouth-to-mouth respiration. If breathing has ceased, apply artificial respiration using oxygen and a suitable mechanical device such as a bag and mask. Keep the affected person warm and at rest. Obtain medical attention as soon as possible.

First aid supplies must be immediately available at the Site. Personnel performing work must have a first aid kit as part of their field supplies. First aid kits will consist of appropriate items for the work being performed and anticipated emergencies. In addition, a portable eyewash bottle and solution should be part of the first aid supplies taken to the Site.

Employees that will work at the Site are responsible for checking the contents of the first aid kit before the kit is sent to the job site to ensure that all required items are present and that expended items are replaced. This employee is also responsible for ensuring that the kit is readily accessible at the site. When more than one person is on site the most senior person has the responsibility for the contents of the kit.

9.2 EMERGENCY EVALUATION, INVESTIGATION AND DOCUMENTATION

The Site Emergency Coordinator will evaluate the available information about the incident and KEY's emergency response capabilities, including what happened, any injuries or casualties, further accident potential, and what can be done to remedy the emergency. The type of response action will be based on the available information about the emergency incident.

The emergency incident will be investigated by KEY and all findings put in writing as soon as conditions return to normal. The KEY Supervisor/SHSO will ensure that documentation is as complete as possible by including a chronological history of the incident, facts about the incident and when they became available, titles and names of personnel and composition of teams, actions made, orders given, actions taken, samples and results, possible exposures, and a history of all injuries or illness during or as a result of the emergency. After the situation has returned to normal, all aspects of the emergency incident and the response will be reviewed to assess procedures used, how to improve response, and how to prevent further emergencies.

10.0 TRAINING

10.1 GENERAL

All employees or other personnel entering the Site (other than the support zone) that are also involved in operations that could involve exposure to hazardous waste must receive training in compliance with OSHA 29 CFR 1910.120(e). The training requirements are intended to provide employees with the knowledge and skills necessary to perform hazardous waste site operations while minimizing the potential for injury. Initial training consists of a minimum of 40 hours of off-Site classroom and practical exercise training and 3 days of actual field experience. Training must be updated annually with 8 hours of off-Site training. Supervising personnel will complete an 8-hour training session for supervisors. Training must be certified by record and/or certificate.

10.2 SITE-SPECIFIC TRAINING

Site-specific training must consist of an initial health and safety briefing on the following information:

- Names of individuals responsible for Site health and safety and methods of communicating safety and health concerns;
- Site-specific health and safety hazards;
- Use of PPE;
- Work practices by which employees can minimize risk;
- Safe use of equipment on-site;
- Recognition of symptoms and signs of exposure to hazardous materials;
- Site control measures;
- Decontamination procedures; and,
- Emergency response procedures.

The SHSO or Site supervisor should give the health and safety briefing prior to initiation of field activities. This briefing must be of sufficient duration to address all of the material covered in this HASP. All personnel that will be participating in field activities must have the opportunity to read this HASP prior to this initial meeting so that any questions they have can be addressed at the initial meeting.

10.3 SAFETY MEETINGS

Prior to commencing field activities each day, a short briefing may be conducted by the Site Supervisor to address the day's activities. The daily briefing also provides the opportunity for the SHSO to address any special health and safety issues and to notify individuals of any deficient areas that need to be corrected or operational changes made that affect field work. The briefing should emphasize the specific concerns associated with the day's planned field activities. Daily weather reports should be reviewed to determine work/rest regimens.

TABLES

TABLE 1
Exposure Limits and Other Properties of Potential Site Constituents
Sparrows Point
Baltimore, Maryland

Constituent	Exposure Limits [a]	STEL [b]	IDLH [c]	Vapor Pressure [d]	Ionization Potential [e]
Naphthalene	10 ppm	15 ppm	250 ppm	0.08 mm	8.12 eV
Benzene	0.5 ppm	5 ppm	500 ppm	75 mm	9.24 eV
Ethylbenzene	100 ppm	125 ppm	800 ppm	7 mm	8.76eV
Toluene	20 ppm	NA	500 ppm	21 mm	8.82 eV
Xylene	100 ppm	150 ppm	900 ppm	9 mm	8.56 eV

Constituent	Carcinogen [f]	Skin Exposure [g]	LEL/UEL [h]	Odor Threshold [i]	3M/NIOSH Respirator Selection [j]
Naphthalene	YES	NO	0.9 - 5.9%	0.015 ppm	OV
Benzene	YES	NO	1.2 - 7.8%	8.65 ppm	OV
Ethylbenzene	NO	NO	0.8-6.7	2.3 ppm	OV
Toluene	NO	YES	1.1-7.1	0.16 ppm	OV
Xylene	NO	NO	1.1-7.0	0.851 ppm	OV

Notes:

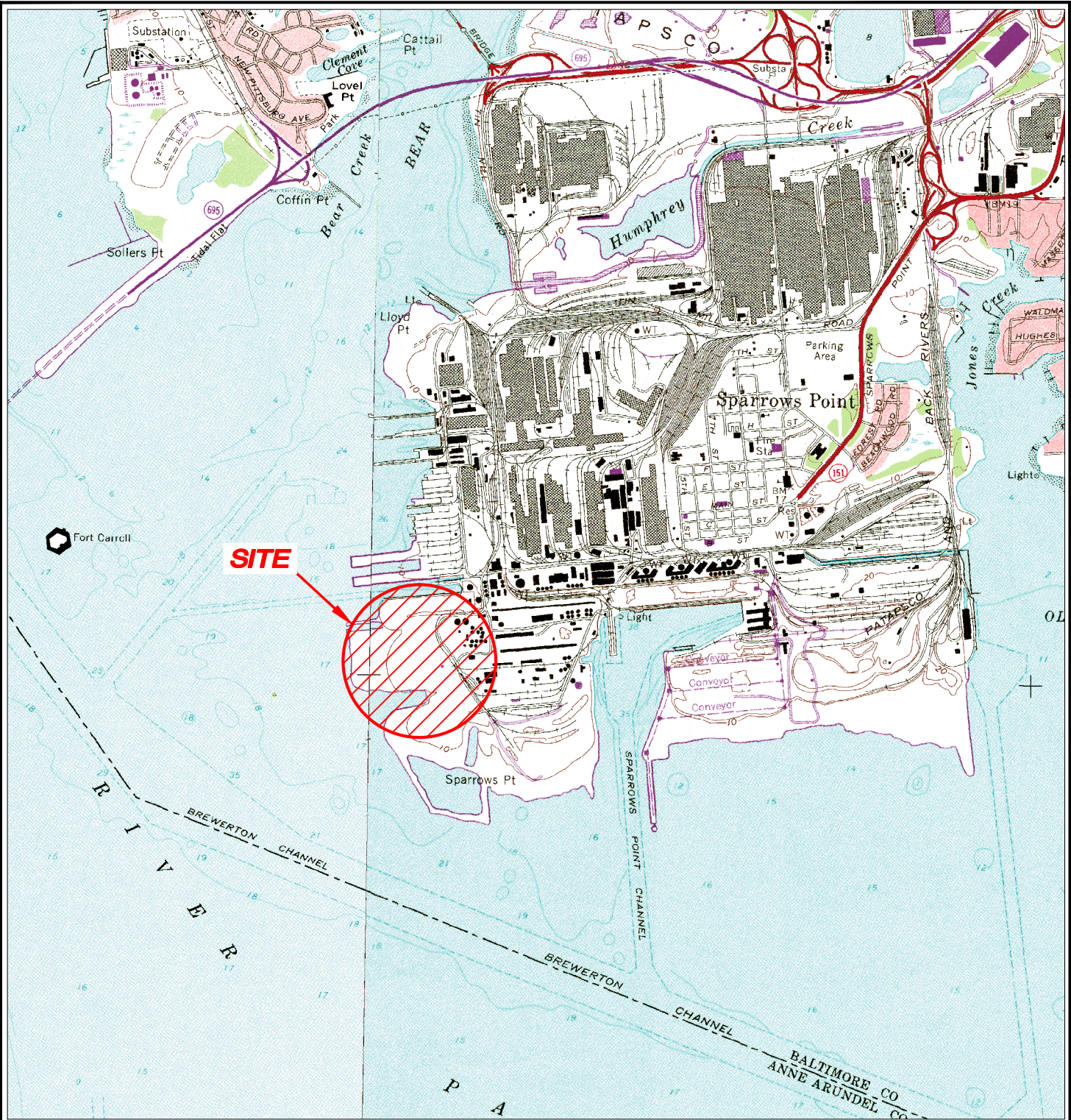
- [a] Exposure Limit: 8-hour Time Weighted Average (TWA) from the Threshold Limit Values of the ACGIH, or OSHA Permissible Exposure Limit (PEL), whichever is lower.
- [b] STEL: Short Term Exposure Limit, denotes a 15 minute average that may not be exceeded.
- [c] IDLH: Immediately Dangerous to Life or Health - Maximum concentration from which one could escape within 30 minutes without a respirator and without experiencing any irreversible health effects.
- [d] Vapor Pressure: From NIOSH Pocket Guide to Chemical Hazards. Water = 0 mm. Above 1 mm is considered volatile; above 100 mm is considered highly volatile
- [e] Ionization Potential: Expressed in electron volts (eV) from NIOSH Pocket Guide to Chemical Hazards. Used to determine type of detector bulb for the PID.
- [f] Carcinogen: "Yes" indicates compound is a confirmed or suspected human carcinogen by NIOSH, OSHA or ACGIH.
- [g] Skin Exposure: "Yes" indicates potential significant exposure through skin and mucous membranes, either by airborne or, more particularly, by direct contact to ambient vapors.
- [h] LEL/UEL: Lower and upper explosive limits. Percent of material needed in air for ignition when exposed to an ignition source.
- [i] Odor Threshold: Air concentration at which most people can smell the chemical.
- [j] 3M/NIOSH Respirator Selection: Type of respirator recommended by the 3M Respirator Selection Guide or the NIOSH Pocket Guide to Chemical Hazards. SA = Supplied Air (Level B); OV = Organic Vapor Respirator (Level C); N, R, or P 95, 97, or 100 = Dust and mist respirator (Level C).

TABLE 2
Task-Specific Hazard Assessment with
Proposed Initial Levels of Protection and Air Monitoring Requirements
Sparrows Point
Baltimore, Maryland

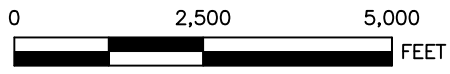
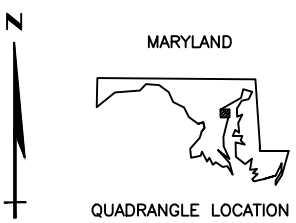
Task	Chemical Hazard Assessment	Estimated Initial Level of Protection	Air Monitoring
			O ₂ /LEL & VOCs
Installation of test borings and test trenches	Low-Med	D	YES
Installation of groundwater monitoring wells using Rotosonic drilling techniques	Low-Med	D	YES
Groundwater sampling, including Dense Non-Aqueous Phase Liquid (DNAPL) and Light Non-Aqueous Phase Liquid (LNAPL) thickness measurements	Low	D	YES
Vacuum extraction testing on certain wells	Low	D	NO

Note: Continuous monitoring is not required unless conditions change or an initial positive reading has been obtained.

FIGURES



y:\env\spawrrows point\Figure 1.dwg - Last Saved By: Scomer 2/25/2014 9:10 AM Plotted By: Shelly Comer 2/25/2014 9:11 AM Scale: 1:1,0167



ENVIROANALYTICS GROUP, LLC
ST. LOUIS, MISSOURI

DRWN: SCC	DATE: 02/25/14
CHKD: JEF	DATE: 02/25/14
APPD: AEB	DATE: 02/25/14
SCALE: AS SHOWN	



SPARROWS POINT
1430 SPARROWS POINT BOULEVARD
BALTIMORE, MARYLAND

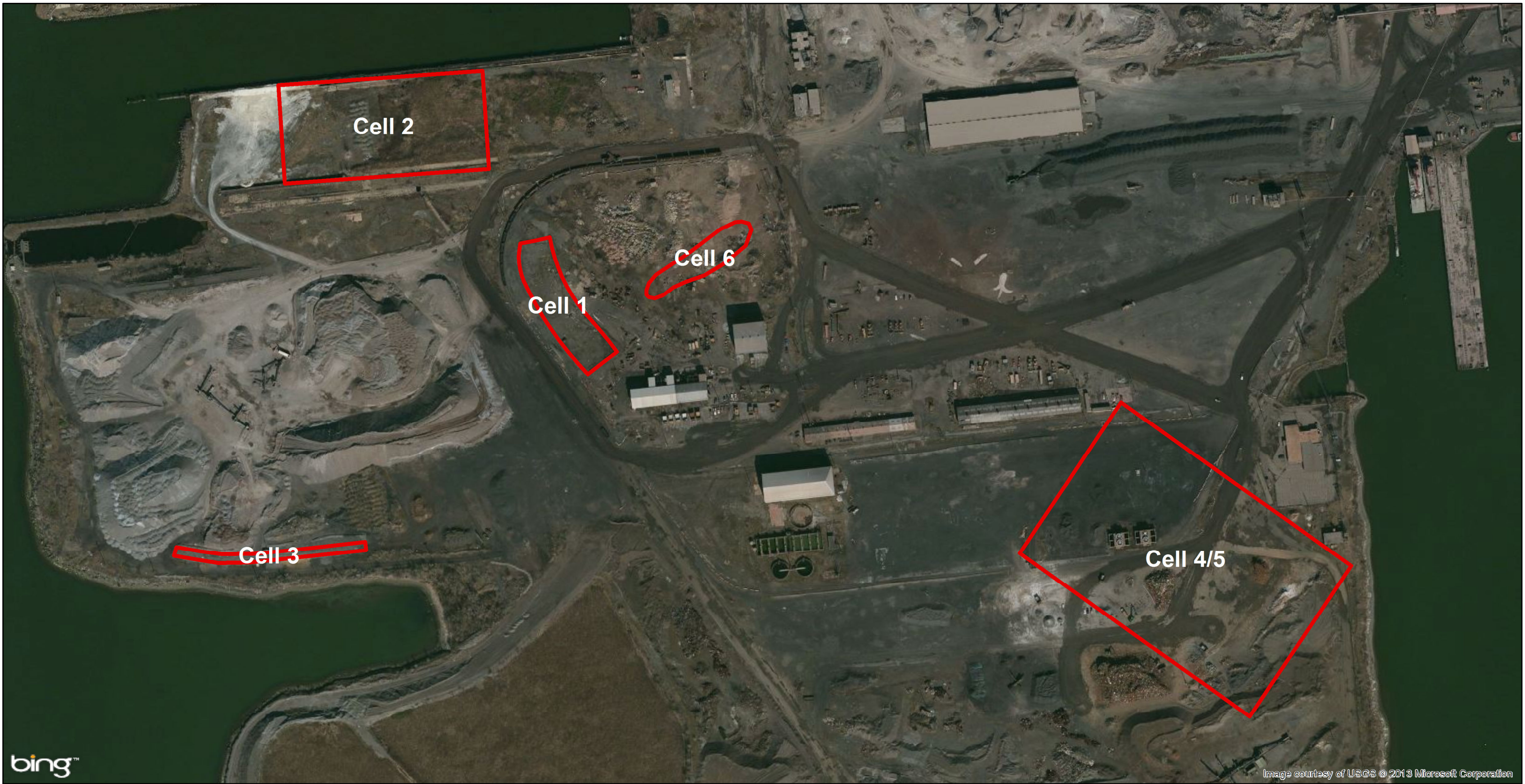
SITE LOCATION MAP

PROJECT NO: 14-835
FIGURE 1

REFERENCE: USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLES:
- CURTIS BAY, MARYLAND 1969 REVISED 1974
- SPARROWS POINT, MARYLAND 1969 REVISED 1974

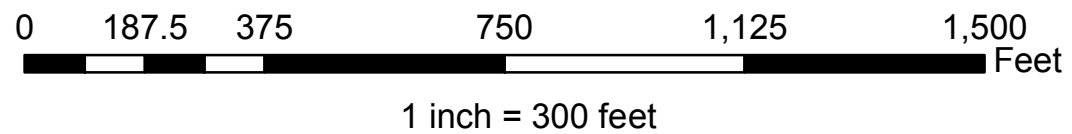
ISSUE DATE:

KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106



August 2013

Sparrows Point Former Coke Oven Area Interim Measures Site Location Map

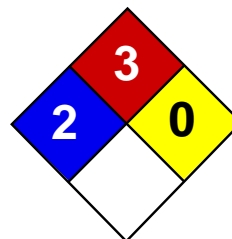


Legend
[Red outline] COA IM Cells

Figure 1-1

APPENDIX A
MATERIAL SAFETY DATA SHEETS

The following Material Safety Data Sheets (MSDSs) are provided for general information on the chemical and physical properties and potential health hazards of constituents that may be present at the Site. The use of manufacturer names does not imply that these products were in fact used at the Site; nor imply or infer any liability on the part of the manufacturer of any product represented, or the preparer of the MSDS.



Health	2
Fire	3
Reactivity	0
Personal Protection	H

Material Safety Data Sheet Benzene MSDS

Section 1: Chemical Product and Company Identification

Product Name: Benzene

Catalog Codes: SLB1564, SLB3055, SLB2881

CAS#: 71-43-2

RTECS: CY1400000

TSCA: TSCA 8(b) inventory: Benzene

CI#: Not available.

Synonym: Benzol; Benzine

Chemical Name: Benzene

Chemical Formula: C6-H6

Contact Information:

Sciencelab.com, Inc.

14025 Smith Rd.

Houston, Texas 77396

US Sales: **1-800-901-7247**

International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:

1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Benzene	71-43-2	100

Toxicological Data on Ingredients: Benzene: ORAL (LD50): Acute: 930 mg/kg [Rat]. 4700 mg/kg [Mouse]. DERMAL (LD50): Acute: >9400 mg/kg [Rabbit]. VAPOR (LC50): Acute: 10000 ppm 7 hours [Rat].

Section 3: Hazards Identification

Potential Acute Health Effects:

Very hazardous in case of eye contact (irritant), of inhalation. Hazardous in case of skin contact (irritant, permeator), of ingestion. Inflammation of the eye is characterized by redness, watering, and itching.

Potential Chronic Health Effects:

CARCINOGENIC EFFECTS: Classified A1 (Confirmed for human.) by ACGIH, 1 (Proven for human.) by IARC. **MUTAGENIC EFFECTS:** Classified POSSIBLE for human. Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/or yeast. **TERATOGENIC EFFECTS:** Not available. **DEVELOPMENTAL TOXICITY:** Classified Reproductive system/toxin/female [POSSIBLE]. The substance is toxic to blood, bone marrow, central nervous system (CNS). The substance may be toxic to liver, Urinary System. Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact:

Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. WARM water MUST be used. Get medical attention immediately.

Skin Contact:

In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.

Serious Skin Contact:

Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation:

If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention if symptoms appear.

Serious Inhalation:

Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.

Ingestion:

Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Flammable.

Auto-Ignition Temperature: 497.78°C (928°F)

Flash Points: CLOSED CUP: -11.1°C (12°F). (Setaflash)

Flammable Limits: LOWER: 1.2% UPPER: 7.8%

Products of Combustion: These products are carbon oxides (CO, CO₂).

Fire Hazards in Presence of Various Substances:

Highly flammable in presence of open flames and sparks, of heat. Slightly flammable to flammable in presence of oxidizing materials. Non-flammable in presence of shocks.

Explosion Hazards in Presence of Various Substances:

Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available. Explosive in presence of oxidizing materials, of acids.

Fire Fighting Media and Instructions:

Flammable liquid, soluble or dispersed in water. SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use alcohol foam, water spray or fog.

Special Remarks on Fire Hazards:

Extremely flammable liquid and vapor. Vapor may cause flash fire. Reacts on contact with iodine heptafluoride gas. Dioxygenyl tetrafluoroborate is as very powerful oxidant. The addition of a small particle to small samples of benzene, at ambient temperature, causes ignition. Contact with sodium peroxide with benzene causes ignition. Benzene ignites in contact with powdered chromic anhydride. Vigorous or incandescent reaction with hydrogen + Raney nickel (above 210 C) and bromine trifluoride.

Special Remarks on Explosion Hazards:

Benzene vapors + chlorine and light causes explosion. Reacts explosively with bromine pentafluoride, chlorine, chlorine trifluoride, diborane, nitric acid, nitryl perchlorate, liquid oxygen, ozone, silver perchlorate. Benzene + pentafluoride and methoxide (from arsenic pentafluoride and potassium methoxide) in trichlorotrifluoroethane causes explosion. Interaction

of nitryl perchlorate with benzene gave a slight explosion and flash. The solution of permanganic acid (or its explosive anhydride, dimanganese heptoxide) produced by interaction of permanganates and sulfuric acid will explode on contact with benzene. Peroxodisulfuric acid is a very powerful oxidant. Uncontrolled contact with benzene may cause explosion. Mixtures of peroxomonsulfuric acid with benzene explodes.

Section 6: Accidental Release Measures

Small Spill: Absorb with an inert material and put the spilled material in an appropriate waste disposal.

Large Spill:

Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:

Keep locked up.. Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, acids.

Storage:

Store in a segregated and approved area. Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:

Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:

Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:

TWA: 0.5 STEL: 2.5 (ppm) from ACGIH (TLV) [United States] TWA: 1.6 STEL: 8 (mg/m³) from ACGIH (TLV) [United States] TWA: 0.1 STEL: 1 from NIOSH TWA: 1 STEL: 5 (ppm) from OSHA (PEL) [United States] TWA: 10 (ppm) from OSHA (PEL) [United States] TWA: 3 (ppm) [United Kingdom (UK)] TWA: 1.6 (mg/m³) [United Kingdom (UK)] TWA: 1 (ppm) [Canada] TWA: 3.2 (mg/m³) [Canada] TWA: 0.5 (ppm) [Canada] Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid.

Odor:

Aromatic. Gasoline-like, rather pleasant. (Strong.)

Taste: Not available.

Molecular Weight: 78.11 g/mole

Color: Clear Colorless. Colorless to light yellow.

pH (1% soln/water): Not available.

Boiling Point: 80.1 (176.2°F)

Melting Point: 5.5°C (41.9°F)

Critical Temperature: 288.9°C (552°F)

Specific Gravity: 0.8787 @ 15 C (Water = 1)

Vapor Pressure: 10 kPa (@ 20°C)

Vapor Density: 2.8 (Air = 1)

Volatility: Not available.

Odor Threshold: 4.68 ppm

Water/Oil Dist. Coeff.: The product is more soluble in oil; $\log(\text{oil/water}) = 2.1$

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, diethyl ether, acetone.

Solubility:

Miscible in alcohol, chloroform, carbon disulfide oils, carbon tetrachloride, glacial acetic acid, diethyl ether, acetone. Very slightly soluble in cold water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Heat, ignition sources, incompatibles.

Incompatibility with various substances: Highly reactive with oxidizing agents, acids.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity:

Benzene vapors + chlorine and light causes explosion. Reacts explosively with bromine pentafluoride, chlorine, chlorine trifluoride, diborane, nitric acid, nitryl perchlorate, liquid oxygen, ozone, silver perchlorate. Benzene + pentafluoride and methoxide (from arsenic pentafluoride and potassium methoxide) in trichlorotrifluoroethane causes explosion. Interaction of nitryl perchlorate with benzene gave a slight explosion and flash. The solution of permanganic acid (or its explosive anhydride, dimanganese heptoxide) produced by interaction of permanganates and sulfuric acid will explode on contact with benzene. Peroxodisulfuric acid is a very powerful oxidant. Uncontrolled contact with benzene may cause explosion. Mixtures of peroxomonsulfuric acid with benzene explodes.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Dermal contact. Eye contact. Inhalation.

Toxicity to Animals:

WARNING: THE LC50 VALUES HEREUNDER ARE ESTIMATED ON THE BASIS OF A 4-HOUR EXPOSURE. Acute oral toxicity (LD50): 930 mg/kg [Rat]. Acute dermal toxicity (LD50): >9400 mg/kg [Rabbit]. Acute toxicity of the vapor (LC50): 10000 7 hours [Rat].

Chronic Effects on Humans:

CARCINOGENIC EFFECTS: Classified A1 (Confirmed for human.) by ACGIH, 1 (Proven for human.) by IARC. **MUTAGENIC EFFECTS:** Classified POSSIBLE for human. Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/or yeast. **DEVELOPMENTAL TOXICITY:** Classified Reproductive system/toxin/female [POSSIBLE]. Causes damage to the following organs: blood, bone marrow, central nervous system (CNS). May cause damage to the following organs: liver, Urinary System.

Other Toxic Effects on Humans:

Very hazardous in case of inhalation. Hazardous in case of skin contact (irritant, permeator), of ingestion.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans:

May cause adverse reproductive effects (female fertility, Embryotoxic and/or foetotoxic in animal) and birth defects. May affect genetic material (mutagenic). May cause cancer (tumorigenic, leukemia) Human: passes the placental barrier, detected in maternal milk.

Special Remarks on other Toxic Effects on Humans:

Acute Potential Health Effects: Skin: Causes skin irritation. It can be absorbed through intact skin and affect the liver, blood, metabolism, and urinary system. Eyes: Causes eye irritation. Inhalation: Causes respiratory tract and mucous membrane irritation. Can be absorbed through the lungs. May affect behavior/Central and Peripheral nervous systems (somnolence, muscle weakness, general anesthetic, and other symptoms similar to ingestion), gastrointestinal tract (nausea), blood metabolism, urinary system. Ingestion: May be harmful if swallowed. May cause gastrointestinal tract irritation including vomiting. May affect behavior/Central and Peripheral nervous systems (convulsions, seizures, tremor, irritability, initial CNS stimulation followed by depression, loss of coordination, dizziness, headache, weakness, pallor, flushing), respiration (breathlessness and chest constriction), cardiovascular system, (shallow/rapid pulse), and blood.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:

Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are less toxic than the product itself.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: CLASS 3: Flammable liquid.

Identification: : Benzene UNNA: 1114 PG: II

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:

California prop. 65: This product contains the following ingredients for which the State of California has found to cause cancer, birth defects or other reproductive harm, which would require a warning under the statute: Benzene California prop. 65 (no significant risk level): Benzene: 0.007 mg/day (value) California prop. 65: This product contains the following ingredients

for which the State of California has found to cause cancer which would require a warning under the statute: Benzene Connecticut carcinogen reporting list.: Benzene Connecticut hazardous material survey.: Benzene Illinois toxic substances disclosure to employee act: Benzene Illinois chemical safety act: Benzene New York release reporting list: Benzene Rhode Island RTK hazardous substances: Benzene Pennsylvania RTK: Benzene Minnesota: Benzene Michigan critical material: Benzene Massachusetts RTK: Benzene Massachusetts spill list: Benzene New Jersey: Benzene New Jersey spill list: Benzene Louisiana spill reporting: Benzene California Director's list of Hazardous Substances: Benzene TSCA 8(b) inventory: Benzene SARA 313 toxic chemical notification and release reporting: Benzene CERCLA: Hazardous substances.: Benzene: 10 lbs. (4.536 kg)

Other Regulations:

OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):

CLASS B-2: Flammable liquid with a flash point lower than 37.8°C (100°F). CLASS D-2A: Material causing other toxic effects (VERY TOXIC).

DSCL (EEC):

R11- Highly flammable. R22- Harmful if swallowed. R38- Irritating to skin. R41- Risk of serious damage to eyes. R45- May cause cancer. R62- Possible risk of impaired fertility. S2- Keep out of the reach of children. S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S39- Wear eye/face protection. S46- If swallowed, seek medical advice immediately and show this container or label. S53- Avoid exposure - obtain special instructions before use.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 3

Reactivity: 0

Personal Protection: h

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 3

Reactivity: 0

Specific hazard:

Protective Equipment:

Gloves. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

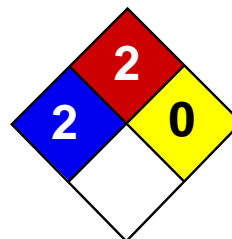
References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 08:35 PM

Last Updated: 05/21/2013 12:00 PM

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Health	2
Fire	2
Reactivity	0
Personal Protection	E

Material Safety Data Sheet Naphthalene MSDS

Section 1: Chemical Product and Company Identification

Product Name: Naphthalene

Catalog Codes: SLN1789, SLN2401

CAS#: 91-20-3

RTECS: QJ0525000

TSCA: TSCA 8(b) inventory: Naphthalene

CI#: Not available.

Synonym:

Chemical Name: Not available.

Chemical Formula: C₁₀H₈

Contact Information:

Sciencelab.com, Inc.

14025 Smith Rd.

Houston, Texas 77396

US Sales: **1-800-901-7247**

International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:

1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Naphthalene	91-20-3	100

Toxicological Data on Ingredients: Naphthalene: ORAL (LD50): Acute: 490 mg/kg [Rat]. 533 mg/kg [Mouse]. 1200 mg/kg [Guinea pig]. DERMAL (LD50): Acute: 20001 mg/kg [Rabbit]. VAPOR (LC50): Acute: 170 ppm 4 hour(s) [Rat].

Section 3: Hazards Identification

Potential Acute Health Effects:

Very hazardous in case of ingestion. Hazardous in case of eye contact (irritant), of inhalation. Slightly hazardous in case of skin contact (irritant, permeator). Severe over-exposure can result in death.

Potential Chronic Health Effects:

CARCINOGENIC EFFECTS: A4 (Not classifiable for human or animal.) by ACGIH. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Classified Development toxin [POSSIBLE]. The substance is toxic to blood, kidneys, the nervous system, the reproductive system, liver, mucous membranes, gastrointestinal tract, upper respiratory tract, central nervous system (CNS). Repeated or prolonged exposure to the substance can produce target organs damage. Repeated exposure to an highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

Section 4: First Aid Measures

Eye Contact:

Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.

Skin Contact:

After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. Wash contaminated clothing before reusing.

Serious Skin Contact: Not available.

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation:

Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. **WARNING:** It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.

Ingestion:

Do not induce vomiting. Examine the lips and mouth to ascertain whether the tissues are damaged, a possible indication that the toxic material was ingested; the absence of such signs, however, is not conclusive. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Flammable.

Auto-Ignition Temperature: 567°C (1052.6°F)

Flash Points: CLOSED CUP: 88°C (190.4°F). OPEN CUP: 79°C (174.2°F).

Flammable Limits: LOWER: 0.9% UPPER: 5.9%

Products of Combustion: These products are carbon oxides (CO, CO₂).

Fire Hazards in Presence of Various Substances: Not available.

Explosion Hazards in Presence of Various Substances:

Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:

Flammable solid. **SMALL FIRE:** Use DRY chemical powder. **LARGE FIRE:** Use water spray or fog. Cool containing vessels with water jet in order to prevent pressure build-up, autoignition or explosion.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill: Use appropriate tools to put the spilled solid in a convenient waste disposal container.

Large Spill:

Flammable solid. Stop leak if without risk. Do not touch spilled material. Use water spray curtain to divert vapor drift. Prevent entry into sewers, basements or confined areas; dike if needed. Eliminate all ignition sources. Call for assistance on disposal. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:

Keep locked up Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe dust. Avoid contact with eyes Wear suitable protective clothing In case of insufficient ventilation, wear suitable respiratory equipment If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents.

Storage:

Flammable materials should be stored in a separate safety storage cabinet or room. Keep away from heat. Keep away from sources of ignition. Keep container tightly closed. Keep in a cool, well-ventilated place. Ground all equipment containing material. Keep container dry. Keep in a cool place.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:

Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:

Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:

Israel: TWA: 10 (ppm) STEL: 15 (ppm) from ACGIH (TLV) [1995] TWA: 52 STEL: 79 (mg/m³) from ACGIH [1995]
Australia: STEL: 15 (ppm) Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Crystalline solid.)

Odor: Aromatic.

Taste: Not available.

Molecular Weight: 128.19 g/mole

Color: White.

pH (1% soln/water): Not available.

Boiling Point: 218°C (424.4°F)

Melting Point: 80.2°C (176.4°F)

Critical Temperature: Not available.

Specific Gravity: 1.162 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: 4.4 (Air = 1)

Volatility: Not available.

Odor Threshold: 0.038 ppm

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties:

Partially dispersed in hot water, methanol, n-octanol. Very slightly dispersed in cold water. See solubility in methanol, n-octanol.

Solubility:

Partially soluble in methanol, n-octanol. Very slightly soluble in cold water, hot water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Highly reactive with oxidizing agents.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: May attack some forms of rubber and plastic

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Dermal contact. Eye contact. Inhalation. Ingestion.

Toxicity to Animals:

WARNING: THE LC50 VALUES HEREUNDER ARE ESTIMATED ON THE BASIS OF A 4-HOUR EXPOSURE. Acute oral toxicity (LD50): 490 mg/kg [Rat]. Acute dermal toxicity (LD50): 20001 mg/kg [Rabbit]. Acute toxicity of the vapor (LC50): 170 ppm 4 hour(s) [Rat].

Chronic Effects on Humans:

CARCINOGENIC EFFECTS: A4 (Not classifiable for human or animal.) by ACGIH. DEVELOPMENTAL TOXICITY: Classified Development toxin [POSSIBLE]. The substance is toxic to blood, kidneys, the nervous system, the reproductive system, liver, mucous membranes, gastrointestinal tract, upper respiratory tract, central nervous system (CNS).

Other Toxic Effects on Humans:

Very hazardous in case of ingestion. Hazardous in case of inhalation. Slightly hazardous in case of skin contact (irritant, permeator).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans: Not available.

Section 12: Ecological Information

Ecotoxicity: Ecotoxicity in water (LC50): 305.2 ppm 96 hour(s) [Trout].

BOD5 and COD: Not available.

Products of Biodegradation:

Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: CLASS 4.1: Flammable solid.

Identification: : Naphthalene, refined : UN1334 PG: III

Special Provisions for Transport: Marine Pollutant

Section 15: Other Regulatory Information

Federal and State Regulations:

Rhode Island RTK hazardous substances: Naphthalene Pennsylvania RTK: Naphthalene Florida: Naphthalene Minnesota: Naphthalene Massachusetts RTK: Naphthalene TSCA 8(b) inventory: Naphthalene TSCA 8(a) PAIR: Naphthalene TSCA 8(d) H and S data reporting: Naphthalene: 06/01/87 SARA 313 toxic chemical notification and release reporting: Naphthalene: 1% CERCLA: Hazardous substances.: Naphthalene: 100 lbs. (45.36 kg)

Other Regulations:

OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):

CLASS B-4: Flammable solid. CLASS D-1B: Material causing immediate and serious toxic effects (TOXIC). CLASS D-2B: Material causing other toxic effects (TOXIC).

DSCL (EEC):

R36- Irritating to eyes. R40- Possible risks of irreversible effects. R48/22- Harmful: danger of serious damage to health by prolonged exposure if swallowed. R48/23- Toxic: danger of serious damage to health by prolonged exposure through inhalation. R63- Possible risk of harm to the unborn child.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 2

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 2

Reactivity: 0

Specific hazard:

Protective Equipment:

Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

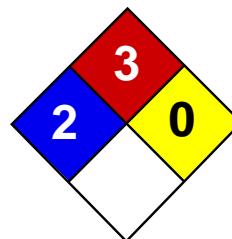
References: Not available.

Other Special Considerations: Not available.

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Last Updated: 05/21/2013 12:00 PM

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Health	2
Fire	3
Reactivity	0
Personal Protection	H

Material Safety Data Sheet Xylenes MSDS

Section 1: Chemical Product and Company Identification

Product Name: Xylenes

Catalog Codes: SLX1075, SLX1129, SLX1042, SLX1096

CAS#: 1330-20-7

RTECS: ZE2100000

TSCA: TSCA 8(b) inventory: Xylenes

CI#: Not available.

Synonym: Xylenes; Dimethylbenzene; xylol; methyltoluene

Chemical Name: Xylenes (o-, m-, p- isomers)

Chemical Formula: C₆H₄(CH₃)₂

Contact Information:

Sciencelab.com, Inc.

14025 Smith Rd.

Houston, Texas 77396

US Sales: **1-800-901-7247**

International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:

1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Xylenes	1330-20-7	100

Toxicological Data on Ingredients: Xylenes: ORAL (LD50): Acute: 4300 mg/kg [Rat]. 2119 mg/kg [Mouse]. DERMAL (LD50): Acute: >1700 mg/kg [Rabbit].

Section 3: Hazards Identification

Potential Acute Health Effects: Hazardous in case of skin contact (irritant, permeator), of eye contact (irritant), of ingestion, of inhalation.

Potential Chronic Health Effects:

CARCINOGENIC EFFECTS: 3 (Not classifiable for human.) by IARC. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance may be toxic to blood, kidneys, liver, mucous membranes, bone marrow, central nervous system (CNS). Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact:

Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

Skin Contact:

In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.

Serious Skin Contact:

Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation:

If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention if symptoms appear.

Serious Inhalation:

Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.

Ingestion:

Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Flammable.

Auto-Ignition Temperature: 464°C (867.2°F)

Flash Points: CLOSED CUP: 24°C (75.2°F). (Tagliabue.) OPEN CUP: 37.8°C (100°F).

Flammable Limits: LOWER: 1% UPPER: 7%

Products of Combustion: These products are carbon oxides (CO, CO₂).

Fire Hazards in Presence of Various Substances:

Highly flammable in presence of open flames and sparks, of heat. Non-flammable in presence of shocks.

Explosion Hazards in Presence of Various Substances:

Risks of explosion of the product in presence of mechanical impact: Not available. Slightly explosive in presence of open flames and sparks, of heat.

Fire Fighting Media and Instructions:

Flammable liquid, soluble or dispersed in water. SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use alcohol foam, water spray or fog. Cool containing vessels with water jet in order to prevent pressure build-up, autoignition or explosion.

Special Remarks on Fire Hazards: Vapors may travel to source of ignition and flash back.

Special Remarks on Explosion Hazards:

Vapors may form explosive mixtures with air. Containers may explode when heated. May polymerize explosively when heated. An attempt to chlorinate xylene with 1,3-Dichloro-5,5-dimethyl-2,4-imidazolidindione (dichlorohydrantoin) caused a violent explosion

Section 6: Accidental Release Measures

Small Spill: Absorb with an inert material and put the spilled material in an appropriate waste disposal.

Large Spill:

Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined

areas; dike if needed. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:

Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, acids.

Storage:

Store in a segregated and approved area. Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:

Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:

Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:

TWA: 100 (ppm) [Canada] TWA: 435 (mg/m³) [Canada] TWA: 434 STEL: 651 (mg/m³) from ACGIH (TLV) [United States]
TWA: 100 STEL: 150 (ppm) from ACGIH (TLV) [United States] Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid.

Odor: Sweetish.

Taste: Not available.

Molecular Weight: 106.17 g/mole

Color: Colorless. Clear

pH (1% soln/water): Not available.

Boiling Point: 138.5°C (281.3°F)

Melting Point: -47.4°C (-53.3°F)

Critical Temperature: Not available.

Specific Gravity: 0.864 (Water = 1)

Vapor Pressure: 0.9 kPa (@ 20°C)

Vapor Density: 3.7 (Air = 1)

Volatility: Not available.

Odor Threshold: 1 ppm

Water/Oil Dist. Coeff.: The product is more soluble in oil; $\log(\text{oil/water}) = 3.1$

Ionicity (in Water): Not available.

Dispersion Properties: Not available.

Solubility:

Insoluble in cold water, hot water. Miscible with absolute alcohol, ether, and many other organic liquids.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Heat, ignition sources, incompatibles

Incompatibility with various substances: Reactive with oxidizing agents, acids.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Store away from acetic acid, nitric acid, chlorine, bromine, and fluorine.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Dermal contact. Eye contact. Inhalation.

Toxicity to Animals:

WARNING: THE LC50 VALUES HEREUNDER ARE ESTIMATED ON THE BASIS OF A 4-HOUR EXPOSURE. Acute oral toxicity (LD50): 2119 mg/kg [Mouse]. Acute dermal toxicity (LD50): >1700 mg/kg [Rabbit]. Acute toxicity of the vapor (LC50): 5000 4 hours [Rat].

Chronic Effects on Humans:

CARCINOGENIC EFFECTS: 3 (Not classifiable for human.) by IARC. May cause damage to the following organs: blood, kidneys, liver, mucous membranes, bone marrow, central nervous system (CNS).

Other Toxic Effects on Humans: Hazardous in case of skin contact (irritant, permeator), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals:

Lowest Lethal Dose: LDL [Human] - Route: Oral; Dose: 50 mg/kg LCL [Man] - Route: Oral; Dose: 10000 ppm/6H

Special Remarks on Chronic Effects on Humans:

Detected in maternal milk in human. Passes through the placental barrier in animal. Embryotoxic and/or foetotoxic in animal. May cause adverse reproductive effects (male and female fertility (spontaneous abortion and fetotoxicity)) and birth defects based animal data.

Special Remarks on other Toxic Effects on Humans:

Acute Potential Health Effects: Skin: Causes skin irritation. Can be absorbed through skin. Eyes: Causes eye irritation. Inhalation: Vapor causes respiratory tract and mucous membrane irritation. May affect central nervous system and behavior (General anesthetic/CNS depressant with effects including headache, weakness, memory loss, irritability, dizziness, giddiness, loss of coordination and judgement, respiratory depression/arrest or difficulty breathing, loss of appetite, nausea, vomiting, shivering, and possible coma and death). May also affects blood, sense organs, liver, and peripheral nerves. Ingestion: May cause gastrointestinal irritation including abdominal pain, vomiting, and nausea. May also affect liver and urinary system/kidneys. May cause effects similar to those of acute inhalation. Chronic Potential Health Effects: Chronic inhalation may affect the urinary system (kidneys) blood (anemia), bone marrow (hyperplasia of bone marrow) brain/behavior/Central Nervous system. Chronic inhalation may also cause mucosal bleeding. Chronic ingestion may affect the liver and metabolism (loss of appetite) and may affect urinary system (kidney damage)

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:

Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are less toxic than the product itself.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: CLASS 3: Flammable liquid.

Identification : Xylenes UNNA: 1307 PG: III

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:

Connecticut hazardous material survey.: Xylenes Illinois chemical safety act: Xylenes New York acutely hazardous substances: Xylenes Rhode Island RTK hazardous substances: Xylenes Pennsylvania RTK: Xylenes Minnesota: Xylenes Michigan critical material: Xylenes Massachusetts RTK: Xylenes Massachusetts spill list: Xylenes New Jersey: Xylenes New Jersey spill list: Xylenes Louisiana spill reporting: Xylenes California Director's List of Hazardous Substances: Xylenes TSCA 8(b) inventory: Xylenes SARA 302/304/311/312 hazardous chemicals: Xylenes SARA 313 toxic chemical notification and release reporting: Xylenes CERCLA: Hazardous substances.: Xylenes: 100 lbs. (45.36 kg)

Other Regulations:

OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):

CLASS B-2: Flammable liquid with a flash point lower than 37.8°C (100°F). CLASS D-2A: Material causing other toxic effects (VERY TOXIC).

DSCL (EEC):

R10- Flammable. R21- Harmful in contact with skin. R36/38- Irritating to eyes and skin. S2- Keep out of the reach of children. S36/37- Wear suitable protective clothing and gloves. S46- If swallowed, seek medical advice immediately and show this container or label.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 3

Reactivity: 0

Personal Protection: h

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 3

Reactivity: 0

Specific hazard:

Protective Equipment:

Gloves. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

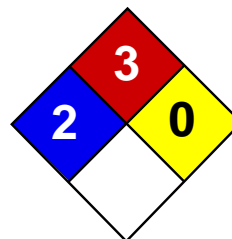
References: Not available.

Other Special Considerations: Not available.

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Last Updated: 05/21/2013 12:00 PM

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Health	2
Fire	3
Reactivity	0
Personal Protection	H

Material Safety Data Sheet Toluene MSDS

Section 1: Chemical Product and Company Identification

Product Name: Toluene

Catalog Codes: SLT2857, SLT3277

CAS#: 108-88-3

RTECS: XS5250000

TSCA: TSCA 8(b) inventory: Toluene

CI#: Not available.

Synonym: Toluol, Tolu-Sol; Methylbenzene; Methacide; Phenylmethane; Methylbenzol

Chemical Name: Toluene

Chemical Formula: C6-H5-CH3 or C7-H8

Contact Information:

Sciencelab.com, Inc.

14025 Smith Rd.

Houston, Texas 77396

US Sales: **1-800-901-7247**

International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:

1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Toluene	108-88-3	100

Toxicological Data on Ingredients: Toluene: ORAL (LD50): Acute: 636 mg/kg [Rat]. DERMAL (LD50): Acute: 14100 mg/kg [Rabbit]. VAPOR (LC50): Acute: 49000 mg/m 4 hours [Rat]. 440 ppm 24 hours [Mouse].

Section 3: Hazards Identification

Potential Acute Health Effects:

Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator).

Potential Chronic Health Effects:

CARCINOGENIC EFFECTS: A4 (Not classifiable for human or animal.) by ACGIH, 3 (Not classifiable for human.) by IARC. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance may be toxic to blood, kidneys, the nervous system, liver, brain, central nervous system (CNS). Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact:

Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

Skin Contact:

In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.

Serious Skin Contact:

Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation:

If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation:

Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. **WARNING:** It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek medical attention.

Ingestion:

Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Flammable.

Auto-Ignition Temperature: 480°C (896°F)

Flash Points: CLOSED CUP: 4.4444°C (40°F). (Setaflash) OPEN CUP: 16°C (60.8°F).

Flammable Limits: LOWER: 1.1% UPPER: 7.1%

Products of Combustion: These products are carbon oxides (CO, CO₂).

Fire Hazards in Presence of Various Substances:

Flammable in presence of open flames and sparks, of heat. Non-flammable in presence of shocks.

Explosion Hazards in Presence of Various Substances:

Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:

Flammable liquid, insoluble in water. SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray or fog.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards:

Toluene forms explosive reaction with 1,3-dichloro-5,5-dimethyl-2,4-imidazolididione; dinitrogen tetroxide; concentrated nitric acid, sulfuric acid + nitric acid; N₂O₄; AgClO₄; BrF₃; Uranium hexafluoride; sulfur dichloride. Also forms an explosive mixture with tetranitromethane.

Section 6: Accidental Release Measures

Small Spill: Absorb with an inert material and put the spilled material in an appropriate waste disposal.

Large Spill:

Toxic flammable liquid, insoluble or very slightly soluble in water. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage**Precautions:**

Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents.

Storage:

Store in a segregated and approved area. Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame).

Section 8: Exposure Controls/Personal Protection**Engineering Controls:**

Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:

Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:

TWA: 200 STEL: 500 CEIL: 300 (ppm) from OSHA (PEL) [United States] TWA: 50 (ppm) from ACGIH (TLV) [United States] SKIN TWA: 100 STEL: 150 from NIOSH [United States] TWA: 375 STEL: 560 (mg/m³) from NIOSH [United States] Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid.

Odor: Sweet, pungent, Benzene-like.

Taste: Not available.

Molecular Weight: 92.14 g/mole

Color: Colorless.

pH (1% soln/water): Not applicable.

Boiling Point: 110.6°C (231.1°F)

Melting Point: -95°C (-139°F)

Critical Temperature: 318.6°C (605.5°F)

Specific Gravity: 0.8636 (Water = 1)

Vapor Pressure: 3.8 kPa (@ 25°C)

Vapor Density: 3.1 (Air = 1)

Volatility: Not available.

Odor Threshold: 1.6 ppm

Water/Oil Dist. Coeff.: The product is more soluble in oil; $\log(\text{oil/water}) = 2.7$

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, diethyl ether, acetone.

Solubility:

Soluble in diethyl ether, acetone. Practically insoluble in cold water. Soluble in ethanol, benzene, chloroform, glacial acetic acid, carbon disulfide. Solubility in water: 0.561 g/l @ 25 deg. C.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Heat, ignition sources (flames, sparks, static), incompatible materials

Incompatibility with various substances: Reactive with oxidizing agents.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity:

Incompatible with strong oxidizers, silver perchlorate, sodium difluoride, Tetranitromethane, Uranium Hexafluoride. Frozen Bromine Trifluoride reacts violently with Toluene at -80 deg. C. Reacts chemically with nitrogen oxides, or halogens to form nitrotoluene, nitrobenzene, and nitrophenol and halogenated products, respectively.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Dermal contact. Eye contact. Inhalation. Ingestion.

Toxicity to Animals:

WARNING: THE LC50 VALUES HEREUNDER ARE ESTIMATED ON THE BASIS OF A 4-HOUR EXPOSURE. Acute oral toxicity (LD50): 636 mg/kg [Rat]. Acute dermal toxicity (LD50): 14100 mg/kg [Rabbit]. Acute toxicity of the vapor (LC50): 440 24 hours [Mouse].

Chronic Effects on Humans:

CARCINOGENIC EFFECTS: A4 (Not classifiable for human or animal.) by ACGIH, 3 (Not classifiable for human.) by IARC. May cause damage to the following organs: blood, kidneys, the nervous system, liver, brain, central nervous system (CNS).

Other Toxic Effects on Humans:

Hazardous in case of skin contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator).

Special Remarks on Toxicity to Animals:

Lowest Published Lethal Dose: LDL [Human] - Route: Oral; Dose: 50 mg/kg LCL [Rabbit] - Route: Inhalation; Dose: 55000 ppm/40min

Special Remarks on Chronic Effects on Humans:

Detected in maternal milk in human. Passes through the placental barrier in human. Embryotoxic and/or foetotoxic in animal. May cause adverse reproductive effects and birth defects (teratogenic). May affect genetic material (mutagenic)

Special Remarks on other Toxic Effects on Humans:

Acute Potential Health Effects: Skin: Causes mild to moderate skin irritation. It can be absorbed to some extent through the skin. Eyes: Causes mild to moderate eye irritation with a burning sensation. Splash contact with eyes also causes conjunctivitis, blepharospasm, corneal edema, corneal abrasions. This usually resolves in 2 days. Inhalation: Inhalation of vapor may cause respiratory tract irritation causing coughing and wheezing, and nasal discharge. Inhalation of high concentrations may affect behavior and cause central nervous system effects characterized by nausea, headache, dizziness, tremors, restlessness, lightheadedness, exhilaration, memory loss, insomnia, impaired reaction time, drowsiness, ataxia, hallucinations, somnolence, muscle contraction or spasticity, unconsciousness and coma. Inhalation of high concentration of vapor may also affect the cardiovascular system (rapid heart beat, heart palpitations, increased or decreased blood pressure, dysrhythmia,), respiration (acute pulmonary edema, respiratory depression, apnea, asphyxia), cause vision disturbances and dilated pupils, and cause loss of appetite. Ingestion: Aspiration hazard. Aspiration of Toluene into the lungs may cause chemical pneumonitis. May cause irritation of the digestive tract with nausea, vomiting, pain. May have effects similar to that of acute inhalation. Chronic Potential Health Effects: Inhalation and Ingestion: Prolonged or repeated exposure via inhalation may cause central nervous system and cardiovascular symptoms similar to that of acute inhalation and ingestion as well liver damage/failure, kidney damage/failure (with hematuria, proteinuria, oliguria, renal tubular acidosis), brain damage, weight loss, blood (pigmented or nucleated red blood cells, changes in white blood cell count), bone marrow changes, electrolyte imbalances (Hypokalemia, Hypophosphatemia), severe, muscle weakness and Rhabdomyolysis. Skin: Repeated or prolonged skin contact may cause defatting dermatitis.

Section 12: Ecological Information

Ecotoxicity:

Ecotoxicity in water (LC50): 313 mg/l 48 hours [Daphnia (daphnia)]. 17 mg/l 24 hours [Fish (Blue Gill)]. 13 mg/l 96 hours [Fish (Blue Gill)]. 56 mg/l 24 hours [Fish (Fathead minnow)]. 34 mg/l 96 hours [Fish (Fathead minnow)]. 56.8 ppm any hours [Fish (Goldfish)].

BOD5 and COD: Not available.

Products of Biodegradation:

Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are less toxic than the product itself.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: CLASS 3: Flammable liquid.

Identification: : Toluene UNNA: 1294 PG: II

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:

California prop. 65: This product contains the following ingredients for which the State of California has found to cause cancer, birth defects or other reproductive harm, which would require a warning under the statute: Toluene California prop. 65 (no significant risk level): Toluene: 7 mg/day (value) California prop. 65 (acceptable daily intake level): Toluene: 7 mg/day (value) California prop. 65: This product contains the following ingredients for which the State of California has found to cause birth defects which would require a warning under the statute: Toluene Connecticut hazardous material survey.: Toluene Illinois

toxic substances disclosure to employee act: Toluene Illinois chemical safety act: Toluene New York release reporting list: Toluene Rhode Island RTK hazardous substances: Toluene Pennsylvania RTK: Toluene Florida: Toluene Minnesota: Toluene Michigan critical material: Toluene Massachusetts RTK: Toluene Massachusetts spill list: Toluene New Jersey: Toluene New Jersey spill list: Toluene Louisiana spill reporting: Toluene California Director's List of Hazardous Substances.: Toluene TSCA 8(b) inventory: Toluene TSCA 8(d) H and S data reporting: Toluene: Effective date: 10/04/82; Sunset Date: 10/0/92 SARA 313 toxic chemical notification and release reporting: Toluene CERCLA: Hazardous substances.: Toluene: 1000 lbs. (453.6 kg)

Other Regulations:

OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):

CLASS B-2: Flammable liquid with a flash point lower than 37.8°C (100°F). CLASS D-2A: Material causing other toxic effects (VERY TOXIC).

DSCL (EEC):

R11- Highly flammable. R20- Harmful by inhalation. S16- Keep away from sources of ignition - No smoking. S25- Avoid contact with eyes. S29- Do not empty into drains. S33- Take precautionary measures against static discharges.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 3

Reactivity: 0

Personal Protection: h

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 3

Reactivity: 0

Specific hazard:

Protective Equipment:

Gloves. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

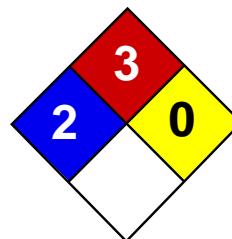
References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 08:30 PM

Last Updated: 05/21/2013 12:00 PM

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Health	2
Fire	3
Reactivity	0
Personal Protection	H

Material Safety Data Sheet Ethylbenzene MSDS

Section 1: Chemical Product and Company Identification

Product Name: Ethylbenzene

Catalog Codes: SLE2044

CAS#: 100-41-4

RTECS: DA0700000

TSCA: TSCA 8(b) inventory: Ethylbenzene

CI#: Not available.

Synonym: Ethyl Benzene; Ethylbenzol; Phenylethane

Chemical Name: Ethylbenzene

Chemical Formula: C₈H₁₀

Contact Information:

Sciencelab.com, Inc.

14025 Smith Rd.

Houston, Texas 77396

US Sales: **1-800-901-7247**

International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:

1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Ethylbenzene	100-41-4	100

Toxicological Data on Ingredients: Ethylbenzene: ORAL (LD50): Acute: 3500 mg/kg [Rat].

Section 3: Hazards Identification

Potential Acute Health Effects:

Hazardous in case of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant, permeator).

Potential Chronic Health Effects:

Slightly hazardous in case of skin contact (irritant, sensitizer). **CARCINOGENIC EFFECTS:** Classified 2B (Possible for human.) by IARC. **MUTAGENIC EFFECTS:** Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/or yeast. **TERATOGENIC EFFECTS:** Not available. **DEVELOPMENTAL TOXICITY:** Not available. The substance may be toxic to central nervous system (CNS). Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact:

Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. WARM water MUST be used. Get medical attention.

Skin Contact: Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops.

Serious Skin Contact: Not available.

Inhalation:

If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation:

Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek medical attention.

Ingestion:

Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Flammable.

Auto-Ignition Temperature: 432°C (809.6°F)

Flash Points:

CLOSED CUP: 15°C (59°F). (Tagliabue.) OPEN CUP: 26.667°C (80°F) (Cleveland) (CHRIS, 2001) CLOSED CUP: 12.8 C (55 F) (Bingham et al, 2001; NIOSH, 2001) CLOSED CUP: 21 C (70 F) (NFPA)

Flammable Limits: LOWER: 0.8% - 1.6%UPPER: 6.7% - 7%

Products of Combustion: These products are carbon oxides (CO, CO₂).

Fire Hazards in Presence of Various Substances: Highly flammable in presence of open flames and sparks, of heat.

Explosion Hazards in Presence of Various Substances:

Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available. Slightly explosive in presence of heat.

Fire Fighting Media and Instructions:

Flammable liquid, soluble or dispersed in water. SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use alcohol foam, water spray or fog.

Special Remarks on Fire Hazards:

Vapor may travel considerable distance to source of ignition and flash back. Vapors may form explosive mixtures with air. When heated to decomposition it emits acrid smoke and irritating fumes.

Special Remarks on Explosion Hazards: Vapors may form explosive mixtures in air.

Section 6: Accidental Release Measures

Small Spill: Absorb with an inert material and put the spilled material in an appropriate waste disposal.

Large Spill:

Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:

Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Avoid contact with eyes. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents.

Storage:

Store in a segregated and approved area. Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame). Sensitive to light. Store in light-resistant containers.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:

Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:

Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:

TWA: 100 STEL: 125 (ppm) from OSHA (PEL) [United States] TWA: 435 STEL: 545 from OSHA (PEL) [United States] TWA: 435 STEL: 545 (mg/m³) from NIOSH [United States] TWA: 100 STEL: 125 (ppm) from NIOSH [United States] TWA: 100 STEL: 125 (ppm) from ACGIH (TLV) [United States] TWA: 100 STEL: 125 (ppm) [United Kingdom (UK)] TWA: 100 STEL: 125 (ppm) [Belgium] TWA: 100 STEL: 125 (ppm) [Finland] TWA: 50 (ppm) [Norway] Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid.

Odor: Sweetish. Gasoline-like. Aromatic.

Taste: Not available.

Molecular Weight: 106.16 g/mole

Color: Colorless.

pH (1% soln/water): Not available.

Boiling Point: 136°C (276.8°F)

Melting Point: -94.9 (-138.8°F)

Critical Temperature: 617.15°C (1142.9°F)

Specific Gravity: 0.867 (Water = 1)

Vapor Pressure: 0.9 kPa (@ 20°C)

Vapor Density: 3.66 (Air = 1)

Volatility: 100% (v/v).

Odor Threshold: 140 ppm

Water/Oil Dist. Coeff.: The product is more soluble in oil; $\log(\text{oil/water}) = 3.1$

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, diethyl ether.

Solubility:

Easily soluble in diethyl ether. Very slightly soluble in cold water or practically insoluble in water. Soluble in all proportions in Ethyl alcohol. Soluble in Carbon tetrachloride, Benzene. Insoluble in Ammonia. Slightly soluble in Chloroform. Solubility in Water: 169 mg/l @ 25 deg. C.; 0.014 g/100 ml @ 15 deg. C.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Heat, ignition sources (flames, sparks, static), incompatible materials, light

Incompatibility with various substances: Reactive with oxidizing agents.

Corrosivity: Not considered to be corrosive for metals and glass.

Special Remarks on Reactivity:

Can react vigorously with oxidizing materials. Sensitive to light.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Inhalation.

Toxicity to Animals: Acute oral toxicity (LD50): 3500 mg/kg [Rat].

Chronic Effects on Humans:

CARCINOGENIC EFFECTS: Classified 2B (Possible for human.) by IARC. MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/or yeast. May cause damage to the following organs: central nervous system (CNS).

Other Toxic Effects on Humans:

Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant, permeator).

Special Remarks on Toxicity to Animals:

Lethal Dose/Conc 50% Kill: LD50 [Rabbit] - Route: Skin; Dose: 17800 ul/kg Lowest Published Lethal Dose/Conc: LDL[Rat] - Route: Inhalation (vapor); Dose: 4000 ppm/4 H

Special Remarks on Chronic Effects on Humans:

May cause adverse reproductive effects and birth defects (teratogenic) based on animal test data. May cause cancer based on animals data. IARC evidence for carcinogenicity in animals is sufficient. IARC evidence of carcinogenicity in humans inadequate. May affect genetic material (mutagenic).

Special Remarks on other Toxic Effects on Humans:

Acute Potential Health Effects: Skin: Can cause mild skin irritation. It can be absorbed through intact skin. Eyes: Contact with vapor or liquid can cause severe eye irritation depending on concentration. It may also cause conjunctivitis. At a vapor exposure level of 85 - 200 ppm, it is mildly and transiently irritating to the eyes; 1000 ppm causes further irritation and tearing; 2000 ppm results in immediate and severe irritation and tearing; 5,000 ppm is intolerable (ACGIH, 1991; Clayton and Clayton, 1994). Standard draize test for eye irritation using 500 mg resulted in severe irritation (RTECS) Inhalation: Exposure to high concentrations can cause nasal, mucous membrane and respiratory tract irritation and can also result in chest constriction and, trouble breathing, respiratory failure, and even death. It can also affect behavior/Central Nervous System. The effective dose for CNS depression in experimental animals was 10,000 ppm (ACGIH, 1991). Symptoms of CNS depression include

headache, nausea, weakness, dizziness, vertigo, irritability, fatigue, lightheadedness, sleepiness, tremor, loss of coordination, judgement and consciousness, coma, and death. It can also cause pulmonary edema. Inhalation of 85 ppm can produce fatigue, insomnia, headache, and mild irritation of the respiratory tract (Haley & Berndt, 1987). Ingestion: Do not drink, pipet or siphon by mouth. May cause gastrointestinal/digestive tract irritation with Abdominal pain, nausea, vomiting. Ethylbenzene is a pulmonary aspiration hazard. Pulmonary aspiration of even small amounts of the liquid may cause fatal pneumonitis. It may also affect behavior/central nervous system with

Section 12: Ecological Information

Ecotoxicity:

Ecotoxicity in water (LC50): 14 mg/l 96 hours [Fish (Trout)] (static). 12.1 mg/l 96 hours [Fish (Fathead Minnow)] (flow-through)]. 150 mg/l 96 hours [Fish (Blue Gill/Sunfish)] (static). 275 mg/l 96 hours [Fish (Sheepshead Minnow)]. 42.3 mg/l 96 hours [Fish (Fathead Minnow)](soft water). 87.6mg/l 96 hours [Shrimp].

BOD5 and COD: Not available.

Products of Biodegradation:

Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are less toxic than the product itself.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: CLASS 3: Flammable liquid.

Identification: : Ethylbenzene UNNA: 1175 PG: II

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:

Connecticut hazardous material survey.: Ethylbenzene Illinois toxic substances disclosure to employee act: Ethylbenzene Illinois chemical safety act: Ethylbenzene New York release reporting list: Ethylbenzene Rhode Island RTK hazardous substances: Ethylbenzene Pennsylvania RTK: Ethylbenzene Minnesota: Ethylbenzene Massachusetts RTK: Ethylbenzene Massachusetts spill list: Ethylbenzene New Jersey: Ethylbenzene New Jersey spill list: Ethylbenzene Louisiana spill reporting: Ethylbenzene California Director's List of Hazardous Substances: Ethylbenzene TSCA 8(b) inventory: Ethylbenzene TSCA 4(a) proposed test rules: Ethylbenzene TSCA 8(d) H and S data reporting: Ethylbenzene: Effective Date: 6/19/87; Sunset Date: 6/19/97 SARA 313 toxic chemical notification and release reporting: Ethylbenzene

Other Regulations:

OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):

CLASS B-2: Flammable liquid with a flash point lower than 37.8°C (100°F). CLASS D-2A: Material causing other toxic effects (VERY TOXIC). CLASSE D-2B: Material causing other toxic effects (TOXIC).

DSCL (EEC):

R11- Highly flammable. R20- Harmful by inhalation. S16- Keep away from sources of ignition - No smoking. S24/25- Avoid contact with skin and eyes. S29- Do not empty into drains.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 3

Reactivity: 0

Personal Protection: h

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 3

Reactivity: 0

Specific hazard:

Protective Equipment:

Gloves. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information**References:**

-Manufacturer's Material Safety Data Sheet. -Fire Protection Guide to Hazardous Materials, 13th ed., National Fire Protection Association (NFPA) -Registry of Toxic Effects of Chemical Substances (RTECS) -Chemical Hazard Response Information System (CHRIS) -Hazardous Substance Data Bank (HSDB) -New Jersey Hazardous Substance Fact Sheet -Ariel Global View -Reprotext System

Other Special Considerations: Not available.

Created: 10/09/2005 05:28 PM

Last Updated: 05/21/2013 12:00 PM

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APPENDIX B
HEALTH AND SAFETY FORMS



TAILGATE SAFETY MEETING

Project Name:	Date:
Project Number:	Time: Start: Stop:
Location:	Sheet: ___ of ___
Presented By:	
Topics Covered:	

I have reviewed the Site Health and Safety Plan for the Sparrows Point Coke Oven Area Investigation Site and understand the potential health and safety hazards at this operation and the emergency response procedures. I agree to conduct all on-site work in conformity with the requirements of the Health and Safety Plan.

NAME (print)	SIGNATURE	COMPANY

Safety and Health Concerns Expressed during Meeting:

Corrective Actions Taken or Planned:

REAL-TIME MONITORING LOG

Date:		Person performing sampling:						
Project Name:		Signature:						
Project No.:								
Time	Monitoring Location (be specific)	READINGS						COMMENTS (Where was sample taken? e.g., breathing zone or other) and Duration of Monitoring
		O ₂ %	LEL %	VOC ppm	Dust mg/ m ³	Noise dB	Detect or Tube (spec. tube)	

Real Time Instrument Calibration Log should accompany this form.

INCIDENT AND INJURY REPORT

This form must be completed and forwarded to Corporate Health and Safety within 24 hours of any incident/injury.
For serious injuries, also complete page 2 and forward the entire form to Corporate Health and Safety by the end of the day.

Employer Name:	
Employer Address:	
Employer Phone #	Employers FAX #

EMPLOYEE		
Name:	Soc. Sec. #	
Home Address:		
County:	Zip Code:	
Home Telephone:	Date of Birth:	Age:
Occupation: (Job Title):	Sex: Male <input type="checkbox"/> Female <input type="checkbox"/>	
Department:	Married: Yes <input type="checkbox"/> No <input type="checkbox"/>	
How long employed:	Years Mo.	No. Children under 18 yrs.

ACCIDENT/INJURY		
Project Name:	Project Number:	
Address of Accident:		
County:	Zip Code:	
Was accident on company property: Yes <input type="checkbox"/> No <input type="checkbox"/>		
Date and Time of Injury:	Date Reported:	
What was Employee doing when injured? (Be specific – include tools, equipment, materials, or objects involved):		
How did the injury occur? (Describe the event that resulted in injury):		
Body Part injured and nature of injury (Be specific):		
Name of object or substance that directly injured the employee:		

MEDICAL		
First aid given by:		
Date of medical assistance:	Was accident fatal?	
Name of medical provider:		
Address of medical provider:		
Diagnosis:		
If hospitalized, name and address of hospital:		
EMPLOYEE'S SIGNATURE:	Date:	
PREPARER'S SIGNATURE:	Date:	
SUPERVISOR'S SIGNATURE:	Date:	
HEALTH & SAFETY SIGNATURE:	Date:	

INCIDENT AND INJURY REPORT

ACCIDENT INVESTIGATION AND FOLLOW-UP	
Provide additional information on what the employee was doing and how the injury occurred:	
Witness names (also addresses and phone numbers if not company personnel):	
What did the employee do or fail to do that caused or contributed to the accident?	
What caused or influenced the unsafe act?	
What condition of tools, equipment or the jobsite caused or contributed to the accident?	
What caused or influenced the unsafe condition?	
What action has been taken or is planned to prevent recurrence?	
Person(s) responsible for completion of the action:	
Target date:	Actual completion date:
Completed by:	

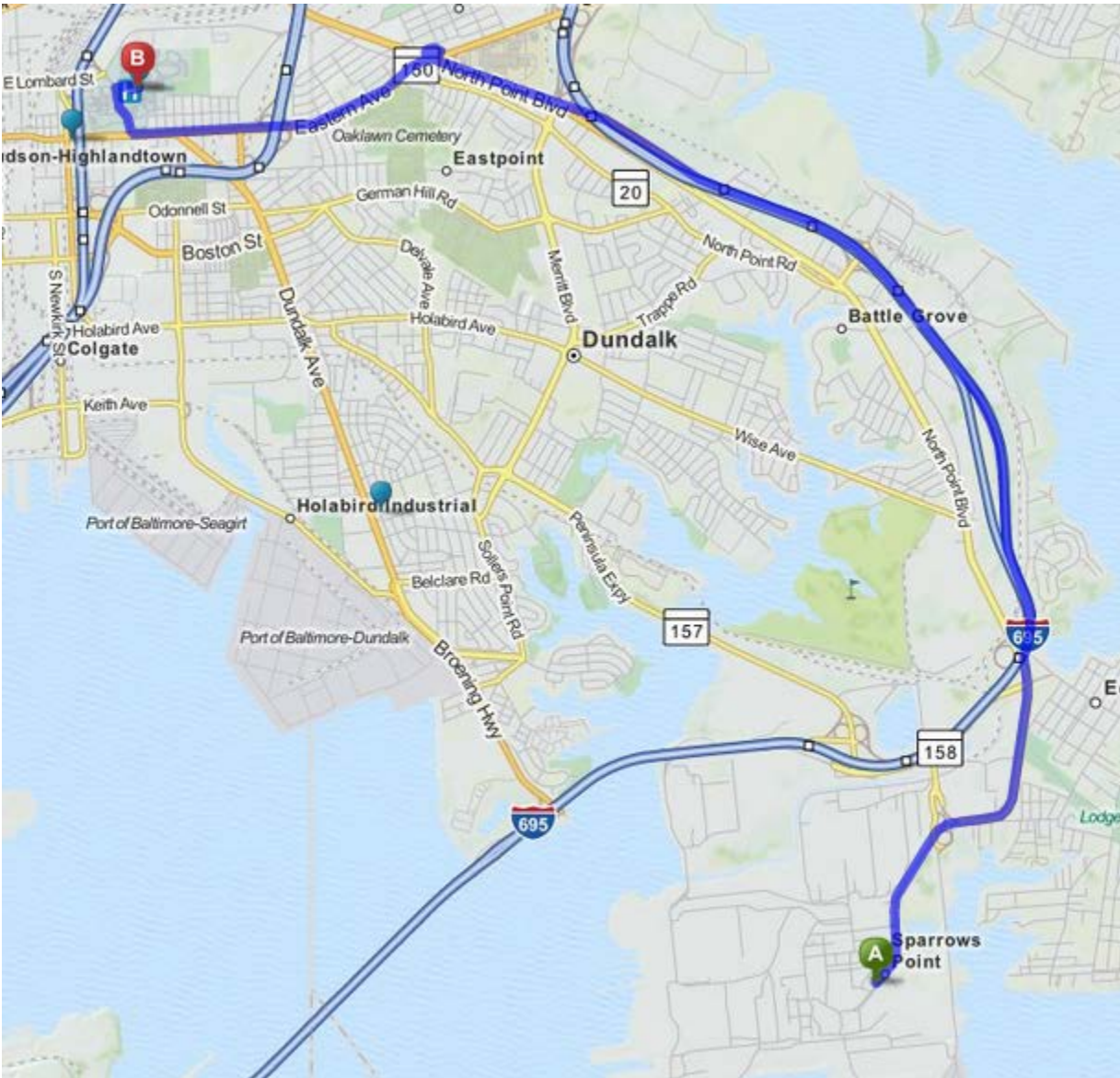
OFFICE USE ONLY	
Case Type: First Aid <input type="checkbox"/> Medical <input type="checkbox"/> Restricted <input type="checkbox"/> Days Away from Work <input type="checkbox"/>	
OSHA Recordable: Yes <input type="checkbox"/> No <input type="checkbox"/>	
Worker's Comp Claim Filed: Yes <input type="checkbox"/> No <input type="checkbox"/>	Date Filed:
Project Manager:	
Date lost work time began:	
Total days away from work:	
Date of restricted activity:	
Total restricted workdays:	
Date returned to full duty:	

APPENDIX C

**EMERGENCY CONTACTS AND
HOSPITAL ROUTE MAP**

EMERGENCY NUMBERS Sparrows Point Baltimore, Maryland	
Fire	911
Police	911
Ambulance	911
Hospital – Johns Hopkins Bayview Medical Center ER	(410) 550-0350 Emergency (410) 550-0100 General Information
Key Environmental Inc. Project Manager – Al Briggs	(412) 279-3363
National Response Center (spill, release reporting)	(800) 424-8802
DIRECTIONS TO EMERGENCY ROOM	
<p>Go Northeast on Sparrows Point Road toward Penwood Road – 1.2 miles Stay straight to go onto North Point Blvd./MD-151 N – 1.0 miles Merge onto I-695 N/Baltimore Beltway Outer Loop toward Beltway/Essex – 3.5 miles Take the MD151/N Point Blvd. North, Exit 40 toward MD-150/East Blvd. West/Baltimore, ½ mile Turn slight right onto North Point Blvd./MD-151 N – 1.3 miles Merge onto MD-150 N/Eastern Avenue – 1.9 miles Turn Right onto Bayview Blvd. – 0.3 miles Turn Right onto Nathan Shock Dr. – 0.1 miles Arrive at 4930 Eastern Avenue</p> <p>Total estimated distance is about 9.8 miles. Total estimated time is about 16 minutes.</p>	
UTILITY NUMBERS	
Houston One-Call Center	(800) 669-8344

HOSPITAL ROUTE MAP



Johns Hopkins Bayview Medical Center ER (410) 550-0350 Emergency,
4930 Eastern Avenue

Go Northeast on Sparrows Point Road toward Penwood Road – 1.2 miles
Stay straight to go onto North Point Blvd./MD-151 N – 1.0 miles
Merge onto I-695 N/Baltimore Beltway Outer Loop toward Beltway/Essex – 3.5 miles
Take the MD151/N Point Blvd. North, Exit 40 toward MD-150/East Blvd. West/Baltimore –
½ mile
Turn slight right onto North Point Blvd./MD-151 N – 1.3 miles
Merge onto MD-150 N/Eastern Avenue – 1.9 miles
Turn Right onto Bayview Blvd. – 0.3 miles
Turn Right onto Nathan Shock Dr. – 0.1 miles
Arrive at 4930 Eastern Avenue
Total estimated distance is about 9.8 miles. Total estimated time is about 16 minutes.

APPENDIX B
STANDARD OPERATING PROCEDURES

01 – PRE-INVESTIGATION WORK TASKS

1.0 SCOPE AND PURPOSE

Two tasks typically make up the pre-investigation work: background data review and a site reconnaissance visit. The objectives of these work tasks are to gain sufficient data to support:

- Development of a Work Plan
- Development of a Field Sampling and Analysis Plan (FSAP)
- Development of a project Health and Safety Plan (HASP)

The extent of required pre-investigation work is, to some extent, project-specific. For this reason, a pre-investigation work plan should be developed by the project manager that specifies the budget allowed for the work, the nature and extent of the information already known about the site, and additional information that must be obtained to complete the aforementioned objectives. The Standard Operating Procedures (SOPs) that follow identify the type of information that should be compiled during this phase of an investigation. Additional information that may be needed should be requested by the project manager on a project-specific basis.

1.1 Referenced SOPs

02- Utilities Clearance

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

Each field team member should bring the following items to a site visit:

- Field logbook
- Indelible ink pens
- Suitable field clothing
- Appropriate personal protective equipment

In addition, the field team leader should also bring

- Digital camera
- Tape measure
- Paper, colored pencils and other materials to prepare site drawings
- Contact names and phone numbers
- Any field screening equipment specified by the Health and Safety Officer or Project Manager

3.0 METHODOLOGIES

3.1 Background Data Review

This work may involve reviewing published and unpublished reports relevant to the site and conducting personal and telephone interviews with employees of the client; representatives of federal, state, and local government agencies; and others with specific information about the site. A list of information that should be acquired during this work task follows, and specific details about these topics are then discussed:

- Site location
- Potential constituents of concern
- Site topography and drainage
- Regional geology and hydrogeology
- Federal, state, and local regulatory programs that may affect the site work

Site Location

Site location information is necessary to facilitate many project tasks. The location should include a complete mailing address, a street address with zip code, the county name, latitude/longitude or township/range/section number, and directions to the site office from the nearest commercial airport, hospital, and major highways. This information will be necessary to complete the project HASP.

Potential Constituents of Concern

In order to fully and safely investigate a site, potential constituents of concern should be identified. It would not be sufficient to list only gasoline components as the possible contaminants for an investigation at a leaky underground gasoline tank if a solvent storage area, a wastewater lagoon, a large transformer, or a Superfund site is located nearby. Ask the client specifically if other contaminant sources may be present at the site. Provide the client with some examples (such as possible solvent spills or releases or activities of a former facility operator) so that the client is aware of the type of information we are seeking. If the client cannot be fully responsive (e.g., the client has only limited information about past activities at the site), ask if the client has other information, such as a site environmental audit, that may provide information about past activities at the site or if the client would object to our researching past activities at the site and in the surrounding area through other sources.

The state environmental regulatory agency or the U.S. Environmental Protection Agency (EPA) regional office may provide additional information about past activities at a site and in the area (contact with the state or the EPA should be preapproved by the project manager or the client). A formal request under the Freedom of Information Act (FOIA) may be required to obtain this information, but collection of project data through a FOIA should only be done with the permission of the client (because they may be in litigation or have other reasons to not bring attention to their site via a FOIA request). If a FOIA request is necessary, the client's environmental or compliance departments should be consulted for advice in preparation of this request.

From the information collected, prepare a list of potential constituents and indicate the probability of the contaminant being present. The following descriptions should be used in assigning the probability:

- Probable - Major contaminants of concern (e.g., gasoline components at a gasoline underground storage tank [UST]);
- Likely - Other contaminants known to be present in the area (e.g., lead; soils known to be contaminated with lead-based paint in the area); or
- Possible - Contaminants related to the past or present activities of the site (e.g., low pH and metals; former site operator had a spent acid waste pit upgradient of the site).

Site Topography and Drainage

These characteristics will provide initial indications of the direction and velocity of ground water flow, potential site access problems, and may identify wetland areas. The U.S. Department of the Interior, Geological Survey (USGS) topographic quadrangle maps (7 1/2-minute series) are readily available and generally provide sufficient topographic detail at this stage of the investigation. These maps can be obtained online from the USGS

Recent aerial photographs of sites are typically available from Google Earth, as well as local planning departments and/or state environmental agencies. Aerial photographs are useful for evaluating current site conditions and for planning field activities. Historical aerial photographs available through the USGS or commercial vendors may be used to provide information on past practices and changes in land use on the site.

Regional Geology and Hydrogeology

Regional geologic and hydrogeologic information is generally available from the state or USGS. These data are necessary to identify the type and depth of subsurface materials, likely depth to ground water, and aquifer characteristics that may be encountered at a site. Reports are usually available online, and are paid for using a credit card. Out-of-print documents may be located at agency or university libraries, and may be available via institutional interlibrary loans or a visit (if local).

Federal, State, and Local Regulatory Programs

A list of the regulatory programs that may affect the site work should be compiled. It is important not to overlook programs that may be administered by local agencies while compiling this list. It is possible that cities and counties may have permit requirements for well construction, and local building codes may have a bearing on the project. At a minimum, the agencies involved and particular requirements should be documented for the following:

- Well construction standards, permits, and registration
- Solid waste and wastewater disposal
- Notification and reporting requirements
- Floodways, floodplains, and wetland issues
- Project-specific (e.g., UST or Resource Conservation and Recovery Act) program administration.

The jurisdictional responsibilities of the following agencies may be of concern to a specific project:

- Federal Agencies
 - EPA
 - U.S. Army Corps of Engineers
 - Nuclear Regulatory Commission

- State Agencies
 - Environmental
 - Health
 - Water resources
 - Fire marshal

- Local (city, county)
 - Health
 - Planning and/or zoning
 - Building codes

3.2 Site Reconnaissance Visit

In projects where field sampling will be performed, a site reconnaissance visit is generally required. The purpose of the visit is to collect information necessary to support development of the FSAP. In particular, the site reconnaissance should determine if there are site-specific conditions that could affect field activities (e.g., topographic or man-made features that could limit certain activities or the use of certain equipment). Information collected during the site reconnaissance will also support development of safety instructions to be followed by field personnel or the development of a Health and Safety Plan. Such information includes the location of nearby essential facilities such as hospitals or fire/ambulance stations.

The FSAP usually represents a large commitment of both personnel and equipment resources to a job and its success is dependent on the information collected during the site reconnaissance visit. For out-of-town projects, this visit may be the only opportunity you have to collect all the necessary information. Consequently, the visit must be well planned and the information collected complete. The following is a list of items that should be addressed in the site visit:

- Obtain Site map
- A list of the information to be collected

- A list of the people to speak with

The plan for the site reconnaissance should be reviewed by and approved by the project manager to assure that all necessary information is collected. The visit should be scheduled to allow enough time to complete all of your work at the site. Travel arrangements should be made with enough flexibility that additional time can be spent at the site if necessary.

Site Map

Ask the client for a copy of a site map, if one is available. This should be obtained before the visit is scheduled so that the map may be modified if necessary. The map should be reduced to a page-size format (either 8 1/2 by 11 inches or 11 by 17 inches) making it convenient to work with on a clipboard in the field. Take several copies of the site map with you so that all of the information does not have to be put on one copy of the map.

Take equipment with you to draw maps in the field if a site map is not available or if details need to be drawn at a larger scale than the site map. To help keep the field map legible and drawn to scale, have graph paper, colored pencils, and an engineering scale available. Additionally, take a measuring wheel or measuring tape with you or be able to accurately estimate distance with a range finder or by pacing. If site photographs can be taken (obtain permission from the client's project manager), document the site map with photographs wherever applicable. Include in each photograph a building or other prominent structure to help orient the photograph and provide scale. The date, time, location and direction of each photograph should be plotted on a copy of the site map and noted in the field logbook.

Information to be Collected

The following information should be collected during the site visit, other information may be required by the project manager on a project-specific basis:

- **Site Access** – Obtain keys or combinations to locked gates. Determine if access to the site will be adequate for the type of field sampling equipment that may be required. Determine if the roads and/or grounds can be traversed by the equipment and if weather, season, or time of day will make the site inaccessible. Check for overhead obstructions along access routes. Show on the site map all fencing, access routes, entrances, exits, and obstructions, including overhead obstructions or berms.
- **Traffic Patterns** – If fieldwork will be conducted in an area where traffic may pose a hazard, observe ingress/egress routes, roads and shoulders, parking lots, flight lines, etc during the site reconnaissance. If these are issues at the site, they must be addressed in the site-specific planning documents.

- **Facility Regulations** - Verify facility safety rules, working hours, and security rules and procedures. Locate on the site map any areas where personal protective equipment is required and any areas requiring security clearance.
- **Permits** – The site visit should be used to determine which, if any, permits are required for proposed field activities, particularly when the activities will be conducted off site.
- **Utilities** - The responsibility for locating all underground and overhead utilities should be the client's. This, however, does not obviate the need for Key Environmental, Inc. (KEY) to assure that utilities have been fully identified and to avoid those areas where it is difficult or impossible to adequately locate underground utilities. Locating utilities is discussed in detail in *SOP 02 – Utilities Clearance*.
- **Structures and Tanks** – During the site reconnaissance, field check the site map against actual site conditions. Note the current configuration if buildings have been added or removed, or if only foundations remain. Note the locations and capacities/contents of all aboveground storage tanks, and surface manifestations of underground tanks such as fill or dispensing portals.
- **Facility Operations** - To the extent possible, identify past and present practices at the facility that may have impacted the environment. Locate the following on the site map: any past or present disposal sites on the property; past and present storage areas for both chemical feed stocks and wastes; known spills, leaks, or other releases of chemical supplies or wastes at the facility in the past; or fires that may have caused a release.
- **Surface Conditions** – During the site visit, note the presence of stained soil, stressed vegetation or other conditions that may indicate a release. Take note also of the presence and flow direction of surface water bodies that could receive non-point source discharges from the property. Look for stormwater outlets in adjacent surface waters.
- **Adjacent Land Use** – Upon entering or leaving the property, observations of adjacent land use should be noted on the site map. Include residential areas, schools or daycare facilities as these may represent sensitive receptors. Also note if there are industrial or commercial facilities nearby, and the types of operations conducted on these properties. For example, it may be useful to managers to know if there are operations such as oil recyclers or dry cleaners nearby that could also be sources of constituents of interest. Company names, addresses, or other information gleaned from a drive-by should be noted.
- **Subcontractor Interviews** - Three types of subcontractors are typically used on site characterization field projects: analytical laboratories; drilling contractors; and surveyors. In order to have a listing of possible subcontractors in an area, acquire a copy of the local telephone directory yellow pages (your motel may allow you to take the copy from your room).

There is little advantage to interviewing prospective surveyors face-to-face rather than over the telephone. This task should not be part of the site visit, unless it is important to inspect their equipment and facilities. When considering a potential drilling contractor, however, a meeting may be the best way to judge if their equipment will meet the special requirements for your job. If this is an important consideration, make arrangements with the prospective contractor to meet with him at his office or at another job site if the equipment is in use.

List of People to Speak With

Prepare a list of the people you intend to speak with regarding the information listed above. Verify that the people with whom you need to speak will be available during your visit. If several key people will not be available, find appropriate alternates or reschedule your visit. Work with the facility contact to establish an interview schedule. Leave some space in your schedule to catch up if your interviews run longer than planned and to complete your interview notes while the information is fresh in your mind.

Prepare an interview questionnaire form for your use during each of the interviews. Consult with the project manager in the development of the questionnaire. The form will help to assure that all of the questions you intend to ask get answered and to keep your interview focused. Allow some flexibility, however, as your interviews may have to be altered as new information is gained. Be sure your form has sufficient space to include the entire answer to your questions.

4.0 QUALITY ASSURANCE AND QUALITY CONTROL

(Reserved)

5.0 DOCUMENTATION AND RECORD KEEPING

The report of the pre-investigation work tasks is typically an informal report given to the project manager for in-house use only. It should contain all the necessary data to develop the Work Plan, FSAP, and HASP. A summary of the information gained during the background data review should be provided, with the full citation to any published documents used. The names and telephone numbers should be provided of persons that proved helpful in acquiring background data. The report should include notes from all telephone and personal interviews. These notes should provide: the full name and telephone number of the person interviewed, the date and time of the interview, and a summary of the interview findings. Include all site maps in the report. The maps should clearly show all site access information, areas of known or potential contamination, and information regarding underground utilities. Include in the report a listing of potential subcontractors and any information regarding KEY's past experience with them and any other qualifying information.

6.0 REFERENCES

(Reserved)

02 – UTILITIES CLEARANCE

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) presents procedures for locating utilities, particularly underground utilities, prior to conducting intrusive field work. Information regarding the location of underground and overhead utilities may be obtained from the client or site owner in some instances. This, however, does not eliminate the need by Key Environmental, Inc. (KEY) to assure that utilities have been fully identified and to avoid those areas (where possible) where it is difficult or impossible to adequately locate underground utilities. If available information does not conclusively determine the presence/absence of utilities in a particular area, alternative measures (*i.e.*, metal detectors, magnetometers or hand excavation) may be employed.

Damage to gas and electric lines could result in loss of life or serious personal injuries. Damage to utilities may also result in loss of service to factories and home owners and potentially result in lawsuits filed by affected parties. The purpose of this section is to provide a procedure for KEY employees to follow in order to identify, locate, and avoid utility lines. This procedure does not, however, cover every possibility in terms of identifying utilities. The field crew must always be alert to the possibility of buried or overhead utilities whether known to be present in the area or not, as well as utilities embedded in walls, floors, or ceilings if working indoors. Thus, a visual inspection of the area must be conducted to identify any indication of the possible presence of utilities (*i.e.*, fire hydrants, meters, repaired pavement, disturbed soils, markers, *etc.*)

The location and identification of utilities is applicable to all sites, particularly when subsurface exploration is carried out.

1.1 Referenced SOPs

03 – Field Logbook

1.2 Definitions

One-Call System: A communication system established by utilities, governmental agencies, or other operators of underground utilities to provide a single telephone access number for excavating contractors and the general public to notify utilities of their intent to use equipment for excavating, tunneling, demolition, or any other similar work that could affect underground utilities. This system may go by other names (*e.g.*, “Miss Dig,” “Miss Utility,” or “Dig Safe”).

2.0 REQUIRED MATERIALS

The following equipment is required to document the utility clearance activities:

- Field logbook, with all contact information (names, organization, phone number);
- Utility clearance checklist forms; and
- Indelible ink pens.

3.0 METHODOLOGIES

No subsurface work should be performed until the presence or absence of all possible utilities has been verified. In some cases, it will not be possible to map the exact location of all known utilities on the site, but it should be possible to define those general areas where utilities are known to be present and those areas believed to be free of underground utilities.

If KEY is required to locate buried utilities, the utility representatives should be called and an on-site meeting will be required. At no time should KEY employees use equipment to locate utilities on their own. Often the most convenient initial step in locating buried utilities in an area is to contact the appropriate one-call telephone number. The one-call markings are only considered good for two weeks. For projects of longer durations, the one-call contact may need to be repeated periodically. After making the one-call, a reference or I.D. number will need to be recorded in the field notes.

All communications with utility companies should be documented in writing. When meeting in the field, include in the field notes and/or forms the name of the utility representative, the date and time of the meeting, a summary of the discussions, and a sketch of where utilities are located. A map of the utility locations should be made in the field notes since the physical marks (paint or flags) left by the utility representative may not survive to the completion of the investigation. Many times the utility will have area maps that show the location of their lines. Copies of these maps, if available, could be filed with the project notes. Ask the utilities' representatives to sign the summary in the field notes (they may not be willing to do this).

The KEY representative should ensure that the utility representative physically marks the utility locations. They should be identified for the entire area or as much as is feasible since it is difficult or impossible to know at the beginning of a study how extensive the investigation may be. It may also be important to know where utility lines may cross potential contaminant source area(s) as utility trenches may provide migration pathways. If discrepancies exist between utility locator's information and obvious signs of buried utilities or other location information (e.g., utility maps), then work should not proceed at that location until the discrepancies have been resolved.

The KEY field supervisor should coordinate with the project manager and facility personnel to compile a list of all possible underground utilities. The following list of possible underground utilities should be used as a reference list; it is not, however, inclusive of all possible buried utilities:

Public Utilities	How to Locate ⁽¹⁾
Natural gas and petroleum pipelines	1
Water mains	1
Natural gas	1 and 2
Electrical power	1 and 2
Telephone	1 and 2
Cable television	1 and 2
Sanitary sewers	3

Storm sewers	3
Traffic control signals	4

Private or Facility Utilities

Natural gas	5, 6, 7, and 8
Electrical power	5, 6, 7, and 8
Telephone	5, 6, 7, and 8
Sanitary sewer	5, 6, 7, and 8
Process waste tanks and effluent pipes (National Pollutant Discharge Elimination System discharges)	5, 6, 7, and 8
Septic system drain fields	5, 6, 7, and 8
Storm sewers and rain gutters	5, 6, 7, and 8
Liquid feed stock tanks and distribution lines	5, 6, 7, and 8
Liquid fuel tanks and distribution lines	5, 6, 7, and 8
Cooling water	5, 6, 7, and 8

1. Call the pipeline or utility company for location information.
2. Call one-call or similar service.
3. Check utility maps at the city engineer's office (request field verification).
4. Check maps or other guidance with the city traffic engineer.
5. Use professional locator service.
6. Check with facility engineering department.
7. Identify where utility enters and exits property with the public utility.
8. Check with private contractors that have or are currently working for the facility.

The above methods of locating utilities should not be substituted for field observation and good judgment. Prior to initiating an excavation or boring, an inspection of the excavation/drilling zone may provide additional indications about the location of nearby underground utilities. Depressions or mounds on the ground surface, new paving patches, manholes, meters, valves, fill lines, vents, power line drops from power poles, sewer clean cuts, catch basins, outfalls, utility connections into nearby structures, areas with linear patches of cleared vegetation, and old utility markup points, such as spray painted lines on curbs and roadways, all may be indications of the presence of utilities. If questions remain regarding the presence of utilities in a work area, contracting a company that specializes in underground utility locating should be considered.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

(Reserved)

5.0 DOCUMENTATION AND RECORD KEEPING

An accurate record of all people and organizations contacted during a site utilities search should be recorded in a field logbook (see *SOP 03 – Field Logbook*) and/or Attachment 1 of this SOP. A brief summary of any phone, or face to face conversations, should be recorded. Utilities identified should be sketched or mapped. Field observations (indications) that infer the presence of utilities should be described in the field logbook.

6.0 REFERENCES

(Reserved)

**ATTACHMENT 1
 SOP 02 – UTILITIES CLEARANCE
 UTILITY NOTIFICATION COMPLETION CHECKLIST**

UTILITY NOTIFICATION COMPLETION CHECKLIST	
Notification Service (name): _____ Phone Number: _____	To Be Provided by Utility Notification Operator Assigned Serial Number: _____ Clearance Date and Time: _____
KEY Project Number: _____ Project Name: _____ Project Location: _____	
Time and Date of Notification: _____ Caller's Name: _____	
<p><u>Contractor Information</u></p> Contractor Name: KEY Environmental, Inc. (address) 200 Third Avenue (address) _____ (address) Carnegie, PA 15106 Contact Person: _____ Contractor Phone Number: (412) 279 - 3363 Contractor FAX Number: (412) 279 - 4332	
<p><u>Notification Type</u></p> <input type="checkbox"/> Construction (requires no less than 3 and no more than 10 working days) Dig Date: _____ Time: _____ Depth of excavation: _____ Diameter of drilling: _____ <input type="checkbox"/> Design (requires no less than 10 and no more than 90 working days)	

Site Information:

County: _____

Municipality: (boro, township, etc.): _____

Street Address: _____

Nearest Intersection: _____

Site location relative to intersection
(distance and orientation): _____

Description of Site Location: _____

Working In: Sidewalk

Public Property

Private Property

Other (specify) _____

Property Owner: _____

Property Owner Contact: _____

Phone Number: _____

Additional Remarks: _____

Utilities to be notified: _____

Notes: _____

03 - FIELD LOGBOOK

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) establishes the requirements of the entry of information into logbooks to ensure that KEY field activities are properly documented. Field logbooks are the primary source of documentation for site activities, and serve as legal record of all occurrences during those activities. The project manager and the field team leader are responsible for ensuring the logbook entries provide sufficient information for the completion of an accurate and detailed description of field operations.

Complete and accurate logbook entries are essential to

- Ensure that data collection associated with field activities is sufficient to support the successful completion of the project
- Provide sufficient information that someone not affiliated with the project can independently reconstruct the field activities at a later date
- Maintain quality control throughout the project
- Document changes to or deviations from the Work Plan
- Fulfill administrative needs of a project
- Support potential legal proceedings associated with a specific project

1.1 Referenced SOPs

None

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

The required materials for maintaining a field log book include a water-resistant, permanently bound notebook (such as *Rite in the Rain ALL-WEATHER ENVIRONMENTAL No. 550F* notebook (or equivalent) and a pen with permanent ink.

3.0 METHODOLOGIES

Pertinent information regarding the site and work procedures must be documented. Information recorded in the notebook should be noted with the date and time of entry. Each field crew shall maintain a single logbook. Legibility must be maintained. The following items are commonly included as logbook entries:

- Name and location of site
- Date and time of arrival and departure
- Name and affiliation of person keeping log
- Names and affiliations of project personnel present on site
- Sampling event description; including methodology, sample numbers and volumes, description of samples, date and time of sample collection, and name of collector
- Prevailing weather conditions and weather delays
- Technical measurements and readings, with notation of anomalous measurements
- Record of phone calls/and or contact with individuals at the site
- Record of approval of field changes to the scope of work
- Diagrams and sketches as needed to document sample locations
- Physical obstructions encountered during field activities
- Reference to global positioning system data collected, if applicable
- Description of equipment used
- Equipment problems encountered and resolution of such problems
- Management or disposal of investigation-derived wastes
- List and descriptions of photographs including camera used, photographer's name, and the direction or view angle of the photograph
- Equipment calibration information

Information should be recorded in permanent ink for the legal record. The company name, address, and phone number should be entered at the beginning of the log book. The title page should also include the start/finish dates for the activity, and whether more than one logbook is included in the record (e.g., Book __ of __). The pages of the logbook should be numbered for ease of reference. Blank spaces should be crossed out and initialed. No pages may be removed from the logbook for any reason.

All notes should be written at the time of observation. If this is not possible, the logbook should indicate when the observations were recorded and the reason for the delay. Changes or deletions should be crossed out with a single line and initialed by the individual making the change.

At the end of each field day, the project scientist/engineer or designee should sign and date each page of the notebook on which entries were made to verify the day's activities. Unused lines at the end of each day's work shall be marked with a diagonal line, signed and dated. The field team leader (or designee) must also sign and date the final daily entry page of each field crew member maintaining a separate logbook. Each day's work shall be recorded starting on a new page, with the date, time, weather conditions, and team members present.

On at least a weekly basis, completed pages must be copied to the project files on the office served so that the loss or accidental destruction of the logbook will result in a minimal loss of data. Copies shall be reviewed to ensure that they are legible.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

At the end of each day of field activities, the individual or individuals maintaining the field logbook should review the notes for accuracy and completeness. Corrections, deletions, or additions should be stricken, initialed and dated.

5.0 DOCUMENTATION AND RECORD KEEPING

The first page of all field logbooks must contain the holder's name and contact information.

It is recommended that a running activity log be maintained, indicating the times of activities and observations; recorded data be written in the form of tables with an appropriate title; and that diagrams be included to illustrate pertinent information. Logbooks should be labeled with the project name, project number, and a consecutive number for cataloging purposes.

Copies made for the project file will become the primary record of the job activities. The filled logbook remains a working copy until project completion, at which time the logbook is physically stored in the project files.

6.0 REFERENCES

Environmental Research Center, University of Nevada - Las Vegas, March 1989, Soil Sampling Quality Assurance User's Guide: U.S. Environmental Protection Agency EPA/600/8-89/046, 260 p.

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U.S. EPA, 2005, Compliance-Focused Environmental Management System – Enforcement Agreement Guidance: National Enforcement Investigations Center, EPA-330/9-97-002R. http://www.epa.gov/oecaerth/resources/policies/neic/cfems_05.pdf.

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U.S. EPA, 1991, Guidance for Performing Site Inspections Under CERCLA: Office of Solid Waste and Emergency Response, OSWER 9345.1-05. <http://www.epa.gov/superfund/sites/npl/hrsres/>.

04 - MANAGEMENT OF INVESTIGATION-DERIVED WASTES

1.0 SCOPE AND PURPOSE

This standard operating procedure (SOP) presents general guidelines for the management of investigation-derived wastes (IDWs), such as, but not limited to the following:

- Drill cuttings generated during soil boring investigations or well installations
- Drilling fluids generated during soil boring investigations or well installations
- Groundwater generated during well development, monitoring well purging, aquifer testing (i.e., pumping tests), or remedial activities
- Water and sediment generated during equipment decontamination
- Used personal protective equipment
- Miscellaneous debris (e.g., well construction materials generated through abandonment of monitoring wells)

Due to the wide range of materials which may be generated and the variety of situations which may arise, it is likely that these SOPs will need to be supplemented with project-specific procedures. Where project-specific procedures are necessary, they should be developed to be consistent with the general guidelines presented below. Determination of the need for and scope of the development of project-specific procedures, will be determined as part of the initial project planning.

1.1 Referenced SOPs

None

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

Management of investigation-derived wastes requires limited equipment. The following should be available onsite:

- Clean, new 55-gallon drums with lids
- Grease pen or paint stick for labeling
- Labels indicating drum contents and origin

3.0 METHODOLOGIES

3.1 Containerization

Project-specific requirements for containerization of waste materials will be developed during initial project planning. If applicable, this information may be presented in a project-specific waste management plan. Project-specific containerization requirements should be developed to be consistent with the general guidelines provided below.

1. All potentially impacted materials generated during any investigation or remedial activity must be containerized unless one of the exceptions described below under Item 10 apply. Unless directed otherwise by the client, containers (drums, frac tanks, roll-off boxes, etc.) are to be provided by the consultant or contractor.
2. All potentially impacted materials shall be placed in new or reconditioned 55-gallon (DOT-UN1A2) drums. All drums brought onsite must be clean and in sound condition, free of any rust, dents, holes, or other types of damage.
3. Various types of waste materials (e.g., soils, groundwater, PPE, etc.) must be containerized separately without exception. Additionally, dry and wet soils should be containerized separately, if feasible.
4. Materials generated from various plant process areas, which may require potentially different waste classifications, should be containerized separately. As an example, soils generated in the vicinity of a surface impoundment which managed sludge from the treatment of wastewater from wood treating operations that use creosote and/or pentachlorophenol (EPA Hazardous Waste K001) should be containerized separately from soils generated in a creosote drip track area (EPA Hazardous Waste F034). Likewise, materials generated at off-site locations should be managed separately from those generated on-site.
5. If possible, drums should be filled to approximately 90% capacity. As necessary, drums containing liquids should have enough freeboard to prevent rupture in the event of freezing.
6. Containers inside of containers are not permitted by waste management regulations. As a result, PPE must be placed directly into the drum. **Do not place PPE in a plastic bag and in turn place the plastic bag into a drum.** This constitutes a violation of waste management regulations. Similarly, all soil samples must be removed from jars or plastic bags and the jars crushed or plastic bags torn prior to being placed in a drum.
7. All lids and gaskets must be securely fastened prior to moving from one location to another. The consultant or subcontractor is responsible for transporting containers to an on-site temporary staging area as directed by the Facility Waste Management Director. Containers must be loaded, transported and unloaded in a safe manner.

8. The exterior of all containers must be thoroughly cleaned prior to staging. All mud, dirt or debris must be removed, with no exception. Waste management facilities will not accept containers which are visibly dirty on the outside.
9. Under no circumstances shall non-waste materials or general trash be placed in waste containers. The consultant/subcontractor should provide a dumpster for management of non-waste materials and general trash.
10. Under certain circumstances, the following exceptions to the above requirements may be made if provided by regulations and state/federal concurrence:
 - Some regulatory agencies may allow for all or a portion of generated materials (i.e., auger cuttings, drilling fluids) to be placed back into or onto the ground from which they were generated. The consultant is responsible for identifying these requirements.
 - If an operating water treatment facility exists on-site, groundwater and/or decontamination liquids may be managed into the treatment system if the discharge permit for the treatment facility provides for management of those liquids, and the liquids do not contain materials (e.g., solids or oils) which could potentially effect the operation of the system in an adverse manner. In this instance, consideration must be given to the classification and management of waste materials generated through the treatment of the liquid (e.g., spent activated carbon, filtered soils, etc.)

3.2 Container Designation and Labeling

Project-specific requirements for container identification and labeling will be developed during initial project planning. If applicable, this information may be presented in a project-specific waste management plan. Project-specific container designation and labeling requirements should be developed to be consistent with the general guidelines provided below.

1. Each container will be assigned a unique designation. This designation should include a sequential number associated with each waste type, a code which identifies the type of waste (e.g., “S” for soil, “GW” for groundwater, etc.), and the date the material was placed in the container (e.g. 1-GW-12/12/98; 2-GW-12/12/98 etc...). The container designation must be clearly marked on the lid and the side of the container prior to transport to the temporary on-site staging area. The markings must be made in a manner such that the markings are legible, highly visible and permanent (i.e., weather resistant). A “Mean Streak[®]” grease pen or a paint stick is recommended for marking the container.
2. A “Non-Hazardous Waste” label shall initially be affixed to the exterior side of the drum at a location at least two-thirds of the way up from the bottom of the container. Under the optional information section on the label, the following statement may be included “Material Classification Pending Results of Analysis”.

3. The following information is to be recorded by field personnel in the field logbook, as appropriate.
 - Container Designation
 - Contents (e.g., soil, groundwater, PPE)
 - Date that the container was filled
 - Location where the drums are staged
 - Location, and plant process area, where the material was generated (e.g., soil boring number, monitoring well designation)
 - Relative moisture content (e.g., dry, moist, damp, wet, saturated) for soils only, for the purpose of managing the materials for disposal, damp or moist soil are considered “liquid”
 - Approximate volume or percentage of the container filled

3.3 Container Storage

Project-specific container storage requirements will be developed during the initial planning phase. If applicable, this information may be presented in a project-specific waste management plan. Project-specific container storage requirements should be developed to be consistent with the general guidelines provided below.

1. If the investigative or remedial work is conducted at active or inactive sites owned formerly by the consultant’s client, plans for container storage must be developed in conjunction with the current property owner.
2. If containers are to be transported to an on-site staging area, all container handling and moving must be conducted in a safe manner. Contractors are responsible for providing the necessary equipment (e.g., front-end loader, fork lift with drum grappler, etc.) to provide for safe and efficient staging of containers.
3. All containers shall be stored in a neat and organized fashion with all labels clearly visible. Containers shall not be stacked.
4. Containers holding materials of different waste classifications should be staged together to facilitate loading of the materials onto transport vehicles.
5. To the extent practicable, all containers should be protected from the elements.
6. If stored outdoors in an area where precipitation could accumulate, all containers must be placed on pallets.
7. In accordance with DOT requirements, all containers must be rust-free and in sound condition for shipment.
8. Prior to demobilization, field personnel should conduct an inspection of the container storage area to ensure all containers are clearly marked, clean and staged in a neat and organized manner.

3.4 Waste Material Inventory

KEY personnel are responsible for completing an inventory of waste materials stored at the project site. The inventory should be completed and entered into the central computer file at

KEY's main headquarters in Carnegie, Pennsylvania as soon as possible following field demobilization. The central file is located on the data server by site name in the general directory - Dataserver-P:\projects\IDW\Year\SiteName.exe. The inventory will include a tabular summary of all containers stored at the project site and their respective contents. An example is provided as Attachment 1. Information should be entered into a tabular summary located by site name in the central file under the following headings:

- **Related Activity of Waste Generation** (e.g., RFI, Pilot Study, Interim Measures, etc.)
- **Type of Container** (e.g., drum, roll-off box etc.)
- **Container Designation** (the unique label affixed to the drum)
- **Container Contents** (e.g., soil, groundwater, PPE)
- **Generation Date** (date that the container was filled)
- **Staged Location** (location where the drums are staged pending removal)
- **Location and Plant Process Area Where Waste Was Generated** (e.g., former Process Area, Former Drip Track Area, etc.)
- **Relative Moisture Content** (e.g., dry, moist, damp, wet, saturated) for soils only. For the purposes of managing these materials, damp or moist soils are considered wet.
- **Volume or Percentage Contained (gallons)** (volume or percentage of drum filled - not to exceed 90 percent)
- **Comments** (other pertinent information, as appropriate)
- **Date Removed** (the date the drums are removed from the site for disposal)

3.5 Waste Material Sampling and Analysis

Composite samples of the containerized materials for laboratory analysis may be collected for each IDW media. The results of the analysis may be used for waste profiling purposes required by the waste management facility and/or waste classification purposes. Project-specific requirements for waste sampling and analysis will be developed during initial project planning. If applicable, this information may be presented in a project-specific waste management plan. Project-specific waste material sampling and analysis requirements should be developed to be consistent with the standard procedures provided below. To the extent practicable, historical information, site-specific analytical data and knowledge of the waste composition should be utilized to minimize sampling and analysis requirements.

1. Specific details regarding the number and types of samples to be collected, required laboratory turn-around time, analytical parameters and analytical methods will be determined on a project-specific basis during the initial planning phase. If applicable, this information may be presented in a project-specific waste management plan.
2. At a minimum, samples must be collected and handled in accordance with standard industry protocols. If an approved project-specific Sampling and Analysis Plan or Quality Assurance Project Plan exists, then sample collection and handling procedures, as specified therein, must be followed.

3. All analyses must be performed using the appropriate analytical methods specified in EPA SW846 "Test Methods for the Evaluation of Solid Wastes".
4. The sampler must complete and maintain copies of all chain-of-custody documentation.
5. In accordance with Subpart CC or 40CFR Par 264/265 which became effective on December 6, 1996, hazardous wastes containing greater than 500 parts per million by weight total volatile organic compounds (VOCs), are subject to the emission control requirements of this rule. Determination of VOC content may be made through laboratory analyses or generator knowledge. Thus, analysis for VOCs will likely be required by the waste disposal facility for profiling purposes in the future. Analysis is to be performed using method 25D in 40CFR Part 60 Appendix A, or through the use of an approved alternate method. Knowledge-based waste determinations must be thoroughly documented.
6. Composite samples of similar waste classification of containerized materials will be profiled based on the characteristics presented in 40 CFR Part 261 Subpart C - Characteristics of Hazardous Wastes:
 - §261.21 - Characteristic of Ignitability
 - §261.22 - Characteristic of Corrosivity
 - §261.23 - Characteristic of Reactivity
 - §261.24 - Toxicity Characteristic

3.6 Transportation and Disposal

Transportation, disposal, and manifesting of IDW are generally the responsibility of the owner. However, on occasion, KEY may assume responsibility for this task upon client request.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

(Reserved)


5.0 DOCUMENTATION AND RECORD KEEPING

All field notes, waste inventories, and disposal manifests are to be kept as part of the permanent project records.

6.0 REFERENCES

(Reserved)

ATTACHMENT 1
SOP 04 – MANAGEMENT OF INVESTIGATION-DERIVED WASTES
IDW INVENTORY LOGSHEET

		IDW INVENTORY LOG		
Project Name:		Date:		
Location:		Project Number:		
Container Identification Number	Type of IDW (SW, GW, NAPL, PPE, Other)	Date Filled	Comment / Label Description	Staging Location

05 - GIS ELECTRONIC DATA DELIVERABLES

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) specifies the formatting requirements for the submission of electronic laboratory analytical data.

Attachment 1 presents the file layout structure for the "Labdata.dbf" file as utilized by GIS/Key's™ Winbuild module. The file may be submitted as a dBase (.dbf), text (.txt), or Excel (.xls) file.

Files should be submitted initially via e-mail, with a CD of the deliverable mailed to Key Environmental, Inc.'s Pittsburgh office.

If laboratory personnel have any questions regarding this format, they should direct their inquiries to Key Environmental, Inc.'s GIS coordinator. A template of the labdata.dbf format is available upon request from Key Environmental, Inc.

1.1 Referenced SOPs

None

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

All work is to be conducted using KEY's network.

3.0 METHODOLOGIES

(Reserved)

4.0 QUALITY ASSURANCE/QUALITY CONTROL

When the data are received, the complete files are reviewed, including the results of the quality control samples and field duplicates. This step ensures that the data meet the project specifications with respect to accuracy and completeness.

5.0 DOCUMENTATION AND RECORD KEEPING

All data are retained in electronic format and in hard copy. Original data CDs are kept in the file to support any regulatory questions about the original data. Data are formatted into tables per the project manager's specific requirements, e.g., organized by chemical, medium, date, or other criteria to support discussion of the nature and extent of impacts or the development of risk assessments, remedial actions, etc. Comparison to remedial action or regulatory requirements can also be performed by the data manager or project personnel.

6.0 REFERENCES

(Reserved)

ATTACHMENT 1
SOP 05 – GIS ELECTRONIC DATA DELIVERABLES
FILE LAYOUT

Remark	Required	Justify	Field Name 10 Character	Type	Len	Dec	Notes (Default parameters)
user	X *	L	SITE_ID	C	15		Well or sampling location as labeled on the GIS\Key Map. An entry in SITE_ID is required for all Primary results, duplicates, and splits. Spike results may be associated with samples from another location, and therefore SITE_ID is not required although recommended if appropriate. The import routine requires all sites to be in the project database.
user	X *	L	SP_ID	C	7		Sample Period (EVENT_ID) is used to group QA/QC data to within the data range of the sample period. An entry in the EVENT_ID field is required for Blanks, Control Samples and Spikes. The import routine requires the EVENT_ID to be defined in the project database.
lab	X		SAMP_TYPE	C	1		Sample types are <W>ater, <S>oil, Sediment, Solid. Others sample types can be added, but these are not supported by GIS\Key. The import routine requires < W, S> entry.
lab	X	L	RES_CODE	C	4		Preliminary code used to determine the type of chemical result. See notes at end of table for details of valid entries. RES_CODE is used by the GIS/Build routine to derive the GIS\Key RES_TYPE and RES_CLASS fields. Initially assigned by the lab and modified as required by the user to reflect sample status not known by the lab.
GIS	internal		RES_CLASS	C	1		Assigned by GIS/Build from the RES_CODE field, this code refers to the type of result received from the lab. Allowable RES_CLASS entries are <P>rimary/duplicate/split <C>ontrol sample lank sample and <S>pike sample.
GIS	internal	L	RES_TYPE	C	3		Assigned by GIS/Build from the RES_CODE field, this code works in conjunction with RES_CLASS to describe the type of result. It consists of a one character code, a test sequence number, and a result occurrence.
lab			RES_COLUMN	C	1		The column number of a multiple column test. RES_COLUMN should = 0 for the result set of record of a record. This corresponds to a RES_CODE result set occurrence = 0 for the result set of record. For other result sets, the column number of the test should be given. Used primarily for IRPIMS reporting.
lab	X*	L	RES_ORIG	C	3		Points to the originating result of a result set of record in a multiple column or dilution test. A result set of the record may be a combination of one or more column/dilution tests. The RES_ORIG points to the result in the test run from which the result of the record came and should equal the last 3 characters of the RES_CODE for that result. Used primarily for IRPIMS reporting.
lab	X*		SURROG_FLG	L	1		The field is set to AT@ for a surrogate result and AF@ for all other result types.
user	X	L	SAMP_ID	C	15		SAMP_ID is the unique identifier provided to the laboratory on the sample bottle.

Remark	Required	Justify	Field Name 10 Character	Type	Len	Dec	Notes (Default parameters)
user		L	SAMP_ID2	C	15		SAMP_ID2 is used ONLY for Field Spike Duplicates or for Blind Control Sample Duplicates.
user	X *		SAMP_DATE	D	8		Date sample was collected (mm/dd/yy format). Required for all results except blanks, spikes and control samples.
lab/user	X *		SAMP_TIME	C	5		Time sample was collected (##:## 24hr format). Required for all primary, duplicate, split and surrogate results but not required for blank, spike, and control sample results. If not required and not specified, the import routine enters a default of 00:00.
user	X *		SAMP_DEPTH	N	8		Depth below ground surface in meters (metric) or feet (American) at which sample was collected. Required for SAMP_TYPE = <S>, Recommended for SAMP_TYPE = <W>. Depths above ground surface are assigned a negative number. Note that primary key in American version is based on depth measurements to a hundredth of a foot only.
user			S_DEPTH	N	8	3	Depth below ground surface in feet to the top of the sample interval range.
user			E_DEPTH	N	8	3	Depth below ground surface in feet to the bottom of the sample interval range.
user	X *	L	CASE_ID	C	5		Case and blank Ids or case and QA/QC IDs are used to associate primary results with quality control results. CASE_ID is a required entry for quality control data and should be entered for primary results if quality control data is being entered. For small projects, many GIS\Key users use sampling event as CASE_ID. IRPIMS projects should enter the IRPIMS site in the CASE_ID.
lab/user	X*	L	SDG_ID	C	25		SDG or sample delivery group ID. This field (in combination with CASE_ID) is used to associate rinsate blank results with primary results. Required for rinsate blanks.
lab	X*	L	QAQC_ID	C	25		QA/QC Batch ID's are normally assigned only by labs. This field is used to associate laboratory quality control results (i.e. method blanks, lab blanks, matrix spikes, control samples) with primary results. QAQC_ID entries must uniquely identify each batch of samples analyzed by the laboratory and may not be repeated. Required for method blanks.
lab/ user	X*	L	BLANK_ID	C	25		Field Blank identifier. BLANK_ID is used in combination with CASE_ID to associate field blank results with primary results. Required for field blanks.
user	X	L	TCL_ID	C	10		TCL ID, or Template Constituent List is required for all results. A TCL is a data entry template which groups sample results into logical sets. The user defines a TCL to include a lab code (LAB_ID) and optionally a test method (METHOD_ID) and a list of chemicals with reporting limits. GIS/Build can automatically assign a TCL, if METHOD_ID and LAB_ID are provided.
GIS/ user	X		TCL_TYPE	C	1		TCL Type. Used to differentiate lists of chemicals having the same test method and lab. GIS/Build assigns the GIS/Key default value to this field if it is left blank.

Remark	Required	Justify	Field Name 10 Character	Type	Len	Dec	Notes (Default parameters)
lab/user		L	METHOD_ID	C	10		Test Method identification. The import routine will generate error messages if the METHOD_ID is not in the GIS\Key database.
lab	X*	L	EXTRACTION	C	6		Extraction method code. The import routine requires definition of entries in the GIS/Key database.
user		L	LAB_ID	C	5		Lab ID code. The Import routine requires codes to be defined in GIS\Key database. Lab ID codes must be incorporated into the definition of a TCL_ID.
GIS	internal	R	SEQ_NUM	C	3		Used to order the compounds in a TCL (SEQ_NUM=1 for the first compound on a TCL). When editing results after data import, the sequence number controls the order in which the results are viewed. GIS/Build assigns a SEQ_NUM based on the SEQ_NUM of the chemicals defined in the TCL. If a TCL definition is not found in the project, the SEQ_NUM assignment is based on the order within the TCL in LABDATA.dbf.
user	X *	L	SPLIT_ID	C	10		SPLIT_ID records the TCL_ID of the first split sample of the primary sample. This field is left blank unless the record is for a primary result and a split sample was analyzed. A split sample result entered as a separate record will be orphaned unless this field is filled in for the primary result record.
user	X *	L	SPLIT_ID2	C	10		SPLIT_ID2 records the TCL_ID of the second split sample of the primary sample. This field is left blank unless the record is for a primary result and a second split sample was analyzed. The second split result, entered as a separate record, will be orphaned unless this field is filled in for the primary result record.
lab	X*	L	LSAMP_ID	C	15		Lab sample ID.
lab		L	LSAMP_ID2	C	15		lab sample ID of duplicates, entered by the lab for known-control sample duplicates and lab spike duplicates.
lab	X *	R	LAB_CAS_ID	C	11		CAS Registry number assigned by the Lab for the constituent. Either a LAB_CAS_ID or a LAB_CHEM must be included with each record. The import routine requires any LAB_CAS_ID to match a CAS_NUM in GIS\Key COMPOUND.DBF.
GIS	internal	R	CAS_NUM	C	11		CAS number from the GIS\Key compound.dbf. This is internally assigned based on a match with LAB_CHEM or LAB_CAS_ID, with preference given to LAB_CAS_ID
lab	X *	L	LAB_CHEM	C	40		Constituent name from lab. Either a LAB_CAS_ID or a LAB_CHEM must be included with each result. If LAB_CHEM is used, then it must match a GIS\Key COMPOUND.DBF alias.
GIS	internal	L	NAME	C	40		Constituent name assigned by comparing LAB_CHEM to COMPOUND.DBF. If LAB_CAS_ID is used without a matching LAB_CHEM, NAME is assigned based on alias 0 in GIS\Key Database.
GIS	internal	R	ALIAS_NUM	C	2		Alias numbers are internally assigned by comparing LAB_CAS_ID and LAB_CHEM to COMPOUND.DBF.

Remark	Required	Justify	Field Name 10 Character	Type	Len	Dec	Notes (Default parameters)
lab	X *	L	CONC	C	11		Utilized to store constituent concentrations for primary results, duplicates, splits & blanks and concentrations added to spikes and control samples. The field is left blank for surrogates. Warning code generated when CONC and LIMIT1 are both left blank for primary results, duplicates, splits and blanks. Stored as a character string to preserve significant figures. May be expressed in scientific notation (e.g. 1.3E03). All entries must be numeric with the exception of AE@ (i.e. scientific notation), A+@, or a A+/-@. A A+@ after concentration amount means greater than while a concentration followed by A+/-@ and a number expresses an uncertainty factor.
lab	X *	L	LIMIT1	C	10		Detection Limit 1 for a sample result. Stored as a character string to preserve the significant figures. May be expressed in scientific notation (e.g. 1.3E03). Required for primary results, duplicates, splits & blanks if CONC is blank. Left blank for control samples, matrix spikes and surrogates. All entries must be numeric with the exception of AE@ (i.e. scientific notation) or A?@. A A?@ means that the detection limit is unknown. The entered detection limit should reflect dilution. Generally, LIMIT1 refers to the method detection limit. However, GIS\Key places no restrictions on the use of this field.
lab	X *	L	DL_FLAG	C	2		Place a {<} in this field if the result is non-detect, otherwise leave it blank. Required for primary results, duplicates, splits and blanks. The field is left blank for control samples, matrix spikes and surrogates. For IRPIMS files, DL_FLAG corresponds to the PARVQ field. DL_FLAG corresponds to RF_FLAG on the data entry screen.
lab	X *	L	UNITS	C	5		Reported units of concentration. GIS\Key can automatically convert concentrations in mg/l, mg/kg, ug/l, ug/kg, ppm, ppb, and %. Other units are allowed but will generate warning codes.
lab		L	LIMIT2	C	10		Practical quantitation limit for a blank or primary sample result. Format limitations for LIMIT2 are the same as described for LIMIT1. The entered quantitation limit should reflect dilution. GIS\Key places no restrictions on the use of this field.
lab		L	INSTRUMENT	C	20		Identifying number or name of laboratory equipment used to perform the analysis. Used primarily for Air Force reporting.
lab		L	CALIBRATE	C	20		Calibration reference number for the test. Used primarily for Air Force reporting.
GIS	internal		SPIKE_DUP	L	1		Flag indicating a spike control sample duplicate record. Information is combined in the same record as the spike or control sample.
lab/ user		L	TEST_ORIG	C	3		Used for spikes to identify the res_code of the sample that was spiked.
lab			S_CONC	C	11		Spike Concentration
lab	X *		RECOVER	N	3		Constituent Recovery in %. Required for spike, surrogate, and control sample results. The field is left blank for primary samples, duplicates, splits and blanks. Supplied by the Lab for surrogates, lab matrix spikes and known control samples.

Remark	Required	Justify	Field Name 10 Character	Type	Len	Dec	Notes (Default parameters)
lab	X *		D_RECOVER	N	3		Duplicate constituent recovery in %. Required for spike and control sample duplicates results. The field is left blank for primary sample, duplicates, splits, blanks, and surrogates. Supplied by the Lab for lab matrix spikes and known control samples.
lab/user		L	T_CONC	C	11		Target concentration for spikes (i.e. calculated total of concentration in sample plus concentration spiked).
lab		L	R_CONC	C	11		Measured concentration in control samples and spiked samples. Supplied by the Lab for lab matrix spikes, field matrix spikes, blind control samples and known control samples.
lab		L	D_CONC	C	11		Measured concentration in duplicate control samples and spiked samples. Supplied by the Lab for lab matrix spikes, field matrix spikes, blind control samples, and known control samples.
lab			RPD	N	3		Relative Percent Difference (RPD). Supplied by the Lab for matrix spike and control samples that are run in duplicate. When RES_CODES DL#/DF#/DB#/DK# are used, the RPD is entered with these records.
lab			B_RECOVER	N	3		Lower percent recovery goal for surrogates, spikes, and control samples and spikes reported by the Laboratory.
lab			E_RECOVER	N	3		Upper percent recovery goal for surrogates, spikes, and control samples reported by the Laboratory.
lab			MAX_RPD	N	3		Maximum relative percent difference goal for control samples and spikes reported by the Laboratory.
lab/user	X		PF_CODE	C	1		Preparation Fraction Code: The import routine requires the preparation fraction to be specified and to match a user-defined code in GIS\Key database, standard codes include AT@ (total), AD@ (dissolved fraction), AA@: Acid Rain Extraction, AC@ TCLP Extraction, AE@ EPTOX Extraction, AS@: California Wet Extraction, AW@: Deionized Water Extraction.
lab			CR_C	C	1		CLP data concentration AC@ column. The import routine requires entry to match a code defined in GIS\Key Database.
lab		L	CR_M	C	2		CLP data method AM@ column. The import routine requires entry to match a code defined in GIS\Key Database.
lab		L	CR_Q	C	3		CLP data qualifier AQ@ column. The import routine requires entry(s) to match 1 character code(s) defined in the GIS\Key Database.
user		L	ER_Q	C	3		Expert review data qualifier. The import routine requires entry(s) to match 1 character code(s) defined in the GIS\Key Database.
user		L	ER_R1	C	2		Expert review reason 1 AR1@ code. The import routine requires entry to match a defined code in GIS\Key Database.
user		L	ER_R2	C	2		Expert review reason 2 AR2@ code. The import routine requires entry to match a defined code in GIS\Key Database.
user		L	ER_R3	C	2		Expert review reason 3 AR3@ code. The suggested use of this field is to track updates. The import routine requires entry to match a defined code in GIS\Key Database.

Remark	Required	Justify	Field Name 10 Character	Type	Len	Dec	Notes (Default parameters)
user			FILTERED	C	1		Was sample field filtered, <Y>es or <N>o. It is the user's responsibility to ensure that preparation fraction codes reflect field filtering status.
user			PRESERVED	C	1		Sample preservation code, AH@ = HCl, AN@ = HNO3, AS@ = H2SO4, AU@ = unknown, A@ = none, and AO@ = other sample preservation
user			ICED	C	1		Field preservation Code, AY@ = stored/shipped on ice, AN@ = stored/shipped at ambient temperature.
lab	*	L	CUSTODY	C	25		Chain of custody ID. Used to associate travel blanks with primary samples. Required for travel blanks.
lab	*		DILUTION	N	7	2	Dilution factor for sample run ranging from 0.01 to 9999. A required field for all primary results, duplicates, splits and blank results. The field is left blank for all other results.
GIS/user	X*		PROG_TYPE	C	1		Program codes are required for all results. The import routine requires codes to be defined in GIS\Key Database. Program codes must be identical for all chemical results for a particular TCL. GIS/Build assigns the GIS/Key default value to this field if it is left blank.
lab			RECEIVED	D	8		Date sample was received by the Lab (mm/dd/yy format).
lab			REC_TIME	C	5		Time sample was received by the Lab (##:## 24hr format).
lab			PREPARED	D	8		Date sample was prepared or extracted by the Lab (mm/dd/yy format).
lab			PREP_TIME	C	5		Time sample was prepared or extracted by the Lab (##:## 24hr format).
lab			TESTED	D	8		Date sample was analyzed by the Lab (mm/dd/yy format for American Version).
lab			TEST_TIME	C	5		Time sample was analyzed by the Lab (##:## 24hr format).
lab			REPORTED	D	8		Date sample was reported by the Lab (mm/dd/yy format for American Version).
lab			APPROVED	D	8		Date sample was result approved by the Lab (mm/dd/yy format for American Version).
lab/ user		L	LOT_NUMBE R	C	4		IRPIMS lot control number (LOTCTLNUM) used to associate primary samples with QC.
lab/ user		L	SA_CODE	C	3		IRPIMS sample type code (SA_CODE) used to identify the type of sample collected.
lab/ user		L	MATRIX	C	2		IRPIMS sampling matrix code.
lab/ user			BASIS	C	1		Used to indicate whether results are reported on a (W)et or (D)ry basis. Required for soil results.
lab/ user			MOISTURE	N	4	1	Percent moisture of a soil sample.
GIS	internal	L	EXC_CODE	C	30		Exception codes are generated by the import routine to alert the user to problems in the LABDATA.DBF file which must be addressed before the data can be appended to the project database.
GIS	internal	L	WARN_CODE	C	20		Warning codes are generated by the import routine to alert the user to possible problems in LABDATA.DBF file. Warning codes do not prevent user from appending LABDATA.DBF file to the project database.

Remark	Required	Justify	Field Name 10 Character	Type	Len	Dec	Notes (Default parameters)
GIS	internal		BUILD_FLAG	C	1		Internal flag used during the GIS\Build process.
lab/ user		L	NOTE	C	20		Lab/user notes for samples (i.e. placed in CSAMPLE.DBF). May be expanded to 50 characters.
lab/user		L	TEST_NOTE	C	20		Lab/user notes for tests (i.e. placed in CTEST.DBF). May be expanded to 50 characters.

Notes:

RES CODES:

PP0<1-9> Primary Results
 PD[1-9]<1-9> Duplicate
 PS[1-2]<1-9> Split
 BF[1-9]<1-9> Field Blanks
 BL[1-9]<1-9> Lab Blanks
 BM[1-9]<1-9> Method Blanks
 BR[1-9]<1-9> Rinsate Blanks
 BT[1-9]<1-9> Travel Blanks
 CB[1-9]<1-9> Blind Control Sample

 CK[1-9]<1-9> Known Control Sample
 SL[1-9]<1-9> Lab Spike
 SF[1-9]<1-9> Field Spike
 DL[1-9]<1-9> Duplicate Lab Spike
 DF[1-9]<1-9> Duplicate Field Spike
 DB[1-9]<1-9> Duplicate Blind Control Sample
 DK[1-9]<1-9> Duplicate Known Control Sample

Numbers in [] denote test sequence numbers

Numbers in <> denote result set occurrence

* = Conditionally Required

EXCEPTION CODES: (an exc_code indicates bad or missing data)

AN = No entry in ALIAS_NUM
 BI= No entry in BLANK_ID (for a field blank)
 CI= No entry in CASE_ID
 CN= Cas Number is not found in COMPOUND.DBF
 CU= No entry in CUSTODY (for a trip blank)
 DI= DILUTION <= 0
 DP= Sample depth precision > 2 (not allowed for American or unspecified project)
 DR= Duplicate record
 HT= Holding times out of sequence (SAMP_DATE, RECEIVED, PREPARED, TESTED and REPORTED)

 LB= No entry in LAB_ID
 PF= Invalid in PF_CODE
 PS= No primary sample for duplicate or split
 PT = Invalid in PROG_TYPE
 QC = No entry in QAQC_ID (for a lab blank, method blank, spike or control sample)
 RC= Invalid RES_CODE
 SD= No entry in SAMP_DATE
 SG= No entry in SDG_ID (for a rinsate blank)
 SI= No entry in SITE_ID
 SP= No entry in SP_ID(event) or 3rd character of id is not a ==
 SK= No spike duplicate match or invalid spike dup fields
 ST= Invalid SAMP_TYPE
 TC= No entry in TCL_ID
 TM= SAMP_TIME format invalid

WARNING CODES:

BA = BASIS should be =W=et or =D=ry for soil results
 CI = No entry in case id for a primary sample
 DL = No detection limit and no conc
 DP = Sample Depth = 0 or not within range of S_DEPTH & E_DEPTH
 PF = PF_CODE not defined in project
 PS = No primary sample for duplicate or split
 PT = PROG_TYPE not defined in project
 SD = No entry in sample date for a rinsate or field blank
 RE = B_RECOVER > E_RECOVER
 TM = Invalid TEST_TIME for rinsate or lab blank
 TT = TCL_TYPE not defined in project
 U = No entry in UNITS

Notes (continued):

DUPLICATE RECORD KEY FOR PRIMARIES, DUPLICATES AND SPLITS (RES_CODE = PP0#, PD##, PS##):
SAMP_TYPE + SITE_ID + SAMP_DATE + SAMP_TIME(water) or SAMP_DEPTH(soil) + RES_CODE + TCL_ID + PF_CODE + CAS_NUM

Index file = EXPRI.IDX TO use in FOXPRO enter: USE EXCDATA INDEX EXCPRI

DUPLICATE RECORD KEY FOR BLANKS (RES_CODE = BR##, BM##, BT##, BF##):
SAMP_TYPE + CASE_ID + BLANK_ID + RES_CODE + TCL_ID + PF_CODE + CAS_NUM

Index file = EXCQC.IDX TO use in FOXPRO enter: USE EXCDATA INDEX EXCQC

DUPLICATE RECORD KEY FOR SPIKES AND CONTROL SAMPLES (RES_CODE = SF##, SL##, CB##, CK##):
SAMP_TYPE + CASE_ID + QAQC_ID + RES_CODE + TCL_ID + PF_CODE + CAS_NUM

Index file = EXCQC.IDX

ASSIGNING RES_CODE SEQUENCE NUMBERS [1-9]:

The test sequence number refers to a sample sequence used to differentiate test results that otherwise have the same primary key. For example, a test sequence number of 2 for a duplicate sample would mean that the result set is for the second of 2 duplicate samples originating from the same primary sample. A test sequence number of 2 for a method blank would mean that 2 method blanks were run for the same batch (QAQC_ID). Note that matrix spikes and control samples and their duplicates should always have matching test sequence numbers.

ASSIGNING RES_CODE RESULT SET OCCURRENCES <1-9>:

The result set occurrence is used to differentiate multiple column or dilution runs of the same sample and test method that otherwise have the same primary key. Occurrence = 1 is the set of record and the set used for reporting and graphics.

ASSIGNING RES_ORIG CODES

RES_ORIG codes are equal to the last three characters of RES_CODES for all results except when multiple column/dilution runs are being reported and the result being reported is for the combined Abest estimate@ result. In this case, the RES_ORIG code equals the last three characters of the RES_CODE of the originating column/dilution run.

ADDITIONAL GUIDANCE FOR FIELD/LAB MATRIX SPIKE DUPLICATES AND BLIND/KNOWN CONTROL SAMPLE DUPLICATES:

Field/lab matrix spike duplicate and blind/known control sample duplicate concentrations are always entered in the D_CONC field, with recoveries in the D_RECOVER field. Spike and control sample duplicates may be entered as individual records using RES_CODES DL##, DF##, DB##, DK##, or can be combined with the record storing the original spike or control sample when using RES_CODES SL##, SF##, CB##, CK##.

10 - DRILLING METHODS FOR SUBSURFACE INVESTIGATIONS AND WELL INSTALLATION

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) presents a brief summary of drilling methods commonly used for completing monitoring wells and test borings. The application and limitations of the following methods are discussed in this SOP:

- Hollow-stem auger
- Direct push
- Driven-casing
- Fluid-rotary
- Air-rotary
- Solid-stem auger
- Cable tool

Test borings are completed to determine both physical and chemical conditions of subsurface soils. Monitoring wells or piezometers may be installed within these borings for the purpose of collecting representative groundwater samples, for measuring water levels to determine groundwater flow direction, and for performing tests to determine physical aquifer characteristics.

The drilling method selected for a particular site, well, or borehole depends on subsurface conditions and, in some instances, regulations. In some cases, a combination of drilling techniques is needed to complete a boring when different formations are encountered. It is important to determine the inside diameter of each borehole so that the boring can provide adequate sample material for analysis or so it can be used for its intended purpose. For these reasons, the selection of drilling methods should be made in consultation with the Project Manager and Hydrogeology Task Manager. A qualified geologist or engineer must supervise the drilling activity.

1.1 Referenced SOPs

- 02 - Utilities Clearance
- 11 - Rock Coring
- 13 - Monitoring Well Grouting Techniques
- 25 - Equipment Decontamination
- 33 - Subsurface Soil Sampling

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

Materials used for drilling and well installations will vary according to the chosen drilling and subsurface sampling methods, and well design and installation methods. Based upon the chosen drilling method, the subcontracted drilling firm will be responsible for providing a drilling rig, support equipment, and trained drilling crew capable of performing the requested subsurface boring, sampling, and well installation activities.

Any qualified drilling subcontractor will typically know, based on experience, what equipment will be required for specific situations. It is necessary, therefore, to provide the driller with as much information as possible regarding the requirements and objectives of the drilling program, as well as the subsurface conditions expected to be encountered.

A generalized list of materials and equipment to be utilized by the driller may include the following:

- Drill rig appropriately equipped to advance a borehole of the appropriate diameter, to the appropriate depth, through the anticipated subsurface materials
- Drilling support equipment capable of safely handling and maneuvering drilling equipment, including auger sections, casings, drilling rods and bits, bailers, pumps, *etc.*
 - Auxiliary compressor (for air rotary/hammer drilling)
 - Hydraulic or manual hammers (for split-spoon sampling)
 - Various pumps (mud, trash, grout, *etc.*)
 - Various hoses for fluids and air
 - Wellhead diverters
 - Cyclone separator
 - Mud tub(s)
 - Sampling devices (split-spoon samplers, Shelby tubes, rock core barrels);
 - Casing lifts (cables, clamps, hoists)
 - Portable water tank, transfer lines, and pump (if necessary)
 - Cutting torch and welder
 - High-pressure, hot water washing system (steam genny)
 - Decontamination solutions and equipment (buckets, brushes, *etc.*)
 - Lifting straps, chains, and cables
 - Various wrenches and specialized tools

Before mobilization to each boring location, the drill rig and all downhole equipment should be decontaminated. The drill rig must not leak any fluids that could enter the borehole or contaminate equipment placed in the boring.

The use of drilling mud, synthetic drilling fluids, or petroleum- or metal-based pipe joint compounds should be avoided unless absolutely necessary. Material safety data sheets should be provided by the drilling contractor for all such materials used. If drilling mud is needed to stabilize a hole or to control downhole fluid losses, only high-yield bentonite clay free of organic polymer additives should be used.

In addition to the equipment and material needs of the drilling subcontractor, the geologist, engineer, and/or hydrogeologist overseeing the drilling and construction activities will require particular items to assist in documenting sampling, drilling, and well construction activities. Equipment and materials likely to be used by oversight personnel may include:

- Field logbook
- Digital camera
- Marking pens
- Boring, sampling, and well construction log sheets
- Sample jars, coolers, ice, packing tape, and chains-of-custody (if samples are to be submitted for laboratory analyses)
- Sample containers for geotechnical samples
- Field screening sample containers (glass jars, Ziploc® bags, foil, *etc.*)
- Field screening equipment (PID, FID, pH paper, immuno-assay testing, field GC, *etc.*)
- Mud balance (for measuring grout and mud densities)
- Fine-mesh sieve or strainer (for collecting and washing drill cuttings for identification)
- Weighted tape for measuring borehole depths, and well construction material placement
- Tape measure and/or ruler
- Water-level and/or interface probe
- Water quality monitoring instrument (for well development documentation)
- Stopwatch
- Magnifying glass or hand lens
- Knife
- Hydrochloric acid
- Munsell Soil Color and Rock Color Charts
- Grain-size identification chart
- Hard hat
- Safety glasses
- Steel toe boots

3.0 METHODOLOGIES

Drilling methods should be selected after evaluating site subsurface conditions, including available information on contaminant characteristics, and be consistent with the intended data use and goals of the project work plan. Final selection of the drilling method to be used should be based on relative cost, time constraints, and sampling and testing requirements. A detailed discussion of drilling techniques is presented in Driscoll, 1986, Pages 268 to 533, and Aller, *et al.*, 1989, Pages 40 to 143.

An underground utilities clearance must be verified before drilling at any location. A comprehensive discussion of the procedures for locating utilities is contained in *SOP 02 – Utilities Clearance*.

3.1 Hollow-Stem Continuous-Flight Augering Method

This method of drilling consists of advancing hollow-stem augers into unconsolidated materials. As the borehole is advanced, cuttings are brought to the surface by the lifting action of the augers. Drill rods with an attached sampler can be passed through the center of the auger section to retrieve soil samples (*SOP 33 – Subsurface Soil Sampling*). After drilling has advanced to the desired depth, a monitoring well can be installed inside the auger stem and backfilled as the augers are simultaneously withdrawn from the borehole.

Boreholes should be advanced using pre-cleaned and decontaminated augers and sampling equipment. Boreholes that are not converted to monitoring wells or piezometers should be abandoned according to *SOP 13 – Monitoring Well Grouting Techniques*.

This method is fast and efficient for shallow drilling (less than 100 feet) and permits both sample collection and installation of small diameter wells. Advantages of this type of drilling include:

- Representative soil samples can be retrieved with either split-barrel or thin-wall samplers
- Water quality sampling can be done while drilling
- Monitoring well installation can be achieved in most unconsolidated formations
- The hollow-stem auger can serve as temporary casing for coring rock or advancing a bedrock borehole by other drilling methods
- Varying rig sizes can perform drilling in limited access areas, including indoors, and skid rigs are available for very limited spaces. Also, many firms maintain all-terrain auger rigs

Disadvantages and limitations of this method of drilling include:

- Augering can only be performed in unconsolidated materials or soft rock; more dense formations will limit capability at depth
- Preserving sample integrity in heaving formations is a concern
- Formation invasion by water or drilling mud is a concern when used to control heaving
- Cross contamination between aquifers can occur where the annular space is not positively controlled by water or drilling mud or surface casing
- Inside diameter of augers limits the well casing size generally to four inches in diameter or less
- Smearing of formation clays by the lifting action of the augers may seal off the aquifer to be monitored

3.2 Direct Push Systems

Direct push system (DPS) technologies involve a category of drilling equipment that hydraulically pushes or drives small-diameter, hollow steel rods into the subsurface without rotating the drill rods. Some drill rigs may be “combo rigs,” capable of conducting both direct push and rotating HAS drilling operations. DPS drilling uses a combination of a hydraulically-powered percussion hammer, a downward hydraulic push, and the weight of the vehicle on which the system is mounted to drive rods into the subsurface. DPS methods push a continuous tube sampler into the subsurface by

laterally displacing soil to make a path for the sampler, so no cuttings are generated. DPS drilling is commonly used for shallow applications (less than 50 feet).

DPS technology is typically limited to unconsolidated formations that are relatively free of cobbles or boulders. Refusal may occur if there are too many cobbles, boulders, or other consolidated formation materials. However, since DPS drilling is relatively fast, refusal at a desired location because of cobbles may be mitigated by abandoning the hole, moving to a nearby location, and re-drilling.

DPS boreholes generally cannot be sampled deeper than the water table because unconsolidated materials cave in once the drive rods are removed. However, caving may be mitigated by advancing a casing with an inner drill rod used for sampling, allowing for sampling and well installation far below the water table.

Outside diameters of samplers and boring tools generally range from 0.75 to 3.5 inches. If installation of monitoring wells is planned, the inside diameter of the boring should typically ranges from 1.5 to 3.5 inches (for 1- to 2-inch wells).

DPS technologies provide the following advantages over conventional drilling methods:

- Minimal ground disturbance, with a small-diameter boring that is easy to abandon
- No cuttings, which eliminates the need for handling, containerizing, sampling, and disposing of potentially contaminated IDW (unless samples are brought to the surface);
- Faster boring advancement
- Faster monitoring well installation if small-diameter wells (0.75 to 1 inch in diameter) with pre-packed screens are installed

Boreholes should be completed using pre-cleaned and decontaminated drive points, rods, and sampling equipment according to *SOP 25 - Equipment Decontamination*. Boreholes that are not converted to wells should be abandoned according to *SOP 13 – Monitoring Well Grouting Techniques*.

3.3 Driven-Casing Method

The driven-casing method consists of alternately driving casing into the ground and cleaning out material within the casing, using a rotary bit and air or potable water to flush out the materials. This method is used in unconsolidated formations or soft caving rock. When the boring is to be used for well installation, the driven casing used should be at least four inches larger in diameter than the well casing to be installed.

Advantages to this method of drilling include:

- Sampling can be conducted while drilling
- Well installation is easily accomplished
- Well development procedures are minimal

- Drill rigs used are relatively small and mobile

Some of the disadvantages include:

- Use restricted to unconsolidated, noncohesive formations
- Relatively slow advancement of the borehole
- Depth of the borehole will vary with the size of drill rig, the casing diameter used and the nature of the formations
- Introduction of drilling fluids into the borehole is discouraged by some regulatory agencies

3.4 **Fluid-Rotary Drilling Method**

During fluid-rotary drilling, the borehole is drilled by a rotating bit; cuttings are removed by continuous circulation of a drilling fluid as the bit penetrates the formation. The bit is attached to a string of drill rods that transmits the rotating action and drilling fluid from the rig to the bit.

There are a variety of fluids that can be used in conjunction with this drilling method. The usual drilling fluid is water or water mixed with bentonite (referred to as “mud-rotary”). Under some geologic conditions, it may be necessary to add other compounds to the drilling fluid to increase the fluid weight or viscosity. These additions may include inorganic compounds such as barite or organic polymers. For monitoring wells constructed to sample groundwater quality, the use of any organic polymers in the drilling fluid should be avoided and inorganic additions made only if they will not interfere with the groundwater sampling protocol. The Project Manager should be consulted before a drilling fluid other than clear water is to be used. The decision as to whether drilling fluid additives should be used should be based on consultation with the client and review of any guidance documents used by the lead regulatory agency, if appropriate. Even if an agency is not currently involved with the project, it may be advisable to utilize their method of preference so environmental data and analytical results cannot be questioned at a later date.

There are two general types of fluid-rotary drilling methods: direct circulation rotary drilling and reverse circulation rotary drilling. In direct circulation rotary drilling, the drilling fluid is circulated down through the drill rods, out the bit, and up the annular space to the settling pit at the surface. In the reverse circulation rotary method, the drilling fluid and cuttings move down the annulus and upward inside the drill rod to be discharged into the settling pit. Upon boring completion, clean water should be circulated through the system to remove residual additives from the borehole and facilitate subsequent well development.

Advantages to rotary drilling methods include:

- The ability to advance a hole in most formations at a relatively quick pace
- Split-barrel samples, Shelby tubes, and rock cores can be obtained
- Casing may not be needed because the drilling fluids may keep the borehole open
- They are relatively common methods that are used by water well drillers in most areas
- The open hole can be geophysically logged

Disadvantages to this method include:

- Formation logging is difficult if split-barrel samples are not taken
- Drilling fluid reduces formation permeability to some degree, may circulate contaminants, or alter groundwater quality in the vicinity of the well
- Limited or no information on depth to water and/or occurrence of water-bearing zones is obtainable while drilling
- Development techniques for wells may be more extensive when compared to other drilling methods
- Drill rigs are usually large and heavy and need proper access
- Federal and state regulatory agencies may prohibit the use of this method for some applications because of the addition of fluids in the hole
- Potable water is required for mixing drill fluids. This water should be sampled and the water source should remain the same throughout the program. This method may require a large volume of water. The availability of a potable water source should always be considered in the selection of this method.

3.5 Air-Rotary Drilling Methods

This method is similar to fluid-rotary drilling, except that compressed air is used to cool the drill bit and remove cuttings. Two drilling methods that use air as the primary drilling fluid are direct air-rotary and down-the-hole air hammer. Applications of air-rotary methods include:

- Rapid drilling of semiconsolidated and consolidated rock
- Good quality/reliable formation samples (particularly if small quantities of water and surfactant are used)
- Equipment generally available
- Allows easy and quick identification of lithologic changes
- Allows identification of most water-bearing zones
- Allows estimation of yields in strong water-producing zones with short “down time”

Limitations of this method include the following:

- Surface casing is frequently required to protect the top of the hole from washout and collapse
- Its use is restricted to semiconsolidated and consolidated formations
- Samples are reliable but due to small size are difficult to interpret
- Drying effect of the air may mask low yield water producing zones
- Air stream may require filtration to prevent introduction of contaminants from the air compressor
- The injected air may modify the chemical or biological conditions of the aquifer in the immediate vicinity of the borehole

3.6 Solid-Stem Continuous-Flight Augering Method

The solid-stem continuous-flight augering method operates in the same manner as the hollow-stem auger. Practical application of this method is restricted when compared with hollow-stem augers. Sampling is performed by completely removing the augers from the borehole, which may allow the hole to cave in. This method is effective in silty-clayey soils with hole depths limited to about 50 feet. Depth to water is difficult to determine while drilling. This method is ineffective for well installation in loose soils or when drilling below the water table. Applications and advantages include:

- Conducting shallow soils investigations and collecting disturbed soil samples
- Installing vadose zone monitoring wells (lysimeters)
- Identifying depth to bedrock
- Drill rigs are small and mobile, allowing access where larger rigs cannot operate

Disadvantages include:

- Soil sample data limited to areas and depths where borehole remains open during auger removal
- Unacceptable soil samples unless split-barrel or thin-wall samples are taken
- Monitoring wells cannot be installed in most unconsolidated aquifers because of borehole collapse following auger removal
- The depth capability decreases as the diameter of the auger increases
- Monitoring well diameter is limited by the auger diameter

3.7 Cable Tool

This method was one of the first mechanized methods to be widely used for drilling deep water wells. The drill hole is advanced using a heavy bit (a 500- to 2,500-pound tool) hung from a steel cable and suspended from a mast. The tool is placed into the hole and successively dropped from 2 to 3 feet above the bottom of the hole. This action pulverizes the rock or soil in the bottom of the hole. The drilling tool is pulled out and a large bailer is used to remove the cuttings; water may be added to aid in the removal of materials in unsaturated conditions. Casing is driven into the ground just behind the advance of the bit. Advantages include:

- Sampling can be conducted during drilling
- Well installation is easily accomplished, and development is generally minimal
- Large diameter installations can be completed, which may be valuable if telescoping required
- Advances through gravels and running sands
- Casing can be used as temporary casing for rock coring

Disadvantages include:

- Advancement is slowed in more cohesive materials
- May involve introduction of water into borehole that must be monitored/sampled

- Use is restricted to unconsolidated materials (*e.g.*, no rock coring can be performed)
- Services are not always available through environmental drilling contractors

4.0 QUALITY ASSURANCE/QUALITY CONTROL

All field activities are to follow the guidelines enumerated in the project planning documents. Any changes required based on conditions encountered in the field are to be documented in the Field Logbook and receive approval of the Project Manager.

5.0 DOCUMENTATION AND RECORD KEEPING

Information to be collected during the completion of a subsurface drilling and monitoring well installation program will include:

- Soil types, thicknesses, and depths
- Bedrock types, depths, and thicknesses
- Identification of the presence and extent of subsurface contamination
- Depths to water-bearing zones, their respective yields, and presence of contamination
- Well construction details

Recording of the data should be completed in the field at the time of measurement or observation. The field book should be the primary repository for field data and observations (SOP # 106); however, field forms may provide a more suitable format for collecting and analyzing the data.

Soil boring and sampling information may be recorded entirely in the field notebook or on an appropriately designed boring log form and should include, at a minimum, the following information:

- Drill rig make/model, name of drilling subcontractor, and driller's name(s)
- Weather conditions
- Boring location identification, including physical description of location in reference to site features, and description of surface conditions at location
- Borehole advancement method (augering - include size, mud rotary, *etc.*)
- Sample number
- Sample depth
- Sample time
- Sample collection method (split-spoon, cuttings, *etc.*)
- Blow counts
- Recovery (length and percentage)
- Soil color (from Munsell Soil Color Chart)
- Soil texture and physical description (*SOP 33 – Subsurface Soil Sampling*)
- Observations of contamination (field screening results and visual observations)
- Occurrence and estimated yield of water-bearing zones
- Depth to water at completion of boring

• Any problems or significant events that occurred during drilling and sampling
Rock boring and coring data recording requirements are similar to those for soil borings. Information may be recorded in either a field notebook or an appropriately designed boring log form and should include, at a minimum, the following data:

- Drill rig make/model, name of drilling subcontractor, and driller's name(s)
- Weather conditions
- Boring location identification, including physical description of location in reference to site features, and description of surface conditions at location
- Borehole advancement method (augering - include size, mud rotary, *etc.*)
- Sample number
- Sample depth
- Sample time
- Sample collection method (cuttings, coring - indicate type)
- Recovery (for coring)
- Rock Quality Data (RQD) (for coring) (*SOP 11 – Rock Coring*)
- Rock color (from Munsell Rock Color Chart)
- Description of rock type, texture, fractures, *etc.*
- Rate of borehole/coring advancement (per foot)
- Observations of contamination (field screening results and visual observations)
- Occurrence of water-bearing zones and their respective yields
- Depth to water at completion of boring
- Any problems or significant events that occurred during drilling and sampling

6.0 REFERENCES

Aller, L., Bennett, T.W., Hackett, G., Petty, R.J., Lehr, J.H., Secoris, H., and Nielsen, D.H., 1989, Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells: Dublin, Ohio, National Water Well Association.

American Society for Testing and Materials, D2488, Standard Recommended Practice for Description of Soils - (Visual-Manual Method).

Driscoll F.G., 1986, Groundwater and Wells - Second Edition: St. Paul, Minnesota, Johnson Screens, 1089 p.

12 – MONITORING WELL CONSTRUCTION IN UNCONSOLIDATED FORMATIONS

1.0 SCOPE AND PURPOSE

The purpose of this SOP is to provide procedures for the proper construction of groundwater monitoring wells in unconsolidated formations. Groundwater extraction, or pumping test wells, will be constructed following the same general procedures, but will be designed incorporating site and project-specific parameters.

Monitoring wells are used for many purposes: collection of groundwater samples for chemical analysis; measurement of groundwater levels; detection of free-phase constituents; and conducting aquifer tests. The specific purpose for which the well is constructed, the regulatory framework within which the well is constructed, the expected useful life of the well, and other factors may have significant bearing on the construction technique employed. However, all wells, regardless of the intended purpose, should be constructed to minimum standards to assure the following:

- Good hydraulic connection is established between the well and the aquifer of interest
- Water from separate aquifers is not allowed to mix (*i.e.*, cross-contamination is prevented)
- Well construction activities do not alter the chemical characteristics of the aquifer
- The well is properly sealed to prevent entry of surface water
- The well is properly identified

1.1 Referenced SOPs

10 – Drilling Methods for Subsurface Investigations and Well Installation

13 – Monitoring Well Grouting Techniques

25 – Equipment Decontamination

1.2 Definitions

Bentonite: A hydrous aluminum silicate composed principally of the clay mineral sodium montmorillonite. Bentonite possesses the ability to expand significantly when hydrated; the expansion is caused by the incorporation of water molecules into the clay lattice. Hydrated bentonite in water typically expands 10 to 15 times the volume of dry bentonite. Bentonite forms an extremely dense clay mass with an in-place permeability typically in the range of 1×10^{-7} to 1×10^{-9} centimeters per second when hydrated.

Bentonite Grout: A slurry generally prepared by mixing dry bentonite powder into fresh water in a ratio of approximately 15 pounds of bentonite to 7 gallons of water to yield 1 cubic foot (ft³) of bentonite slurry. The bentonite and water are mixed by moderate agitation, either manually in a large tank or with a paddle mixer. The use of high-shear mixing equipment increases the viscosity development of the slurry and can reduce the ultimate working time by as much as 20 percent. Thick bentonite slurries may swell quickly into nonpumpable gel masses that cannot be emplaced. Premix and/or polymer (organic and inorganic) additives delay the wetting of the bentonite and prevent premature hydration. Where additives are used, the additives should be evaluated for potential effects on groundwater quality. Once the slurry is mixed, it should remain workable for between ½ to 2 hours. During this time, a positive displacement mud or grout pump (typically a centrifugal, diaphragm, piston, or moyno-type pump) is used to emplace the grout at the desired depth.

Cement/Bentonite Grout: A slurry generally prepared by mixing Portland cement (Type I, American Society for Testing and Materials C 150) and bentonite powder into fresh water in a ratio of 1 bag of cement (94 pounds or 1 ft³) to 2 to 5 pounds of bentonite to 5 to 6 gallons of clean water. The bentonite improves the workability of the slurry, reduces the slurry weight and density, and reduces shrinkage as the slurry sets. Bentonite also reduces the set strength of the grout, but this is rarely a problem because the grout is seldom subject to high stress.

Grout: A slurry of high water content fluid enough to be poured or injected as a slurry into fissures, joints, permeable rocks, or subsurface voids, such as a borehole, in order to reduce their permeability.

2.0 REQUIRED MATERIALS

Materials used for drilling and constructing monitoring wells in unconsolidated formations will vary according to the chosen drilling and subsurface sampling methods, and well design. Based upon the chosen methods, the subcontracted drilling firm will be responsible for providing a drilling rig, support equipment, and trained drilling crew capable of performing the requested drilling and installation activities. Any qualified drilling subcontractor will typically know, based on experience, what equipment will be required for specific situations. It is necessary, therefore, to provide the driller with as much information as possible regarding the requirements and objectives of the drilling and well installation program, as well as the subsurface conditions expected to be encountered.

Besides the general equipment necessary to drill the boring, well installation equipment will likely include the following:

- Various pumps (mud, trash, grout, *etc.*)
- Various hoses for fluids and air
- Casing lifts (cables, clamps, hoists)
- Portable water tank, transfer lines, and pump (if necessary)
- Cutting torch and welder
- Grout and slurry mixing machines
- Tremie lines and drop pipes

The drilling subcontractor will also obtain the required materials for the well installations. Material specifications will be the responsibility of the overseeing geologist, engineer, and/or hydrogeologist. The specifications are dependent upon subsurface conditions expected to be encountered. The process by which the proper materials are selected is presented in section 3.0 of this SOP.

Well construction materials typically include the following:

- Temporary casing
- Well screen
- Riser pipe (to extend from the screen to the surface)
- Centralizers
- Sand and/or gravel pack
- Sealing materials (bentonite pellets, powders, etc.)
- Grouting materials (Portland cement and appropriate additives)
- Protective steel casings, manholes, and/or flush-mount caps
- Compression caps
- Locks and keys
- Concrete for construction of a sloping pad

In addition to the equipment and material needs of the drilling subcontractor, the geologist, engineer, and/or hydrogeologist overseeing the monitoring well construction activities will require particular items to assist in documenting construction activities. Equipment and materials likely to be used by oversight personnel may include:

- Field logbook and indelible pens
- Personal protective equipment as specified in the Health and Safety Plan
- Digital camera
- Mud balance (for measuring grout densities)
- Weighted tape for measuring borehole depths, and well construction material placement
- Tape measure and/or ruler
- Water-level and/or interface probe
- YSI 556 Multimeter or equivalent, to measure pH, temperature, specific conductivity, and turbidity during well development

3.0 METHODOLOGIES

3.1 Borehole Construction

Drilling methods and borehole construction practices are discussed in *SOP 10 – Drilling Methods for Subsurface Investigations and Well Installation*. When a boring may be used for construction of a monitoring well, the driller should use a high-pressure, hot water, power washer (steam cleaner) to clean all bits, pipe augers, and any other drilling or sampling tools that may be used in the advance of the borehole (*SOP 25 – Equipment Decontamination*). No grease

or other machine lubricants should be used during the well construction (some regulatory agencies will allow selected lubricants with prior approval). The borehole must be of suitable diameter (the diameter of the boring should be at least four inches greater than the outside diameter of the well pipe) and depth for the monitoring well planned. If the boring extends more than a few feet below the planned depth of the monitoring well, the lower portion of the boring should be sealed with a structurally suitable grout to provide a base for the well. The grout should be hydrated and placed as a slurry under pressure through a tremie pipe. Cement grouts should not be used to seal borings because of possible effects on groundwater chemistry.

3.2 Well Casing and Screens

The well casing (riser pipe) and screen for most monitoring well installations will be two- or four-inches in diameter. Two-inch diameter wells are generally used because:

- They require smaller borehole diameters, which reduce drilling costs
- The smaller diameter reduces the volume of cuttings, which may have to be disposed
- Construction material costs are lower
- The volume of water that must be purged during well sampling is less

A four-inch diameter well may be preferred when wells are built to collect groundwater samples from silt and/or clay sediments. Wells screened in these sediments tend to produce turbid samples. Increasing the well screen diameter reduces the groundwater entrance velocity, which helps to reduce the turbidity of the samples. Using "wire wrapped" as opposed to slotted screens will also help to reduce sample turbidity for the same reason. Increasing the well diameter also reduces the surge energy that reaches the formation when a snug fitting bailer is dropped into the well to collect samples. The selection of well diameter for low yielding silt and/or clay aquifers should take into account the volume of water to be purged from the well during sampling. Costs associated with disposal of purge water and slow labor requirements for purging/sampling wells recharge wells may negate the advantage of installing a larger diameter well. A four-inch diameter well may also be preferred when wells are built to collect groundwater samples from sand and/or gravel material. Wells screened in highly transmissive aquifers are occasionally difficult to fully develop without pumping. For this reason, well diameters may be increased to accommodate a submersible pump. Deeper wells may also require a submersible pump to efficiently lift groundwater during development and purging.

For most groundwater monitoring applications, polyvinyl chloride (PVC) is a suitable material for both well casing and screens. It is readily available, is low in cost, and generally unaffected by the chemistry of most groundwaters. However, when sampling for chlorinated organic compounds, PVC pipe and screens may be unacceptable. Also, some phase-separate liquids, including some petroleum products or high concentrations of some solvents, may have an adverse effect on the integrity of PVC pipe and screens. The material supplier can usually provide information regarding material incompatibilities if the nature and concentration of the contaminants are known. Some regulatory agencies require specific well construction materials for monitoring well use. Wells intended for the collection of monitoring data subject to

regulatory review must be constructed of materials and in a manner approved by the designated agency.

Stainless steel pipe and screens are usually an acceptable alternative when PVC cannot be used. Stainless steel is more expensive than PVC and will usually require one or two weeks lead time to assure delivery of materials.

In some cases, where metals are a contaminant of concern, stainless steel is unacceptable and PVC or other well screen and casing materials (*e.g.*, Teflon[®]) should be used. Combinations of materials may also be used in some cases (for example, using stainless steel or Teflon[®] for those portions of the well below the water table and PVC through the unsaturated zone). Attention must be given to the joints of these hybrid wells. To eliminate corrosion where dissimilar construction materials connect (for example, if a well is constructed of stainless and black steel pipe) nonconductive joint rings may be necessary at the fittings. The material supplier can usually provide information regarding material incompatibilities. Terminating the well with a section of PVC pipe may also make the well completion easier to accomplish, especially where the top of the well pipe must be cut to fit inside a surface-mounted well cover.

Threaded well casing and screens are generally available for most monitoring well applications and are preferred over other joint types. The threaded joints typically include an O-ring that, when properly installed, assures a leak-tight joint. Threaded joints also reduce the chance of introducing organic constituents to the well, which may occur when solvents are used to weld PVC pipe. The threaded joints also provide a smooth interior, which reduces the likelihood that sampling tools or measuring tapes will become hung up inside the well. Teflon[®] tape may be used to lubricate threads, and clean water or hydrated bentonite may be used to lubricate O-rings.

The well casing and screens should always be new material. Proper storage, both at the site and before delivery, is required to assure the pipe is clean.

A threaded, slip-over or an expanding-type well cap should top each well. The well cap should have a small hole drilled through it to maintain atmospheric pressure at all times. This allows wells to recover more quickly to static conditions after sampling and will help prevent the cap from sticking due to a low-pressure condition in the well. A threaded plug should be installed in the bottom of the well. A small hole should be drilled through the plug to allow the well to completely drain should the water table drop below the bottom of the well, if applicable.

Centralizers should be used depending upon the depth of the well to assure the well casing is centered in the borehole unless the well is installed through hollow stem augers. Hollow stem augers will keep the well reasonably centered without the use of centralizers. One centralizer should be placed at the bottom of the well screen and another approximately 10 feet below the top of the well. Additional centralizers should be placed at 25-foot intervals.

Well screen slot size should be selected based on the grain size of the formation to be sampled. The well screen should retain 90 percent of the formation sand for naturally developed wells or 90 percent of the filter pack sand. If a grain size distribution is not available for the formation, the following guideline (Gass, 1988) should be followed.

<i>Anticipated Strata</i>	<i>Well Screen Size (inches)</i>	<i>Filter Pack Material (Approximate Range of Standard United States Sieve Sizes)</i>
Sand and gravel	0.030	20 to 4
Silt and sand	0.020	30 to 8
Clay and silt	0.010	50 to 16

3.3 Annulus Filling

Naturally developing a monitoring well (allowing the natural formation sands to cave around the well screen) is acceptable when the grain size distribution of the formation is known and the well screen was properly selected to retain the formation sand. However, this information is not usually available before the well is constructed. Consequently, most monitoring wells will be filter packed.

Filter pack sand should be clean, well-rounded, uniformly sized (uniformity coefficient of 3.0 or less) silica sand, free of organic matter and carbonate grains. The filter pack should be placed from the bottom of the well to no less than 1 foot nor more than 2 feet above the well screen. The filter pack should not be allowed to free fall through the water column, as this may cause the sand to segregate by grain size. The filter pack sand should be washed into place through a tremie pipe with water from a potable source. A 0.5-foot thick layer of very fine sand (sand blotter) should be placed at the top of the filter pack to separate the filter pack from the overlying bentonite seal.

A bentonite seal should be placed in the well above the filter pack sand. Bentonite pellets or natural chunks may be used if they are installed below the water table and do not have to free fall through more than approximately 15 feet of water. Where the bentonite is installed through more than 15 feet of water, the bentonite should be hydrated and emplaced as a slurry under pressure through a tremie pipe. The slurry should consist of approximately 15 pounds of powdered bentonite to 7 gallons of potable water. The tremie pipe should have a deflector at the bottom to prevent the grout from being jetted into the filter pack sand.

The bentonite seal should extend from the top of the sand blotter up the annular space to the water table surface for a minimum of 3 feet. A second 0.5-foot thick sand blotter should top the bentonite seal. The annular space above the water table should be filled to within 5 feet of the surface with a cement/bentonite grout consisting of 2 to 5 pounds of powdered bentonite per bag of Portland cement mixed with 5 to 6 gallons of potable water (*SOP13 – Monitoring Well Grouting Techniques*). The cement/bentonite grout should be tremied into place from the bottom of the annulus to the top. The tremie pipe should have a deflector at the bottom to prevent jetting of the grout into the bentonite seal.

Cement/bentonite grout should be used as the annulus seal directly above the filter pack or the sand blotter when the well screen extends above the water table. Within the unsaturated zone, the formation may not yield sufficient water to keep a bentonite seal fully hydrated. If a bentonite seal dries out, it may crack, jeopardizing the integrity of the seal.

Where the concentration of total dissolved solids in the groundwater is high (greater than approximately 500 parts per million), the chloride concentration is high, or when substantial thickness of phase-separated liquids are present, neither bentonite nor cement/bentonite grouts may be suitable. Under these cases, the grouting material must be selected based on the specific characteristics present at the site.

The upper five feet of the annulus (or to the top of the bentonite seal when it terminates at depth less than five feet) should be filled with concrete. This portion of the annulus seal needs the structural strength of concrete to protect the casing and the well cover. The concrete should extend below the frost depth. The concrete should be no more than a few inches larger in diameter than the well borehole. This will prevent frost action from lifting the well. The top of the concrete should slope away from the well to direct rain water away. Where a concrete apron surrounding the well is desired or required by regulation, it should be constructed with a joint around the concrete that fills the top of the annulus to assure separation of the well from the apron.

3.4 Well Covers and Surface Finishing

A well cover should be set in the concrete at least three feet below the ground surface and extend one to two inches above the well pipe. The diameter of the well cover should be sufficient to allow room to remove the well cap with gloved hands. The well cover should have a locking, hinged lid that prevents the entrance of rain water. A small hole should be drilled in the side of the well cover approximately six inches above the ground surface to allow moisture to drain from the well cover. The space between the well cover and the well pipe should be filled with coarse sand or fine gravel.

Alternately, the well may terminate in a specifically-built surface mount well cover. The surface mount well cover should never be used when the ground surface is low and storm water could pond over the well. When the existing surface is low and a flush-mounted well is designed, the surface should be regraded to prevent water from standing over the well. In paved parking lots or driveways, a small mound two to three inches high sloping away from the well may be sufficient to divert storm runoff away from the well opening.

Permanent labels should be affixed on both the inside and outside of the well cover lid. The label should include a unique well identification code and the elevation of the water level measuring point. The label may also include the date the well was drilled. A notch should be cut or filed in the top of the well pipe to mark the water level measuring point.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Field Quality Assurance/Quality Control (QA/QC) procedures can be implemented to ensure that a monitoring well has been installed according to the designed specifications as described in the project planning documents.

Field QA/QC begins with an inspection of the well construction materials. The materials should conform to those specified in the design, or to generally approved and accepted materials.

Damaged materials, as well as opened or visibly contaminated materials (sandpack, well screens and risers) should not be used. Small samples of well backfill materials (sandpack, gravel pack, and bentonite) should be collected. Should the well malfunction or fail at a later date, these samples may assist in identifying the source or cause of the malfunction or failure.

Placement of monitoring well construction materials should be monitored closely to ensure placement of backfilled materials to the appropriate depths. All materials should be placed slowly into the borehole to prevent backfilling to a level beyond the designed level. A weighted tape, or a known length of lightweight rigid PVC, can be used to measure the depth below ground surface to the top of the well construction materials placed within the borehole.

Although lengths of screen and riser pipe are manufactured to close tolerances, variations in length typically occur. Therefore, good practice necessitates that the total length of the well be measured once it is assembled and placed in the borehole. The length can be measured by dropping a weighted tape into the bottom of the well. Based on the measured total well depth and the relative stick-up above ground surface, the depth of the well can be adjusted to obtain the proper depth below ground surface.

Close monitoring of grouting should be performed to ensure that grout of an appropriate consistency is administered to the borehole. The density of the grout can be measured with a mud balance scale and compared to design specifications. The grout should be measured on a per batch basis. As grout is pumped into the borehole to seal the well from the surface, grout flowing from the borehole should be of the same consistency as that being pumped into the borehole. Grout should be pumped into the borehole until the observed consistencies are the same, thereby indicating that diluted grout has been displaced from the borehole.

Occasionally, cutting of the well riser is necessary to accommodate surface finishing. Should the riser require cutting, all efforts should be made to prevent shavings, grindings, etc, from entering the well. A temporary expandable plug should be placed within the riser at a safe distance below the cut line. The plug and shavings can be removed after cutting.

Throughout the construction process, the well should be checked for obstructions due to flexing and kinking of the well, or collapse of weak construction materials. A rigid “dummy” block, constructed of an appropriate material, can be lowered into the well to check for clearances and obstructions. The diameter and length of the dummy should be similar to that of equipment to be installed in the well (pumps, controls, data loggers, *etc.*).

If the plumbness and alignment of the well is critical for its intended use, the well should be tested in accordance with AWWA Standard A-100-84. Test methods and allowable tolerances should be provided in the drilling specifications.

5.0 DOCUMENTATION AND RECORD KEEPING

Information to be collected during monitoring well installation will include, at a minimum, the following information:

- Well construction material type (stainless steel, PVC, *etc.*)
- Diameter of well materials
- Well screen length and specifications
- Diameter and depths of boreholes
- Casing diameter, depth, and material
- Drilling methods
- Type, quantity, and depths of borehole sealing materials (above and below the well)
- Type, quantity, and depths of screen packing (gravel and/or sand)
- Grout volumes and densities
- Total depth of well (ft below ground surface)
- Depths of screen materials (ft below ground surface)
- Protective casing stick-up (ft above ground surface)
- Riser stick-up (ft above ground surface, or ft below ground surface if flush-mount system)
- Static depth to water (ft below an identified reference mark)
- Methods of material placement

Recording of the data should be completed in the field at the time of measurement or observation. The field logbook should be the primary repository for field data and observations; however, field forms may provide a more suitable format for collecting and analyzing the data.

In addition to the well construction specifics identified above, the following information should be recorded to provide a clear account of the well construction project:

- Drill rig make/model, name of drilling subcontractor, and driller's name(s)
- Weather conditions
- Boring location identification, including physical description of location in reference to site features, and description of surface conditions at location
- Borehole advancement method
- Depth to water at completion of boring
- Any problems or significant events that occurred during drilling and sampling

6.0 REFERENCES

Aller, L., Bennett, T.W., Hackett, G., Petty, R.J., Lehr, J.H., Secoris, H., and Nielsen, D.H., 1989, Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells: Dublin, Ohio, National Water Well Association.

Driscoll F.G., 1986, Groundwater and Wells - Second Edition: St. Paul, Minnesota, Johnson Screens, 1089 p.

Gass, T.E., 1988, Monitoring Well Filter Pack and Screen Slot Selection: A Reassessment of Design Parameters: Water Well Journal, v. 42, no. 5, p. 30-32.

U.S. EPA, 1986, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document: Office of Solid Waste and Emergency Response, Washington, D.C.

13 - MONITORING WELL GROUTING TECHNIQUES

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) provides general reference information and technical guidance on monitoring well grouting techniques. This procedure gives general guidelines only and may be modified by requirements necessary to meet project specific objectives. Selected monitoring well grouting techniques, which can be applied to monitoring well installation, are also presented in this procedure. Grouting consists of filling an annular or other space with an impervious material. The primary reasons for grouting are as follows:

- Preventing water movement between aquifers, for purposes of maintaining water quality and preserving the hydraulic response of the monitored zone(s)
- Protecting the well against the entry of water from the ground surface or shallow subsurface zone
- Abandoning a boring not converted to a monitoring well

Another purpose of grouting is to protect the casing against attack by corrosive waters.

1.1 Referenced SOPs

None

1.2 Definitions

Neat Cement Grout: A fluid mixture of Portland cement and potable water of a consistency that can be forced through a pipe and placed as required. This mixture consists of 5.2 gallons of water per 94-pound bag of Type I or Type II Portland cement. When using Type III Portland cement, the mixture is to be 6.3 to 7 gallons of potable water per 94-pound bag of cement.

Cement/Bentonite Grout: A mixture of approximately 8.3 gallons of potable water and 5 pounds of bentonite per 94-pound bag of Type I or Type II Portland cement. Powdered bentonite is used to reduce shrinkage and permeability, increase fluidity, and/or control setting time. Potable water must be used for this mixture. The amount of powdered bentonite used in the neat cement grout is approximately 5 percent by weight. For every additional 2 percent of bentonite added by weight, 1.3 gallons of water should also be added for each 94-pound bag of cement.

2.0 REQUIRED MATERIALS

Acceptable grout mixtures for monitoring well installation include neat cement grout and bentonite/cement grout. The drilling contractor is responsible for supplying these materials.

3.0 METHODOLOGIES

There are several methods for monitoring well grouting. In determining the specific grouting requirements for a monitoring well, considerations must be given to existing subsurface geologic and groundwater conditions. The most effective grouting method should be selected by the site hydrogeologist based on the particular site conditions. Selection of the grouting technique and material may be limited by state or local regulations. Consultation with appropriate agencies prior to beginning grouting activities is advisable. Site-specific methodologies should be stipulated in the project work plan.

Prior to grouting, the annular space should always be flushed to assure that the space is open and able to receive the sealing material. This is performed by circulating water or other drilling fluid in the annular space. Grouting should be performed in one continuous operation in which the annular space is filled. Grout containing cement should be placed entirely before the occurrence of the initial set. It is essential that the grout always be introduced at the bottom of the space being grouted such that positive displacement of any water in the annular space occurs.

The grout may be forced into the annular space by suitable pumps or by air or water pressure. Under certain conditions (*i.e.*, when no water exists in the annular space), placement by gravity is practical and satisfactory.

The following sealing and grouting procedure is recommended for most monitoring wells. Following placement of the filter pack, a 2-foot bentonite seal should be placed above the filter pack. Granular bentonite, bentonite pellets, or bentonite chips are suitable for this application. For monitoring wells that are less than 30 feet deep, the bentonite may be dropped directly down the borehole within the annular space. This should be performed gradually and uniformly in order to prevent bridging. In addition, a tamping device should be used to prevent bridging. For monitoring wells that are greater than 30 feet deep, bentonite should be delivered using a tremie pipe. If a bentonite seal is installed in the unsaturated zone, granular bentonite should be used, gradually hydrated with potable water, and allowed to cure prior to grouting.

Grouting of the remaining annular space should be performed using a tremie pipe with side discharge ports, a grout pump, and the neat cement grout or bentonite/cement grout in slurry form. The grout slurry should be pumped to the bottom of the borehole through the tremie pipe which should be kept full of grout for the duration of the procedure. The tremie pipe should be raised slowly as the annular space fills with grout. As the tremie pipe is raised, the discharge ports should be kept submerged within the grout until the desired zone is completely grouted. An annular space of at least 2 inches between the borehole wall and the well casing should exist, and the minimum inside diameter of the tremie pipe should be 1.5 inches.

4.0 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

The grouting of any well or piezometer should be performed by a well driller licensed in the state in which the well is located. The grouting activities should also be supervised by a geologist or

engineer who is competent in well drilling and construction techniques, and knowledgeable of project specific requirements. The volume of grouting materials used should be monitored to ensure that bridging or borehole collapse did not occur during grout placement. When grouting multiple casings, the grout should be permitted to set for a minimum of 24 hours before drilling is resumed at the well location. The grout should be visually inspected for settling following curing, and additional grout should be added, as necessary, to raise the grout to the desired elevation.

5.0 DOCUMENTATION AND RECORD KEEPING

The supervising geologist / engineer should record the following information:

- Types and quantities of grouting materials
- Grouting technique
- Degree of grout settling
- Interval grouted below ground surface

6.0 REFERENCES

Driscoll, F.G., 1986, *Groundwater and Wells – Second Edition*: St. Paul, Minnesota, Johnson Screens, 1089 p.

New Jersey DEP, August 2005, *Field Sampling Procedures Manual*: Trenton, New Jersey.

Ohio EPA, February 1995, *Technical Guidance Manual for Hydrogeologic Investigations and Ground Water Monitoring*: Columbus, Ohio, Division of Drinking and Ground Waters.

U.S. EPA, September 1986, *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*: Office of Waste Programs Enforcement, Washington, D.C., EPA/530/SW-86/055.

14 – WELL DEVELOPMENT

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) provides guidance for developing monitoring wells or extraction wells following installation and prior to their designated use for data acquisition (*e.g.*, groundwater sampling, aquifer testing). Some of these procedures may also apply to well purging conducted prior to collection of water quality samples. However, development should not be confused with purging, the purpose of which is to evacuate the monitoring well of stagnant water which may not be representative of the aquifer.

Monitoring well development is necessary to ensure that complete hydraulic communication is made and maintained between the well screen and the water-bearing formation. Development is necessary after original installation of a monitoring well to:

- Restore aquifer properties near the boring that were disturbed during drilling by reducing the compaction and mixing of grain sizes that occurred during drilling
- Remove fine-grained materials from the filter pack that were introduced during drilling and well installation, which could potentially affect water quality analyses
- Improve the hydraulic characteristics of the filter pack and the hydraulic communication between the well and the screened hydrogeologic unit by removing any drilling fluids or mud that cake the sides of the borehole or that may have invaded the adjacent natural formation
- Remove all water introduced into the borehole while drilling.

Formation characteristics change during drilling and well installation, and usually include the compaction of unconsolidated particles surrounding the annulus. In fine-grained soils, this can result in a mudwall around the boring annulus, which can impede free flow of formation water into the well. Monitoring well development physically agitates the formation around the well boring by pushing and pulling water through the filter pack and surrounding formation. This repetitive process flushes fine-grained soils into the well, where they either settle within the filter pack or are removed from the well during development and purging.

Common well development methods include surging, pumping, and bailing. The most effective technique involves using both a surge block in combination with pumping or bailing, so that water moves in both directions through the filter pack and the native formation surrounding the well screen.

This well development procedure also applies to rehabilitation of monitoring wells in which siltation has occurred. After a well has been in place for some period of time, the well depth may decrease due to accumulation of fine soil particles (siltation), and rehabilitation will be necessary to reestablish complete hydraulic communication with the aquifer.

1.1 Referenced SOPs

25 – Equipment Decontamination
26 – Depth to Groundwater and NAPL Measurements

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

The following equipment may be required when performing well development. Not all equipment may be required, depending on the well development method used.

- Surge block on a cable or line
- Appropriate pump (centrifugal pump, submersible pump, or peristaltic pump)
- Bailers and bailer cord
- Compressed gas source and air discharge line; water discharge line
- Storage containers for the purge water
- Water level probe and/or oil-water interface probe
- Copy of the well construction diagram
- Field logbook
- Well development sheets
- Personal protective equipment as specified in the Health and Safety Plan
- Water quality monitoring instrument capable of measuring dissolved oxygen (DO), conductivity, pH, turbidity, temperature and oxidation-reduction potential (ORP)

The various specific development procedures discussed in Section 3.2 identify the different types of equipment which may be used to develop monitoring wells or extraction wells. Exact equipment needs will be specific to the monitoring well and will depend upon the diameter of the well, the depth to water, and other factors such as project objectives and intended use of the well.

3.0 METHODOLOGIES

Newly installed monitoring wells shall be developed no sooner than 48 hours after installation. The entire vertical screened interval should be developed using surge blocks, bailers, pumps or other equipment that frequently reverse the flow of water through the screen and prevent bridging of the formation or filter pack particles.

3.1 General Well Development Procedures

1. The depth to water in the well and the possible presence of NAPLs are measured in accordance with *SOP 26 – Depth to Groundwater and NAPL Measurements*. The total depth of the well should be measured with a weighted tape and the result compared to the original depth reported in on the well construction form and/or the field notes.

2. Remove a small quantity of water from the well using a decontaminated pump or bailer. Measure and record initial pH, temperature, conductivity, DO, ORP, and turbidity.
3. Begin well development by surging the bottom of the well and removing any sediment that has accumulated. To do this, slowly lower a decontaminated surge block into the well so that the block is approximately 6 to 12 inches from the bottom of the well or the measured sediment level. Slowly raise and lower the surge block approximately 1 to 2 feet to create a mild surging effect at the bottom of the well. This will resuspend accumulated sediment. Do not agitate the water violently. After several surge strokes, remove the surge block and immediately begin to pump or bail the sediment-laden water. Repeat this process until accumulated sediment is removed from the bottom of the well and total well depth is as reported on the well construction diagram and/or field notes.
4. Work upwards from the bottom of the screened interval using the same alternating techniques of surging and pumping or bailing. If an air compressor is used to remove the sediment-laden water, a filter must be installed on the compressor to prevent introduction of oil into the well.
5. The minimum volume of water (*e.g.*, three casing volumes) which must be removed during development is usually specified in the project work plan. In practice, development of the well is continued until the water removed is essentially free of suspended silt and clay particles, to the extent practicable. In some aquifers, it may not be possible to remove all suspended solids regardless of the extent of development activities. The supervising hydrogeologist is ultimately responsible for the determination that the well has been sufficiently developed and that development can be terminated.
6. Field measurements (pH, DO, ORP, specific conductance, temperature, and turbidity) can be taken as a confirmation of sufficient development. Adequate development can be verified by stable readings of these field parameters.
7. Measure and record a final depth to water and a total well depth after development. Record all well development data on the Well Development form and/or in the field logbook.

3.2 Specific Well Development Procedures

The appropriate development method will be selected for each project on the basis of the specific circumstances, objectives and requirements of that project. Further, some agencies have developed comprehensive guidelines for groundwater monitoring and subsurface investigation procedures. The provisions of this SOP will be adapted to these project-specific requirements in the project work plan. The work plan will specify the well development method(s) to be used and the rationale, including trade-offs associated with the nature of the aquifer formation, analytical objectives, well use, and client or agency requirements.

Aside from agency requirements, the criteria for selecting a well development method include well diameter, total well depth, static water depth, screen length, the intended well use, and the type of geologic materials in the aquifer.

The limitations, if any, of each specific procedure, are discussed in each of the following procedure descriptions.

3.2.1 Surging

A surge block consists of a rubber (or leather) and metal plunger attached to a rod or pipe of sufficient length to reach the bottom of the well. Well drillers usually can provide surge blocks for large diameter wells (greater than 6 inches). Surge blocks for smaller diameter wells can be constructed easily of materials readily accessible in any hardware store. A recommended design is shown in Figure 1. Surging alone will not cause sufficient well development; however, surging used in conjunction with groundwater removal *via* pumping, bailing, or air-lifting effectively develops most monitoring and extractions wells.

The procedure to be followed when using the surge block is:

1. Construct a surge block using the design in Figure 1 as guidance. Specific materials will depend upon the diameter of the well to be developed. The diameter of the plunging apparatus must be sufficient to force the groundwater in the well out through the well screen, and the rods must be of sufficient length to reach the bottom of the monitoring well.
2. Insert the surge block into the well and lower it slowly to the level of static water. Start the surge action slowly and gently above the well screen using the water column to transmit the surge action to the screened interval. A slow initial surging, using plunger strokes of 3 to 5 feet, will allow material which is blocking the well screen to disengage from the screen and become suspended.
3. After a number (5 to 10) of surge strokes, remove the surge block and purge the well using a pump or bailer. The returned water should be heavily laden with suspended fine particles. As development continues, slowly increase the depth of surging to the bottom of the well screen. For wells with long screens (greater than 10 feet) surging should be undertaken along the entire screen length in short intervals (2 to 3 feet) at a time.

Continue this cycle of surging and pumping/bailing until well development is complete.

3.2.2 Pumping

Groundwater pumping is necessary to remove large quantities of sediment-laden groundwater from a well after using the surge block. In some situations, pumping is performed without surging. Since the primary purpose of well development is to remove suspended solids from a well, the pump must be capable of moving some solids without damage. The preferred type of pump is a centrifugal pump because of its ability to pump solids. However, a centrifugal pump

will work only where the depth to groundwater is less than approximately 25 feet. If depth to groundwater is too great, a positive-displacement pump such as a submersible or bladder pump will be necessary.

Well development using a pump is more effective in those wells that will yield water continuously. Effective development may not be accomplished if the pump has to be shut off to allow the well to recharge.

The procedure to be followed for well development *via* pumping is:

1. Set the intake of the pump in the center of the screened interval of the monitoring well.
2. When appropriate, use the pump to fill the monitoring well to the top of the casing and allow the water level to decline to the static level, thereby forcing water back into the formation. This action will cause water to exit the well screen and reduce the bridging of materials caused by water flowing in one direction through the well screen while pumping.
3. The water used to fill the monitoring well should be the same water removed from the well during the previous pumping cycle. The sediment previously pumped from the well must be removed from the water prior to re-introduction to the well. A steel drum can be used as a sediment-settling vessel.

Continue pumping water out from the well until well development is complete.

3.2.3 Bailing

A bailer is an effective tool for development of small diameter monitoring wells where removal of only a relatively small volume of water is required for development. A bottom-filling bailer can also be used to remove sediment-laden water from wells after using the surge block.

The procedure to be followed for well development *via* bailing is:

1. Lower the bailer into the screened interval of the monitoring well.
2. Using long, slow strokes, raise and lower the bailer in the screened interval simulating the action of a surge block.
3. Periodically bail standing water from the well to remove fine particles drawn into the well.

Continue surging the well and removing water from the well until well development is complete.

3.2.4 Air-lifting

Air-lifting with compressed air can be used to both surge and purge a monitoring well. An air compressor is used to inject gas at the bottom of the water column, driving sediment-laden water to the surface. Compressed air can also be used for “jetting” - a process by which the air stream is directed at the slots in the well screen to cause turbulence (thereby disturbing fine materials in the adjacent filter pack). Compressed air is not limited to any depth range.

The hose or pipe which will be installed in the well for jetting should be equipped with a horizontal (side) discharge nozzle and one or more small holes in the bottom of the hose to enhance the lifting of sediment during jetting.

Provisions must be made for controlling the discharge from the wells. This is generally accomplished by attaching a “tee” discharge to the top of the casing and providing drums or other containers to collect the discharged water.

Although the equipment used to develop a well using this method is more difficult to handle and use, well development using compressed air for jetting the well screen is considered to be a very effective method. This method also is the most generally applicable because it is not limited by well depth, well diameter, or depth to static water.

The procedure to be followed for well development *via* air-lifting is:

1. Lower the gas line from the gas cylinder into the well, setting it near the bottom of the screened interval. Install the water discharge control equipment at the well head.
2. Set the gas flow rate to allow continuous discharge of water from the well. The discharge will contain suspended clay and silt material.
3. At intervals during gas-lifting, especially when the discharge begins to contain less suspended material, shut off the air flow and allow the water in the well to flow out through the screened interval to disturb any bridging that may have occurred. Restart the gas flow when the water level in the well has returned to the pre-development level.
4. Jetting of the screened interval also can be done during gas-lifting of water and sediment from the well. This is accomplished by using a lateral-discharge nozzle on the gas pipe or hose and slowly moving the nozzle along the length of the screened interval. Jetting should be done beginning at the bottom of the well screen and moving slowly upwards along the screened interval. To enhance gas lifting of sediment, occasionally raise the discharge nozzle into the cased portion of the well and discharge sediment-laden water.

Continue air-lifting and/or jetting until well development is complete.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Development of new monitoring wells or extraction wells is the responsibility of the hydrogeologist involved in the original installation of the well. The geologist may, in fact, contract with the well driller to develop new wells under the geologist's guidance and oversight. If the project involves sampling of existing monitoring wells, the hydrogeologist is also responsible for verifying the original well construction details and determining if a previously installed well requires rehabilitation.

Monitoring Well Construction Details

A copy of the original well construction diagram for the well to be developed must be obtained from the Project Manager. This form provides critical information regarding the construction of the monitoring well and must be in the possession of the well development crew so that pertinent well construction details, such as total well depth and screened interval, are known.

Equipment Decontamination

All equipment which contacts development water or is placed inside a well should either be dedicated for use on only a single monitoring well or should be decontaminated, in accordance with *SOP 25 - Equipment Decontamination*, to prevent cross-contamination between monitoring wells or recovery wells.

Successful Development Criteria

A well has been successfully developed when one or more of the following criteria are met:

- The well yields clear, sediment-free water to the extent possible
- field measurements of pH, specific conductance, temperature, and turbidity have stabilized
- aquifer response and well yield are observed to be representative of the type of lithologic formation over which the well is screened

the well is free of sediment, the measured well depth is consistent with the well construction diagram, and that depth is maintained for some extended period of time

Development Water Management

The work plan must specify the means for managing development and purge water. At active facilities, an active water treatment facility may be available for management of development and purge water. Otherwise, the water should be containerized until analytical results are available to determine the applicable management options.

5.0 DOCUMENTATION AND RECORD KEEPING

If required, a Well Development Form (Attachment 1) will be completed by the geologist or hydrogeologist conducting the development. In addition, a Field Log Book should be maintained detailing any problems or unusual conditions which may have occurred during the development process.

All documentation will be retained in the project files following completion of the project. In addition to the hard copies, files will be scanned and placed in the permanent digital project files.

6.0 REFERENCES

American Society of Testing and Materials, 1996, ASTM Standard D5521-05: Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers: West Conshohocken, Pennsylvania.

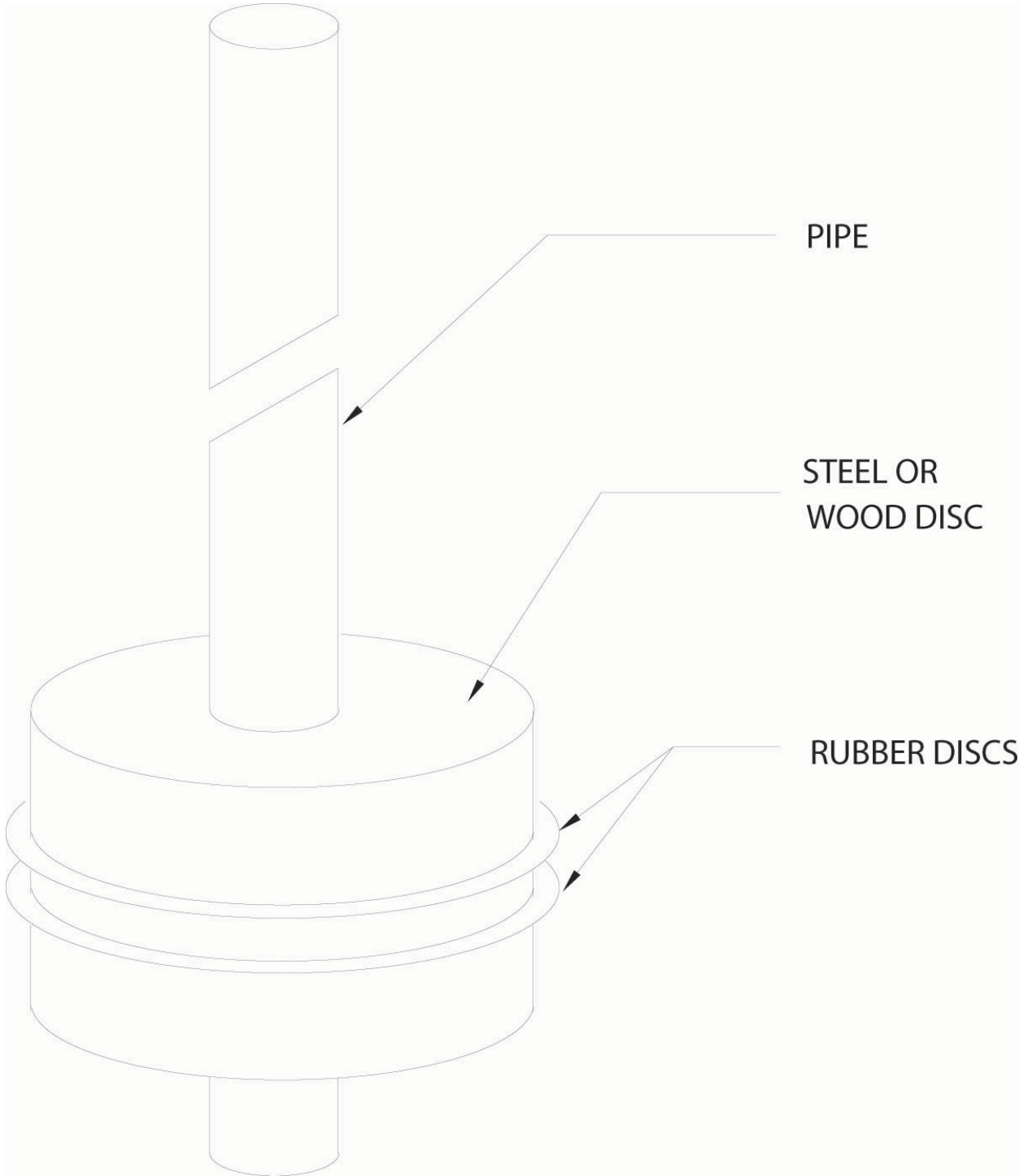


Figure 1. Example Surge Block Design

ATTACHMENT 1
SOP 14 – WELL DEVELOPMENT
WELL DEVELOPMENT FORM

KEY Environmental, Inc. - Well Development Form																							
Project Name: Project No.: Site Location: Purge/Development Method: (e.g. bailing, pumping, surge block, etc.) Notes:	Well #: Total Depth of Well (ft-TOC, ⁽¹⁾): _____ Water Level (ft-TOC, ⁽¹⁾): _____ Date of Measurement: _____ Time of Measurement: _____ Measurement of TOC: (1) to TOC, (2): _____																						
Feet of water in well = _____ Diameter of well (in) = _____	Well Volume Calculation Diameter (in)* = _____ Gallons per Foot* = _____ ¹ Well Volume = Gallons per Foot x Height of Water in Well = _____ gallons ¹ Well Volume = _____ gallons *See Table to Right					<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Well Diameter</th> <th style="text-align: left;">Gallons Per Foot</th> </tr> </thead> <tbody> <tr><td>1.5</td><td>0.092</td></tr> <tr><td>2</td><td>0.163</td></tr> <tr><td>3</td><td>0.367</td></tr> <tr><td>4</td><td>0.653</td></tr> <tr><td>6</td><td>1.469</td></tr> <tr><td>8</td><td>2.611</td></tr> </tbody> </table>				Well Diameter	Gallons Per Foot	1.5	0.092	2	0.163	3	0.367	4	0.653	6	1.469	8	2.611
Well Diameter	Gallons Per Foot																						
1.5	0.092																						
2	0.163																						
3	0.367																						
4	0.653																						
6	1.469																						
8	2.611																						
Time	Gallons of Water Pumped	Well Volumes Pumped	Turbidity (NTUs)	Temperature (degrees F or C)	Conductivity (um)	pH (standard units)	Dissolved Oxygen (mg/L)	eH (mv)	COMMENTS														
Hydrogeologist / Engineer (signature) _____					Reviewed By / Date: _____																		

Notes: (1) ft-TOC, indicates foot below top of inner casing/liner; (2) TOC, indicates below top of outer annular casing; (3) n/a indicates data not collected

18 - GROUNDWATER FLOW DIRECTION AND HYDRAULIC GRADIENT DETERMINATION

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) provides information and guidance for determining groundwater flow direction and hydraulic gradient. This information is used typically to support hydrogeologic assessments and site investigations performed to evaluate the fate and transport of constituents in groundwater. Data from a minimum of three wells are required for this determination.

1.1 Referenced SOPs

None

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

Determining groundwater flow directions and horizontal hydraulic gradients requires both field and office materials. The necessary field materials are as follows:

- A minimum of three wells and/or piezometers with similar screen lengths and screened intervals located within the same water-bearing unit
- A water level probe with graduated measuring tape
- A surveyed measuring point of known elevation on the inner or outer well casing

The following office materials are recommended for calculations and illustrations related to groundwater flow direction and gradient:

- Calculator
- Scale (ruler)
- Site map with surveyed well/piezometer locations
- Flexible curve
- Computer contouring software

3.0 METHODOLOGIES

3.1 Potentiometric Surface

Groundwater flow direction and horizontal hydraulic gradient should be determined by first constructing a representation of the groundwater potentiometric surface in the form of a potentiometric surface contour map. This requires a network (of at least three but preferably

more) groundwater monitoring wells and/or piezometers screened at similar intervals in the same, continuous, water-bearing unit. Potentiometric surface elevations are to be contoured, using an appropriate contour interval that provides sufficient spatial information without cluttering the map.

Potentiometric surface elevation data are determined by measuring the depth to water in each well or piezometer from the surveyed measuring point elevation. Subtracting this depth from the measuring point elevation yields the elevation of the potentiometric surface (total head) at that particular location, as follows.

$$E_{ps} = E_{mp} - D_w$$

where

- E_{ps} = Potentiometric surface elevation;
- E_{mp} = Measuring point elevation; and
- D_w = Depth to water from surveyed measuring point.

Potentiometric surface elevation data for each individual monitoring point are plotted on a map with the surveyed locations of the wells and piezometers. The next step is to contour these data for the purpose of depicting the configuration of the potentiometric surface. For a large well network with several data point locations, a computer contouring package is recommended in order to manage the large amount of data. Such software should be used according to the respective user's manual. In addition, computer-generated contours should most always be reviewed by the scientist or engineer producing the potentiometric surface contour map and personnel familiar with site conditions. Necessary modifications to the contours should be made as necessary to eliminate any computer-generated artifacts that are not representative of site conditions.

At sites with a fewer number of wells and/or piezometers, manual data analysis and production of potentiometric surface elevation contour maps may be preferable. When manually producing these maps, potentiometric surface elevation data should also be plotted adjacent to the surveyed monitoring locations. Potentiometric surface elevations should then be estimated at locations along a transect between two reference wells or piezometers for which data have been obtained. These estimated elevations should correspond to an appropriate contour interval. This estimation can be performed using the following equation.

$$dl = (dh \times dL)/dH$$

where

- dl = Scaled distance from one of the reference wells to the contour location;
- dh = Difference in head from the reference well to the contour location;
- dL = Scaled distance between the two reference wells; and
- dH = Difference in head between the two reference wells.

After completing the procedure described above for all pairs of monitoring wells, contours should be drawn to connect points of equal potentiometric surface elevation. This step should be performed using a flexible curve and according to standard contouring procedures. For example,

contours of different elevations should not intersect and contours should not have sharp or jagged bends. Contours should also be drawn with consideration to known information regarding site-specific hydrogeology and surface hydrology. In other words, one should not simply “connect the dots.”

With the potentiometric surface configuration determined, the groundwater flow direction can be evaluated. The direction of groundwater flow is perpendicular to the equipotential lines (contours) of the potentiometric surface map assuming homogeneous and isotropic conditions. Groundwater flow directions may be variable across a particular site depending on the complexity of the potentiometric surface. Consequently, one should determine specific site areas of interest when evaluating the various groundwater flow directions at a site.

3.2 Horizontal Hydraulic Gradient

The horizontal hydraulic gradient should also be determined along a transect that is perpendicular to the equipotential lines that comprise the potentiometric surface contour map. The equation for calculating the horizontal hydraulic gradient is as follows:

$$I = dh/dl$$

where

- I = Horizontal hydraulic gradient;
- dh = Change in head; and
- dl = Change in horizontal distance (over which the head loss occurs).

Where possible, differences in head should be determined from measured potentiometric surface elevations associated with existing wells and/or piezometers, as opposed to referring to estimated potentiometric surface elevations associated with contour lines. However, this should only be done when the transect defined by the two wells and/or piezometers is nearly perpendicular to the equipotential lines.

3.3 Vertical Hydraulic Gradient

Vertical hydraulic gradients can be determined by comparing water elevations in adjacent (clustered) wells or piezometers that are screened at various intervals. If the water elevation is higher as the screened depth increases, the vertical gradient is upward indicating a discharge condition; conversely, if water elevations decrease with increased depth, the vertical gradient is downward indicating a recharge condition. An actual gradient can only exist at clustered locations if hydraulic communication between the depth intervals is known to exist.

In order to evaluate vertical gradients throughout a site, the data are manipulated to generate ratios used for comparative purposes. To develop the ratio (dh/dl) for each set of clustered wells, the change in elevation (or head), dh, is divided by the change in distance (length), dl, between the midpoint of the screens (or open borehole) for the wells of interest. When designing well placement to measure vertical gradients, the horizontal distance between clustered wells should not exceed the vertical distance between the midpoints of the screens. The negative or positive

characteristic of the resultant value will indicate the nature of the flow (*i.e.*, recharge or discharge).

4.0 QUALITY ASSURANCE/QUALITY CONTROL

In order to assure quality when evaluating groundwater flow directions and gradients, the person performing the evaluation should verify that all measured and calculated numbers are correct and correspond to the appropriate well or piezometer. If regional or other groundwater flow and/or gradient data are available, it is recommended that the evaluator determine whether the site groundwater flow direction(s) and gradient(s) are consistent with the regional information. Similarly the determined groundwater flow direction(s) and gradient(s) should be evaluated within the context of other available hydrologic information to verify accuracy. Individual contour lines should be compared to adjacent control points and calculations should be reviewed.

5.0 DOCUMENTATION AND RECORD KEEPING

The following information should be recorded or otherwise available when performing an evaluation of groundwater flow directions and hydraulic gradients:

- Monitoring well / piezometer identification
- Depth to water in well from point of surveyed elevation
- Elevation of monitoring well / piezometer reference point
- Time and date of water level measurement
- Monitoring well / piezometer location
- Screened intervals and hydrostratigraphic framework
- Calculated potentiometric surface elevation
- Calculated hydraulic gradients

All information developed should be shown in figures or tables appropriate for inclusion in a report.

6.0 REFERENCES

Domenico, P.A. and Schwartz, F.W., 1990, Physical and Chemical Hydrogeology: New York, John Wiley & Sons, Inc., 824 p.

Fetter, C.W., 1994, Applied Hydrogeology: New York, Macmillan College Publishing Company, Inc., 691 p.

Heath, R.C., 1983, Basic Ground-Water Hydrology: U.S. Geological Survey Water Supply Paper 2220, 84 p.

Saines, M., 1981, Errors in Interpretation of Ground-Water Level Data: Ground Water Monitoring and Remediation, v. 1, p. 56-61.

20 - VOLATILE ORGANIC SCREENING

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) presents Key Environmental Inc.'s standard methodology for performing field screening of samples for the presence of volatile organic compounds (VOCs). Field screening may be performed either directly by holding the instrument over the sample or via headspace screening by placing the sample in a sealed jar prior to screening. Additionally, headspace screening can be used when first opening a well prior to measuring water levels or purging/sampling.

Screening for the presence of VOCs may also be used to help determine whether site workers may need breathing protection during site activities, although this information alone is not adequate for making a final health and safety decision. Such screening may occur when personnel first arrive on site by screening ambient air. Screening may also be used to determine appropriate protection required to safely sample wells, soils, or other matrices. However, the most common use of VOC screening is to aid in a soil sampling program or determining where a well screen should be set.

Key generally uses two models of the HNu™: HW-101 and PI-101. The HNu™ is a portable, nonspecific, vapor/gas detector employing the principle of photo ionization to screen for a variety of volatile organic compounds in air. PIDs operate by photo ionizing molecules with an ultraviolet lamp and measuring the current generated by ions at a collection point in the ionization chamber.

Organic vapor monitoring using a PID generally serves two purposes:

- To monitor potential airborne chemical constituents and thereby assess the potential exposure of site workers, as specified in the site-specific Health and Safety Plan
- To evaluate organic vapor concentrations in various media to assist in site characterization

Field screening of subsurface soils is performed to qualitatively identify the presence of VOCs. This information may be subsequently used to:

- Aid in defining the lateral and vertical extent of VOCs in the subsurface (to the extent permitted by the data quality obtained *via* the screening instruments)
- Identify relative changes in VOC concentrations with depth or between boring locations
- Aid in the selection of samples for laboratory analysis based on criteria defined in the site work plan
- Aid in the selection of depths and locations for screen installation in ground water monitoring wells
- Aid in the determination of approximate volumes of solid materials (*e.g.*, soil, waste) for excavation or remediation

The screening equipment will be selected based on knowledge of potential VOCs expected to be present at the Site. Organic vapor meters (OVMs) (including flame ionization detectors [FIDs], see below) detect a wide variety of compounds, including methane, and can be used for general screening. An HNu™ (photoionization detector [PID], see below) will also be a good general screening device in most cases but will not detect methane; therefore, in landfill situations where methane is a by-product and VOCs are also present, both pieces of equipment can be used to determine the relative amount of methane versus VOCs. If the screening is being used to detect a known contaminant, the HNu™ can be calibrated to a standard and/or the appropriate lamp may be selected for screening a particular range of compounds.

PIDs may be susceptible to impacts of temperature and high humidity; therefore, alternative air monitoring devices (*e.g.*, Draeger tubes) which are less sensitive to the effects of high humidity may need to be maintained onsite

1.1 Referenced SOPs

None

1.2 Definitions

Organic Vapor Meter (OVM): A detector that uses a flame or ultraviolet (UV) light to ionize organic molecules and subsequently reports the concentration relative to a known standard.

Flame Ionization Detector: An OVM that uses a hydrogen flame to ionize organic molecules. The unit is calibrated to a methane standard and, in addition to methane, is most responsive for hydrocarbons but also detects oxygenated and nitrated compounds.

Photoionization Detector: An OVM that uses an UV light to ionize organic molecules. The unit is factory calibrated to benzene and can be field calibrated to one of several standards (commonly isobutylene or the compound of interest, if known). The use of different ionizing probes provides differing scales of detection. For use in landfills, the PID probes do not detect methane and are more applicable to volatile screening in these atmospheres.

Headspace Analysis: A field test to evaluate absence/presence of volatile organics in a soil/solid sample.

2.0 REQUIRED MATERIALS

Use of a PID does not require an extensive amount of equipment. The following items should be available at the work site:

- PID and operations manual, including charging mechanism
- Calibration sheets and pens/pencils
- Calibration gas
- UV lamps

- Field logbook and indelible ink pens
- Clean cloth and distilled water for decontamination
- Sample jars or zip-lock type bags

3.0 METHODOLOGIES

To ensure that the photo ionization detector operates properly, the equipment should be calibrated daily before use. Project-specific requirements may require additional, more frequent calibration. The instrument manual should be consulted for calibration standards. Calibration information should be recorded in the Field Logbook and on Instrument Calibration Log Sheets.

The HNu™ may need to have the battery recharged for approximately eight hours following a use of six to eight hours. The user should check the battery charge at the end of each work day to determine if recharging is necessary.

All screening equipment should be calibrated and warmed up prior to use. If field activities take place when ambient air temperatures are below 50 degrees Fahrenheit (°F), the screening equipment and samples should be placed in a heated/warm area if possible.

During operation, the background level should be set at 0 using the 1 to 20 scale. The needle may drift below 0 if the lamp is extinguished, when weather conditions are not favorable to operation, or there is an oxygen deficiency in the ambient air near the probe (particularly below 50 degrees Fahrenheit and if there is precipitation; during headspace analysis, condensate in the jar causes the needle to drift in this manner).

Gas vapor concentrations will vary due to mixing with ambient air during screening. Consequently, the range, not just the peak level, should be identified in the field notes and reports.

The following sections discuss the use of photo ionization detectors in various field activities.

3.1 Air Monitoring

Monitoring for volatile organic compounds will be conducted prior to and during all intrusive site activities, confined space entries, monitoring well inspection and/or sampling and any other field activities where inhalation may occur. Air monitoring for VOCs may also be conducted at the property perimeter to document background air conditions and to ensure that surrounding properties are not being adversely affected by site operations.

Periodic measurements should be taken in the breathing zone to monitor for organic vapors. If the organic vapor levels exceed the air monitoring action levels (for the constituents listed in the project specific health and safety plan) for a sustained period greater than five minutes, ventilate the immediate work area, employ vapor suppression techniques or work upwind of the contamination. If these methods are not feasible or do not reduce the potential exposure below the acceptable levels, then employees must upgrade to Level C protection if benzene is not

present. If benzene is present above the action level of 1 ppm, stop work, cover the area, and contact the Project Manager.

3.2 Soil Core and Split-Barrel Screening

Prior to opening the split barrel, determine and record background reading(s) (the work area should be placed in a location upwind of the drill rig and rig exhaust). When the split barrel is opened, scan the length of the sample with the probe within 1/8 inch of the surface. The screening should proceed slowly enough to permit appropriate equipment response (allow for a 2-second delay). Record the range of readings, if any, and the approximate depth of the maximum reading.

3.3 Small Test Pit Screening

Surface soil, newly exposed soil, soil stockpiles, and excavation surfaces can be screened for the presence of organic vapors using a PID or FID. Before screening newly exposed soil, soil stockpiles, and excavation surfaces, dig a small sample test pit at least 6 inches deep into the soil using a clean, decontaminated sampling tool such as a stainless-steel spoon and/or shovel. For surface soil or other soil directly exposed to the atmosphere for greater than 1 hour, dig a little deeper, approximately 12 inches before soil screening. When digging, minimize the diameter of the test pit, if possible, to reduce advection of soil vapors out of the test pit. Immediately insert the sample tip of the PID or FID into the test pit approximately 1 to 2 inches from the bottom of the hole, taking care not to foul the sample tip with soil particulates or water droplets. Record the maximum detector reading as the final sample concentration on the Soil Sampling Log Sheet or in the Field Logbook.

3.4 Headspace Screening

Headspace organic vapor screening involves the measurement of vapors emitted from solid or liquid samples into the headspace of a sealed container. The results generated from this measurement are semi-quantitative estimates of readily volatilized constituents.

Immediately following split-spoon sample collection, any borehole slough and/or the outer portion of the sample will be removed to prohibit potential cross contamination from overlying materials. The soil of interest should be placed directly into a clean and labeled 4-ounce sample jar using a decontaminated stainless steel knife or spatula. The jar should be filled approximately one half full, leaving sufficient room at the top (headspace) for buildup of VOCs. The jar should be tightly covered with aluminum foil to prohibit the emission of volatilizing compounds; a lid can also be placed overtop the jar, but without the screwing on the lid. After the jars are sealed, they should be placed in an area of moderate temperature (50°F to 70°F) and permitted to stand for a period of time to allow equilibration. At the end of the predetermined time, each sample will be screened by penetrating the foil cover with the equipment probe (after determining and recording background conditions). The evaluation should be of sufficient duration to permit appropriate equipment response (a minimum of 5 seconds should be permitted).

Instead of using a glass sample jar and foil seal, zip-lock bags can be used to store soil samples for headspace screening. Procedures for this method require placing a volume of sample material (should be equivalent for all screened samples) into a quart-sized zip-lock bag. The sample should be crumbled to increase surface area to enhance volatilization. Seal the crumbled sample in the bag being sure to maintain an air pocket within the bag. The bag can be labeled with a marking pen to indicate sample location, depth, and time, and the bag can then be set aside to permit accumulation of volatile organic vapors. Following the predetermined equilibration interval, the sample may be screened by inserting the probe through the bag, or by inserting the probe tip into a small opening along the bag's re-usable seal. The maximum measurement should be recorded in the Field Logbook and/or on sample log sheets.

For more precise field screening measurements, the zip-lock bag method may be modified to include the installation of a stainless-steel air-valve to provide a lead-free monitoring point. The air valve can also be used to administer a volume of hydrocarbon-free air using a volume pump and bottled air (or purified site air using carbon filters).

To avoid problems associated with high relative humidity, when the HNu™ device is used for headspace analysis, the instrument should be maintained at the same or higher temperature than the samples to be analyzed. If erratic instrument responses occur due to high VOC concentrations or elevated headspace moisture, the instrument behavior should be recorded in the field notes. Such a result may render the data unusable.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Instrument calibration must occur on a daily basis, prior to each day's use. More frequent calibration may be specified in the site-specific planning documents. The Field Supervisor must ensure that calibration information is recorded as required.

5.0 DOCUMENTATION AND RECORD KEEPING

Readings should be recorded to indicate the calibration and, for the HNu™, the voltage of the UV lamp. For instance, if a reading of 17 parts per million by volume (ppmv) is reported by the HNu™, the notation should read "17 ppmv VOCs by HNu™ with a 10.2 electron volt lamp calibrated using isobutylene to a benzene standard."

Upon completion of the field activity, all data log sheets must be scanned for the permanent electronic project file. Hard copies of the log sheets also become part of the permanent job records.

6.0 REFERENCES

United States Environmental Protection Agency, May 1993, Subsurface Characterization and Monitoring Techniques: Washington, D.C., EPA/625/R-93/003b.

United States Environmental Protection Agency, December 1987, A Compendium of Superfund Field Operations Methods: Washington, D.C., EPA/540/P-87/001.

21 - GROUNDWATER FIELD TESTING

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) identifies general calibration, measurement, and decontamination procedures for common field testing equipment, including pH and specific conductance meters and thermometers. Defining the procedures that are to be consistently implemented will promote project quality assurance and control measures.

Because certain field parameters (*e.g.*, pH, temperature) are sensitive to climatic effects, field testing is performed on water collected from the first sample aliquot extracted for analysis following purging (generally, this aliquot is split between the volatile organic sample bottles and the field parameters) to ensure that representative measurements are obtained to the extent practicable. Evaluation of various parameters in the field, specifically pH, specific conductance, and temperature, can be used as a preliminary means of identifying potentially impacted areas and to assess changes in water chemistry, which may occur during purging. Measurement of turbidity may be a means of evaluating the adequacy of well development.

The sampling plan may require that measurements of pH, specific conductance, and temperature be reported during purging of the well until these parameters are consistent. This helps to ensure that water representative of conditions in the saturated zone is present in the well prior to sampling. The procedures that follow are generic and may be modified in the site sampling and analysis plan based on the project-specific requirements, the equipment to be used, or the preference of the state or federal agency providing regulatory oversight. Variations from these SOPs should be clearly noted in the field logbook made during the sampling.

1.1 Referenced SOPs

03 – Field Logbook

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

Equipment and materials necessary for completing groundwater field testing include, at a minimum, the following:

- Thermometers (minimum of 2 required for instrument calibration in New Jersey)
- YSI 556 multipurpose meter and calibration solutions
- Spare batteries for the YSI 556 to preclude loss of work time due to discharged batteries
- Clean, plastic sample container (of appropriate size and depth to accommodate the specific probes)
- Squirt bottle and supply of distilled or deionized water

- Field logbook and indelible ink pen
- Appropriate sampling record logs

3.0 METHODOLOGIES

Unless otherwise directed by the site sampling and analysis plan, KEY personnel should follow the procedures indicated below.

3.1 Calibration

All field testing equipment will be calibrated in accordance with the equipment manufacturers' recommendations. The equipment model, readings, and necessary adjustments will be documented in the field logbook and field instrument calibration sheets (Attachment 1).

The YSI field meter, which simultaneously measures pH, oxygen reduction potential (ORP), specific conductivity, total dissolved solids, temperature, dissolved oxygen, and salinity, is calibrated using a prepared solution that is provided by the equipment rental company.

3.2 Measurement

If field parameter measurements are performed during well purging to evaluate the representativeness of the groundwater for sampling, the first testing is performed from the very first bail removed from the well and subsequent testing is performed on the final bail from the first, second, and third well volumes purged (in some cases, removal of four or five well volumes may be required by the sampling plan).

If field parameters are stable (± 10 percent) after three well volumes are removed (or the minimum required by the sampling plan), purging may be discontinued; if conditions have not stabilized, purging should be continued and the water evaluated intermittently until the field parameters have stabilized.

The water to be tested should be placed in a clean, plastic container and readings obtained immediately in the following order:

- Temperature
- pH
- Specific conductance

Each parameter should be measured at least twice to insure data quality. The instrument probe should be immerse in the core of the sample container (*i.e.*, not set on the bottom or against the side of the container) and agitated slowly until the readings are stable. Between readings, the sensor should be thoroughly rinsed with distilled or deionized water.

While every effort should be taken to ensure that indicator parameters stabilize prior to sampling, some indicator parameters are more critical with respect to certain contaminant types. It is

important to identify which indicator parameters are most important to the project prior to initiating field activities so that unnecessarily long purge times can be avoided. For example, the critical indicator parameter associated with volatile organics analysis is dissolved oxygen, while the critical indicator parameter for metals analysis is turbidity. If, after two hours of purging, critical indicator parameters have not stabilized, purging should be discontinued and the samples collected. The efforts made to stabilize the parameters (e.g., changing the pumping rate) should be documented in the field logbook.

3.3 Decontamination

Between samples, whether from the same well or between well locations, the sampling probe should be thoroughly rinsed with distilled or deionized water.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Prior to initiating field activities, the Field Supervisor must review the project planning documents. By maintaining a record of field measurements, calibration notations, and the field logbook, project quality control will not be called into question.

At the end of each day, field logbook and sample log sheet entries should be compared to ensure that no well numbers have been entered incorrectly.

At the end of each day, the YSI should be recharged so that it is ready for the next day.

Meter calibration should be performed on a daily basis before starting the day's field activities. Calibration information should be recorded in the field logbook. Recalibration is required during the day if anomalous readings are obtained or parameters do not stabilize during purging. These conditions could indicate that the meter requires calibration.

5.0 DOCUMENTATION AND RECORD KEEPING

Documentation of field measurement activities should be recorded in the project field logbook (*SOP 03 – Field Logbook*). The field logbook should serve as the primary repository for field data and observations; however, field forms may provide a more suitable format for collecting and analyzing the data.

All data should be recorded at the time of measurement. Information to be recorded should include, at a minimum, the following:

- Project and site identification
- Weather conditions
- Date and personnel present and performing measurements
- Listing of equipment, including name, model and serial numbers
- Calibration procedures and results for each piece of equipment
- Equipment malfunctions

- Measurement results
- Any factors which may have an effect on the project and/or the measurements being collected such as deviations from the project planning documents

At the end of each week, all field calibration sheets and field logbook pages should be scanned and placed in the permanent project files. See *SOP 03 – Field Logbook* for particular requirements.

6.0 REFERENCES

(Reserved)

ATTACHMENT 1
SOP 21 – GROUNDWATER FIELD TESTING
FIELD INSTRUMENT CALIBRATION SHEET

FIELD INSTRUMENT CALIBRATION SHEET

DATE: _____ CALIBRATION: _____
 TIME: _____ DRIFT CHECK: _____
 INSTRUMENT: _____

pH (s.u.)	Spec. Cond. (ms/cm)	Eh/ORP (mV)	Dis. O ₂ (mg/L)	Turb (NTU)	Salinity (%)	TDS (G/L)

DATE: _____ CALIBRATION: _____
 TIME: _____ DRIFT CHECK: _____
 INSTRUMENT: _____

pH (s.u.)	Spec. Cond. (ms/cm)	Eh/ORP (mV)	Dis. O ₂ (mg/L)	Turb (NTU)	Salinity (%)	TDS (G/L)

DATE: _____ CALIBRATION: _____
 TIME: _____ DRIFT CHECK: _____
 INSTRUMENT: _____

pH (s.u.)	Spec. Cond. (ms/cm)	Eh/ORP (mV)	Dis. O ₂ (mg/L)	Turb (NTU)	Salinity (%)	TDS (G/L)

DATE: _____ CALIBRATION: _____
 TIME: _____ DRIFT CHECK: _____
 INSTRUMENT: _____

pH (s.u.)	Spec. Cond. (ms/cm)	Eh/ORP (mV)	Dis. O ₂ (mg/L)	Turb (NTU)	Salinity (%)	TDS (G/L)

22 - ENVIRONMENTAL SAMPLE PREPARATION

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) presents procedures for selecting appropriate sample containers and preservatives when collecting environmental samples for analysis at a selected laboratory. Procedures for packaging and shipping environmental samples are presented in KEY SOP 23 – *Sample Handling, Preservation, Packaging and Shipping*.

Environmental samples are those that are anticipated to be relatively low in analyte concentration. These samples consist of materials that may have been impacted by source area materials, but do not consist of source area materials such as sludge, material from drums, material from bulk storage tanks, *etc.* Examples of environmental samples include: soil samples collected adjacent to or underlying a source area, stream and sediment samples, and groundwater samples (which do not contain non-aqueous phase liquid).

1.1 Referenced SOPs

23 – Sample Handling, Preservation, Packaging and Shipping

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

Required materials for sample containers and preservation may include:

- Laboratory-provided various sized glass containers (with Teflon[®]-lined lids or caps, clear or amber colored) as required for analysis
- Laboratory-provided various sized polyethylene containers (with Teflon[®]-lined lids or caps) as required for analysis
- Nitric acid
- Sulfuric acid
- Hydrochloric acid
- Sodium hydroxide
- Sodium thiosulfate
- Filtration equipment, if required

Project-specific, appropriate sample container size, sample volume, holding times, and preservatives should be presented in the Quality Assurance Project Plan (QAPP). The selected laboratory should be able to provide the most complete guidance on this topic, and will have been consulted during the preparation of the QAPP. This SOP is intended to provide general information to field and office personnel while preparing the project planning documents, ordering and shipping supplies, and performing sample collection activities.

3.0 METHODOLOGIES

3.1 Sample Containers

To limit potential chemical or physical changes in a sample during collection and transport, the sample container selection should be based on the following:

- Sample containers should be new and certified clean prior to sampling activities
- Sample containers should be constructed of non-reactive materials
- Sample containers should not chemically or physically alter the sample

The most widely used containers for aqueous samples are composed of glass or polyethylene.

3.2 Aqueous Samples

Glass Containers

Glass containers will be used when organic compounds are the analytes of interest. Sample volume will be sufficient to fill each sample container to allow the laboratory to attain the method-specific detection limits. Specific to volatile organic analysis, sample volume will be sufficient to fill each sample container so that no air bubbles are present. Once the sample container is full and preserved, if appropriate, it will be sealed with a Teflon[®]-lined screw cap. Specific container sizes for each analytical category are presented in the project-specific QAPP.

Polyethylene Containers

Polyethylene containers will be used for aqueous samples when metals and/or inorganic analytes are the parameters of interest. One-liter polyethylene bottles with solid polyethylene or polyethylene-lined caps will generally be used to collect groundwater samples for metals and inorganic analysis. Once the sample container is full and preserved, if appropriate, it will be sealed with the polyethylene screw cap. Specific container sizes for each analytical category are presented in the project-specific QAPP.

3.2 Solid Samples

Sample containers for the soil matrix are typically clear glass with a volume of 8 ounces. Larger sample containers may be necessary depending upon the number and type of analyses.

3.3 Sample Preservation

Sample preservation is important to retard physical and chemical alterations of unstable analytes within the sample matrix. Sample preservation methods are limited and are generally intended to:

- Retard biological action
- Retard hydrolysis of chemical compounds and complexes

- Limit photolysis
- Reduce volatility of constituents
- Reduce sorption effects

Preservation is usually limited to acidification, treatment with an alkaline chemical, reducing light exposure, filtration, and refrigeration.

Prior to any form of preservation, the following parameters, at a minimum, will be measured in the field on water samples and recorded in the field notebook:

- pH
- Specific conductance
- Temperature

These field measurements record baseline information on the water sample prior to external influences such as temperature, dissolved carbon dioxide, or oxygen affecting the sample.

Acidification

Acidification of samples is generally performed for two purposes. Acidifying a (water) sample serves to limit metal adsorption to the sample container and will maintain the metal in a dissolved state. Secondly, acidification will act to inhibit bacterial growth. Samples to be acidified for either purpose will require a minimum volume of 100 ml and will be acidified to a $\text{pH} < 2$. Acidification is performed immediately after taking field measurements or following sample filtration.

Alkaline Treatment

Samples are preserved with an alkaline chemical (*e.g.* NaOH) to form salts with volatile compounds such as cyanide. Samples undergoing this preservation require a minimum volume of 100 ml and will be treated to a $\text{pH} > 12$.

Preservation of the sample will be performed by the addition of NaOH until the desired pH is achieved ($\text{pH} > 12$). Preservation of a water sample is performed immediately after the field measurements are collected and recorded.

Filtration

Filtration of samples will be used only for specific analytical parameters. It will be used when the dissolved metal content of water is of concern. Filtration will not be performed for samples to be analyzed for volatile organics, semi-volatile organics, or total recoverable metals.

When sample filtration is required, the sample will be drawn through a 0.45 micron filter. The filter material will either be paper or fiberglass dependent on the nature of the sampled water. Filtration is performed immediately following the field measurements and prior to any other

preservation methods. If the sample contains a significant level of suspended solids, a paper prefilter will be used prior to the 0.45 micron filter.

Temperature Control

All field samples that are to be analyzed by the laboratory will be sealed and then refrigerated during transfer to and storage at the laboratory. Refrigeration of samples is a bacterial inhibitor and slows the chemical and biological changes of a sample exposed to an oxidizing atmosphere. Transfer and storage of samples will be between 0°C and 10°C, with a target temperature of 4°C. Solid samples are typically limited to this preservation method.

3.4 Laboratory Selection and Coordination

Choosing a qualified analytical laboratory is an integral part of sampling activities. Regulatory program requirements and certifications must be considered in selecting the laboratory to ensure that the laboratory is capable of meeting project-specific requirements. Also, the provisions of any Consent Orders or Unilateral Orders applicable to the project must be reviewed and communicated to the laboratory to ensure project-specific requirements are met.

Laboratory Selection

An analytical laboratory will be chosen based on the following criteria:

- Capabilities of the laboratory including performance history, certifications, and regulatory program experience
- The qualifications and experience of the laboratory staff
- Availability of a designated technical client representative who serves as a single point of contact for all KEY projects
- Quality and completeness of standard deliverables, including electronic data transfer availability
- The specified analyses and turnaround time
- The adequacy of the laboratory's quality assurance/quality control program

Coordination

After selecting a laboratory, the laboratory will be contacted and the following information requested pertaining to the sampling activities:

- Identification of a responsible party to act as sample custodian at the laboratory who is authorized to accept samples and verify the data entered from the accompanying chain-of-custody forms into the laboratory tracking system
- Provisions for a laboratory sample custody log consisting of serially numbered, standard laboratory tracking report sheets
- Specifications of laboratory sample custody procedures for sample handling, storage, and disbursement for analysis

The laboratory will be notified within 48 hours prior to receipt of samples. The samples will be packaged and shipped *via* express courier or hand delivered within 48 hours of collection to the laboratory. The laboratory will then be contacted to verify receipt of the samples and estimated turnaround time.

3.5 Sample Packaging and Shipping

Proper sample packaging and shipping accomplishes the following:

- Allows individual samples to be tracked through transport and analysis
- Limits the possibility of breaking or losing a sample bottle during transport
- Is part of formal chain-of-custody (COC) procedures (tracking of possession of the samples)

Samples will be packaged and shipped according to the procedures in *SOP 23 – Sample Handling, Preservation, Packaging and Shipping*.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

(Reserved)

5.0 DATA RECORDING OR MANAGEMENT

(Reserved)

6.0 REFERENCES

U.S. Environmental Protection Agency, 1986, RCRA Groundwater Monitoring Technical Enforcement Guidance Document: Washington, D.C., OSWER-9950.1.

U.S. Environmental Protection Agency, 1986, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods - SW-846 3rd Edition (with revisions): Washington, D.C.

U.S. Environmental Protection Agency, 1987, A Compendium of Superfund Field Operations Methods, Part 1: Washington, D.C., EPA/540/P-87/001.

U.S. Environmental Protection Agency, 1991, Compendium of ERT Groundwater Sampling Procedures: Washington, D.C., EPA/540/P-91/007.

23 - SAMPLE HANDLING, PRESERVATION, PACKAGING AND SHIPPING

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) describes the procedures associated with the handling, preservation, packaging, and shipment of environmental samples for laboratory analysis or testing. Environmental samples may consist of air, groundwater, surface water, sediments or soil. The objective of sample preparation, handling, packaging, and shipping protocols is to develop standard procedures which will preserve the integrity of the samples and minimize the potential for sample tracking errors, sample spillage or leakage, and/or sample container breakage. The field team leader is responsible for the implementation of the sample handling, preservation, packaging, and shipping requirements outlined in the project-specific work plan.

1.1 Referenced SOPs

24 – Chain of Custody

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

Required materials may include the following:

- Sample containers (preserved, as necessary, provided by the laboratory)
- Sample bottle labels
- Chain-of-Custody forms
- Sample cooler
- Bubble wrap or other suitable packing material
- “Blue Ice” (*i.e.*, reusable, freezable ice packs) or sealed bagged ice
- Shipping bills (Federal Express, UPS, etc.)
- Field Logbook
- Indelible ink pens
- Packaging tape
- Zip-lock type plastic bags

3.0 METHODOLOGIES

3.1 Sample Handling

Sample Containers

Sample containers and appropriate preservatives (where necessary) will be supplied by the analytical laboratory. After the respective sample containers have been filled with appropriate sample media and preserved as necessary, samples will be properly identified using sample container labels, and the samples will be stored at an appropriate temperature (usually <4°C) to preserve the integrity of the samples.

Sample Preservation

Preservatives will be supplied by the laboratory. When possible, preserved containers should be supplied by the lab. Common preservatives include hydrochloric acid (HCl), sulfuric acid (H₂SO₄), nitric acid (HNO₃), or sodium hydroxide (NaOH). Samples will be preserved in accordance with EPA protocol specified in SW-846 or the project specific protocols outlined in the quality assurance project plan (QAPP). Use of the preservatives will be noted on the COC for each particular sample and analytical parameter.

Sample Labels

Blank sample labels will be supplied by the analytical laboratory and affixed to the sample container. Sample labels will be completed using waterproof permanent markers or ink. The labels will be filled out at the time of sample collection by the field sampling personnel. The following identifying sample information will be included on the label:

- Client/Site
- Sample identification alpha-numeric code defined in the project planning documents
- Sample collector's initials
- Date and time (military) of sample collection
- Analytical method
- Laboratory analysis to be performed

Chain-of-Custody Forms

A chain-of-custody (COC) record will be established and maintained to document sample possession from the time of collection until receipt by the laboratory. A sample is considered to be in custody if it is in your physical possession, if it is in your view after being in possession, or if it is placed in a secure area with access controlled by you. Once samples are received by the laboratory, they will be handled under the laboratory internal COC procedures. Field sampling personnel will initiate a COC record by recording the following minimum data as the samples are collected:

- Client/Site
- Name(s) of sampler(s)
- Sample identification alpha-numeric code
- Date and time (military) of sample collection
- Type of sample (e.g., soil, groundwater)
- Number of containers per sample location
- Requested analyses
- Type of containers and preservatives used
- Name and address for the completed laboratory reports
- Name and address for the laboratory invoices
- Specific instructions/notes for the laboratory, as necessary

Sample COC forms will be placed in waterproof plastic bags and taped to the underside of the cooler lids. Sample COC forms will generally be supplied by the subcontracting analytical laboratory.

Subsequently, at each change of possession, the COC record will be signed by the person relinquishing the samples and by the person receiving the samples. The date and time of the transfer of possession of the sample will be recorded on the COC form; this occurs when the samples are transferred from the sampling personnel to the courier and when the samples are received at the analytical laboratory. Sample COC forms shall be completed in ink. Any transcription errors shall be corrected by striking the erroneous information with a single horizontal line. The correct information will be added immediately adjacent to the strikeout. The sampler should initial the correction. (Refer to *SOP 24 – Chain of Custody* for additional information).

3.2 Sample Packaging and Shipping

All samples will be transported to the analytical laboratory in durable, waterproof, secured metal or plastic coolers. Sample coolers will generally be supplied by the laboratory. All samples will be packaged very carefully to prevent sample breakage. Samples will be shipped *via* overnight carrier (e.g., Federal Express or United Parcel Service) or hand delivered to the analytical laboratory, generally within 48 hours of collection. Airbills serve as custody documentation during shipping. However, project specific protocols will be checked to assure that specified sample holding times are not exceeded in the event that samples are not shipped on the same day that they were collected. Additionally, the sample security and preservation must be maintained if samples are not to be transported immediately to the laboratory. The following procedure should be followed for packaging samples for shipment to the laboratory for testing and/or analysis.

1. Place plastic bubble wrap matting or suitable material over the base and bottom corners of each cooler or shipping container.
2. Obtain a chain-of-custody record (similar to the example shown in Attachment 1 of *SOP 24 – Chain of Custody*) and enter all the appropriate information as discussed above. Chain-of-custody records will include complete information for each sample. One or

more chain-of-custody records shall be completed for each cooler or shipping container as needed to manifest each sample.

3. Place bubble wrapping or other suitable material around glass bottles and place standing upright on the base of the cooler, taking care to leave room for packing material and ice or equivalent. Rubber bands or tape may be used to secure wrapping completely around each sample bottle.
4. Place additional bubble wrap and/or Styrofoam pellet packing or equivalent material throughout the voids between sample containers within each cooler.
5. Place cold packs or ice in heavy duty zip-lock type plastic bags, completely close the bags, and distribute such packages over the top of the samples. Add additional bubble wrap and/or Styrofoam pellets or other packing materials to fill the balance of the cooler or container.
6. If shipping the samples by express, courier, or delivery service, sign the chain-of-custody record thereby relinquishing custody of the samples. The date and time of custody transfer should be recorded on the chain-of-custody form. The custody transfer should be documented when directly transferring custody to a receiving party or when transmitting to a shipping service for subsequent receipt by the analytical laboratory. The shipping service should not be asked to sign chain-of-custody records.
7. Remove the last copy from the chain-of-custody record and retain with the field records. Place the original and remaining copies in a zip-lock type plastic bag and tape the bag to the underside of the lid of the cooler or shipping container.
8. Close the top or lid of the cooler or shipping container and with another person gently rotate the container to verify that the contents are packed so that they do not move. Improve the packaging if needed and reclose.
9. Packaging tape should be wrapped entirely around the sample shipping containers. A minimum of two full wraps of packaging tape will be placed in at least two places on the cooler or shipping container. Some project-specific QAPP may require custody seals be placed on the sample shipping containers. Sign and date the chain-of-custody tape.
- 10a. When transporting samples by automobile to the laboratory, and where periodic changes of ice are required, the cooler should only be temporarily closed so that reopening of the cooler can be easily performed. In these cases, chain-of-custody will be maintained by the person transporting the samples and chain-of-custody tape need not be used. If the cooler is to be left unattended, then chain-of-custody procedures should be implemented.
- 10b. If shipment is required, transport the cooler to an overnight express package terminal or arrange for pickup. Obtain copies of all shipment records as provided by the shipping service.

11. Upon receipt of the samples, the analytical laboratory will open the cooler or shipping container and will sign "received by laboratory" on each chain-of-custody form. The laboratory will verify that the chain-of-custody tape has not been broken previously and that the chain-of-custody tape number corresponds with the number on the chain-of-custody record. The analytical laboratory will then forward the back copy of the chain-of-custody record to the sample collector to indicate that sample transmittal is complete.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Prior to the samples leaving the site, each sample number and analyses, etc. are to be checked against the project planning documents, sample log sheets/field logbook, and chain of custody forms to ensure that all required samples have been collected and are labeled appropriately, and that bottles are filled for all required analyses.

Quality control samples such as rinsate blanks and duplicates will be specified by the project QAPP. A sample jar containing water should be sent as a temperature blank with each sample shipment requiring temperature preservation to ensure proper temperature is maintained. Also, a trip blank, provided by the laboratory will accompany shipments with samples intended for volatile organic chemical (VOC) analysis.

5.0 DOCUMENTATION AND RECORD KEEPING

The documentation for supporting the sample handling, preservation, packaging and shipping will consist of chain-of-custody records, shipping records and laboratory reports. In addition, a description of sample packaging procedures will be written in the Field Log Book. All documentation will be retained both physically and electronically in the project files.

6.0 REFERENCES

U.S. Environmental Protection Agency, 1986, RCRA Groundwater Monitoring Technical Enforcement Guidance Document: Washington, D.C., OSWER-9950.1.

U.S. Environmental Protection Agency, 1986, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods - SW-846 3rd Edition (with revisions): Washington, D.C.

U.S. Environmental Protection Agency, 1987, A Compendium of Superfund Field Operations Methods, Part 1: Washington, D.C., EPA/540/P-87/001.

U.S. Environmental Protection Agency, 1991, Compendium of ERT Groundwater Sampling Procedures: Washington, D.C., EPA/540/P-91/007.

24 - CHAIN OF CUSTODY

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) presents procedures for documenting possession/custody of environmental samples from the time of collection through delivery to the receiving analytical laboratory. At this point, internal laboratory records should document sample custody until final disposition. This SOP also discusses sample identification and the use of chain-of-custody (COC) forms.

Possession of a sample must be traceable from the time it is collected until analysis is completed. To document sample possession, chain-of-custody procedures are followed. Chain-of-custody evidence includes all documentation associated with the sample including the chain-of-custody form, sample label, custody seal, courier's receipt (if applicable), and field notebook.

A sample is under custody if one or more of the following criteria are met:

- It is in possession of the custodian or a designated member of the sampling team
- It is in plain view, after being in possession
- It was in possession and is secured against tampering
- It is placed in a designated secure area.

1.1 Referenced SOPs

23- Sample Handling, Preservation, Packaging and Shipping

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

- Sample containers
- Sample container labels
- Chain-of-custody forms
- Zip-lock type plastic bags and tape
- Field logbook and permanent ink, waterproof pen
- Shipping airbills
- Shipping containers
- Locks or packaging tape
- Custody seals.

3.0 METHODOLOGIES

The Project Manager (or designee) is responsible for ensuring that sample labeling is completed in accordance with this SOP and that chain-of-custody forms are completed for sample shipments. All individuals relinquishing and receiving samples shall sign, date, and record the time on the chain-of-custody forms.

3.1 Sample Identification

Blank sample labels will be supplied by the analytical laboratory and affixed to the sample container. Sample labels will be completed using waterproof permanent markers or ink. The labels will be filled out at the time of sample collection by the field sampling personnel. The following identifying sample information will be included on the label:

- Client/Site
- Unique sample identification alpha-numeric code as specified in the Sampling and Analysis Plan
- Sample collector's initials
- Date and time (military) of sample collection
- Analytical method
- Laboratory analysis to be performed

3.2 Chain-of-Custody Forms

Once the sample containers have been filled with the sampled media and properly labeled, they will be prepared for shipment to the receiving analytical laboratory. Coolers containing samples will be accompanied by a chain-of-custody form (see example COC form in Attachment 1).

The field team leader (or designee) shall complete a chain-of-custody form for each lot of packaged samples (*e.g.*, each cooler). COC forms shall be completed in ink. Any transcription errors shall be corrected by striking the erroneous information with a single horizontal line. The corrected information shall be added immediately adjacent to the strikeout. The sampler should initial the correction.

The following information will be recorded on the COC form:

- Client/Site
- Name(s) of sampler(s)
- Sample identification alpha-numeric code
- Date and time (military) of sample collection
- Type of sample (*e.g.*, soil, groundwater)
- Number of containers per sample location
- Requested analyses
- Type of preservatives used

- Name and address for the completed laboratory reports
- Name and address for laboratory invoices
- Specific instructions/notes for the laboratory, as necessary

Any area of the COC, where sample information is not completed should have a diagonal line initialed by the sampler to show that this portion of the COC will not be completed.

Each COC will be placed in a waterproof zip lock plastic bag and affixed to the underside of the shipping container lid. Samples will be packaged properly for shipment as described in *SOP 23 – Sample Handling, Preservation, Packaging and Shipping*, and dispatched to the appropriate laboratory for analysis. Shipping containers will be padlocked or otherwise sealed for shipment to the laboratory, including the placement of custody seals that would indicate a container has been tampered with.

All shipments should be accompanied by the completed Chain-of-Custody Record. The original record will accompany the shipment to the laboratory, and a copy will be retained by the field team leader for the project file. Shipping bills and receipts must be retained as part of the chain-of-custody documentation. These documents should be scanned weekly and will become part of the permanent project files. Paper copies will be maintained in the project files in the office.

Upon receipt of the samples by the laboratory, the laboratory person assigned to log-in samples will confirm that the shipping container seals are in good condition and have not been disturbed. If a disturbance is noted, the laboratory shall notify the Key Project Manager at once. The original chain-of-custody form is to be signed and dated by the laboratory person logging in the samples. In addition, the receiving laboratory is to inspect each sample and indicate the condition of the sample on the COC. The receiving laboratory is to retain a copy of each chain-of-custody form along with the shipping bill. Internal laboratory chain-of-custody procedures will be followed once samples are logged in by the receiving laboratory.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Prior to shipment, the Field Supervisor shall check to ensure that sample numbers are correct, sample paperwork is complete, field logbooks are maintained, and that the Sampling and Analysis Plan has been followed. If a particular sample location is inaccessible or if a sample could not be collected for any reason, the Project Manager is to be notified immediately. Such information must be included in the field logbook.

5.0 DATA RECORDING/MANAGEMENT

All sampling activities are to be documented in the field logbook. As discussed in Section 3.0, information related to tracking environmental samples will be recorded on the COC forms which will be retained in the project files.

All pages of the field logbooks relevant to sampling, as well as copies of all paperwork (COC forms, shipping labels, etc.) are to be scanned. Both paper copies and the digital copies become part of the permanent project file.

6.0 REFERENCES


U.S. Environmental Protection Agency, 1986, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document: Office of Waste Programs Enforcement, Washington, D.C., EPA/530/Sw-86/055.

U.S. Environmental Protection Agency, 1986, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846 3rd Edition (with revisions): Washington, D.C.

U.S. Environmental Protection Agency, 1987, A Compendium of Superfund Field Operations Methods, Part 1: Washington, D.C., EPA/540/P-87/001.

U.S. Environmental Protection Agency, 1991, Compendium of ERT Groundwater Sampling Procedures: Washington, D.C., EPA/540/P-91/007.

Attachment 1 Example Chain-of-Custody Form

		CHAIN OF CUSTODY 200 Third Avenue Carnegie, PA 15106 Phone (412) 279-3363 Fax (412) 279-4332										Requested Analyses	
		Project No.:					Project Name:						
Samplers: (signatures)													
Sample I.D.	Date	Time	C O L L E C T E D	G I D E N T I F I E D	Sample Location Description	Number of Containers							
Relinquish By: (signature)					Date	Time	Received By: (signature)			Date	Time	Notes:	
Relinquish By: (signature)					Date	Time	Received By: (signature)			Date	Time		
Relinquish By: (signature)					Date	Time	Received By: (signature)			Date	Time		

Distribution: Original to Accompany samples; Copy Returned with Report

C:\Users\ral\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\869030\MLCOC form Revised 9/13/2012 Form #3

25 - EQUIPMENT DECONTAMINATION

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) presents general guidelines and step-by-step methods for on-site decontamination of sampling equipment, heavy equipment, and personal protective equipment. Decontamination is performed as a quality assurance measure and a safety precaution. Decontamination prevents cross-contamination between samples, minimizes contaminant transport, and also helps to maintain a clean working environment for the safety of the field personnel.

Although this SOP defines on-site decontamination procedures, it is highly recommended that (1) dedicated disposable sampling implements are used whenever possible, and (2) sufficient dedicated sampling implements are taken to the field so that the need for field decontamination is eliminated or reduced. For example, in collecting groundwater samples, dedicated, disposable bailers should be used, where practicable.

Decontamination is mainly achieved by washing and rinsing with liquids which include; soap and/or detergent solutions, tap water, distilled water, acetone, hexane, and nitric acid. The actual procedure will vary depending on project-specific requirements as listed in the Quality Assurance Project Plan (QAPjP), the type of equipment to be used, and the analytical parameters of interest.

1.1 Referenced SOPs

05 – Management of Investigation-Derived Wastes

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

This section contains a general list of materials that may be required to conduct field decontamination of sampling equipment. A particular project may have slightly different requirements; the QAPjP should be consulted prior to gathering and shipping equipment to the site.

- Concrete or lined decontamination pad (as required by project planning documents)
- Plastic sheeting
- Garden-type water sprayers
- Pressure washer, if required
- Portable steam cleaner, if required
- Cleaning brushes
- Distilled water
- Phosphate-free detergent (e.g., Liquinox[®] or Alconox[®])

- Potable water supply
- Hexane
- Acetone
- Isopropanol
- 10% Nitric acid
- Chemical-free paper towels or shop cloths
- Cleaning brushes and scrapers
- Aluminum foil
- Drop cloth or plastic sheeting
- Gloves; safety glasses, protective clothing as specified in the Health and Safety Plan
- Cleaning containers (e.g., buckets, basins, pans)
- Chemically-compatible dedicated squirt or spray bottles for each solvent above and/or distilled water

Additional supplies such as those listed below could be required for waste disposal:

- Trash bags
- Trash containers
- 55-Gallon drums
- Metal or plastic buckets with lids for storage and disposal of decontamination liquids

3.0 METHODOLOGIES

Where feasible, all sampling equipment should be cleaned prior to use and dedicated to one sampling location for each sampling event, to minimize the need for cleaning equipment in the field. In some instances, the use of dedicated sampling equipment may not be a practical option, depending on the scope of the project.

In general, decontamination is accomplished by manually scrubbing, washing, or spraying equipment with one or more of the following: detergent solutions, tap water, distilled/deionized water, steam, acids, or solvents. Equipment can be allowed to air dry after being decontaminated or may be wiped dry with chemical-free paper towels, if immediate use is necessary.

The field decontamination methods and agents are to be determined on a project-specific basis and should be stated in the project planning documents. Decontamination plans should be based on a conservative, worst-case scenario, using all available information about a work area. An initial assumption is usually made that all protective clothing and equipment that leave the actual work location are contaminated. Based on this assumption, all nondisposable equipment is washed and rinsed, and disposable equipment and clothing are handled appropriately.

It is the primary responsibility of the field team leader to assure that the proper decontamination procedures are followed. Project-specific decontamination procedures are to be included in the field SAP. It is the responsibility of the project safety officer (or designee) to develop and implement safety measures which provide protection for all persons involved directly with decontamination.

A decontamination plan will be developed in the Health and Safety Plan. A decontamination line should be set up before any personnel or equipment enters areas of potential exposure. The decontamination plan should include

- The layout of decontamination stations and methods
- Disposal methods for contaminated clothing, equipment and solutions
- Procedures to minimize the potential for contamination, including work practices, the use of remote sampling techniques, the use of disposable or dedicated equipment; and avoiding laying down equipment in areas of obvious contamination

The contaminants encountered and type of equipment used will dictate the type of field decontamination procedures required.

At a minimum, the following procedures will be used:

1. Remove adhered material from the sampling equipment by brushing and/or rinsing with tap water.
2. Wash with non-phosphate detergent and tap water.
3. Rinse with distilled tap water.
4. Repeat the first three steps as necessary until all residue is removed.
5. Rinse with appropriate solvent specified in the Sampling and Analysis Plan, if organic constituents are of interest.
6. Rinse with distilled tap water to remove solvent.
7. Rinse with 10% nitric acid, if metals are a constituent of interest.
8. Rinse with distilled tap water.
9. Air dry or dry with clean, chemical free paper towels or shop cloths.

If metals are not a constituent of interest, the nitric acid rinse and the subsequent distilled water rinse steps can be eliminated.

3.1 Decontamination Area

During the project planning activities, a localized decontamination area will be identified for large equipment such as drill rigs and earthmoving equipment. This decontamination area should be located such that fluids and solids wastes can be managed in a controlled area with minimal risk to the surrounding environment.

In some cases, an existing concrete pad can be used. In other cases, one may need to be constructed. This determination will be made following an initial site visit. Decontamination areas may be lined with heavy-gauge plastic sheeting and include a collection system to capture decontamination Investigation Derived Waste (IDW).

Smaller decontamination tasks, such as the cleaning of soil or water sampling equipment, may take place at the sampling location. In this case, all required decontamination supplies and equipment must be mobilized to the site. These small decontamination areas may include basins or tubs to capture the decontamination IDW, which can be transferred to larger containers as needed.

3.2 Health and Safety Precautions

Decontamination procedures may involve:

- Potential exposure to constituents within the medium being investigated or solvents employed
- Physical hazards associated with the operation of the decontamination equipment

When decontamination is performed on equipment which has been in contact with the constituents of interest or when the quality assurance objectives of the project require decontamination with chemical solvents, the measures necessary to protect personnel should be addressed in the Health and Safety Plan. The Health and Safety Plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing equipment decontamination and must be adhered to as field activities are performed. Material Safety Data Sheets for any solvents stored or used on-Site should be available at the Site.

At a minimum, eye protection, safety shoes, and gloves are to be worn. There are several types of gloves that may be worn, depending on equipment being cleaned, type and extent of equipment contamination, and cleaning solutions or solvents being used.

Polyvinyl gloves may be worn when the equipment to be decontaminated is not heavily coated with constituents such as tars/oils. In cases where heavy accumulations of tars/oils are present on the equipment, neoprene or similar chemically compatible gloves are recommended. If a potential for skin contact exists, protective clothing should be worn.

3.3 Equipment Decontamination Planning Considerations

Decontamination methods, solutions, and frequencies must be considered and addressed during the formulation of a decontamination strategy, and should be outlined in the project plans. Each are dependent on site logistics, site-specific parameters of interest, the nature of the sample media, and the objectives of the study.

There are several factors which should be considered when deciding upon a decontamination solution or solvent:

- The solution or solvent should not contain any of the analytes of interest
- The solvent or solution must be effective at removing the constituents of interest
- The solvent must be relatively stable so that it can be handled and stored in the field without special handling requirements
- All sampling equipment must be resistant to the solvent or solution

Regulatory agencies may have specific requirements regarding decontamination solvents.

Methanol, acetone, and hexane are typical solvents of choice for equipment decontamination for general organic analyses. A 10% nitric acid and deionized water solution is the typical solvent of choice for sampling equipment decontamination for general metals analyses. If used on metal equipment, nitric acid may corrode the metal and lead to the introduction of metals to the collected samples. If it is necessary to use metal sampling equipment to collect samples for metals analysis, consideration of the aforementioned should be included during the evaluation of field and laboratory QA/QC samples.

Decontamination should be performed far enough away from the source of contamination so as not to be affected by the source, but close enough to the sampling site to keep decontaminated equipment handling to a minimum.

If heavy equipment, such as drill rigs or backhoes, is to be decontaminated, then a central decontamination station should be considered. Power may be required to run steam generators or high pressure water pumps. A potable water source may also be necessary. The construction of a suitable temporary structure to contain sprays and splashes may be necessary. Rinse and wash solutions should be collected and contained until the materials are characterized to identify appropriate management options, or, if available and appropriate, conveyed directly to an on-Site treatment facility for management.

Depending on the nature of the sample media or the solvents utilized, it may be necessary to collect, contain, and manage all particulate matter and wash solutions. If containment is necessary, it may be achieved by performing the decontamination in large galvanized tubs or over plastic sheeting.

3.4 General Equipment Decontamination Procedures

All sampling equipment must be decontaminated before use to ensure that contaminants have not been introduced to the sample during the sampling process through contact with the sampling device. Heavy equipment such as trucks, drilling rigs and backhoes should be decontaminated upon arrival at the site to prevent the introduction of road chemicals or constituents from a previous site. Monitoring well riser pipes, screens and drilling augers must also be decontaminated, as appropriate, to prevent the introduction of constituents.

Unless the decontaminated sampling devices are to be used immediately, they should be wrapped in aluminum foil, shiny side out, and stored in a designated “clean” area. Field equipment can also be stored in plastic bags to eliminate the potential for contamination. Larger size

equipment, such drill rods, augers, backhoe buckets, etc. need not be wrapped or covered. This equipment should be stored on horses or otherwise, kept from storage directly on the ground surface. Field equipment should be inspected and decontaminated prior to use if the equipment has been stored for long periods of time.

If specific procedures are not stated in the project plans, the standard procedures specified herein should be followed.

1. Determine from the project plans the method of containment for the particulate and wash solution generated during decontamination.
2. Typically, smaller equipment will be decontaminated in a plastic or galvanized tub.
3. The brush and container used for the decontamination process should be new or decontaminated prior to use.
4. Remove all solid particles from the equipment or material by brushing and then rinsing with available tap water. This initial step is performed to remove gross materials. Depending on the size of the equipment being decontaminated, this step may be preceded and/or followed by a steam or high pressure water rinse to remove solids and/or residual oil or grease.

3.5 Personnel and Personal Protective Equipment (PPE)

Decontamination of personnel and PPE prevents undesired human-health exposure to contaminants via ingestion, absorption, and inhalation. All personnel and PPE will be decontaminated as outlined in the Health and Safety Plan (HASP). Any further concerns regarding personnel and PPE decontamination procedures may be addressed directly with the Health and Safety Officer and/or Project Manager.

3.6 Decontamination of Sampling Equipment

Conduct consistent decontamination of sampling equipment to ensure the quality of the samples collected. Decontaminate all equipment that comes into contact with potentially contaminated samples. Disposable equipment intended for one-time use that is factory-wrapped generally does not need to be decontaminated before use, unless evidence of contamination is present.

Disposable equipment, such as disposable bailers, spoons, TerraCore® or Encore® VOC samplers, is preferred over reusable equipment; use wherever appropriate. Decontaminate sampling equipment, including split-barrel samplers, hand augers, reusable bailers, spoons, trowels, shovels, and pumps used to collect samples for chemical analyses before each use and before sampling at a new sampling location. Decontamination personnel will wear the appropriate PPE as required by the HASP.

Take the following steps to decontaminate non-dedicated sampling equipment:

1. Remove as much gross contamination (such as pieces of soil) as possible off equipment at the sampling site.
2. If heavy petroleum residuals are encountered during sampling, an appropriate solvent such as methanol will be used to remove any petroleum residues from sampling equipment. If a solvent is used, it must be properly used, collected, stored, and disposed of according to the HASP and the project-specific planning documents. If heavy petroleum residuals are not encountered, this step should be omitted.
3. Wash water-resistant equipment thoroughly and vigorously with potable water containing non-phosphate laboratory-grade detergent such as Liquinox[®], Alconox[®], or equivalent, and using a bristle brush or similar utensil to remove any remaining residual contamination.
4. Rinse equipment thoroughly with potable water (1st rinse).
5. Rinse equipment thoroughly with distilled or deionized water (2nd rinse).
6. For sensitive field instruments, rinse equipment with distilled, deionized, or American Society for Testing and Materials (ASTM) reagent grade water (3rd rinse).
7. Air dry at a location where dust or other fugitive contaminants may not contact the sample equipment. Alternatively, wet equipment maybe dried with a clean, disposable paper towel to assist the drying process. All equipment should be dry before reuse.
8. If the equipment is not used soon after decontamination, it should be covered or wrapped in new, oil-free aluminum foil or new, unused plastic bags to protect the decontaminated equipment from fugitive contaminants before reuse.
9. Store decontaminated equipment at a secure, unexposed location out of the weather and any potential contaminant exposure.

3.7 Decontamination of Groundwater Sampling Equipment

(Note: This procedure does not apply to dedicated submersible pumps which have been permanently installed in groundwater extraction wells.)

Proper decontamination between wells is essential to avoid introduction contaminants from the sampling equipment to another well. If peristaltic pumps are being used, it is necessary only to replace the pump head tubing after sampling each well. If sampling with submersible pumps or reusable bailers that come into direct contact with groundwater, the equipment must be decontaminated. The following procedure will be used to decontaminate submersible pumps before and between groundwater sample collection points, as well as the end of each day of use.

1. During decontamination, the submersible pump will be placed on a clean surface, such as a new plastic sheet.
2. When removing the submersible pump from each well, the power cord and discharge line will be wiped dry using chemical-free disposable towels. Should the pump be fitted with a disposable discharge line, disconnect the line for proper disposal.
3. Clean an upright plastic-nalgene cylinder first with a methanol, 10% nitric acid, or other specified solvent and then a distilled/deionized water rinse, wiping the free liquids after each.
4. For reversible pumps, reverse the pump to backwash all removable residual water present in the pump tubing. The pump should be shut off as soon as intermittent flow is observed from the reverse discharge.
5. Rinse the stainless steel submersible down hole pump section with a detergent solution followed by a water rinse and the specified solvent.
6. Place the submersible pump section upright in the cylinder and fill the cylinder with tap water, adding 50-100 ml of specified solvent for every one liter of water.
7. Activate the pump in the forward mode, withdrawing water from the cylinder.
8. Continue pumping until the water in the cylinder is pumped down and air is drawn through the pump. At this time air pockets will be observed in the discharge line. Shut off the pump immediately.
9. Remove the pump from the cylinder and place the pump in the reverse mode to discharge all removable water into a disposal container.
10. Using the water remaining in the cylinder, rinse the sealed portion of the power cord and discharge tube by pouring the water carefully over the coiled lines.
11. On reaching the next monitoring well, place the pump in the well casing and wipe dry both the power and discharge lines with a chemical-free paper towel as the pump is lowered.

3.8 Decontamination of Measurement Devices and Monitoring Equipment

For water quality instruments, oil-water interface indicators, water level indicators, continuous water level dataloggers, and other field instruments that have the potential to come into contact with site media, at a minimum, wash with dilute laboratory-grade detergent (Liquinox[®] or similar) and double rinse with potable and distilled/deionized water before and after each use using a similar procedure as discussed in Section 3.6. If heavy petroleum residuals are

encountered during sampling, use an appropriate solvent such as methanol to remove petroleum residues per the manufacturer's maintenance guidelines.

3.9 Decontamination of Drilling and Subsurface Soil Sampling Equipment

Drilling equipment and associated materials will be decontaminated by the drilling contractor prior to any drilling operations and between borings. Decontaminate tools used for soil sampling (for example, split spoon samplers) before and between collecting any analytical samples, as outlined in Section 3.6. Thoroughly clean external and internal surfaces of drilling equipment (that is, drill bits, auger, drilling stem, and hand tools) before beginning any drilling operations and between borings using the following basic sequence:

1. Remove as much gross contamination as possible off equipment at the sampling site.
2. Wash equipment thoroughly and vigorously with high-temperature potable water using a high-pressure washer and/or steam cleaner. A bristle brush is also suggested to remove any persistent gross contamination.
3. Rinse equipment twice thoroughly with potable water (1st and 2nd rinse).
4. Air dry at a location where dust or other fugitive contaminants may not contact the sample equipment. All equipment should be dry before reuse.
5. Store decontaminated equipment at a location away from any potential exposure from fugitive contamination.

3.10 Decontamination of Heavy Equipment

Wash earthwork equipment (such as excavators, back-hoes, and trucks) with high-pressure potable water, if possible, before leaving a contaminated area, using similar steps as outlined in Section 3.9. Portable steam-cleaners and hand washing with a brush and detergent, followed by a potable water rinse, can also be used. In some instances, tires and tracks of equipment maybe only need to be thoroughly brushed with a dry brush. Take particular care with the components in direct contact with contaminants, such as tires and backhoe buckets. Any part of earthwork equipment that may come in direct contact with analytical samples (that is, sampling from the excavator bucket) must be thoroughly decontaminated before excavation activities and between sample locations.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

To ensure that sampling equipment is cleaned properly and sample cross-contamination does not occur, field rinsate blanks will be collected as required by the Sampling and Analysis Plan. A rinsate blank will consist of pouring deionized organic-free water over the specific sampling device or pouring it through the device after it has been cleaned. The rinsate sample is collected in the field under the same conditions as occurred for the sampling activity, and is handled exactly like any other samples collected that day.

Generally, one rinsate blank is collected each day of sampling or at a rate of 1 per 20 for each parameter, whichever is less, for each matrix being sampled or for each type of sampling instrument decontaminated and reused per day. The rinsate samples are analyzed for the specific parameters of concern (for each matrix). Rinsate blanks should be labeled like a routine environmental sample, and laboratory analysis instructions should be included on the chain-of-custody form.

Rinsate blanks are not required if dedicated sampling equipment is used. Additional quality assurance samples may be collected if deemed necessary by project specific requirements. All project specific quality assurance sampling will be defined in the sampling and analysis plan (SAP) or QAPjP prior to initiation of the field work.

5.0 DOCUMENTATION AND RECORD KEEPING

The field team leader will maintain a record of the decontamination procedures. Notations shall be made in the field logbook concerning the decontamination procedures and which equipment was decontaminated. An Equipment Decontamination Record form shall be completed for all rental equipment (see Attachment 1).

The following information should be recorded in the Field Logbook:

- Decontamination personnel
- Decontamination solutions used
- Start and finish date and time
- Location of decontamination activities
- General methods used, tools used, and observations, including any deviations from this SOP
- Equipment identification numbers
- Manufacturer names and lot numbers of decontamination solutions
- Location and amount of decontamination IDW collected, stored, and/or disposed, including the sources (e.g., well or boring numbers) of the IDW (see SOP 05 – *Management of Investigation-Derived Wastes*)
- Any spills or releases, and associated corrective actions taken

6.0 REFERENCES

United States Environmental Protection Agency, January 1991, Compendium of ERT Groundwater Sampling Procedures: Washington, D.C., EPA 540/P-91/007.

United States Environmental Protection Agency, December 1987, A Compendium of Superfund Field Operations Methods: Washington, D.C., EPA 540/P-87/001.

ATTACHMENT 1
SOP 25 – EQUIPMENT DECONTAMINATION
EQUIPMENT DECONTAMINATION RECORD

EQUIPMENT DECONTAMINATION RECORD	HS-15
This form must be completed for all rental equipment. A copy of this form should accompany all returned equipment.	

EQUIPMENT IDENTIFICATION

Type of equipment: _____

Model: _____

Serial Number: _____

Rented From (Name & Address): _____

DECONTAMINATION

Decontamination Method: _____

Date of Decontamination: _____

Site Name: _____

Project Number: _____

DECONTAMINATION CERTIFICATION

To be signed by the Site Supervisor or Site Health and Safety Officer.

Name: _____

Title: _____

Signature: _____

Date: _____

26 - DEPTH TO GROUNDWATER AND NAPL MEASUREMENTS

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) describes Key Environmental, Inc.'s standard procedures to be followed for determining depth to groundwater, as well as a description of the procedures to be followed for determining the depth to and apparent thickness of any non-aqueous phase liquid (NAPL) in monitoring wells.

Generally, water level measurements from boreholes, piezometers, or monitoring wells are used to construct potentiometric surface maps and product elevation maps. These maps are used in evaluating groundwater and product migration. Potentiometric surface maps are also used to assess potential seasonal variations in groundwater movement when measurements can be made over several sampling intervals.

In order to ensure an accurate representation of groundwater and product elevations, ideally all measurements will be collected within a 24-hour period. The site-specific planning documents (Work Plan, Sampling and Analysis Plan, Scope of Work or other similar planning documents) shall be consulted to identify the specific wells to be investigated and the types and frequency of required measurements.

1.1 Referenced SOPs

03 – Field Logbook
20 – Volatile Organic Screening
25 – Equipment Decontamination

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

The following list identifies the preferred types of materials to be used when measuring depth to water, depth to light NAPL (LNAPL), or depth to dense NAPL (DNAPL):

- Personal safety equipment (hard hat, steel-toed boots, safety vests, etc)
- Electronic water level meter (for water level measurements only)
- Interface probe (suitable for groundwater, LNAPL and DNAPL measurements)
- Photoionization detector (see *SOP 20 – Volatile Organic Screening*)
- Field logbook and/or sampling forms
- Indelible ink pens
- Clipboard
- Decontamination solutions in dedicated squirt bottles
- Paper towels

3.0 METHODOLOGY

The wells to be gauged will be identified in the project planning documents. In the field, the sampling team must verify the list of wells to be sampled with the well number on the casing. Prior to opening the well, the condition of the well casing and pad should be noted on the sampling forms and in the field logbook (see *SOP 03 – Field Logbook*). If there is any damage, particularly any that threaten the integrity of the sampling point, the Project Manager and Field Team Leader should be notified immediately.

3.1 Depth to Groundwater Measurements

1. Open the well and monitor the headspace with the appropriate monitoring instrument to determine the presence of volatile organic compounds if there is information to suggest that volatiles may be present at levels to warrant an upgrade in the level of PPE. Record the measurement in the field logbook and/or sampling forms.
2. Locate the surveyed measuring point of the well. The surveyed measuring point location is typically the top of the inner well riser, and should be clearly marked in permanent ink on the well riser or identified in previous sample collection records. The measuring point location should be described in the Field Logbook and should be the same point used for all subsequent measurements.
3. To obtain a water level measurement, lower a decontaminated water level meter into the monitoring well. Care must be taken to assure that the water level measuring device hangs freely in the monitoring well and is not adhering to the wall of the casing. The water level measuring tape will be lowered into the well until the audible sound of the unit is detected or the light on an electronic sounder illuminates. At this time, the precise measurement should be determined (to one hundredth of a foot) by repeatedly raising and lowering the tape to converge on the exact measurement. The water level measurement should be entered in the Field Logbook and/or sample log sheets (Attachment 1).
4. The water level measuring device shall be decontaminated in accordance with *SOP 25 – Equipment Decontamination* immediately after use. Generally, only that portion of the measuring tape which penetrates the water table will require decontamination. If NAPL is encountered, use of a solvent (*e.g.*, hexane) will be required to clean the probe before it is used in another well.

3.2 NAPL Measurements

NAPL measurements should be made using an interface probe. Interface probes are commonly used to detect the presence of any floating (LNAPL) or sinking (DNAPL) immiscible layers. These probes can also be used to measure the water levels inside wells.

1. Using the grounding cable attached to the interface probe, ground the probe to a metal object (*i.e.*, protective steel locking well cover) to prevent electric shock.

2. The probe should be lowered slowly inside each well. When LNAPL is detected, the probe will make a solid tone. Record the measurement from the surveyed point on the top of the well casing to the top of the LNAPL. Continue lowering the probe (observing the calibrated drop line) until the steady tone stops. When water is detected, the probe will make a beeping noise to signify the beginning of the water column. When the beeping noise is heard, observe the calibrated drop line to determine the water level. Record this measurement. The measurement on the drop line between when the steady tone began (*i.e.*, LNAPL was encountered) and when it stopped (*i.e.*, groundwater was encountered) will determine the apparent thickness of the LNAPL layer.
3. The depth to DNAPL can also be determined using the interface probe. Lower the probe through the water column to the bottom of the well. The probe will make a solid tone if a DNAPL is encountered. Record the depth to the top of the DNAPL layer, and the depth to the bottom of the well to determine the apparent thickness of the DNAPL layer.
4. The NAPL measuring device should be thoroughly cleaned after each use in accordance with the Sampling Equipment Decontamination SOP. If NAPL is encountered, use of a solvent (*e.g.*, hexane) will be required to clean the probe before it is used in another well.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance and quality control for water level and NAPL measurements shall consist of several steps. First it is important to verify the well identification number, check transcription to the Field Logbook and/or sample log sheets, and ensure that the well is one that is included in the project planning documents as a point of interest.

Additional quality control measures include repetitive measurements of the depth to water or NAPL to ensure that accurate and precise results are obtained. Once the measuring device indicates that the water level or NAPL layer has been encountered, the probe should be raised slightly and lowered several times to check and confirm the measurement. A single final reading should be recorded in the field logbook or on the project specific form.

Water levels in piezometers and monitoring wells should be allowed to stabilize for a minimum of 24 hours after well construction and development, prior to measurement. Also, measurements should always be taken from the least to the most contaminated wells while decontaminating the equipment between each well.

If water level data are to be used for groundwater flow direction determination, all measurements should be taken within the shortest time frame feasible. Typically, this is within 24 hours, however, with large numbers of wells, one day may not be adequate.

5.0 DOCUMENTATION AND RECORD KEEPING

Proper field data collection and management is important. Data may either be entered into a bound field logbook or other form specified in a site-specific work plan, as described in *SOP 03 – Field Logbook*.

6.0 REFERENCES

United States Environmental Protection Agency, January 1991, Compendium of ERT Groundwater Sampling Procedures: Washington D.C., EPA/540/P-91/007.

United States Environmental Protection Agency, September 1986, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document: Office of Waste Programs Enforcement, Washington, D.C., EPA/530/SW-86/055.

ATTACHMENT 1
SOP 26 – DEPTH TO GROUNDWATER AND NAPL MEASUREMENTS
GROUNDWATER SAMPLE COLLECTION RECORD

GROUNDWATER SAMPLE COLLECTION RECORD							
Project No.: _____		Date: _____		Time: Start: _____ am/pm			
Project Name: _____				Finish: _____ am/pm			
Location: _____							
Weather Conditions _____				Collector: _____			
1. WATER LEVEL DATA (measured from top of well casing)						Conversion Factors (cf) (ex cf = f)	
a. Total Casing Length: _____ (ft)	b. Well Casing Type: _____				Casing I.D. (in)	Conv. Fact.	
c. Depth to Water: _____ (ft)	d. Casing Diameter: _____ (in)				1	0.041	
e. Length of Water Column: _____ (ft) (a-c)				2	0.163		
f. Well Volume: _____ (gal)				3	0.367		
				4	0.653		
				6	1.470		
2. WELL PURGE DATA						See reverse side for graph	
a. Purge Method: _____							
b. Field Testing Equipment: _____							
c. Number of Well Volumes to Remove: _____							
d. Required Total Purge Volume (1f x 2c): _____							
Vol. Purged (total gal)	Temp (°C)	pH (s.u.)	Spec. Cond. (ms/cm)	Eh/ORP (mV)	Diss. O ₂ (mg/L)	Turbidity (NTU)	
3. SAMPLE COLLECTION Method: _____							
Comments: _____							

34 - GROUNDWATER SAMPLING

1.0 SCOPE AND PURPOSE

This standard operating procedure (SOP) provides guidelines for collection of groundwater samples from monitoring wells and extraction wells. Groundwater samples are typically collected for laboratory analysis to support an evaluation of the nature and extent of constituents in groundwater. Samples may also be collected for analysis of parameters which provide general groundwater chemistry information or are indicators of natural attenuation. This SOP includes a discussion of all aspects of the physical process of collecting the samples – sample handling and shipping are discussed in a separate SOP.

Effort must be made to ensure that the sample collected is representative of the particular zone being sampled. This SOP may be varied depending on site conditions and client or regulatory agency requirements. This SOP should be used in conjunction with the site-specific Sampling and Analysis Plan. The Project Manager or his/her deignee has the responsibility to oversee the groundwater sampling activities.

1.1 Referenced SOPs

- 03 – Field Logbook
- 04 – Management of Investigation-Derived Wastes
- 21 – Groundwater Field Testing
- 22 – Sample Preparation
- 23 – Sample Handling, Preservation, Packaging and Shipping
- 24 – Chain of Custody
- 25 – Equipment Decontamination
- 26 – Depth to Groundwater and NAPL Measurements

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

Groundwater sampling may require a relatively extensive list of equipment and protective clothing. In most cases, a pump or bailer can be used for purging and sampling. The type of pump or bailer selected depends on the well diameter, depth to water, and, in some cases, the analytical parameters. The advantages and disadvantages of various types of pumps are presented below:

- **Suction Lift Pumps**

- Advantages:**

- Readily available, relatively portable, and inexpensive

Disadvantages:

- Use is limited to situations where depth to water is less than 20 feet
- Reducing the pressure on the water may cause the volatile organic compounds (VOCs) to come out of solution. These pumps are not recommended for sample collection

• **Portable Submersible Pumps**

Advantages:

- Portable; can be used to sample several monitoring wells in a brief period of time
- Dependent upon the size of the pump and pumping depths; relatively large pumping rates are possible

Disadvantages:

- Most submersible pumps require a minimum well casing inside diameter of 4 inches

• **Air Lift Pumps**

Advantages:

- Portable; light-weight; easily transported and handled in the field
- Capable of handling lifts of as much as 100 feet
- Capable of producing flows of several gallons per minute (flow rate is dependent on lift)

Disadvantages:

- Air contacts the sample, which can cause a loss of volatile fraction
- consequently, not acceptable for collecting samples for organic analysis
- Not suitable for collecting samples for pH sensitive parameters such as metals
- Requires bottle gas or oilless air compressor to drive the pump

• **Bladder Pumps**

Advantages:

- Portable light-weight; easily transported and handled in the field
- Small diameter pumps are available, which can easily accommodate 2-inch diameter monitoring wells
- Drive gas does not touch sample; generally accepted method for collecting samples for all groundwater testing parameters

Disadvantages:

- Slow pumping rates make them inefficient for pumping large volumes of water
- Require compressed gas source, either bottled gas or oilless air compressor

Bailers used by Key Environmental are constructed of various materials (Teflon[®], stainless steel, or polyvinyl chloride) and are available in various diameters and lengths. Additional bailer options include bottom or top filling and bottom or top draining. The appropriate bailer should be identified in the site work plan in accordance with specific study needs:

Advantages:

- Available in a wide variety of materials compatible with the parameter of interest.
- Sufficiently economical and convenient to allow a separate bailer to be assigned to each well to minimize the potential for cross contamination.
- No external power source required.
- Low surface to volume ratio reduces outgassing of volatile organics

Disadvantages:

- Sometimes impractical to evacuate stagnant water in a well with a bailer
- Transfer of water sample from bailer to sample bottle can cause aeration
- Cross contamination can be a problem if equipment is not adequately decontaminated prior to each use.

An extensive amount of equipment may be needed for groundwater sampling. Prior to mobilization, the site-specific planning documents should be consulted to ensure that the appropriate equipment is obtained and transported to the site. Sampling equipment that may be needed is summarized below:

- Purging/Sample Collection Equipment
 - Bailers (Teflon[®], polyvinyl chloride (PVC), or stainless steel; bottom- or top-filling/draining)
 - Pumps (sized to well, specifications reviewed and accepted)
- Related Sampling and Field Measurement Equipment
 - Water quality monitoring instrument (capable of measuring temperature, pH, dissolved oxygen, conductivity, turbidity, and/or Oxidation/Reduction Potential (ORP))
 - PVC or other appropriate material discharge line
 - Filtration apparatus (vacuum or disposable)
 - Depth sounder
 - Water-level and/or NAPL-level measurement equipment (e.g., electric sounder, steel tape, transducer, etc.)
- General Equipment
 - Field logbook and indelible ink pens
 - Field data sheets (see Attachment 1)
 - Safety Glasses or equivalent eye protection
 - Distilled water and dispenser bottle
 - Decontamination solutions

- Calculator
- Sample preservation solutions
- Sample containers, labels, shipping containers; chain of custody forms
- Buckets and intermediate containers
- Coolers
- First aid kit
- Key(s) for well locks
- Stopwatch

- Disposable Materials
 - Plastic sheeting/garbage bags
 - Paper towels and/or clean shop cloths
 - Tape (clear, packing, and duct)
 - Pump tubing
 - Bailer cord
 - Gloves
 - Filters
 - Decontamination solutions, bottles, etc. (*SOP 25 – Equipment Decontamination*)
 - Chemical-free paper towels
 - Protective coveralls (e.g., Tyvek), if necessary

3.0 METHODOLOGIES

Several methods or combination of methods may be used to collect groundwater samples from monitoring wells. The chosen methodology(ies) will depend on the parameters to be analyzed, depth of the well, diameter of the well, depth to groundwater, and the required volume of water. In general, bailers are preferred over pumping for sample collection, where practical, for several reasons. Some of the more important reasons include: (1) pumping rates can agitate well water and alter volatile component concentrations, (2) pumps require a power source near to the well, and (3) pumps are more difficult to decontaminate after use than bailers. Where practical, dedicated, disposable bailers should be used for purging and sample collection to reduce field decontamination requirements and minimize the potential for cross contamination of samples.

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

1. Log in proper sample bottles received from laboratory, prepare any deionized water or preservatives needed for the sampling.
2. If necessary, prepare bailers and/or pumps with standard decontamination procedures and wrap in foil until needed (*see SOP 25 – Equipment Decontamination*).
3. Don the necessary personnel protective equipment (PPE) stipulated in the Site health and safety plan (HASp).

4. Measure static water level prior to well purging (see *SOP 26 – Depth to Groundwater and NAPL Measurements*). Water levels may 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, all measurements should be taken during the same work day or over as short a time period as possible.

Following water level measurements, all wells will be purged to assure collection of representative groundwater samples.

3.1 Well Purging

Well purging is performed prior to sampling to safeguard against collecting unrepresentative samples from stagnant water. All monitoring wells should be purged prior to sampling.

Prior to beginning activities at each well, the ground surface around the protective well casing should be covered with new plastic sheeting to limit contact between the ground surface and purging/sampling equipment.

Measure the depth to groundwater and the total well depth as described in *SOP 26 – Depth to Groundwater and NAPL Measurements*. Record this information on the well purge sheet and in the Field Logbook. Subtract the depth to static water level from the total well depth to determine the length of the water column in each well.

To calculate the amount of water to purge from each well, the depth of standing water must be measured using one of the above noted procedures. In addition, the inside casing diameter of each well must be known. These measurements, along with the following appropriate numbers, must be inserted into a formula for volume of a cylinder ($\pi r^2 h$), where r is well radius and h is height of water column, as follows:

$$V_{cf} = (\pi r^2) (L)$$

where:

$$V_{cf} = \text{volume of water in cubic feet (ft}^3\text{)}$$

r = radius of the well in feet

L = length of the water column in feet.

and

$$V_{gal} = V_{cf} \times 7.481$$

where:

$$V_{gal} = \text{volume in gallons}$$

$$V_{cf} = \text{volume in ft}^3$$

Wells will be purged until at least three casing volumes of water are removed from each well or until the pH, conductivity, and temperature of the purge water has stabilized. If a well is purged dry prior to removal of three well casing volumes, purging will be considered complete. Groundwater samples will be collected once a sufficient volume of groundwater has accumulated in the well to completely fill the necessary sample containers. To verify the removal of the required well volumes during purging, a graduated bucket will be used to measure purge water quantities.

Measure the necessary purge volumes by pumping or bailing into a graduated bucket. If the purged water contains a nonaqueous phase (free product) or it is required by the sampling plan, the graduated bucket should be intermittently emptied into a larger storage container (see *SOP 05 – Management of Investigation-Derived Wastes*). If possible, this purge water can be delivered to an onsite treatment system. If an onsite treatment system is not available, options for management of the purge water will be based upon the results of analyses. If no free product is present and the water is not a hazardous waste, the purged water may be disposed of on the ground away from the top of the well. If sufficient water is not present for purging of the required volumes, the well should be bailed or pumped dry and permitted to recharge prior to sampling. The time required for purging should be recorded in the field notes and on the Groundwater Well Purge Sheet.

3.1.1 Purging with Bailers

If using a bailer for purging, a laboratory-cleaned bailer with new disposable rope attached should be used at each well. The rope should be cut to sufficient length to allow the bailer to be lowered to the bottom of the well. While purging with a bailer, care must be taken to minimize turbidity in the samples. Never let the bailer fall into the well, lower it slowly to the water surface. Fill the bailer from the top of the water column and retrieve slowly until the bailer is free of the water column.

Bailing may not be feasible for wells that require purging of more than 20 gallons of water. Time constraints may require the use of pumps.

3.1.2 Purging with Surface Pumps

Groundwater withdrawal using pumps located at the ground surface is commonly performed with centrifugal, air diaphragm or peristaltic pumps.

Peristaltic, air diaphragm, and centrifugal pumps are limited to conditions where groundwater need only be raised through approximately 20 feet of vertical distance. Surface pumping can be used for many applications of well purging and groundwater sample collection. In all cases, pumping cannot be used for the collection of samples to be analyzed for volatile organic compounds (VOCs).

Peristaltic Pumps

Peristaltic pumps provide a low rate of flow, typically in the range of 0.02-0.2 gal/min (75-750 ml/min). Therefore, they are not particularly effective for well purging, except in cases where disturbance of the water column must be kept minimal for particularly sensitive analyses. Peristaltic pumps are most often used in conjunction with field filtering of samples and therefore can be used to obtain water samples for direct filtration.

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

1. New Nalgene suction line is used on each well being purged.
2. The suction line should be lowered to a depth in the water column to assure continued collection should drawdown of the water column occur.
3. To determine the proper amount of water to be purged, the pumping rate should be measured in gallons per minute by recording the time required to fill a selected volume of a calibrated bucket. Flow measurements should be performed three times on each well to obtain an average rate.
4. Monitor the pumping to ensure proper pump operation and assure continuous discharge. If drawdown occurs, lower the tubing deeper into the water column.
5. When the required amount of water is purged from each well allow for sufficient recovery before sampling.
6. All purge water is managed in an onsite treatment system, if available, or otherwise contained pending determination of appropriate management options (see *SOP 04 – Management of Investigation-Derived Wastes*). All tubing is discarded after each use.

Air diaphragm pumps are design to pump varying rates of groundwater from 1 gal/min to 20 gal/min depending on the pump capacity and the compressed air supply capacity. Air diaphragm pumps are often used where increased mixing may pose a problem and higher groundwater extraction rates are required.

Centrifugal pumps are designed to provide a high rate of pumping, in the range of 10-40 gal/min, depending on pump capacity. Discharge rates can also be regulated if the pump has an adjustable throttle. Samples should be collected from the influent (suction) line during pumping via a sampling port. It is suggested, if samples cannot be collected prior to going through the pump, a bailer be utilized for sample collection once pumping has ceased. Sample collection from the pump discharge is not recommended.

If using a pump to purge, measure sufficient rope and/or discharge line necessary for the pump use. Unless directed otherwise by the sampling plan, install a pump with the pump intake

located immediately above the well screen. If a pump is not dedicated to each well, the pump should be thoroughly decontaminated (see *SOP 25 – Equipment Decontamination*) between locations, and new discharge line should be used. Take care to purge (and sample) wells in order from the least impacted to the most impacted, if known.

3.1.2 Purging with Submersible Pumps

Submersible pumps provide an effective means for well purging. They are particularly useful for situations where the depth to the water table is greater than 20 feet or the diameter of the well requires that a large volume of groundwater be removed during purging.

1. Prior to using a submersible pump, a check will be made of well diameter and alignment to ensure the well is adequate to accommodate the submersible pump. All observations would be entered on the Groundwater Sample Collection Form.
2. Slowly lower the submersible pump (which is properly secured to a surface structure) into the monitoring well. Set the pump at a predetermined depth slightly below top of the static water column within the monitoring well. Secure the discharge line and power cord to the well casing.
3. Drawdown should be monitored continuously by remaining near the well at all times and listening to the pump. When excessive drawdown occurs, a metallic rotary sound will be heard as the pump intake becomes exposed and ceases to discharge groundwater, but continues to run. The pump should be lowered immediately to continue pumping water within the uppermost section of the static water column.
4. If drawdown continues to the extent that the well is pumped dry, the pump should be shut off and the well allowed to recharge. This on/off cycle may need to be repeated several times in order to purge the well properly.
5. Measurements of pumping rate, pH, temperature, and specific conductance should be made periodically during well purging. All readings and respective purge volumes should be entered on the Groundwater Sample Collection Form
6. If a pump is not dedicated to each well, the pump should be thoroughly decontaminated (see *SOP 25 – Equipment Decontamination*) between locations, and new discharge line should be used.

Bladder Pumps

The bladder pump is a 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.

These pumps are used when large volumes of water must be purged from monitoring wells. Usually these pumps are used on wells with diameters of 2 inches or greater and wells with depths up to 150 feet.

The line assembly is dedicated for use on one well only. After use the tubing is wrapped, marked, and stored for future use in the well to which it is dedicated.

The bladder pumps are primarily used to remove the required amount of water from the monitoring well prior to sampling. When this is accomplished, the groundwater is sampled using a bailer. The general procedure for the use of bladder pumps is outlined below:

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 down the well by unrolling the line off the spool until the pump touches bottom. Raise the pump to the desired position inside the well allowing sufficient room for drawdown of the water column.
3. Secure the cable to hold the pump at the desired depth.
4. Connect the gas line to the control box. The discharge line should be placed in a container (e.g., 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. As noted, the tubing is used on one well only; after each sampling event it is packed, sealed, and stored for future use on that well.

3.2 Sample Collection

When possible all samples will be collected using bailers. Hand bailing for sample collection is preferred because bailers can be decontaminated much more reliably than pumps. Also, since pumping rates are difficult to control, and most pumps operate through a pulsating action, the degassing of volatile organic concentrations may occur.

After water level recovery, the well should be sampled within 24 hours of completion of the purge event. Dedicated, laboratory clean stainless steel or disposable Teflon[®] or polyethylene bailers should be used to collect each sample. The sampling technician should wear a clean pair of surgical gloves for each well. The bailer should be gently lowered into the well. Samples will be collected in decreasing order of their volatility. This order is generally as follows:

- Volatile Organic Chemicals (VOC)
- Total Organic Halogens (TOX)
- Total Organic Carbon (TOC)

- Semivolatile Organics Chemicals (SVOC)
- Pesticides and polychlorinated biphenyls/dioxins
- Metals
- Total Phenols
- Cyanide
- Other chemical parameters (e.g., chloride, sulfide, nitrate, etc.)
- Radionuclides

The initial bail after purging should always be used to fill the VOC vials. Sample collection procedures and chain-of-custody outlined in *SOPs 22, 23, and 24* should be followed. Samples collected for volatile organics should be carefully placed into 40 ml 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. Other common laboratory-provided sample bottles include polyethylene or clear glass for metals and amber glass for phenols and semi volatiles.

In situations where analysis of dissolved metals is required, field filtration of each sample will be necessary (Note: filtering is not recommended for VOC or SVOC analysis).

Filtering is performed using either hand vacuum pumps with funnels or peristaltic pumps with disposable funnels/filters. If using the vacuum pump method, a laboratory cleaned funnel is used for each well. Funnels are decontaminated in the laboratory using the standard decontamination procedures. 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. Whether using a vacuum pump or peristaltic pump, all samples are filtered through 0.45 micron filter paper. After filtering, samples requiring preservatives are preserved and all containers are securely placed in coolers and chilled to an appropriate temperature (usually < 4°C). Each cooler containing samples; will contain a completed chain-of-custody form or tag.

3.2.1 Sampling with Bailers

The following procedures are followed when wells are purged and samples are extracted using bailers;

1. Place plastic sheeting (or unused trash bags) around the well casing or in a bucket to create a clean surface for the placement of sampling cord and equipment.
2. Use a dedicated, cleaned, stainless steel bailer or dedicated disposable polyethylene or Teflon[®] bailer at each well for the required purging and sampling. Remove the protective wrapping from the bailer (if applicable).
3. Use new surgical or nitrile gloves when working on each well.
4. Use new nylon cord to tie on each bailer.
 - Make sure the knotted cord is securely tied to the bailer.

- Unwind a sufficient length of cord to allow for the bailer to travel to the bottom of the well.
 - Remove an additional length of cord and tie it securely to the well head to serve as a safety line for the bailer.
5. Raise the bailer using each hand in a “rocking” action. The bailer cord should never touch the ground surface. For slowly recharging wells, the bailer is generally withdrawn slowly through the entire water column. Rapidly recharging wells should be purged by varying the level of bailer insertion to ensure that all stagnant water is removed. If feasible, the water column should be allowed to recover to a minimum of 70% of its static level prior to sample collection, however, refer to site-specifications for sampling protocols. Typically, groundwater sampling is to be completed within three hours of purging. Samples should be collected from midpoint or lower within the water column.
6. Samples collected by bailing will be poured directly into sample containers. Bailers will not be permitted to come into contact with the sample containers during sample collection.

3.2.2 Sampling with Pumps

As noted above, when possible, pumps are not typically used to sample wells. When pumps are used to purge wells, pumping will be done from the top of the water column and flow will be checked to ensure removal of the proper volume of water. Also, in some instances, pumps are the only means by which samples can be extracted from monitoring wells.

The types of pumps used for sampling include peristaltic, bladder, and submersible pumps.

Peristaltic Pumps

New silicone pump head tubing will be used if a peristaltic pump is utilized for sampling. The type of tubing used to collect the sample will be contingent on the parameters of interest.

- If conventional parameters are being analyzed, then standard nalgene tubing is sufficient to collect the sample.
- If volatile, semi-volatile, or metals parameter are the constituents of interest, Teflon[®] tubing is used to collect the sample.

Submersible Pumps

When possible, the submersible pumping apparatus is pulled to allow for sampling with a dedicated or a clean stainless steel bailer. If this is not feasible the submersible pump will remain intact and will be used to collect the samples.

3.2.3 Sample Filtration

Groundwater samples collected for dissolved metal analyses will be filtered prior to being placed in sample containers. Groundwater sample filtration will be performed using a peristaltic pump and a 0.45 micron water filter.

The filtration of groundwater samples shall be performed either directly from the monitoring well or from intermediate sample containers. In either case, well purging shall be performed first. Fresh groundwater shall then be filtered and discharged from the filtration apparatus directly into sample containers.

For most dissolved metal analyses, pH adjustment of the sample is also required and shall be performed after filling the sample bottles. This is generally accomplished using laboratory-supplied preservatives such as nitric acid or sodium hydroxide. The preservative shall be identified in the site-specific planning documents. Pre-preserved bottles may be supplied by the laboratory.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance and quality control for groundwater sampling activities will consist of several distinct elements. Double checking of planned sample numbers versus numbers recorded on the field log sheets, on the sample label, and on the chain-of-custody form shall be completed to ensure that no mix up of samples versus locations occurs. Collection of field quality control samples will be completed as specified in the project planning documents and will typically consist of field duplicate samples, matrix-spike/matrix spike duplicates, and possibly rinsate blanks. Trip blanks and field blanks are typically not required, but may be required on a project-specific basis.

Decontamination of sampling equipment between sample locations is to be performed as outlined in *SOP 25 - Equipment Decontamination*. Sample preparation will follow *SOP 22 - Environmental Sample Preparation*. Sampling handling, preservation, packaging and shipping will follow *SOP 23 - Sample Handling, Preservation, Packaging and Shipping*. Chain of custody will be maintained at all times, following *SOP 24 - Chain of Custody*.

5.0 DOCUMENTATION AND RECORD-KEEPING

All relevant observations and information about the sample location and sample collection effort shall be recorded in the field logbook in accordance with the relevant KEY Field Logbook SOP. Groundwater sample collection record forms (see Attachment A) shall be filled out completely for each well. Detailed information regarding the sampling and required analyses shall be recorded on a groundwater sample form, including, but not limited to, sample number; collection date, time, and location; soil texture and color; relevant observations for the sample location (staining, odors, stressed vegetation).

All Sample Collection forms as well as the Field Logbook become part of the permanent project record. Both physical and electronic copies are maintained in Key project files.

6.0 REFERENCES


United States Environmental Protection Agency, 1981, Manual of Groundwater Quality Sampling Procedures: Washington, D.C., EPA 600/2-81/160.

United States Environmental Protection Agency, 1985, Practical Guide for Groundwater Sampling: Washington, D.C., EPA 600/2-85/104.

United States Environmental Protection Agency, 1986. Groundwater Monitoring Technical Enforcement Guidance Document: Office of Waste Programs Enforcement, Washington, D.C., EPA/530/SW-86/055.

United States Environmental Protection Agency, 1982, Handbook for Sampling and Sample Preservation of Water and Wastewater: Washington, D.C., EPA 600/4-82/029.

ATTACHMENT 1
SOP 34 – GROUNDWATER SAMPLING
GROUNDWATER SAMPLE COLLECTION RECORD

	WELL NO.: _____																																																
GROUNDWATER SAMPLE COLLECTION RECORD																																																	
Project No.: _____ Date: _____ Time: Start: _____ am/pm Project Name: _____ Finish: _____ am/pm Location: _____ Weather Conditions _____ Collector: _____ <div style="text-align: right; font-size: small;"> Print _____ Sign _____ </div>																																																	
<p>1. WATER LEVEL DATA (measured from top of well casing)</p> <p>a. Total Casing Length: _____ (ft) b. Well Casing Type: _____</p> <p>c. Depth to Water: _____ (ft) d. Casing Diameter: _____ (in)</p> <p>e. Length of Water Column: _____ (ft) (a-c)</p> <p>f. Well Volume: _____ (gal)</p> <p>2. WELL PURGE DATA</p> <p>a. Purge Method: _____</p> <p>b. Field Testing Equipment: _____</p> <p>c. Number of Well Volumes to Remove: _____</p> <p>d. Required Total Purge Volume (1f x 2c): _____</p>	<table border="1" style="width:100%; border-collapse: collapse; font-size: x-small;"> <thead> <tr> <th colspan="2">Conversion Factors (cf) (e x cf = f)</th> </tr> <tr> <th>Casing I.D. (in)</th> <th>Conv. Fact.</th> </tr> </thead> <tbody> <tr><td>1</td><td>0.041</td></tr> <tr><td>2</td><td>0.163</td></tr> <tr><td>3</td><td>0.367</td></tr> <tr><td>4</td><td>0.653</td></tr> <tr><td>6</td><td>1.470</td></tr> </tbody> </table>	Conversion Factors (cf) (e x cf = f)		Casing I.D. (in)	Conv. Fact.	1	0.041	2	0.163	3	0.367	4	0.653	6	1.470																																		
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<p>3. SAMPLE COLLECTION INFORMATION</p> Sampling Method(s): _____ Sample Identification (name, time, date): _____ QC Samples (name, time, date): _____ _____ Analytical Parameters _____ and Methods: _____ Comments: _____ _____ _____																																																	

36 - LOW-FLOW (MINIMAL DRAWDOWN) GROUNDWATER SAMPLING PROCEDURES

1.0 SCOPE AND PURPOSE

This standard operating procedure (SOP) provides guidelines for the collection of representative groundwater samples from monitoring wells. Groundwater samples are typically collected from monitoring wells for laboratory analysis to support the characterization of representative groundwater quality. Low-flow purging has the advantages of minimizing the turbidity and mixing between the overlying stagnant casing water and water within the screened interval. Low-flow refers to the velocity with which water enters the pump intake from the formation pore water in the immediate vicinity of the well screen. Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrological situation. Typically, flow rates on the order of 0.1-0.5 liter/minute are used, however, these flow rates may be varied dependent upon site-specific hydrogeology.

1.1 Referenced SOPs

- 03 – Field Logbook
- 22 – Sample Preparation
- 23 – Sample Handling, Preservation, Packaging and Shipping
- 24 – Chain of Custody
- 25 – Equipment Decontamination
- 26 – Depth to Groundwater and NAPL Measurements
- 34 – Groundwater Sampling

1.2 Definitions

(Reserved)

2.0 REQUIRED MATERIALS

The following list identifies the types of equipment which may be used during groundwater sampling tasks. Project-specific equipment should be selected based upon project objectives, the depth of groundwater, purge volumes, analytical parameters, and well construction. 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 Teflon®

Note that bailers are inappropriate devices for low-flow sampling.

Peristaltic pumps may be the least desirable choice, and for some projects, may not be an option at all. Some regions have specific requirements regarding what type of pumps should be used for sampling of particular analytical parameters. For example, USEPA Region II does not allow the use of peristaltic pumps for collecting samples for analysis of organic parameters. For this reason, region-specific requirements regarding pump selection shall be specified in the project-specific work plan. Another consideration is the soft silicon tubing required for use with the peristaltic pump mechanism. There is potential that this tubing may react with more complex organic compounds.

- 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 Horiba® U-10 or U-22
 - 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)
 - An in-line dissolved oxygen meter
 - An in-line turbidity meter
 - An in-line filtration apparatus, 0.45 micron, if dissolved metals are a constituent of interest at the site;
 - A water level meter
 - 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 and log book
 - Sample preservation solutions
 - Sample containers
 - Buckets and intermediate containers
 - Coolers
 - Shipping labels
 - Permanent markers/pens
 - Packing tape
 - First aid kit
 - Key(s) for well locks
 - Stopwatch
- Disposable Materials:
 - Plastic sheeting/bags
 - Pump tubing
 - Gloves

- Filters
- Chemical-free paper towels
- Personal protective equipment, 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. This lag time will depend on site conditions and method of installation. New Jersey protocols require a minimum lag time of two weeks. USEPA protocols recommend an evaluation of site conditions with a typical minimum lag time of one week. (Note: Project personnel shall review applicable regulatory guidelines regarding the required lag time on a project-specific basis).

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

1. Log in sample bottles received from laboratory, prepare any deionized water or preservatives needed for the sampling;
2. If necessary, prepare pumps with standard decontamination procedures;
3. Don the necessary personnel protective equipment (PPE) stipulated in the Site health and safety plan (HASP);
4. Measure static water level prior to well purging. Water levels may 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, all wells should be measured over as short a time period as possible. Water level measurements will be consistent with the procedures specified in *SOP 26 - Depth to Groundwater and NAPL Measurements*.
5. Unless specified otherwise in the project-specific work plan, well depth should be obtained from the well logs, rather than from measuring total depth, as this activity may disturb material that has settled to the bottom of the well and increase turbidity in samples. If it is necessary to measure total depth, or to measure dense non-aqueous phase liquid (DNAPL), perform these measurements after the sample has been collected.

3.2 Equipment Calibration

Prior to purging and sampling, all sampling devices and monitoring equipment should be calibrated according to manufacturer's recommendations, the site Quality Assurance Project Plan

(QAPP) and the project-specific work plan. Dissolved oxygen calibration must be corrected for local barometric pressure readings and elevation.

3.3 Well Purging

For low-flow, minimal drawdown sampling protocols, an in-line water quality measurement device such as a flow-through cell is used to establish the stabilization time on a well-specific basis for several indicator parameters, as follows:

- pH
- Specific conductance
- Dissolved oxygen
- Turbidity
- Oxidation-Reduction Potential (ORP) (as required on a project-specific basis)

This differs from the general guideline used in conventional purging and sampling protocols that requires removal of a minimum of three casing volumes prior to sampling. Following are recommendations to be considered before, during, and after purging and sampling:

- Establish a flow rate that maintains minimal drawdown in the well during both purging and sampling
- Maximize tubing wall thickness and minimize tubing length
- Place the sampling device intake at the middle or slightly above the middle of the screened interval, unless specified otherwise in the project-specific work plan
- For wells completed as open boreholes in bedrock, placement of the sampling device will be specified in the project-specific work plan
- Minimize disturbances of the stagnant water column above the screened interval during water level measurement and sampling device insertion
- Make proper adjustments to stabilize the flow rate as soon as possible
- Monitor water quality indicators during purging

Pump 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.

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.

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. These pumps are used when large volumes of water must be purged from monitoring wells or when water depths exceed the limits of a peristaltic pump. Usually these pumps are used on wells with diameters of 2 inches or greater and wells with depths up to 150 feet. When economically feasible the bladder pumps will be dedicated to each well. The line assembly is dedicated for use on one well only. After use, the tubing is wrapped, marked, and stored for future use in the well to which it is dedicated.

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 down 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. The discharge line should be connected 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.
5. Connect the gas supply to the control box and adjust the pressure according to the manufacturer's manual.
6. As noted, the tubing is used on one well only; after each sampling event it is packed, sealed, and stored for future use on that well.

Submersible Pumps

When wells are encountered which require excessive lift (depth to water is greater than 20 feet) or have diameters greater than 2 inches, positive displacement submersible pumps may also be used to purge the required amount of water. When economically feasible, the submersible pumps will be dedicated to each well. However, in some cases, this is not economically feasible, and the same pump must be used in several wells. When this must be done, the pumps will be appropriately decontaminated between wells. Also, a pump will be used on wells known to contain similar constituent levels, or used first in wells with lower constituent levels before use in wells with historically higher constituent concentrations.

1. The submersible pump should be lowered to the desired depth using a safety line that is secured to the well casing.

2. Connect the power cord to the power source (generator) and turn on the pump.
3. 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.
4. Continue to monitor the pumping rate and water level in the well, slowing the rate if drawdown occurs.

Peristaltic Pumps

Peristaltic pumps must be 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 sample collection.

1. New Nalgene[®] or low density polyethylene (LDPE) suction line is used on each well being purged. New silicone pump head tubing will also be used if the pump is also used for sampling.
2. The type of tubing used to collect the sample will be contingent on the parameters of interest.
 - 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[®] tubing is sufficient to collect the sample.
 - If volatile, semi-volatile, or metals parameters are the constituents of interest, Teflon[®] tubing is used to collect the sample.
3. All tubing is discarded after each use or packed, sealed and stored for future use within the same well.

Unless authorized otherwise, all purged groundwater is collected, containerized, and when possible, managed in an onsite treatment system.

3.4 Monitoring or Water Level and Water Quality Indicator Parameters

Performance criteria for determining stabilization should be based on water-level drawdown, pumping rate, and specifications for indicator parameters. Check the water level periodically during purging and sampling to monitor drawdown in the well as a guide to any necessary flow rate adjustment. The goal is minimal drawdown (<0.1 meter) during purging. This goal may not be possible to achieve under some circumstances and may require adjustment based on site-specific conditions and personal experience.

In-line water quality indicator parameters should be continuously monitored during purging as discussed in SOP 34 – Groundwater Sampling, as follows:

- Temperature
- pH
- ORP
- Specific conductivity
- Dissolved oxygen
- Turbidity

Measurements should be taken every three to five minutes. Stabilization is achieved after all parameters have stabilized for three successive readings. The three successive reading should be within the following guidelines to indicate stabilization:

- $\pm 10\%$ for temperature
- ± 0.2 SU for pH
- $\pm 3\%$ for conductivity
- ± 10 mv for ORP
- $\pm 10\%$ for turbidity
- $\pm 10\%$ for dissolved oxygen

Note that these are guidelines only; for example, in those instances where the field parameters measure at very low readings, even minor fluctuations can exceed the guidelines, even though stabilization has been achieved. In these instances, the field technician must use professional judgment to determine that parameter stabilization has been achieved.

Parameters will typically stabilize in the following order: pH, temperature, and specific conductance, followed by ORP, dissolved oxygen, and turbidity. If parameter stabilization criteria are too stringent, then minor oscillations in indicator parameters may cause purging operations to become unnecessarily protracted. It should also be noted that turbidity is a very conservative parameter in terms of stabilization and is normally the last parameter to stabilize. Excessive purge times are invariably related to the establishment of too stringent turbidity stabilization criteria. Note that natural turbidity levels in groundwater may exceed 10 nephelometric units (NTU). Pumping rate, drawdown, and the time or volume required to obtain stabilization of parameter readings can be used as a future guide to purge the well.

3.5 Groundwater Sampling

Once parameters have stabilized, begin sample collection as soon as possible. Disconnect or bypass the in-line monitoring device that was used to measure field parameters prior to sample collection. The sampling flow rate should remain at the established purge rate or may be adjusted slightly to minimize aeration, bubble formation, turbulent filling of sample bottles, or loss of volatiles due to extended residence time in tubing. Typically, flow rates <0.5 liters/minute are appropriate. The same device used for purging should be used for sampling. 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., Fe^{2+} , CH_4 , $\text{H}_2\text{S}/\text{HS}^-$, alkalinity)
- Total organic carbon (TOC)
- Semivolatile organics chemicals (SVOCs)
- Inorganic parameters

If filtered samples are to be collected, these should be collected last

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. Other common laboratory-provided sample bottles include polyethylene or clear glass for metals and amber glass for phenols and SVOCs.

If the project-specific work plan or QAPP specifies dissolved metals analysis, field filtration of each sample will be necessary. Filtering is performed using an in-line filtration device, hand vacuum pumps with transfer vessels, or peristaltic pumps with disposable 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 project-specific work plan. After filtering, samples requiring preservatives are preserved and all containers are securely placed in coolers and chilled to an appropriate temperature (usually $< 4^\circ\text{C}$). Each cooler containing samples will contain a completed chain-of-custody form.

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

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Quality control requirements depend upon project-specific circumstances and objectives and should be addressed in the QAPP or the project-specific work plan.

Quality assurance and quality control for groundwater sampling activities will consist of several distinct elements. Double checking of planned sample numbers versus numbers recorded on the field log sheets, on the sample label, and on the chain-of-custody form shall be completed to ensure that no mix up of samples versus locations occurs. Collection of field quality control samples will be completed as specified in the project planning documents and will typically consist of field duplicate samples, matrix-spike/matrix spike duplicates, and possibly rinsate blanks. Trip blanks and field blanks are typically not required, but may be required on a project-specific basis.

Decontamination of sampling equipment between sample locations is to be performed as outlined in *SOP 25 - Equipment Decontamination*. Sample preparation will follow *SOP 22 – Environmental Sample Preparation*. Sampling handling, preservation, packaging and shipping will follow *SOP 23 – Sample Handling, Preservation, Packaging and Shipping*. Chain of custody will be maintained at all times, following *SOP 24 – Chain of Custody*.

5.0 DOCUMENTATION AND RECORD KEEPING

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:

- Field logbook (*SOP 03 – Field Logbook*)
- Groundwater Sample Collection Forms (Attachment 1)
- Chain of custody forms (*SOP 24 – Chain of Custody*)
- 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
- Sampler's name

6.0 REFERENCES

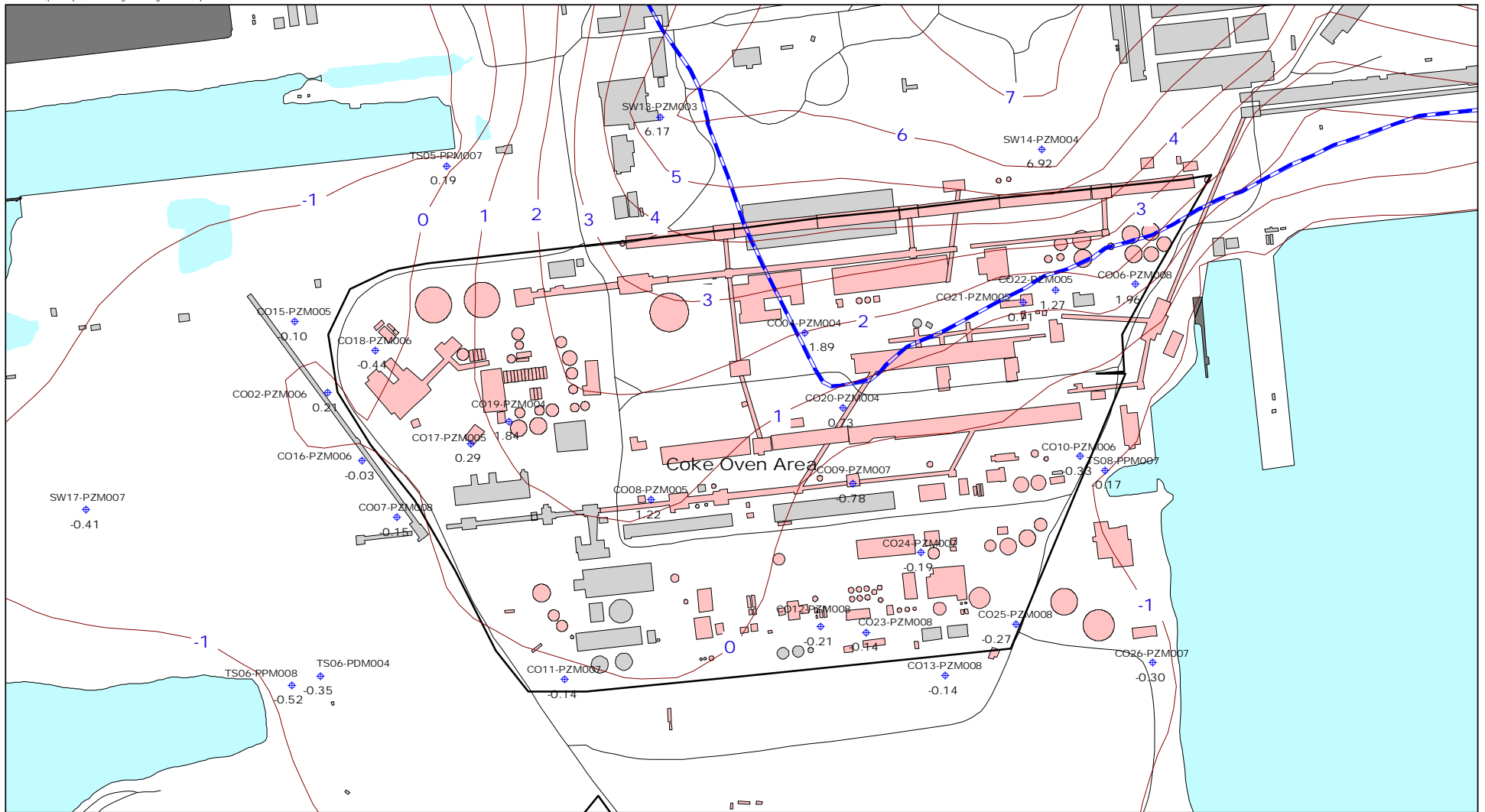
U.S. EPA, 1996, Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures: Robert W. Puls and Michael J. Barcelona, EPA/540/S-95/504.

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

**ATTACHMENT 1
 SOP 36 – LOW-FLOW (MINIMAL DRAWDOWN)
 GROUNDWATER SAMPLING PROCEDURES
 GROUNDWATER SAMPLE COLLECTION RECORD**

	WELL NO.: _____																																																
GROUNDWATER SAMPLE COLLECTION RECORD																																																	
Project No.: _____ Date: _____ Time: Start: _____ am/pm Project Name: _____ Finish: _____ am/pm Location: _____																																																	
Weather Conditions _____ Collector: _____ <div style="display: flex; justify-content: space-between; font-size: small;"> Print Sign </div>																																																	
1. WATER LEVEL DATA (measured from top of well casing)																																																	
a. Total Casing Length: _____ (ft) c. Depth to Water: _____ (ft) e. Length of Water Column: _____ (ft) (a-c) f. Well Volume: _____ (gal)	b. Well Casing Type: _____ d. Casing Diameter: _____ (in)																																																
Conversion Factors (cf) (e x cf = f)																																																	
<table border="1" style="width:100%; border-collapse: collapse; font-size: x-small;"> <thead> <tr> <th style="width: 60%;">Casing I.D. (in)</th> <th style="width: 40%;">Conv. Fact.</th> </tr> </thead> <tbody> <tr><td>1</td><td>0.041</td></tr> <tr><td>2</td><td>0.163</td></tr> <tr><td>3</td><td>0.367</td></tr> <tr><td>4</td><td>0.653</td></tr> <tr><td>6</td><td>1.470</td></tr> </tbody> </table>		Casing I.D. (in)	Conv. Fact.	1	0.041	2	0.163	3	0.367	4	0.653	6	1.470																																				
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2	0.163																																																
3	0.367																																																
4	0.653																																																
6	1.470																																																
2. WELL PURGE DATA																																																	
a. Purge Method: _____ b. Field Testing Equipment: _____ c. Number of Well Volumes to Remove: _____ d. Required Total Purge Volume (1f x 2c): _____																																																	
<table border="1" style="width:100%; border-collapse: collapse; text-align: center; font-size: x-small;"> <thead> <tr> <th style="width: 12.5%;">Vol. Purged (total gal)</th> <th style="width: 12.5%;">Temp (°)</th> <th style="width: 12.5%;">pH (s.u.)</th> <th style="width: 12.5%;">Spec. Cond. ()</th> <th style="width: 12.5%;">ORP (mV)</th> <th style="width: 12.5%;">Diss. O₂ (mg/L)</th> <th style="width: 12.5%;">Turbidity (NTU)</th> <th style="width: 12.5%;"></th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table>		Vol. Purged (total gal)	Temp (°)	pH (s.u.)	Spec. Cond. ()	ORP (mV)	Diss. O ₂ (mg/L)	Turbidity (NTU)																																									
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3. SAMPLE COLLECTION INFORMATION																																																	
Sampling Method(s): _____ Sample Identification (name, time, date): _____ QC Samples (name, time, date): _____ _____ Analytical Parameters _____ and Methods: _____ Comments: _____ _____ _____																																																	

APPENDIX C
HISTORICAL GROUNDWATER CONTOUR MAPS
(SHALLOW AND INTERMEDIATE ZONE)



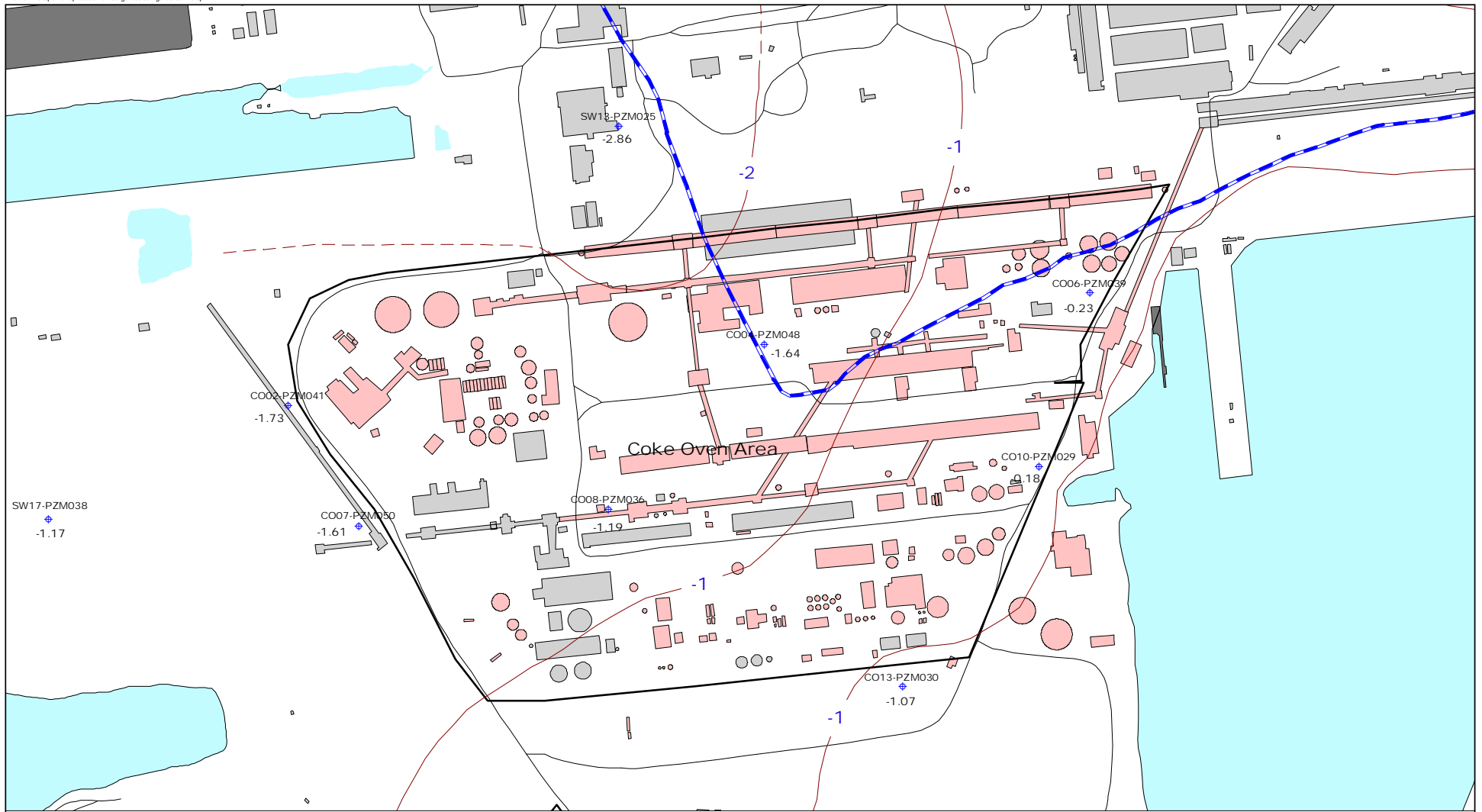
LEGEND

- ◆ Water Table Piezometer
- Water Level Contour (1 Ft Contour Interval)
- Special Study Area
- Water Body
- Dam/Pier/Boat Ramp/Dry Dock
- Existing Buildings
- Demolished Buildings
- Original 1917 Shore Line
- Roads
- Railroads



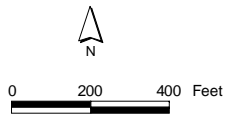
Note: Surface elevation of Bear Creek, Patapsco River, Old Road Bay, and Jones Creek is -1.25 feet NAVD

Figure 2.2-11
 Water Level Elevations - March 19, 2002, Water Table
 Coke Oven Area
 Release Site Characterization
 Bethlehem Steel Corporation - Sparrows Point Facility



LEGEND

- ◆ Deeper Sand Piezometer
- - - Deeper Sand Water Level Contour (1 Ft. Contour)
- Special Study Area
- Water Body
- Dam/Pier/Boat Ramp/Dry Dock
- Existing Buildings
- Demolished Buildings
- - - Original 1917 Shore Line
- - - Roads
- - - Railroads



Note: Surface elevation of Bear Creek, Patapsco River, Old Road Bay, and Jones Creek is -1.25 feet NAVD

Figure 2.2-12
 Water Level Elevations - March 19, 2002, Deeper Sand Piezometric Surface
 Coke Oven Area
 Release Site Characterization
 Bethlehem Steel Corporation - Sparrows Point Facility

**APPENDIX D
HISTORICAL BENZENE AND
NAPHTHALENE ISOCONCENTRATION CONTOUR MAPS**

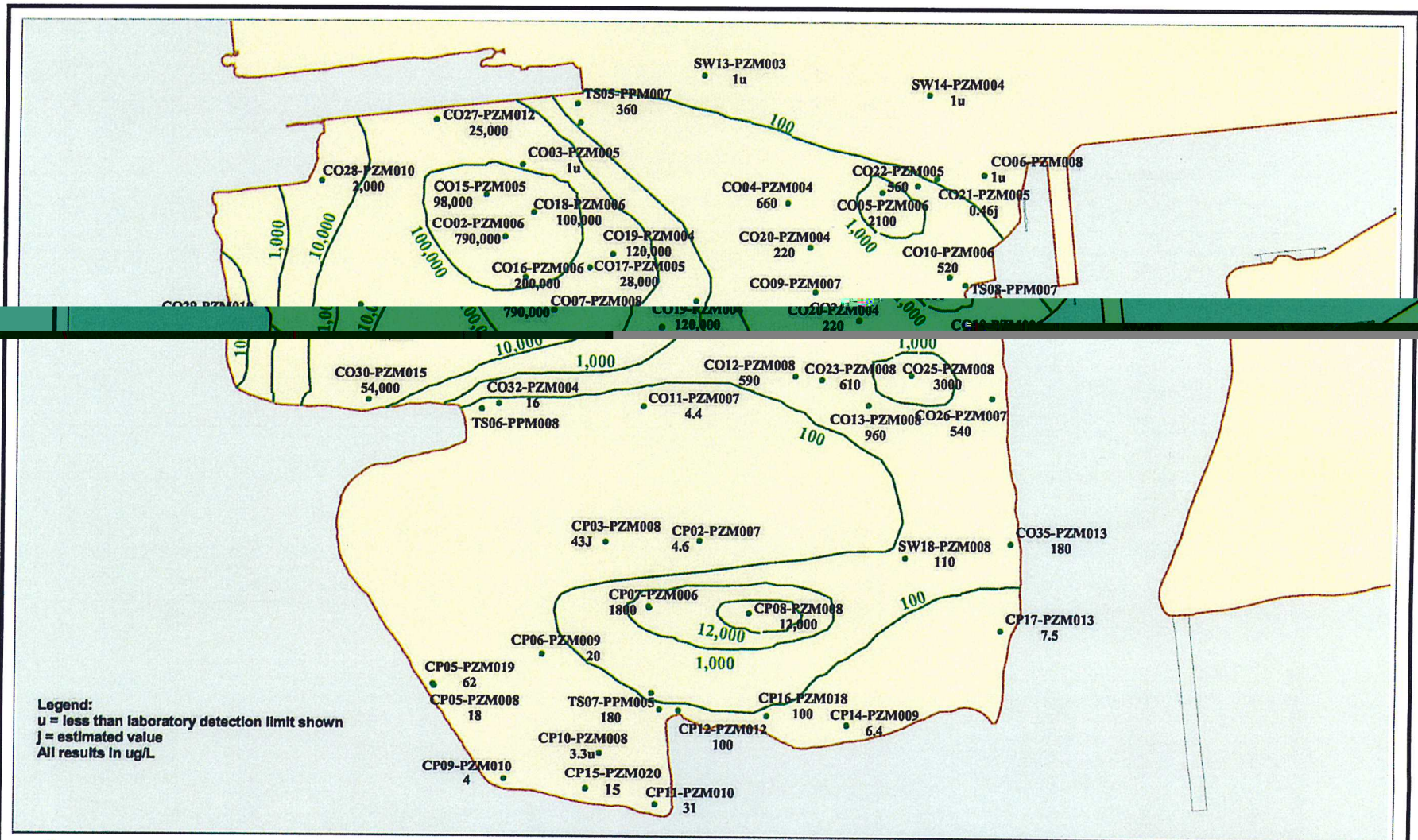
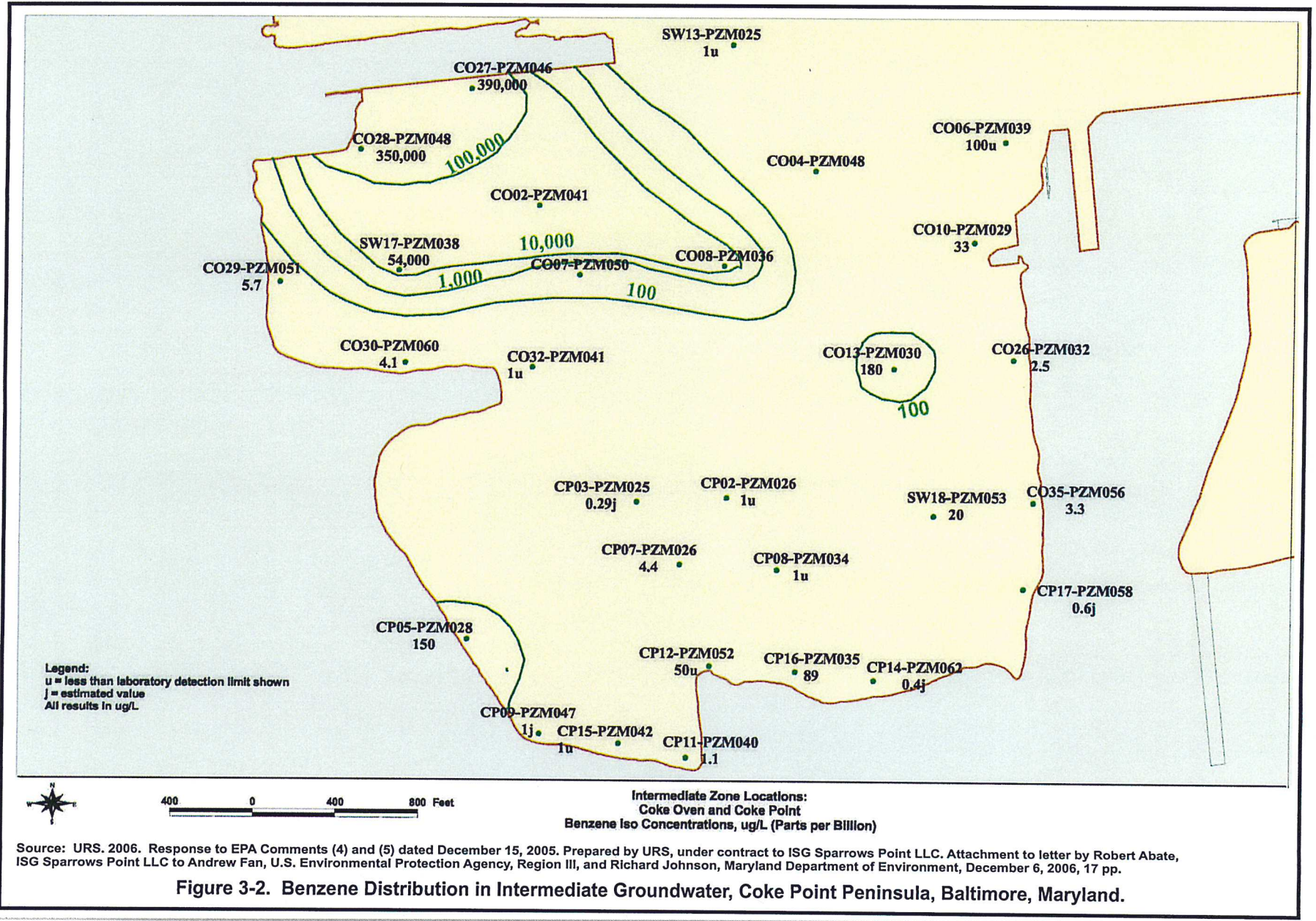


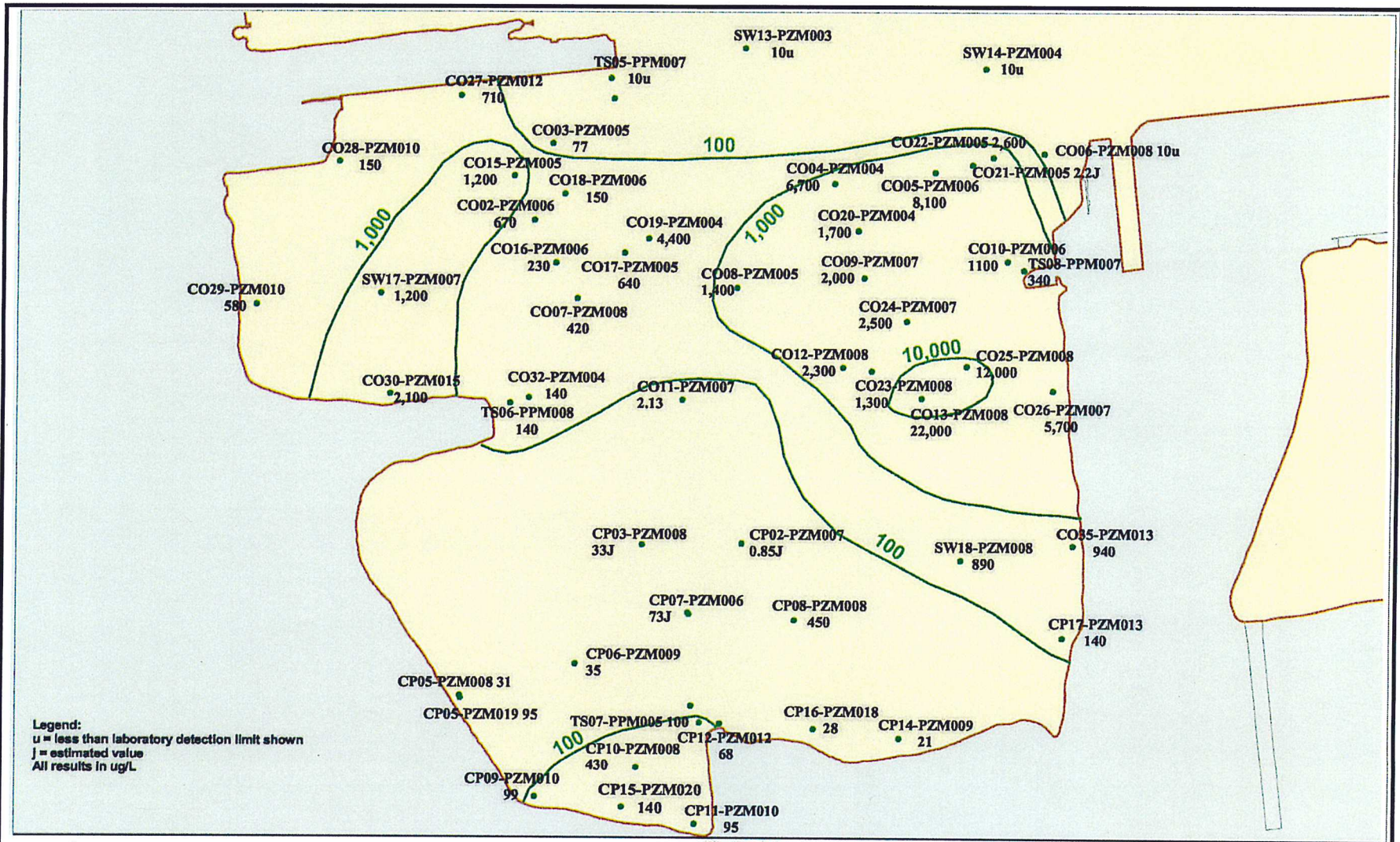
Figure 3-1. Benzene Distribution in Shallow Groundwater, Coke Point Peninsula, Baltimore, Maryland.

Source: URS. 2006. Response to EPA Comments (4) and (5) dated December 15, 2005. Prepared by URS, under contract to ISG Sparrows Point LLC. Attachment to letter by Robert Abate, ISG Sparrows Point LLC to Andrew Fan, U.S. Environmental Protection Agency, Region III, and Richard Johnson, Maryland Department of Environment, December 6, 2006, 17 pp.



Source: URS. 2006. Response to EPA Comments (4) and (5) dated December 15, 2005. Prepared by URS, under contract to ISG Sparrows Point LLC. Attachment to letter by Robert Abate, ISG Sparrows Point LLC to Andrew Fan, U.S. Environmental Protection Agency, Region III, and Richard Johnson, Maryland Department of Environment, December 6, 2006, 17 pp.

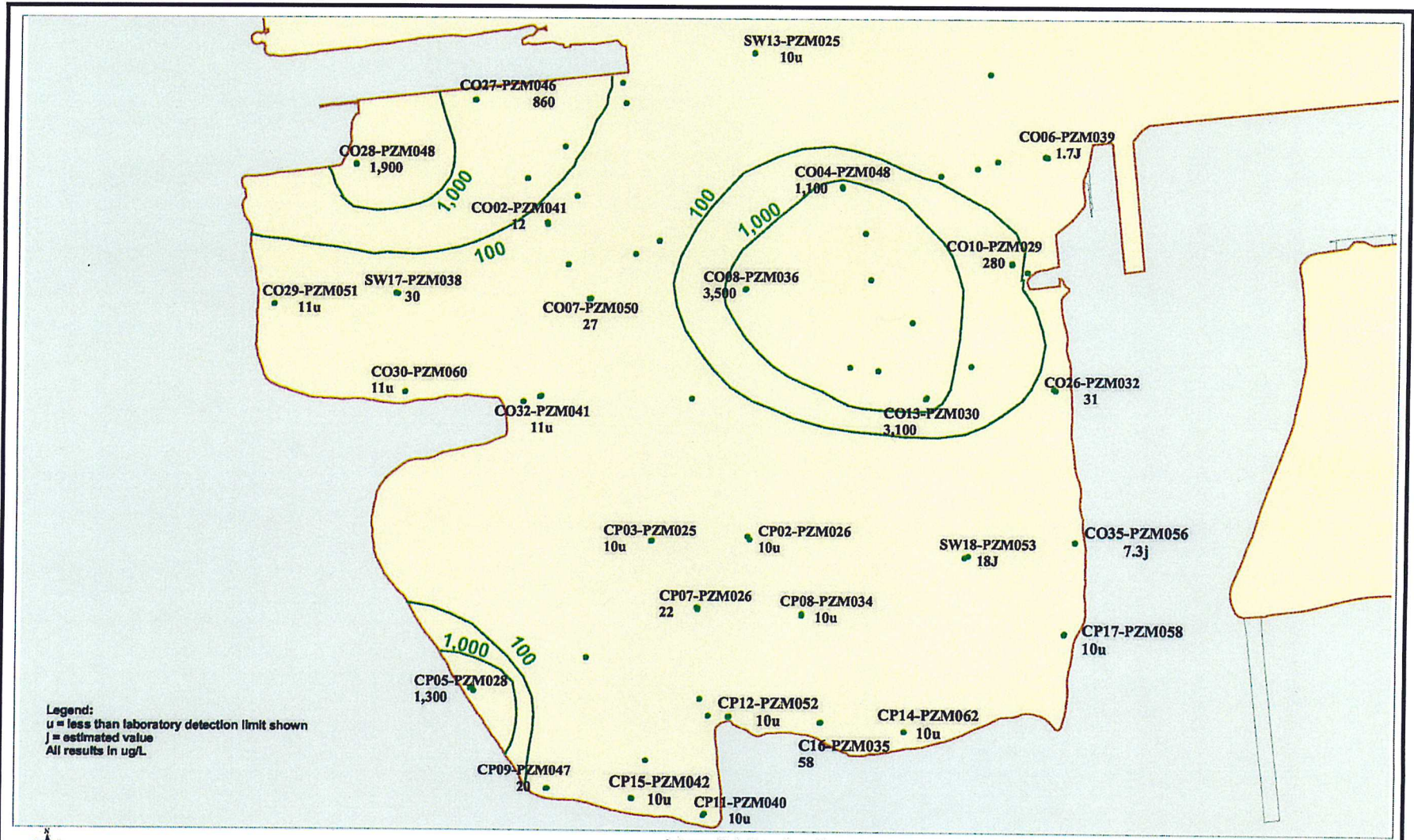
Figure 3-2. Benzene Distribution in Intermediate Groundwater, Coke Point Peninsula, Baltimore, Maryland.



Shallow Zone Locations:
 Coke Oven and Coke Point
 Napthalene Iso Concentrations, ug/L (Parts per billion)

Source: URS. 2006. Response to EPA Comments (4) and (5) dated December 15, 2005. Prepared by URS, under contract to ISG Sparrows Point LLC. Attachment to letter by Robert Abate, ISG Sparrows Point LLC to Andrew Fan, U.S. Environmental Protection Agency, Region III, and Richard Johnson, Maryland Department of Environment, December 6, 2006, 17 pp.

Figure 3-3. Naphthalene Distribution in Shallow Groundwater, Coke Point Peninsula, Baltimore, Maryland.



Intermediate Zone Location:
 Coke Oven & Coke Point
 Napthalene Iso Concentrations, ug/l (parts per billion)

Source: URS. 2006. Response to EPA Comments (4) and (5) dated December 15, 2005. Prepared by URS, under contract to ISG Sparrows Point LLC. Attachment to letter by Robert Abate, ISG Sparrows Point LLC to Andrew Fan, U.S. Environmental Protection Agency, Region III, and Richard Johnson, Maryland Department of Environment, December 6, 2006, 17 pp.

Figure 3-4. Naphthalene Distribution in Intermediate Groundwater, Coke Point Peninsula, Baltimore, Maryland.

APPENDIX E
MONITORING WELL DESIGNATION REVISIONS

**Appendix E
Monitoring Well Designation Revisions**

Location Designation	New Monitoring Well Designation	Previous Well Designation
CO36	CO36-PZM008	Cell 2 - MW1 (S)
	CO36-PZM043	Cell 2 - MW8 (I)
CO37	CO37-PZM003	Cell 2 - MW2 (S)
	CO37-PZM038	Cell 2 - MW9 (I)
CO38	CO38-PZM006	Cell 2 - MW3 (S)
	CO38-PZM043	Cell 2 - MW10 (I)
CO39	CO39-PZM007	Cell 2 - MW4 (S)
	CO39-PZM042	Cell 2 - MW11 (I)
CO40	CO40-PZM008	Cell 2 - MW5 (S)
CO41	CO41-PZM001	Cell 2 - MW6 (S)
	CO41-PZM036	Cell 2 - MW12 (I)
CO42	CO42-PZM004	Cell 2 - MW7 (S)
CO43	CO43-PZM048	Cell 2 - GW Extraction Well 1
CO44	CO44-PZM048	Cell 2 - GW Extraction Well 2
CO45	CO45-PZM047	Cell 2 - GW Extraction Well 3
CO46	CO46-PZM047	Cell 2 - GW Extraction Well 4
CO47	CO47-PZM046	Cell 2 - GW Extraction Well 5
CO48	CO48-PZM044	Cell 2 - GW Extraction Well 6
CO49	CO49-PZMXXX	Cell 2 - RIW 1
CO50	CO50-PZMXXX	Cell 2 - RIW 2
CO51	CO51-PZMXXX	Cell 2 - RIW 3
CO52	CO52-PZMXXX	Cell 2 - RIW 4
CO53	CO53-PZMXXX	Cell 2 - RIW 5
CO54	CO54-PZMXXX	Cell 2 - RIW 6
CO55	CO55-PZM000	Cell 5 - MW1 (S)
CO56	CO56-PZP001	Cell 5 - MW2 (S)
CO57	CO57-PZP002	Cell 5 - MW3 (S)
CO58	CO58-PZM001	Cell 5 - MW4 (S)
CO59	CO59-PZP002	Cell 5 - MW5 (S)
CO60	CO60-PZP001	Cell 5 - MW6 (S)
CO61	CO61-PZM007	Cell 5 - DPE Well 1
CO62	CO62-PZM007	Cell 5 - DPE Well 2
CO63	CO63-PZM007	Cell 5 - DPE Well 3
CO64	CO64-PZM006	Cell 5 - DPE Well 4
CO65	CO65-PZM005	Cell 5 - DPE Well 5
CO66	CO66-PZM005	Cell 5 - DPE Well 6
CO67	CO67-PZM006	Cell 5 - DPE Well 7
CO68	CO68-PZM005	Cell 5 - DPE Well 8
CO69	CO69-PZM005	Cell 5 - DPE Well 9
CO70	CO70-PZM005	Cell 5 - DPE Well 10
CO71	CO71-PZM006	Cell 5 - DPE Well 11
CO72	CO72-PZM005	Cell 5 - DPE Well 12
CO73	CO73-PZM007	Cell 5 - RIW 1
CO74	CO74-PZM007	Cell 5 - RIW 2
CO75	CO75-PZM006	Cell 5 - RIW 3
CO76	CO76-PZM006	Cell 5 - RIW 4
CO77	CO77-PZM006	Cell 5 - RIW 5
CO78	CO78-PZM006	Cell 5 - RIW 6
CO79	CO79-PZMXXX	BP-MW-02S
CO80	CO80-PZMXXX	BP-MW-02D
CO81	CO81-PZMXXX	OBS-1
CO82	CO82-PZMXXX	OBS-2
CO83	CO83-PZMXXX	OBS-3
CO84	CO84-PZMXXX	OBS-4
CO85	CO85-PZMXXX	OBS-5
CO86	CO86-PZMXXX	EXT-1
CO87	CO87-PZMXXX	AS-1
CO88	CO88-PZMXXX	BP-MW-04
CO89	CO89-PZMXXX	BP-MW-05
CO90	CO90-PZMXXX	BP-MW-06
CO91	CO91-PZMXXX	BP-MW-07
CO92	CO92-PZMXXX	BP-MW-08
CO93	CO93-PZMXXX	BP-MW-09
CO94	CO94-PZMXXX	BP-MW-10
CO95	CO95-PZMXXX	BP-MW-11
CO96	CO96-PZMXXX	RW-1
CO97	CO97-PZMXXX	RW-2
CO98	CO98-PZMXXX	RW-3
CO99	CO99-PZMXXX	RW-4
CO100	CO100-PZMXXX	RW-5
CO101	CO101-PZMXXX	Cell 3-1
CO102	CO102-PZMXXX	Cell 3-2
CO103	CO103-PZMXXX	Cell 3-3
CO104	CO104-PZMXXX	Cell 3-4
CO105	CO105-PZMXXX	CT-MW-01
CO106	CO106-PZMXXX	CT-MW-05
CO107	CO107-PZMXXX	OBS-6
CO108	CO108-PZMXXX	OBS-7
CO109	CO109-PZMXXX	OBS-8
CO110	CO110-PZMXXX	OBS-9
CO111	CO111-PZM006	OBS-10
CO112	CO112-PZMXXX	AS-2
CO113	CO113-PZM004	EXT-2
CO114	CO114-PZM002	Cell 4-1
CO115	CO115-PZM006	Cell 4-2
CO116	CO116-PZM003	Cell 4-3
CO117	CO117-PZM003	Cell 4-4
CO118	CO118-PZM007	Cell 4-5
CO119	CO119-PZM009	Cell 4-6
CO120	CO120-PZM009	Cell 4-7